

Name of the Student: _____

Max. Marks : 27 Marks

Time : 27 Minutes

Mark Schemes

Q1.

Question Number	Answer		Mark
(a)(i)	$\text{N} + \alpha \rightarrow {}^{17}_8\text{O} + {}^1_1\text{p}$ All values correct	(1)	1
(a)(ii)	In nuclear fission a chain reaction can be set up Or in a chain reaction the (total) energy released can be very large Or heavier/larger nuclei release much more energy Or a very high reaction rate releases much more energy	(1)	1
(b)	Attempt at mass deficit calculation Use of $\Delta E = c^2 \Delta m$ (Allow use of $1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$) Use of $1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$ (Allow use of $1 \text{ u} = 931.5 \text{ MeV}/c^2$) $\Delta E = 174 \text{ MeV}$ <u>Example of calculation</u> $\Delta m = (390.29989 - 233.99404 - 152.64708 - (2 \times 1.67493)) \times 10^{-27} \text{ kg}$ $\Delta m = 3.0891 \times 10^{-28} \text{ kg}$ $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 3.0891 \times 10^{-28} \text{ kg} = 2.780 \times 10^{-11} \text{ J}$ $\Delta E = \frac{2.780 \times 10^{-11} \text{ J}}{1.60 \times 10^{-13} \text{ J MeV}^{-1}} = 173.8 \text{ MeV}$	(1) (1) (1) (1)	4
(c)(i)	Same number of protons [do not accept atomic/proton number]. Different numbers of neutrons [do not accept mass/nucleon/neutron number]	(1) (1)	2

(c)(ii)	Correct calculation for ω [see 6283 or 2000π or $\frac{60\,000 \times 2\pi}{60}$] $a = (-) 5.9 \times 10^6 \text{ m s}^{-2}$ <u>Example of calculation</u> $a = -\left(\frac{60000 \times 2\pi}{60\text{s}}\right)^2 \times 15 \times 10^{-2} \text{ m} = 5.92 \times 10^6 \text{ m s}^{-2}$	(1) (1)	2
(c)(iii)	Max 2 Stiff/stiffness Strong/strength Low density	(1) (1) (1)	2
(d)	Use of $\Delta E = mc\Delta\theta$ Rate at which energy is removed = $3.1 \times 10^9 \text{ (W)}$ Use of the efficiency equation [must have $2.2 \times 10^9 \text{ (W)}$ on top line] Efficiency = 42% [accept 0.42] <u>Example of calculation</u> $\Delta E = 70000 \text{ kg} \times 3990 \text{ J kg}^{-1} \text{ K}^{-1} \times 11\text{K} = 3.07 \times 10^9 \text{ J}$ $\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100 = \frac{2.2 \times 10^9 \text{ W}}{(2.2 + 3.1) \times 10^9 \text{ W}} \times 100 = 41.5\%$	(1) (1) (1) (1)	4

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	- a π^0 may be $u\bar{u}$ Or $d\bar{d}$ (1) - it must be a quark combined with its own antiquark so that overall charge is 0 (1) <u>OR</u> it can only contain up or down quarks (as it is not a strange particle)	Allow $s\bar{s}$	(2)
(a)(ii)	mesons are made up of quarks, whereas leptons are fundamental particles (1)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	• use of $v = s/t$ (1) • $t = 5.05 \times 10^{-5} \text{ s}$ (1)	<u>Example of calculation:</u> $t = \frac{s}{v} = \frac{15 \times 10^3 \text{ m}}{0.99 \times 3 \times 10^8 \text{ ms}^{-1}} = 5.05 \times 10^{-5} \text{ s}$	(2)
(b)(ii)	• use of $\lambda t_{1/2} = 0.693$ (1) • $\lambda = 3.15 \times 10^5 \text{ s}^{-1}$ (1) • use of $N = N_0 e^{-\lambda t}$ (1) • $\frac{N}{N_0} = 1.23 \times 10^{-7}$ (1)	<u>Example of calculation:</u> $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{2.2 \times 10^{-6} \text{ s}} = 3.15 \times 10^5 \text{ s}^{-1}$ $\frac{N}{N_0} = e^{-\lambda t} = e^{-3.15 \times 10^5 \text{ s}^{-1} \times 5.05 \times 10^{-5} \text{ s}} = 1.23 \times 10^{-7}$ $\frac{N}{N_0} = 1.1 \times 10^{-7} \text{ if "show that" value used}$	(4)
(b)(iii)	• This is much smaller than 10% indicating the muon lifetime is much greater than the expected value (1) • The high speed of the muon has led to relativistic effects (1)		(2)