

A level Physics B

H557/02 Scientific literacy in physics

Question Set 17

1

A radioisotope that decays forming another isotope is known as a **parent** isotope and the newly formed isotope is known as the **daughter** product. For a sample initially made up of pure parent isotope, with a daughter product which does not decay, **Fig. 1.1** shows how the number of parent and daughter nuclei change with time. The daughter product in this case is described as 'stable'.

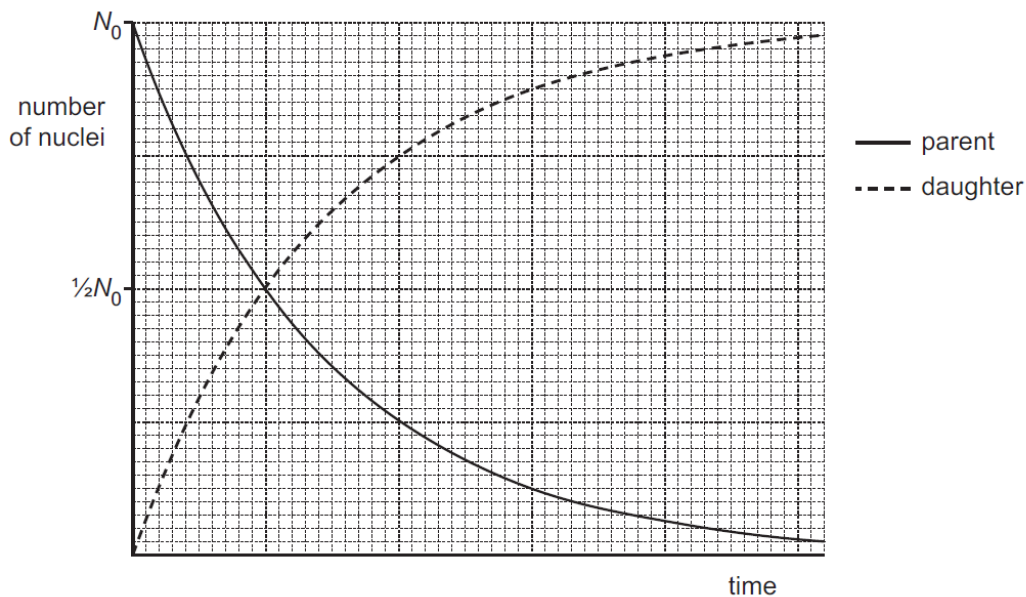


Fig. 1.1

- (a) For a stable product, the number of daughter nuclei D at time t is given by the equation

$$D = N_0 - N$$

where N_0 is the original number of parent nuclei and N is the number of parent nuclei at time t .

Show that the number of daughter nuclei after time t is given by

$$D = N_0(1 - e^{-\lambda t})$$

[1]

- (b) The ratio of the number of parent nuclei to number of daughter nuclei can be used to calculate the age of rocks.

The uranium isotope ${}_{92}^{238}\text{U}$ is the beginning of a 'radioactive series' that ends with the stable isotope of lead, ${}_{82}^{206}\text{Pb}$.

- (i) Show that a total of eight alpha decays and six beta decays will produce ${}_{82}^{206}\text{Pb}$ from ${}_{92}^{238}\text{U}$.

[2]

- (ii) The half-life of the series is 4.47×10^9 years. This means that it will take about 4.5 billion years before half the uranium-238 (${}_{92}^{238}\text{U}$) has decayed into lead-206 (${}_{82}^{206}\text{Pb}$).

Show that the decay constant for this process is about $1.6 \times 10^{-10} \text{ year}^{-1}$.

[1]

- (iii) A rock is assumed to have contained no lead-206 when it was formed.

In a sample of the rock, the ratio

$$\frac{\text{number of lead-206 atoms present in rock sample}}{\text{original number of uranium-238 atoms present in rock sample}}$$

is measured to be 0.39.

Calculate how long ago the rock formed, assuming that all the lead-206 formed has remained in the rock.

time since formation of rock =years

[3]

(c)

The same rock sample also contains uranium-235, which undergoes a series of decays to form the stable isotope lead-207.

The half-life of this series is 7.0×10^8 years. The ratio

$$\frac{\text{number of lead-207 atoms present in rock sample}}{\text{number of remaining uranium-235 atoms present in rock sample}}$$

is measured to be 22.8.

- (i) Use the relationship $N = N_0 e^{-\lambda t}$ to show that the number of daughter nuclei after time t is given by

$$D = N \left(\frac{1}{e^{-\lambda t}} - 1 \right)$$

where N is the number of parent nuclei remaining at time t .

[1]

- (ii) Use the equation for D given in (c)(i) and the data given to calculate the value for the age of the rock based on the uranium-235 decay series.

age of rock =years

[3]

- (iii) Rocks are often dated using three separate decay series. Suggest and explain an advantage of three decay series to date rocks rather than just one.

[2]

Total Marks for Question Set 17: 13

OCR

Oxford Cambridge and RSA

Copyright Information

OCR is committed to seeking permission to reproduce all third-party content that it uses in its assessment materials. OCR has attempted to identify and contact all copyright holders whose work is used in this paper. To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced in the OCR Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download from our public website (www.ocr.org.uk) after the live examination series.

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

For queries or further information please contact The OCR Copyright Team, The Triangle Building, Shaftesbury Road, Cambridge CB2 8EA.

OCR is part of the Cambridge Assessment Group; Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge