

- 8 When studying beta decay, scientist discovered that the energies of the beta particles emitted by radioactive source had a distribution of energies.

The energy spectrum of the beta particles emitted is being shown in Fig. 8.1.

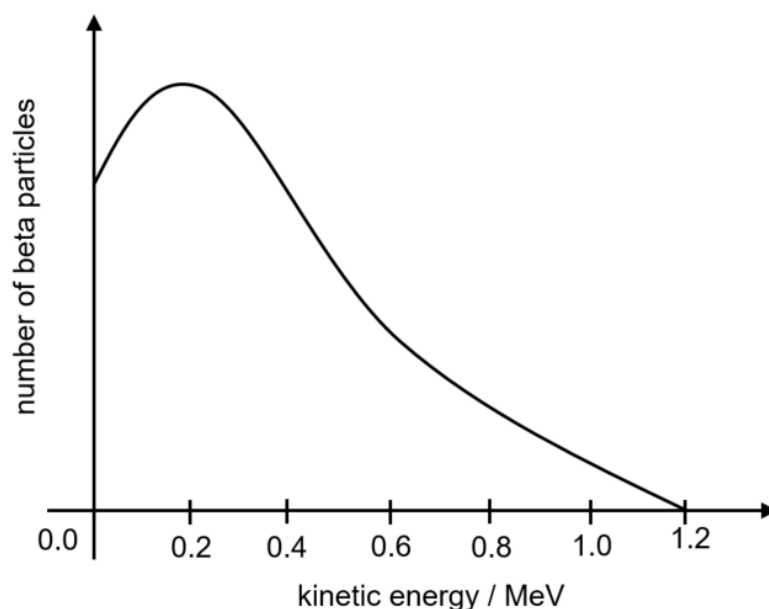


Fig. 8.1

- (a) The continuous spectrum of kinetic energy possessed by the beta particles was a problem to many physicists. This is because, if a stationary nucleus decayed into a beta particle and a stable daughter nucleus only, it should lead to a distinct single value of energy for the beta particle.

Using conservation of mass-energy and linear momentum, explain why a continuous spectrum of kinetic energy for the beta particles is obtained.

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.....[3]

(b) The radioisotope of Bismuth $^{210}_{83}\text{Bi}$ undergoes beta decay into a stable isotope of Polonium (Po).

(i) Write down a nuclear reaction that describes the above nuclear reaction.

..... [1]

(ii) Using data from Fig. 8.1 and Fig. 8.2, determine the mass of the resultant Polonium nucleus in terms of u , expressing your answer to 3 decimal places.

Particle	mass / u
$^{210}_{83}\text{Bi}$ nucleus	209.939
proton	1.00729
neutron	1.00867
electron	0.000548795
neutrino	negligible

Fig. 8.2

mass of polonium nucleus = u [4]

(iii) Research has shown that stable isotopes of heavy elements have an optimal neutron to proton ratio and lies on the belt of stability. Unstable isotopes will undergo transmutation through radioactive decay such the resulting nucleus achieve this optimal ratio to become stable.

Using your answer in **(b)(i)** or otherwise, suggest if Bismuth-210 has an excess of neutrons or protons, as compared to the optimal ratio.

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 [2]

- (c)** A Geiger-Muller tube was being used in an experiment at a fixed distance from a radioactive sample to measure the count rate of the sample against time. The graph obtained was shown in Fig. 8.3

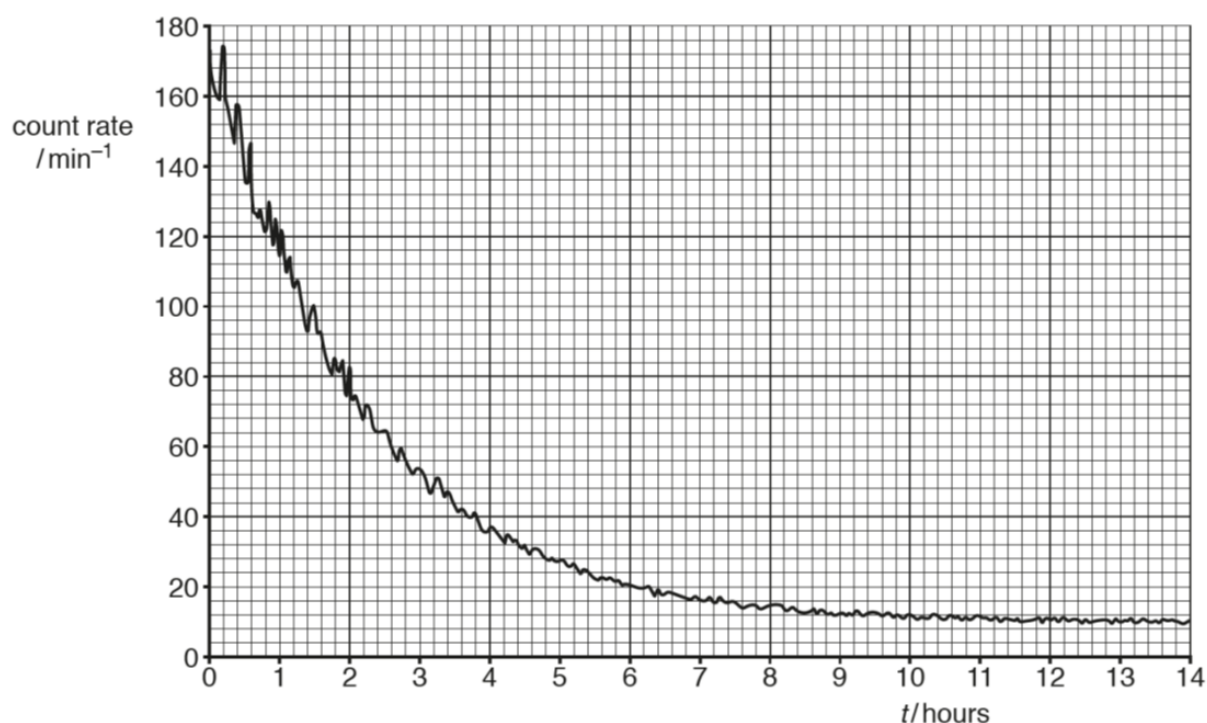


Fig. 8.3

- (i)** Explain why the data points on the graph do not lie on a smooth curve.

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 [1]

- (ii)** Suggest two reasons why the count rate recorded is not equal to the activity of the radioactive sample.

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- (iii) Explain why the count rate of the graph does not tend to 0 count min⁻¹ after a long period of time.

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..... [1]

- (iv) The physicist that is performing the experiment found that the decay rate is too slow. In an effort to increase the decay rate, he decided to conduct the experiment again at a higher temperature.

Sketch the decay curve that the physicist is expected to get on Fig. 8.3. [1]

- (v) Explain for the shape and position of your curve you have sketch in (c)(iv).

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..... [2]

- (d) The Rutherford scattering experiment was being performed to study atomic structure.

- (i) Describe the experimental result that provides evidence for the small size of the nucleus.

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- (ii) Explain why the gold foil used in the experiment must be thin.

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..... [1]

END OF PAPER