Question Number	Answer		Mark
20(a)	Top row correct Bottom row correct Example of calculation $^{225}_{89}\text{Ac} \rightarrow {}^{221}_{87}\text{Fr} + {}^{4}_{2}\alpha$	(1) (1)	**2**
20(b)	Use of 1 u = 1.66×10^{-27} kg Use of $\Delta E = c^2 \Delta m$ Use of 1 J = 1.6×10^{-19} eV 1 u = 934 (MeV) Example of calculation $\Delta E = (3.0 \times 10^8 \text{ m s}^{-1})^2 \times 1.66 \times 10^{-27} \text{ kg} = 1.494 \times 10^{-10} \text{ J}$ $\therefore \Delta E = \frac{1.494 \times 10^{-10} \text{ J}}{1.6 \times 10^{-13} \text{ J MeV}^{-1}} = 934 \text{ MeV}$	(1) (1) (1) (1)	**4**
20(c)	Use of 1 u = 934 MeV (ecf from (b) [Accept calculation from first principles] The mass of the Fr nucleus is much greater than the mass of the α Momentum is conserved so (recoil) velocity of Fr nucleus is much less than the velocity of the α So the kinetic energy of the α is much greater than the kinetic energy of the Fr **Or** (after the decay) the α has most of the kinetic energy [MP4 dependent upon MP2 or MP3] **OR** Use of 1 u = 934 MeV (ecf from (b) [Accept calculation from first principles] Mathematical statement of momentum conservation Use of $E_k = \frac{p^2}{2m}$ **Or** use of $E_k = \frac{1}{2}mv^2$ **and** $p = mv$ E_k calculated and statement that E_k is just less than 5.9 MeV **Or** E_k calculated and statement that α has most of the kinetic energy Example of calculation $\Delta E = 6.35 \times 10^{-3}$ u × 934 MeV $u^{-1} = 5.93$ MeV [5.91 MeV if "show that" value used]	(1) (1) (1) (1) (1) (1) (1) (1)	**4**

20(d)	Use of $\lambda\, t_{1/2} = \ln 2$ (1) Use of $A = -\lambda N$ (1) Use of $N = N_0 e^{-\lambda t}$ (1) $N = 5.6 \times 10^{13}$ (1) Example of calculation $\lambda = \dfrac{\ln 2}{9.9 \times 24 \times 3600\ \text{s}} = 8.10 \times 10^{-7}\text{s}^{-1}$ $N = \dfrac{7.4 \times 10^{7}\text{s}^{-1}}{8.10 \times 10^{-7}\text{s}^{-1}} = 9.13 \times 10^{13}$ $N = 9.13 \times 10^{13} \times e^{-8.10\times10^{-7}\text{s}^{-1}\times7.0\times24\times3600\ \text{s}} = 5.59 \times 10^{13}$	**4**
	Total for question 20	**14**