A Level Physics A

H556/02 Exploring physics

Question Set 21

1 An isotope of polonium-213 ($^{213}_{84}Po$) first decays into an isotope of lead-209 ($^{209}_{82}Pb$) and this lead isotope then decays into the stable isotope of bismuth (Bi).

Fig. 24 shows two arrows on a neutron number *N* against proton number *Z* chart to illustrate these two decays.

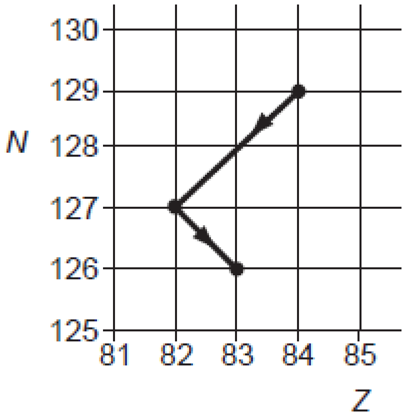

Fig. 24

(a) Complete the nuclear decay equations for

(i) the polonium isotope

$$^{213}_{84}Po \longrightarrow \, ^{209}_{82}Pb + \, ^{4}_{2}He$$ **[1]**

(ii) the lead isotope.

$$^{209}_{82}Pb \longrightarrow \, ^{209}_{83}Bi + \, ^{0}_{-1}e + \bar{\nu}_e$$

[2]

(b) A pure sample of polonium-213 is being produced in a research laboratory.

The half-life of $^{213}_{84}Po$ is very small compared with the half-life of $^{209}_{82}Pb$.

After a very short time, the ionising radiation detected from the sample is mainly from the beta-minus decay of the lead-209 nuclei.

(i) Briefly describe and explain an experiment that can be carried out to confirm the beta-minus radiation emitted from the lead nuclei. **[2]**

– Place aluminium sheet between source and detector to show that count rate decreases.

(ii) The activity of the sample of $^{209}_{82}Pb$ after 7.0 hours is 12 kBq.

The half-life of $^{209}_{82}Pb$ is 3.3 hours.

Calculate the initial number of lead-209 nuclei in this sample.

$$\lambda = \frac{\ln(2)}{T_{1/2}} = \frac{\ln(2)}{3.3} = 0.21\ hr^{-1}$$

$$A = A_0 e^{-\lambda t}$$

Sub in $t = 7$ $A = 12 \times 10^3$

$$12 \times 10^3 = A_0 e^{-0.21 \times 7} \Rightarrow A_0 = 5.22 \times 10^4\ Bq$$

$A = \lambda N$ so $A_0 = \lambda N_0$ but first need λ in second^{-1}

$$0.21\ hr^{-1} = \frac{0.21}{3600}\ s^{-1} = 5.84 \times 10^{-5}\ s^{-1}$$

$$N_0 = \frac{A_0}{\lambda} = \frac{5.22 \times 10^4}{5.84 \times 10^{-5}} = 8.9 \times 10^8$$

number of nuclei = 8.9×10^8 .... **[4]**

Total Marks for Question Set 21: 9