

Question Number	Answer	Mark
19(a)(i)	<p>Top line correct (1) Bottom line correct (1)</p> <p><u>Example of calculation</u></p> ${}_{27}^{60}\text{Co} \rightarrow {}_{28}^{60}\text{Ni} + {}_{-1}^0\beta^{-} + {}_0^0\bar{\nu}_e$	2
19(a)(ii)	The mass of the Ni nucleus is much larger than total mass of the other two particles (1)	1
19(b)	<p>Use of $\lambda = \frac{\ln 2}{t_{1/2}}$ (1) Use of $A = A_0 e^{-\lambda t}$ (1) t = 6.0 (years) (1)</p> <p><u>Example of calculation</u></p> $\lambda = \frac{\ln 2}{5.27 \times 3.16 \times 10^7 \text{ s}} = 4.16 \times 10^{-9} \text{ s}^{-1}$ $1.85 \times 10^{14} \text{ Bq} = 4.07 \times 10^{14} \text{ Bq} e^{-4.16 \times 10^{-9} \times t}$ $\therefore t = \frac{\ln \left(\frac{4.07 \times 10^{14} \text{ Bq}}{1.85 \times 10^{14} \text{ Bq}} \right)}{4.16 \times 10^{-9} \text{ s}^{-1}} = 1.886 \times 10^8 \text{ s}$ $\therefore t = \frac{1.894 \times 10^8 \text{ s}}{3.16 \times 10^7 \text{ s year}^{-1}} = 5.996 \text{ years}$	3
19(c)	<p>Required % transmission calculated (1) Distance x read from graph for required transmission (1) x = 1.1 cm, so shielding would be insufficient (1)</p> <p>OR</p> <p>Required % transmission calculated (1) % transmission read from graph for 1.0 cm shielding (1) % transmission \approx 33%, so shielding would be insufficient (1)</p> <p><u>Example of calculation</u></p> $\text{Required \% transmission} \leq \frac{1.2 \times 10^{14} \text{ Bq}}{4.0 \times 10^{14} \text{ Bq}} \times 100\% = 30\%$ <p>From graph, for required % transmission thickness of shielding = 1.1 cm,</p>	3
Total for question 19		9