AQA

A Level

A Level Physics

Radioactive decay

Name:

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Total Marks: /30

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1. Radioactive decay is something that has only come to be understood in the twentieth century, after having been discovered by accident in 1896. It is now widely exploited for its medical, military and industrial uses.

Total for Question 1: 10

   (a) What are the two defining characteristics of radioactive decay? [2]

   (b) What is meant by ionising radiation? [1]

   (c) Compare and contrast the nature and range of α, β and γ radiation. [4]

(d) Outline an experiment you could perform to verify that the intensity of gamma radiation decays with the square of the distance from the source. Be precise about the apparatus you would use, any measurements you would take and any analysis you would perform. [3]

2. Zircons are minerals typically found in old igneous rocks. Uranium and lead are usually found in small quantities within zircons. ^{238}U decays radioactively, eventually forming ^{206}Pb.

Total for Question 2: 13

(a) Rewrite the following equation for α decay, replacing each instance of x with the correct substitution: [2]

$$ {}^{\mathrm{A}}_{x}\mathrm{P} \longrightarrow {}^{\ x}_{\mathrm{Z}-2}\mathrm{Q} + {}^{4}_{x}\mathrm{x} $$

(b) How many α-decay events are involved in the decay chain from ^{238}U to ^{206}Pb? [1]

(c) Outline an experiment that could be performed to determine the half-life of a ^{238}U atom. [3]

(d) Given that the half-life of ^{238}U is 1.41×10^{17} s, calculate its decay constant. [2]

(e) Write an equation for the number of ^{206}Pb atoms present at a time t in terms of the initial number of ^{206}Pb atoms, the number of ^{238}U present, the decay constant of ^{238}U and t. [3]

In reality, this technique cannot often be used as it is here: it is unfortunately almost impossible to calculate the initial amount of ^{206}Pb. However, this is why zircons are chosen: their crystal structures are not welcoming to Pb atoms and so the initial Pb is thought to be very low.

(f) Ignoring any ^{206}Pb that was initially present, calculate the crystallisation age, in years, of a rock which now has a lead-uranium of $\frac{^{206}\text{Pb}}{^{238}\text{U}} = 0.798$ [2]

3. A complex physical argument suggests that the initial isotopic ratio for two uranium isotopes was $\frac{^{235}\mathrm{U}}{^{238}\mathrm{U}} = 1$. The half-lives of ^{235}U and ^{238}U are 704 Myr and 1.41×10^{17} s, respectively.

Total for Question 3: 7

(a) Write an equation that expresses the ratio $^{235}\mathrm{U}/^{238}\mathrm{U}$ in terms of the original abundances, time and the decay constants of each isotope. [2]

(b) Given the present isotopic ratio is $\frac{^{235}\mathrm{U}}{^{238}\mathrm{U}} = \frac{1}{138}$, calculate an estimate for the age of Earth. [4]

(c) This is an upper bound. Why? [1]