DESCRIPTION OF PLATES 12 to 14

PLATE 12. FIGURE 1. Nuclei on potassium and ammonium alums.

potassium alum		ammonium alum	
a	111 face	*b*	111 face
c	001 face	*d*	001 face
e	011 face	*f*	011 face

PLATE 13. FIGURE 3. Nuclei on alums.

a Rubidium alum, 111 face.
b Caesium alum, 111 face.
c Iron ammonium alum, 111 face.
d Ammonium alum, 111 face. Effect of 0·776 mm. water vapour during growth at 40° C.
e Ammonium alum, 111 face. Effect of 2·05 mm. water vapour during growth at 40° C.
f Potassium alum, 111 face. Effect of 0·776 mm. water vapour during growth at 30° C.

PLATE 14. FIGURE 4. Nuclei on $K_2SO_4[Al, Cr](SO_4)_3 . 24H_2O$.

Slow neutron-induced activity in gold

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The 2·7 day activity in ^{198}Au has been studied by means of a β-spectrometer of the lens type in conjunction with a special technique for studying the γ-radiation. The β-spectrum has an upper limit = 0·92 MeV. An absorption measurement on the γ-radiation in Pb shows that no high-energy γ-radiation is existent, as has previously been reported. Only one γ-ray of medium energy (0·401 MeV) follows the β-disintegration.

If gold is irradiated with slow neutrons (Fermi, Amaldi, d'Agostino, Rasetti & Segrè 1934), a strong activity appears with a half-life period of 2·7 days. This must be due to the gold isotope 198, as gold has only one stable isotope with the mass 197. The same active isotope can be produced in several other different ways, for example, by deuteron-irradiation of gold (Cork & Thornton 1937) and platinum (Lawson & Cork 1940). At the same time, however, other active gold isotopes are produced, and hence the methods mentioned are not suitable if it is desired to study ^{198}Au alone. Fast neutrons, on the other hand, give rise, besides the above-mentioned activity, to two others, though considerably weaker, with the half-life periods 13 hr. and 3·3 days (MacMillan, Kamen & Ruben 1937).

Several investigations of the disintegration of ^{198}Au have already been performed, different methods being used: absorption measurements, coincidence measurements, investigations in the Wilson chamber and the β-spectrograph. The results have hitherto shown little mutual agreement, which, in some cases, may be explained by the presence of active isotopes other than ^{198}Au. A survey of earlier measurements has been published by Feather & Dainty (1944). For the sake of completeness some of the essential results will be repeated here.

^{198}Au emits both β- and γ-radiation. It is transformed by β-emission into ^{198}Hg. Sizoo & Ejkman (1936) have, however, found, in absorption measurements on the γ-radiation, a weak γ-energy at 2·5 MeV. This is explained by assuming that ^{198}Au may also be transformed into ^{198}Pt by K-capture.

The β-spectrum has been studied by, among others, Richardson (1939) in a Wilson chamber. The sample consisted of a gold foil that had been irradiated with slow neutrons. The spectrum proved to consist of a highly asymmetrical, continuous distribution, with its upper limit at 0·83 MeV. Besides, a strong β-line was found, corresponding to an internally converted γ-energy of 440 keV. The conversion coefficient was as high as 0·1. The upper limit of the β-spectrum has been further studied by Sizoo & Ejkman, using the absorption method. The result $E_{\text{max.}} = 0{\cdot}90$ MeV was obtained. Using the same method, Cork & Halpern (1940), among others, obtained the result $E_{\text{max.}} = 0{\cdot}74$ MeV and Clark (1942) $E_{\text{max}} = 0{\cdot}78$ MeV (corrected by Feather & Dainty (1944) to 0·87 MeV). Using a particularly exact absorption method (Feather 1938), Feather & Dainty determined $E_{\text{max.}}$ $0{\cdot}985 \pm 0{\cdot}010$ MeV.

The γ-radiation accompanying the disintegration is of special interest. In several different cases, two γ-lines were discovered, with energies of about 250 and 450 keV respectively. At the same time, a weak radiation of about 70 keV was obtained. The latter radiation has been supposed to be X-radiation from ^{198}Hg (K-radiation). This explanation may be considered plausible, in view of the existence of the strong β-line. The following investigation on the γ-radiation may be given brief mention. Richardson (1939) determined, in a Wilson chamber, the distribution of the photo-electrons ejected by the γ-radiation from a lead foil. He obtained three photo-lines, corresponding to the γ-energies 70, 280 and 440 keV. A slight trace of yet another γ-energy of about 0·7 MeV was also obtained. The ratio between the intensities for γ_{280} and γ_{440} was estimated as 1·0 : 1·2. Using the absorption method, Sizoo & Ejkman (1936) obtained the γ-energies 73, 250 and 410 keV. Besides, they obtained a weak γ-radiation of about 2·5 MeV (about 2 quanta per 100 disintegrational). The two medium soft γ-components were also found by Cork & Halpern (1940) (240 and 500 keV) and Krishnan (1941) (210 and 500 keV). Plesset (1942) studied the γ-radiation from gold, irradiated with deuterons of 11 MeV, lead being the secondary radiator. He obtained a number of photo-lines, three of which were attributed to ^{198}Au. The photo-lines had the energies 63·9, 323 and 389 keV. As the difference between the two latter corresponds to the difference between the K- and L-absorptions energies of lead, the origin of both lines may be one γ-line with the

energy 402 keV. On the other hand, the intensities of the two lines were nearly equal, which, our supposition being right, would not be the case. (The ratio should be about 7 : 1.)

A coincidence investigation by Clark (1942) showed that γ-γ as well as β-γ coincidences were obtained. By the use of Norling's (1941) efficiency curve for lead γ-γ-tubes, the coincidence measurements could be accounted for on the basis of Richardson's disintegration scheme (figure 1) which assumes that the two γ-rays are emitted in cascade and that each β-particle is accompanied by two γ-quanta (disregarding the suggested possibility of an extremely weak γ-transition direct to the ground state). Clark's coincidence measurements seem quantitatively to agree very well with the corresponding investigations of Feather & Dainty (1944). Norling (1941), on the other hand, could not obtain any γ-γ coincidence effect. On the other hand, he obtained a very strong β-γ coincidence effect, which undoubtedly indicates that at low energies, the γ-efficiency curve passes through a maximum (see p. 55 in Norling's paper).

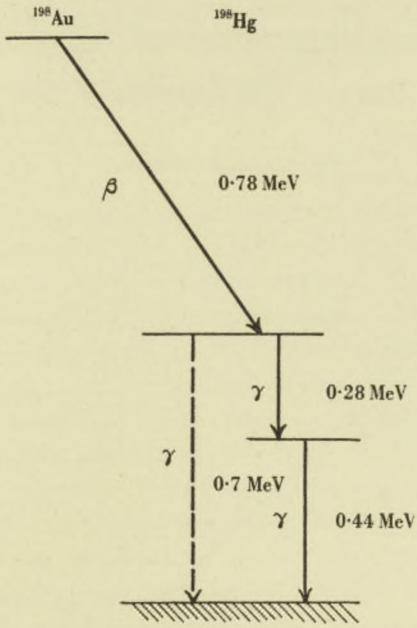

FIGURE 1. Previously proposed level scheme for the disintegration of ^{198}Au.

THE β-SPECTRUM

Since at present there is no method, admitting of a substantial concentration of active in relation to inactive gold, gold in the form of a thin foil (0·02 mm. thick) was irradiated with slow neutrons from the Stockholm cyclotron. A sample of such a thickness cannot, of course, be expected to give a β-spectrum other than with considerable distortion. The foil, whose diameter was 8 mm., was placed in the

β-lens spectrograph (Siegbahn 1946), the resolving power of which was at a value of $\Delta H\rho/H\rho = 5\,\%$. At this adjustment of the spectrograph, the diaphragm system transmits $2\,\%$ of the radiation. With the spectrograph so adjusted it has proved possible, with preparations of sufficiently long half-life period, to measure the β-spectrum at intensities as small as some hundredths μC.

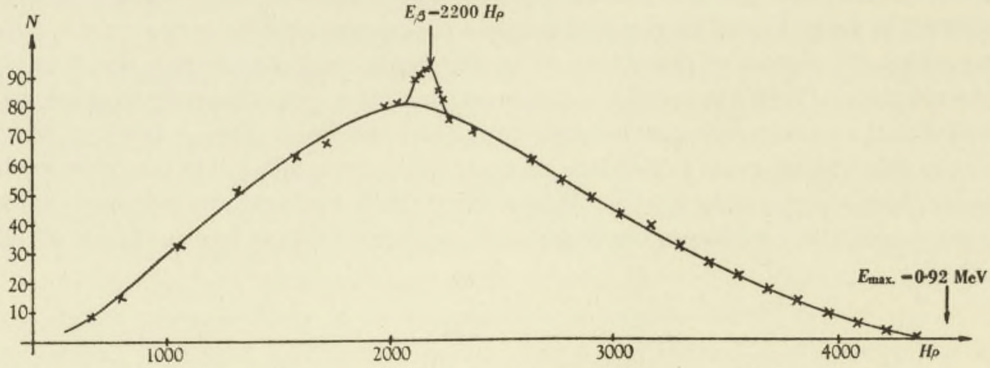

FIGURE 2. The β-spectrum of ^{198}Au.

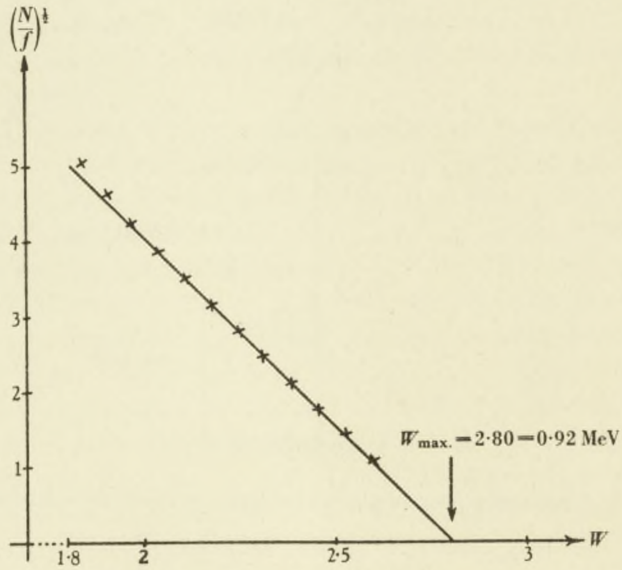

FIGURE 3. The Fermi diagram for ^{198}Au.

Figure 2 shows the β-spectrum of ^{198}Au. It is simple in character, as seen from the relatively symmetrical form. At low energies, however, it can be observed that the absorption in the gold foil has become perceptible, the spectrum displaying a comparatively small number of low-energy electrons. The spectrum shows only

one β-line, with $H\rho = 2200$, corresponding to an energy for the γ-quantum = 0·401 MeV. The corresponding L-line $H\rho$ 2470 was also observable but has been omitted, as the statistics employed hardly permitted any definite conclusion regarding its magnitude. The size of the β_K-line relative to the remaining continuous spectrum is smaller than that previously observed, which may in some part be due to the absorption in the gold foil. According to Richardson's determination, the β-line should correspond to an internal conversion coefficient α_K of 10 %, whereas Plesset finds $\alpha_K = 4$ %. The uncorrected value of α_K is found from figure 2 to be about 1 %.

The upper limit of the spectrum is most accurately obtained by finding the Fermi curve for the spectrum. Figure 3 shows the end of this curve. The upper limit is determined from this as $0{\cdot}92 \pm 0{\cdot}01$ MeV.

Even if the β-spectrum reveals only one γ-line, there are possibilities of more than one such line occurring through disintegration. The high value of α_K for the β-line at 0·401 MeV is probably due to this radiation having a quadrupole character. If there are other γ-lines of a dipole nature, these are not certain to bring about internal conversion to an extent large enough to give detectable β-lines. It is therefore necessary to study the γ-radiation directly.

γ-ABSORPTION IN LEAD

In the first place, the question arose of ascertaining, by an absorption measurement, the presence of the weak, hard γ-component of 2·5 MeV, reported by Sizoo & Ejkman (1936). For this purpose a γ-tube was used, the cathode being a 1 mm. thick brass cylinder. The absorption process was observed for absorption thicknesses up to 28 mm. of lead. Figure 4 shows, in a logarithmic scale, the curve obtained. The intensity, at the last point measured, is only about 4 % of the intensity without absorption screens. Nevertheless, even these last points lie entirely within the limits of error on the straight line that may be drawn through the other points, and hence the determination does not support the presence of any hard component. This is in agreement with the conclusion of Feàther & Dainty (1944) based on less extensive evidence. Since it was necessary to extend the absorption measurements to such large absorption thicknesses in order to establish the presence of the hard component, the sample could not be placed, owing to difficulties of intensity, as far from the GM tube as would be desirable for a good quantitative determination of the energy of the γ-radiation. The crude γ-ray absorption coefficient corresponds to an energy = 0·46 MeV. This value is considerably higher than the more accurately determined $E_\gamma = 0{\cdot}401$ MeV from the β-spectrum.

One cannot expect to establish from the absorption curve, considering the thickness of the wall of the γ-tube, presence of the γ-ray of 70 keV reported by several authors. It is remarkable, however, that the γ-component of about 250 keV, also often reported, cannot be detected by any procedure. With regard to the geometry not being ideal, it is, however, difficult to draw any definite conclusion from

the absorption curve as to the non-existence of this γ-energy. It is certainly known that it is sometimes possible to deduce a purely exponential absorption process, even on occasions when several γ-lines occur (Roberts, Downing & Deutsch 1941).

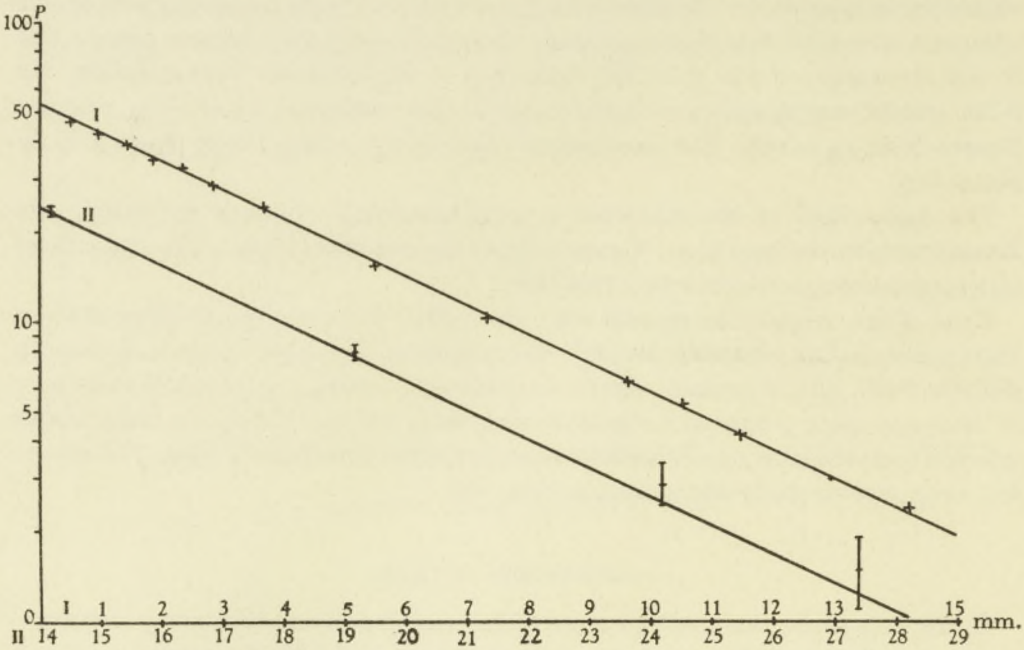

FIGURE 4. Absorption curve for the γ-radiation of ^{198}Au in lead.

THE STUDY OF THE γ-RAYS IN THE SPECTROGRAPH

In order to investigate this question closer, it is suitable to apply the more accurate photo-Compton method with the aid of the β-spectrograph. Gold in the form of 0·02 mm. foils was irradiated in the cyclotron with slow neutrons for a few days, so that the total activity was equivalent to 10 μC Ra. The gold was then packed into a small cylindrical Cu radiator (ϕ = 8 mm.), the wall thickness of which was sufficiently large, according to Feather's formula, to absorb entirely the electrons of the continuous β-spectrum. The energy distribution of the secondary electrons released in the Cu radiator was studied in the β-spectrograph. A 0·1 mm. thin lead foil was then placed in front of the Cu radiator, and a new energy distribution curve was recorded. In the first case, it is fairly certain that the Compton effect in the copper provides the main component in the secondary spectrum and in the latter case both the Compton effect and the photo-effect in the lead foil will be seen.

Figure 5 shows the former registration. In order to give an idea of the sensitivity of the arrangement, I have not plotted along the axis, in this figure and figure 6, the intensity, i.e. the number of impulses counted per min. P divided by the corresponding $H\rho$-value, but P alone. Figure 5 suggests at first sight the existence of two γ-components, the lower energy corresponding to that first obtained from the

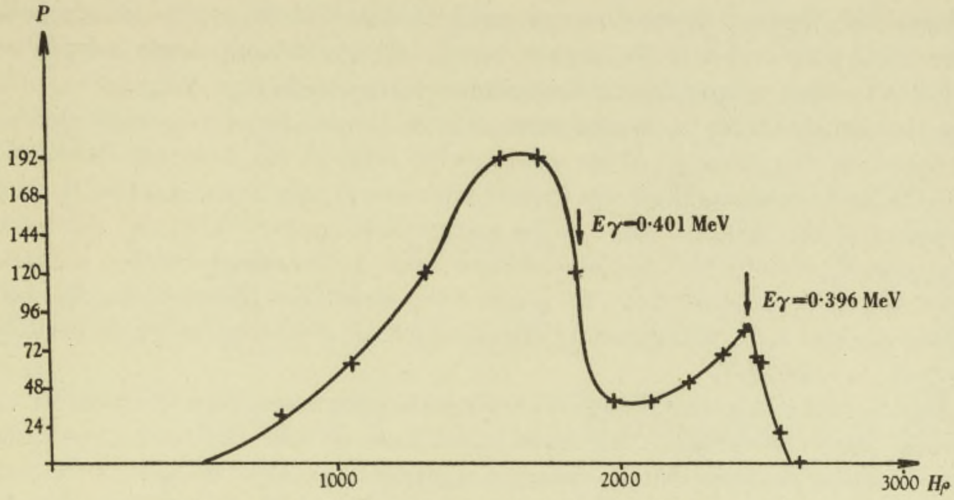

Figure 5. Secondary electron spectrum expelled from a Cu radiator by the γ-radiation of ^{198}Au.

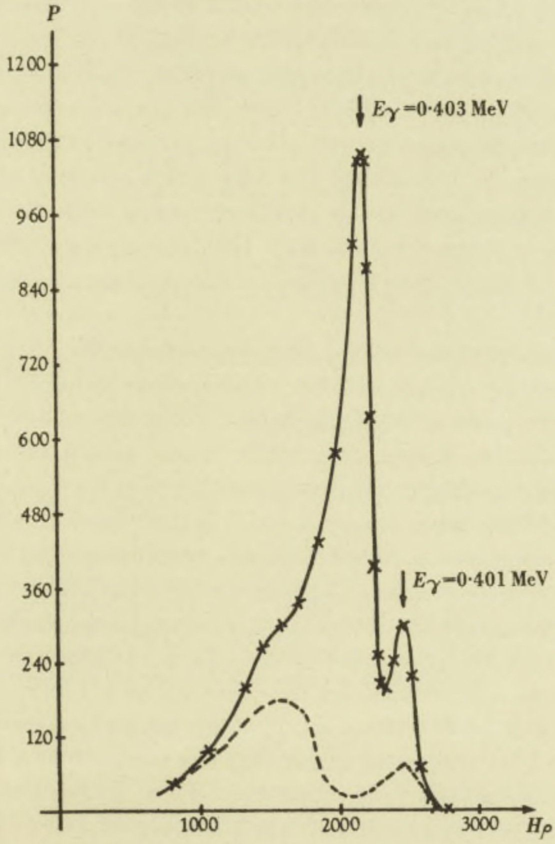

Figure 6. Secondary electron spectrum expelled from a Cu radiator covered with a 0·1 mm. lead foil.

β-spectrum. The next figure, however, makes it clear that the second energy peak is due to the photo-effect in the copper, which, though certainly weak, is quite perceptible at these comparatively low energies of the γ-radiation. The present author has previously found, in several cases, that the most accurate possible value is obtained for the γ-energy, if the upper energy limit of the Compton distribution (i.e. the limit corresponding to the impact angle $\theta = 0$ in the Compton effect formula) is placed at the inflexion point of the energy distribution. Using this procedure, the value $E_\gamma = 0{\cdot}401$ MeV is obtained from figure 5. The energy of the γ-radiation may also be determined from the peak of the photo-line. This has the $H\rho$-value 2484, i.e. 0·387 MeV. If the work of liberation for the K shell in Cu, 9 keV, is added, then $E_\gamma = 0{\cdot}396$ MeV.

Figure 6 shows the distribution of the secondary electrons, when the lead foil was placed before the radiator. This curve is composed of three different components: the Compton electrons (the broken line represents the curve of figure 5 for comparison), the K photo-line in Pb and the L photo-line in Pb. It is evident that the higher energy maximum in figure 5 cannot be a Compton distribution from a second γ-component, as the photo-line that would correspond to this γ-energy in figure 6 is missing. The peak of the K photo-line occurs at $H\rho = 2161 = 0{\cdot}315$ MeV. Hence E_γ is obtained by adding the K absorption energy of the lead $= 0{\cdot}088$ MeV, i.e. $E_\gamma = 0{\cdot}403$ MeV. E is obtained in the same way from the L photo-line, the $H\rho$-value of which is 2451 as ($E_{L_{\text{abs.}}} = 0{\cdot}016$ MeV) 0·401 MeV. It is satisfactory that the energy values deduced from the internal and external conversion effects agree so closely, and it should further be noted that the final value of the γ-ray energy deduced from the present experiments are in excellent accord with the value obtained by Plesset (1942). It is further satisfactory that the strange relation between the intensities of the two photo-lines reported by Plesset does not appear in the present investigation.

Figure 6 illustrates well the sensity of the spectrograph. It proves, among other things, that the activity of only 1 μC Ra γ equivalence would still have given about 100 kicks/min. at the peak of the K photo-line. Since the zero effect of the GM tube gives about 5 kicks/min., it appears possible to use, within this energy range, still weaker samples for recording γ-spectra.

The conclusion drawn from figures 5 and 6 is that there is only one γ-line, and, accordingly, that the γ-line at about 250 keV, earlier reported by several authors, must be regarded as non-existent. The present investigation is not concerned with the very low energy range at about 70 keV, in which a γ-line has earlier been reported. As pointed out earlier this was considered to be X-radiation from mercury, being the result of internal conversion from the γ-energy at 401 keV. Feather & Dainty (1944), however, have made a closer study of the absorption process in this energy range and seem to have succeeded in proving the presence of a nuclear γ-line, the energy of which is somewhat lower than that of the X-ray, i.e. about 65 keV. If the existence of a nuclear γ-radiation of 65 keV is accepted, there are two possibilities for its emission. It may be emitted after the whole β-spectrum or it may be

responsible for a complexity in the β-spectrum, the latter being composed by two components differing by 65 keV in energy. In the first case the two γ-lines must be of equal intensity. Very carefully performed coincidence experiments might probably give some further information on this point.

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Mixed boundary conditions in the relaxational treatment of biharmonic problems (plane strain or stress)

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Relaxation methods have already been applied to the solution of four problems of (i) extension and (ii) flexure of flat elastic plates, in which (*a*) displacement or (*b*) traction is specified at the boundary. Here the method is adapted to the case in which the two types of boundary condition are mixed, where photo-elastic methods are difficult to apply.

Two examples are treated by relaxation methods, and the results obtained indicate that this method may be a valuable alternative in engineering problems.

Introduction

1. Part VII A of the series 'Relaxation methods applied to engineering problems' (Fox & Southwell 1941), was concerned with the solution of problems involving flexure or extension of flat elastic plates, for which the governing equations are