Radioactivity.

BY P. W. ROBERTSON, M A , F.C.S.
(RHODES SCHOLAR.)

PERHAPS no scientific discovery ever aroused such excitement in the minds of men of science, and among people generally, as Radioactivity · for experimental results have been obtained that seem to be contrary to the law of conservation of Energy and the Atomic Hypotheses, which are the very foundation of modern Chen istry and Physics.

Radioactivity may be defined as the spontaneous emission of radiations capable of passing through substances opaque to ordinary light and having the power of discharging electrified bodies. In addition to this they are able to cause fluorescence and fog a photographic plate. This property is possessed by several elements and their compounds, more especially radium, and to a smaller degree by uranium and thorium, all of which elements are characterised by high atomic weights.

The original discovery of Radioactivity was made in the case of the uranium compounds by the French chemist Becquerel, in 1896. Two years later Schmidt and Mme. Curie discovered independently that thorium and its compounds had the power of emitting radiations of a similar nature. Mme. Curie then examined a number of compounds of uranium and found that they all were radioactive. But in the case of certain minerals the activity was greater than that exhibited by an equal amount of pure uranium. The mineral possessing this propperty in the highest degree was pitchblende, an impure oxide of uranium. Mme. Curie considered that this substance must contain some unknown element considerably more active than uranium itself. The chemical examination of pitchblende resulted in the discovery of two new substances of enormously high activity. One of these separated out with the bismuth, and received the name polonium. The other was found to remain with the barium which was co verted into its chloride. By fractionally crystallising this a great number of times, at last a minute quantity of a substance free from barium was obtained with an activity two million times that of uranium. This proved to be the chloride of a new element to which, in consequence of its characteristic property, Mme. Curie gave the name *radium*.

Radium chloride is slightly luminous in the dark, and its radiations produce intense luminescence on many substances, such as the mineral willemite (zinc silicate). In addition they are capable of exerting a powerful chemical action on many substances. Glass and even quartz is discoloured, yellow phosphorous is converted into the red non-inflammable variety, and iodine is rapidly liberated from iodoform. A solution of radium chloride in water causes decomposition in the same manner as electrolysis with the continuous liberation of oxygen and hydrogen. Radium compounds have a powerful physiological action. Unfertilised ova when acted on by the radiations develop without fertilisation by spermatozoids. The action of the radiations on the human skin is to destroy the epidermal tissues, producing a painful burn which takes a considerable time to heal. In consequence of this property, radium has been successfully employed in curing certain forms of surface cancer, but it has no apparent effect on deep-seated tumours

The most remarkable property of radium was discovered by M. and Mme. Curie, who in 1902 startled the world with the announcement that it maintains itself 5°F. in temperature above the surrounding objects. Thus radium continually emits energy in the form of light and heat.

The latest discovery in connection with radium is due to Ramsay and Soddy, who showed in 1903 that one of the products of the breaking down of the radium atom was helium, that peculiar element whose presence was recognised on the sun before it was known on the earth. This was fully confirmed by the experiments of Himsteat and Meyer in 1904.

The radiations which are emitted by radium are not homogeneous, but consist of three classes of rays. These have been named *Alpha*, *Beta* and *Gamma*, respectively after the three first letters ofthe Greek alphabet.

Alpha-RAYS.—These are characterised by having a feeble power of penetration completely absorbed in a few inches of air. Sir William Crookes showed that phosphorescence of zinc sulphide under the *Alpha*-rays, when examined through a lens, appeared as flashes or scintillations. The instrument known as the spintharioscope simply consists of a magnifying glass focussed on a screen of crystalline zinc sulphide, above which at a distance of about ¼ in. is a pointer holding a minute fragment of some radium preparation.

For a long time the exact nature of the *Alpha*-rays remained unknown, till Professor Rutherford in 1903 showed that they consisted of positively charged particles, since they were deviated in an intense electric field. Professor Rutherford now considers that these *Alpha*-particles are atoms of helium.

Beta-RAYS.—These produce a powerful fluorescence and act strongly on a photographic plate. They appear to be identical with the cathode rays of Crookes, that is they are electrous particles one thousandth of the weight of a hydrogen atom, bearing a negative charge and moving with a velocity almost as great as that of light. In consequence of the fact that they are negatively charged, these *Beta*-particles are deviated in an electric field like the *Alpha*-radiations, but to a greater extent and in the opposite direction.

Gamma-RAYS.—These are characterised by their extraordinary power of penetration, being readily detected after passing through five feet of water. They cause fluorescence and have a photographic action. When heated by the most powerful electric or magnetic fields, they remain undeviated ; in this respect they resemble the *X*-rays, though they have a far greater penet ating power. Recent experiments by Rutherford have shown that the *Gamma*-rays are caused by the expulsion of the *Beta*-particle and that the two types of radiation are proportional to each other.

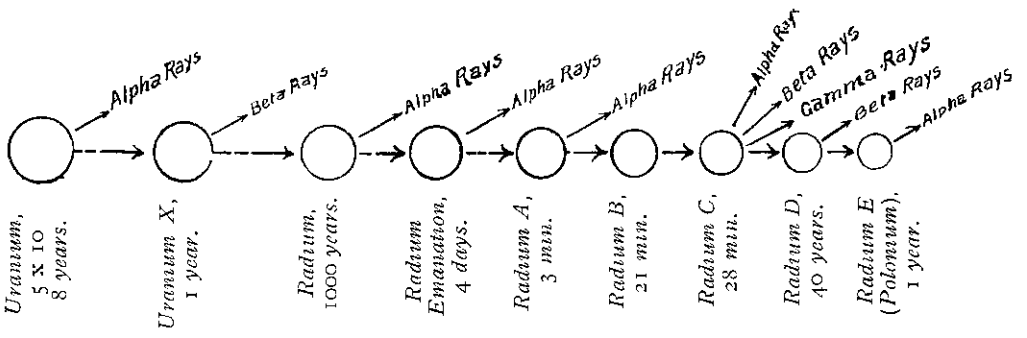
As the radiations are emitted from the radioactive elements fundamental changes occur and new substances are produced. Thus in the case of uranium the first product of the change can be separated by heating a uranium salt with excess of ammonium carbonate, when a slight precipitate is obtained many times more active than the original uranium. This is known as *Uranium-X*, and Becquerel has shown that in a year it loses its power of radiation, whilst the bulk of the uranium regains its original activity.

The first product in the case of radium is a radioactive gas, which has received the name *Radium Emanation*. It has all the properties of a gas, being incapable of penetrating through glass or metals, but readily diffusing through porous substances. It liquefies under the influence of extreme cold. From the fact that it is not altered by such drastic treatment as passing through concentrated sulphuric acid, or passing electric sparks through it when mixed with oxygen, it is considered to be a member of the Argon group of elements. It emits *Alpha*-rays, and in a short time (four days) loses the greater part of its activity and is changed into other transformation products. In consequence of this emanation, radium has the property of imparting Radioactivity to surrounding objects.

Radium appears to be a transformation product of uranium, though the rate of change must be excessively slow. The changes undergone by radium itself are represented by Rutherford as in above diagram.

The times given in each case represent the average length of life, and must be directly proportional to the amount capable of existence at one time. The quantities of uranium, radium and polonium in pitchblende is in the ratio 109 : 103 . 1 , which is practically the same as the ratio of the numbers representing their average life.

Our knowledge of the changes that occur in the case of thorium is almost entirely due to Rutherford and Soddy. They showed that if the thorium hydroxide is precipitated from solution with ammonia, the precipitate no longer gives *Alpha*-rays and the *Beta*-radiation is considerably reduced. On evaporating the solution to dryness an exceedingly minute quantity of a substance was left emitting both *Alpha* and *Beta*-rays. This they called Thorium-*X*. It gradually loses its activity at the same rate at which the thorium freed from Thorium-*X* regains its power of radiation. Thorium-*X* produces an emanation in the same manner as radium, and is also capable of communicating Radioactivity to bodies in its neighbourhood.



All the elements that exhibit Radioactivity possess high atomic weights—uranium 240, thorium 232, radium 225. From this it appears that there is going on in nature a change resulting in the breaking down of elements of high atomic weight. It must be left as a problem of the future to ascertain whether all the known elements are products of a similar change

---

A prominent land mark at Petone is the new brick chimney stack of the Wellington Woollen Mills, which is 130ft. high, and is claimed to be the most graceful and best proportioned chimney in the colony. Nearly £28,000 has been spent in buildings and plant within the last two years. This, with the original mill and plant, makes one of the largest and best equipped mills south of the line. Two Lancashire boilers, 30ft. x 8ft. tested to a pressure of 340lb. and to work at a steam pressure of 170lb. to the square inch, have replaced the original five boilers. These new boilers weigh 30 tons each, and are fitted with every up-to-date appliance for economy and safety. The new engine, which replaces the old 240-h p., is of the horizontal tandem Corliss condensing type, fitted with all latest improvements, including an electric stop motion, which can be operated by the youngest employee from any part of the mill, in case of an accident, bringing the engine to a standstill instantly. The fly-wheel is 16ft. in diameter, weighs 16 tons and makes 75 revolutions a minute. The power is transmitted by 14 ¾inch driving ropes.