Mark scheme for Support Worksheet – Topic 6, Worksheet 5

1 **a** $\lambda = \dfrac{\ln 2}{4.5\times 10^{9}\times 365\times 24\times 3600} = 4.88\times 10^{-18}\ \text{s}^{-1}$;

$N_0 = \dfrac{12}{234}\times 6.02\times 10^{23} = 3.09\times 10^{22}$; the initial activity is λN_0 i.e.

$4.88\times 10^{-18}\times 3.09\times 10^{22} = 1.5\times 10^{5}$ Bq [3]

b The idea suggested by the calculation in **a** is to find the decay constant through $\lambda = \dfrac{A_0}{N_0}$ and then the half-life through $T_{1/2} = \dfrac{\ln 2}{\lambda}$; the initial activity then has to be measured as well as the mass of the isotope so that knowing the molar mass of the isotope we determine the number of moles and hence N_0. [2]

2 Substitute $A = 0.35A_0$ in $A = A_0 e^{-\lambda t}$ to get $0.35 = e^{-\lambda t}$; the decay constant is

$\lambda = \dfrac{\ln 2}{22} = 0.0315\ \text{s}^{-1}$; and so taking logs of $0.35 = e^{-0.0315t}$ gives

$t = \dfrac{\ln 0.35}{-0.0315} = 31.7 \approx 32$ s [3]

3 After time t the number of X and Y nuclei is respectively $N_X = N_0 e^{-\lambda t}$ and

$N_Y = N_0(1-e^{-\lambda t})$; and so $\dfrac{N_0(1-e^{-\lambda t})}{N_0 e^{-\lambda t}} = 1.4 \Rightarrow 2.4e^{-\lambda t} = 1$; and finally

$t = \dfrac{\ln(2.4)}{\dfrac{\ln 2}{2.2}} = 2.78$ min [3]

4 **a** The number of nuclei that have decayed. [1]

b The area under the curve is about 160 (form trapezium area and subtract small strip); the energy released is then $0.5\times 160\times 10^{6}\times 1.6\times 10^{-19} = 1.28\times 10^{-11}$ J;

and so the average power is $\dfrac{1.28\times 10^{-11}}{2.0} = 6.4\times 10^{-12}$ W (It would be incorrect to just add the initial and final activity and then divide by 2; this holds only for straight line graphs or approximately straight-line graphs.) [3]