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RADIIUM
A Bibliography of Unclassified Literature

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Technical Information Division, ORE, Oak Ridge, Tennessee
Radium

compiled by
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ABSTRACT
This bibliography, which is arranged chronologically, consists of 745 references covering the period 1898 to 1950. Indexes to authors, subjects, patent numbers and report numbers are included. Subject coverage does not include the properties of radium emanation and radiation.

INTRODUCTION
This bibliography, which covers the period from the discovery of radium (1898) to 1950, has been compiled from references obtained by searching a number of indexes, abstract journals, and topical reviews. The compilers have leaned heavily upon the abstracts found in Chemical Abstracts, Science Abstracts A, and Nuclear Science Abstracts for annotations.

The two outstanding inorganic source books, Gmelin's Handbuch and Mellor's multivolume work, were used as supplementary sources of references. These are the standard, authoritative sources for the chemistry and physics of radium.

The references in this bibliography have been arranged, as nearly as possible, by the year of publication and are further arranged alphabetically by senior author within that year. It should be remembered, particularly for recent research and papers which were at one time classified, that there is a considerable time-lag between the completion of research and publication of results. Some of the very old references contain just journal citations without article titles. These represent references taken from secondary sources which were not checked against the original articles.

A comprehensive coverage of the research on radium has been attempted, but it is emphasized that this coverage is on radium and its properties and not on the properties and effects of radium radiations and emanations. For example, the decay constants and toxicity of radium are included; however, the properties of the "active deposit" of radium and the use of radium needles in therapy have been excluded, as are the effects of radium radiations on fungi. Since the majority of these references were entered without physical comparison with the original article, some inappropriate references undoubtedly have been included. The responsibility for such errors of inclusion, or omission must be borne by the compilers.

Indexes to authors, subjects, patent numbers, and to report numbers follow the list of references. Index references are made to the sequential numbers which have been assigned to each item listed.
RADIUM--A BIBLIOGRAPHY OF UNCLASSIFIED LITERATURE

1898

1 Curie, M., Curie, P. and Bémond, G. "Another New Radio-active Element." *Compt. rend. 127, 1215-17 (1898).

In addition to the new element polonium an entirely different element has been found in small traces in pitchblende residues, in company with barium and analytically behaving as such, but extremely radioactive. By fractional precipitation of the chlorides of barium from solution by means of alcohol, chlorides have been obtained containing chlorides of the new element ("radium") which have 900 times the radiant activity of metallic uranium. M. Demaray has examined the spectrum and finds a notable line at \( \lambda = 3814.8 \) (Röntgen scale) not otherwise identifiable. The trace must be small, for the atomic weight of the barium is only very slightly altered, although it is always altered in one direction, that of increase as compared with inactive barium. The chloride of "radium" makes a photographic negative in half a minute where uranium or thorium or their compounds would take hours; and, through aluminium, it can render a film of platinumcyanide of barium permanently luminous sufficiently to make it visible in the dark without any apparent supply of energy. Uranium and thorium do not produce this latter effect, probably because their action is too feeble.

1899


By extraction from a large quantity of uranium ore, the author has obtained substances which possess the properties ascribed by M. and Mme. Curie to "radium". Two preparations have been made. Preparation A exhibits the properties of Becquerel rays. It excites fluorescence in a barium platinumcyaide screen even across opaque substances, affects the photographic plate, makes air electrically conducting, and has an additional property not hitherto described, that of being itself strongly luminous. Preparation B possesses in general the same properties as preparation A, but the excitement of the screen is more intense, whereas the self-luminosity is feeble. In both cases the rays which produce fluorescence penetrate bodies like black cardboard more readily than they penetrate glass. Both preparations must be carefully preserved from moisture, especially the first preparation, which loses its own luminosity in a few hours when exposed to the moisture of the atmosphere. Once the luminosity is lost it is difficult to restore it. The only expedient which succeeds as a rule is that of melting the substance in the oxyhydrogen blowpipe.


An account of the photographic spectrum of radium obtained from specimens of barium chloride containing radium. The wave-lengths of fifteen of the strongest of the new rays are given; many of them are as strong as the strongest of those of barium. All the lines are narrow and sharply defined, and resemble those of barium.

4 Giesel, F. *Physik. Z. 1, 16-17 (1899).

The author reports that the crystals of \( \text{RnCl}_2\cdot2\text{H}_2\text{O} \) are white at first and become yellowish with time. Information is also included on radium iodide.

1899


Article includes information on radiumiodide.


Observations on the magnetic susceptibility of Ra are described.

1900


Radium radiations are of three kinds - a part deviable by a magnetic field; a part non-deviable and readily absorbed; and a part weaker and diffused, non-deviable, attributable partly to secondary rays.


M. and Mme. Curie have shown that the radiations from radium carry negative electric charges. They therefore, like cathode rays, probably depend on the transport of matter. Measurements of the electrostatic deviation in a magnetic field are difficult; details are given. From the results of these measurements, with calculations of the trajectories, it appears that the velocity \( v = 1.6 \times 10^7 \) cm/sec. and the mass charge ratio for the molecules, \( m/e = 10^{-7} \), quantities of the same order as in the case of cathode rays. And on taking into account M. and Mme. Curie's value for the rate of loss of charge, it follows that the energy radiated/cm.\(^2\) is about 5 ergs/sec. and the quantity of matter lost/cm.\(^2\) is about one milligram in a milliard years.


The author first employed active barium chloride (activity 240) and active barium bromide, using a platinum spiral heated electrically, so that very small quantities might be used, and examined the spectra for the radium lines. Of these he found only \( \lambda = 3814.591 \) of intensity 2, when the intensities are reckoned from 6 to 1 so that 6 indicates the greatest intensity. Using another specimen of active barium chloride (activity 1000) he obtained \( \lambda = 4682.346 \), Int. 1; \( \lambda = 3814.591 \), Int. 4; and a new line \( \lambda = 2708.6 \), Int. 1. Up to \( \lambda = 2100 \) no more radium lines were found.


Polonium (which chemically resembles bismuth) falls off slowly in its radioactive power. Radium (similar to barium) seems to have a higher atomic weight than barium, for the atomic weight of barium seems higher (146) in radiferous barium compounds than it does (137) in compounds free from radium. The solid compounds of radium become more radioactive as time goes on, and do not reach their maximum activity within a month; their initial condition is restored by dissolving them and recrystallizing. The chloride and bromide of radium are the most brightly luminous compounds; but all the salts are so to some extent, induced phosphorescence and induced radioactivity in the neighborhood of radium as described by Becquerel were discovered by the authors.
1900


A method of measuring radioactivity by means of an electrometer is described, and a list of uranium compounds and their activities is added. The report deals also with thorium, polonium, and radium, the spectrum and atomic weight of the latter, and the penetrating power and activity-inducing power of the rays.


A specimen of very pure radium, with barium lines very feeble, gave no lines beyond those already found, but some weak nebulous rays are much better marked. The spectrographic characters of radium are similar to those of the alkaline earths.

13 Miethe, A. Physik. Z. 2, 267 (1900).

A description of the spark spectrum of Ra is given.


The author criticizes the fifteen spectrum lines ascribed by Demarcey to radium. He points out that the accuracy with which these fifteen lines were determined is not very great, the error being about 0.7 of an Angstrom unit. Hence Demarcey's line 4863.0 might be anywhere between 4862.3 and 4863.7. But in this interval there are no less than six Fraunhofer lines, according to Rowland, and that makes the evidence for the separate identity of radium much feeble than it was. The author has therefore redetermined the spectrum of radioactive barium chloride with a greater dispersive power than that employed by Demarcey, and has definitely located three of Demarcey's lines. These are situated at 4826.14, 4882.346, and 3814.591 respectively. The remainder were either invisible or were found in the spectrum of barium chloride when free from radium. An economical method of obtaining the spectrum was that of dipping a thin platinum wire into the powdered preparation and heating the wire by means of an electric current until a bead was formed, which was then made an anode in a spark-gap. But it is possible that the luminescent intensity attained was not great enough to reveal some of the feeble lines described by Demarcey. But the three lines mentioned are definitely established, and they are not contained in the solar spectrum.

1901


Experiments were made to determine whether radium exerted any decomposing action on iodine pentoxide, this reaction being chosen on account of its endothermic character. The radioactive material had a mass of 0.145 g., about one-eighth of this being chloride of radium, and the remainder chloride of barium. It was placed in a very small sealed glass tube which was surrounded by a thin, somewhat wider, tube, around which was placed 4 to 5 g. of white iodine pentoxide, any volatile products of decomposition being carried off by a current of dry air. The decomposition of the iodine pentoxide was noticed only under the influence of radium, and when the tube containing it was not surrounded by black paper, that is, under the conditions in which the phosphorescence of the mixture manifests itself. The radiations which produce this phosphorescence in consequence of a double transformation of energy played a characteristic part in the actual experiment. Series of experiments were carried out at 10° and at 100°. According to Curie and Béquier, the energy radiated by a layer of radioactive matter of 2 mm. thickness spread over 1 cm.² of surface is about 5 c.g.s. units of energy/sec. Calculating from these numbers the amount of iodine set free by the endothermic decomposition of IO₃ in the experiment described would amount to not more than ½ₜ₀ of a milligram. This value corresponds to the order of magnitude of the phenomena observed by the author.

16 Curie, M. and Debarne, A. Compt. rend. 133, 768 (1901).

Some properties of metallic Ra are given.


The spark spectrum of Ra is described.

1902


By fractional crystallization of a large quantity of radiferous barium chloride a decigram of radium chloride was obtained of such purity as to show in the spectroscope only faint lines of barium. Three determinations of the silver chloride obtained by precipitation with silver nitrate gave a mean atomic weight of 226, which is considered correct within one unit. When certain quantities of Ba and Ra are present, the crystals have a yellow or rose color. Radium chloride itself is colorless and spontaneously luminous. The element by its chemical properties belongs to the alkaline-earth series, and in the periodic system takes its place between Ba and Th and U.


Observations on the chemical behavior and radiactive properties of various salts of Ra, Po, and other radio-active elements.


The preparation of radium chloride is described: when approaching purity it gives a carmine red flame instead of the green of barium. The spectrum has two bright lines in the red, one bright line in the blue, and two fainter ones in the violet. The spark spectrum is probably not the same as the flame spectrum.


The authors report the half-life period of Ra³₂⁴ to be about 4 days.

The radioactive substance was placed in a groove hollowed out in a block of lead. Above this, at a height of about 1 cm., was arranged a metallic screen with a slit in it parallel to the groove, and above this again a photographic plate. The whole was put in the field of an electromagnet, the slit being parallel to the field. When the magnetic field was excited first in one sense and then in the other, two images of the beam were obtained on the proof, which shows that the pencil of rays was deviated first in one direction and then in the other. In one case, a distance between the images of 1 mm. was obtained. Further experiments showed that the direction of the deviation agreed with the results obtained by Rutherford.


Proofs have been obtained that the α-rays from Ra and the radiation from Po are identical. It was previously pointed out that the degrees of absorption of the two kinds of rays were very similar. They are shown to behave similarly as regards deviability. A photographic method of experiment was adopted, the two proofs - the feeble one of polonium and the intense one of radium - appeared superimposable. The direction of the deviation of both kinds of radiation was the inverse of that of cathode rays. The different kinds of radiation emitted by active bodies may be thus classified: (1) Uranium emits only radations charged with negative electricity and very penetrating. (2) Polonium emits only rays charged with positive electricity and very penetrating. (3) Thorium and radium emit both these kinds of radiation. Radium sends out besides these, very penetrating non-deviable rays. The nature of these is unknown, but they exhibit various characteristics which are also found in the case of Roentgen rays.


The ultra-violet spectrum of Ra is described.


The spark spectrum of a solution of radium nitrate was photographed with the iron spark spectrum in juxtaposition as standard. Self-induction was used in order to eliminate the air lines. Details of the 5 quartz-prism spectrograph and the methods of measurement and calculation are given in the paper. A reproduction of the radium spectrum is also appended.


The author points out that the value 258, which was given by Runge and Precht for the atomic weight of radium on the basis of an experimental law dealing with the distribution of lines in the spectra of the neighboring elements, Ca, Sr, and Ba, is arrived at by extrapolation, and is probably not the true number. The suggestion of Runge and Precht that the radium which was examined by the author, and which gave the atomic weight 224, contained barium is untenable, as it was shown to be spectrally pure.

27 Curie, P., and Cheneveux, C. Bull. soc phys. 1, (1903).

The authors found the magnetic susceptibility of RaCl₂ to be +1.05 x 10⁻⁴, so that the element is feebly paramagnetic in combination. Ba is diamagnetic, −0.40 x 10⁻⁴; hence, observations on samples contaminated with Ba are very unreliable.


It has been proved that the salts of radium disengage heat in a continuous manner. A thermo-couple, iron-constantan, of which one junction was surrounded by radiferous barium chloride, and the other by pure barium chloride, shows a difference of temperature between the two substances. The radiferous salt was found to have a temperature 1.5° higher than the other. On performing a control experiment with two specimens of pure barium chloride, the differences of temperature observed were only of the order of magnitude of 1/100°. It was sought to measure quantitatively the heat disengaged in a given time by the radium. (1) The heat set free was compared with that produced by the passage of a known current through a known resistance. (2) The heat disengaged by radium was measured by direct observations with Bunsen’s calorimeter. One gram of radiferous barium chloride which was used in the experiments, set free about 14 cal. per hour. The composition of the product used was not exactly known. According to its radiant activity it ought to have contained about 1/6 of its weight of pure barium chloride. Measurements were also made with a sample of 0.08 g. of pure radium chloride. These led to results of the same order of magnitude as before. One gram of radium disengages a quantity of heat which is of the order of 100 cal. per hour. One gram-atom of radium (225 g.) would set free each hour 22,500 cal., an amount comparable with that produced by the combustion in oxygen of 1 gram-atom of hydrogen.


The separation of radium salts by fractional crystallisation is described.


On Dec. 5, 1903, 30 mg. of the strongest radium bromide available were sealed up in a tube of alkali-free Jena glass for the purpose of determining the supposed loss of weight by radium salts. On May 27, 1903, six months later, it was designed to open the tube, and for this purpose a triangular file was used. Immediately the file touched the surface of the tube, the glass was pierced by an electric spark which was clearly visible in broad daylight immediately in front of the window. The sound was so loud that an assistant who in the room at the time mistook it for the discharge of a small induction coil. It is suggested that the escape of the negatively charged β-particles and the retention by the glass of the positively charged α-particles had produced a strong positive charge on the inside of the glass, and that ultimately the potential difference (which must have amounted to some thousands of volts) had proved sufficient to pierce through 0.3 mm. of glass.
1903
31  Giesel, F.  "Radium."  Ber. 25, 342-7(1903).
A solution of 1 g. of "5 per cent" radium bromide liber-
ated in 16 days 3.5 cc. of gas containing 78% hydrogen and
17% oxygen, while the solution became colored with bromine.
Radium thus sets up a kind of electrolysis, the cation being
hydrogen and the anion hydroxyl or bromine. It is calculated
that the 5 cc. of radium bromide generate (or transform) in
this way energy to the extent of 1.3 watts -sec.s =0.42 cal.
=18,000 g. cm. per day.

32  Huggins, W. and Huggins, Lady.  "Spectrum of the
Spontaneous Luminous Radiation of Radium at Or-
72A, 196-8(1903).
A photograph of this spectrum showed no lines due to ra-
dium, but eight other lines which were so close to the bands
in the nitrogen spectrum as to justify the conclusion that
they were due to this gas.

33  Precht, J.  "Position of Radium in the Periodic System

The authors report that 1 g. of Ra generates about 113 cal./
hour.

34  Ramsay, W. and Soddy, F.  "Gases Occluded by Ra-
adium Bromide."  Nature 68, 246(1903).
The gases evolved from 20 mg of radium bromide, which
had been kept for a long time in the solid state, were exam-
ed. After the hydrogen and oxygen were removed the spec-
troscope showed the presence of carbon dioxide. After freeze-
ing out this gas together with the emanation, the residue
gave the D2 line of helium. This was repeated with a further
quantity of the radium salt, when the spectrum was found to
be that of pure helium with two new lines. From Rutherford's
work upon the mass of the "a-rays," the authors consider
that their results prove that these "rays" consist of helium.

35  Ramsay, W. and Soddy, F.  "Production of Helium
from Radium."  Proc. Roy. Soc. (London) 72A,
204-07(1903).
The maximum amount of the emanation obtained from 50
mg. of radium bromide was conveyed by means of oxygen
into a U-tube cooled in liquid air, and the oxygen was then
extracted by the pump. It was then washed out with a little
fresh oxygen, which was again pumped off. The vacuum tube
sealed on to the U-tube, after removing the liquid air showed
no trace of helium. The spectrum was apparently a new one,
probably that of the emanation. After standing four days the
helium spectrum appeared, and the characteristic lines were
observed identical in position with those of a helium tube
thrown into the field of vision at the same time. On the fifth
day the yellow, the green, the two blues, and the violet were
seen, and in addition the three new lines also present in the
helium obtained from radium. A confirmatory experiment
gave identical results.

36  Runge, C. and Precht, J.  "Flame Spectrum of Ra-
A piece of platinum wire with a looped end was heated to
redness by an electric current, and a small fragment of ra-
dium bromide was brought against it. The salt adhered to
the wire and melted, so that a bead was formed with phos-
phoresced brightly on cooling. When this bead was brought
into a Bunsen flame a red coloration was produced, the lines
of whose spectrum were visually measured. The wave-lengths
of these lines are given in the paper; the most important
lines occur at = 6553, 6349, and 4826. Three bands also occur
in the red, two of which are very strong, namely, those from
= 6700 to = 6530, and from = 6330 to = 6130; these
very possibly belong to the spectrum of the compound radium
bromide.

37  Runge, C. and Precht. J.  "Spark Spectrum of Ra-
A table is given of the wave-lengths of 40 lines in the
spark spectrum of radium bromide, taken by an induction
coil on platinum poles, and photographed with a large con-
cave Rowland grating. Comparisons with the values given
by Demaray and Exner and Haschek are indicated.

38  Runge, C. and Precht. J.  "Position of Radium in
the Periodic System as Determined by its Spectrum."  Physik. Z. 4, 285-7(1903).
By means of their behavior in the magnetic field the
authors selected the lines in the radium spectrum which
form the first pair in the principal and the first and second
subordinate series respectively. These lines correspond ex-
actly to the similar lines in the spectra of magnesium, cal-
cium, strontium, and barium. It is well known that the fre-
quency differences of all the pairs of the two subordinate
series and the first pair of the principal series are all equal.
This frequency difference is nearly proportional to the
square root of the atomic weight for the elements of one
chemical family. This is not strictly true, and the authors
state the law as follows: The atomic weight in proportional
to a power of the frequency difference, or the logarithms of
the atomic weights are a linear function of the logarithms of
the frequency differences. These frequency differences
for magnesium, calcium, strontium, and barium are 91.7,
225, 801 and 1691; on plotting the logarithms of these num-
bers against the logarithms of the atomic weights a straight
line is drawn through the points and is extrapolated to find
the atomic weight of radium, taking its frequency difference
as 4858.5. In this way the atomic weight is found to be 257.8.
This value does not deserve more consideration than that
experimentally determined by M. Curie as 225, but it must
be remembered that barium and radium bromides are iso-
morphous, and therefore very difficult to separate. An in-
complete separation would tend to lower the atomic weights
as determined by chemical means. The value 225, on the
other hand, fits in with the periodic system much better than
257.8.

39  Runge, C. and Precht, J.  "Heat Production of Ra-
38, 783-6(1903).
The authors have compared the output of heat of 57 mg. of
radium bromide with that produced in a platinum spiral by
the passage of an electric current. The heat produced was
found to be 65 cal.s, per hour for 1 g. of radium bromide:
or if 257 is assumed as the atomic weight of radium, the
heat produced by 1 g. of radium is 105 cal.s/hour. This
agrees with Curie's and Laborde's result, which gave the
output of energy as of the order of 100 cal.s per hour.

Measurements of the rate of leak produced in various gases by the γ-rays from radium are given, and a table of the relative ionizations produced by the three varieties of radium-rays and by Roentgen-rays. The values of these latter for the γ-rays are about the same as those for the β-rays.


From experiments previously described the author concluded that each of the corpuscles given out by radium generates at least 13 ions per cm. in air at 1 mm. pressure. Durack in his observations found the number 0.4. It is here suggested that the difference in the values is due to the differing thickness of the aluminum through which the radium corpuscles had to pass before reaching the gas. The thickness was greater in the author’s experiments, so that the corpuscles passing through the gas would be travelling with diminished velocity and consequently would each produce a larger number of ions per cm. in the gas.

42 Watts, W. M. “Atomic Weight of Radium.” Phil. Mag. 6: 64-6 (1903).

The author has previously shown that there appear to be two distinct kinds of connection between the spectra of the elements and their atomic weights. In the case of the znc, cadmium, and mercury, and of gallium and iridium, the differences between the oscillation-frequencies of certain lines of the one element are to the differences between the oscillation frequencies of the other element as the squares of their atomic weights. In applying this method some uncertainty exists as to the correspondence of the lines in the different spectra, but it is possible by accumulating evidence of this kind to obtain indications as to the probable atomic weight of radium from a comparison of its spectrum with those of mercury, barium, and calcium. By selecting appropriate lines it is possible to deduce for the atomic weight of radium the values 226.32, 226.42, 225.21, 226.32, 226.52, from the first type of relationship, and the values 225.05, 223.47, 220.36, 223.13, 227.39, and 224.53 from the second type of relationship. The mean of all these results is 224.89, the experimental value being 225. While the spectroscopic evidence now adduced is not of a very certain character, it serves to throw doubt upon the calculations by which Buné and Precht deduced the value 258 for the atomic weight of radium, and indicates that the analytical value is not incapable of being reconciled with the spectroscopic evidence.


Observations were made based upon the self-electrification of radium. The two kinds of radiation appeared to be sent out in too different amounts considering the quantity of electricity. Taking Des Coudres’ observations on the ratio m/e, viz., 1.6 x 10^-4 for the positive particles and 1 x 10^4 for the negative, m = 2.5 x 10^-50 g. per sec. for the negative and 4.6 x 10^-77 for the positive. Hence the energy of the radiation is not inconsiderable. Taking y = 2.5 x 10^-6 for the negative and 1.85 x 10^-8 for the positive, the first 1/2mv = 8.7 ergs and for the others 1/2mv^2 = 60 ergs per sec.

1904


Using 100 mg of specially pure radium bromide, the author found that 1 gm. of radium bromide gives out 1.14 cal. per min. or 68.5 cal. per hour, so that 1 g. of pure radium would give (taking the atomic weight of radium as 225) 117 cal. per hour (or 110 cal. for atomic weight 258). These values are somewhat higher than those obtained by Precht. In 7 months the radium gave off altogether 345,000 cal. per g.


From the thermochemical data it would appear that the separation of the metal would be increasingly difficult in the series Ca, Sr, Ba, but when a mercury cathode is used the voltage required is greatly reduced owing to the energy liberated in the formation of amalgam, and the order in which the metals separate is reversed. Thus it requires 0.2 volt more to separate strontium from barium, and 0.25 volt more to separate calcium than strontium; if the series were continued, radium should require less voltage than barium by considerably more than 0.25 volt, and it is actually found that metallic radium is precipitated by barium amalgam. Owing to the very small proportion of radium in the crude bromide it is impossible to effect a sharp separation of the metals except at an impractically small current-density, but a considerable concentration may be effected by this method. It is of interest to note that freshly prepared (unoxidized) radium amalgam, like the salts of the metal, only slowly attains its maximum activity, while the (silver) anode, which appears to attract to itself the greater part of the excited activity and is at first more radio-active than the cathode, soon becomes altogether inactive.


A spectroscopic examination of the gas pumped off from radium bromide showed that it contained helium.


From observations on minute specks of radium bromide heated upon the platinum ribbon of the molybdenum its melting-point is found to be 728°C. At higher temperatures — up to 1,600° — there is every appearance of decomposition, a quartz glass finally remaining on the hot platinum. This is insoluble in hot or cold water or HCl.


A method for extracting radium by converting the sulfates to chlorides is described.


A method for obtaining a radium amalgam from a concentrated solution of Ra- Ba chloride by repeated shaking with a sodium amalgam is described.


A method of separating radium chloride from barium chloride is described. If a concentrated solution of radium bar-
ium chloride is shaken up with a fifth of its weight of sodium amalgam, a radium and barium amalgam is formed, and the proportion of radium to barium in the amalgam is very much higher than in the solution. By repeating the process many times the radium can be accumulated.

51 Matout, L. “The Radiation from Radium.” *Radium,* Le 1, 6-14(1904).

A general paper dealing with the examination of the different actions of the radiation by (1) phosphorescence methods, and (2) the magnetic field. An experimental arrangement of Becquerel’s, comprising two concentric cylindrical lead screens provided with small openings at different places, the radium, being in the interior of the inner screen, is recommended as a convenient photographic method of studying the absorptive power of a screen for rays of a definite velocity. Illustrations are given showing the results obtained.


A quantity of radium bromide, enclosed in a glass tube with walls 0.8 mm. thick, was insolated in a vacuum by a quartz suspension and found to gain in potential at the rate of 132.5 v./min. owing to the escape of the negatively-charged β-rays. The radium salt was then enclosed in a sheath of lead 1 cm. thick, and the change of potential was again determined. The absorption coefficient of the β-rays by lead is 62.5, and the absorption by 1 cm. should reduce the amount of radiation to e^{-26.5} or 10^{-6} of that originally transmitted. The actual increase of potential, was, however, only reduced in the ratio 1:85, and this residual effect the author attributes to γ-rays, which therefore regards as negatively charged. The following table shows the way in which the coefficient of absorption varies with the thickness of lead through which the radiation has travelled. The absorption coefficient for the β-rays as determined by Strutt is 62.5, while the most penetrating rays in the case described above have a coefficient only one-fiftieth as great.

<table>
<thead>
<tr>
<th>Thickness of lead, d...</th>
<th>0</th>
<th>0.0034</th>
<th>0.028</th>
<th>0.43</th>
<th>1.33</th>
<th>1.50 cm</th>
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<tr>
<td>Capacity…………………...</td>
<td>1.93</td>
<td>3.57</td>
<td>2.57</td>
<td>3.31</td>
<td>4.65</td>
<td>5.97 x 10^{-8} Paras</td>
</tr>
<tr>
<td>Rate of potential…………</td>
<td>152.5</td>
<td>19.45</td>
<td>9.02</td>
<td>5.89</td>
<td>3.872</td>
<td>2.084 volts/second</td>
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<tr>
<td>Current…………………...</td>
<td>48.2</td>
<td>67.14</td>
<td>97.7</td>
<td>15.8</td>
<td>5.21</td>
<td>5.44 x 10^{-6} amp</td>
</tr>
<tr>
<td>Absorption coefficient a</td>
<td>0.13</td>
<td>0.25</td>
<td>0.56</td>
<td>1.32</td>
<td>1.27</td>
<td>1.50 cm</td>
</tr>
</tbody>
</table>

53 Paschen, F. *Physik. Z.* 5 583(1904).

The author reports that 1 g. of Ra generates about 126 cal./hour.

54 Precht, J. Jahrb. Radioakt. u. Elektrosalin 1 61(1904)

The spark spectrum of Ra is described.


The author measured, by means of an ice calorimeter, the heat given out by 34.1 mg. of radium bromide. The mean value was 2.085 cal./hour. Thus 1 g. of radium bromide produces 61.15 cal./hour, and taking RaBr₃ as the formula, and assuming the atomic weight of radium obtained from spectroscopic observations, viz., 228, the output of heat of 1 g. of Ra per hour would be 98.83 cal. The number is 110.3 cal. If M. Curie’s number for the atomic weight of radium (225) is taken. The number obtained agrees well with earlier observations.

1004


The paper describes the continuation of the research undertaken with the object of ascertaining the volume of emanation produced in a given time from a given weight of radium bromide, and also the quantity of helium resulting. The values found are extremely small, and the determinations involved repeated separations from minute quantities of nitrogen occurring as impurities. It was concluded that 1 g. of radium produced 3 x 10^{-4} mm³ of Rn/sec.


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The authors give a number of new lines in the spark spectrum of radium, for which a more highly purified sample of radium bromide was employed than that used in their previous measurements.


Several of the chief lines in the radium spectrum have been examined under the action of a strong magnetic field, and the results analyzed in connection with similar determinations on the spectrum lines of the elements Mg, Ca, Sr, Ba, the intensity of field being about 30,000 c.g.s. A plate is given from a photograph of the line 5814, showing the six components clearly. Logarithmic curves show an intimate relation in the behavior of the radium spectrum and those of the above elements.


The question whether the radio-activity of radium depended upon its concentration was tested by measuring the radio-activity of radium bromide (1) when in the solid state and (2) when diffused throughout a solution more than a thousand times the volume of the solid. It was found that in the sec-
1904

and case no appreciable influence on the radioactivity of the compound was exerted. The radio-activity of radium over the range investigated is not affected by its own intense radiations. It is thus improbable that the energy given out by radium is due to absorption of an unknown external radiation which is similar in character to the radiations which are emitted.


(Paper read before the American Physical Society, St. Louis, Dec. 25, 1903). Experiments were undertaken to determine how the emission of radium is connected with its radio-activity. The heating effect of 30 mg. of pure radium bromide was first measured in a differential air calorimeter. The radium bromide was then heated to a sufficient temperature to drive off the Rn and the latter was condensed by passing through a short glass tube immersed in liquid air, and then the tube were sealed off. On testing the de-emanted radium the heating effect diminished rapidly during the first few hours, falling to a minimum corresponding to about 30% of the original value, and then slowly increased again. On substituting the emanation tube in the calorimeter, the heating effect at first increased, for a few hours, to a maximum corresponding to about 70% of the original heat emission of the radium, and then slowly decayed with time. The sum-total of the heating effect of the radium together with that of the emanation tube was found to be equal to that of the original radium. About 6% of the emanation in one experiment appeared not to be released from the radium by the heating. About 75% of the heating effect observed from radium is not directly due to the radium but to the emanation and induced activity. There is a close connection between the variation of the radio-activity of the radium and its rate of heat emission. After separation of the emanation, the activity of the radium falls to a minimum of about 25% in the course of a few hours and then gradually increases again. At the same time, the activity due to the emanation increases with time, on account of the excited activity produced by the emanation on the walls of the vessel. The curves of recovery of the heating effect of radium and the gradual decrease of the heating effect of the emanation are almost exactly the same as the corresponding curves for the recovery of activity of the radium and the loss of activity with time of the separated emanation. The heating effect of radium appears to be proportional to its activity measured by the α-rays; or the heat emission seems to be an accompaniment of the expulsion of α-particles. There is a very sudden drop in the heating effect observed for both the emanation tube and the radium, after removal of the emanation. The activity drops to 82% of the maximum value. Thus the radiation supplies about 18% of the total activity of radium measured by the α-rays. There then follows a fairly rapid decrease for 6 to 8 min., and then a more gradual decay to a minimum of 25%. The other results indicate that the heating effects accompany the emission of α-rays. The heating effect from the emanation together with that of the active product to which it gives rise is equal to about 75% of the total heat emission of radium. Since 1 g. of radium emits heat at a rate of 100 g. cal./hour; the emanation from 1 g. of radium a few hours after its removal radiates heat at the rate of 75 g. cal./hour. It is calculated that the total amount of heat derived from the emanation from 1 g. of radium is about 10,000 g.-cal. The amount of heat liberated per hour from 1 cc. of the emanation would lie between 1.25 x 10^6 and 1.25 x 10^7 g.-cal. This amount from 1 cc. would probably be sufficient to raise to a red heat, if not to melt down, the glass tube containing it. The emanation behaves as if it were a gas of heavy molecular weight, and the authors calculate that 1 lb. of the emanation, while the heating continued, would emit an amount of energy between 6 x 10^6 and 6 x 10^7 h.p.-days. On the disintegration hypothesis the large amounts of energy involved are derived from the energy latent in the radium atoms, which is released in the successive stages of the disintegration.


An account is given of an experiment which tends to show that the polonium found in radio-active minerals is a product of the radium they contain.

64 Sutherland, W. "Atomic Weight of Radium." Nature 70, 627(1904).

Runge and Precht worked out the atomic weight of radium from its spectrum to be 238 instead of 225 found by M. Curie. The author of this note discusses the numerical relationships shown in spectra, and points out that the spectral data of radium support the value of the atomic weight given by M. Curie, if handled according to the method previously described by him.


The author has carried out a series of long-continued experiments on the time rate of decay of the radio-activity of radium, and on the life of radium in very small quantities with the object of testing the view of J. J. Thomson that the radiation intensity depends upon its state of subdivision. Pure radium bromide in small quantities (10^-2 to 10^-4 mg.) in different thicknesses on glass plates was examined for the ionizing effect on an Elster-Geltel-Ebert electroscope without aspirator. The rates of discharge with and without the radium were examined, care being taken that the emanation produced no effect. As a result it was found that the weakest plates became quite ineffective after 15 days' others after 21, 61, and more days' the stronger ones had diminished in effectiveness after 100 days, but were still radioactive. The life, as a function of the concentration, gives a rapidly rising curve, from which one can see that from 10^-2 mg. the radio-activity would only cease after years. The life attributed to radium by P. and Mme. Curie, and by Ramsay, Soddy, and others is considered consistent with these results.


On radium-barium chloride, freshly prepared from crude radium-barium carbonate, being electrolyzed (mercury cathode and platinum anode), the amalgam formed at the beginning
of the electrolysis was found to be more strongly radio-active than that formed later.

1905


Two metal vessels contain, the one a quantity of radium bromide, the other a heating coil. A current is sent through the latter until the steady temperature in each vessel is the same, this equality being shown by a thermocouple. No matter what the vessels are composed of - lead, copper, or aluminum - the amount of heat developed by the radium is the same, viz., 1,158 g. cal./min. for every g. of the radium bromide. The heating effect of the γ-rays is therefore small.

69 Ångström, K. "Heat Given Out by Radium." Physik. Z. 6, 685-8 (1905). (Paper read before the Liege Congrès de Radiologie.)

This article is similar to the previous reference.


Emanations from radio-active substances (RaBr₂, Giesel's material) carry no electrical charges, and are therefore probably neither residues of atoms which have lost positive ions nor are they those positive ions themselves.


A discussion of some of the author's results in the light of more recent knowledge.

If the ionization varies inversely as the nth power of the velocity, n is found nearly equal to 2.


(Paper read before the Royal Society of S. Australia June 6, 1904.)

The authors have improved the apparatus previously used by them, and have repeated their observations on the range of the α-particles from radium. The fact that there are four sets of these differing only in velocity is clearly established.

The substances on which range observations have been made are the following: Gold, platinum, tin, silver, copper, aluminum, air, methyl bromide and iodide, carbon tetrachloride, ether, and hydrogen. Instead of giving numbers showing the stopping powers of strata of different materials of the same weight, they are referred to layers containing the same number of atoms, an imaginary air atom of atomic weight 14.4 being taken as having unit stopping power. The law of absorption as given by the usual exponential equation is considered to be altogether untrue. From a discussion of the results the following conclusions are arrived at: (1) That the α-particle makes the same number of ions during its course, no matter what the gas it traverses; (2) that the energy required to make a pair of ions is always the same; and (3) that the observed variations in the conductivities, in some cases are due to the failure of ions to get free from the molecule in which they are made.


1905


Attempts to make electroscopes having a very small natural leak have been repeatedly unsuccessful in the physics laboratory of the McGill University. It has been found that all the materials in the laboratory have become radio-active owing to the presence of radium emanation. About 90% of the activity can be removed by strong hydrochloric acid. The author recommends that, in laboratories not already infected, any radium should be kept in closed vessels, and none of the emanation discharged except into the outside air.


According to Volter the life of radium is considerably shortened if the radium salt which is tested is taken in very small amounts. Thus if the mass is 10⁻² mg, the life is 126 days, if 10⁻³ mg, the life is reduced to 15 days. This is opposed to the usual theories of radio-active change that Eve has repeated the experiments. The results entirely negate those of Volter. The activity is always proportional to the quantity of the salt present, and in one case where 10⁻⁴ mg. was spread over 76 cm², by deposition from solution, more than 40 days passed since the maximum activity was reached, although, according to Volter, the activity should have disappeared entirely in about 20 days. Eve points out that as Volter's experiments were carried out with the radium exposed to the free atmosphere, the decrease in activity is due to the dispersion of the active matter into the surrounding space. In his own investigations the salt is always tested in a closed vessel.


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This article is similar to the previous reference.

77 Godlewsky, T. Phil. Mag. (6), 10, 35-9 (1905).

A method for the separation of Ra²₂² (AcX) from Ac preparations by precipitating Ac and Th by ammonia. The Ra²₂² remains in the filtrate. A value of 10.3 days is reported for the Ra²₂² half-life.

1905

The author reports the half-life of ThN (Ra²⁴) to be 4.6 days.


A method for leaching radium ore with Na₂CO₃ or K₂CO₃ and then with acid for Ra extraction is given.


It was possible that the effect on the photographic plate in the experiments of B. Walker and the author might be due to fluorescence of the quartz window in the neighborhood of the radium salt. Further experiments have shown that this is not the case, but that the air above the radium preparation actually becomes luminous.


It has several times been found that when water is decomposed by radium bromide an excess of hydrogen is obtained. One of the probable causes, which also frequently occurs, is oxidation of the grease of stopcocks. The emanation acting on pure water in absence of oxidizable substances gives a gas mixture which consists of H and O in explosive proportions.


A suggested explanation of the appearances observed by J. B. Burke. Minute grains of solid radium bromide sprinkled on a gelatin broth medium would sink slowly below the surface, where they would dissolve and decompose the water, liberating oxygen and hydrogen, together with emanations, which would remain mixed with these gases. The gases would form minute bubbles, probably of microscopic dimensions, and the coagulating action of the emanation on the albumen of the liquor would surround each with a skin, so that the product would appear like a cell; its contents, however, would be a mixture of the gases oxygen and hydrogen. The emanation, enclosed in such a sack, would still decompose water, for enough would diffuse through the moist walls of the sack. The accumulation of more gas would almost certainly burst the walls of the cell in one or two places. Through the cracks more gas would issue, carrying with it the emanation, and with it the property of coagulating the walls of a fresh cell. The result of the original bubble would resemble a yeast cell, and the second cell a bud, or perhaps more than one, if the original cell happened to burst. This process would necessarily be repeated as long as the radium continued to evolve the emanation. The 'budding' therefore, would be a long one, and the 'budding' would impress itself on an observer as equally continuous with that of a living organism. (W.A.D. Rudge. Nature 72, 631(1905)). When radium-barium bromide, and also when various barium salts which did not contain radium, were placed upon sterilized gelatin, effects were observed which resembled the growth of an ordinary mould.


A brief account of the results of this paper appeared earlier in Nature. The charge on the α-rays is detected by methods already given. The total charge emitted by a known weight of radium bromide, and carried by the α-rays, is measured by a comparatively simple method, and assuming the charge on each α-particle is ionic, it is deduced that 1 g. of radium bromide at its minimum activity expels 3.6 x 10¹⁰ particles per sec. Assuming the formula RaBr₂, the number for pure radium at its minimum activity is 6.2 x 10¹⁰. The number from 1 gm. of radium in radio-active equilibrium is four times this amount and is equal to 2.5 x 10¹¹. This is in good agreement with the number 2 x 10¹¹ previously deduced from the heating effect. It has been suggested that the α-particles are uncharged at the moment of expulsion. In these experiments the charge they carry is independent of the state of the vacuum over a considerable range, and this would not be expected if they gain their charge by collision and consequent loss of an electron. By a method similar to that used for the α-rays, the number of β-rays expelled per sec. from 1 gm. of radium is found equal to 7.3 x 10⁹. Reasons are given why this number may probably be too high. The results indicate that four α-particles are expelled from radium in equilibrium for each β-particle. Knowing the number of α-particles expelled per sec., the magnitude of other important physical constants in radio-activity may be deduced. Thus the half-life for radium is calculated to be 1,280 years.

The maximum volume of the emanation to be obtained from 1 g. of radium in equilibrium is 0.83 mm³, while Ramsay and Soddy found experimentally about 1 mm³. The emission of energy in the form of α-particles is calculated to be 125 cal./g./hr., in good agreement with 100 as found by Curie and Laborde.


It has been shown by both Boltwood and Strutt that the proportion of Ra to U in radio-active minerals is constant. The authors now seek to determine the weight of Ra in radio-active equilibrium with 1 g. of U and find it equal to 7.4 x 10⁻⁷ g. This is obtained by comparing the quantity of emanation obtainable from a mineral of known U content with that from a solution of the purest RaBr₂ obtainable. This amount is about that to be expected if U is the parent of Ra.


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86 Soddy, F. "Production of Radium from Uranium." Phil. Mag. (6), 9, 769-79 (1905).

1 kg. of uranium nitrate is dissolved in water, H₂SO₄ added, and then successive quantities of Ba(NO₃)₂ solution, filtering following each addition. The solution is enclosed in a bottle and air drawn through; testing by an electroscope shows that the solution is practically free from radium. This test has been repeated over a period of eighteen months, showing a
1905

Gradual growth of radium in the solution. The amount of radium produced is only 1/1000 of the amount that should be produced on the assumption of a direct change from UX into radium. Any intermediate products whose life is long compared with the time of the experiments would account for this. Reasons are given for supposing that either biolumin or lead are the final products of the radio-active changes.

87 von Lerch, F. Monatsh. 26, 901 (1905).
The author reports the half-life period of ThX(Ra26) to be 3,637 days.

The separation of ThX(Ra26) by electrolysis in an alkaline solution is described. The separation does not take place in an acid solution.

W. and Lady Huggins suggested that the luminosity of radium bromide was probably due to the impact of the β-rays against the nitrogen molecules of air, and that the light might therefore originate at some distance from the salt. This conclusion, which they were not able to confirm experimentally, is shown to be correct by experiments in which a long exposure was given to photographic plates screened from the radium salt but capable of receiving light emitted 2 cm. above it.

1906

The β- and γ-rays from radium are shot at between two metal plates, which are at very different potentials, into a chamber containing an electroscope. By recording the leak with the field on and off, and also with a magnetic field in similar circumstances, the e/m can be found. It is found, however, that the effects of the fields are much less than theory would indicate, both at atmospheric pressure and in a vacuum. This is shown to be due to the secondary and tertiary radiations emitted from the apparatus at places where the β-rays strike it. The primary β-rays, as before, pass between charged plates, but the somewhat large opening in the electroscope chamber is partially closed by a brass plate so that the direct rays do not enter. The primary and secondary rays can now be deflected, either by magnetic or electric fields, until they pass the edge of the brass plate. Knowing the values of the fields, e/m is found. A slightly modified arrangement, for purposes of calculation, gives mV/e; hence e/m is found. The values given are those possessed by particles which can just penetrate the electroscope chamber and cause ionization. They show that e/m decreases from 1.27 x 10^10 to 0.76 x 10^10 while V changes from 2.37 x 10^10 cm./sec. to 2.83 x 10^10 cm./sec. By stopping the primary rays, the secondary rays can be dealt with; e/m varies between 1.27 x 10^10 and 1.08 x 10^10 when V alters from 2.35 x 10^10 cm./sec. to 2.58 x 10^10 cm./sec.


1906

The solution obtained on dissolving one kilogram of carnottite in dilute hydrochloric acid was treated with hydrogen sulfide and the precipitated sulfides removed. To separate the actinium from the solution thus prepared 0.5 gram of thorium nitrate was added, followed by a solution of several grams of oxalic acid. The precipitated oxalates were converted into nitrates and again submitted to precipitation with oxalic acid. The oxalates, which were now assumed to contain all the actinium present in the mineral, were converted into chlorides and sealed up in a glass bulb. Two months later the emanation which collected was found to correspond to the presence in the actinium solution of 5.7 x 10^-5 g. of radium.

92 Boltwood, B. B. “Production of Radium from Actinium.” Nature 75, 54 (1906).

1 kg. of carnotte is treated so as to separate from it all the AC, and the solution containing the latter is sealed in a glass bulb. About two months later the emanation is boiled off and tested. The activity corresponds to a content of 5.7 x 10^-5 g. In 193 days 8.5 x 10^-5 g. of Ra have been produced. This gives λ(year)^-1 for Ra as 2.2 x 10^-4. The half-value period is about 3,100 y. It is noteworthy that the amount of Ac in a mineral is apparently always proportional to the amounts of U and Ra.

93 Boltwood, B. B. “Production of Radium from Actinium.” Physik. Z. 7, 915-16 (1906).

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A discussion of some of the author’s results in the light of more recent knowledge. If the ionization varies inversely as the nth power of the velocity, a is found nearly equal to 2.


A small vacuum tube having beeds of radium bromide fused on to the ends of its Pt electrodes was exhausted and sparkled, CO2 being evolved: again exhausted and sparkled, with further evolution of CO2. No helium was, however, detectable. Examined after an interval of four months, the helium line λ = 5875.9 was distinctly visible. Although too faint to be measured, the parhelium line was also observable.
RADIIUM—A BIBLIOGRAPHY OF UNCLASSIFIED LITERATURE

1906

The author reports the half-life period of ThX(Ra226) to be 3.6 days.

The author has previously shown that the γ-rays from radium, thorium, and radio-thorium are similar in character and equally absorbed by lead, and that it is possible to find the amount of these substances in a mineral by cutting off the easily absorbed U and Ac γ-rays, and comparing the remaining γ-radiation with that from a known weight of radium. Had it not been for the results of those obtained by the emanation method, this has been traced to the inconstancy of the standard radium solution used in the latter method. It is found that half of the salt has come out of solution. This can be prevented by the addition of HCl. With a new standard, Boltwood’s results, obtained by the emanation method agree with those of Eve by the γ-ray method. Incidentally, it is found that radium E gives out no γ-rays or else rays that are easily absorbed.

The author determines the ratio of the γ-activities of radium and thorium when both are in radio-active equilibrium. He also ascertains the relative amounts of radio-thorium in thorium and thorium nitrate respectively by measurement of the γ-radiations. He finds that radium bromide is 4.5 million times as active as ThO2 or that radium is 6 million times as active as thorium, measured by the γ-rays, when both are in radio-active equilibrium. The ratio of the quantity of radio-thorium per g. of thorium present in thorium and thorium nitrate has been measured by Boltwood, using the α-ray method and by Dalloul, using the emanation method. The results obtained agree in good agreement with the author’s results obtained by the γ-ray method.

Crystals of radium bromide were fastened in the slit of the spectroscope. The collimator was in successive experiments, with CO2, CO, H2, air, and He. In all cases the photographs obtained after 7 to 10 days’ exposure showed the continuous spectrum of the phosphorescent light of the crystals. In addition there was produced, in air, the band spectrum of N and in He apparently some of the lines of this gas. None of the other gases gave characteristic lines. The effect upon N and He is thought to be due to the α-rays.

This article contains information similar to that shown for the previous reference.

The diffusion coefficient of ThX(Ra226) in water at 18° is reported to be 0.86 cm²/day.

1906

It has been recently shown that the air immediately surrounding a sample of radium bromide is glowing and shows four of the bands of the nitrogen spectrum. The author confirms this observation and extends it to include all the nitrogen bands. When the radium salt is enclosed in a thin glass tube the air immediately surrounding the tube is not rendered luminous, which shows that the luminosity is not due to the β-radiation which passes freely through glass.

Information on the electrical conductivity of RaBr2 2H2O.


The expression \( k \theta A \xi \) is obtained, for the absorption coefficient, \( \alpha \), of any material, for the β-rays of radium, \( R \) being the atomic weight of the material, \( \xi \) its density, and \( k \) a constant. The relative absorption exhibited by plates of different metals is found by a photographic method, and \( \alpha / \theta A \xi \) are tabulated. The values range from 4.30 and 5.31, while \( \alpha \) varies from 24 for Al to 103 for Pt. The results of experiments are thus in good agreement with the formula.

Ra226 was separated from radiothorium and the active deposit removed by heating on a platinum plate to a high temperature. As soon as cold, separate measurements were made of both the α- and β-activities. The β-rays activity was found to be only 3.5% of the maximum reached one day later, while the α-activity had an initial value of 60%. Since during this time the activity of the ThX(Ra226) had been diminishing, the maximum observed is less than the theoretical value. When this was calculated, the initial value for the β-ray activity is reduced to 2.61%, and that of the α-ray activity of 48%, which represents the initial activity due to both ThX and the emanation, since, on account of its rapid change, the latter reaches its equilibrium in a few minutes. If each of the α-ray products present with the ThX supply an equal proportion of the total equilibrium activity, then the activity due to ThX and the emanation together should be 50% of the total. By similar reasoning if ThX emits β-rays, the initial activity for the β-rays should be also about 50%. Since it is only 2.61%, it is concluded that the transformation of ThX into the emanation is accompanied only by the emission of α-rays. In a similar way the initial β-ray activity of thorium containing radiothorium but free from subsequent products amounted to only about 3%; from which it is likewise inferred that thorium or radiothorium emit β-rays. Experiments performed in a similar way show that AcX(Ra226) and its emanation give out only α-rays, while actinium itself...
1906
Rayless. The presence of the product radioactinium was confirmed, and a method was found for its separation from actinium. It was finally concluded that the $\beta$-rays from thorium in equilibrium arise only from ThC, while the $\beta$-rays from actinium are emitted by AcB.


This article contains information similar to that indicated for the previous reference.


By whatever channel radium is introduced it seems to find its way into practically all the tissues and fluids of the body. It is eliminated to a certain extent in the urine and largely with the feces, in which it leaves the body continuously in small amounts. Its excretion may be continued over a long period. No observations were made on its removal through the skin or lungs. The range of distribution of radium in the body is influenced somewhat by the channel of its introduction as well as by the radioactivity (purity) of its compound and the time that elapses after its administration before the death of the animal. So far as its distribution and elimination are concerned radium is like the alkaline earths. Recent observations on the excretion of barium have been discussed.


The amount of heat evolved per hr. from 25.02 mg. of radium bromide entirely free from water of crystallization was determined in an ice calorimeter with special precautions to insure accuracy. With the radium bromide inclosed in a small thin-walled glass tube this amounted to 122.2 cal./hr./g. radium. When the glass tube was surrounded by a cylinder of lead 2.9 mm. in thickness, the heat generated in the calorimeter now amounted to 134.4 cal./hr./g. radium, an increase of 10%. Increasing the thickness of the wall of the lead cylinder beyond 2.9 mm. produced no change in the amount of heat evolved. It is therefore concluded that this increase of 12.2 cal./hr./g. radium represents the energy of the $\beta$-radiation. From these data and assuming that the mean velocity of the $\beta$-particles is $2.5 \times 10^{-13}$ cm. per sec., the author calculates that the mass of the $\beta$-particles given off per hour from 1 g. of Ra amounts to $1.6 \times 10^{-14}$.


The heat produced by 0.025 g. anhydrous RaBr$_2$ was determined in a specially constructed ice calorimeter. The observed heating amounted, for 1 g. of radium in 1 hour, to 122.2 cal., when the radium compound was not surrounded by lead; to 126.9 cal. when covered with 1 mm. of sheet lead; and to 134.4 cal. for 3 mm. or more of lead. The difference between the last and first values is ascribed to the effect of the $\beta$-rays. Taking the velocity of the latter as $2.5 \times 10^{10}$ cm./sec., the mass of the $\beta$-rays produced per hour from 1 g. of radium is $1.6 \times 10^{-12}$ g. There appear to be two hydrates of radium bromide which contain 2H$_2$O and 6H$_2$O, respectively.


On Dec. 27, 1904, the author sealed up 25 mgm. of purest radium bromide in a glass tube of 2 mm. internal diam., and 0.5 mm. thickness of wall. It was finely powdered and desiccated. In Nov., 1905, it was several times immersed in liquid air. Three minutes after it had been removed from the bath and laid on a wooden table the tube exploded spontaneously, the glass being broken up into almost microscopic fragments. The radium was visible in the dark like a starry sky, and was recovered piecemeal. The pressure, no doubt due to emanation, must have been 20 atmospheres.


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The author reports that RaBr$_2$ is isomorphous with BaBr$_2$, 2H$_2$O and crystallizes in the monoclinic system.

114 Rutherford, E. "Properties of the $\alpha$-Rays from Radium." Phil. Mag. (6), 11, 166-70 (1906).

Becquerel has questioned the views of Rutherford and Bragg that the $\alpha$-rays from radium are not homogeneous, and that their velocity is altered by passing them through layers of aluminum-foil. Rutherford's experiments, here described, conclusively uphold his own views, and he further shows that Becquerel's experimental results can be simply explained by the same theory. The $\alpha$-rays from one half of an active wire in an evacuated space pass through aluminum; from the other half proceed without obstruction to a photographic plate. An image of a fine slit is thus obtained both with and without a magnetic field acting on the rays. The deviation so produced is much greater for those rays which have passed through aluminum. If a salt of radium is used instead of the active wire, dispersion of the rays is clearly shown, proving that they are not homogeneous. For the author's explanation of Becquerel's results see the original paper.


In a previous paper it has been found that 7.4 $\times 10^{-7}$ g. of radium is in equilibrium with 1 g of uranium in minerals. Later work has shown that the radium standard is not constant, and a revision of the work was necessary. The revised number is 3.4 $\times 10^{-7}$ g. of Ra/g. U.
116 Swinton, A. A. C. "Radium and the Visible Electric Discharge in Vacuo." Phil. Mag. (6), 12, 70-3 (1906).

It is found that the presence of radium on the cathode materially increases the amount of current that passes through a vacuum tube with any given voltage. When the radium is not heated the effect is not noticed, but when the radium-coated cathode was heated to redness there was a very marked effect in the phototube which produced a luminous discharge.

A strip of Pt-foil was used in some experiments; this before mounting in the tube was dipped into a solution of radium bromide and dried. The amount of radium on the foil must have been extremely small, but with a suitable vacuum, and with the cathode heated to a bright red color, the discharge passed and the gas in the tube lighted up brightly with electrical pressures as low as 80 volts. In various other cases it was always found that a visible discoloration could be made to pass, using the radium-treated electrode, with about 100 volts less than when the untreated electrode was employed.


The author has taken photographs of radicals of radium bromide by means of the light emitted from the radio-active substance. Such photographs are not reproduced owing to their want of sharpness, due to the unsuitability of ordinary photographic lenses for work in the ultra-violet region. The plates obtained have, however, shown that there are always radicals which produce a great show of less marked brightness; this is believed to be due to non-uniformity in the distribution of the activity, but, from microscopic examination, to the fissured condition of the salt at the more active portions, allowing more of the emanation to escape.

118 Walter, B. "Radium and Helium." Nature 75, 102 (1906).

Referring to the hypothesis that radio-active phenomena are associated with atomic degradation, and that the loss of an atom of helium (atomic weight 4) frequently accompanies such changes, it is observed that the transformation of the uranium atom (238.3) into radium (225) occurs owing to the loss of three helium atoms, while the change of radium into lead (206.5) is due to the loss of five such atoms. The discrepancy in the numbers, 238.5 - 3x4 = 226.5, whereas 225, and 225 - 5x4 = 205 instead of 206.5, can be satisfactorily accounted for if it is assumed that the atomic weight of radium is not 225 but 226.5, for then 238.5 - 3x4 = 226.5 and 226.5 - 5x4 = 206.5. This assumption of a slightly higher atomic weight for radium than that found by M. Curie, is supported, as the values given for the atomic weight of radium have become greater and greater as the material used in the determination has been obtained increasingly purer.

120 Boltwood, B. B. Physik. Z. 8, 550-60 (1907).

The precipitation of the MnTh (Ru\(^{228}\)) salt from a solution of thorium salts with NH\(_3\) is described, as is the pptn. of ThX(Ru\(^{228}\)).


A few tenths of a milligram of pure radium bromide were sealed in a quartz tube under diminished pressure, and placed in a small electric furnace directly beneath an electroscope which was protected from convection currents by being surrounded by two layers of asbestos and one of lead. The temperature of the furnace was gradually raised to 1800\(^\circ\)C, and simultaneous observations of temperature and activity taken at intervals of two or three minutes. The length of time during which the temperature was above 1500\(^\circ\)C was sufficient to make it possible to detect a variation of 1% in the rate of transformation of the emanation, RaB or RaC, but there was no evidence of any change in the activity as thus measured by the penetrating \(\gamma\)-rays. The results obtained by Mazower (Proc. Roy. Soc., 77, 241), who concluded that the rate of decay of RaC is increased by high temperatures, is explained by the author on the assumption that the RaC volatilizes and deposited itself near the ends of the tube.


A redetermination of the atomic weight of radium was made using 0.4 gram of pure radium chloride. The purification process consisted, as in the previous determination, of fractional crystallization from water containing HCl. To guard against the formation of radium sulphate, which increased the difficulty of purification, all the reagents used had to be specially purified to remove the last traces of sulphuric acid. The method employed for the determination of the atomic weight was the same as previously used. It consisted in estimating, as silver chloride, the chlorine contained in a known weight of the anhydrous radium chloride. Three determinations all of which agreed closely, gave for the atomic weight of radium, the mean value 226.13 (H = 1) or 226.45 \((0 = 16.00)\), assuming that radium is a bivalent element. The value previously found was 225. The author attributes the difference in the numbers to less pure reagents used in the older determinations, and to inferior accuracy of the experiments which were performed with only 90 mg. of radium salt.


Barium-radium chloride, together with the emanation, A, B, and C, contained in a nickel steel cylinder was subjected to pressures up to 20,000 atm., the estimated pressure at a depth of 50 miles below the earth's surface. From this fact it is concluded that radium generates heat by disintegration equally at the surface of the earth and at depths of 40 or 50 miles beneath the surface. Judging from the known temperature gradient of the earth's crust and the amount of radium found in rocks, it is concluded that the radium content of the interior of the earth must be smaller than that near the surface.
1907


A method for leaching radium ores with H₂SO₄ is described.

125 Giesel, F. Ber. 40, 3011 (1907).

The separation of AcX (Ra₂₂₉) from actinium preparations by the precipitation of the actinium with ammonia is described. The AcX remains in solution.


An account of experiments supporting Boltwood's conclusions concerning the parent substance of radium, and showing that it possesses chemical properties closely allied to thorium. It has been noticed that old preparations of pure thorium contain relatively large amounts of radium; and this is the more noteworthy since the monazite sand from which the thorium is prepared contains but little uranium. A systematic study of the quantity of radium in samples of thorium salts of different ages has been undertaken. An aqueous solution of pure nitrate is made, boiled, and sealed up. After a sufficient interval the Rn is collected by boiling the solution, and after allowing time for the thorium emanation to decay, is transferred to an eoscsensecope and measured. It is found that the older the sample the larger the quantity of radium contained in it. This cannot be ascribed to insufficient purity, nor is it probable that thorium itself decomposes into radium. It is therefore probable that in the technical preparation of thorium an active substance is separated with the latter, and that this is the direct parent of radium. Various tests are given showing the growth of radium in thorium solutions. A solution of radiothorium is prepared from thoriumite using BaSO₄; this does not contain the parent substance. Knowing the proportions of uranium and thorium in monazite sand, and assuming that all the thorium and parent substance are separated therefrom during the extraction of thorium, the life of radium can be calculated by determining the quantity of radium in a given weight of thorium of known age. The period of decay lies between 2,000 and 3,000 years.


The rate of evolution of radium emanation by barium-radium chloride, of activity 250 times uranium, was measured at various temperatures. During the heating, the radium preparation was held in a platinum tube, enclosed in a quartz glass tube. The emanation retained by the solid chloride is completely evolved, in a very short time, at the melting point of the salt, about 945°. The barium-radium chloride, which has been fused and allowed to solidify, gives off only 1/8 of its emanation at ordinary temperature. The fraction of the emanation evolved increases with temperature up to 830°. Between 830° and 920° an abnormally small fraction of the emanation was evolved. Barium-radium fluoride also showed an abnormally small evolution of emanation between 960° and 1150°.

129 Kolowrat, L. Radium 4, 319 (1907).

The preparation of RaF₃ is described.


The authors report the half-life of MeTh₃ (Ra₂₂₉) to be 5.5 years.


The half-life period of AcX (Ra₂₂₉) is reported to be 11.8 days.

132 Porter, A. W. "Decomposition of Radium Bromide." Nature 75, 151 (1907).

On opening a tube of radium bromide a strong odor of bromine was noticed. It is calculated from the time the tube had been closed that 2 × 10⁻⁸ g Br would be present, and it is asked whether this would be detectable by its odor. A. C. G. Egerton (Ibid. 174(1907)) states that the minimum quantity of bromine that is detectable by smell is between 10⁻¹⁸ and 10⁻²⁰ g/cc.


The determination of these constants is approached from three different points of view: The first method, as developed by Ramay, depends upon the volume of emanation evolved by a gram of radium in a unit of time. The radioactive constant of radium is expressed by \( \frac{r}{\lambda} \), in which \( r = 225 \), the at. wt. of radium; \( \lambda = 0.600088 \times 10^{-9} \) the wt. of 1 cc. of hydrogen, and \( \gamma = \) the volume of the emanation given up by 1 g. of radium in 1 sec. From this \( \lambda = 0.303 \times 10^{-9} \), Based
1907

on this result the period of radium is 1940 years. The second method makes use of the spontaneous heating effect produced by a radium compound. The author assumes that the heating is due solely to the absorption of the α-rays within the radium itself. By this method of calculation λ = 0.31 × 10-7, and the period of radium is 1050 years. The third method, that of Wein, based on a measurement of the electric charge acquired by a tube of radium protected by an aluminum jacket is criticized as being unreliable.


The formation of bacteria-like cells first observed by Burke to take place when a gelatin culture medium was treated with a speck of radium salt, and to which was given the name Radiumb (Nature 72, 78), was likewise found to be produced when the gelatin was treated with a salt of barium, strontium, or lead. No growth took place when salts of metals were used having valence of +4 or +6. Care was taken to remove all traces of sulfuric acid from the gelatin, a growth was not found to take place in any case until a soluble sulfate was added. Negative results always followed the use of thorium or uranium salts. Experiments with a high power microscope failed to show any trace of a nucleus or any evidence of sub-division of the body of the cell-like objects obtained. The author, therefore, concludes that there is no connection between radioactivity and the formation of the cells; that they are not organized bodies, but due simply to the precipitation of barium sulfate.


In the Bakerian lecture for 1904 the author gave a brief account of experiments he had commenced to see whether actinium produced radium. From a solution of actinium in acid the greater part of the radium was removed by precipitating barium in the solution. The radium remaining was determined by the emanation method and comparison with a standard solution of radium. No certain evidence was obtained over a period of 3 months that the amount of radium had increased. For various reasons the solution was not further tested for 2 1/2 years, but since Boltwood's experiments appeared further measurements have been made on it. Preliminary measurements showed a large growth of radium, but unfortunately the solution was contaminated with radium while these were in progress. The original salt from which the solution had been prepared was available and its radium content had, at that time, been determined. Experiments with this now show an increase of at least four times the initial amount of radium in 2 1/2 years. The earlier failure to observe these effects is ascribed to the unsuitable chemical treatment used to separate the radium from the actinium, giving rise to an excess of H₂SO₄ in solution, which would precipitate the radium as sulfate. In this condition only a small portion of the emanation would be removed by drawing air through the solution. The contaminated solution has now been successfully freed from radium, except for a minute quantity, and the growth of this substance observed over a period of five weeks. This growth amounts to 80% of the initial value. At this rate the amount of radium in solution should be eight times its initial value at the end of one year. This production of radium might arise, not from the actinium itself, but from another substance normally separated from the radioactive mineral with the actinium. A comparison of the actual rate of growth with that to be expected on the simple theory that actinium is transformed directly into radium shows that the two agree if the period of half transformation of radium is about 2,800 years. Such an agreement, however, implies that the activity due to actinium in pitchblende is about equal to that of radium and its products, and this is not the case, as Boltwood has shown. If radium arises from actinium, it should be produced by AøB and AøB. An active deposit from actinium is produced on a platinum plate, and the rate of growth of radium is found not more than 1/5 of the theoretical amount. This may be due to the presence of another change between AøB and radium, or, what is more probable, to the loss in an electric field of the radium formed on the plate. There is no doubt that the immediate parent of radium is present in actinium from pitchblende, but it is not definitely proved that radium is the direct lineal descendant of actinium.


It has been pointed out in a previous paper that although radium is produced in preparations of actinium there is no definite evidence that actinium itself is the true parent of radium. In the solution previously used it is found that the growth of radium is uniform over 120 days. By successive precipitation with ammonium sulfide an actinium solution has been obtained which initially is almost entirely free from radium, but which contains an excess of radium. The radium again grows at a uniform rate, but 1.5 times greater than the normal. This indicates that the radium-producing substance is present in excess of the normal amount. After suitable chemical treatment a small precipitate of actinium is obtained which is 100 times as active as the original preparation. This is dissolved in HCl, and in this solution no appreciable growth of radium has been observed over 80 days. It is therefore concluded that in commercial preparations of actinium there exists a new substance which is slowly transformed into radium. It is not possible at present to decide whether this substance is the final transformation product of actinium; it may be a product between UX and radium, in which case the position of actinium in the radio-active series still remains unsettled.

137 Rutherford, E. “Production and Origin of Radium.” Phil. Mag. (6), 14, 733-49(1907). (Paper read before the British Association at Leicester, August 1907.)

The results presented in this paper have been previously reported in papers which are noted above. The data is, however, given a more rigorous mathematical treatment.


In dogs and rabbits the kidney, liver and small intestine eliminate radium; in normal rabbits the large intestine also, though the passage through its wall is probably much less. Its elimination into the coecum of rabbits is slight or
absent. Nephrectomized rabbits eliminate through the liver and small intestines at a rate no more rapid than normal. There does not seem to be any vicarious elimination elsewhere except possibly through the stomach.


It was shown by experiments, the details of which are not given, that the radioactivity of radium is not altered by as much as one-third per cent, by a pressure of 2000 atms.


Soddy has previously found that uranium gives rise to radium, but only to 1/100th of the amount it should, theoretically, if the radium is produced directly. Boltwood, on the other hand, found no such growth, and therefore concluded that Soddy's results are without significance. It is here pointed out that the uranium solutions used by these two observers were purified in different ways, and therefore it is quite possible that intermediate products were removed in one case and not in the other, thus accounting for the contradictory results obtained. This view is supported by the recent experiments of Rutherford on the production of radium by actinium.


The first part of the paper summarizes what has been done to show the production of radium from uranium. In the old experiments of Soddy the uranium was freed from radium by repeated precipitation of barium as sulfate. After 550 days the radium content had increased a hundred-fold, but was still much less than was expected theoretically, this being probably due to the formation of intermediate products. According to the process of purification initially adopted these intermediate products may or may not be removed; a new method of purification has now been used, viz., the solution of uranyl nitrate in ether. The first experiments started in Oct., 1905; the results on this sample of uranium to-date show that the amount of radium produced in 600 days by 250 g. of uranium is too small to be conclusive. In another experiment the gases from the solutions are being stored and tested in case a rayless change intervenes. A third experiment leaves it doubtful whether radium has been produced in a quantity of UX; further time is required. Other experiments show that the residual activity of actinium is not due to radium. The paper is rather a description of experiments that are in progress than of results attained.


The early part of the paper gives a summary of the methods that have been used to fix the half-life period of radium. The later part gives a new method of determining this constant independently of the purity of all standards, and hence resting on the smallest amount of assumption. If the amount of radium in a mineral is in equilibrium with its parent substance, iodine, be determined, io say, and the amount of di produced in unit time, one year, by this same quantity of iodine be also found then the constant, $\lambda$, of radio-active change is the ratio di/io. Both di and io are found by measuring the leak produced in an electroscope by the emanation boiled out of a solution of the mineral. A solution of the mineral is made, and the emanation from a definite quantity is measured; this gives io. The iodine is then separated from radium, and the quantity of the latter produced in a known time is also determined by the emanation method. Correction is made for the decay of the emanation in the period between successive tests. The final result shows that the half-life of radium is 2,000 years.


The rate of production of He from 70 mg. of Ra was calculated from the increasing pressure produced in a McLeod gauge and measured by a radiometer. All adventitious gases generated in the apparatus other than $H_2$ or He were absorbed by means of coconut charcoal cooled in liquid air. At the beginning of the experiment an exhaustion of 0.000044 mm. was obtained. During 5 days a steady growth of pressure was observed corresponding to an increment of approx. 0.3 mm./g. Ra/day. At the end of this time the Ra in the apparatus was heated to a low red heat, which resulted in an increase of pressure of about 40%. During the following week the pressure showed no sign of decreasing and on again heating a further increase was observed. This treatment was repeated ten times at varying intervals during 1100 hours. In each case the pressure rose on heating, and remained fairly steady on standing. The quantity of permanent gas produced up to the end of the experiment corresponded to an increment of 0.37 mm./g. Ra/day. A preliminary and less satisfactory experiment gave a daily increment of 0.417 mm./g. Ra. Additional experiments were described which verified the purity of the He producing the permanent pressure and which proved that no gas was occluded either in the cooled charcoal or the surrounding glass.


70 mg. of RaCl$_2$ was used. The apparatus for the measurements was a McLeod gauge without India-rubber joints, the Hg reservoir being connected to an exhaust pump, while the elevation and lowering of the Hg was carried out by admitting and exhausting air in the reservoir. Sealed on to the gauge was a long U-tube containing 1 g. of coconut charcoal placed in an enlargement at the bend, the whole being arranged for cooling by means of liquid air. The object of the charcoal was to take up all adventitious gases, other than $H_2$ or He. The RaCl$_2$ was contained in a small bottle standing in a cylindrical glass bulb connected by a T-joint
1908

to the U-tube. To the other arm of the T was sealed a bulb containing about 15 g. coconut charcoal for producing high exhaustion in the apparatus when cooled to −100 °C. An exhaust of 0.0000045 mm. could be obtained. The increase in pressure in the apparatus due to the formation of He was noted from time to time, the RaCl₂ being occasionally heated to liberate occluded He. The first experiment gave a result of 0.417 mm. /g Ra/day taken over the whole period. A second experiment gave 0.37 mm. /g/day and differs from that of Cameron and Ramsay which was about eight times as large.


A method for leaching radium ores with H₂SO₄ is described.

147 Hahn, O. Physik. Z. 9, 404(1908).

The author reports the half-life of Ms₁₉ (Ra²⁸) to be 6.7 years.


The separation of RaCl₂ by fractional crystallization is described.


The separation of RaCl₂ by fractional crystallization is described. The leaching of pitchblende for Ra recovery using alkali and dii. H₂SO₄ is also described.

150 Marchwald, W. Ber. 41, 1526(1908).

Article on the leaching of pitchblende with H₂SO₄ and HNO₃, and the extraction of RaSO₄ with alkali.


Results are negative. Layers of RaBr₂ and Cu(NO₃)₂ were formed in separate silica capsules by evaporating solutions of the salts. The capsules, each containing, were placed in a glass tube and exhausted to 0.1 mm. After 3 months no Li was found. RaBr₂ of strength 1,000,000 was allowed to act on CuSO₄ in the same way. No Li was found. RaBr₂ and CuCl₂ were allowed to stand in solution 4 months. No Li was found. A direct-vision Hilger spectroscope capable of detecting 0.005,001 mg. Li was used. RaBr₂ will not convert 1.0 × 10⁻⁵ g of Cu or 0.5 × 10⁻⁶ of Au into Li per day.


This article contains similar information to that indicated for the previous reference.


In 1907, 0.5 g. RaBr₂ was sealed up and sent to Sir William Ramsay in London, but upon its arrival it weighed only 0.38 g. It was partly soluble in water, and gave off H₂, O, and Br in dissolving. Curious physiological effects appeared eight months after exposure to the salt.


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A specimen of radium bromide weighing 0.5 g is found after a time to be reduced in weight to 0.388 g. These experiments are carried out in order to find the cause of this decrease in weight. A weighed specimen is compared as regards activity, with a weighed quantity of pure radium chloride. For this purpose the discharging effects of beta and gamma rays are used. Then both the specimens used are treated with pure hydrobromic acid until their weights are constant. Calculations based on the results of these experiments show that 0.388 g., of the salt are equivalent to 0.4971 gm. RaBr₂·2H₂O. Other experiments indicate that the original salt must, in the two years since its preparation, have been changed into carbonate. When the original salt is treated with water the gas collected consists mainly of oxygen with comparatively small quantities of CO₂, hydrogen, nitrogen and helium.


The authors report that the number of α-particles emitted per second by 1 g. of Ra is 3.4 × 10¹⁴ and the half-life is calculated therefrom.


The following table is given to show the results obtained, and methods adopted by previous observers, for estimating the quantity of heat generated by 1 g. of the radium metal:

<table>
<thead>
<tr>
<th>Author</th>
<th>Preparation</th>
<th>Method</th>
<th>g. cal/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Curie</td>
<td>1 g.</td>
<td>per cent</td>
<td>100</td>
</tr>
<tr>
<td>and A. Laborde</td>
<td>17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Runge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and J. Precht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Rutherford</td>
<td>30 mg.</td>
<td>Differential</td>
<td>105</td>
</tr>
<tr>
<td>and H. T. Barnes</td>
<td>pure</td>
<td>air</td>
<td></td>
</tr>
<tr>
<td>J. Precht</td>
<td>34 mg.</td>
<td>Ice calorimeter</td>
<td>110</td>
</tr>
<tr>
<td>K. Ångström</td>
<td>90 mg.</td>
<td>Electrical</td>
<td>113.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pure</td>
<td></td>
</tr>
<tr>
<td>J. Precht</td>
<td>25 mg.</td>
<td>Ice calorimeter</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>pure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The radium preparation used in the present experiments was 1.0523 g. of radium-barium chloride, dried at 130°C. and containing 0.7651 g. of metallic Ra, on the basis of the atomic weight of Ra = 226. The principle on which the quantity of heat generated is estimated is as follows: Two calorimeters having as nearly as possible equal capacities for heat are placed in a space which is kept at a constant temperature. One calorimeter is heated by radium, and the other by passing a known current through a heating spiral. The current is so regulated that both calorimeters are kept at the same temperature. It is found that the quantity of heat generated by 1 g. of radium metal in one hour is 118.0 g.-cal. The probable error is estimated to be not more than 1.4%. With reference to the rays used in these experiments it is re-
marked that only those rays are not used which could penetrate 1 mm. of glass and 5 mm. of copper.


The rate of production of heat by a known mass of Ra was measured by the method of Ångström, a differential colorimeter with compensation by electrical heating and with thermo-electric temperature measurement being used. The RaCl₂ used was dried at 130° and weighed 1.0523 g. The material was probably 99.7% pure, assuming 226 as the at. wt. of Ra. As a final result it was found that 1 g. of pure Ra (element) containing the equilibrium amounts of the emanation, A, B and C (and perhaps also enough F to add 1/2% to the activity), produced 118.0 g. cal./hr. The error of the heat measurement is estimated as 0.4%, the possible error in Ra content 0.5%, and the uncertainty in the activity due to RaF, 0.5%; a total error of ±1.4%. Other observers have found from 100 to 134 cal. per hr.

Soddy, F. "The Relation Between Uranium and Radium (III)." Phil. Mag. (6), 16, 632-8(1908).

The results reported confirm the original experiment, started in 1903, in showing the existence of a minute quantity of a radium-producing substance in commercial uranyl salts. In the specimens tested the amount present was always below one part in a thousand of the theoretical equilibrium quantity which should be present in the natural mineral. In one of the carefully purified salts prepared by T. D. Mackenzie in 1905, the growth of Ra is not greater than 5 x 10⁻¹¹ g. per kilo of uranium in 2-3/4 yrs. and in the other sample it is not more than 10⁻¹¹ g. per kilo in 1-2/3 yrs. Assuming that only one intermediate body between U and Ra exists, its average life must not be less than 16,500 yrs., or six times that of Ra; so that at least six times more of it than of Ra must exist in minerals. Assuming that two intermediate bodies exist, with equal periods, each must not have a half-life of less than 100 yrs.


The mean value of the atomic weight determined by the author is 226.7.


The mean value of the atomic weight determined by the author is 226.7.


500 kg. of pitchblende from the mines at Joachimsthal were worked up by Armet de Lisle at his factory and the 413 g. of BaCl₂ obtained showed an activity of 560 times that of uranium. The author obtained from this, by the method of M. Curie, 64 mg. of radium chloride, the manipulations involved some 9400 recrystallizations. The chloride was precipitated by silver nitrate in a little weighing flask and washed by decantation, a method that seemed justified in view of the small quantity of material worked upon. The first determination gave 226.8 as the atomic weight of radium. After converting to the chloride a second determination gave 225.7. The radium was recovered and combined with 24 mg. of radium chloride from another source and the 78.4 mg. of radium chloride gave 75.3 mg. of silver chloride, which indicated 227.7 as the atomic weight of radium. The author considered that the preparation used did not contain enough BaCl₂ to affect the result, which may be taken as 227, measurably.

Ulzer, F. and Sommer, R. German Pat. 254,241 (1908).

In the manuf. of crude sulfates enriched with radium, the Ra-containing materials are heated with conc. H₂SO₄, or are allowed to remain in contact therewith for a long time, or are fused with acid sulfates, then washed with H₂O, decanted, and filtered. The filter residue is heated, under increased pressure, with alkali or alkali carbonates, or mixts. thereof, or it is fused therewith. The residue after washing out and filtering yields crude Ra sulfate by heating with dil. H₂SO₄ and filtering.


The author submits a table of multiple differences between known atomic weights from which he deduces a factor for anticipating unknown atomic weights. From this table and from the relations of the specific gravities of the alkali earth metals to their atomic weights and the similar relations of the alkali metals he assigns to Ra an atomic weight of 184. The author's results on the combining weight of Ra after the method of Marignac and Dumas are given in confirmation of his theoretical conclusions.


The combining equivalent of radium chloride with Ag, determined by the method of Marignac and Dumas, is 1.176:1, whence the combining weight of radium with chlorine is 92, or exactly one-half the atomic weight of 184 already assigned to the element by the author for considerations of periodicity.


A method for leaching carnitite with NaCl and NaOH for Ra recovery is reported.


The rate at which gas is given off from a solution of a salt of Ra in water was observed for a period of over 6 months. Contrary to the results found by Ramsay, the rate at which the gas was evolved remained constant and in the case of RaCl₂ amounted to 13 cc./day/g. of Ra. The decomposition of water is caused by the α, β and γ rays, and not by the direct action of Ra and its products, as Ramsay has suggested, was shown by placing a comparatively large amount of pure RaBr₂ contained in a sealed glass bulb, in a glass tube which was then immersed in a vessel of distilled water. The vessel was joined with a Hg
manometer and completely exhausted of air. Although the rays had to pass through a total thickness of glass of 0.5 mm., yet a regular increase in pressure was observed to take place in the manometer, and continued to increase for several months at a rate almost exactly proportional to the time. The vol. of gas given off by the water, when thus exposed to only the penetrating rays of Ra, amounted on an average to 0.115 cc./day/g. of Ra. This amount is about 1% of the vol. given off when the Ra is dissolved in the water. But the energy of the rays passing through the glass in the second experiment is only about 1% of the total energy. It would thus seem that the amount of gas evolved in any case is dependent upon the proportion of rays absorbed by the water.

Heat evaporation by Ra compounds.

168 Exner, F. "Uber Radiumforschung." Vienna. (1909?).


A method for obtaining AcX (RaA) by recoil on a negatively charged plate is described. It is also reported that AcX is not volatile at red heat.

A description of experiments carried out with the view of ascertaining whether Ra itself emits any β-radiation. A full account of the method of preparing the substances used is given, and the results are shown graphically. The general results of the work are as follows: The β-rays from Ra preparations do not originate, as has up to the present been accepted, solely from RaB, RaC, and RaE, but Ra itself gives out a typical β-radiation. This radiation can be distinguished with absolute certainty from the other β-rays by its penetrating powers. One half of these β-rays are absorbed by 0.0022 cm. of aluminum, so that they possess an absorption coefficient represented by λ = 312 cm. -1. According to the hypothesis put forward by the authors, that complex rays correspond to complex substances, Ra must be now considered as a complex substance because of the presence of this β-radiation.

An estimate of the half-life of Ra is given.

It is shown that the gas given off when the penetrating rays from Ra act upon distilled water across glass in the manner referred to by Debye "The Decomposition of Water by the Salts of Radium." Compt. rend. 148, 703-5, consists almost exclusively of H, while H2O2 is formed at the same time in solution.

1909

174 Landin, I. Swedish Pat. 31,711 (1909).
Substances containing radium are prepared by pulverizing Ra-contg. material, sliming it, and treating the resulting soln. with Ba fluosilicate.

The results of the investigation of the excretion of Ra in the urine of clinical cases are tabulated. These show that the radioactive substances are eliminated by the body in a few years. The longest period noted for the complete elimination was 3 yrs. in one case. Radioactive substances are found in the urine.

Four small bulbs containing 172 mg. of Ra salts in solution were sealed to a small Töpler pump, and the mixed O and H gases formed were pumped off at intervals of 4 days for a period of three years. With the emanation accompanying the mixture of gases various experiments were performed, the results of which have already been published. An additional 0.388 g. of pure RaBr was then washed into a small bulb and sealed to the pump along with the other bulbs. The electrolytic gas now pumped off amounted to 30 cc. per week. This regular evaporation ceased from Feb. until Nov. 11th. On Nov. 18th the gas was pumped off again and amounting only to 13 cc. A week later only 1.5 cc. were obtained, and the following week 0.5 cc. It is pointed out that either the RaBr has ceased to decompose water, or the reverse reaction, viz., the velocity of combination of H and O to form water, has increased to such an extent as to reverse the decomposition. It would thus appear that one of the ways in which Ra expends at least a portion of its energy has been stopped.


An attempt to separate BaBr and RaBr by fractional sublimation. The authors used electrically heated quartz tubes as containers for the comds. experimented upon, and exps. were carried on under a pressure of 0.02 mm., attained by a Hg pump. CaBr sublimes at about 720°, SrBr 710° and BaBr 820°. RaBr sublimes 900°. Three sets of exps. were made in the attempt to separate RaBr and BaBr. In each, a part of the salt used was retained as a control experiment; the Ra content was detd. in two sublimates in exps. 1 and 2 and in one sublimate in exp. 3; it was detd. in the residues in all 3 exps. In all cases, the Ra content was detd. by means of an electroscope previously calibrated by using a Ra soin. of known content. Results show that RaBr is more difficult to volatilize than BaBr, and that by partial sublimation the residue is enriched in its Ra content; the less the sublimate, the greater the difference in Ra content of the sublimate residue. Authors express the hope that other investigators having larger amts. of material at hand will pursue the exps. with other Ra comds. and if possible get pure Ra salts.
1909
Various methods for the precipitation and adsorption of ThX(Ra<sup>+</sup>) are described.

The authors report that 1 g. of Ra generates about 118 cal./hr.

In obtaining radium salts or compds. and substances contg. large proportions of Ra, the Ra-contg. materials are first treated with conc. H<sub>2</sub>SO<sub>4</sub> for a shorter time at normal temp., or melted with bistulates, and the residue remaining after washing is melted with carbonates of alkalies or caustic alkalies or mixts. of the same, or boiled with other conc. H<sub>2</sub>O solns. under pressure, or the order of stages may be reversed in such manner that the treatment with the acid agents follows the treatment with alkaline agents.

1800 kg. of the hydrates obtained by the pptn. with NH<sub>4</sub>HCl of the HCl exts. (Debierne process for the prep. of Ra) from 10 tons of pitchblende residues, were given to the author by the Radium Commission of the Imperial Academy of Sciences to det. the chem. nature of the radioactive substances contained and, if possible, to isolate these. A qual. exam. showed the main constituents to be iron, alumina, lime, rare earths, bismuth, uranium, silica and many other elements in smaller quantities. Two general methods were used. The "sulfate" method, which while complicated gave more insight into the chem. relations, and permitted the pptn. of radioactive products in part without the use of ignitions. The "oxalate" method was worked out on the basis of results obtained in working up 120 kg. of the paste by the "sulfate" method. Aside from polonium (RaF) there was present ionium and actinium. The former seemed homogeneous whereas the latter seemed complex. Ionium follows the reactions of thorium, while actinium comes between lanthanum and calcium. Thorium salts containing about 2% of ionium were prepared—data as to the content of actinium preps. are not yet available. The author says that many observations lead him to believe that ionium can cause chemically related substances to become radioactive on long-continued action.

183 Watt, W. M. "Calculation of the Atomic Weight of Radium from Spectroscopic Data." Phil. Mag. 6(1), 411-16 (1909).
Runge and Precht, by comparing the wave-lengths of corresponding lines in the spectra of Mg, Ca, Sr, Ba, and Ra with the atomic weights, calculated the atomic weight of Ra to be 257.8. This relation the author points out is not linear as assumed by Runge and Precht. The lines representing the above relation are slightly curved, and the author now gives the curves for four families, and has calculated an interpolation formula which gives the atomic weights as follows: Mg, 24.32; Ca, 40.08; Sr, 87.62; Ba, 137.41; Ra, 226.56. This shows that the spectroscopic data are quite consistent with the atomic weight found for Ra by chemical methods.

1910
For the preparation of metallic Ra the authors used the method employed by Guntz in the prep. of metallic Ba (Compt. rend. 133, 872; 141, 1240). The principle of the method consisted in preparing the amalgam after which the Hg was driven off by distillation. The amalgam was obtained by electrolyzing a soln. containing 0.106 g. of pure RaCl<sub>2</sub> with a Hg cathode and Pt-Ir anode. When the electrolysis was stopped 0.0065 g. of salt still remained in soln. The amalgam which was entirely liquid was dried and quickly transferred to an iron boat previously reduced in pure H. The boat was placed in a quartz tube which was then immediately exhausted and replaced by an atm. of pure H. By keeping the pressure of H always greater than the pressure of the vapor of Hg at the temp. of the boat the Hg was distilled off below the b.p. of the amalgam and in this way lost of material by spurring was guarded against. The distillation was stopped at a temp. of 700° at which temp. the distillation of Hg was complete and the metal remaining behind likewise began to volatilize and strongly attack the walls of the quartz tube. The metal which was shown to be practically pure Ra was of a brilliant white color but rapidly became black on exposure to the air, due it is supposed to formation of nitride. Some particles of the metal having fallen on a piece of white paper produced a blackening similar to a burn. Radium decomposes water very energetically and dissolves for the most part, showing that the hydroxide is soluble. The dark residue which remained and which was supposed to be the nitride readily dissolved in dilute HCl. Preliminary radioactive measurements indicated that the increase in activity followed the production of Em, and that the final activity of the metal would be normal. Since it was found that metallic Ra is much more volatile than Ba, it is proposed to purify it by sublimation in vacuo.

The methods used for several years by the author to measure small quantities of Ra, which are based on the principle commonly adopted, are described in detail. Most concordant results indicating an accuracy of 0.5% are obtained when the emanation has accumulated for from 15 to 48 hours. A few hours accumulation gives, naturally, a less definite result; periods of several days less concordant results are also obtained. The amount of emanation in this case is generally too small, due perhaps to occlusion by the glass containing vessel. Standard solns. have been prepared, starting with the pure RaCl<sub>2</sub> used in 1907 to measure the at. wt. of Ra. In dilution great care must be exercised as regards cleanliness of containing vessels, and purity of reagents, to prevent pptn. of Ra. Even with greatest care a small percentage of Ra in these standards is lost in time probably by absorption by the glass. Secondary standards are improved by addition of Ba salts. The saturation current from the equilibrium amt. of emanation from 1 g. Ra
1910

is 3.5 × 10⁶ e.s.u., for a cylindrical ionization chamber, 6.7 cm. in diam., 12.5 cm. high, and 440 cc. capacity, with an axial wire electrode 3 mm. thick and charged to 800 volts. A series of results show some divergence. The amount of emanation from freshly crystall. RaCl₂ shows a slight increase with time, while solns. from which the Ra has been pptd. by H₂SO₄ show progressive diminution. These facts suggest the existence of an element intermediate between Ra and the emanation (RaX).


In a previous research the rate of production of helium from 70 mg. of radium chloride was determined by a succession of observations on the growth of pressure measured by a McLeod gauge, the observations extending over 6 weeks. It was thought desirable to make an experiment to determine the rate of production of Radium resulting from this same sample of radium, after standing in a sealed bulb for an extended period. For this purpose the bulb containing the radium chloride was sealed off at the conclusion of the above-mentioned experiment of 1908 and kept for 9 months. In order to measure the He thus produced it was necessary to devise a vacuum-light joint between the sealed radium bulb and a McLeod gauge so constructed that, after thoroughly exhausting the gauge, the drawn-out end of the radium bulb could be broken off, thus allowing the pressure of the accumulated He in the radium bulb to be rapidly determined. This is described by aid of a figure. The capillary sealed-up part of the bulb had a file mark on it and could be rocked from the outside so as to be snapped off by pressure against a neighboring protuberance. The data of the experiment show that a corrected pressure of 0.01913 mm. in a volume of 320 cm.³ was due to the He produced from 70 mg. of pure radium chloride during a period of 275 days. It is hence deduced that the rate of production of He is 0.465 mm.²/g. Ra/day. In the 1908 paper the production rate was given as 0.37, but on again examining the apparatus it was discovered that the volume of that gauge and apparatus then used was 270 cm.³, and not 200 cm.³ as formerly supposed. The previous value is thus corrected to 0.499 mm.² of helium/g. Ra/day, which is in good agreement with the present determination. Indeed, the author thinks the true value may lie between these two results 0.463 and 0.499.


A rabbit killed 18 mos. after 0.05 mg. of RaSO₄ had been injected into its ear showed no morbid manifestation. After incineration the lungs, kidneys, spleen, liver and brain were found to contain Ra. A second rabbit killed 14 mos. after 0.02 mg. of RaSO₄ had been injected into the veins showed no radioactivity in any of the organs.


1910

1 mg. of insol. RaSO₄ was injected into the jugular vein of a horse. The injection was followed by a regularly decreasing Ra elimination in the urine, which could not be detected after 4-5 mos. A large portion of the Ra remained in the animal, and Ra could still be measured in the blood after 6 mos. The horse was not injured by the injection, but gained considerably wt. during the succeeding mos. The authors suggest that the injection of insol. Ra salts may be of therapeutic value.


Five methods were tried with a view to determ. the energy of the Ra rays. A bolometer, a radiometer and a thermopile did not give good results, but positive results were obtained with a differential gas thermometer and a sensitive calorimeter. Details are given in the paper. The results are in the last case. Judging from the preliminary exprts. it is hoped to obtain by this method a good measurement of the energy of the α-rays the whole length of their range, and also of the β and γ-rays providing this is not less than 1/100 of the total energy of the α-rays.


The method employed in the prep. of metallic Ra consisted in preparing Ra(NH₄)₂ which on heating in a vacuum decomposed into the metal and N. In preparing the azomide, a soln. of 1 mg. of Ra — bromide containing 9% RaBr₂ was treated with (NH₄)₂CO₃. The ppt. was filtered off in a micro-filtering app. and dissolved in H₂SO₄. The soln. was evaporated dry and carefully dried to constant wt. in a vacuum over H₂SO₄. The dry salt was then transferred to a small melting pt. tube which was in turn placed in a larger tube and exhausted with a Hg pump. On heating the tube with its contents for several hrs. at a temp. of 180-250°, about 75% of the Ra mixed with the Ba was converted into the metallic form and appeared as a shining metal surface. It is thus shown that Ra is a metal analogous to Ba and not a radical like NH₄⁺, and was found, from measurements made of the γ-rays, to lose none of its properties in the metallic state. Attention is called to the importance in this exprt. of having the azomide perfectly dry before being heated for otherwise the metal cannot be obtained in a bright metallic state. Preliminary exprts. showed that Ba(NO₃)₂ is not decomposed by Ra rays.


Ba salts reported to be chemically pure were tested for their Ra content. The results are expressed in 10⁻⁸ g. Ra/g. salt: BaCl₂ 2.84; Ba(OH)₂ 0.11; Ba(NO₃)₂ 0.36. These substances contain therefore about as much Ra as many rocks or soils, and great care is necessary in measuring minute quantities of Ra in the event of chem. treatment with a Ba salt. Certain ppt. appear to occlude Ra and in that way to check the escape of Rn. Thus a soln. of RaBr₂ in 220 cc. water, containing a trace of Br₂, liberated 100% Rn, while another to which 10 cc. 10% BaCl₂ and 1 cc. H₂SO₄ were added liberated only 15%.

Hahn and Meitner have found that a radium salt freed from its emanation and active deposit, emits a very absorbable β-radiation. The author has repeated these experiments and obtained results showing a general agreement with them. In the experiments a piece of Pt-foil, containing a little Ra, was heated for several hours to drive off the emanation and active deposit, in a thin sheet of Al being then fixed hermetically over it. The intensity and absorbability of the radiation given off was then observed both initially and at subsequent intervals. From these observations it is calculated that a radiation arises from Ra itself, its intensity being about 2 per cent of the equilibrium β-ray intensity and its absorbability of the order 200 cm⁻¹. Allowance had to be made for a small initial amount of RaEm which it was impossible to get rid of.


Hahn and Meitner found that any material containing Ra still emits β-rays of small penetrating power after the Em. and active deposits have been removed by heating, or in a chemical way, and that this radiation amounts to about 2% of the total β-radiation when the Ra is in radioactive equilibrium. With a different arrangement the author was able to verify this result. The exception that the intensity of the rays was found to be only 2% of the β-radiation corresponding to the equilibrium amount. The method employed consisted in heating a small amt. of a salt of Ra on a sheet of Pt after which the activity was deter. at intervals with a series of Al screens of variable thicknesses interposed above the Ra at each set of measurements. When a soln. containing about 0.5 mg. of pure RaCl₂ was evaporated on a Pt sheet it was found impossible to drive off all the Em. by heating, even when placed in an electric furnace at a temp. of 1320°. With a chloride, or bromide, salt of Ba containing about 1% of Ra this difficulty was not met with. The coeff. of absorption, μ, of the β-radiation is of the order of 200 cm⁻¹ at first, but it decreases regularly and in several days finally reaches the fixed value of μ = 60 cm⁻¹. The rate at which μ decreases agrees with the theoretical value calculated on the assumption that the rays observed result from the combined effect of an activity which does not vary with time and which is in absorbable amount, of the order of 1% of the equilibrium activity and having μ = 200 cm⁻¹ and of an activity with μ = 60 cm⁻¹ and proportional at each instant to the sum of the rates of decay of RaB and RaC.


A dilute solution of RaCl₂ was treated with several drops of H₂SO₄ and filtered, and the filtrate placed in an emanation "bubbler". The rate of disengagement of emanation was measured and found to fall gradually to nearly half its original value in about a month, while on the application of heat the rate of release of emanation increased. The author explains this, and other experiments described in the paper, by assuming that the RaSO₄ remains partly in solution but gradually becomes precipitated and no longer gives up its emanation. Under the action of heat, part of the precipitate redissolves and gives off the whole of the emanation accumulated since its precipitation.


Modification of the treatment of radium-containing substances, ext. with acid after conversion into a salt insol. in H₂O in which a soln. of Ba, Ca, Sr, or Pb salt is dissolved, in order to ppt. out those acid radicals which would otherwise interfere or prevent the soln. of the Ra in the acid.

1910 Landin, J. Swiss Pat. 34,200 (1910).

In the preparation of radium sulfate, the material containing Ra is treated with conc. fuming H₂SO₄ and the product is either dried or heated to obtain the sulfate.


The effect of foreign substances upon the amt. of RaEm extracted from a Ra soln. was examined. BaSO₄ freshly pptd. in the soln. greatly lessened the amt., as did BaCO₃ and carbonates in general. Pptn. of insol. chlorides, oxides, chromates, etc., lessened the amt. not more than 3%. Repeated extraction of the Em from a soln. which had been pptd. with BaSO₄ gave amts. which increased until the correct one was reached. To obtain accurate results in estimating Ra by the extraction of its Em, HCl or HNO₃ must be added, and if BaSO₄ is also present, repeated detns. made until a constant maximum is reached.

1910

As the properties of mesothorium are very similar to those of Ra which has 300 times as long a life, great care must be taken not to confuse the two. To test a Ra prep. for the latter, heat it a short time, to drive out the emanation; in a few hours it will lose its power of emitting γ-rays, which it regains in the course of several weeks. Instead of heating, the compd. may be dissolved in H₂O; the soln. is evaporated and all the RaEm is driven out. If any γ-rays remain behind, they come from the mesothorium. The ratio of the γ-rays before and after this treatment is a measure of the amts. of Ra and mesothorium present.


The author reports that 1 g. Ra generates about 116.4 cal./hr.


A Ba-Ra salt containing about 200 mg. of Ra, from which Po and RaC had been removed chemically, was placed in a Pt capsule which was in turn sealed in an exhausted tube of hard glass. At the end of 83 days, the gases were completely removed by heating and exposed to charcoal cooled in liquid air. The unabsorbed gases were pumped out and repeatedly exposed to fresh cooled charcoal. The residual gas consisting of essentially pure He had a volume corresponding to the production of He at the rate of 163 mm.³/g. Ra/year, a value somewhat higher than that found by Dewar of 135 mm.³/g. Ra/year, but close to the quantity, 158 mm.³, calculated by Rutherford and Geiger from their experiments on counting the α-particles.


Additional data on Ra presented: 0.585 mm.³ Ra produced/g. Ra/year; 115 cal./hr./g. Ra heating effect; life of Ra = 1760 yr.


1800 kg. of the hydrates obtained by the pptn. with NH₃ of the HCl exts. (Debierne process for the prep. of Ra) from 10 tons of pitchblende residues, were given to the author by the Radium Commission of the Imperial Academy of Sciences to det. the chem. nature of the radioactive substances contained and, if possible, to isolate these. A qual. exam. showed the main constituents to be iron, alumina, lime, rare earths, bismuth, uranium, silica and many other elements in smaller quantities. Two general methods were used. The "sulfate" method, which complicated gave more insight into the chem. relations, and permitted the prep. of radioactive products in part without the use of ignitions. The "oxalate" method was worked out on the basis of results obtained in working up 120 kg. of the paste by the "sulfate" method. Aside from polonium (RaF) there was present ionium and actinium. The former seemed homogeneous whereas the latter seemed complex. Ionium follows the reactions of thorium, while actinium comes between lanthanum and calcium. Thorium salts containing about 2-1/2% of ionium were prepared - data as to the con-

1910
tent of actinium preps. are not yet available. The author says that many observations lead him to believe that ionium can cause chemically related substances to become radioactive on long-continued action.

204 Bleecker, W. F. (to the Standard Chemical Company) U. S. Pat. 1,065,581 (1911).

A method for leaching carnottite first with alkali, then with acid.


The rate of production of He by a Ra salt (containing 0.193 g. Ra) was measured accurately, and found to be equal to 0.107 mm.³ He/day/g. Ra (element), which is equiv. to 156 mm.³ He/yr./g. Ra in equiv. with its first disintegration products, the Em., RaA, and RaC. This shows good agreement with the figure previously found by Dewar working with only 0.07 g. Ra, and which, corrected to the authors' Ra standard is 164 mm.³ He/yr. The rate of production found is in excellent agreement with the figure 158/mm.³ He/yr., calc. by Rutherford and Geiger from the results of their expts. on the number of α-particles emitted by Ra. The amt. of He formed in 21 days from the volume of RaEm in equiv. with 0.126 g. Ra was measured and found to be 0.202 mm.³. The theoretical amt. is 0.220 mm.³, in fair agreement. The production of He from Po, and from a prep. containing radio-lead (and therefore RaE, and Po) was observed.


The authors have made an extended determination of the volume of He produced from a large quantity of Ra, and found it to correspond to approximately 156 mm/year/g. Ra in equilibrium with its disintegration products to RaC. This observed rate of production of He is in close agreement with the rate calculated from the counting experiments of Rutherford and Geiger (158 mm.³/yr.), thus proving that the α-particle, during its flight, consists of a He atom carrying two unit positive charges and that He itself is monatomic. The authors point out that agreement of the observed and calculated values is independent of the purity of the Ra-standard employed, as the same standard has been used in both measurements.


An investigation was made on the comp. of the β-rays from the Ra group by adopting under improved conditions the method first used by Becquerel which consisted in photographing the trajectories of the rays when acted upon by a magnetic field. The source of the rays consisted of RaEm, from 0.12 g. RaCl₂, which was condensed in a small glass tube with walls only 0.04 mm. in thickness. In this way the interference of secondary rays was avoided. The magnetic
1911

spectrum obtained showed the existence of seven distinct
homogeneous beams of rays. The velocity of the different
rays were calculated to be approx., 0.98, 0.95, 0.86, 0.81,
0.75, 0.69, and 0.63, the velocity of light being taken as
unity.

209 Dominicz, H., Petit, G. and Jabotin, A. "Persisting
Radioactivity of the Organism under the Influence of
Injection of Insoluble Radium Compounds. Radioactive
Serotherapy." Compt. rend. 153, 1509-11(1911).

One yr. after the injection of 1 mg. RaSO₄ into a horse
the serum of this animal was still radioactive. This radio-
active serum possesses therapeutic properties and is of
service in the treatment of cancer and infectious diseases.

210 Ebler, E. "Fractional Adsorption of Radium-
Barium Salts and Fractional Electrolysis of the
Resulting Adsorption Compounds." Orig. Com.

Freshly pptd. Fe(OH)₃ in 20% gelatin-gel-acety cellulose
adsorbs Ra salts less than does silicic acid. Manganese
dioxide hydrate shows high adsorbing power for nearly all
Ra salts. Basic Fe carbonate shows strong adsorptive
power for RaCO₃. Bolling with dil. HCl splits the adsorption
compd. into RaCl₂ and a sol. Fe(OH)₃Cl which are readily
sedpt., but by electrolysis using a Hg cathode. By
measuring the α-adsorption of eap, portons of the cathode
liquid and change of the cathode solns., fractions can be
obtained as desired. The Ra-Be-adsorption compds. with
MnO₄ and SiO₂ need not be changed to the sol. condition
before dialysis.

211 Ebler, E. Z. anal. Chem. 50, 611(1911).

In the reduction of crude sulfates PbSO₄ can be removed
without loss of Ra by using a hot solution of NH₃NO₃.

212 Ebler, E. German Pat. 243,736 (1911).

In the manuf., isolation, and enrichment of substances
contg. radium and the like, certain colloidal substances
(gelatin) are employed as absorbents for radioactive sub-
stances, being sedpt. from the material from which the active
substance is absorbed, and then driving off the colloidal
substance, as by burning, volatilizing as haloid, sulfide, or
ester or otherwise, the radioactive substances remaining
in a concd. state.

213 Ebler, E. and Fellner, M. "The Concentration and
Isolation of Radioactive Substances by Fractional
Adsorption." Ber. 44, 2352-3(1911).

Using very pure metasilicic acid, Ra, RaEm, RaD, RaE,
RaF, and UX were adsorbed from their solns. Ads. achieved
by shaking solns. containing radioactive material with silicic
acid. Acid then sedpt. by filtering or centrifuging. A com-
parison of the activity in filtrate and residue shows a con-
centration factor much higher than that obtained by prn.
or crystallization.

Klasse Akad. Wiss. Wien 120, 2a, 967(1911).
The arc spectrum of Ra is described.

215 Geiger, H. and Nuttall, J. M. Phil. Mag. (6), 22,
615(1911).

1911

Range, velocity, momentum, and kinetic energy of the
alpha particles of Ra are discussed.

The absorption coefficient of the β-rays of Ra was found
to be 200 cm." Al.

217 Hattler, L., Peters, K., and Meyer, S. "Radium
and Mesothorium in Monazite Sand." Sitzber. math.-
naturw. Klasse Akad. Wiss. Wien 120, 2a, 1199-1204
(1911).

A preparation of radium extracted in 1904 from monazite
sand has been examined in the light of recent researches to
find if mesothorium also is present, and it was found that the
preparation consists chiefly of mesothorium with only a very
small quantity of radium. The authors find that the meso-
 thorium is similar to barium in its chemical properties,
separation, however, being effected by fractionation of the
chlorides. It cannot be separated from radium. A simple
method of separating radiothorium from mesothorium is
given. It is found that the bromides of radium and meso-
thorium are very soluble in water and can be separated from
the insoluble radiothorium by decantation.

218 Herschinkel, H. "Attempts to Prepare Metallic
Radium." Radium, Le 8, 299-301(1911).

Repitition of Ebler's work aiming to obtain metallic
Ra by heating Ra-Ba hydrazoate in vacuo (1 mg. Ra in 11 mg.
substance). Decomp. took place, with production of small
quantities of N, and very impure metal which may have con-
tained a little Ra. It seems likely that Ra hydrazoate cannot
be prepared, since the radiations would decompose it as
fast as it was formed.

219 Höngschmid, O. "Revision of the Atomic Weight
Wien 120, 2a, 1617-52(1911).

Six detns. were made to ascertain the ratio RaCl₃/AgCl.
In all 6.0076 g. of RaCl₃ were used, which yielded 5.8933 g.
AgCl, when the ratio RaCl₃/AgCl is 1.03554, and the at. wt.
of Ra, assuming 107.88 for Ag, has the value 225.95 ± 02. The
specimens of RaCl₃ used in the final exps. were purified by
repeat crys. from aq. solns. followed by crys. from conc.
HCl soln. The process of the purifications was fol-
lowed by chem. analysis, finding the ratio RaCl₃/AgCl. The
various refinements introduced by T. W. Richards for at.
detns. were carefully followed throughout the work. The
samples of RaCl₃ used were fused in an atm. of HCl to render
them anhydrous. A specimen of RaCl₃, of 0.57575 g., de-
hydrated in a current of air at 200 for 45 min., gave a value
of 225.93 for the at. wt. of Ra.

220 Höngschmid, O., Sitzber, math.-naturw. Klasse
Akad. Wiss. Wien 120, 2a, 1611(1911).

The author reports the melting point of RaCl₃ to be
about 900°.

221 Kolowrat, L. "An Attempt to Measure the
Electric Conductivity of Radium." Radium, Le
8, 401-4(1911).

In 3 exps. 20, 125 and 120 millilitres of Rn resp. were
forced into a narrow capillary tube of glass after being
freed as far as possible from all traces of other gases,
especially O. The capillary was furnished with 2 Pt wires of almost the same diameter entering the glass a few mm. apart, and in the first 2 expts., in order to insure good contact, the interior of the glass was silvered except between the Pt terminals. With a layer of Pb of the same thickness as that to be expected for the RaD, the resistance should be about 40 ohms. The resistance was always greater than 10^6 ohms showing that no continuous deposit of metal had been formed. The Ag slowly disappeared, showing apparently minute residual traces of O, and to the same cause is attributed the nonappearance of metallic RaD in the quantity expected. In the first expt., after 3 or 4 days, a brown ring appeared about midway between the electrodes, about a mm. in length, and giving a metallic reflection. It remained constant for 3 days and then slowly disappeared; heating did not cause it to reappear. The explanation suggested is that the RaD was deposited metallically after most of the O had combined with the Ag, while the last traces of O slowly oxidized it and so caused it to disappear. A somewhat similar appearance was obtained in the 3rd expt. where other elaborate precautions were taken to get rid of last traces of O.


223 Marchwald, W. Ber. 44, 772(1911). An article on the leaching of pitchblende with H2SO4 and HNO3, and the extraction of RaSO4 with alkali.

224 Meyer, S. and Hess, V. F. "The Attainment of the Saturn. Values with Ionization through Alpha Rays." Chem. Ztg. 35, 937(1911). Curves and tables for polonium, Ra and radium are given, from which the values of current can be ascertained, if, as is the case with strong prep., satn. is not reached by use of high potential.

225 Navrat, Y. and Haschek, E. "The Arc and Spark Spectra of Radium." Chem. Ztg. 35, 842(1911). The spectrum obtained by Runge and Precht and considered as a spark spectrum was in reality the arc spectrum.


228 Radcliffe, S. British Pat. 6,936(1911). A method for the extraction of Ra from earth poor in Ra using NaHSO4.

229 Radcliffe, S. German Pat. 32,950(1911). Fusing of radium ore with NaCl and NaHSO4 used for Ra recovery.

230 Smith, E. B. "Distribution and Excretion of Radium and Its Emanations and Internal Administration." Q uart. J. Med. (1), 5, 550-55(1911). After the administration of Ra by mouth or by injection, a wide-spread degree of radioactivity is evident throughout the body. Elimination of Ra takes place principally and rapidly by the bowel, in a lesser and slower degree by the kidneys, and by the liver and skin not at all. There is an active excretion by the small intestine, and also probably by the colon. In the lungs there is at all times, after inoculation, the presence of the Em., possibly due to the extreme vascularity of these organs. The duration of the activity in the body, or the time taken in excretion, differs with regard to the nature of the prep. used. Sol. salts, however administered, are rapidly eliminated. The insol. salts, per os, are excreted directly by the bowel, and there is no evidence of any absorption and circulation. When given by injection, however, an exceedingly slow elimination occurs by the bowel.

231 Soddy, F. The Chemistry of the Radio-Elements. N. Y., Longmans. 1911(?).

232 Soddy, F. U. S. Pat. 1,051,593 (1911). A method for the extraction of Methe, (RaO2?) from monazite sand is given.

233 von Baeyer, O., Hahn, O., and Meitner, L. "Magnetic Spectra of the β-rays of Radium." Physik. 2, 12, 1099-1110. The magnetic spectrum of the β-rays from the short lived active deposit of RaB was photographed. The negatives revealed a discontinuous spectrum consisting of 9 lines, 4 of which belong to RaB, with velocities between 0.8 and 0.98 that of light, the remaining 5 lines belong to RaA, and have velocities between 0.36 and 0.74 that of light. Ra itself emits 2 β-rays whose velocities are approx. 0.65 and 0.52 that of light.

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234 Curie, M. Die Radioaktivität. (tr. by B. Finkelstein) Leipzig, Akademische Verlagsgesellschaft m.b.H. 1912. Volume I contains a large amount of information on the compounds of radium and their properties. The halides and nitrates of radium are particularly well treated.

235 Curie, M. "International Radium Standard." J. Phys. (5), 2, 795-826(1912). The paper contains an account of the methods of comparing quantities of radium, particularly the γ-ray method. An ionization chamber or γ-ray electroscope is recommended with lead walls at least 5 mm. thick. For correction, if the radium samples are not contained in the same vessels, μ for glass may be taken to be 0.1 cm. -1, and for lead 0.5 cm. -1. For glass vessels of 1/2 mm. thickness the absorption of the γ-rays is only about 0.5%. Correction may be necessary in some cases for the absorption of the γ-rays by the material itself. It is necessary that the radium samples should have been sealed up at least a month previous to measurement so that the equilibrium amount of emanation may have been produced. The international radium standard is next described. This was prepared by Mme. Curie from the material used in 1907 for the determination of the atomic weight of Ra, the value found being 226.5. Part of this radium was purified from RaDn, E, and F, and weighed in the form of anhydrous RaCl2, the weight being 0.02199 g.
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(RaCl₂). This was placed in a glass tube of wall thickness 0.27 mm. and diam. 0.9 mm., and sealed off in Oct., 1911, with a piece of thin Pt-wire also sealed into the tube. The standard was compared with that prepared by Höngschmid (0.03117 gm. RaCl₂) and the two were found to have γ-ray activities corresponding to the weights to within 0.2%. The International Congress has therefore accepted the Curie radium preparation as the standard to be placed in the Bureau International des Poids et Mesures. It is pointed out that as the radium was prepared from Jochimstal pitchblende, which contains little Th, no appreciable disturbance can arise from mesothorium, which cannot be chemically separated from Ra.


By reduction of Ra sulfate, AgCl, CaCO₃ and C in a silica crucible a radioactive Ag-Ra alloy of yellowish white color was obtained; the alloy is malleable and ductile. By electrolysis of Ra acetate with use of Pt electrodes a highly radioactive brown deposit was obtained on the cathode; this deposit renders a Ba cyanoplatinate screen phosphorescent and affects a photographic plate. By placing Ra acetate in a vessel and using a metal cover with an embedded quartz crystal, a photographic plate (the plate was wrapped in black paper when used in the light, but was not so protected when exposed in a dark room) being placed on the crystal, it was found that quartz is permeable in the luminous radiations, but not to the α, β, and γ radiations.

237 Edler, E. German Pat. 276,071 (1912). (Addition to German Pat. 243,736)

Isolating and concentrating radium and other radioactive materials by adsorption, with the aid of MeO₃, from soaks containing Ba together with the radioactive materials are described.

238 Fischer, S. W. (to R. E. Booraem and C. R. Hill) U. S. Pat. 1,054,102 (1912).

A method for leaching carnottite with alkali-lye mixtures for Ra recovery.


An article on the leaching of autunite with HCl and Na₂CO₃ for Ra recovery.


The authors have examined the Ba-content of the radium used by Höngschmid in his determination of the atomic weight (value 225.85). The spectrum of the salt showed no Ba lines, and from observations of the amount of added Ba necessary to show the lines the authors conclude that the original salt did not contain more than 0.002% Ba.


The author has made measurements, using the radium purified by Höngschmid and the apparatus of Meyer and Hess. The radium salt, 570.10 mg. RaCl₂, was crystallized from an acid solution, dried, and introduced into the calorimeter, and the rise of the heating effect observed over a period of several days. The observations were found to agree well with the theoretical formula $Q_t = Q_{R+} + Q_{E}(1-e^{-\lambda t})$, where $Q_t$, $Q_{R+}$, and $Q_E$ are the heat evolution of the whole, the radium itself and the emanation respectively and $\lambda$ is the transformation constant of RaE. The values deduced for $Q_{R+}$ and $Q_E$ are 25.2 and 107.1 g. cal./hr. respectively, giving a total of 132.3. $Q_E$ includes the products as far as RaC in their equilibrium amounts. In the experiments all the α and β-rays and 18% of the γ-rays were absorbed.

Assuming that all the heating effect of the radium, without its products, is due to the kinetic energies of the α-particles and the recoil atoms the velocity of the former is deduced to be $1.595 \times 10^8$ cm./sec.

242 Höngschmid, O. Monatsh. 22, 258 (1912).

A method for obtaining chemically pure RaCl₂ as well as some properties of RaBr₂ and RaCl₂ are described.


A method for obtaining chemically pure RaBr₂ is described as is the prepn. of RaSO₄ from other Ra salts by gtn. with H₂SO₄. The prepn. of dry RaCl₂ from RaBr₂ by heating in HCl stream is also described. It is reported that complete dehydration of RaBr₂.2H₂O can be accomplished by heating in dry air stream at 200°, the color change upon dehydration is reported.


Occasional explosions of specimens of RaBr₂ are attributed to gradual absorption of moisture resulting in a weakening of the forces of cohesion in the crystal to the point where the pressure of the accumulated emanation (He) suddenly ruptures the crystal.


Discussion of Curie’s and Höngschmid’s methods for showing purity of Ra (addn. of 0.6% Ba and note the strengthening of Ba spectrum lines, and recryst. to constant at. wt., resp.) Claims results are not proof of purity but that the method of H. could be if another salt were formed and the atomic wt. confirmed with it. Discussion of at. wt. results.


The standard preparations consist of the RaCl₂ prepared by Höngschmid in his determination of the atomic weight of Ra. The present paper deals with (1) the heat evolution; (2) the ionization due to the α-rays from a very thin film of the substance; (3) the ionization due to the γ-rays, and (4) the amount of emanation in equilibrium with the material. The heat evolution of 1 g. radium element in equilibrium with its products (emanation, RaA, B, and C) when all the α- and β-rays and 18% of the γ-rays were absorbed was found to be 132.26 g. cal./hour, or if all the γ-rays were absorbed 138 g. cal./hour. The calculated
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value based on the ordinary results for the initial velocities of 
expulsion of α-rays is approximately the same as the 
experimental value. Different methods of determining the 
Ra-content of a preparation from its γ-ray ionization were 
tested, and data are given for various dispositions, by means 
of which an ordinary preparation of radium can be 
standardized without the necessity of comparing it directly 
with a standardized preparation. The measurements of the 
current produced by 1 cc. of RaEm in a cylindrical chamber 
without subsequent products gave the value 2.7 × 10^5 e.u., 
which is in good agreement with the result of Flammon 
and Macne. From the thorium content of the residues from 
which the Ra was extracted, and the fact that iodum is sepa-
rated out with Th, it was deduced that the period of average 
life of iodum cannot exceed about 200,000 years.

Experiments on the use of NaHSO₃ for the extraction of radium from earths poor in Ra are described.

248 Rutherford, E. Radioactive Substances and Their 
Radiations. Cambridge, Cambridge Univ. Press. 1912(?).

249 Rutherford, E. and Chadwick, G. "A Method of 
Compensation for the Comparison of Quantities 
of Radium, and Some Applications of This Method." 
Radium, Le 9, 190-200(1912).
The compensation method employed consists in the 
comparison of ionization produced in one ionization 
chamber by the γ-radiation from Ra prep., with that 
produced by a layer of U₂CO₃ in a second chamber in which the 
electrode is in metallic communication with that in the 
first. By varying the distance of the Ra from the ionization 
chamber exact compensation is obtained and is verified by a 
Dolzak electrometer. The first ionization chamber was 
covered by Pb of thickness either 3 mm. or 1 cm. It is 
shown that ionization in the first chamber varies according 
to the expression \( \frac{e^{-\mu r}}{r (r + a)} \), where \( \mu \) is the coeff. of ab-
sorption of γ-rays by air, \( r \) is the distance of the Ra from 
(a) the chamber, and \( a \) is the depth of the chamber to the elec-
trode. This has been experimentally verified, with good 
agreement (1 in 400) at distances over 60 cm.; at smaller 
distances the error increases. An expression is given for the 
deten. of quantities of Em. Using the method the period 
of half decay of the Em has been found to be 3.854 days, 
in good agreement with preceding figures. The max. γ activity 
from the Em is attained after 255 minutes. No measurable 
effect on the emission of γ-rays was observed on placing a 
tube containing Em between the poles of a powerful electro-
magnet.

250 Schmidt, H. W. and Nick, H. "Experiments with 
Weak Radium Solutions." Physik. Z. 13, 199-207 
(1912).
Standard solns. of Ra, acidified with HCl, whose conc. of 
Ra (metal) ranged from 2.1 × 10^{-4} to 2.3 × 10^{-4} g. were 
stored in 2 types of glass vessels, some in ordinary glass, 
others in Jena, for various periods, and their content of 
emanation detd. for equil. conditions by the electroscopic 
method. The elec. capacity and the potentials corresponding 
to the scale readings were carefully detd. The value of the 
ionization current can then be expressed in abs. units. The 
avr. of 10 detns. using a cylinder 6.5 cm. high, 7.1 cm. diam., 
capacity 4.34, gave 3.19 × 10^4 e.u. for the ionization cur-
rent produced by 1 cc. of the emanation in equil. with 1 g. Ra. 
The value of the current produced by 1 cc. when the ionization 
chamber was 25.2 cm. high, and 7.1 cm. in diam., capacity, 
6.33, was found to be 3.84 × 10^4 e.u., av. of 40 detns. The 
kinds of glass did not affect the results.

251 Soddy, F. The Interpretation of Radium, 3rd ed. 
Rev. N. Y., Putnam. 1912(?).

252 Soddy, F. "Origin of Radium." Engineering 93, 
389-90(1912?).
General discussion.

253 Soddy, F. "Origin of Radium." Rev. gen. sci. 22, 
343-7(1912?).
General discussion.

 u. Elektrochem 9, 498-500(1912).
Dehydrated RaCl₂ can be obtained from RaSO₄ by dehy-
drating the sulfate in dry air at 300° then bringing it to red 
heat in a current of HCl and CCl₄ in a quartz tube. No loss 
of Ra is experienced. The resulting RaCl₂ has a density of 
4.9. The bromide, RaBr₂, can be obtained from the chloride in a 
similar manner using HBr gas. The density of the bromide 
is reported to be 5.76.

255 Whytlaw-Gray, R. and Ramsay, W. "Atomic Weight 
(1912).
The final value arrived at is 226.36 for the at. wt. of Ra, 
thus confirming M. Curie's results but disagreeing with 
Röntgen's. The density of RaBr₂ is reported to be 
5.76.

256 Whytlaw-Gray, R. and Ramsay, W. "The Atomic 
Weight of Radium." Z. physik. Chem. 80, 257-79 
(1912).
The work of previous investigators is reviewed and dis-
cussed. The authors used quartz vessels only in their work, 
which is given in detail. The sulfate was transformed into 
the chloride by heating in an atm. of HCl and CCl₄. The detns. 
were based on the transformation of RaCl₂ into RaBr₂, and 
the RaBr₂ back to RaCl₂. RaCl₂ is converted into RaBr₂ by 
heating in a current of HBr gas; the bromide into chloride 
as above. It is concluded that the at. wt. is 226.36. If only 
α-particles (He atoms) are given off in the disinte-
gration of Ra, the difference in at. wt. between U and Ra = 11.88 
(3.994 × 3); the at. wt. of U by Richards = 238.4 and 238.41 
- 11.88 = 226.43. If the Ra series ends in Pb after giving off 
5 particles, one would expect the at. wt. of Pb to be 226.4 
- 19.92 = 206.48 instead of 206.97 reported by Clark or 207.1 
as given by Baxter. This might be explained in one of the 
following ways: (a) Pb is not the final product of the disinte-
gration of Ra however, there is no known element of at. wt. 
206.5 and there is no place in the periodic system for such; 
(b) the at. wts. of U and Ra are approx. 0.5 unit too low. This 
is not impossible if the value reported (226.4) be considered 
as only a minimum; (c) during the transformation of Ra into 
Pb a number of β-particles escape sufficient to explain the
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difference of 0.6 unit; (d) if He is not the only gaseous disintegration product, the calculations based on such an assumption are valueless. It is urged that new detns. of the at. wts. of U and Pb are necessary; the at. wt. of Pb must be close to 207, but on adding 20 a value (227) is obtained for Ra, essentially higher than reported; however, the result reported is considered a minimum value, since all probable impurities would lower the true value. The sulfates of the alkali and alkaline earths are readily converted quantitatively into the chlorides by heating in an atm. of HCl + CCl₄. On converting BaCl₂ into BaBr₂ as with Ra, the values 137.37 and 137.32 were found for the at. wt. of Ba.  

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The experiments were made on the penetrating γ-rays from Ra in equilibrium with its products (to RaC). The tube containing the Ra was placed in a copper test tube just fitting into a vacuum test-tube into which liquid hydrogen could be poured. The tubes were surrounded by an air-tight ionization vessel, the thickness being insufficient to cut off β-rays. The ionization was balanced by an ionization current in a secondary chamber due to γ-rays from a secondary radium preparation. Liquid hydrogen was then poured in and a change in the balance looked for. Only a few experiments could be carried out, and the authors state that it would have been desirable to have made a greater number and to continue these during a greater length of time. Nevertheless the results show that cooling the radium down to the temperature of liquid hydrogen (20.3° absolute) during a period of 1 1/2 hours does not cause a change in the γ-radiation of 1 in 1000, and probably not even of 1 in 5000.


An app. for estg. Ra by the Em method is described. It consists of a flask to hold the soln., with a capillary lead-in tube provided with a tap. By means of a ground joint, the flask is attached to a small condenser, provided at the upper end with a tap. This tap is connected by a 2nd ground joint to a bulb, provided above and below with taps. After the Em is driven out by boiling the soln. under decreased pressure, a soln. is admitted to the flask through the capillary lead-in tube in order to drive the Em into the bulb. The lower tap of the bulb is then closed, and the latter detached from the flask, after which the Em is admitted to the ionization chamber of an electroscope. Measurements follow the usual methods.

259 Ebler, E. German Pat. 274,874 (1913).

A method of the reduction of crude Ba-Ra sulfate with CaH₂ is described.

260 Ebler, E. German Pat. 278,260 (1913).

In a process of working mixtures containing radium or mesothorium, the crude sulfates are mixed intimately with CaCl₂ or materials yielding it, and heated for 6-8 hrs., with

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exclusion of air, to a bright red. The product is extd. with H₂O or acid or with solns. of acid salts. By the reducing action of the carbide and of the resulting Ca vapor, the sulfides are formed from the sulfates, and these sulfides dissolve in dil. HCl or HOAc, while the PbS formed at the same time is insol. in these solvents. The SiO₂ present in the crude sulfates is reduced at the high temp. to elementary Si or rendered insol. in dil. acid, thereby losing the property of taking Ra out of soln. by adsorption and fixing it, just as the PbS lost this property. The other products of the heat treatment, such as the Fe, Mg, Sr and Ca compts., as well as the Ca of the carbide, go into soln. in the dil. HCl as chlorides, so that upon evap. of the ly, only crude chlorides are obtained. From these, pure Ba-Ra chloride or Ra-Meso-Th-Ra chloride may be converted, as by treatment with H₂SO₄, into sulfates and these may be converted, through the carbonates, into pure chlorides.

261 Ebler, E. German Pat. 296,132 (1913).

A method for the extraction of radium from earths poor in Ra is described.

262 Ebler, E. and Bender, W. "Purification and Enriching of Crude Radium Barium Chlorides." *Ber. 46*, 1571-3 (1913).

By treating the crude Ba-Ra chlorides with HCl gas, the Ba and Ra chlorides are pptd. The Ra is more readily pptd. than the Ba. Practically all of the Ra present in the crude material is pptd. in the first fractions, while only 3/4 of the Ba is pptd.


By this method all the sulfates are reduced to sulfides, and by a single operation the Ra and other alk. earths are obtained in a form which is sol. in HCl. The process presents 2 advantages over the older methods; a disadvantageous equil. does not occur, as is the case with the transformation of the sulfates with alk. carbonates solns., and, secondly, on account of the small solubility of PbS in HCl, most of the Pb can be sep. from the Ra in the same operation. The process possesses the further advantage that the reduction proceeds automatically and does not require heating. The CaH₂ reacts with the sulfates in accordance with the equation MeSO₄ + 4CaH₂ = MeS + 4CaO + 4H₂. The evolved H breaks up the reaction mass so that afterwards it is easily pulverized. When the H ceases to burn, the reaction is ended. The procedure is as follows: The completely dry and finely powdered sulfate, after being mixed with finely powdered CaH₂, is pressed into a crucible and is fired by means of Mg ribbon and a priming mixt., as in the thermite process. The reaction proceeds violently, and the H burns off in a few mins. Since SiO₂ is not reduced under these conditions, only just enough CaH₂ is added to reduce the sulfates present. The violence of the reaction increases with the amt. of Pb present, and mixes. with more than 20% of Pb are dangerous in large quantities. The product is then quickly stirred into hot dil. HCl, free from H₂SO₄, and the H₂S expelled by boiling. If Pb is present N HCl is used, as PbS is insol. in acid of this strength, while when Pb is absent
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5 N acid is employed. By passing HCl into the soln. until 3/4 of the BaCl₂ is ppt., all the Ra is carried down. With the crude sulfate from carnottite, where equal parts of sulfate and Ca₃ were used, the pptd. BaCl₂ weighed 37% of the sulfate taken, and contained 80.8% of all the Ra. With other crude sulfates, the pptd. BaCl₂ contained 80.2% of all the Ra present. The reduction is very complete and the method shortens the process of extracting Ra.


The use of colloidal SiO₂ in the conc. of radioactive substances has been described in a previous paper. It has now been found that for the adsorption of certain elements, the adsorption capacity of the colloidal sol increases with the concentration of the silicic acid, the concentration of the silicic acid in a conc. sol. was determined by the amount of R added to it. The amount of R adsorbed by the colloidal sol. increases with the concentration of the silicic acid. The adsorption of R from the silicic acid sol. was studied by the method of equilibrium adsorption. The results obtained are in agreement with the theory of adsorption. The adsorption of R from the silicic acid sol. is not affected by the presence of other ions.

265 Fajans, K. Ber. 46, 422 (1913).
An article on radium isotopes.

266 Fajans, K. Physik. Z. 14, 131-134 (1913).
An article on radium isotopes.

267 Fajans, K. Radium, Le 10, 57-61, 171 (1913).
An article on radium isotopes.


A small splintered and weighed fragment of the radioactive mineral or salt (0.001-0.001 g.) is placed in a hollow in a C rod, and this is heated to 2000-3000° for from 10 to 30 sec. in a closed micro-furnace by the passage of an elec. current of 10 amperes at 250°, near which temp. rapid increase in the amt. of the liberated gas takes place. Complete de-emanation takes place at full redness. In investigating solns. (as in dealing with filtrates) an accurately known small quantity of the soln. is placed on the C rod by a capillary pipette and the C rod is examed. after a month.

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The reduction of the electric osmose of water by electrolytes shows a well-marked dependence upon the valency of the ions, being much stronger in multivalent than in univalent ions. This suggests a method of determining the valency of an element which is only available in small quantities. The authors work out a method of observing the flow of the liquid past a bubble in a capillary tube. The amount of the cation need not exceed 0.01 or even 0.001 mg. Experiments with RaBr put it in the same category as Mg or Ba salts, and its bivalence is thus corroborated.


Ranges of α-particles (in air?) at 0 and 15° (c.mm.) and initial velocity (x 10⁶ cm/sec.) given for Ra (3.13, 3.30, 1.61), ThX(Ra₂⁶) (4.08, 4.30, 1.75), and A°CX(Ra₂⁶) (4.17, 4.40, 1.77).

271 Glaser, F. German Pat. 272,429 (1913).
A method for the extraction of MnTh₃ (Rα₂⁶) from monazite sand is described.

272 Glaser, F. Chem. Z. 37, 1105 (1913).
The separation of ThX (Rα₂⁶) from RaTh (Th₂⁶) is described.

273 Hahn, O. and Rothenbach, M. Physik. Z. 14, 409 (1913).
The half-life of A°CX (Rα₂⁶) is reported to be 11.6 days.


The object of the investigation was the exam. of the Wulf quartz fiber electroscope for γ-rays, with reference to its fitness for standardisation, so as to enable it to carry out absolute radium measurements by the γ-ray method, without the use of a Ra standard. The form of the electroscope was changed to include that of a vertical cylinder of 968 cc. capacity the height being approx. equal to the diam. The microscope was fixed directly into one of the vertical walls opposite an air-tight window for the observation of the quartz fiber system, which hangs in the vertical axis of the cylinder. This form gave satisfactory satn. currents over the range of 100-300 v. for the max. rate of discharge of 2.4 v. per sec. But in testing with relation to the law of the sq. of the distance of the prep. from the electroscope, the discharge was too great with increasing distance, the discrepancy reaching the value of 10% at the greatest distance. This was due to the proximity of the wall or other objects in the room from which the secondary penetrating radiation is set up by the primary penetrating rays. To obviate this difficulty, it is recommended to have both prep. and electroscope at least 2 m. from the walls, employing, of course, some standard distance between prep. and electroscope, depending on its calibration and the strength of the radiating source being examined. A description is also given of a new method and app. for the rapid direct reading of radioactive values by the γ-ray method. This consists of a large flat cylinder (20 cm. in diam.) entirely closed and placed vertically so as to receive the γ-rays through one of the walls of Zn, 5 mm. in thickness. The
vertical electrode is a metal plate, 15 cm. in diam., insulated by amber, and is connected with an Elster and Geitel single fiber electrometer. A normal battery of the Krueger type furnishes 300 v., and the necessary high resistance in series with the electrometer is the mkt. recommended by Campbell (10 parts xyylene to 1 part abs. alc.) contained in a sealed vessel provided with Pt electrodes. With this arrangement, the deflection of the electrometer was strictly proportional to the γ-ray radiation; and in using a standard for comparison, one may, for convenience, choose the distance from the ionization chamber such that one scale division equals one mg. of Ra, or any other suitable quantity.


Wull’s double-fibre string electrometer may be used for the measurement of the strength of Ra or mesothorium preparations by means of the ionization produced within the electrometer case by the γ-rays of the preparation when placed at a certain distance (say, 1 m. for 30 mg. metallic Ra) from the preparation. When the capacity and sensitivity of the electrometer are accurately known, the Ra measurement may be made an absolute one with the knowledge of the ionizing power of γ-rays and the amount of γ-rays emitted by a given quantity of Ra. The absolute measurement thus made is liable to errors of 2 or 3 per cent. Comparisons with standard preparations may be made to within 1/5 per cent. The sensitivity preferred is 4 volts per division. The wall of the case consists of brass 3 mm. thick. The author also describes a method not involving a time measurement. It employs a single-fibre electrometer, with the ionization chamber grounded through a zyrol resistance and connected to the fibre. The deflection of the fibre is accurately proportioned to the ionization.


The bromide used for the detn. was prepared from RaCl₂, with which the value 225.95 had been obtained for the At. wt. of Ra. The bromide was recrystd. repeatedly. From 7 preps., each representing a diff. number of crystals, the same value was obtained for the at. wt. of Ra. Besides the criterion of purity, spectroscopic exam. showed the bromide to be absolutely free from Ra. Six detns. were made to ascertain the ratio RaBr₂/AgBr. In all 5.06711 g. of RaBr₂ were used, which yielded 4.9339 g. of AgBr, whence the at. wt. of Ra, assuming 107.88 for Ag and 79.919 for Br, has the value 225.96 ± 0.1. From 2 analyses it was found that 1.23852 g. of RaBr₂ require 0.72045 g. of Ag for the formation of the Ag salt, whence the at. wt. of Ra has the value 225.97. Whytlaw-Gray and Ramsay’s work is discussed, and it is pointed out that they have made a const. error in the vacuum correction employed in their calculations. Two detns. of the at. wt. of Ra, in which the method of Whytlaw-Gray and Ramsay was employed gave Ra = 225.94.


An article on radium isotopes.

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An article on radium isotopes.

279 Lorenzen, J. German Pat. 278,121 (1913).

Processes used heretofore for obtaining thorium-X (Ra²⁴⁴) are troublesome and costly and require either large amounts of H₂O for soln. or yield an impure product with considerable amts. of NH₄ salts or NaCl. A separ. of the ThX from the Th can be effected by subjecting a colloidal ThO₂ soln. containing ThX to dialysis. The ThX passes through, while the colloidal ThO₂ remains in the dialyzer. In this manner a very pure cond. soln. of ThX is obtained. If this soln. is removed and replaced by distd. H₂O, uniform solns. of ThX may be removed, at definite periods, since ThX forms continuously from the Radio-Th contained in the ordinary ThO₂. The colloidal Th soln. can be prepared by pptg. Th(OH)₂ with NH₄OH, from a conc. Th(NO₃)₄ soln. containing, besides Th, also Radio-Th and ThX, washing the ppt., and digesting with a little H₂O after the addition of a little Th(NO₃)₄.


Methods for the separation of Me²⁰₃ (Ra²⁴⁴) and ThX (Ra²⁴⁴) salts from a solution of thorium salts are described. Adsorption methods used primarily.


The half-life of ThX (Ra²⁴⁴) is reported to be 3.64 days.


Redetn. of decay constant for AcX (Ra²⁴⁴) by α-ray method yields t₁/₂ = 11.35 days. Purification carried out by Th carrier pptn. for HAc removal and BaSO₄ carrier for Ra pptn.


Although the at. wt. of Ra, as recently detd. by Höngschmid does not agree with the value deduced from the at. wt. of U, the difference between the at. wt. of Pb and Höngschmid’s value for Ra is exactly equal to 5 times the at. wt. of the α-particle.


A method for the determination of the half-life of radium is described.


A method for leaching radium ore with Na₂CO₃ and NaOH is described.


Experiments on the use of NaHSO₄ for the extraction of radium from earths poor in Ra are described.
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An article on Ra isotopes.


For all elements which emit α-rays there exists a quantum relationship between the decomp. const., λ, and the initial velocity, v₀, of the α-particle. This relationship is expressed either by the equation, \( \log \lambda = A + B \log v_0 \), or by the equation, \( \log \lambda = a + bv^2 \), where A and a are constants. For any radioactive series, and B and b are general constants.
Both equations give the same values for \( v_0 \). The consits have the following values: B = -156 and b = 42.5, in all 3 radioactive series; A = -43.1 and a = -79.5, in the U series; A = -44.5 and a = -80.7, in the Th series; and A = -45.2 and a = -82.7, in the Ac series. \( v_0 \) has been calc. for 20 substances emitting α-rays, and the values obtained agree closely with the experimental values obtained by Geiger and Nuttall. The difference between the initial velocity of an α-particle emitted by a member of one radioactive family and that emitted by its analog by another radioactive series is consit. For the Ra and the Th series this difference is \( 0.15 \times 10^4 \text{ cm./sec.} \), and for the Ra and the Ac series it is \( -0.20 \times 10^5 \text{ cm./sec.} \). Further, for those substances which emit α-particles, the ratio of the decomp. const. of analogous members of diff. radioactive series is approx. const. The foregoing results suggest a new arrangement of the last members of the radioactive deposits.

Radio-elements are arranged in a series. Methods used in determining the positions are discussed. Ra and its isotopes are the most electropositive of the radio-elements according to the arrangement shown.

This article presents the same data as the previous paper.

Discussion includes data on diffusion constants and mobilities of Ra, ThX (Ra₂⁴²), and AcX (Ra₂³⁹). These are reported as, 0.667, 57.3; 0.659, 58.0.; and 0.664, 56.1 respectively. Each of the isotopes is reported to have a valence of 2. Results for other radio-elements are also included.

Article reports the same information as the previous reference.

293 von Hevesy, G. Physik. Z. 14, 1205-6(1913).
The diffusion coefficient of Me₃Th(Th⁴⁸) loss in water at 18 °C is 0.66 cm²/day, the same as the values for the other radium isotopes. Valence and affinity characteristics are also discussed.

1914
294 Beer, P. Radium, Le 11, 124(1914).
An article on Ra isotopes.

The residues are fused with sufficient alkali, e.g., Na₂CO₃, to convert about 99% of the sulfates into acid-sol. form and the residues are then treated with H₂O and HCl to remove the acid sol. Ba compts. from the RaSO₄ which remains as an insol. residue. The process is repeated until the desired degree of concn. is effected.

The material is treated with boiling H₂SO₄ in small amt. to dissolve the Ba as bisulfate without dissolving the RaSO₄, the soln. is sepdt. and treated with H₂O to ppt. mixed sulfates and the residue is repeatedly treated with small amts. of boiling H₂SO₄ to effect fractional sep. of the Ba and Ra compts. The latter are dissolved in the last stage of the process and are pptd. by adding H₂O.

An article on the extraction of radium from American carnottite poor in Ra with SO₄ in solution.

298 Burfind, J. H. U. S. Pat. 1,095,377(1914).
A method for the extraction of radium from American carnottite poor in Ra with SO₄ in solution.

Article on the extraction of radium from poor American pitchblende with chlorine.

300 Coeho, A. Ber. 37, 811(1914).
A method for obtaining a radium amalgam by the electrolysis of a methyl alcohol solution of Ra-Ba salts. The cathode is amalgamated zinc, the anode: silver.

A comparison of the different processes for the extraction of Ra with a reducing agent is given. Better results are obtained with strong agents.

302 Eber, E. and Bender, W. Z. anorg. Chem. 84, 77 (1914).
The separation of Ra-Ba chlorides by adsorption with MnO₂ is described.

303 Eber, E. and Bender, W. "Extraction of Radium from Crude Sulfates by Calcium Carbide and Mixtures of Calcium Carbide and Hydride." Z. anorg. Chem. 88, 255-64(1914).
Autogenous reduction of sulfates by CaH₂ is profitable only with rich concentrates. For crude sulfates containing silicates reduction by C is possible but unless the amount of silica is small not more than 30% of the Ra present is converted to sulfide. Using 4CaC₂ + MnO₂ intimately mixed and...
kept at red heat for 4 hrs., about 80% of the Ra is reduced even in the presence of much silicate. Addition of CaS, makes the reaction rapid and autogenous but is practicable only when little silicate is present. The process is best used on a large scale because of greater heat utilization.


Crude sulfates containing Ra or MoTh sulfates are reduced to sulfides by heating with CaC$_2$. The reaction may be effected without heating if a part of the carbide is replaced by CaH$_2$, Ca, Mg, Al, or other substance that will react with sulfates in the manner of an aluminomeric mixt.; or CaH$_2$ or Ca together with an equiv. quantity of a sulfate, may be added to the mixt. of CaC$_2$ and crude sulfates. The reduced mass is dissolved in H$_2$O, HCl, or HNO$_3$, and the Ra or MoTh and Ba are pptd. by satd. the soln. with HCl or HNO$_3$. Practically all the Ra or MoTh salt is deposited before the whole of the Ba salt.

305 Gesellschaft für Elektro-Osmose. British Pat. 10,083 (1914).

In obtaining radium salts, the ions adsorbed in colloids are exchanged for other ions by treatment with a soln. of an electrolyte, the exchange being made selective by choosing suitable salt solns. at suitable concns. so that closely related elements, such as the rare earths, may be sepd. In an example, a MnS$_2$ adsorption product of Ra and Ba in a fine state of division is boiled with an N$_2$H$_4$ soln. of stated strength. The solid matter after filtration is stated to contain 32.7% of the Ba and 64.7% of the Ra originally present.


It is well known that mesothorium is chemically non-separable from radium, so that commercial mesothorium obtained from monazite sands generally contains of the order of 20% of Ra. Estimations of the relative amounts of Ra and MoTh in a specimen are easy by the emanation method, but this involves breaking the containing tube. The author has made careful measurements of the absorption by lead of the $\gamma$-rays of various preparations with a view to distinguishing them by this method. The preparations used were: (1) RaBr$_2$, pure. (2) Commercial mesothorium freshly prepared. (3) Commercial mesothorium, 2 years old (i.e., having grown radio-thorium). (4) Freshly prepared mesothorium, free from Ra. (5) Radio-thorium. The electroscope used was of lead with walls 3.3 mm. thick, and the following relative ionizations were obtained:

<table>
<thead>
<tr>
<th>mm.</th>
<th>Lead</th>
<th>Radium</th>
<th>Mesothorium (New)</th>
<th>Mesothorium (Old)</th>
<th>Mesothorium (without Ra)</th>
<th>Radio-thorium</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>84.5</td>
<td>86.7</td>
<td>85.5</td>
<td>87.3</td>
<td>86.5</td>
<td>86.5</td>
</tr>
<tr>
<td>10</td>
<td>59.3</td>
<td>60.9</td>
<td>61.1</td>
<td>60.0</td>
<td>61.1</td>
<td>61.1</td>
</tr>
<tr>
<td>15</td>
<td>41.9</td>
<td>44</td>
<td>44.6</td>
<td>42.2</td>
<td>47.1</td>
<td>47.1</td>
</tr>
<tr>
<td>20</td>
<td>31.5</td>
<td>32.5</td>
<td>32.5</td>
<td>31.5</td>
<td>36.8</td>
<td>36.8</td>
</tr>
<tr>
<td>25</td>
<td>24.2</td>
<td>23.7</td>
<td>25.2</td>
<td>25.2</td>
<td>29.1</td>
<td>29.1</td>
</tr>
<tr>
<td>30</td>
<td>18.3</td>
<td>17.7</td>
<td>19.4</td>
<td>16.7</td>
<td>33.3</td>
<td>33.3</td>
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<tr>
<td>35</td>
<td>14.3</td>
<td>13.4</td>
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<td>19.8</td>
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<td>40</td>
<td>11.0</td>
<td>9.9</td>
<td>12.8</td>
<td>9.2</td>
<td>12.3</td>
<td>12.3</td>
</tr>
<tr>
<td>45</td>
<td>9.0</td>
<td>7.5</td>
<td>9.1</td>
<td>6.8</td>
<td>12.4</td>
<td>12.4</td>
</tr>
</tbody>
</table>

1914

307 Ikle, M. Radium, Le 11, 124(1914). An article on radium isotopes.

308 Keetman, B. and Jost, F. U. S. Pat. 1,100,743 (1914).

Recovering salts of mesothorium and radium in extraction of thorium from minerals such as monazite sand by treating the ore with a Ba salt and hot conc. H$_2$SO$_4$ and adding sufficient H$_2$O to form a slimy or muddy product and then adding to this product an aq. soln. containing sufficient BaCl$_2$ or BaSO$_4$ to render the radioactive substances such as MoTh and Ra absolutely insol. so that they may be recovered from the ppt.


A method for the separation of AcX(Ra$^{228}$) from actinium preparations is described. The Ac and RaAc are precipitated with ammonia. A little barium salt is added to the filtrate and the AcX is removed from the soln by co-precipitation with BaSO$_4$ or the filtrate can be evaporated to dryness, and the residue heated to expel the other decay products, since AcX is not volatile at red heat.

310 McCoy, H. N. U. S. Pat. 1,098,282 (1914).

Ultraviolet radium ore is mixed with diluted or concentrated H$_2$SO$_4$; the slurry is heated to 300° or higher. Water is then added to the mixture, the Fe, U, and V salts are dissolved, and insoluble RaSO$_4$ remains.

311 McCoy, H. N. U. S. Pat. 1,103,600, July 14.

Concentrating and separating Ra, Math(Ra$^{228}$) and ThX (Ra$^{219}$) from Ba compds., by partially pptd. the hydroxides of Ba and the radioactive metals by NaOH or KOH and fractionally sepd. the Ba(OH)$_2$ from soln. by crystn. and addition of more NaOH or KOH. The Ba compds. remaining in soln. after the first pptn. are richer in radioactive compds. than the ppt.

312 Radcliffe, S. Chem. Zentr. 1, 190(1914).

Experiments on the fusing of carnotite with NaH$\text{SO}_4$ are described.


Experiments on the fusing of carnotite with NaH$\text{SO}_4$ are described.

314 Ramsauer, C. Radium, Le 11, 107(1914).

The detection of ThX(Ra$^{228}$) and AcX(Ra$^{228}$) by the emanation method is described.


Radium itself freed from its products is found to emit three types of $\gamma$-rays with values of $\mu$/D in Al of 130, 6, and 0.1 cm$^{-1}$. The intensity of the $\gamma$-radiation of Ra itself is from 1 to 1½ per cent of that of Ra in equilibrium with its short lived products. The results show further that
Radio-\text{Ac} emits two types of $\gamma$-rays, the values of $\mu/D$ in Al being 8 and 0.1.


The paper commences with a discussion on the relative merits of the various methods of separation and collection of Ra\text{Em} from the ore, the Ra content of which is required. Two standard methods of separating the emanation from the specimen are outlined: (1) The "solution" method, and (2) the "fusion" method, introduced by Joly. The author states that the results obtained by the fusion method are generally higher than the values by the solution method. In the latter case the solution avoids 10% of the precipitation in the solutions, and these probably cause the separation of some Ra which does not release its emanation completely on boiling. Since the apparatus designed by Joly is rather expensive, experiments have been directed towards devising and testing the accuracy of a simple fusion method which can be conducted with inexpensive apparatus. For a description of this apparatus and the various methods used for separating and collecting the emanation the original paper must be consulted. Tables containing the results from analyses of the following minerals are given: Uraninite, carnotite concentrate, carnotite ore, spring deposit. In all, 12 different methods of separating the emanation have been employed and the mean value of a number of determinations by each method is given. From a consideration of the tables the author draws the following conclusions: (1) The solution method, that is, fusion with mixed carbonates, followed by solution and boiling, gave results that are only 70 to 80% of the values obtained by the fusion method with mixed carbonates. (2) Fusion with mixed carbonates appears to be superior to fusion with potassium acid sulfate. (3) Fusion with borax probably gives a low result as a result of the retention of some of the emanation in the "melt". At the temperatures attained in the experiments the evolution of gas, and its flow through the melt, is necessary for complete release of the emanation. (4) High emanating power in the cold indicates a large release of emanation by heating. In the case of a specimen of carnotite ore a rough assay may be made by merely heating to bright redness. (5) A complete separation of the emanation from uraninite is obtained by solution in nitric acid and by fusion with some of the ordinary fluxes. No experiments were conducted with the resulting fused mass to ascertain whether the equilibrium quantities of emanation can be again separated by a subsequent fusion. In the discussion, S. C. Lind gave a short account of his determinations of the Ra/Ur ratio in carnotites, obtaining results by precipitating the radium and uranium to 20% low, in agreement with the results mentioned above. He also found that the fusion method, successful with carnotites, is a complete failure under the same conditions for crude sulphates, while the solution method succeeded with pitchblende but failed with carnotites. These observations render the variety of methods described in the present paper all the more valuable.

W. G. Brown communicated a brief resume of some experiments on this problem which he had carried out in collaboration with O. E. Sheppard. Their determinations by solution in sulfuric and nitric acids are in fair agreement with the results obtained in the present experiments, but the lower values by fusion with mixed carbonates stand in direct contrast to the higher values of the author.

Stern, H. German Pat. 280,694 (1914). A method for the separation of Ra-Ba salts with permittite and zeolite is described.


Solid substances having a Ra content as low as $4 \times 10^{-4}$ mg. Ra/cc. may be measured by the $\gamma$-ray method more conveniently than by the usual Em method by using a special form of electroscope. B. describes a cylindrical form of electroscope 32 cm. high, 20 cm. internal diam. covered internally with Pb 0.5 mm. thick. The central electrode, which stands vertically from the bottom where it is insulated by a ball of S, consists of a hollow cylinder of brass 16 cm. high and 2.8 cm. internal diam. lined on the outside with Pb. The cylindrical electrode is round at both ends and is provided above with a removable cap through which the solid material to be examined is introduced after being sealed in a glass test-tube which just fits inside the cylinder. The distance between the bottom of the electrode and the insulation is 11 cm., which permits the Au leaf to be attached just below the bottom of the cylinder. The leaf is observed in the usual way by means of mica windows in the wall of the outer cylinder. The central electrode carrying the leaf system is charged from above. Several advantages are attained by placing the active material inside the inner electrode. The radiation is effective in all directions, and the effective vol. is const. and definite. Two kinds of corrections must be taken into account, the absorption of the radioactive material itself, and its special distribution inside the electrode with respect to its radiation. The latter was examined by placing a point source of radiation at various points inside the cylinder, where in, and other internal with Pb. This correction was found to be represented by the center of the cylinder. The absorption correction was examined by using a point source buried at various locations in the cylinder filled with silica as absorbent. Again the conclusion was reached that the av. of the entire vol. is represented by the center, and therefore it is only necessary with different absorbent materials to make one measurement with a point source at the center. This correction for SiO$_2$ was 7.5%; for PbCrO$_4$, 26.3; for a mixt. of SiO$_2$ and PbCrO$_4$, 17.2; for CaO, 3.7; and for a pd. weakly active Ba(Ra)SO$_4$ (sp. gr. 0.53), 4.8. For substances of d. <1 the percentage is given by multiplying the d. by 7. The result for SiO$_2$ by the point method was verified by taking 2 equal quantities of Ra salt, one of which was used to impregnate the Sio$_2$, and the other was sealed as a point source. The correction in this case was found to be 8.23%. The percentage accuracy of the measurements decreases with the Ra content until the error reaches 7% for material containing about $4.2 \times 10^{-4}$ mg. Ra/cc. This would easily include high grade pitchblende and most crude sulphates but not the usual grades of carnotite nor any of the other low grade minerals nor radioactive rocks for which the Em method must be used.

Danforth, C. W., Samuels, W., and Martersteck, W. U. S. Pat. 1,126,182 (1915).

A method for obtaining BaCO$_3$ and RaCO$_3$ by leaching carnotite with H$_2$SO$_4$ and treating the residue with NaOH and Na$_2$CO$_3$. 

1914
1915

320 Ebler, E. and Bender, W. Z. angew. Chem. 28, 1, 33-41 (1915).

Discussion included on fractional pptn. of RaCl₂ from alcohol; adm. of soln. of Ra-Ba salts using silicic acid; fractional crystallization of Ra salts from precipitate, bromide, ferrocyanide, and silicofluoride solns.; fractional pptn. from HCl for RaCl₂; redn. of crude Ra-Ba sulfate with CaCl₂ and/or CaH₂; several methods using NaHSO₃, NaCl, NaOH, and alkali-lye mixtures for leaching of carnotte, sulfate, and low-grade Ra ores.

321 Keetman, B. "Obtaining Radiorhumorium and Solutions Containing Thorium-X." U. S. Pat. 1,151,187 (1915).

The material under treatment is pptd. with NH₄OH and the mixt. of ppt. and supernatant liquid thus obtained is evapd. to dryness and washed with H₂O to remove the NH₄ salts and leave a dense pure radiothorium hydroxide from which a sohn. containing Th-X(Ra²⁺) is made by treatment with H₂O or dil. NaCl sohn. and shaking.


L. describes a new electroscope of very simple construction made in 2 detachable parts; the upper the telescope and leaf system, and the lower the discharge chamber. The former can be used on any number of sep. lower parts. The method of procedure in making dens, by the emmanation method is described.


Methods are given for the chem. treatment and other manipulations involved in preparing Em for electroscope measurements. A soln. containing an excess of Ba in a rather high concn. of HNO₃ is recommended as the best medium for storing Ra in soln. without danger of loss through pptn. Ra solns. for use in analysis and which are low in Ba and HNO₃ should, therefore, have these reagents added before allowing to stand to collect Em. In cases where no Ba but an excess of a Ba precipitant, as sulfate, is present, it is suggested to add a suitable vol. of the Ra sample to a soln. containing Ba in excess; the ppt. is filtered off, and the filtrate acidified with HNO₃, boiled and sealed; the ppt. of BaSO₄ is fused with Na₂CO₃-K₂CO₃ mixture, sealed in a glass tube for a known time, and the accumulated Em then drawn into the electroscope by suction before and after treatment of the fusion with HNO₃ heated to boiling. For convenience the filtrate may be sealed at the same time as the fused ppt. in order that both lots of Em may be introduced into the same electroscope. Instead of boiling the fused mass in acid as in the analysis of Ra-bearing BaSO₄ or other insoluble material, fusion may be employed both before and after the collection of the Em if preferred.


The fractional crystallization of radium hydroxide is described.

325 McCoy, H. N. and Leman, E. D. "The Relation between the Alpha-Ray Activities and Ranges of Ra-

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It has been shown that for the Th and Ac series of the α-rays activity for each substance present, as measured by the ionization current, is proportional to the 2/3 power of its range. Further proof of the rule is that the ratio of the activities of RaEM + RaA + RaC to that of Ra itself as calc'd. on this basis is 4.09 and the ratio measured as 4.11. The Ra was prepared free from decom. products by bubbling air through 10 cc. of a dil. soln., heated almost to boiling, for 30 min. to remove RaEm and to allow RaA to disintegrate completely. Pb(C₂H₅O₂)₂ was added and pptd. with BaB, RaC, RaD, RaE, and RaF by H₂S. The treatment was twice repeated. The addition of BaCl₂ and H₂SO₄ then pptd. the Ra, which was spread over a brass plate in alc. suspension and dried. The final measurements, made after the disintegration products had accumulated for 6 months, were corrected for β-ray activity, escaped Em, and loss by recoil.


The week Rutherford-Bollwood standard soln. at McGill Univ., with 1.57 × 10⁻⁸ g. Ra/cc. was found 2% lower than the Washington standard; the strong standard soln., 100 times as strong, is 4% lower than the Washington standard. The measurements were made by the Em method, the Em being driven from the soln. by boiling and measured in a gold-leaf electroscope. On successive boilings the solns. lose their emanating power and give results 10%; too low, but the full value is restored by the addition of HCl soln. (19%). No explanation of this is offered.


This publication gives a detailed description of the commercial separation of radium from carnitite. The work has been carried out as a result of a cooperative agreement of the National Radium Institute and the Bureau of Mines. After a lengthy introduction, in which the details of the plant, etc., are considered, the different methods of treating radium ores are given in great detail. Special emphasis is laid on the Bureau of Mines method for treating carnitite. This is followed by a description of the methods of refining radium. Methods of measuring quantities of radium, recoveries and losses in the various manufacturing processes, and cost data are fully discussed.


In view of the increasing demand for radium, any research which will point out efficient and practical methods for the recovery of this element will be of both scientific and practical value. This paper presents the results of a critical investigation of various methods of treating carnitite with the object in view of extracting not only U, V, and Ra, but also other long-lived radio-active constituents, ionium, RaD, RaF, and actinium. Several of the commercial methods now in use for removing vanadium and uranium from a carnnotite ore have been examined and modified so as to be effective in treating ore which was found to contain quantities of vanadi-
1915

ferous silicate. In the method finally adopted the U is re-
moved by boiling the carnottite concentrates with a sodium
carbonate solution, precipitated as uranyl sodium carbonate
by merely concentrating the filtrate, and the soda is again
recovered. The radium, actinium, and the radio-lead are
contained in the filtrate obtained by boiling the residue (in-
soluble in soda solution) with hydrochloric acid. That part
of the radium still held in the residue is then removed with
boiling nitric acid. The iodion is finally recovered from the
residue by boiling with sulfuric acid, and is then concen-
trated with cerium rather than with thorium (from which it
cannot be separated).

329 "Radium and Plant Growth." Gardeners' Chronicle
(3), 58, No. 1501, 206(1915).

In comments on the results of a number of experiments
said to have been carried out by M. F. H. Sutton, it is stated
that in no case was it apparent that any of the radium prepa-

rations had a beneficial effect on the growth of the crops.

In not a few instances there were definite indications that
the preparations had exercised an adverse influence on the
plants.

330 Vogt, L. F. (to Standard Chemical Company)
U. S. Pat. 1,129,029 (1915).

The leaching of carnottite with soda and H₂SO₄ is described.

Primary purpose is Ra recovery.

331 von Bayer, O., Hahn, O., and Meltzer, L. Physik.
Z. 16, 6(1915).

The separation of ThX(Ra²⁺) by electrolysis is described.

1916

(1916).

The reduction of RaSO₄ with carbon is described.

333 Buseck, O. "Radium and Its Physical Properties."
Hahnemannian Monthly 51, 335-50(1916).

Review. Physiological action is discussed.

334 Danforth, C. W., Samuels, W., and Martersteck, W. Chem.

An article on the leaching of carnottite with H₂SO₄ and

the residue with NaOH and Na₂CO₃. The silicate is
dissolved, BaCO₃ and RaCO₃ remain.


The author has made a series of measurements on the
growth of radium in solutions of ionium preparations sepa-
rated from different uranium minerals—namely: (1) from
uranite (North Carolina), (2) from cleveite (Norway), and

(3) from broggerite (Norway). The results obtained from
the first two minerals indicate that the constant of change
of Ra has a higher value than the one generally accepted,
3.48 × 10⁻⁸ (year)⁻¹. Neither of them, however, can claim
a very high degree of accuracy. The objections raised in
the case of uranite and cleveite do not apply in the case of
broggerite, a mineral which is one of the oldest uranites,
and particularly free from all alteration products. The
results obtained for the most carefully prepared solutions
are:-(a) The disintegration constant of radium has a value

of 4.22 × 10⁻⁸(year)⁻¹, and 4.14 × 10⁻⁸(year)⁻¹. (b) The half-
life of Ra indicated is accordingly 1642 years and 1674
years. The result agrees very closely with the value found
by Rutherford.


A description of various experiments for the extraction of
radium from American carnottite poor in Ra.


A method for the extraction of Ra from carnottite by treat-
ment with acids is described.


A method for obtaining radium salts by treating the ore
with HCl and neutralizing the solution with Na₂CO₃ or NaOH
is given, also gives a method for HNO₃ treatment.

339 Moran, J. "A Comparison of Radium Standard
(1916).

The object of this ext was to re-determine the values of the
Rutherford-Boltwood weak and strong soln. standards.

They were prep'd in the first place by means of the Rutherford-
Boltwood solid standard, now at Manchester Univ., Eng.,
and this solid standard was found by Rutherford to be 4½
low. If no error was made in their prep. we should expect
the soln. standards to come out similarly. Results of last
session showed the weak and strong solns. to be 98% and 96%

in value, resp., as compared with the Washington standard.

Present results show the corresponding values to be 96.4%
and 97.3%. In the work of last year it appeared that the
RbBr solns. deteriorated with each boiling. Also, that if a
sufficient amt. of HCl were added, the soln. seemed to re-
cover its emanating power. At that time no pure HCl free
from radioactive material was available. The work of the
present year with pure HCl proves that the whole of the in-
crease must have been due to the radioactive matter in the
HCl. The excess then found was evidently due to lack of
refinements in the app. The boiling effect which seemed to
be apparent last year was also traced to the same cause.


Experiments on the leaching of radium ores with HNO₃
are described.

341 Parsons, C. L., Moore, R. B., Lind, S. C., and


The reduction of crude Ba-Ra sulfate with carbon is de-
scribed.

342 Schlundt, H. "Extraction of Radium from Carnottite

At the present time the carnottite ores of S. W. Colorado and
E. Utah constitute the principal source of radium in the U.S.A.
The carnottite consists of a sandstone with a clay binder
variably impregnated with the mineral carnottite, a hydrous
potassium uranium vanadate containing Ba and Ca. By boili-
g carnottite ores with concentrated H₂SO₄ the Ba and Ra
compounds present are converted into bisulfates which re-
main in solution in an excess of the acid, and may then be
separated from the insoluble components by filtration fol-
lowed by washing the residue with concentrated $H_2SO_4$. From the acid liquor so obtained the Ra is recovered by diluting with water, whereby barium-radium sulfide is precipitated. The experiments outlined in this paper are based on the preceding principle.

Article contains information similar to that indicated for the previous reference.

A method for the leaching of carnotite with $H_2SO_4$ and separating the Ra-Ba sulfate with water is described.

345 Schundt, H. U. S. Pat. 1,194,659 (1916).
A method for the leaching of carnotite with $H_2SO_4$ and separating the Ra-Ba salts with water is described.


In an earlier paper the results were given of an investigation of the L-series of the elements from Ta to Bi. At least 11 groups of lines were determined. The measurements are now extended to the elements Po, Ra, Th, and U. In the case of polonium (deposited electrolytically on copper), two characteristic lines ($\alpha\omega$, $\beta\omega$) were observed, and in addition a number of other lines probably due to impurities. Using 0.1 mg of $RaBr_2$ to obtain the Ra spectrum, only a very weak $\alpha$-line could be obtained. Both Th and U gave multiple line spectra. The values of the wave-lengths, relative intensities, etc., of the various lines are tabulated. Plotting the values of $\lambda/\alpha$ against atomic numbers it is found that the new $\alpha\omega$, and $\beta\omega$ values fall exactly on the same straight line as the old values, while the remainder ($\beta_1$, $\beta_2$, $\lambda_1$, $\lambda_2$, $\alpha\omega_1$) are too high.

Experiments on the leaching of radium ores with $HNO_3$ are described.

Experiments on the leaching of carnitite with soda and $H_2SO_4$ are described.

1917

A detailed study has been made of the absorption in Pb and Al of $\gamma$-rays from Ra and its decay products. The absorption of a parallel beam of rays has been examined after passing through "filters" of various materials and various thicknesses of the same material. The paper contains a large amount of tabulated information on this question, for particulars of which the original paper should be consulted. It has been shown in the case of a parallel beam of $\gamma$-rays from Ra in equilibrium with its successive products, that the form of the absorption curve depends on the method of measurement. A. The absorption does not conform to a simple exponential law, if the secondary radiation originating in the absorber does not reach the ionization vessel. B. The absorption, apart from initial softening, is exponential if the hard secondary rays are measured as a part of the incident radiation.

1918

The bisulfate fusion for Ra liberation from various substances in order to det. the Ra content is described. Apparatus, method, and results are discussed in detail. Comparison of this method with others in use shows good agreement.
1918

Cable, R. and Schlundt, H. "Extraction of Radium from American Pitchblende Ores by Chlorination." Chem. News 117, 244-6(1918).

The experimental results presented in this paper were obtained by a new method of extracting radium by direct chlorination of the ore. This method has particular application to pitchblende ores in which the uranium occurs intimately associated with iron pyrites. Good results have been obtained. A few chlorination experiments with carnottite ore did not give results of promise for a method of extracting radium.


This paper contains information similar to that presented in the previous reference.


Page 313 describes various methods for the extraction of radium from ores poor in Ra. The sep. of RaCl₃ by fractional crystallization is described on pages 205 and 302. The reduction of Ba-Ra sulfates (crude) using CaC₂ and CaH₂ is treated on page 315, and on page 342 information on the sep. of ThK(Ra²⁺) from RdT₂H₂(Th²⁺) is located.


The only direct experimental determination of this constant is that of Rutherford and Geiger (1908) which gave a value 3.4 x 10⁻⁶ or 3.5 x 10⁻⁶ when corrected to the international radium standard. On theoretical grounds the authors considered that a re-determination of this constant was advisable. The method employed was the same in principle as the ionization by collision method of Rutherford and Geiger. "Counts" were made in air, CO₂, and in mixtures of air and CO₂, using the string electrometer of Elster and Geitel. They found that in air the β- and γ-rays were as effective as the α-particles in CO₂ and in mixtures of CO₂ and air (containing not less than 54% CO₂) only the α-particles produced ionization by collision. Thus, in the exact determination of the number of α-particles emitted from RaC, in the presence of β- and γ-rays, a mixture of 54% CO₂ and 46% air was employed. The conditions of the experiment were varied as much as possible and control experiments carried out frequently. 266 determinations, each count lasting not less than 10 minutes, gave a value Z = (3.72 ± 0.02 x 10⁻⁶) for the number of α-particles emitted/sec./g. of Ra.

The value of Z determined from measurements of the heating effects and ranges of α-particles of radium gives

\[ Z = 3.88 \times 10^{-6} \text{ (for a range } r_{35} = 3.30 \text{ cm.)} \]

and

\[ Z = 3.78 \times 10^{-8} \text{ (for a range } r_{35} = 3.44 \text{ cm.)} \]

Reciprocally, the value Z = 3.72 x 10⁻⁶, given above, furnishes a determination of the velocity and of the range of the α-particles of radium. These values are \( v = 1.59 \times 10^{8} \text{ cm./sec. and } r_{35} = 3.52 \text{ cm.-assuming a rate of heat emission of 25.2 cal./hr.} \]

1918

The authors use their value of Z to calculate the period of radium, \( Z = \lambda N \), whence \( \lambda = 1.39 \times 10^{-11} \text{ sec.}^{-1} = 4.38 \times 10^{-44} \text{ years}^{-1} \), giving a period of half-transformation \( T_{1/2} = 1580 \text{ years} \).


The necessity for pptg. Ra and Ba together as sulfates at some stage in any of the processes for recovering Ra from its ores made desirable the det. of the soly. of pure RaSO₄. In order that the true satn. might be obtained with the greatest accuracy, equil. was approached from both sides, i.e., soln. made by dissolving pure RaSO₄ in solns. of N, 0.1 N and 0.01 N H₂SO₄ and in pure water, and by pptg. it from RaBr₂ soln., were prepd. and measured. RaSO₄ was detd. directly by the emanation method for Ra itself. The soly. of pure RaSO₄ in 1 cc. H₂O at 25° is 2.1 x 10⁻⁶ g. or 1% of that of BaSO₄. Its soly. in H₂SO₄ solns. from 0.01 N to 50% acid is identical with that in H₂O, showing that the presence of acid produces no repressive effect as might be expected. At higher concns. of H₂SO₄ the soly. rises greatly and between 65 and 70% it increases 12 fold.


Two methods for the extraction of MsTh₂ (Ra²⁺) from thorianite or Th itself, are given.


The author reports the half-life period of MsTh₂ (Ra²⁺) to be 6.7 years.


A method for leaching carnottite with alkali-lye solns. is described.

1919


A method for treating ores with Na₂CO₃ and water under pressure for Ra recovery.


It is comparatively simple to obtain the L absorption spectrum of radium. The author has also obtained this spectrum by placing a thin tube containing 1 mg. of solid radium sulfate before the slit of the spectograph. The wave-length obtained, \( \lambda = 0.659 \times 10^{-8} \text{ cm.}, \) assigns to Ra the atomic number 88, in good agreement with the accepted value.


(Abstract of paper read before the Am. Phys. Soc., April, 1919.)

In the determination of the radium content of sealed specimens that have not reached equilibrium it is very desirable
1919

to ascertain promptly the concordance of each observation with those that have preceded it. A simple graphical method used during several years past at the Bureau of Standards, Washington, is described.


Comprehensive treatment of the subject "removal of Ra from ores". Various methods are described, and various kinds of ores are treated. Adsorption (using MnO₂), fusion and soln. methods are discussed. The use of NaOH, Na₂SO₄, Na₂CO₃, and H₂SO₄ in the recovery processes is treated. The reduction of crude Ra-Ba sulfates using CaC₂ and CaH₂ is also described. The dialysis method for the removal of ThX (Ra₂³⁹) from colloidal Th(OH)₂ is also discussed.


Discusses some apparent changes of β-activity observed when radium preparations are treated chemically.

1920


Procedure: Take two glass plates; place a droplet (2-4 mm. in diam. at the most) of RaBr₂ soln., containing about 3 parts per 1,000 on one, and a droplet of BaBr₂ of equiv. strength on the other. At a very little distance from each of these droplets place similar vols. of 10% iodic acid. Join the drops, using a Pt wire. Feathery crystals of the monoclinal system are formed in both cases. They cannot be distinguished one from the other even at great magnifications. If now, dil. is increased five- or even ten-fold, i.e., 0.20 parts per 1,000, the crystals of the two salts are seen to be entirely different. Drawings are given for the two dilutions. The difference in crystal form suggests the study of a new method of asp. of Ba and Ra. A mg. of RaBr₂ was used in the expts.


The relation of the activity of radium to the activity of the uranium with which it is in radio-active equilibrium has been re-determined. The results obtained indicate that if the activity of uranium is taken as unity the activity of the radium is equal to approximately 0.49.


The relation of the activity of radium to the activity of the uranium with which it is in radio-active equilibrium has been re-determined. The results obtained indicate that if the activity of uranium is taken as unity the activity of the radium is equal to approximately 0.49.


1920

The crystallization factor of mesothorium and radium in bromide solutions was found to be independent of the concentration of hydrobromic acid. A determination was made of the crystallization factors corresponding to different concentrations of crystals separating. For concentrations of mesothorium up to 5 mg./g. of salt, the crystallization factor remains constant. The separation of mesothorium and radium from barium can be conducted advantageously in neutral or dilute acid solutions of the bromides.


Ra of any degree of purity can be obtained by the fractional crystn. of a Ra-Bar soln. The bromides offer a more efficient system for crystn. than the chlorides. The concn. of Ra in the crystals and in the mother liquor may be caled. by the simple formulas given, which involve the factor of enrichment, K—the relative concn. of Ra in the crystals to Ra in the original material. When K has certain definite values the calcd. concns. of the different dishes give a complete system of crystn., one which allows of the proper combining of dishes. Several such systems are given with a modified form, which is very efficient in the crystn. of high grade Ra. The conditions of crystn., and some facts noticed during crystn. are given. The formation of a salt, RaBr₂-2BaBr₂·6H₂O, in crystals from slightly acid solns., is indicated.

1921


Radium and mesothorium are isotopic elements which up to the present have not been chemically separated. It is difficult also to distinguish between these substances (in equilibrium with their decay products) by measurement of the penetrating powers of their γ-rays. But it is possible to make the distinction by measurements of heat emission due chiefly to the α-rays, from these substances. The author makes a calculation of the difference to be expected and shows the practical possibility of determining by this method the amounts of Ra and Mo in a mixture.


A method for the extraction of Ra from carnitite with HNO₃ is described.

373 Ebler, E. and van Rhyn, A. J. Ber. 54, 2899-906 (1921).

An article on the separation of Ra-Bar salts by adsorption with silicic acid which also includes information on the pptn. of Ra salts using H₂SO₄.


Standardized solns. of RaCl₂ were boiled with definite amts. of BaSO₄. Ra remaining in soln. was detd. Kroeger’s law, Freundlich’s law, and all adsorption laws which apply to other substances hold.

375 Meitner, L. Z. Physik 4, 146 (1921).

An article including data on the nuclear structure of the radium atom.
1921


The radiation absorbed by the salt is added to that given out to find the total Ra content of the compound. The Ra content of the sample was measured by the combined ionization chamber and gold leaf chamber. The tube contg. the Ra was first measured. The absorption of the activity by ZnS was measured, in 4 ways by the γ-ray method: (1) The sulfide was placed in a cell between the Ra and the chamber. (2) The Ra tube was placed on the axis of a tube contg. the sulfide and the Ra content measured. (3) The Ra salt was mixed with the sulfide and the Ra content measured. (4) The Ra salt was mixed with the sulfide and the Ra content mixed in the mixture. The absorption of γ -radiation was found to be about the same as in ZnS. Four tables are given. Table III gives the ratio of true content to the apparent content. For a tube 3 cm. in diam. it is 1.13. Table IV gives the absorption coeff. for several compounds.

377 Pascal, P. Compt. rend. 173, 144(1921).

Observations on the magnetic susceptibility of Ra are described.


A review of information on Ra and its decay products.

379 Simmersbach, B. Edel.-Erdern u.-Erze 2, 137-46 (1921).

The fusing of radium ore with NaHSO₄ is discussed.


1100 g. of BaCl₂ containing 11 mg. of MsTh and 3 mg. of Ra were prepbd. from monazite residues. Concs. were made by the McCoY hydroxide method and by the bromide method. All concs. were made from the same MsTh/Ra ratio. In this work a large number of transformations and crystals, are made, but the ratio does not change. This work furnishes further evidence that MsTh and Ra are isotopic.

1922


Standard RaCl₂ solns., contg. from 0.02115 to 0.0001897 mg. Ra/g., some HCl and a little BaCl₂, which had been used in the analysis of pitchblende in 1914, were once more compared with the same pitchblende in 1922. The Ra content was found unchanged, on the assumption of const. Ra content of the ore, within the working error (1%).


Experiments on the treatment of radium ore with Na₂CO₃ and water under pressure are described.


A method for the extraction of radium from carnotite using H₂SO₄ and HF is described.

1922

384 Bohr, N. Z. Physik 9, 58 (1922).

An article on the configuration of the electrons in the radium atom.


B. makes a few remarks concerning the recovery of lost Ra prepns. by means of a ZnS screen and an electroscope.


X-ray wave length and absorption limits for Ra included.


The author describes a modification of W. Bothe's method of measuring the radium content of feebly radioactive substances. It consists of a triple cylinder ionization chamber attached to an electroscope, the active material being introduced into the inner cylinder. It has distinct advantages over Bothe's arrangement in the ease of manipulation. The sensitivity of the instrument used by the author was about 2.8 divisions per second per milligram of radium. Specimens of radium concentrates containing from 7 to 60 microgram and small preparations containing as much as 300 microgram of radium were satisfactorily measured to a precision of at least 1%. Though the instrument is well suited to the determination of the radium content of concentrates, it is not suitable for work with low-grade ores. For such work a more sensitive instrument or one utilizing a larger amount of active material would be required.


A Ra-Ba salt such as the sulfate, chloride or bromide is dissolved by a solvent such as a hot oxalic acid soln., having a relatively greater action on the Ra than on the Ba material. The filtered soln. is then treated, e.g., by adding a small quantity of H₂SO₄, to obtain a ppt. of higher Ra content than the material originally treated.


Paint is roasted and Ra sepd. as (Ra-Ba)SO₄. This is converted to chloride and Ra concd. by fractionation. Less than 1% Ra loss and purification to 57% Ra is reported.


The (Ra) emits only alpha rays. The range R of the alpha rays at 0° and 15° respectively is Rₐ = 4.127 cm., Rₐ = 4.354 cm. The initial velocity is 1.543 x 10² cm/sec. The initial energy is 5.603 x 10⁶ V. The number of ion pairs produced by one alpha particle is 1.77 x 10⁸. The corresponding values for AcX (Ra) are: Rₐ = 4.141 cm., Rₐ = 4.394 cm., 1.64 x 10⁶ cm./sec., 5.615 x 10⁶ V., and 1.78 x 10⁶.

When carnotite or other materials are filled into the space between two concentric tubes or spheres, the gamma-ray effect in the center of the inner cube or sphere can be calculated. This formula was taken as a basis of a direct method of determining the radium content of such substances. The samples were filled in wooden containers which were closed hermetically. The gamma-ray electrometer was introduced into the center. The observed ionization, expressed in absolute units (e.s.u.) reduced to normal pressure and temperature, multiplied by certain constants, gives directly the radium content per gram of material. The method is sensitive enough to give correct figures for material with 10^-6 g. radium per gram of material. It is very simple, and requires no chemical treatment of the samples before the measurements. The results on ore samples were compared with the results derived from the chemical analysis of the uranium content, and were found to be in good agreement.


Because of absorption of the rays by the salt, the present gamma-ray method is rather inaccurate for concentrations less than 10^-6, and for concentrations above 10^-5 the emanation method is too sensitive. To bridge the gap, the authors have modified the first method by adopting a shallow container with two curved sides, each concentric with the cylindrical string electrometer used to measure the rays, and only a small fraction of the radium. This shape has the effect of reducing the absorption due to the salt small and also very nearly equal to half the maximum absorption. The procedure is to take readings with the container in position (full of salt to be measured) first alone, then with a small radium tube of known strength placed first just in front and then just behind the container. The ratio of the first reading to the mean of the other two gives the ratio of the strength of the unknown to the sum of the strengths of the known and unknown within one per cent. The method is both quicker and more accurate than the emanation method for concentrations between 10^-4 and 10^-7. The container used was made of tin plate and was 10 x 10 x 2 cm., the radii being 30 and 32 cm.

1922 Lemay, P. and Jalousjtre, L. Compt. rend. 173, 916(1922).
The action of Ra salts as catalysts in some oxidation processes is described.

1922 Meitner, L. Z. Physik 9, 142(1922).
An article on the ß-rays emitted by Ra.


1922 Tables have been compiled giving the corrections that have to be applied to the observed radium content of sealed platinum and silver tubes to obtain their true radium content. Two cases have been considered, (1) that in which the active deposit is uniformly distributed throughout the volume of the tube such as in a full tube of salt, and (2) that in which the active deposit is uniformly distributed over the inner wall of the tube, such as in a tube containing a minute quantity of highly concentrated salt. The results show that when the wall thickness is kept constant, the correction increases with the external diam. of the tube. Also for the same increase of external diam., the increase of correction is more pronounced for the "empty" than for the full tube.

The first crystals formed in cooling a soln. of Ra and Ba salts as in the commercial refining of Ra contain a larger percentage of Ra than the succeeding crystals. It is pointed out that the efficiency of the refining process may be increased by sep. liquor and crystals above room temp. With rapid cooling a smaller per cent of Ra is adsorbed than with slow cooling.

The author reports that BaCl₂·2H₂O is isomorphous with BaCl₂·2H₂O.

S. describes a portable electrometer, having a flexible sensitivity. The charger consists of an ebonite rod, which rotates against a brush of hair. The sensitivity is varied by altering the eccentricity of the fixed quadrant of the electrometer, with respect to the movable quadrant. The instrument is especially useful for field exam. of rocks. One division on the micrometer scale represents a current of 10^-4 e.s.u., which would be produced by placing 0.001 g. of U₂O₃ in the amp. Analysis of 500 g. of rock containing 10^-9 g. of Ra was accurate to 2.5.

Starting with a hot concd. soln. of BaCl₂, contg. MsTh₂, (Ra²⁸⁰) and Ra, these 3 substances were pptd. by means of HCl (concd.). This left MsTh₂, Radio-Th., and active deposit in soln. The Ac isotope was pptd. with salts of various rare earths as the hydroxide while the Th remained in soln. A study of the chem. properties of the MsTh₂ (Ac²⁸⁰) disclosed a very close relation to La.

The preparation of a radio-active standard solution for the determination of the relatively small amounts of radium in minerals is not easy owing to the tendency towards formation of insoluble deposits from the solution. The attempt is here recorded for the preparation of a solid standard. Radiferous barium chloride was first tested, but found unsatisfactory, and recourse was had to the insoluble and non-hygroscopic carbonate. Methods for the preparation of the latter are included, with an illustrative diagram of the ap-
paratus employed. Data are given showing that a standard content of radium can be secured by the method described to 0.5%.

1923


The methods used for the extraction of radium from uranium ores are grouped under the three headings; (1) direct solution by means of acids, with or without preliminary conversion of the radium and barium into carbonates; (2) concentration of the radium by reduction of the gangue material; and (3) miscellaneous processes. These are discussed in detail, and their advantages, disadvantages, and conditions of application indicated. For control work in plant operations and for the measurement of radium in general three standard methods are used: the emanation, gamma-ray, and alpha-ray methods. The application of these methods to the case of carnotite ores, and the chemical treatment involved in the latter are described in detail. A new method for charging electrosopes, due to le Roy and Schlundt, consists in transforming an ordinary lighting circuit voltage, say 110 volts, to 3000 volts, rectifying this by means of a "kronotron" rectifying tube, and using a special high-resistance potentiometer to secure any potential required to charge the leaf system of the electroscope to the desired degree.


A phosphoric acid method for the detn. of Ra by the emanation method is described. The method is similar to Barker’s bisulfate method. It is also shown that mixts. of HNO<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> and of HNO<sub>3</sub> and H<sub>2</sub>PO<sub>4</sub> may be used. B. prefers the H<sub>2</sub>PO<sub>4</sub> method.

403 Bohr, N. Naturwissenschaften 11, 619 (1923).

An article on the configuration of the electrons in the radium atom.

404 Bohr, N. and Coster, D. Z. Physik 12, 344 (1923).

An article on the configuration of the electrons in the radium atom.


This is an account of the recovery and purification of RaBr<sub>2</sub>, accidentally spilled on a pavement and of the observations made in the process. The method used was an adaptation of the process used by Deiberenn in segp. Ra from its ores.


By irradiating different substances with γ-radiation from radium and mesothorium, and studying the β-radiation emitted with the apparatus described in a previous paper, the authors have arrived at the wave-lengths of some of the lines in the γ-ray spectra of the radium and thorium series. The values of the wave-lengths of the five lines which were obtained with radium are 51.9, 42.6, 35.6, 30.2, and 20.8×10<sup>-11</sup> cm. Those of the five lines observed with mesothorium are 171.0, 59.7, 53.0, 47.0, and 29.7×10<sup>-11</sup> cm. The longest wave-length in the thorium series corresponds to an electron from the L ring. All the other lines both in the radium and the thorium series correspond to K electrons. The values of the wave-lengths in the radium series agree well with those previously published by Ellis.


A method used commercially in Russia for segp. Ra and Ba is to pass HCl gas into a soln. of Ra and Ba chlorides. The chief advantages are that this method does not require the usual preliminary purification of the chlorides and the evap. of solns. is eliminated.


Intravenous injection of 100 micrograms of Ra in dogs produced an increase in the N, the total S and the neutral S excretion maintained over 3 days. The excretion of creatine and of uric acid was not affected. Local application of 16 micrograms for 4 days and 70 micrograms for 4 days was studied in a case of carcinomas. There was a N retention of 1.4 g., S of 0.5 g., CaO of 0.27 g., MgO of 0.29 g., and P of 0.8 g. The analytical picture of the urine was normal.


Experiments with the leaching of carnotite with alkali-lye mixtures described.


Experiments on the treatment of radium ore with Na<sub>2</sub>CO<sub>3</sub> and K<sub>2</sub>CO<sub>3</sub> are described.


The extraction of Ra from pitchblende using H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub>; the redn. of the crude sulfate with C, CaC<sub>2</sub>, and CaH; the use of NaOH in the segp. of Ra from low-grade ores; and the segp. of Ra-Ba chlorides by MgO, ads. Information on the preparation of RaCl<sub>2</sub>-2H<sub>2</sub>O from RaCl<sub>2</sub>, using conc. HCl, or from RaBr<sub>2</sub> using repeated evaporation with HCl is given.


On pages 166-88 and 206-7 the effects and characteristics of radium rays are described. Extensive references.

1924


An article on the extraction of radium from carnotite with H<sub>2</sub>SO<sub>4</sub> and HF.
1924

The method employed, which takes advantage of the different coefficients of absorption of the γ-rays of these elements when sent through a lead filter, has been used by Hahn, who employed filters up to 4.5 cm. thick. The author has improved the experimental conditions by employing a series of much thicker filters and a very sensitive measuring device, with which the γ-rays penetrating through them can be measured. A series of four concentric lead cylinders was used, in the common axis of which the radio-active preparation was placed, the total possible thickness of lead being 11 cm. The ionization chamber was a cylindrical ring-shaped vessel surrounding the lead cylinders, and had a ring-shaped electrode of sheet iron concentric with the walls of the chamber. Curves were obtained for a number of different preparations, showing the radium equivalent, A, as a function of the filter thickness, by measuring for each thickness the velocity of fall of the gold-leaf of the electroscope, first for the preparation and then for a normal radium preparation, the normal value of which through 0.5 cm. of lead was taken as unity. Curves are given for pure radium, pure radio-thorium, old mesothorium preparations containing radium (in which a considerable amount of RaTh has formed), fresh mesothorium preparations separated from the old preparations containing a great deal of radium, and one containing very little radium; finally a curve is deduced for pure mesothorium from the above, and another for a mixture of the three substances, in which for three different thicknesses the radium equivalent is unity, but which rises above the pure radium line, drops below it, and then again rises above it as the thickness goes on increasing. The curve for each of the pure substances is so distinctive that, with very few exceptions, it is possible from the form of curve of a mixture to deduce the proportions of the three constituents.

1924
In the emanation method, as developed by Schulte and Moore, and by Lind, in radium analyses, or calibrating a β-ray electroscope, it is best to draw out and seal the neck of the flask, and not to use a rubber stopper or rubber tubing; the tip must be broken off after the flask has been connected, by means of tubing, to the emanation gas burette, but the small piece of glass broken off frequently lodges in the lower stop cock of the burette, and spoils the experiment. Three forms of trap are described which prevent this; in the simplest and most effective of these the flask is connected by rubber tubing to a short length of tube which slopes upward to join the horizontal tube leading to the burette, at an angle somewhat less than 90°; the inclined tube is prolonged a few millimeters past the joint, forming a tiny hemispherical trap, into which the glass tip may be projected, and fall back again, without lodging in the horizontal tube.

1924
Hahn, O. Radium. German Pat. 472,857 (1924).
Stable Ra prepns. with high emanating properties are prepd. by treating Ra salt solns. with soin. of substances which, with a common pptg. agent, give a ppt. with a greater surface. Thus, BaBr₂ is mixed with La(ClO₄)₂ and H₂O added. The RaF₃ produced is stable and of good emanating quality. FeCl₃ and RaBr₃ may be pptd. with NiH₂O. Other examples are given.

1924
High-grade Ra is pptd. as carbonate upon a Pt wire so that only 0.1% of Ra is occluded. The carbonate is then baked so that its emanating power is nil. With this line source of radiation, the β-ray spectrum of Ra was photographed. Ra emits 3 lines whose Hp values are 1037, 1508, and 1757, corresponding to the K, L and M levels of the decoupling. Ra atom, resp. The β-rays are excited by Kernel γ-rays accompanying the α-ray transformation and having a wave length of 6.8 × 10⁻⁸ cm.

1924
The authors criticize the results of Geiger and Werner, and conclude that the larger number obtained by the present authors in 1916 is more reliable. The method of arriving at the true number of scintillations from the observations of three observers is also criticized. Replying to a remark of Geiger and Werner, the authors call attention to the fact that their own final result is not deduced from the photo-
graphic registration, as Geiger and Werner assume, but from numerous subjective counts.

This article is similar to the previous reference.

In measuring the heat produced by different samples of radium, the author has found certain irregularities in the deflection of the galvanometer connected with the thermocouple; this was in general, for the samples employed, about 40 cm., but once or twice a month it diminished by 10 to 15 mm. The second sample behaved like the first, the times of the minima coinciding. The walls of the cell in which the experiments were made showed no signs of radioactivity.

A Wulf double-leaf electroscope of small capacity is used to measure the penetrating radiation from Ra preparations or ores which are inclosed in shallow containers, placed directly underneath it. The floor of the electroscope is of Zn 3 mm. thick. An additional screen of brass 3 mm. thick allows only penetrating radiation to enter the ionization chamber. The arrangement is particularly adapted to measurement of high-grade pitchblende.

Investigations were made with pure RaBr\(_2\) and with mixts. of RaBr\(_2\) and BaBr\(_2\). The intensity of luminosity of a RaBr\(_2\) capsule heated to 600° decreases according to an exponential law. Equil. was reached after 500 hrs. The initial luminosity of mixts. of RaBr\(_2\) and BaBr\(_2\) after removing from the furnace increases exponentially with the temp. In all cases the compn. and temp. det. the equil. value. The results are consistent with Rutherford's theory of "active centers." R. concludes that the active centers are formed on the absorption of heat energy, and that high temps. by rapid cooling favor their formation.

426 Stumener, E. C. Phil. Mag. (6), 49, 719 (1924)
An article on the configuration of the electrons in the radium atom.

Experiments on the treatment of radium ore with Na\(_2\)CO\(_3\) and K\(_2\)CO\(_3\) are reported.

The electrolytic methods employed by von Baeyer, and by Hahn and Meitner, for depositing these elements on a platinum wire have been investigated in the cases of radium and its isotopes (ThX and AcX), thorium and its isotopes, actinium and mesothorium II. ThX (Ra\(_{42}\)) was specially dealt with; when much calcium was present a minute quantity of barium was added to act as carrier for the ThX, and was precipitated with chromic acid, the calcium remaining in solution; the chromate precipitate was dissolved in HCl, and deposited electrolytically with a small excess of acid, a stream of CO\(_2\) being passed through the liquid, and a high current density employed. In this way the precipitation of carbonate is confined to a narrow alkaline zone close to the cathode, on which the precipitate settles. Thorium in weakly acid solutions, precipitates, when electrolyzed, in thick flakes of thorium hydroxide, owing to the OH\(^-\) ions left behind when H\(_2\) is produced at the cathode; these flakes do not in general form a solid layer on the cathode. To get over this difficulty a strongly acid solution is necessary, so that the alkaline zone is reduced to a diffusion layer of 20-50 \(\mu\) in thickness. The excess of H\(^+\) ions up to this layer prevents a premature production of flakes, since positive colloids, such as Th(OH)\(_4\), are peptized by H\(^+\). It is shown that in the case of mesothorium II also the deposition is due to precipitation at the cathode, and that here, as in the other cases, the current only affects matters by bringing the necessary ions to the electrode.

Fractional sepnu of Ra and Ba salts is effected by repeatedly adding a salt having the same anion to the acid or neutral soln. of the salts so as to ppt. crystals having different activities; e.g., CaCl\(_2\) or AlCl\(_3\) may be added to soln. of Ra and Ba chlorides. An app. is described.

430 Bashilov, I. Y. Separation of Salts of Radium and Barium. German Pat. 515,681 (1925).
Same as Russian Patent 5046.

431 Briggs, G. H. Phil. Mag. (6), 50, 600 (1925).
The sepnu of ThX (Ra\(_{42}\)) from RdT (Th\(_{42}\)) by the recoil method is described.

Summary and review.

The heat evolved by a radium salt, prepared in August 1907, was compared with that of a recent preparation, the amounts of radium being compared by means of measurements of the \(\gamma\)-rays given out from RaC contained in them. The heat per gram of radium had increased in 16.75 years by 11%, and this was due to the formation of polonium. The authors conclude that this formation has proceeded in a normal manner in RaCl\(_2\).

In the presence of a large excess of Ba over Ra, sulfate ions will precipitate the clearly. Product of RaSO₄ is not exceeded. Postulating that the Ra/Ba ratio in the surface of a ppt. is proportional to the Ra/Ba ratio in soln. for each successive stage of ppt., the distribution of Ra and Ba after partial ppt. is given by the equation: Log [Ra⁺⁺ (final)]/[Ba⁺⁺ (initial)] = K log [Ba⁺⁺ (final)]/[Ba⁺⁺ (initial)]. Exptl. data from a quant. study of the reaction of a Ra-Ba chloride soln. with (a) H₂SO₄ and (b) BaSO₄ support this equation. K is approx. 1.8. Application of this equation to adsorption and fractional crystal. is discussed. [On page 675 in the summary the equation should read as above. -- Abst.]  

In vol. 1, p. 455 the rays emitted by MsTh, (RaB²⁴⁰) and MsTh, (Ac²²⁸) are described.  

An increase in the concn. of the union can be used for the fractional cryst. of Ba-Ra salt instead of evap. The fractional pptn. of the chloride by ac. HCl has been worked out on a com. scale. The distribution of the Ra between solid and liquid phases follows the Berthelot-Nernst distribution law as a first approximation. The value of the concn. coeff. is variable after partial pptn. or partial soln.  

The rays emitted by radium are described.  

Landé, A. Naturwissenschaften 13, 604 (1925).  
An article on the configuration of the electrons in the radium  

From a tube contg. 65 mg. of Ra element sealed in 1007 in a glass tube about 0.5 mm. thick, the rays were analyzed by absorption in Pt into the following groups: Primary γ-rays -- 3 groups; primary β-rays -- 4 groups; secondary β-rays produced by γ-rays -- 3 groups; secondary γ-rays produced by β-rays -- too weak to analyze.  

The total heat development of 1 g. of Ra, free from its disintegration products, is calcld. to be 22.28 or 22.47 cal./hr., according as the no. of atoms of Ra disintegrating/sec./g. of the element is taken to be 3.40 or 3.72 x 10⁹, resp. Hess's expln. value is 25.2 cal./hr., but when cognizance is taken of the amnt. of γ-radiation unabsoled under the expln. conditions employed, it is computed that the corrected value cannot greatly differ from 25.5 cal./hr. Support is thus given to the essential correctness of the value Z = 3.72 x 10⁹, in harmony with Kovarik's work. The data employed in the calcns. are quoted.  

The cases described represent a hitherto unrecognized form of occupational poisoning. The anemias encountered are proved to be due to the ingestion of radioactive elements with the deposition of insol. fixed particles in the phagocytic cells of the sinusoids of the reticulo-endothelial system, where they continuously emit irritative rays, which in time produce exhaustion of the adjacent hematopoietic center.  

Description of U.S. Bureau of Chem. method for determining Ra in solns. by emanation method. Apparatus diagram, standardization methods, and 11 item bibliography are included.  

Sommerfeld, A. Physik. Z. 26, 70 (1925).  
An article on the configuration of the electrons in the radium atom.  

An article on the configuration of the electrons in the radium atom.  

In pptg. Ra from an alkali-metal carbonate soln., the soln. is acidified with H₂SO₄, a sol. Ba salt such as BaCl₂ is added, the ppt. is dissolved in coned. H₂SO₄ and, after filtering, H₂O is added to the soln. until Ra-Ba sulfate is repptd.  

Formulas are given for obliquity corrections in Ra estn. applicable in the following cases: (1) Point source; (2) uniform line source; (3) uniform rectangular laminar source perpendicular to OC; (4) uniform square lamina source centrally placed perpendicular to OC; (5) uniform circular disk source in a plane perpendicular to OC; (6) uniform cylindrical source, axis cutting OC at right angles; (7) short uniform cylindrical source, axis coinciding with OC; (8) uniform source in the form of a short prism of square section, axis coinciding with OC; (9 and 10) as in (7) and (8), with correction for absorption in the source included. OC is the axis (produced) of the ionization chamber, assumed cylindrical in form. Expln. results show that the effect of scattering is much more marked than that indicated by theory.  

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By injection of a tar-oil mixture into the peritoneal cavity of a mouse, an infiltrating lymphoma arising from the mesentery and invading the mediasitum was produced. In another mouse a spindle-cell sarcoma was produced transplantable for 5 generations, retaining the same histological characteristics. In a rat, a tube containing 1 mg. radium was left for 70 days under the skin. From the margin of the subsequently developing ulcer arose a polymorphous cell sarcoma which grew to the size of a hen's egg. Pathogenesis is explained by chemical and chemico-physical stimulation with destruction and regeneration of tissues and passage from hyperplasia to neoplasia.

The separation of ThM (Ra²²⁵) from RdTh by the recoil method is described.

γ-Rays filtered through 2 cm. of Pb have a mass scattering coeff. equal to 0.0026/A, where A is the At. No., and is the γ-γ-rays for which (μ/ρ)Pb is 0.0475 have been isolated. The distribution of the radiation scattered from paraffin wax has been determined. The results indicate that γ-rays filtered through 2 cm. of Pb have an effective wave length in the neighborhood of 0.012 Å.

This volume is to serve as an introduction to the subject for students of elementary physics and medicine. The first 4 chapters deal with the discovery, nature, and dangers of x-rays, with the methods of x-ray examination. The remaining 8 chapters concern radium and include a history of the development of our knowledge of the subject, preparation of radium, preparation and measurement of radium emanation, action of radium upon normal tissue, therapeutic uses of x-rays and radium, facts and theories concerning the modes of action of radiations upon living tissue, the atomic theory, and the present conception of the structure of the atom. Appendices give units of measurement.


Illustrates a nomogram for computing the γ-ray activity of a radioactive prepn. with respect to time.

Von Schweidler has expressed the ratio of the observed intensity of a low grade radium preparation in the form of a mathematical series. The author develops on mathematical grounds a more convenient approximate formula.

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Soly. isotherm (at 25⁰C) of BaCl₂ in water + HCl shows no complex formation, the solv. being 30.7 g. per 100 g. of H₂O and approaching 0 in 28% HCl. A study of the system RaCl₂-BaCl₂-HCl-H₂O shows that the solv. of RaCl₂ at first decreases more rapidly than that of BaCl₂; RaCl₂ does not influence the solv. of the Ba salt. The soln. was at no point said. with respect to RaCl₂; the latter seps. by forming iso- morphous crystals with BaCl₂. The enrichment factor is 2.8 at the beginning of ppn. with HCl and approaches 1 asymptotically.


A method for the separation of radium salt from mixed barium and radium salts with oxalic acid.

Five deaths from jaw necrosis among employees of a plant using luminous paint lead to an investigation of the whole industry. Over 5% of the employees working were examined, but no other cases were discovered in America, nor did an inquiry in Europe reveal any. This jaw necrosis differs from the ordinary necrosis, being of a gelatinous nature, occurring in separated areas in the mouth, and usually developing after some dental intervention. These necrotic areas heal but recur. It is supposed that the condition was caused by the employees painting the brushes between their lips. The luminous material consisted of ZnS with minute quantities of Cu, Mn, Cd, radium or mesothorium. Studies were made of the amount of material an employee might ingest in a day and its elimination from the body. The examination consisted of inspecting the oral cavity, blood examination, and testing for radioactive deposits in the body by means of the alpha and gamma ray electroscope. The writer considers that further studies are necessary to prove that radium or mesothorium causes the necrosis.

In vol. 22, p. 128 there is a discussion on the nuclear structure of the radium atom.

The emanating power (E.P.) is defined as the ratio of the amount of emanation diffusing out of the prepn. at room temp. to that actually produced by the radioactive substance present. The E.P. is much greater for amorphous than for crystal preps. LaF₄, from 10% La(OC₁₈)₃ soln. and HF, with 4 x 10⁻⁵ Ba and 10⁻⁴ Ra per cc. gave preps. of E.P. 69, 65 and 63% after 3, 6 and 12 months, resp., Fe₃(OC₁₈)₉ from FeCl₃, RBR₃, NH₃ and (NH₄)₂CO₃, gave E.P. 99.5%, decreasing only slightly with time.

460 Kendall, J., Jette, E. R., and West, W. "The Separation of Radium and Mesothorium I from Barium by
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The application of the ionic-migration method to the separation of Ra and MeTh (Ra226) from Ba is investigated. It is shown that the mobility of these radioactive ions exceeds that of Ba by a sufficient degree to permit a practicable separation of Ra, MeTh or mixtures of the two from Ba. In a typical run the activity per unit weight of the front segment (after traveling a distance of 500 cm. in 8 days) is 1051: the activity of the rear segment is 99; and the activity of an unimmigrated sample is 33.


The author reports the autopsy, histologic and toxicologic examinations of a girl whose disease had been diagnosed as a leukopenic regenerative anemia due to occupational radium and mesothorium poisoning. She had worked 7 yrs. painting watch dials with luminous paint, pointing the brush tips with her lips. A chronic leukopenic anemia developed with extensive necrosis of the inferior maxilla.

The morphology of the blood during life closely resembled pernicious anemia with the important exception that there was very little evidence of increased hemolysis, the icteric index and van den Bergh tests were negative. Autopsy showed a profound anemia characterized by intense replacement of the normal adult fatty marrow by red regenerating marrow.

Histologically there was regeneration of the megaloblastic type. In the marrow, spleen, liver, heart, and kidneys hemosiderin deposits were either absent entirely or present only in very small amounts. Organs after necropsy were tested for radioactivity and the greatest amount was found in the bones, a very minute amount being found in the spleen, liver, and gastrointestinal tract, and none in other organs. After chemical extraction it was estimated that the entire skeleton contained about 150 micrograms of radioactive substances, around 70% being mesothorium. The amount of radioactive substances in the bones when placed against photographic plates showed distinct photographic impressions after 7-18 days exposure. By the technic of Lacassagne autochromatographies were obtained from paraffin blocks of the tissue from the jaw and femur. The investigations confirm previous work of the author and his coworkers in describing this unusual form of occupational poisoning.


In vol. 22, p. 278 the reduction of crude RaSO4 with carbon is described.


Control tests confirm the work of others that erythrocytes following chronic blood loss, on standing several hrs. in Ringer's solution, and after exposure to P and C1 have an increased resistance to hemolysis by hypotonic saline solutions. Lead produces a greater increased resistance of mature than immature red blood corpuscles. Irradiation with radium emulsion does not change this resistance. Lead and radium combined produce an effect midway between the effect of either alone. Radium hemolyses more readily immature than mature red blood corpuscles, while lead has the opposite effect. Irradiation of "labeled" erythrocytes greatly increases the amount of hemolysis above that produced by either agent alone. This effect is twice as great on immature as on mature red blood corpuscles.

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Luminous paints consisting of ZnS, which has been calcined at 1000-1200° for its transformation into a cryst. modification, and a very slight admixture (50-250 mg. per kg.) of Ra salt lose their luminosity in the course of time, but their Ra content remains practically unchanged and can be recovered. A method for the recovery of Ra from these paints has been given by A. Francis, but it is rather complicated and laborious. B proposes a simple method which is based on the circumstance that the radioactive ingredient is disposed on the surface of ZnS and can be extd. by comparatively weak agents, which hardly affect the other elements. The scraped-off paint in powder-form is first calcined at low temp. to destroy the gum and then treated with dilute HCl. Ra dissolves, the soin. is concd. by evap., a few mg. of BaCl2 and a few vols. of concd. HCl are added and the ppt. of BaCl2 is allowed to settle for several hrs., after which it is pressed out, washed with concd. HCl and dried to absence of HCl odor. An aq. soln. of this BaCl2 ppt. which contains most of the Ra, can be used for activation of fresh ZnS. On account of the slight solv. of BaCl2 in concd. HCl, part of this salt remains in soln., together with some Ra. The aq. ppt. of the latter which remains dissolved may reach up to 25%; it can be recovered after pptn. of BaCl2 by evap. the filtrate to dryness to remove HCl, dissolving in water and using the soln. for activation of ZnS. By this method B. easily extd. 73.3% of Ra contained in old luminous paints scraped off from dials used in aviation. The new Ra paint thus obtained possessed a high degree of luminosity.


A pyrex bulb contg. a large amt. of dissolved Ra salts was badly cracked after 2 yrs., the cracks occurred only above the level of the soln.


Intestinal mucosa was exposed to 3 doses of x-rays, measured biologically, (1) 2/5 human erythema (medium wave), (2) 1 human erythema (short wave), and (3) 7/5 human erythema (short wave); also radium was applied directly to the mucosa. Dose 1 caused complete destruction of mucosa with chronic ulceration, but no leucocytic infiltration. Dose 2 caused loss of villi and destruction of epithelium except in crypt fundi, followed by epithelial proliferation, dedifferentiation, and disappearance of goblet cells. There was little leucocytic infiltration. conspicuous epithelial giant cells also appeared. Dose 3 caused little tissue injury. Goblet cells were more numerous, leucocytic infiltration was
marked, but limited to mucosa. Radium injury resembled what produced by dose 3 of x-rays, but leukocytic infiltration was more widespread. Giant cells, which appear after exposure to 1 human erythema dose, are of both mononuclear and multinuclear type. Both exhibit phagocytic activity and many show active mitosis. Some mitotic figures are abnormal, and the number of chromosomes is always higher than normal—at least double.

The separation of Ra-Ba chlorides with BaSO₄ is described.

Comparison made between results for RdTH and those for Ra.

Fractional ppt. of Ra and Ba chromate from Ra and Ba chloride solns. moderately acidified with HCl or HNO₃ (acidity not over 0.3 N) results in the formation of ppta. whose Ra content per g. of Ba is on the av. 18.5 times that of the resulting solns. This relationship appears to be independent of the fraction of Ba pptd. over the region of Ra/Ba ratio from 10⁻⁴ to approx. 10⁻². In the neighborhood of the upper limit low values were obtained. The results are in agreement with the assumption of solid soln. of RaCrO₄ in BaCrO₄ over the region of Ra/Ba ratio, deviations from the av. value of the sect. factor being explainable on the basis of the slow equalization of concn. within the solid particles of the ppt. In neutral solns. low values of the sect. factor were obtained as a rule. Results with highly acid solns. were irregular, pointing to a decrease in the sect. factor with increasing acid concn.

By employing in general the method of Rutherford and Geiger the charge emitted by one g. of Ra per sec. is found to be 83.4 e.s.u., which corresponds to 3.50 x 10⁶ α particles.

On addition of HBr to a satd. soln. of BaBr₂, the soln. of BaBr₂ is diminished to such an extent that a g. equivalent of the HBr ppt. a g. equiv. of the BaBr₂. For the system BaBr₂, RaBr₂, HBr and H₂O, it is shown that the distribution of the radium between the crystals and the liquid phase follows the Berthelot-Nernst distribution formula. The partition constant of Ra between BaBr₂ and its satd. water soln. is a function of the acid content of the soln., for a neutral soln. the constant is 52.9. The whole course of the concen-

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tration of the Ra through fractional crystallization in HBr soln. follows the formula \( X_{\text{Ra}}/m = K \text{Ra} \times X_{\text{Br}} \times q \), where \( X \) is the quantity of Ra in the crystals, \( 1-X \) the quantity of Ra remaining in soln., \( S \), and \( S \), the corresponding volcs., m the weight of the solid phase, q the weight of the resulting soln., K at 25° is 60.24. It is shown that the evolution of the radioelements as indicators in experimental studies of dilute solid solns. can be of great value.


Description of qual. method for liquids and quant. method for solids, semi-solids, and liquids when Ra must be determined. The methods are those of the Beverage Lab., Bureau of Chem., Washington.


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A description of a method already patented, for the sect. of Ra or mesothorium chloride from BaCl₂ without evaporation. The mixed chlorides are dissolved in water, and a quantity of strong CaCl₂ soln. is added sufficient to ppt. at most ½ of the BaCl₂ present, which then contains about twice as much active chlordie as the original mixt. By repeated fractional pptn. a product rich in Ra or Ba₄Tb is obtained, together with a soln. of Ba and Ca chlorides, which are recovered by evapn. and crystn. The process is suitable for working up chloride mixts. contg. as little as 0.1 part per million of radioactive chloride. Al and ferric chlorides may also be used as pptg. agents, but as they are susceptible to hydrolysis CaCl₂ is preferred.

476 Bashilov, I. Y. Method for Separation of Barium Chloride from Radium Chloride. Russian Pat. 5046 (1928).
Concd. solns. of CaCl₂ or other chloride salts are added to the repeatedly recrystd. Ba and Ra chlorides in soln., which do not form compds. soln. in the soln. of Ba and Ra salts.

Standard Ra solns. were tested with an instrument to measure Ra and results obtained are in good agreement with expected values. Solns. kept for nearly 7 years showed the same results as fresh solns.

The paper includes an historical and critical account of previous determinations. The authors measure the total charge carried by the $\alpha$-particles (using a modified Rutherford and Geiger apparatus), and obtain the number of particles by assuming Millikan's value for the electronic charge. Their final corrected result is $(3.68 \pm 0.04) \times 10^6$ $\alpha$-particles/g. Ra/sec, which is in good agreement with the value which can be calculated from the heating effect of the $\alpha$-particles. It is concluded that there is no evidence of any unrecognized heat-producing mechanism in radioactive disintegrations.


The heat effect of the $\beta$- and $\gamma$-radiation of Ra is detd. by means of an adiabatic microcalorimeter constructed by Swietoslawski and the author. RaBr$_2$ equiv. to about 4.45 mg. Ra is used throughout. The heat is absorbed in Cu, Ag, Pb and Wood alloy calorimeters whose absorbing masses were 17.72, 37.72, 32.13 and 37.85 g./cm$^2$, resp.; the optimum heat capacity of the system was 1-4 cal. with temp. variations from 0.6 to 0.15$^\circ$. The results found were: $Q_\beta = 0.724$, $Q_\gamma = 0.060$ and $Q_\text{total} = 0.687$ cal./hr., where $Q_\beta = Q_\alpha + Q_\beta + Q_\gamma$, $Q_\gamma = Q_\alpha + Q_\beta + Q_\gamma$, and $Q_\text{total} = Q_\alpha + Q_\beta + Q_\gamma$. Where $Q_\alpha$, $Q_\beta$, and $Q_\gamma$ are the heat values of $\alpha$-, $\beta$-, and $\gamma$-radiation respectively. Calcd. for 1 g. Ra the heat effects are 123, 120 and 16.6 cal./hr. for $\alpha$-, $\beta$-, and $\gamma$-radiation respectively. Thus, the heat effect of the $\beta$-radiation is only 3.1%, and that of the $\gamma$-radiation only 12.4% of that of the $\alpha$-radiation. These values, too low in regard to the theoretical ones, are due to the inclusions of RaD and RaE in the analyzed salt.


Extensive, organized review with many literature references interspersed in text. Also covers mesothorium 1 (Ra$^{288}$m), ThX (Ra$^{286}$), and AcX (Ra$^{282}$).


Daily oral administration or a single intravenous injection of radium bromide raises the C:N quotient, due to decreased N elimination.


In view of the fact that Ra has an even at. no. and of the frequent occurrence of the alk. earths on the one hand and of U and Th on the other, expts. were performed to det. whether or not there existed in Ba minerals a stable Ra isotope independent of the radioactive isotopes which appear as disintegration products of U and Th. 220 kg. of BaBr$_2$ was concd. so that the concn. of the hypothetical Ra would be about 500,000 times its original concn. and the concentrate examd. for Ra spectroscopically. No Ra line was obtained. There was a concn. of radioactive Ra, as detd. by the electroscope but this did not reach a spectroscopically determinable atm. There is, therefore, no evidence for the existence of a stable Ra isotope in Ba minerals in an atm. greater than $2 \times 10^{-10}$ g./g. Ba.


Khopin, V. and Polesitzki, A. "Fractional Crystallization of Radioactive Substances. II. The Distribution of Radium between Solid Crystalline BaCl$_2$-2H$_2$O and its Saturated Aqueous Solution at $t = 0^\circ$ and $t = 35^\circ$." Z. anorg. allgem. Chem. 172, 310-20 (1928).

The extremely small quantities of Ra have no practical influence on the 2 phases so that the present case is not analogous with ternary systems of 2 electrolytes which form mixed crystals and water. Henderson and Kracek concluded that the distribution of Ra is analogous to the distribution of a substance between 2 non-miscible solns. The partition factor is $D = c_1/d$, where $c_1$ is the amount in g. of Ra salt per cc. of the satd. soln. and $d = sp.$ gr. of the solid phase. Detns. of Ra differ with different investigators, though these deviations were probably due to variations in temp. and acid concn. The distribution of Ra between solid BaCl$_2$ and the neutral satd.aq. soln. strictly obeys the Berthelot-Nernst distribution law. The distribution ratio, $K$, remains strictly const. at const. temp. and const. compn. of the liquid phase as well as under large differences in the relative amts. of both solvents. Greatly increasing the concn. of the Ra salt (2 $\times 10^6$ times) does not affect $K$, for $K$ depends on temp. and the temp. coeff. for this system, between 0$^\circ$ and 35$^\circ$, is $-0.516/^\circ$C., and from 35$^\circ$ to 57.5$^\circ$ it is $-0.275/^\circ$C. Fractional crystn. of Ra chloride and bromide improves with fall in temp.


Results of Curtiss are confirmed. L. placed in a Pyrex system 265 mg. of Ra (RaCl$_2$ soln.) for collection of Ra. Both longitudinal and transverse cracks developed in 1 year in the upper half of the 250-cc. flask. The flask was half full of RaCl$_2$ soln. Conclusion: The cracks were due to the relief of preexisting strains, by expanding under $\alpha$-radiation. Sealing accompanied by interference colors is indicated. Contraction is possibly caused by $\alpha$-particle bombardment. Glass of high silica content resembles fused silica in becoming cracked by $\alpha$-radiation.


Ra in soln. is recovered in a concd. form by absorption with natural or artificial zeolites or permittives.


Makes use of Aston's latest determination of the atomic weight of helium, which, for the neutral atom, gives 4.00214, and Hönigschmid and Schiliz's value for uranium, 238.14. Calculates the atomic weights of radium and of radium lead, RaG, taking into account the loss of mass due to the ejection
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of α and β particles, and that due to emission of energy. When the facts that 'uranium' is really a complex of UI with from 3 to 4% of AcU, and that radium lead is a complex of Ra+ + AcD in about the same proportion are considered, the calculated and observed values for Ra are almost identical, but the value calculated for radium is almost 0.1 higher than the experimental value of Hönigschmidt. The difficulties in the way of obtaining a correct value for the atomic weight of radium are pointed out.


The Ra–Ba bromide system can be made more than twice as efficient as the Ba–Ra chloride system. The crystals are sep. from the mother liquor by centrifuging. The av. value for the partition coeff. in the Schundt equation is 6.66 and in the Doerner-Hoskins equation 5.6.


The heat evolution of 5 combinations was measured by a resistance thermometer method. Within 2% of the Hess and Lawson rate of emission of α particles from Ra (3.72 x 10^-14 per g. per sec.) was obtained.

490 Yamasaki, I. “Information on Radium Hemolysis.” Science 64, 293-6(1928).

Radium hemolysis takes place both in air and in an atmosphere of N, more rapidly in N. Both β rays and γ rays are able to induce it.


A calorimetric method for the evaluation of the amount of Mo-Th contained in Ra salts is offered. The method is based on measuring the heat given off in the formation of Rd-Th. A microliterimeter is used.


The following values were obtained for k, the no. of ions produced by each α-particle in air at 0° and 760 mm.: U I, 1.18 x 10^4; U II, 1.29 x 10^4; Ra, 1.36 x 10^4. The no. of α-particles per g. of Ra per second is Z = 3.71 x 10^9. Metals for which radioactivity has not been observed were tested. No charactenic activity was found for Cu or Zn, but the metals Al and old Pb were shown to contain an amt. of Ra of the order of magnitude 10^-4 g./g. of metal. Residues and ppts. from solns. of Zn showed certainly the existence of new activities, the nos. of ions produced by each ray being 0.43 x 10^7. 0.69 x 10^7 and 1.01 x 10^7.

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Contains a fully illustrated account of the method employed in the measurements previously recorded. Emphasizes the difficulty of determining the intensity of the different γ-rays concerned, either by the author’s method or by those employed by other experimenters. Considers the origin of certain of the γ-rays in nuclear levels; the results so far obtained are not sufficient to resolve the numerous difficulties which exist in the theory of the nuclear structure and of radio-activity. The author is investigating an electromagnetic spectrophotographic method, which seems capable of getting over the difficulties due to the low intensities of the sources employed.


Intensities of various combinations of Ra preparations were determined in r-units with the condenser dosimeter and small ionization chambers (1/2 cc.) for different filters, distances, etc. The results are collected in a number of curves and tables. The skin unit dose for γ rays was determined as 2000 r.


The "deposition potentials" from normal ionic concns. are estd. for Ra, 1.718, Ba, 1.871, Sr, 1.984, Mg, 1.985, and Ca, 2.041 v. from the normal calomel zero. From the magnitude of the diffusion current, Ra may be followed quant. in mixts. with Ba from the ratio Ra:Ba = 1:10 to 25:1, in concns. 10^-14 M, 2 cc. being necessary for the detn. Traces down to 10^-15 g. equiv. per l. of Ra or Ba are detd. in the same way in any amt. of alkalies or alk. earths; Sr is detd. only in mixts. with alk. earths or Li. The applicability of the polarographic method for the detn. of solubilities of sparingly sol. salts is tested and found comparable to the conducton method. The deposition of Mg and Be even from very small concns. is accompanied by an evolution of H2. By means of this action small amts. of Mg may be roughly estd. "Adsorption currents" with well-defined max. are best shown on current-voltage curves of solns. of the heavy alk. earths. Examples are given of polarographic titrations of Ba, Sr, and Ca ions.


This article contains the same information as the previous reference.


This article contains the same information as the previous reference.

1929


At const. temp. the distribution ratio (expressed as $K = C_2/C_1$, where $C_2$ and $C_1$ are the concns. of Ra in the solid and liquid phases, resp.) is const. over a 3- to 4-fold change in Ra concn. Equal values of $K$ are found by 2 methods; (a) by cryst. of Ba[NO$_3$]$_2$ from active soln. at const. temp. and (b) by prolonged agitation of inactive Ba(NO$_3$)$_2$ crystals with active soln. of Ba(NO$_3$)$_2$. It is concluded that a true state of equil. exists and that the Berthelot-Nernst distribution law applies within the limits of exptl. error. At $0^\circ$, $K = 154 \pm 1.2\%$ and $D = 2.31$; at $25^\circ$, $K = 46 \pm 1.5\%$ and $D = 149$. $D = K$/d defines the partition factor, where $C$ is the concn. of Ba(NO$_3$)$_2$ in g. per cc. of soln. and $d$ is the sp. gr. of Ba(NO$_3$)$_2$ crystals. Fractional cryst. by means of Ba-Ra nitrate is possible but not as favorable as with bromides and chlorides previously studied.


The distribution ratio of Ra between cryst. and liquid phase is a function of the compn. of the system and lies between the values $K = 46$ for pure Ba(NO$_3$)$_2$ and $K = 18$ for pure Pb(NO$_3$)$_2$ in equil. with their resp. satd. aq. solns. at $25^\circ$. With fixed proportions of Ba and Pb in the 2 phases the distribution of Ra obeys the Berthelot-Nernst distribution law within the limits of exptl. error. Analyses of the mixed crystals and their equil. solns. show independence in compn. of the phases, and fair agreement with the earlier results of Glasson and Riggs.


By means of the Geiger and Müller electron counter, 10^4 mg. Ra was estd. with an accuracy of 10%, against $2 \times 10^{-8}$ mg. by the most sensitive method heretofore used. Six hrs. was required for the estn., the record being made automatically.


Seven persons who had worked in Ra refineries or luminous material plants and who might have ingested radioactive material were studied. Electroscope measurements of the $\gamma$-ray activity of the subject were made with a Wall-Hess quartz-fiber instrument. Emanation measurements of the expired air were made with a Lind instrument with a large ionization chamber. Methods for estg. the total radioactive material present, and for discriminating between Ra and MaTh are given.


1929

The $\gamma$-ray method for the detn. of Ra is as accurate and more convenient than the $\alpha$-ray or emanation methods. A $\gamma$-ray electroscope with a sensitivity of $2 \times 10^{-6}$ g. Ra per g. of substance is described.


$\gamma$-Rays from Ra were diffracted by a calcite crystal. Results agree well with those of previous workers. Wave lengths in X. U. were: 34.1, 25.9, 27.9, 23.9, 19.7, 10.6, 21.1. and 17.6 were probably of the second order. Other lines of intermediate and shorter wave length were observed.


The no. of particles has been counted directly by means of a Greinacher counter, which consists of an ionization chamber, a valve amplifier and a recording instrument. The no. of particles emitted from a g. of Ra was found to be $3.0 \times 10^{10}$/sec.

1930


Known vols. of Ra salt solns. of known purity were evap. to dryness and the activity was compared with a standard sample for detn. of solu. Soly, in 100 g. of water was: BaBr$_2$, 70.6 g., RaCl$_2$, 24.6, Ra(NO$_3$)$_2$, 13.9. Comparison with values for similar alk. earth salts shows no simple relationship between solu. and degree of purification by fractional crystn. The soly. difference is less for the bromides than for the chlorides but the degree of purification is greater. Crystn. of Ra(NO$_3$)$_2$ showed little improvement in purity, contrary to previous work, although Ra(NO$_3$)$_2$ is more soln. than Ba(NO$_3$)$_2$.


Ppts. of RaCO$_3$, RaSO$_4$ and RaCrO$_4$ were prepd. in 2 ways with Fe(OH)$_3$ and Al(OH)$_3$ gels. The first series was pptd. by adding FeCl$_3$ and RaCl$_3$-BaCl$_2$ solns. to NaOH and the anion in excess. The ppt. was dried in moist air. In the other series the Ra soln. was added to the gel and the anion soln., then added. The emanating power of the ppt. was tested after 25-47 days on the product dried in moist air and dried with alc. Directions are given for prep. a ppt. of the highest emanating power, which does not lose its strength upon standing.

508 Flint, H. T. and Grimmett, L. G. "Measurement of the Distribution of Gamma Rays around a Four-
1930


The method proposed by Sale for examing radioactive material was applied to a water sample, a sal salt sample and a refractory substance, and was found to be reliable. Several modifications in technique resulting in simplicity and convenience, without loss of accuracy, are suggested. The method was checked by the Schlundt and Moore method (J. Phys. Chem. 9, 320 (1905)) and by Barker’s bisulphate fusion method both of which are in general use at the Univ. of Missouri in making Ra assays.


With certain precautions and under certain conditions the μ unit can be satisfactorily employed to measure the intensity of the γ-rays of Ra. Various types of ionization chambers are described and illustrated. With the γ-rays of Ra, 2000 μ units will produce a reaction on the human skin which is usually designated as a skin unit dose.


The distribution of Ra between cryst. Pb(NO₃)₂ and its satu. qtd. soln. follows strictly the Berthelot-Nernst distribution law. The distribution const. k, is 36.3 and 18.2 at 0° and 35°, resp. Addn. to the satu. soln. of Pb(NO₃)₂ of foreign compds., not isomorphous with it, has a pronounced effect on the distribution const. of Ra. If this addn. diminishes the active concn. of Pb⁺⁺, K increases, and vice versa. The addn. of foreign compds. which form complex ions or little dissoocl. mols. with Pb but not with Ra, raises the coeff. of enrichment of Ra in the crystals of Pb(NO₃)₂. This fact presents a practical possibility for sep.


Two formulas have been proposed for fractional cryst. of Ra salts, one by Doerner and Hoskins (in a/f = λm b/h, where a = amt. Ra in soln. before pptn., y = amt. Ra in soln. after pptn., λ = a const., b = amt. Ba in soln. before pptn. and n = amt. Ba in soln. after pptn.) and one by Khlopov

amm. Ra in crystals = D × amm. Ra remaining in soln.

where D is a const.

If the process is carried out slowly so that equil. exists between the crystals and the soln., the equation of D and H is valid. If the cryst. is done rapidly from a super-satu. soln. no true equil. exists between the soln. and the crystals then the K. equation holds.

1931


This article reports the case of a chemist who worked for about 4 yrs. in a chemical factory filling radium needles. He was constantly handling Ra salts and mesothorium in small quantities. Though his hands were protected as much as possible he suffered occasional Ra burns on his fingers. After 2 yrs. he gradually developed shortness of breath which increased slowly but steadily and about a month before death confined him to bed. At this time X-ray plates of the chest showed a diffuse, finely nodular “snow flur” shadow throughout both lungs. Both the patient and the clinicians believed the condition was due to injury to the lungs as the result of inhaling the volatile fractions of radioactive salts. At autopsy, the main finding was a diffuse interstitial fibrosis of both lungs, which had greatly reduced the vital capacity. Histologically this fibrosis was without specific qualities. The condition resembled “lymphangitis reticularis” of the lung described by von Haeckel (Virchow’s Arch. Path. Anat. u. Physiol. 220, 311-22 (1915)). The patient had no other disease of the lung to which the fibrosis might be related. Portions of lung tissue were tested for radioactive substances, with negative results. The possible etiological relationship of Ra to the lung injury is not proven but is suggested by the absence of other demonstrable etiological factors. There are no similar cases on record.


Measurements made both by the ionization and charge transport methods were obtained on preps. of Po and the results calcld. over to Ra by means of the known equil. between Po and Ra. The no. of α-particles emitted by 1 g. Ra/sec. has thus been detd. to be 3.7×10⁹.


The distribution of a dissolved substance between two immiscible liquid phases is completely analogous to the distribution of a solute in a system of one solid cryst., and one liquid phase. This was shown by study of the distribution of RaBr₂, 2H₂O between solid BaBr₂, 2H₂O and its satu. soln. at 35° and at the b.p., of RaCl₂, 2H₂O between solid BaCl₂, 2H₂O and its satu. soln. at 35° and at the b.p., and of Ra(NO₃)₂ between solid Ba(NO₃)₂ and its satu. soln. at the b.p.


The systems Ba-Ra-Br, Ba-Ra-CI, Ba-Ra-NO₃, and Ba-Pb-NO₃ were studied in (1) slow cryst. from supersatd.
1931

soils. to complete equil., the degree of supersatn. varying; 
(2) interrupted slow crystn. from supersatd. soils. of the 
same initial concn., crystals and soil being extd. after 
varying time intervals; (3) rapid crystn. from soils. of 
varying degrees of supersatn., the crystals being filtered 
from the mother liquid immediately. In (1) the Nernst-
Berheiot equation is valid, the const. D of that equation 
being independent of the degree of supersatn. In (2) the 
crystals formed are homogeneous throughout the process, 
the ratio percentage of Ra pptd./percentage of Ba pptd. 
being const. In (3) the value of $\lambda$ in the equation $\ln (Ba \text{ in } \text{solv. before pptd.}/Ba \text{ in solv. after pptd.}) = \lambda t$ in (Ra in solv. 
before pptd./Ra in soln. after pptd.) was found to be const., 
the degree of supersatn. not influencing its value. However, 
if these crystals obtained as in (3) were allowed to stand 
several hrs. in contact with their mother liquor, a recrysta.
took place and the ultimate product corresponded to the 
crystals obtained in (1). Exptl. methods are given and the 
results well presented in graphs and tables.

518 Schlundt, H. and Falila, G. "The Detection and 
Estimation of Radium in Living Persons. III. The 
Normal Elimination of Radium." Am. J. Roentgenol. 
Radium Therapy 26, 265-71(1931).

The subject for these expts. were 2 girls who had con-
tracted Ra poisoning during employment as dial painters in 
1917-1919, and who carry at the present time approx. 24 
and 36 microgram of Ra, resp. The total daily elimination 
was found to be 0.005 and 0.0026%, resp. This difference 
is explained by a marked difference in the rate of metabolism 
in the 2 subjects.

519 Starik, I. E. and Gurevich, A. M. "Adsorption of 
Radium by Glass." Compt. rend. acad. sci. (U.R.S.S.) 
A. No. 12, 331-5(1931).

Radioactivity of neutral and acid soils. in glass tubes con-
taining 3.6 x 10^{-6} g. Ra in 5 cc. of soil was measured with 
a Schmidt app. The initial activity of the neutral soln. was 
211 divisions/min.; of the acid soln. (N/5 HCl) 297.2 div./min. 
After 20 days the radioactivity became practically constant, 
having decreased in the acid soln. to 210 and in the neutral 
to 145. Addn. in the beginning to the neutral solution of HCl 
to a concentration of N/6 raised the activity to 295.4. Addn. 
of HCl after the neutral soln. reached its min. activity raised 
the activity to 210. Ra is thought to be absorbed and adsorbed 
by glass. Absorption is independent of the acidity of the soln., 
but the adsorbed layer is washed off by acid.

1932

520 Albertson, W. "Classification of Certain Lines of 

The Ra spark lines of 6466.1, 5823.7, 5836.3, 5837.7 and 
2708.9 $\AA$ may be accounted for by assuming a set of doublet 
levels at 73,920; 72,162 cm^{-1} and at 36,917; 36,632 cm^{-1}. 
This is discussed.

521 Behounek, F. and Kobic, O. "The Inhomogeneity of 
Highly Active Radium Barium Chloride." Physik. 

Several preps. of Ra-Ba chloride were divided into many 
small samples. Each of these was weighed and its Ra content 
detd. No significant differences were found. After 18 months 
one of the samples was again divided and tested. Variations 
in Ra content from 56.59 to 70.75% were found. These differ-
ences are ascribed to a concn. of Raci in some of the 
crystals during their preps. No evidence was found to sup-
port the view that on standing the preps. change from the 
chloride to the chlorate.

522 Erbacher, O. and Nikitin, B. A., "Solubility of Radium 
Sulfate in Water at 20°." Z. physik. Chem. A118, 
216-30(1932).

One-hundred cc. of H_{2}O dissolves 1.50 x 10^{-4} g. The solute 
is powerfully adsorbed by filtering materials. BaSO_{4} slowly 
decomposes under the influence of its own radiation, but 
this change occurs chiefly on the surface; it is practically 
immaterial whether the surrounding medium is air or H_{2}O.

523 Karl, A. "Determination of Radium in Insoluble 

The emanation method for detd. Ra by M. Curie and others 
is outlined and a greatly simplified procedure is described 
in which 1 g. of substance is first treated with H_{2}SO_{4} and HF 
in a Pt vessel and the nonvolatile residue then fused with 
10 g. of KHSO_{4}. After the fusion, 2 g. of Li_{2}SO_{4} and 3 g. of 
Na_{2}SO_{4} are added and the mixt. is fused again. This melt 
is cooled in a desiccator over H_{2}SO_{4}. An aliquot part is 
taken for the emanation test but instead of bubbling air 
through an acid soln., as has been the practice hitherto, 
air is bubbled through the melt obtained by heating in an 
elec. furnace.

524 Karl, A. "Determination of Radium in the Presence 
of Alkaline Earth Sulfates." Compt. rend. 194, 913-
14(1932).

An equimol. mixture of NaCl, KCl and LiCl is used in 
place of KHSO_{4} or NaHSO_{4} in the fusion method for the detn. 
of Ra.

525 Nikitin, B. A. and Erbacher, O. "Validity of Mass Law. 
I. Solubility of Radium Sulfate in Sulphuric Acid and 
Sodium Sulfate Solutions." Z. physik. Chem. A118, 
281-5(1932).

The activity product of RaSO_{4} at 20° has approx. the same 
value in H_{2}O, 0.0001-0.1N H_{2}SO_{4} and 0.01-0.1N Na_{2}SO_{4}.

526 Rosenblum, S. "Fine Structure of the Magnetic 
Spectrum of the $\alpha$-Rays of Radium." Compt. rend. 

The photographs obtained showed a sharp edge on 
the high-velocity side and a gradation toward slower 
rays. With long exposures (3-12 hrs.) to Ra a line 
weaker than the high-velocity edge was observed; it is attributed to a 
slower ray. By assuming that the velocity of the $\alpha$-rays 
from RaA is 1.698 x 10^{6} cm. per sec., the following $\alpha$-ray 
velocities were detd.: for Ra, 1.517 x 10^{6}, for the secondary 
$\alpha$-rays of Ra, 1.468 x 10^{6}, for Ra, 1.623 x 10^{6} cm. per sec. 
The value for Ra differs by 0.4% from the accepted value. 
The difference in energy between the main and secondary 
$\alpha$-rays is 165 kev., agreeing with the value of 198 kev. for a 
quantum of $\gamma$-radiation. From the intensity of the secondary 
line the ratio of the no. of quanta of $\gamma$-radiation emitted to 
the total no. of atoms decomp. can be cale.
1932


This work represents the 1st. dttn. of the velocity of X-rays from RdTh and its deriva. The RdTh and MstH (Ac259) were sepd. from MstH, (Ra229) and ThX (Ra229) by double pptn. of BaCl2 in excess HCl.


Of 9 rabbits, 5 received radium chloride and 4 mesothorium injections intravenously once a month. The blood cells were counted once a week. The differential counts were made with the supravital technique. One animal died 25 days after 1 injection; a second was killed after 3 injections; the other 7 were killed at intervals of 11-19 mos. after the first injection. Each animal was killed when signs of some damage became evident, such as a fracture or marked weakness. The animals receiving the radium chloride survived the longest and showed fewer signs. Several phenomena were observed: marked changes in the lymphoid tissues eventually registered by a lymphopenia; a slight anemia associated with a destruction of red blood cells and, within the limits of this experiment, with only minimal changes in the bone marrow; atrophy of the thymus; a damage to the liver cells and a reduction in size of this organ; the frequent development of abscesses; 1 spontaneous fracture; and in 2 instances the development of osteogenic sarcoma. The observations suggest that with certain doses of radioactive material, the fundamental damage in the lymphoid tissues is to the stem cell and that the damage is to the chromatin of the nuclei. The erythroid tissues are apparently less susceptible but an original anemia of secondary type from peripheral destruction may eventually be changed to one of primary type through decreased matura-

1933


The constancy of the escape of Ra from Ra aoin. has been tested over a period of 18 years and found to vary not more than 1%, which corresponds to the exp. error. Sulfate and carbonate have some influence and may lead to considerable errors.


The magneto-optic method shows that Ra has 4 isotopes with probable masses, in order of decreasing abundance, of 226, 228, 230, 232.


Thirty-two references are included.

535 Haisinsky, M. "Separation of Elements 88 (Ra), 89 (Ac) and 90 (Th) by the Use of Organic Solvents." Compt. rend. 196, 1788-9(1933).

The use of org. solvents has enabled H. to separate a mixt. of disintegration products of Th and also a mixt. of AcX (Ra229) and radcaothorium. Only the first sep. is published now. A dry mixt. of 10% Na nitrate and Ba(NO3)2 (to contg. MstTh, (88), MstH, (89), RdTh (90), and ThX (89) is treated with abs. EtOH and filtered. The residue contains the Ba, MstH, ThX (Ra229) and 5/10% MstH, and RdTh and can be freed from the two latter by repeating the EtOH treatment 2-3 times. When Th nitrate and then pyridine are added to the EtOH filtrate a gelatinous ppt. of Th and RdTh in formed and the filtrate contains in a very pure state the La and MstH. The active deposit is chipped in the EtOH-pyridine filtrate and can be removed by adding Pb(NO3)2 and pptg. with H2S. The La and MstH can be sepd. by forming the hydroxide or oxalate.


A brief historical account, dealing particularly with the work of Kroupa.


A study was made of the fractionation of Ra and Ba by the pptn. of BaCl2 with concd. HCl at 20°. The concns. of Ra and Ba in the solid and liquid phases were detd. The coeff. of
enrichment $K_0 = \frac{R_a}{\gamma} R_b$ in the ppt. decreases with increase in the amount of the ppt. The coeff. is independent of the concn. of the original soln.


The function $\lambda = \log \left( \frac{R_a}{R_b} \right) + \log \left( \frac{Ba}{Ba} \right)$, in which $R$ is the concn. of Ra ions in soln. and subscript $b$ and $a$ mean before and after crystal., resp., is called. In slow crystal $\lambda$ is const. but in rapid crystal $\lambda$ decreases as the concn. increases.


Ra boiling pt. (vol. 1 p. 102); density (vol. 1 p. 104), emission spectra (vol. 5 p. 311); melting point (vol. 1 p. 104); persistent lines (vol. 5 p. 324); quantum numbers (vol. 5 p. 408), spectral series (vol. 5 p. 403); X-ray emission spectra (vol. 5 p. 42); Zeeman effect (vol. 5 p. 420); RaBr$_2$ electrical conductivity in Ag (vol. 6 p. 231 and 234); RaCl$_2$ diffusion in H$_2$O (vol. 5 p. 66); RaSO$_4$ soly. in H$_2$O (vol. 4 p. 233) and freezing point-soly. in H$_2$O (vol. 4 p. 353 and vol. 7 p. 344).


The soly. of RaSO$_4$ in water at 20° is $2.1 \times 10^{-4}$ g. per 100 cc. water. The soly. of RaSO$_4$ solns. contg. SO$_4^{2-}$ ions accurately follows the law of mass action if the exptl. procedure excluded errors due to absorption. The soly. product remains const. at $4.25 \times 10^{-4}$ over a wide range of ionic concns.


By using 2 identical ionization chambers 20 cm. in diam. contg. CO$_2$ under 10 atm. pressure connected to the same electrode and leaf system, an app. following the principles of Rutherford and Chadwick’s $\gamma$-ray method for the detn. of Ra is obtained which enables more accurate measurements to be made more quickly. The unknown sample is moved until its effect exactly balances the known and the scale reading observed. The refinements introduced make the method suitable for rapid measurements of av. precision.


Ra and U have recently been extd. from the ores of the Great Bear Lake region. The ore is crushed, roasted, pulverized to 35-mesh, boiled with HCl, filtered on a stone-wear filter, and washed with water. The residue contg. the Ra is treated with satd. NaCl soln. to dissolve the PbCl$_2$. A certain amnt. of Ba must be present before boiling with Na$_2$CO$_3$ to convert both Ba and Ra to carbonate. Filtering leaves the carbonates along with the SiO$_2$. The carbonates are dissoln. in HCl and Ba and Ra repd. as sulfates.

543 and the soln. is purified by the use of Ba(OH)$_2$. Ra and Ba bromides are sepd. by fractional crystl. U is recovered as Na salt, recovery beginning at the point where the HCl leach gives the U in soln.


The arc spectrum of Ra is studied in the region 3000 - 10,000 Å. The ionization potential is 5.776 v.


Equations are deduced from the general theory of thermodynamic potential and the activity theory of strong electrolytes, giving the effect of the compn. of the liquid phase on the distribution ratio and the dependence of the partition const. on the properties of the pure components. The relative importance of the various factors in these equations is discussed. The equations agree with exptl. data for the pairs Pb(NO$_3$)$_2$-Ra(NO$_3$)$_2$ at 25°, BaBr$_2$-RaBr$_2$ at 0° and Ba(NO$_3$)$_2$-Ra(NO$_3$)$_2$.


The Ra and Th contents of phosphorites were detd. by the emanation (sola) method.


A typical secondary anemia occurred upon injection of RaCl$_2$, red blood cells falling as low as 1/5 N. The injected rats gained weight more slowly than controls, and before death lost weight rapidly. There was a decrease in calcification in the central portions of all bones, a concn. of Ca salts in the parts of the bones nearest the joints, abscesses in the soft tissue around the mandibles, hyperplastic and astatic bone marrow, great destruction of lymphocytes in spleen and lymph nodes, and degeneration of certain glands. Analysis of the postmortem specimens showed that over 99% of the retained Ra was found in the bone ash, there being little difference in concn. in different bones. The organs dealing with Ca metabolism had a higher concn. of Ra than other soft tissues. Approx. 50-65% of the Ra injected was eliminated within a week; after that elimination went on at an approx. rate of 0.6% per week. At death the avg. retention was about 28%. A typical secondary anemia occurred upon injection of RaCl$_2$, red blood cells falling as low as 1/5 N. The injected rats gained weight more slowly than controls, and before death lost weight rapidly. There was a decrease in calcification in the central portions of all bones, a concn. of Ca salts in the parts of the bones nearest the joints, abscesses in the soft tissue around the mandibles, hyperplastic and astatic bone marrow, great destruction of lymphocytes in spleen and lymph nodes, and degeneration of certain glands. Analysis of the postmortem specimens showed that over 99% of the retained Ra was found in the bone ash, there being little difference in concn. in different bones. The organs dealing with Ca metabolism had a higher concn. of Ra than other soft tissues. Approx. 50-65% of the Ra injected was eliminated within a week; after that elimination went on at an approx. rate of 0.6% per week. At death the avg. retention was about 28%.


A Ra-Ba carbonate mixt. is heated to 400-500° in a high vacuum to effect selective dissocn. of the BaCO$_3$ and the BaO formed is leached out with water.

1934

1934

The Ba content was detd. by using the salt in an arc between highly purified Ba-free Cu electrodes. The intensities of the Ba lines from the salt were obtained by comparison with lines in the Cr I spectrum. The Ra salt contained 0.002-0.003 atom % Ba.


Complete details are given of a new detn. of the ratio RaBr₂/RaCl₂ leading to a revised atomic wt. of 226.05. The Ra salt contained 0.002-0.003 atom % Ba.


It is proposed to det. the relative order of α- and γ-ray emission from Ra by examn. of the absorption of the K-lines, excited by inner absorption of the γ-radiation, in Ti, Au and Hg filters. Absorption corresponding with the Ra spectrum would indicate emission of γ-radiation after loss of the α-particle. Preliminary results indicate emission of Ra K-radiation.


The amounts of radium detectable in carrots, barley, turnips, nettles, wheat, poppies, corn, and kidney beans were investigated. The quantity of radium measurable in fresh or dry crops varied with the value in the soil, as did also the amt. detectable in the ashes. The least amt. of radium was detectable in the fruits of the plant; the most was found in the leaves. No apparent effect was obtained from radium administered to the soil in small or medium doses; after strong doses, harmful effects were evident. Plants extract from the soil a fraction of the radium contained in it. For soils naturally rich in radioactive elements, the authors suggest investigations to determine if the quantities of radium carried into the living cells by vegetables may not produce harmful effects in time.


Ra naturally present or added to soils was taken up by agricultural crops to the extent of 0.0001-0.001 of the total per year. Crops grown on soils rich in Ra and used for food introduce appreciable quantities of Ra into the animal organism.


The dangers of the use of radioactive waters sold by nostrum vendors are pointed out. A dosage of 2 X 10⁻⁸ g. of Ra has been known to be fatal.


1934

Two methods show a marked decrease in the relative amts. of Ra from the center to the periphery of a crystal of BaBr₂ 2H₂O contg. RaBr₂.


Ra is sep'd. from Ba by pptn. with 10% K₂CrO₄ in the presence of 1.5% trichloroacetic acid. The method is applicable only in narrow limits in concn.


In a study made by Marques on the distribution of Ra in the solid and liquid phases, in the fractional pptn. of BaCl₂ in the presence of HCl, the conclusion was reached that the "partition factor", D, is a function of percentage of BaCl₂ pptd. However, the acidity of the soln. In this case varied and this variation might have affected the distribution of the Ra. P. repeated Marques' work by pptn. BaCl₂ from solns. of various HCl contents and then checked the results by crystg. equal amts. of BaCl₂ from supersatd. solns. contg. various amts. of HCl. He found that D is independent of percentage pptn. of BaCl₂, but is a function of the compl. of the phases, i.e., the acidity of the soln. in this case.


A new interpretation of the connection between the 2 groups of terms in Ra found by Rasmussen is suggested and confirmed by new observations by Rasmussen (privately communicated). Certain term designations are altered. The first ionization potential is 5.252 v.

1935


A Pb-lined container is described for transporting Ra.


A lecture reviewing methods for Ra detn.


1936


The possibility that the distribution of the radioactive isotope between crystals formed from a said. soln. of Ba(ClO₃)₂ to which the radioactive isotope had been added, and the remaining soln. might vary according to the isotope has been examined by crystg. Ba(ClO₃)₂ to which had been
1936

added Ra(Ra^226), AcX(Ra^226), and ThX(Ra^224) and detg. the activities of the products. No difference beyond expl. error was found.

562 Hulubei, H. "L Spectrum of Radium." Compt. rend. 203, 399-400(1936).

Of the L spectrum of Ba 21 lines (643.7_9 -- 1164.7_9) were measured.


Three addnl. (fainter) lines of the L spectrum of Ra were detd., also the absorption spectrum of which the 2 strongest discontinuities had been measured by de Broglie. Lastly the frequencies of 3L, 5M, 6N, 5O and 1P level, based on the expl. value of 1L, have been calc'd.


Numerous expnts. were carried out to det. the distribution of Ra between the liquid and solid phase when Ra-Bar chloride, bromide, sulfure, nitrates and carbonates were crystallized by cooling the satd. soln., by keeping the soln. at constant temp. with and without stirring and by fractional pptn. Under all these conditions the equation of Doerner and Hoskins apparently applies exactly. Secondary factors may modify the distribution found experimentally by yielding a nonuniform crystalline mass and then the equation of Berthelot and Nernst may apply. Solid solns. of salts of Ba and Ra and in general the solid solns. of isomorphic salts are not homogeneous mixts. of their constituents except in the very special case.


Three methods were used: photography, soln. of successive fractions, slow cryst. By each test there was a nonuniform distribution of Ra with a greater concn. in the center than in the surface of the crystals.


The chloride or bromide of radiferous Ba is dissolved in H_2O and the soln. allowed to evap. at 20° until the crystals formed contain about 60% of the original Ba. These crystals will contain about 99.5% of the Ra originally present. They are washed, redissolved in pure water and allowed to evap. until the crystals contain about 60% of the Ba of this soln. They will contain about 99.0% of the original Ra. This process can be repeated as often as desired. After 9 times the salt will contain about 1% of the original Ba and 95% of the original Ra. By this method only one series of crystals is necessary and the no. of crysts. is reduced.


1936

The solv. of Ra(NO_3)_2 in H_2O from 0° to 106° ranged from 0.009395 mol./l. to 0.00296. Its solv. in concd. solns. of KNO_3, Ca(NO_3)_2 and KIO_3 at 25° was detd. for different concns. of electrolyte. The limiting solv. of Ra(NO_3)_2 and the activity coeff. at different ionic strengths were calc'd.


The general features of radium poisoning as observed in human cases have been reproduced in rabbits by oral administration of radium sulfate. Jaw necrosis, a characteristic of the early acute cases among radium dial painters, can be produced experimentally by radium alone without menstruum. In the bone marrow striking changes are produced, consisting of an early hyperplasia of the erythropoietic elements followed by decreased maturation of erythroblasts and the replacement of these elements by myelocytes. Finally this hyperplastic marrow is gradually replaced by fibrous tissue. In the lymph nodes there is noted an initial stimulation of the stem cells with subsequent damage to these cells resulting in depletion and atrophy of the lymphoid tissue. In the circulating blood an absolute lymphopenia is found. The development of myeloid tissue in lymph nodes and spleen associated with the extreme myelocytic hyperplasia in the marrow suggests that the occurrence of leukemia in x-ray and radium workers may not be a coincidence.


Crystallographic investigation of RaF_2 shows it crystallizes in the fluorite lattice, C1-type with a lattice const. of a = 6.368 Å and d = 6.75. The ionic radius of Ra^2+ is 1.52 Å.


Measurement by the method described shows the unfiltered β-radiation to be 200 times as strong as the γ-radiation.


Adsorption isotherms for Ra ions at concns. from 10^-5 to 10^-11 mols./cc. on glass are given for various pH values from 3.0 to 7.0, and are linear when graphed in log-log terms. The log of the adsorption is also almost linear function of the pH, but falls more rapidly at pH less than 2.5. On the basis of these data, V. and S. conclude that the Guy theory for multivalent ions (cf. Frumkin, Ergebnisse der exakt. Naturw. 235(1938) is applicable to this case also.

1936

Russian language presentation of information in previous reference.

1937


The no. of neutrons emitted by a Ra-Be source (94.33 mg. Ra + 2 g. pulverized Be), to be used as a lab. standard, is 2.1 x 10^9 neutrons per millicurie Ra as detd. by the method of Amaldi and Fermi.


Tabulated data show the wide discrepancies in the results of expts. on the production of He by Ra from 1905 to the present time. The need for continued investigation is indicated.


This article contains the same information as the preceding reference.


1-1½ millicuries produced inflammation of the entire eyeball, particularly the ciliary and papillary regions. The end result was an extensive destruction of the retina as far as the pigment epithelium. No effect was produced by ½ mc. and only a slight one by ½ mc.


After fusing mixtures of BaSO₄ and BaCl₂ at 700-1040°, the Ba : Ba ratio is greater in the chloride than in the sulfate; the difference increases with increase in the fusing temp.


A method is described which is based on the production of the nuclear photo-effect in heavy H by mesothorium I, and in Be by Be. The results agree fairly well with those obtained by the emanation method.


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Acetone solns. of Ba⁺ and Ba(CNS)₂ were electrolyzed at 1 mg./sq. cm., with Pt, Au, Ni or Cu cathodes. Ag was best as anode. A thin adherent layer of Ba (as carbonate, etc.) 0.1 to 1 mg./sq. cm. was obtained. This layer was very uniform in structure and very fine grained. Ba was pptd. quantitatively. Mixts. of Ba and Ra iodides and thiocyanates behaved similarly, the 2 metals being deposited simultaneously. The thiocyanates are somewhat better to work with.


A study of the systems Ba-RaCrO₄, Pb-RaSO₄ and Ba-RaSO₄ reveals that the distribution of Ra between the solid and liquid phases attains true thermodynamic equil. If the solubilities of BaCrO₄, PbSO₄ and BaSO₄ are increased slightly by the method of slow crystn. with stirring. Numerous tables and soln. data. Forty-five references.


Ra resembles Ba very closely in many of its chem. properties. A difference greater than usual is found in the solv. of the chromates and carbonates of the two elements. The solv. of BaCO₃ at room temp. in a concd. soln. of (NH₄)₂CO₃ and NH₄Cl is about ten times greater than that of BaCO₃. The reaction, within very narrow concn. limits, may be used for the quant. separn. of the two elements. Some better results are obtained if the two reactions are combined. If the Ra soln. (not the reverse) is added at room temp. to a soln. contg. carbonate and chromate ions in the mol. ratio 23.6, BaCrO₄ ppts. quantitatively. Under analogous conditions, Ba ppts. quantitatively as BaCO₃. Ba-CrO₃ can also be partially converted to BaCO₃ by heating with 0.2% Na₂CO₃ soln., while pure BaCrO₃ remains unchanged. Neither of these reactions can be used to effect quant. separn. of the two elements from their mixts., as both the chromates and carbonates of Ba and Ra form solid solns.


Observations on animals given radium sulfate per os show that the radium is stored not only in the alveolar bone of the jaw but also in the teeth themselves, producing a pronounced alteration of the entire morphologic picture of the tooth. There is a marked disturbance in calcification, with resorption of teeth and the formation of anklylosis by the ingrowth of newly formed bone, which also replaces the absorbed bone of the alveolar process. The essential changes in the enamel organ consist of flattening and atrophy of the ameloblasts, with hyperplasia of the stratum intermediate and subsequent degeneration and necrosis of the entire formative structure. The normal pulp tissue is replaced by abnormal, irregular secondary dentine masses. The surrounding periodontium shows an extreme hyperplasia of fibroblastic tissue, with invasion of surrounding structures. The development of cysts arising from epithelial rests in this membrane is also an interesting finding.
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The extent of Ra adsorption by glass from RaBr$_2$ soln. contg. $5 \times 10^{-8}$ g. Ra/cc. apparently depends on the amt. of impurities present. In a carefully purified soln. the degree of adsorption remains const. in the range pH = 6.5 to 4.5. Further increase in acidity sharply lowers the adsorption, which becomes practically negligible at pH = 2.3. The data for slightly alk. media (pH = 7.9) cannot be compared with those for acid media because of the possible presence of colloidal particles (SiO$_2$ etc.) in the alkali used. Change in adsorption with time is greatly dependent upon the impurities present in the soln. and is probably due to the presence of complex colloidal particles on which Ra is adsorbed.


Expts. on the leaching of Ra and U from klaprothite reveal that the leaching of Ra in neutral, slightly acid, and alk. media is considerably greater than that of U.


For Ra-Ba solns. rich in Ra the crystn. coeff. of RaBr$_2$ (concn. of RaBr$_2$ in ppt./concn. of RaBr$_2$ in soln., as detd. by $\gamma$-ray analysis), detd. by evapn. of strongly acid solns. (4SN HBr) to incipient crystn., is 2.10. This value is approx. 1/7 of that found for very weak Ra solns.

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Ores or other materials contg. compds. of Ra are heated with a chloride to a temp. sufficiently high to effect vaporization of RaCl$_2$. The vaporized products are freed from dust, preferably by electrofiltration, at above 500$^\circ$ and then cooled to about 30$^\circ$ to condense RaCl$_2$, which is recovered, preferably by wet electrofiltration.


The efficiency of the pptn. of Ra in radiferous solns. of BaCl$_2$, on adding increasing quantities of sulfate ion (K$_2$SO$_4$) and varying the concn. of the Ba with respect to the Ra, is studied. By progressively increasing the quantities of the sulfate ion in a soln. of the chlorides of Ba and Ra the latter is preferably pptd. at the beginning. When the quantity of the sulfate ion exceeds a third of that of the equiv. quantity of Ba, the pptn. of the Ra becomes relatively less good. It is more complete in dil. solns. and reaches a max., when the mol. quantity of the sulfate ion is equal to a third of that of Ba present. By increasing the quantity of Ba in proportion to the Ra, the pptn. is less complete. In sea water, i.e., a soln. containing sulfate ion from the beginning, the addition of a very small quantity of BaCl$_2$ causes a great diminution of the Ra in soln. Its pptn. becomes practically complete, when the quantity of added Ba reaches a quarter of that of the equiv. sulfate ion present. On the other hand, when the mol. quantity of Ba exceeds that of the sulfate ion, a part of the Ra remains in soln. Likewise an excess of Ba tends to keep the Ra in soln. The presence of Ca salts, too, impedes the pptn. of the Ra.


The coeff. of fractionation (quotient of the ratios of micro compd. to macro compd. in the solid and in the liquid phases) for the pptn. of Ba-AcX(Ra$^{2+}$) iodate fromaq. solns. of the salts by means of KIO$_4$ increases with the concn. of the soln. (decreases with BaBr$_2$ above 2M) and with the strength of the anion at const. concn., and with the ionic strength of the soln. when other salts are present. The coeffs. of fractionation detd. in the above cases vary from 1.63 to 2.54. The results agree qualitatively with the theory of Rataver. The results of Polesitskii and co-workers are criticized.


Observations were made with a Ag counter to compare the effects of a rock contg. 0.2% of UO$_2$ and an artificial Ra-Be prep. with an energy of 0.3 millicurie. Approx. the same ratio of neutrons to $\gamma$-quanta was obtained from the rock as from the Ra-Be prep. The rock emits approx. one neutron per 2000 $\gamma$ quanta. From a rock with a radioactivity of about $10^{-2}$ g. U/G. about 2 neutrons/hr./cm.$^2$ of outer surface were to be expected, when fast neutrons were counted.


The preps. are sealed in glass tubes. The secondary $\beta$-rays excited by the $\gamma$-rays are passed through a Geiger-Mueller counter and then through Al screens 0.003-0.81 mm. thick and then into the 2nd counter. The variation in penetrating power of the $\beta$-rays from the 3 elements permits their
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detn. The method gives an accuracy of about 15%, in the best case, as compared with 1% when γ-rays are used, but it permits the use of concns. of the elements equiv. to 0.1 g. Ra. The electron absorption curves vary with the concn. of the elements, and if the concn. of 2 elements in a mixt. differs 10-fold, errors of 3 - 4% are introduced. Filtration of the γ-rays by a 2-cm. Pb filter increases the hardness of the β-rays. The distance from the prep. to the counter has little effect on the electron-absorption curve.


The author studied the radium content of the blood following intraven. inj. of 0.01 to 0.03 mg. in humans by means of photographic films. In some cases the Ra content dropped very rapidly on the 4th day. In others the drop occurred rather gradually. 2 mos. later there was still definite blackening of the film. Following subcut. inj. of Ra solns. the Ra content of the blood reaches its peak 24 hrs. later. During the first few days following the inj. the adrenals, bone marrow, kidneys, spleen, liver, lungs, pancreas, and uterus contain Ra. Several wks. later it is still found in the liver, spleen and bone marrow.


By measuring the emanation with a specially constructed Geiger counter it was possible to record the absolute amt. of Ra deposits, the distr. in the various tissues of the body and the emanation emitted. Very small amounts of radioactive substances, as little as 1 μg., in the body sufficed to produce irreparable damage. This could be explained by the intense biologic effect produced by the α-rays which were totally absorbed as well as by the complete accumulation.


The graph obtained by plotting the log of the at. no. of Mg, Sr and Ba vs. the log of the parachor is a straight line. Parachor detd. were 57.7, 85.8 and 106.2, resp. The at. parachor of Ra found by extrapolation was 140.


The best values for at. wt., disintegration const., half-life, no. of α/sec. are, resp.: for U 238.10, 1.51 x 10^-10 yr^-1, 4.58 x 10^8 yr, and 1.21 x 10^4; for Ra 226.07, 4.38 x 10^-10 yr^-1, 1.59 x 10^8 yr^-1, and 3.7 x 10^4.

597 Ollano, Z. "Production of Photo-Neutron by a Ra-Be Source." Nuovo cimento 15, 541-50(1938).

The number of neutrons emitted by a Ra-Be source is determined by a method developed by Amaldi and Fermi in which the density of neutrons of thermal velocity is measured at different points with a Rb detector and calibrated Geiger-Mueller counter when the source is surrounded with water. The average cross-section for the nuclear photo-effect of the harder γ-rays of RaC in Be is found as (2.0 ± 0.3) x 10^-27 cm^-2, in good agreement with measurements of Dementi and Frisch and their co-workers (see Nature 140, 865(1937) and Physik. Z. Sowjetunion 12, 764(1937)).


The neutron yield of a Ra + Be cell is compared with that of a Rn + Be source and is found to be about 83% of the latter. This difference is due to the fact that the α-particles emitted by Ra have a smaller energy. Furthermore the contact between solid salt and Be is less intimate than in the case of the gas.


Results obtained at 0° and 24° are in good agreement with Rater's theory. At 78° and 100° some deviations were observed, probably because equil. was not attained. The true distribution coeff. 1m, calcd. from the expit. values of the distribution coeff., D, was nearly const.


Ra is extd. from torbernite, and less easily from khlopinit. When the minerals are allowed to stand in H₂O for long periods of time. Under these conditions almost no U is extd., although at high temp. in acid solns., in which the crystal structure of the mineral is destroyed by soln., the amt. of U extd. increases. Ra extn. is proportional to surface area of the mineral. When several extns. are made of the same mineral sample, the amt. of Ra extd. is less in the later extns. Ra extn. is increased when ions are added to the soln. The order of their activity is H > Ba > Pb > Ca > K > Na, but the last 3 are only slightly active. ThX(Ra²³⁵) is easily extd. from minerals by H₂O, but radiothorium is not affected.


From the theories of scattering, photo-absorption and the creation of pairs, the total absorption coeff. for the λ corresponding with the various components of the γ-radiation of Ra are calcd. and, with the help of expit. intensities of these components, the absorption curves for Al, Fe, Cu, Sn and Pb are found. Results are in agreement with the absorption measurements of Kohlrausch.

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The test plants were the pea, lettuce, cucumber, flax and oat. They were grown in water and sand cultures supplied with the necessary nutrients and with varying concs. of Ra,
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U, and Ac containing radioactive elements. The absorption of these elements is discussed.


Finely divided Ra–Ba salts of higher fatty acids are homogeneously dispersed in molten paraffin so that a practically single-phase product results on congealing.


When neutron sources composed of Be powder mixed with a Ra salt are prepared commercially, it is sometimes desirable to determine the actual amount of Ra in such a source by γ-ray comparisons with a Ra standard. To do this it is necessary to know the amount of absorption of γ-rays within the source and its container. To compute this correction, a knowledge of the absorption coefficient of the Be powder is required, and the equations involved are difficult to work with in the case of a cylindrical source such as is commonly used. Therefore, this internal adsorption has been determined experimentally for a source contained in a brass cylinder of 6-mm. internal dia. and 24.5-mm. internal length with wall 1 mm. thick. This cylinder contained a mixture of 1,257 mg. of finely powdered Be and RaSO₄ (130.7 mg. of Ra). From measurements made in the usual way with a γ-ray electrometer with 1 cm. of lead filtering, the absorption correction was found to be 5.1%.


Expts. with Ra lasting for 100–105 days gave an av. of \(3.8 \times 10^{-12}\) cc./He/g Ra/sec.; this corresponds to the emission of \(5.67 \times 10^{10}\) α-particles/sec./g. Ra and to a decay const. of \(4.35 \times 10^{-4}\) years⁻¹. These values are in good agreement with the results of detns. by other means.


A stream of air is bubbled at a const. rate through or over the Ra contg. prepns. into an evacuated ionization chamber. After about 25 min., a steady state is reached in which emanation is carried over as fast as formed, and from a measurement of the amt. of emanation carried in a given time, the amt. of Ra present is readily calcd. The method is less time-consuming and nearly as accurate as the older methods.


A variety of commercial photographic and X-ray films were exposed under conditions simulating actual shipping conditions at several distances from a standard 250 milligram radium capsule enclosed in its lead carrying case. The exposures required in each case to produce a density gain of 0.07 were determined and a table was constructed giving the permissible transit times for each kind of film when 15 feet from the radium unit. These values are at the least several times those permitted for the same conditions by present railway express regulations.


Peas (pisum sativum) were raised on Helriegel's solution with an addition of solutions containing \(1.45 \times 10^{-11}\) to \(1.45 \times 10^{-10}\) g. of Ra (as RaCl₂) repeatedly checked by the emanation method. To another series were added solutions containing \(4.73 \times 10^{-9}\) to \(4.73 \times 10^{-8}\) g. of U (as uranic nitrate). Ra penetrates into all parts of the plant in a concentration proportional to the concentration of Ra in the nutrient medium. U could not be found in the green parts. Plants grown in weak U solutions had taken up the U almost quantitatively in the roots. In those grown in solutions containing 100 times more U the amount in the roots had only tripled.


A penetrating radiation from Ra was previously supposed to consist of mesotrons. It was shown to be due entirely to γ-rays excited by neutrons in the Pb protection around the counter, in the brass wall of the counter, and in the air inside it.


The accuracy of so-called emanation methods of detg. Ra in rocks is discussed.


Comparison of the number of neutrons emitted/sec./m·c. by two sources composed of mixtures of Ra salts with Be revealed a significant difference which was traced to faulty mixing in one case.


A soln. of a Ra or RdTh salt is mixed with a neutral soln. of 0.8 g. BeCl₂ in 200 ml. H₂O and also with approx. 2 g. of metallic Be. A soln. of NH₄OH (contg. some Na₂SO₄ in the case of the Ra salt) is added with vigorous stirring. After 15 min. the ppt. is filtered off, dried at 110° and then ignited at 300°. The resulting powder of Be + BeO is placed in a gilded metallic tube and carefully soldered shut to avoid any diffusion of Rn or thoron. Compared with the usual Rn + Be source, the Ra prepns. has an intensity of 0.8; that of the RdTh prepns. is 1.2.
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The distr. of radium in various tissues was detd. in 3 cases of radium poisoning. The normal radium content of the human body is 1.5 x 10^-5 g. A dose of 1.5 x 10^-5 curie-hrs. will alter metabolism. The lethal dose is one γ of radium equivalent.


W. reviews his previous studies on ThX(Ru²⁹) and benzene poisoning and their effects on the circulating blood and the hematopoietic organs. An extensive bibliography is listed.

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The ratio of γ-radiation of the new Ra standard to the old is 1.023, thus 2.3% higher than the ratio of their weight, which amounts to 1.021.


The yields of flax, peas, alfalfa and cucumbers were considerably increased by the addition of small amounts of Ra, U, Th and Ac to the nutrient solutions. As the Ra and U contents of the nutrient solutions were increased, the content of the plants in these elements also increased. The absorption coefficient, however, was not the same in nutrient solutions of different concentration. Ra and U were best absorbed from solutions in which they were present in the smallest amounts. Ra was absorbed during the whole vegetative period, although the most intensive absorption occurred during the period of blooming and fructification. The positive effect of the radioactive substances on the plants was evident chiefly in the production of more seed and an acceleraterion of the maturing process. Ra, U and Th are usually present in soils in amounts which are large in comparison to their consumption by plants, although there are soils on which an increase in yield can be obtained by the addition of Ra, U and Th.


Mathematical. A method is devised for correcting for self absorption.


In the syncretin, 2 salts possessing a common ion, the fractionation is conditioned by the differences of properties of the 2 substitutable ions. The coeff. of fractionation is defined and measured experimentally in this study. It is the quotient of the ratios of the concns. of the 2 components in the crystal phase and in the soln. when the quantity of material crystd. is sufficiently small so that the compn. of the soln. remains practically unchanged during crystn. The study of the triple mixed system of the sulfates of Ba, Sr and Ra has a very practical significance. It is proposed to use Sr in place of Ba for the extn. of Ra from minerals. Sr is capable of giving mixed salts with Ra, and it can be sept. much more easily than Ba by fractional pptn. of their sulfates.


The form and preparation method for RaTh-D and RaTh-Be neutron sources used is indicated. Cross section measurements with these sources and comparative values for Ra-Be source are given for 36 elements.


With neutrons extd. from Be by γ-rays of RaTh, the ratios of angular intensities are found to be: I₉₀/I₀ = 1.75 ± 0.04 and I₉₀/I₀ = 1.03 ± 0.05; identically, for photo-neutrons (RaTh + D), extd. from D₂O, the corresponding ratios are, resp., 1.71 ± 0.04 and 1.05 ± 0.06. These distributions are contrasted with the spherical symmetry of the angular distribution of photo-neutrons (Ra + Be).


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Heated crystals show an intensity several hundred times that of unheated crystals. A max. temp., however, exists, above which the intensity again diminishes. This max. temp. is not related to m.p. or cryst. form.


Add. of sulfates and carbonates that form solid solns. with R₂SO₄ and BaCO₃ results in a decrease in the emanation power of the solns. Addn. of Cu or Bi to ZnS or CaS phosphors reduces their phosphorescence. Two different emanation absorption exptns. show the effect to be due to formation of large centers around the heavy metals.


It is usually assumed that neutron production from Ra-Be and Ra-Be sources is proportional to γ-ray intensity. By assigning the highest proportional yield of neutrons a value of
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1. values of 0.88-1.00 were found for 4 Ra-Be sources (9.87-200 mg.), and 0.58-0.78 for 2 Ru-Be sources (60 and 30 mc.). A serious error may be made by assuming neutron yield to be proportional to γ-ray intensity.

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626 Drobkov, A. A. "Effect of Radioactive Elements (Ra) and Rare Earths (R) upon Yield and Rubber Content of Kok-Saghyz." Compt. rend. acad. sci. U. R. S. S. 32, 687-9(1941).

Plants were grown in 10 kg. of pure sand with rare earths (as nitrate) added in concentrations of 2.5 × 10⁻² and 2.5 × 10⁻² mg. and radium (as chloride) 10⁻⁷ and 10⁻⁷ g., and in addition a normal solution of HCl and a solution of MgCl₂, 10 g.

MnSO₄. At rosette formation all plants were given N, P, and K. With no boron and manganese in the HCl solution, root yield and rubber content is low. A small increase of root yield occurs in the presence of rare earths, but a 72.2% and 101.82% increase in rubber content with the two concentrations. Radium is more effective than rare earths in increasing the yield, but less effective on rubber content.


G. investigated the spectrum of photo-neutrons Rd-Th + Be and Ra + Be by filtering of these photo-neutrons through paraffin slabs of various thicknesses. By this filtration it was shown that neutrons of the first reaction are monochromatic; however, their energy is approx. half of the generally accepted value, i.e., 0.45 mev. instead of 0.86 mev.

Photoneutrons from the 2nd reaction consist mainly of 2 groups with energies of 0.1 and 0.25 mev. The energy of the latter group produced by γ-rays with energy of 2.2 mev. is also found to be less than the accepted value of 0.49 mev. by approx. half. It was also found that in the spectrum of γ-rays of RaC there exists, until now unknown, a weak line with the energy of the order of 3 mev. Filtering of the photo-neutrons mentioned above to give monochromatic conditions is achieved only by surrounding the detecting device with the requisite amt. of paraffin; omission of this leads to erroneous conclusions in the various measurements with these emissions. In both reactions after removal of neutrons from the compound nucleus of Be, there is left a nucleus Be⁸ which then splits into 2 α-particles.


By filtration through paraffin layers of various thicknesses it was found that the photo-neutrons (Rd-Th + Be) are monochromatic and possess an energy of about 0.85 mev. The photo-neutron spectra of Ra + Be contains two groups with energies of 0.1 and 0.5 mev. The scattering cross sections of silicate are measured by these 0.1 and 0.5 mev. photo-neutrons differ considerably. For the Rd-Th + Be photo-neutrons σ × 10⁴ is 4.2 cm.; for the Ra + Be neutrons σ varies from 3.8 to 6 cm. paraffin spheres to a minimum of 1.6 for 13 cm. spheres, and then again increases to 2.6 for 20 cm. spheres.

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Several Ra-Be and Ru-Be neutron sources are compared. On the basis of the usual assumed ratio of γ-ray activity to neutron production, the Ra sources vary in efficiency by a factor of two, and the Ru sources by 15%. Sources manuf. under similar conditions compare more favorably. For the Ra source, the mixing, the size of the Ra grains and the purity of the Be are important. The geometrical shape of the source and the abs. amt. of Be are not especially important. For the Ra sources, it is in addn. especially important that the container be as full as possible, with not little space as possible occupied by the gas alone. The contribution of photo-neutrons is about 0.2 of the total emission.


MsTh and Ra isotopes can be sep. from Th, Pb, Bi and most other common contaminants by taking advantage of the low volatility of the chlorides of the former in a stream of HCl + CCl₄ at 800°. A 1-hr. treatment volatilizes 80-95% of the RdTh and practically 100% of the ThB, as well as some of the ThC, from active BaSO₄. BaSO₄ is changed quantitatively to BaCl₂ and remains with Ra and ThX(Rd²⁶⁺) in the residue. Hexachloroethane is formed from the CCl₄ but can be evapor. readily from the distillate. If the active Ba compd. is BaBr₂ or BaCl₂, the CCl₄ need not be used. At 500° a current of HCl carries away 30-40% of the ThB per hr. from BaCl₂, while RdTh remains quantitatively in the residue; however, no addn. ThB is removed after a 3-hr. treatment. To sep. the isotopes of Pb from RdTh it is best to volatilize the ThB, RaB and RdTh at 900° and then remove the first 2 from the 3rd at 500°. The
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volatilized materials can be collected in water or, preferably, in a trap cooled with liquid air. RdTh is adsorbed strongly on the surface of etched glass, and to a smaller extent on glazed porcelain; it can be removed by rubbing with filter paper wet with a soln. of HF. Less common contaminants (Al, Fe, SiO₂ etc.) are also volatilized in the current of HCl-CCl₄; by use of this property Ra adsorbed on hydrides of Fe, Al, Th, etc., can be recovered. To obtain RdTh systematically from conc. prepns. of MsTh it is convenient to keep the latter in a porcelain boat; after 3 months, when the optimal accumulation of RdTh is present, the boat is placed in the furnace for 1-1.5 hrs. to remove the RdTh and is then allowed to stand for another 3 months.


The slowing down of the photo-neutrons from 100 mg. Ra + Be, 100 mg. Ra + D₂O 10 mg. RdTh + D₂O, and Y + Be were studied by the method of Amaldi and Fermi, using an In detector. The number of neutrons from this source surrounded by Be as measured by the integral under the Amaldi-Fermi curve was compared with the number of neutrons from Ra + Be measured in the same number. This ratio was approximately equal to the ratio of the hard gamma-ray intensities of these sources (as measured through 0 mm. of Pb). This is in agreement with the result that the energy of the γ gamma-rays, 1.67 ± 0.06 mev., is intermediate between the energy of the Ra gamma-rays responsible for photo-neutrons. An attempt was made to determine whether the 2.2 mev. gamma-ray of Ra gives any appreciable contribution to the neutrons from Ra + D₂O. A comparison was made between the curves for Ra + D₂O and RdTh + D₂O and Ra + Be. Curves for both C and D neutrons were studied but no evidence was found for low energy neutrons produced by the 2.2 mev. gamma rays.


A review of recent studies on poisoning by benzene, CS₂, TNT, tetryl, Pb, Hg and Ra, methods of treatment and precautionary measures. Thirty-two references.

634 Wolf, P. M. and Born, H. J. “The Distribution of Naturally Radioactive Substances in the Organism after Parenteral Administration.” Strahlentherapie 70, 342-8(1941).

Expts. on rats revealed that the ThX(Re²⁸) content of the blood decreased very rapidly after intravenous injection of ThX in isotonic soln. contg. Ca and in the complex org. form as pyrocatecholdisulfonate. ThX was therefore, rapidly excreted or taken up by the tissues. In the organs most of the ThX was found in the kidneys, intestines and skeletal parts. The greater part of the ThX in the intestines was excreted. In spite of the high content in the kidneys, however, only 1% was excreted in 24 hrs. in human beings. The distribution of ThX in the organs differed from that of ThB, evidently because of the difference in chem. nature. Further expts. showed that ThX was taken up by the tissues more rapidly after administration in complex form than when administered as the ion.

1941

635 Wolf, P. M. and Born, H. J. “The Degree of Purity of Thorium X Preparations.” Strahlentherapie 70, 349-51 (1941).

Long-lived radioactive substances are injurious to health when introduced into the organism and must be removed from the short-lived substances. After the use of the sepn. processes of W. and B, the short-lived ThX(Re²⁸) still contains 0.05% radiothorium (I). After the administration of 2-3 mg. ThX, 6-7.5 x 10⁻⁹ g. I is retained in the human body; this, in contrast to Ra, however, has a half-life period of (?) only 1.9 years and is, therefore, not harmful. For the sepn. of ThX from (I) a faintly acid (HCl) soln., which contains Fe and Th in admn. to (I), is rendered faintly ammoniacal. Upon filtration ThX passes into the filtrate, while Fe, Th and I are retained on the filter. More ThX can be obtained from the ppt. by resoln. and repptn.

1942


The number of neutrons emitted by a Ra-Be source was measured by integrating the thermal neutron activity of a standard detector in a water tank. It was found that the number of neutrons emitted by Source II (10 g. of Be mixed with 1 g. of Ra) is 14.0 x 10⁶ neutrons/second.

637 Anderson, H. L., Fermi, E., Roberts, J. H., and Whitaker, M. D. The Number of Neutrons Emitted by a Ra-Be Source [Source I]. University of Chicago. March 21, 1942. (MDCC-880; C-21)

Three Ra-Be n-sources of from 0.84 to 1.16 g. Ra each were measured using a BF₃ proportional counter and a carbon moderator (5 ft. thick). Values of 1.24 and 1.25 x 10⁵ m/g. Ra were obtained. Calculation methods are discussed.


Discussion of training of operators and use of 200 mg. Ra capsules for radiography.


Protection against radium involves the use of long forceps or other instruments, lead shields, min. time of exposure, and the use of an exposure meter employing a Geiger-Müller tube counter (described) to check the exposure under changing conditions and to det. safe areas.

1942

Part II describes Ra-Be source consisting of Ra capsule at one end of Al tube with Be block at opposite end. Dimensions and n/mC Ra given.


This article describes processes used for the leaching of various radium ores, methods for the determination of the radium content of a salt or ore, and the separation of the radium salt from mixed barium and radium salts by fractional crystallization. Several flow sheets are given.


Three exposures, 1 with the Ra prep., to be measured and 2 with a standard prep., are made on the same strip of film, being placed behind a Pb filter of 5 mm. thickness. The portions of the film not exposed at the time are shielded from radiation by Pb blocks of 20 cm. thickness. The standard exposures should be approx. 10% higher and 10% lower than that of the prep. measured, to obtain a relationship between d. and exposure. The actual content in mg. of Ra element can be calc. by a formula which is based on a linear relationship between the photographic darkening obtained and the exposure. Comparative results of the photographic and ionization methods are given, showing differences between +1.5% and -4.6% in the measured content.


Various well known examples of Ra poisoning are described. On account of its relation to Ca in the periodic table Ra can replace Ca wherever found in the animal organism. From its point of fixation in the body Ra exercises destructive effects upon the tissues, mainly by virtue of its disintegration products. In small doses the destructive effects are frequently not noticed until after long periods of time, sometimes as long as 10 years. The physical effects of the several disintegration products are described, as are the various means of measuring the radioactivity of samples and the several routes by which radium or its emanations may enter the human body. One of these is the breathing of Ra emanations. Charcoal, silica gel and Permutite were tried, without marked success, for absorbing these emanations. A detailed method is described for exam. of urine, blood, etc., for Ra emanations. Various diagnostic means and a quantitative method for estg. the amts. of Ra in the body and in cadavers are described. Various means of preventing Ra poisoning as prescribed by the safety precautions of the Association of Chemical Industry in Germany. A review of the literature is included.


A 36-yr.-old man received during the period Jan. 21, 1925, to Nov. 24, 1930, a grand total of 440 γ of Ra chloride intravenously for Hodgkin's disease. Successive roentgenograms of the dorsal spine taken from Sept. 1936-Aug. 1941 showed destructive lesions at first attributed to Hodgkin's disease but later found to be due to Ra poisoning. Since Apr. 1937 the development of radiocrescents of the jaw was observed. This case constitutes one of the very few instances in which adequate data exist on the amt. of Ra injected, and on the amt. retained after a period of about 15 yrs. The fractional retention amounted to 11.4 γ of the total amn. of 440 γ or 2.5%.

1943


The intensity of a radon-boron neutron source was compared with a radium-beryllium neutron source (1 g. Ra + 3 g. Be). It was found that, reduced to equal gamma ray intensity, the neutron intensity of the two sources has a ratio of about 4 in favor of the radium-beryllium source if the intensity is measured by the (n,p) reaction in phosphorus, fast neutron fission or integration of the thermal neutron density in a water tank. It was found that the radium-beryllium source excites the 25 minute period of iodine two or three times as strongly as the radon-boron source, if the two sources are so normalized as to give equal fast fission counts in a uranium fission chamber. The impression is conveyed that radium-beryllium neutrons excite, in general, radiative capture more strongly than radon-boron sources.


Ra compds. are made to react with solns. of alkylene-diaminotetraacetic acids (C₅ to C₆) or with halogenated and (or) oxygenated derivs. of these acids, or with alcali or NH₃ salts of these acids. The complexes formed are pptd.


A soln. of Ra and Ba salts is made alk. by addn. of Ba(OH)₂ and is then treated with Ba amalgam, with care to maintain a sufficient tension to avoid soln. of the Ba contained in the amalgam.


Solns. of Ba salts are electrolyzed with a Hg cathode at c.d. lower than 15 amp./dm.². The amalgam obtained is decomposed by means of dil. acids, water, or solns. or suspensions of Hg compds.

649 Cauchois, Y. "Experimental Determinations by (X-ray) Crystal Spectrography of the Inner Atoms which are Multiple Ionized in Inner Shells." Compt. rend. 216, 801-4 (1943).

The positions of the X-ray satellite lines of the L series of heavy elements (with respect to the parent lines) are accounted for in terms of the multiple ionization of inner atomic shells. Energy values are tabulated for Pt, Au, Ti, Pb, Bi, Ra, and Th.
1943

1943

An intercomparison of Ra standards leads to the conclusion that the accuracy of these standards has been overestimated.

1944

1944

A discussion of the preparation of BaF2, which lead to the subsequent preparation of RaBeF2, is given. Information of the efficiency of a RaBeF2 source, as well as the preparative method, is included.

1944
654 Bretschler, E., French, A. P., Martin, G. R., and Poole, M. J., Determination of the Number of Neutrons Emitted by a Radium-Beryllium Source, Ministry of Supply, Great Britain. Decl. 1944. (BR-382)

A comparison was made between the activities induced under suitable conditions in manganese by a Ra-Be source and by a D-D source. The total neutron emission of the D-D source is derived from ionization chamber measurements. From these measurements the estimated strength of the Ra-Be source (.5 g.) is $5.4 \times 10^{10}$ neutrons per sec.

1944
655 Feld, B. T., Neutron Distribution in Paraffin, Argonne National Laboratory. February 24, 1944. (MDCC-1437)

Information on the relaxation length of Ra-Be, Ra-B (n, n) and Ra-Be, Ra-D (y, n) source neutrons is given. The n-emission (pure y) of Ra-Be is reported as $7 \times 10^7$ n/sec. for a 2 g. Ra source. (This document is a declassified portion of CP-1389).

1944

1944
657 Hoecker, F. E., "The Rn/C0 Ratio as an Index to Excessive Ra Absorption," J. Ind. Hygiene Toxicol. 26, 281-8 (1944).

Several methods of breath sampling are described and compared. The preferred method is the partial inflation of a 20-l. meterological balloon by the exhalation of occasional breaths during normal respiration. The detn. of the Rn/C0 ratio must be based on breath samples taken over as long a period of time as possible and under circumstances which avoid respiratory disturbances. Factors which disturb the Rn/C0 ratio in exhaled breath are discussed.

1944

The term "fixed" as applied to Ra in the body is ambiguous: this term should be defined in terms of the rate of elimination. The effect of internal Ra depends on quantity and time. Since the quantity and period of retention, and, therefore, the eventual danger depend on the rate of elimination, the detn. of the rate of elimination should furnish valuable data on the potential danger of internal Ra, 12 references.

1944
659 Monk, A. T. and Allison, S. K., Computed Values of X-Ray Lines and Limits for the Trans-Uranic Elements, University of Chicago, Sept. 6, 1944. (AECD-2263)

Values of lines and limits also included for Ra.

1944
660 Physicaliach-Technische Reichsanstalt, Catalog of Radium Content. Correspondence on the Analysis for Radium of Various Materials. ALSOS Mission, Dec. 1939-June 1944, 204 p. (PB-18576)

Binder containing reports on analysis of various radioactive materials, notes on delivery, sales, etc.

1944

Detailed description of the procedure whereby (1) a 700 mg. sample of RsSO4 (0.5 g. Ra), in which the long-life disintegration products had accumulated for 5 years, was transformed into the chloride by fusion with an equimol. mixt. of Na2CO3 and K2CO3 and a subsequent treatment with HCl, (2) the active deposit of slow evolution was extd. by pptn. with MgS, with Cu as carrier, and (3) an intense source of neutrons was prepared by mixing the RaCl2 intimately with finely powd. metallic Be.

1944

X-ray energy level diagrams tabulated for Ra, Th, and U. Proposed scheme for Pa also included.

1944

The absolute intensities of the y-rays emitted by a radioactive source may be detd. with an ionization chamber if its coeffs. of efficiency, K, are known as functions of the energy of the incident photons and the no. of disintegrations in the source. All that is then needed to det. the no. of photons emitted by the disintegration is a measurement of the ionization current. Expts. with the radiation from RaBr2 through screens of air, Al, Si, A, Pb, etc., are described in illustration of the calibration of a particular ionization chamber, of which the construction is given.

1944
1944
An app. of very simple construction for extn. of radon from Ra solns. is described. It employs a Hg diffusion pump to circulate the gas through the purification tubes, whence it is compressed into a storage bulb for filling ampoules. An initial filling of the app. up to 500 mm. Hg pressure requires 5 to 8 min.; and compression in the storage bulb 15 min. From 97 to 99% of the gas is recovered. Irradiation of the operator is reduced to a min. owing to the simplicity of operation of the app.

On the assumption that a true compound containing radium and beryllium would constitute a more reproducible neutron standard than the mechanical mixtures of radium sulfate and beryllium powder used hitherto, three samples of RaBeF₄ were made. This standard was found to be reproducible to within the limits of experimental error (better than 0.5%). Its yield in neutrons/second/g. was found to be (1.84 ± 0.07) × 10⁹. A simple technique for the calibration of Ra + Be neutron sources is described.

1945
The first chapter of this report deals with neutron sources, the first seven pages having to do with self-contained sources. Ra-Be, Ra-Be, Po-Be, Na₂⁵-Be, Mn₂⁵-DO, Mn₂⁵-Be, Ga₂⁻, D₂O, Ga₂⁻, Be, In₂⁻, Be, Sr₂⁵-Be, La₂⁵-DO, La₂⁵-Be, and Y-Be sources are treated as are several general rules for calculating n-emission.

A discussion of the electroscope, Geiger-Muller counter, and radon methods for measuring Ra, and of the field of application of each. The radon method is suitable for samples of 10⁻⁴ to 10⁻¹⁴ g. of Ra. Any radon method of analysis requires considerable experience for operation, should be run continuously with frequent checks of background and standard samples, and requires at least one experienced person’s full time to maintain equipment in operating conditions. The method requires an operator with an understanding of electronic circuits, such as high-gain amplifiers, or trigger circuits. In view of the fact that such equipment actually requires continuous operation to secure reliable results, in those situations where samples are measured at intervals of several weeks, the cost is prohibitive. Much better results, at lower cost, can be achieved by sending such samples to a lab. maintaining the required app.

357 proton recoils in a photographic emulsion from a Ra-Be mixed source were measured. The effect of the thick lead shielding used was estd. and corrected for by tests with Po-Be source. The energy distribution from the Ra-Be source is given. Test results are tabulated and illustrated by diagrams.

The stable reagent is propd. by mixing 0.5 g. cyanuric acid, 10 cc. NH₃ soln., and 20 cc. distd. water, and shaking frequently for 5-10 min., warming slightly if necessary. After complete soln., add 20 cc. water, mix, and let cool. Mix 1 drop of reagent with a drop of the salt soln. (0.1-4.0%) on a glass slide, or add it to the dry residue from the salt soln., or to a very small particle (0.2-0.3 mg) of the solid compd. If crystals do not form readily, the mixt. should be stirred with a fine rod. Examine the crystals under a 130-50 magnification without covering. The crystal forms are described.

In the absence of radioactive elements no nodules were formed on the roots of peas growing in water culture and no N was fixed even when the medium contained B and Mn and was inoculated with root-nodule bacteria. The addition of Ra to the culture promoted the development of nodules and increased plant growth. The plants assimilated nearly twice as much N as a result of fixation as the Ra-free controls, even when normal doses of N were contained in the nutrient soln. The optimum dose of Ra was 10⁻⁴ g. per l. of nutrient but the plants could stand 10 and 100 times greater doses.

The number of neutrons emitted by a standardized beryllium-radium photo-source has been determined by means of the helium method. The value found is considerably larger than would be expected from Feld and Fermi’s neutron measurements in 1941: one gram of beryllium at a distance of 1 cm. from one gram of radium emits 53,000 ± 800 neutrons per second, as compared with Feld and Fermi’s value of 30,000. The absolute neutron standard (in Montreal) of 600 mg. of radium in a standardized beryllium capsule was found to emit 3.03 ± 0.09 × 10⁷ neutrons per second.

The excellent agreement of calibrations based on the Paris and Vienna standards must be regarded as a fortunate coincidence as the two sets of masses used for weighing the RaCl₂ had not been compared with the standard kilogram.

1945

Weiss' loss of faith in the reliability of the international standards is unwarranted. However, it is suggested to define future standards by the ionization they produce rather than by their wts.


The measurement of Ra content by the γ-ray method involves correction for the absorption of the radiation in the wall of the container and in the radioactive material itself. Corrections are detd. for cylindrical containers made of Pt-Ir, Au, Au-Ag alloy and monel with wall thicknesses up to 2 mm. and external diams. up to 8 mm. Absorption measurements in powd. materials are described. Empirical formulas are derived; the results provide a basis for estg. absorption in Ra salts. Salt-absorption corrections are discussed. Eqptl. absorption in powd. materials in detd. for: UO₃, Th₂O, Th₂O₃, pitchblende, UO₂, PbO, BaSO₄, ZnS, S, MgO, and C. Mass absorption coeffs. are given for: RaSO₄, RaBr₂, RaCl₂, and RaCO₃. Application to radioactive luminous compds. is discussed, in particular those employing ZnS. Applications to Ra concentrates are discussed and to Ra and Be neutron sources.

1946


Detailed description of the procedure whereby (1) a 700-mg. sample of RaSO₄ (0.5 g. Ra), in which the long-life disintegration products had accumulated for 5 years, was transformed into the chloride by fusion with an equimol. mixt. of Na₂CO₃ and KC₃CO₃ and subsequent treatment with HCl, (2) the active deposit of slow evolution was extd. by pptn. with H₂S, with Cu as carrier, and (3) an intense source of neutrons was prepd. by mixing the RaCl₂ intimately with finely powd. metallic Be.


Data on lethal dose, harmful amounts, and elimination studies for humans and animals. Tissue distribution studies. Extensive bibliography.


Information on the smpl. procedure for Ra from U plant sludges and from pitchblendes at Trebicher, Chemische Werke A.-G. Flow sheet, discussion of per cent recovery, cost of raw materials, sources, inventories, history of company, and customers. Brief letters and statements throughout report.


1945

The number of neutrons from a half-gram Ra-Be source (No. 44) has been measured by a method proposed by O. R. Frisch. The measurement consists in finding the volume integral of the neutron absorption rate in a boric acid solution. This absorption rate is determined with the use of thin manganese and indium foils, standardized by means of a boron trifluoride counter. The ratio of the absorption cross sections of boron and hydrogen for thermal neutrons enters as a correction term in the determination of the source strength, Q. This ratio was measured during the course of this experiment, and a value of 2270 obtained, as compared with 2360 found by H. Kubitschek at Chicago. The number of neutrons (Q) from source No. 44 was found to be $5.92 \times 10^8$ neutrons per second, with an estimated probable error of 5 per cent.

1946


The method comprises simultaneous detn. of true α-activity of a powd. sample and detn. of its emanation. This procedure permits detn. of not only the radioactivity of a sample but the approx. content of Ra, AcX(Ra⁹⁵) and ThX (Ra²¹⁴). The α-activity is measured 3 times; the tested powder is placed on a dish in a certain thickness. For the 2nd measurement more sample is added to double the thickness and for the 3rd thickness of the sample is tripled. If the sample contains Th it should be kept in the α-app. for 5 min. in order to attain Tn equil. The ionization current results are plotted by putting the no. of layers on the abscissa and the ionization current on the ordinate. The resulting straight line is horizontal if there is little emanation. If the sample emanates considerably, the line is inclined. The true value of α-activity for an infinitely thin layer is obtained by extrapolating the inclined line to an intersection with the ordinate. The effect of Tn is of ionization in the app. Ionization induced by Tn stabilizes within 15-20 sec. while that induced by Tn intensities for 5 min. An app. for detg. emanation is described. After Tn is detd. Ra is detd. in the usual way. The results are calcld. by the equation $Tb/U = ThX/(Ra \times 3 \times 10^9)$.

680 Bernstein, S. Experimental Nuclear Physics. Neutron Standardization. Clinton Laboratories 1946(?). (M-3533)

The discussion includes data on the strength of Ra-Be sources and methods of determining source strength (absolute and relative). References are included.


Report of experimental therapy on man with a Ra content of 2 μg. Urine tests indicate some success. Discussion of changes in rat mean corpuscular hemoglobin after Ra ingestion.

682 Bystrov, E. N. "The Determination of AcX from its Emanation in the Presence of Considerable
1946


An air stream is passed at moderate velocity through the active sample of ThX (Ra226) and AcX (Ra228) and then through two ionization chambers of 1600 ml. each which differ in electrostatic capacity and sensitivity. The air speed is adjusted so that the α-activity caused by Th will be the same in both ionization chambers. Since only the difference in ionization currents in the two chambers is detected, the apparatus is now insensitive to Th. Any measured current is due to An, which decays completely in the first chamber. With an air-stream velocity of 104 cc/sec., sensitivities of 6 x 10⁻³⁴ g./division/min. for Th were attained.

683


684


685

DeMent, J. "Fluorescence of Radium Burns." Science 102, 631 (1946).

686

Evans, R. D. "Evaluation of the Beta and Gamma Radiation Due to Extended Linear Sources of Radium." J. Ind. Hygiene 28, 243-56 (1946).

687


Apparatus and procedure for assay of radium in solution by an emanation method are described. The radon produced by the radium in a measured time is transferred with a stream of argon into an alpha ionization counting chamber. Interchangeability of emanating flasks and ionization chambers provides economy of time and apparatus and flexibility of operation. The use of a free-electron gas with a relatively low-frequency amplifier makes small amounts of electron-attracting gases and vapors in the chamber tolerable. Methods for calibration of the apparatus determination of the operating characteristics and corrections, and interpretation of results are described. Chemical procedures for obtaining solutions suitable for de-emanation from several types of radium containing materials are described. (See also item 731.)

688


The effects of the parenteral administration of radium chloride on the hematological constituents of the peripheral blood of rats, mice, and rabbits have been studied. Intraperitoneal and intravenous doses of from 0.005 to 0.94 µc./g. have been given to rats; intraperitoneal doses of from 0.000068 to 0.085 µc./g. to mice, and intraperitoneal or intracardial doses of from 0.0016 to 0.1 µc./g. to rabbits. There appeared to be no significant species difference in the sensitivity of the hemopoietic systems of the rat and mouse to radium, but rabbits appeared to be slightly more resistant than the other two species. Also, CF-1 female mice appeared to be somewhat more resistant than ABC male mice, but whether this was a strain or sex difference has not been ascertained. In the rat, mouse, or rabbit no significant hematological alteration occurred after an injection (by any route) of 0.01 µc./g. or less of radium chloride. A dose of 0.02 µc./g. produced an anemia and sustained leukocyte reduction in rats. A dose of 0.03 µc./g. resulted in a severe recurrent anemia in ABC male mice (but not in CF-1 females), comparable changes in heterophil levels in both strains, and in an initial moderate reduction in lymphocytes in the ABC male mice. Doses as high as 0.1 µc./g., however, failed to produce an anemia in the rabbit, but did cause a mild, early, persistent reduction in leucocytes. A dose of 0.04 µc./g. in the rat resulted in an initial reduction in reticulocytes with subsequent overproduction and in a marked reduction in platelets with only moderate recovery. Morphological changes were seen in the nucleated cells of the peripheral blood after radium administration. These were largely comparable to those previously described in animals following the external application of radium such as X ray, γ-rays, and fast neutrons, or internal radiation in animals following the parenteral administration of plutonium. As evidenced by an increased erythrocyte diameter and increased mean corpuscular hemoglobin, macrocytosis became apparent in rats, mice, and rabbits after the parenteral administration of doses of radium between 0.1 and 9.2 µc./g. 33 references.

689


Ra and Ba can readily be separated by chromatographic adsorption on AlO₃ using a radiometric detector. Activity on elution of preps. a few days old it is found that about 50% of the Ra remains on the alumina column. This is not due to ordinary adsorption of the Ra on the Al₂O₃ but is due to a "rebound" effect of the Ra formed from adsorbed Ra. A similar effect is found on adsorbing radioactive Pb(Tb); it can be desorbed only with great difficulty.

690


This chapter has several sections on radium with extensive references at the end of each section.

691


The most important period in defining the fate of radium in the animal body is that closely following administration, providing the material is readily available to the body fluids. This period is demonstrated in rats by the rapid disappearance of radium from the blood after intravenous injection and by the rapid uptake of radium from the peritoneal cavity as indicated by blood concentration curves following intraperitoneal administration. The excretion of intraperitoneally administered radium in rats and mice was very rapid and
reached such a low value within 10 days that further excretion had a negligible function in determining the final retention. There exists a linear logarithmic dependence of per cent of injected dose excreted per day on time. More of the excreted radium was present in the feces than in the urine. The retention of radium, administered intraperitoneally to rats, mice, and rabbits, increased concomitantly with dose level. There exists a linear logarithmic dependence of per cent retention on dose level. Three possible explanations for this effect are offered. In rats and mice, intraperitoneally injected radium was found to cause calcification of some of the soft tissues. The effect was noted in high incidence in the aortas of both species. In rats, calcareous sites were also found in the pylorus, liver, peritoneal wall, the region of the upper gastrointestinal tract, and, occasionally, in the testicles. In mice, the only other observed site of calcification was on the trabecula. Calcification of the soft tissues in rats was often accompanied by pathologic lesions throughout the abdomen and a high radium content in the viscera. The evaluation of the weight data in rats and mice, of the injected to control animals shows simple quantitative relations between weight effects and amounts administered or retained. On an equivalent roentgen basis, X-rays appear to be somewhat more effective in producing weight loss than radium. Evidence is presented to show that there exists a linear logarithmic dependence of mortality on retained microcuries of radium.

1946


A method of treating ores containing uranium, vanadium and radium is described. The ores are reduced mechanically to a relatively fine divided state, and the reduced ores are treated with a solution of an alkali carbonate. Heat and agitation are used to insure the complete dispersal of the radium and uranium. The treated ores and solutions are washed with upward flowing currents of water to separate the solution and suspended fines and floating slimes from a residue of coarse sand grains. The washed solution and its fines and slimes are treated with an acid sulfate until the solution is rendered acid. A solution of a metallic salt is then added to precipitate an insoluble sulfate form of the metallic component of the salt and to take suspended fines and slimes out of solution and thereby leave a clear supernatant solution and a sludge precipitation. The clear supernatant solution is separated from the precipitate mechanically. The supernatant solution is then treated with a caustic alkali base to precipitate concentrations of uranium, radium and vanadium compounds and to produce a basic alkali solution. The basic solution is reactivated for re-use in the washing of the treated ores. The sludge remaining with the residue of coarse sand grains for further concentrations of the remaining vanadium content by salt roasting.

1947


Discussion of prep. of luminous paints primarily from ZnS and Ra. Information on source of Ra, amount on hand, sepn. method for Ra from U, Ra-Ba sepn. method used was fractional crystallization.

1946


A review. The excitation levels and transitions and the intensity and energy of the different rays are given for the 3 natural radioactive families — radium, thorium, and actinium. 52 references.


Two methods have been developed for the estimation of radium in preparations containing insignificant amounts of Pb, Bi, and Po. One method is based on the counting of alpha particles from radium after sufficient aeration of a radium solution to remove radon and permit the decay of the short-lived disintegration products. This method is applicable to pure solutions of radium and its decay products. A second method, which may be applied to biological materials, requires the coprecipitation of radium with barium sulfate after radon has been removed by heating the radium in solution. The radon and short-lived daughters reach equilibrium within the barium sulfate crystals. After a sufficient period of growth, beta rays from Pb and Bi are counted and compared with standard samples. Large errors may be encountered in the latter method, due to self-absorption, unless one measures and corrects for the solid content of the capsules. A modification of the coprecipitation procedure with barium sulfate permits the analysis of biological or other materials containing excessive amounts of inert ash. The beta method has been successfully applied in the analyses of urine, feces and whole carcasses of rabbits, rats and mice.


Brief information on prep. of Ra containing metal foils for protection. Foils applied to Ag by powder metallurgical techniques.


1947


A suspension of Be in an aq. soln. of RaBr₂ is evaporated to dryness. The solid is heated to about 200° to drive off all water, after which it is pressed in a hydraulic press to yield a compact, strong pellet of a density of 1.75 g./sq. cm. The pellet is enclosed in a brass container of 1/16 in. wall thickness. The yield of fast neutrons varies with the masses of the constituents as follows: yield = 1.7x10⁻⁶ Mₐ(H₂O + M₂₂₅) n/sec./g. Ra.

Progress is reported on the following problems: surface dosage measurements of plutonium (Pu239); absolute activities of P239, Sr258, Sr260 and C14; and determination of radium in the body.


Brief information on deposition sites and tumor formation caused by Ra injections in mice, rats and rabbits.


In this report an account is given of experiments performed at Columbia University in November 1941 on certain properties of the photo-neutrons emitted by beryllium irradiated with gamma rays from radium. The slowing down of the photo-neutrons in graphite was investigated by taking activity measurements of indium detectors inside a graphite pile in which the source was included and the slowing down properties were expressed in terms of a two-range formula. Also the number of neutrons emitted by the photo-source was measured by comparison with a Ra-Be source of known intensity.


The explt. data of Kabakjian have been analyzed to det. whether the lattice defects are directly responsible for the phenomenon of luminescence. Plotting the intensity of luminescence vs. temp. shows that the dependence is of the exponential type. The calc. values of the disorder energies are: RaBr2, 10.7 ev.; RaSO4, 2.5 ev.; BaBr2, 4.7 ev.; and two values for BaCl2, 1.5 ev. and 0.49 ev. The nearly const. value of the intensity of luminescence of anhyd. RaBr2 at about 450° and below is attributed to the relatively high value of its disorder energy. In the case of BaCl2 it is suggested that either there are two different disorder energies for the two C1 ions attached to the same Ba ion, or that one of the C1 ions is evaporated away while the other goes into interstitial positions.


The specific alpha activity of radium has been determined by counting the alpha particles emitted by aliquots of weighed radium chloride samples in a high-speed parallel-plate ionization chamber of known counting yield. A special method was devised to correct for the alpha activity of radon and its daughters, which has heretofore been the chief deterrent to the use of this direct method for radium. The measurements yielded a specific counting rate of 1.1448 ± 0.0009 x 1014 counts per minute per gram of radium. Taking the counting yield as 0.515 ± 0.003, this corresponds to a specific activity of 3.086 ± 0.028 x 10 alpha disintegrations per second per gram and to a half-life of 1622 ± 13 years. (See also item 735.)


1947

Radial distribution of Ra-α-Be neutrons about an approximate point source in water were determined by means of In foil activations. Values for migration area derived from the data are: for all activating neutrons, 54.6 cm²; for In resonance neutrons, 45.4 cm².


The abs. evaluation of a neutron flux is measured by the He produced by the reaction: Be20 + n → He4 + Li7 if the fraction of the neutrons captured by B is known. However, difficulties arise in measuring ~ 10⁶ cc. of He if the gas is depd. from large vols. of other substances. An indirect procedure was used: the neutrons were captured in Mn as well as B mixed in an ag. soln. to establish the ratio of Mn activity to B-Be production. A large vol. of the soln. was exposed to the Ra-Be neutron source, the γ-activation was measured and from this amount of He produced during the source irradiation could be calc. A brief description of the lab. procedure is presented. Calc. of the no. of neutrons emitted per sec. from a Ra-Be source was made from the equation: 

Q = \( V_{Ra-Be} \times N_γ \times d_{B-Be} \times (I_m / I_{Mn, Z}) \) 

where \( V_{Ra-Be} \) is the vol. of He in cc. at S.T.P. produced by the pile irradiation, \( N_γ \) is a const. depending on units, \( I_γ \) is the fraction of source neutrons absorbed in the soln., \( I_m \) is the length of time of irradiation, both of the source and in the pile, \( m/M \) is the fraction by wt. of the pile-irradiated soln., that, when roughly mixed with similar inactive soln., yields a measured γ-activity proportional to \( I_m \). \( I_γ \) is proportional to the γ-activity of the source-irradiated soln., and \( Z_m / Z_γ \) denotes the ratio of total neutron capture to capture by the B. The Ra-Be source designated by the lab. as No. 38 contains 504 milli- curies as Ra based on RaBr2; the mass of the Be is 300 mg; the no. of neutrons emitted per sec. Q = (5.5 + 0.4) x 10⁵.


The distribution of a salt (e.g., RaSO4) present in minute concns. between a solid (e.g., BaSO4) and its soln. is detd. thermodynamically. The relation among the equations of Ratner, Imre, and Paneth and Thimann is shown. The true distribution const. depends on the heats of soln., the activity coeff., and the works of transfer, e.g., of RaSO4 from pure RaSO4 into a solid soln. in BaSO4.


Section 4.6 contains information on the method of measurement of Ra226 half-life which is reported to be a 38 sec. α emitter.


The large difference in the yield of neutrons when Be and D are bombarded with the γ-rays of Ra compared to that
obtained with Radium is used as the basis of the method. The photo-neutrons obtained from Be and D with an unknown mixture are compared with those obtained from known standards. The number of neutrons was determined by retarding with the aid of paraffin, activating Ag, and counting the \( \beta \)-rays thus evolved. By measuring the total emission of the original sample, the amts. of Radium, Molybdenum, and Radium can be obtained.


Excretion of radium following intraperitoneal injection was studied in three groups of strain C3H mice. Two groups were given British Anti-Lewisite as a possible means of increasing the elimination rate. In addition the radium content of a few organs of selected mice of the first group was obtained. An average 19% of the injected radium remained in the mouse at death. The average elimination rate in the chronic stage agrees well with that found by other observers.

The radium was found to concentrate in the bone immediately. It was not eliminated from the bone rapidly as it was from most of the soft tissues, notably the spleen. Moreover, the lungs contained very little radium, whereas in the experiments of Evans et al., the lungs were the richest soft tissue. BAL had no effect on the rate of elimination. 10 references appended.

1948

710 Anderson, H. L. *Neutrons from Alpha Emitters.* University of Chicago, December 1948. (NP-751)

This report contains a discussion of many neutrons sources based on Po as an \( \alpha \) emitter. Yields, energies, and measurement methods are discussed. The yield of neutrons from many substances with \( \alpha \)'s of several energies is tabulated. The preparation and properties of Po-B and Ra-Be sources are discussed at length.


Finely powdered beryllium metal is mixed with a solution of radium bromide which has been freed of radioactive decomposition products by boiling. The mixture is formed into a cylindrical pellet, slightly more than three-tenths inch in both height and diameter, in a press capable of applying pressure above ten tons per square inch. This pellet, tightly sealed in a brass cylinder, becomes the source of the desired neutrons.


Information on protection of personnel against Ra hazards.


1948

Studies made in rats injected with RaCl\(_2\). Results show effects to be almost entirely on the phosphatase-forming elements of the bone.

1947


Investigations on CF-1 mice. Studies of femurs and vertebrae of 100 animals given single dose of Ra or Pu two months prior to sacrifice. Ra dosed mice showed atypical fibrous bone. Cortical bone of the shaft contained many empty lacunae.


The source consists of 100 mg. Ra, enclosed in glass, surrounded by a monel tube 1 cm. long, 4.85 mm. outside diam., with 1 mm. walls. With this source a solid cylindrical block of Be 1.8 x 1.5 in. is irradiated; the axis of the Ra source is 4 cm. above, and parallel to, the upper face of the Be cylinder. This reproducible neutron standard emits \( 62 \pm 7 \) n/mC. Ra/sec. When the distance between the axis of the Ra source and the face of the Be cylinder is varied, the distances and relative neutron intensities are: 1 cm., 2.35; 3 cm., 1.52; 4 cm., 1.99; 5 cm., 0.716; 6 cm., 0.567. A Ra-\( \alpha \)-Be source yields 6,800 n/mC. Ra/sec.


Pile irradiation of Ra\(_{226}\) yields Ac\(_{227}\). The \( \alpha \) energy for Ra\(_{229}\) is referred to as 4.701 mev.

717 Hagenmann, F. *Isolation of Actinium(Ac\(_{227}\).* Argonne National Laboratory, Feb. 1948. (AECID-1933)

Discussion indicates that Ac\(_{227}\) is prepared from Ra\(_{226}\) by the reaction. Ra\(_{226}(\alpha,\gamma)\) Ac\(_{227}\) \( \gamma \) (inv.) Ac\(_{227}\) in a quantity indicating a \( \gamma \)-capture cross-section of 18 to \( 20\times 10^{-26} \) cm.\(^2\) for Ra\(_{226}\). (Upon repetition of experiment, value of \( 14\times 10^{-26} \) cm.\(^2\) was obtained.) The results for Ra\(_{226}\) based on work of Peterson.

718 Houtermans, F. G. and Teucher, M. "The Number of Fast Neutrons Emitted from a (Ra-\( \alpha \)-Be) Source." *Z. Physik* 124, 700-4 (1948).

The number of neutrons above the fission threshold energy of 1 Mev emitted by a (Ra-\( \alpha \)-Be) source was found to be \( 3800 \pm 1000 \) sec./mC, i.e., about 50% of all neutrons emitted. The experiments were made using an ionization chamber, lined with UO\(_2\), which was connected to a linear amplifier having a resolving time of approximately 1 usec.

1948

The heat of formation - \( \Delta H \) of a compd. from the elements in the standard states, divided by the valency W (standard-state heat of formation per g., - equiv.) is proportional to the logarithm of the product of the at. nos. Z of the elements. It was found that, from linear plots of \( \Delta H/W \) against log Z, interpolation or extrapolation of unknown - \( \Delta H \) values were permissible. For series RaCl\(_2\) and HCl, the value - \( \Delta H(\text{RaCl}_2) = 230 \) k cal./mole is predicted.


Continuation of study reported in preceding article - \( \Delta H(\text{RaO}) = 150 \) k cal./mole is predicted.


By use of a Wilson chamber with ordinary pressure or under reduced pressure, a study of radiation showed with the normal-pressure type that some beta-rays (less than 3 disintegrations) are attributable to the disintegration of MoV6 (Ra\(_{26}\)), the energy of these rays being less than 15 kev. With reduced-pressure type the number of electrons attributable to MoV6 is 15% at 20 cm. of initial pressure and 16% at 10 cm. Experimental conditions show beta-rays of energy as low as 1.5 kev. which have a course of 5 mm. at initial pressure of 10 cm.


Detailed description of the Ra measurement method with Ra in soln. Methods for dissolving Ra bearing ores, boil out of Rn, method of detn. of Rn, apparatus diagram, etc. (pages 24 to 28).


Method for calculating activity of Ra salts and Ra salts in equilibrium with disintegration products.


Histological survey.


The utilization of selective adsorption capacities of ion-exchange resins in a multistage system is described. Selective absorption of a portion of the ions in a through-going soln. by an exchange cell and regeneration by the acidified output soln. of a previous cell comprise a repetitive cycle for the continuous sepn. of the fractions. Application of the method to a pilot plant for the concn. of Ra-Ba mixta. is discussed.

1948


By the use of a high-capacity cation-exchange resin (Dowex 50), the Ra in a soln. contg. 20 mg Ra, 20 mg Ba, and 20 mg Sr, including Ba and Sr tracers, is essentially completely sepd. from Ba and Sr. The compn. of each fraction of the effluent was detd. from the \( \alpha \), \( \beta \), and \( \gamma \)-ray activity and Al absorption and decay curves of radioactivity. Explnt. conditions and a table and graph showing the compn. of the eluate fractions are given. The method is suggested both for com. sepn. and quant. analysis of Ra.

1949


A method is described for the determination of the absolute intensity of a neutron source, being a modification of the procedure of Gamertsfelder and Goldhaber (Phys. Rev. 69, 368 (1945)). A solution of MnSO\(_4\), used as a moderator, fills a spheric container in the center of which is placed the Ra-Be source; the activity of the stirred solution gives the relative number of neutrons absorbed; by taking this measurement at two different concentrations of the solution, the absolute number of neutrons is obtained. It was found that a 1 mc Ra-Be source emits 6.300 ± 7.5% neutrons/sec., a result which agrees with those obtained by some of the other methods.


A rapid method of assay for radium in solution based on the precipitation of radium with barium as carrier and counting of its \( \alpha \) particles, is described. In sulfate-free solutions (Ba, RalC\(_2\)) is precipitated with concentrated hydrochloric acid and ether. In sulfate-containing solutions (Pb, RalSO\(_4\)) is first precipitated, followed by a (Ba, RalC\(_2\)) precipitation. The chloride is converted to the sulfate on a Pyrex disc for counting \( \alpha \) particles in a parallel-plate ionization chamber. The method is general for all \( \alpha \)-emitting radium isotopes, sensitive to \( 10^{-12} \) g. Ra\(_{26}\), and accurate to 3-10%. It separates radium from all other \( \alpha \)-emitting substances accompanying it in nature. Applications to uranium ore process solutions are described. The method is found suitable for certain control problems in which knowledge of approximate radium concentrations is required in 30-60 min. In this application the sensitivity is limited by interfering activities to \( 10^{-10} \) g. Ra/ml.


Radium injected into mice intraperitoneally at dose levels of 0.3 and 0.03 mc/g, and plutonium, 0.03 and 0.003 mc/g.
given intravenously, produce an overgrowth of bone in the femurs and vertebrae. In the femur this overgrowth begins in the distal metaphysis and is more extensive there than in epiphysis or shaft. This atypical bone, surrounded by gelatinous marrow, fills the metaphysis and encroaches on the marrow of the shaft, which is also invaded by new bone from the endosteum, and, in the extreme cases, the two processes combine in some areas to obliterate the marrow. The bone formed after radium treatment is atypical and fibrous, and much of it becomes devitalized. The cortical bone of the shaft also contains many empty lacunae. After plutonium treatment the newest bone is also fibrous, but the greatly thickened trabeculae of spongy bone becomes progressively more compact, although the extremely irregular arrangement of lamellae and osteocytes distinguishes them from normal bone. Empty lacunae are fewer than after radium. Early changes of an atypical proliferative nature were seen in 3-month specimens after radium and in a 7-month specimen after plutonium, and may represent early sarcoma or a predisposing state. Resorption of the necrotic bone does not seem to have occurred. Infraction of the marrow was seen in two of the radium- and one of the plutonium-injected animals. The changes in the vertebrae are essentially like those in the femurs.


Radium beryllium fluoride (RaBeF₂) is proposed as a new form of Ra-α-Be neutron source, for adoption as a standard. Three such sources have been prepared and calibrated; they give a neutron yield which is proportional to the Ra content to within 1/2%. Details were given of the techniques used in the preparation and standardization of these sources; probable errors in the calibration are discussed. 10 references.


This reference is identical to item 687.


The distribution of radium was studied between the fused mass of the following isomorphous salts and their crystals: barium nitrate, lead nitrate, lead sulfate, and strontium nitrate. It was found that in all cases the distribution follows the Berthelot-Nernst law. The distribution coefficient in these systems is less than one, or equal to one, which shows that, at temperatures of the order of 300-400°, the fused mass is enriched in radium, or, in other cases, the microcomponent is distributed about equally between the fused substance and the crystals.

1949


It is shown that the kinetic ion exchange between a solution and the surface of a crystalline phase is always hampered by substances that lower the surface tension. This is seen in the slowing down of the process, the time required for the establishment of the equilibrium being longer in all cases when substances lowering the surface tension are present, than it is in their absence. If such a substance forms a difficulty-soluble compound with the crystal ions, its presence not only slows down, but can actually suppress the kinetic ion exchange reaction; this is true in cases involving the exchange of ions of the adsorbent, as well as in those of adsorption of isomorphous ions, or co-crystallization of isomorphous substances. Effects of this kind are produced by salts of humic acids; therefore, the current method of quantitative determination of radium by co-precipitation with barium sulfate in a water solution rich in humic substances, can lead to serious errors if no special precautions are taken. In an experimental study on the adsorption of radium on lead sulfate, it is shown that correct results are obtained if both the absorbing suspension and the saturated solution are prepared in the presence of the substances which should be present in the subsequent process of primary ion adsorption.


K₃SO₄, crystg. from a melt of 0.5 g. K₂SO₄ 7 g. KNO₃, contains Ra (5 × 10⁻⁸ to 9 × 10⁻⁶ g./g. K₂SO₄) in conformity with the law of Berthelot-Nernst, the crys. coeff. D = x (100 - y)/y(100 - x) (where x = % Ra occluded in the crystals, y = % of K₂SO₄ cryst.). remaining const. = 0.065. Presence of small amts. of Al⁺⁺ (in the form of dehydrated KA(SO₄)₂) lowers D considerably; thus 0.3 mg. Al suppressed the occlusion of Ra altogether. Consequently, the occlusion of Ra is of the same type as that found in crys. from soln.


This reference is identical to item 703.


In 1947 the activities of the primary Vienna standards prep. in 1911 and 1934 agree well with calc. values. Secondary standards prep. in 1911 show a deviation of less than 0.2% when compared by use of Curie plate condenser, Wulf γ-ray electrometer, and Wulf radiation chamber. The objections of Weiss against the reliability of standard Ra preps. are not valid.
1949  


The actual data concerning $\beta$-radiation of $\text{MsTh}$ (Ra$^{228}$), although somewhat contradictory and incomplete, have been studied and obtained by means of a Wilson cloud chamber. The selection of initial products of $\text{MsTh}$ and the procedures of chem. purification were taken into account in the disposition of $\text{MsTh}$ and, in nos. of disintegrations, 0.8 per 100 of Ra and less than 0.5 per 100 of ThX (Ra$^{230}$). The expts. considered were of some duration. It is first necessary to det. the proper radiation of the $\text{MsTh}$. These studies have been performed by use of the Wilson chamber at pressures varying between ordinary pressures and 10 cm. of Hg. Thus it is possible to det. that: (1) the $\beta$-spectra of $\text{MsTh}$ shows 2 components with intensities gradually becoming equal, these two components blending at approximately 60 kev. The total no. of $\beta$-rays for disintegration of $\text{MsTh}$ is about two. There is no simultaneity in the emission of the radiation belonging to the two components. (2) The disintegration of $\text{MsTh}$ accompanies the emission of a band of $\beta$-rays of weak intensity, only 15 electrons per 100 disintegrations. The energy of these radiation varies between 1.5 and 18 kev. The spectral distribution of these radiation appears to indicate the presence of two or three lines of 3.7, and perhaps 12 kev., which implies the secondary origin of these lines.

1949  


In a previous article on the spectrum of the radiation emitted ThX$^{228}$ + Ra$^{226}$ (ThX) (Rosenblum et al., Compt. rend. 229, 385 (1949)), the existence of a fine structure in the magnetic alpha spectrum of ThX was indicated. The previous experiments have been repeated using almost pure samples of ThX, separated from a Th$^{232}$ source by a method described in detail. A plot of the spectrum is given and it is seen to consist of three components. The energy of one of the components has already been determined (Proc. Roy. Soc. (London) 236, 638(1933)). The other energies may be calculated from this value. It is found that the intensities of the different components are in good agreement with the theory of Gamow.

1949  


The most common $\alpha$-source neutron source is Ra-Be. Also used are Po sources, which have the advantage that they emit only weak $\gamma$-radiation. Properties of photon-neutron sources are tabulated. In using neutron sources containing Ra, protection against $\gamma$-radiation is more important than against neutrons.

1949  


A preliminary study has been made of the thermal neutron fission properties of several naturally occurring radioisotopes. Limits on thermal fission cross-sections have been determined as follows: $\text{Ac}^{235} < 2 \times 10^{-16}$, $\text{Ra}^{228} < 100 \times 10^{-24}$ cm$^2$, $\text{Ra}^{236} < 2 \times 10^{-24}$ cm$^2$. Fission measurements were made in the thermal column of the Argonne heavy-water pile. The procedure for the separation and purification of the several isotopes measured are briefly described.

1949  


While studying the magnetic $\alpha$-spectrum of RaTh, the authors found two lines, whose intensities were 15% and 0.4% of that of the ray of RaTh; these lines belong to ThX formed during the exposure. The difference $\alpha_2 - \alpha_1$, ThX is 245 kev; von Bayer, Hahn, and Meitner (Physik. Z. 16, 6 (1915)) mention a $\gamma$-radiation of 250 kev, which is attributed by them to ThX. The present authors determined $\text{H}_{36\alpha}\text{Th}_x\text{H}_{2\alpha}\text{RaTh} = 1.0079$ and $\text{H}_{4\alpha}\text{Th}_x\text{H}_{2\alpha}\text{RaTh} = 1.0236$; since the energy of $\alpha_2$, ThX is 5681 kev. (Briggs, Proc. Roy. Soc. (London) 139, 638(1933)), the values 5423 and 5538 kev. are obtained for the energies of $\alpha_2$, RaTh, respectively; the difference, corrected for the recoil, is 86.7 kev. The intensity of the line $\alpha_1$ is $39 \pm 1\%$ of that of $\alpha_2$.

1949  


A theoretical treatment of the diffusion of ions in crystaline silicates is followed by reports of studies on the diffusion coefficients of Pb$^{2+}$ and Ra$^{2+}$ in potash (microcline) and sodalifeldspars (albite) at different temperatures. The use of radioactive tracers makes it possible to study diffusion processes with much higher accuracy than by the earlier methods. RaD(Pb$^{2+}$) and RaBr$_2$ were used in the studies; the latter as the source of Ra$^{2+}$. It is shown that the diffusibility depends on the crystallographic directions and that Ra$^{2+}$ diffuses more slowly in all directions in albite than in microcline perlite at the temperatures investigated. From measurements of the distribution coefficient resulting from diffusion the following results were obtained: The potash feldspar distribution coefficients for Ra and RaD, respectively, were 1.045 and 1.87; the sodium feldspar distribution coefficients for Ra and RaD, respectively, were 1.3 and 1.15. It was also shown that diffusion anisotropy seems to increase with increasing temperature.

1949  

Teucher, M. "On the Primary Spectrum of Fast Neutrons from Ra-$\alpha$ + Be Source, and on Their Inelastic Collisions in Be, Bi, and Pb." Z. Physik 126, 410-21 (1949).

The inelastic scattering of fast neutrons in Be, Bi, and Pb was studied with the aid of a Ra-$\alpha$ + Be source occupying the center of a sphere made of the absorbing material under investigation and placed inside an ionization chamber; the latter's walls were coated with uranium or thorium. The energy spectrum of the neutrons was determined by using the tracks of recoil protons in the photographic emulsion.

An extended series of measurements has been made to determine the possible variation in W, the energy to make an ion pair in pure argon, with the energy of the ionizing α-particle. The ionization in argon relative to the ionization produced by a comparison polonium α has been measured for the α emitters Ra224, Bi212, Po218, Po214, and Po212. For α-particles in the energy region from 5 to 9 mev., no deviation of W from the average W for the polonium α could be found amounting to as much as 0.5%. This is in marked contrast to the α ionization in air from the work of Stetter.


The n-standard, prepared by National Bureau of Standards, are Pt-Ir coated RaBr2 capsules in the center of Be metal spheres. Neutron emission is said to be 1.1 x 108 n/sec. Calibration, decay, and duplicate standard problems are briefly discussed.

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