Question Number	Answer		Mark
19(a)	Calculation of mass difference	(1)	
	Conversion from u to kg, using a conversion factor of 1.66×10^{-27} kg u^{-1}	(1)	
	Use of $\Delta E = c^2 \Delta m$	(1)	
	Conversion of energy to eV	(1)	
	$\Delta E = 5.61$ (MeV)	(1)	**5**
	<u>Example of calculation</u> Mass difference = 237.999089 u – 233.991578 u – 4.001506 u = 6.005×10^{-3} u Mass difference = 6.005×10^{-3} u $\times 1.66 \times 10^{-27}$ kg = 9.9683×10^{-30} kg u^{-1} $\Delta E = c^2 \Delta m = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 9.9683 \times 10^{-30} \text{ kg} = 8.9715 \times 10^{-13}$ J $\Delta E = \frac{8.9715 \times 10^{-13}\text{ J}}{1.60 \times 10^{-13}\text{ J MeV}^{-1}} = 5.607$ MeV		
19(b)	Convert α-particle energy from MeV to J	(1)	
	Use of $\lambda = \frac{\ln 2}{t_{1/2}}$	(1)	
	Use of $A = A_0 e^{-\lambda t}$	(1)	
	Use of $P = \frac{\Delta E}{\Delta t}$	(1)	
	$P = 0.083$ (W)	(1)	**5**
	<u>Example of calculation</u> 5.6 MeV = $5.6 \times 1.60 \times 10^{-19}$ J MeV^{-1} = 8.96×10^{-13} J $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{87.7\text{ year}} = 7.90 \times 10^{-3}\text{ year}^{-1}$ $6.75 \times 10^{10}\text{ Bq} = A_0\, e^{-7.90 \times 10^{-3}\text{ year}^{-1} \times 40\text{ year}}$ $\therefore A_0 = 9.26 \times 10^{10}$ Bq $So\ P = 9.26 \times 10^{10}\text{s}^{-1} \times 8.96 \times 10^{-13}\text{ J} = 0.0830$ W		

19(c)	Maximum energy of beta particles read from graph 1 (in range 210 keV → 225 keV) Beta particle range read from graph 2 (in range 0.05 cm → 0.08 cm) **Or** max. energy for 0.5 cm polyethylene read from graph.2 (in range 1000 keV → 1200 keV) Conclusion that 0.5 cm polyethylene would be sufficient MP3 dependent on MP1 **and** MP2	(1) (1) (1)	**3**
	Total for question 19		**13**