9 **(a)** State what is meant by *half-life*.

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…………………………………………………………………………………………………....... [2]

(b) A stationary radioactive isotope P decays by emitting a -particle and -radiation. The daughter nucleus produced during this decay is Q. An incomplete equation to represent this decay is

P → Q + +

The variation with time *t* of the number *N* of undecayed nuclei of radioactive sample of isotope P is shown in Fig. 9.1.

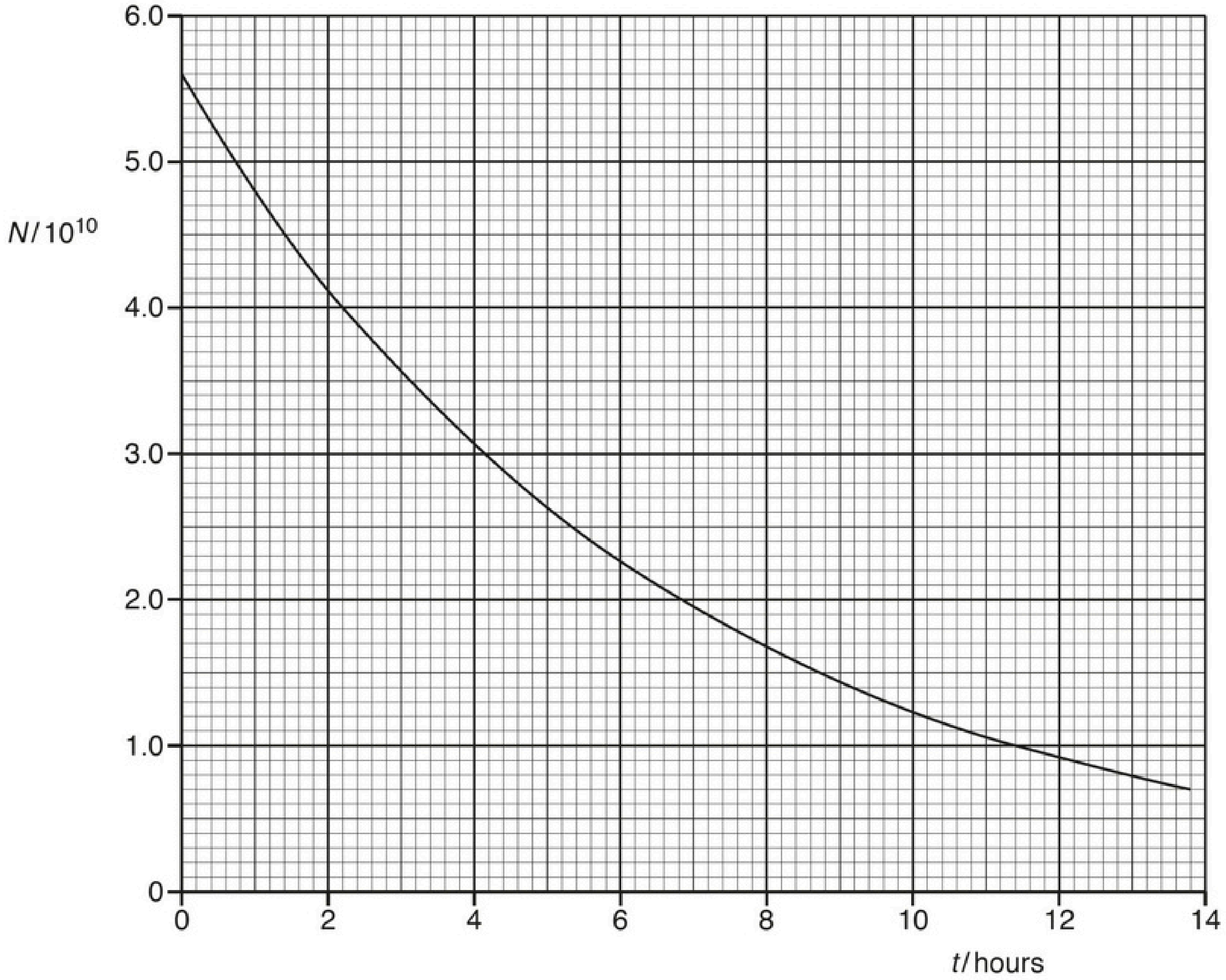

Fig.9.1

(i) Use Fig. 9.1 to estimate the half-life of isotope P.

half-life= …………………………….hours [2]

(ii) Initially, there are no Q nucleus in the sample.

After a period of time *t*, the ratio $\dfrac{\text{numberof} \quad \text{Qnuclei}}{\text{numberof Pnuclei}}$ equals 6.

Calculate *t*.

t = ……………………………hours [2]

(iii) State the significance of the gradient of the graph.

…………………………………………………………………………………….................

…………………………………………………………………………………….……….... [1]

(iv) Determine the activity of isotope P at *t* = 4.0 hours.

activity = ……………………………Bq [3]

(v) The daughter nucleus Q is stable. On Fig. 9.1, sketch a graph to show the variation with time *t* of the number of daughter nuclei Q in the sample. [2]

(vi) State and explain why the sum of the kinetic energy of the □-particle and the energy of the -radiation is less than the total energy released during the decay of isotope P.

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…………………………………………………………………………………….……….... [3]

(c) Isotope P is produced in a laboratorybybombarding a stationary nucleus S with an -particle. It results in the following nuclearreaction.

$$S + \quad \rightarrow P + \quad {}^{1}_{0}n$$

Fig. 9.2shows the positionofisotope P onadiagram in which nucleon number is plotted againstproton number. Eachsmall squarerepresents a unit increase in the nucleon numberand proton numberinthedirectionoftheaxes.

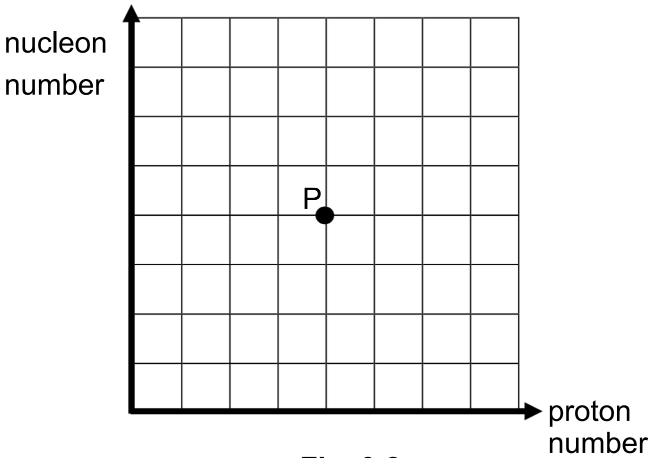

Fig. 9.2

(i) On Fig. 9.2, mark with the symbol S the position of the nuclide S. [1]

(ii) With reference to **(b)**, mark on Fig. 9.2 with the symbol Q the position of the daughter nuclide Q due to the decay of isotope P. [1]

(d) Fig. 9.3 shows an -particle approaching a stationary gold nucleus head-on. The distance of closest approach of the -particle to the nucleus S is *d*.

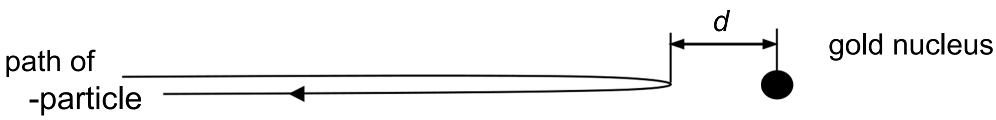

Fig. 9.3

At its distance of closest approach *d*, explain whether it is possible for the gold nucleus and the -particle to be at rest simultaneously.

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………………………………………………………………………………………………........ [3]

[Total 20]