9 Some elements that are normally stable, such as lead (Pb), have isotopes which are radioactive. The nucleus $^{214}_{82}Pb$ is one such isotope of lead.

(a) State what is meant by isotopes.

……...

……...

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

(b) A nucleus of $^{214}_{82}Pb$ decays by β emission into $^{214}_{83}Bi$. This bismuth nuclide is itself radioactive with an unusual decay pattern. Sometimes it decays by α emission into tellurium (Tl) and sometimes by β emission into polonium (Po). Write the nuclear equations for these two decays of $^{214}_{83}Bi$.

α emission: ……………………………………………………………………………………………

β emission: …………………………………………………………………………………………… [2]

(c) The two decay patterns of the $^{214}_{83}Bi$ each give rise to γ ray photons. Suggest why each of these photons have different energies.

……...

……...

……... [2]

(d) A stationary $^{214}_{82}Pb$ decays by β emission into $^{214}_{83}Bi$ as shown in Fig. 9.1.

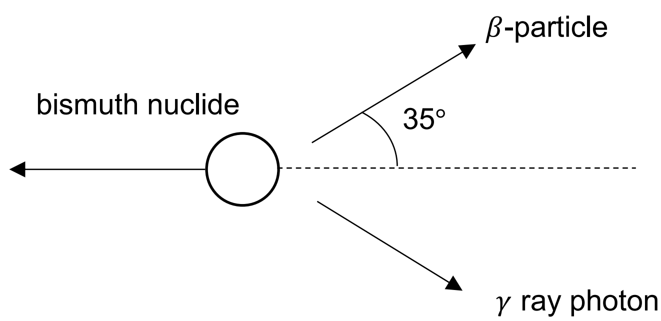

Fig. 9.1

The energy of the β-particle is 0.74 MeV and the energy of the bismuth nuclide is 5.5 eV.

(i) Determine the momentum of

1. the β-particle

momentum = ... kg m s^{-1} [1]

2. and the bismuth nuclide

momentum = ... kg m s^{-1} [1]

(ii) Hence, using the principle of conservation of linear momentum show that the wavelength of the γ ray photon is 1.36 pm.

[4]

(e) At time t = 0 s, a sample consists only of the isotope ${}^{214}_{82}Pb$.

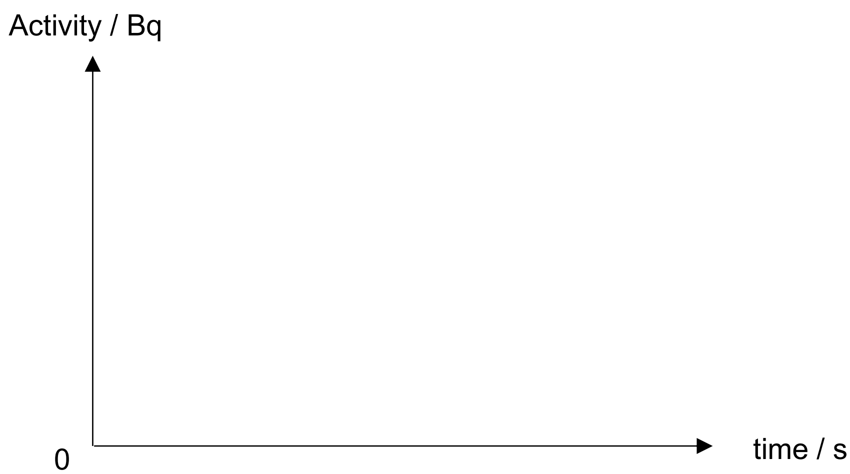

Fig. 9.2

(i) Without numerical values, sketch on Fig. 9.2 a graph of the activity of ${}^{214}_{82}Pb$ with time. Label this graph Pb.

[1]

(ii) Without numerical values, sketch on Fig. 9.2 a graph of the activity of ${}^{214}_{83}Bi$ with time. Label this graph Bi.

[2]

(f) A sample of ${}^{214}_{82}Pb$ has mass 3.5 μg at time t = 0 s. The half-life of ${}^{214}_{82}Pb$ is 27 minutes.

(i) Show that the sample contains approximately 9.8×10^{15} atoms.

[1]

(ii) Show that its decay constant is $4.3 \times 10^{-4}\ s^{-1}$.

[1]

(iii) Calculate its activity at time t = 0 s.

activity = ... Bq [1]

(iv) Hence, calculate the time at which its activity has fallen to 8.8×10^{9} Bq.

time = ... min [2]

[Total: 20]

Blank page

Blank page