OCR

RECOGNISING ACHIEVEMENT

NUCLEAR + PARTICLE

Mark Scheme 2825/04
June 2003

Question	Expected Answers	Marks
1 (a)	graph: curved, *in correct sense* starts at origin and eventually approaches horizontal (straight line scores zero)	1 1 [2]
(b)	r_0 is radius of 1 proton/ neutron/ nucleon/ hydrogen nucleus (not nucleus/ nuclei/ atom/ molecule)	1 [1]
(c)	$r_0 = r/A^{1/3} = 3.53 \times 10^{-15}/16^{1/3}$ correct subs. ($= 1.4 \times 10^{-15}$)m	1 [1]
(d)	$r = r_0 A^{1/3} = 1.40 \times 10^{-15} \times (79 + 118)^{1/3}$ subs. $= 8.15 \times 10^{-15}$ m allow 8.1×10^{-15} or 8.2×10^{-15} *omits 79 or 118 can score 1/2*	1 1 [2]
(e)(I)	$V = (4/3)\,\pi r_0^3$ $= (4/3)\,\pi (1.4 \times 10^{-15})^3$ $= 1.149 \times 10^{-44}$ m^3 allow 1 sf (using gold or oxygen radius can score 1/2 only)	1 1 [2]
(II)	(likely to be) more than16 times as great because of spaces between nucleons (calculated values compared scores zero)	1 1 [2]

2(a)	similarity: both have same number/ 92 (of) protons/ charge/ are radioactive difference: *either* have different numbers/146 and 143 (of) neutrons *or* ^{235}U fissions but ^{238}U does not (not different mass number/nuceon number)	1 1
(b)	Reaction 1: $^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U$ Reaction 2: $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U$ (showing only fission products on RHS does not score)	1 1
(c)(i)	$^{239}_{92}U \rightarrow ^{239}_{93}Np + ^{0}_{-1}e$ (+ν-bar) $^{239}_{93}Np \rightarrow ^{239}_{94}Pu + ^{0}_{-1}e$ (+ν-bar) allow $^{0}_{-1}\beta$ or $^{0}_{-1}e$ (if equation not clear but $^{0}_{-1}e$ comes sideways from = sign, allow 1/2 max)	1 1
(ii)	(anti)neutrino/ ν	1
(d)(i)	two nuclei not nuclides/ isotopes/ atoms/ molecules/ elements/ fragments not specific example (several) neutrons	1 1
(ii)	0.01%	1
(iii)	total mass/number of nucleons of products (from one nucleus) is constant so for every product nucleus which has less than half the mass of the fissile /original nucleus, there is a nucleus which has more than half its mass *or* wtte	1 1

3(a)	high temperature/convert gas to plasma (1) high temperature means (particles move at) high speed /high energy (1) high speed nuclei can overcome repulsion /Coulomb barrier (1) sufficient/high density of tritium and deuterium (1) high density means more nuclei per unit volume so increased probability of reaction (1) containment/confinement by magnetic field (1) to prevent plasma touching the sides/ contamination/ cooling of plasma (1) (not high pressure, not high temp. to form plasma) any 4	4	[4]
(b)	$^{2}_{1}D + {}^{3}_{1}T \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$ (+ energy) *or* $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$ (+ energy) *or* $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{3}_{2}He + 2{}^{1}_{0}n$ (+ energy) LHS 1/2 RHS 1/2	2	[2]
(c)	BE/nucleon: ^{2}H: 1.1; ^{3}H: 2.9; ^{4}He: 7.1 (MeV) BE/nucleus: ^{2}H: 2.2; ^{3}H: 8.7; ^{4}He: 28.4 (MeV) so reactants have total BE = 2.2 + 8.7 = 10.9(MeV) products have total BE = 28.4(MeV) ($^{1}_{0}n$ has BE = 0) so energy released = 28.4 - 10.9 = 17.5(MeV) $= 17.5 \times 10^{6} \times 1.6 \times 10^{-19} = 2.8 \times 10^{-12}$ J using 7.1 - 4 leading to 4.96×10^{-13} scores 2/4 (1 0 0 1)	1 1 1 1	[4]
(d)	lithium blanket (1) neutron absorbed/captured by Li (1) ke of neutron is converted to heat in lithium (1) heat exchanger/heat passed to water (1) (heat made to) boil water to produce steam (1) turns generator/ turbine to generate electrical energy (not electricity) (1) quotes either equation: $^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + {}^{4}_{2}He$ $^{7}_{3}Li + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + {}^{4}_{2}He + {}^{1}_{0}n$ (1) any 5	5	[5]

4(a)	looks correct shape: spirals outwards quality of sketch - looks circular within dees (no tracks between dees can get 1/2 max.)	1 1
(b)(i)	$BQv = mv^2/R$ (so $v = BQR/m$) (magnetic force) $F = Bev$ gets 1 (centripetal force) $F = mv^2/R$ gets 1	2
(ii)	$t = s/v$ or $v = s/t$ $t = \pi R/v$ loses first mark unless πR stated as distance $T = \pi R/(BQR/m)$ ($= \pi m/BQ$)	1 1
(c)(i)	expression for f / time independent of R frequency of source must be same as freq. of/in step with proton (1) proton acceleration changes direction (every half cycle) so pd must change direction (1) pd must synchronise with particle crossing gap between dees (1) any 1	1 1 [2
(ii)	$f = 1/(2T)$ or $f = 1/T$ or f = 1/period $= BQ/(2\pi m)$	1 1 [2
(d)	$f = BQ/(2\pi m) = 1.5 \times 1.6 \times 10^{-19}/(2\pi \times 1.67 \times 10^{-27})$ subs. $= 2.29 \times 10^7$ Hz appropriate unit for number given	1 1 [2]

5(a)(i)	strong (interaction)	1	[1]
(ii)	graph: shape - general shape - (asymptotic to force axis) falls to zero against distance axis labels: attraction and repulsion correctly labelled	1 1 1	[3]
(b)	the neutron inside nucleus: (relatively) stable (1) when free: unstable/ decays (1) half life about 15 mins. (not decays in 15 mins.) (1) the proton inside nucleus: (relatively) stable when free: probably unstable *or* (unstable with) half life of 10^{32} year *or* proton is 'stable' (1) in the nucleus p can decay into n + β^+ /n can decay into p + β^- (1) (doesn't specify inside/outside nucleus - doesn't score) any 5	5	[5]
(c)	charge: $-1 + 1 = 0 + 0$ baryon number: $0 + 1 = 1 + 0$ strangeness: $0 + 0 = 0 + 0$ conclusion: reaction may take place allow ecf (if = sign missing -1 if + sign missing -1)	1 1 1 1	[4]
6(a)	momentum = mv $= 6.68 \times 10^{-27} \times 1.8 \times 10^{7} = 1.20 \times 10^{-19}$ N s	1 1	[2]
(b)	ke of α– particle = $\frac{1}{2}mv^2$ $= \frac{1}{2} 6.68 \times 10^{-27} \times (1.38 \times 10^{7})^2$ $= 6.36 \times 10^{-13}$ J ke of helium nucleus = $\frac{1}{2}mv^2 = \frac{1}{2} 6.68 \times 10^{-27} \times (1.15 \times 10^{7})^2$ $= 4.42 \times 10^{-13}$ J allow 2 sf on each answer	1 1 1	[3]
(c)(i)	so total ke after collision equal to ke of incident α– particle total ke before collision = $(6.36 + 4.42) \times 10^{-13} = 1.08 \times 10^{-12}$ J or other evidence of a calculation	1 1	[2]
(ii)	collision is elastic accept 'kinetic energy is conserved in this collision' allow ecf from **(c)(i)**	1	[1]

7	(a)		Quieter Less pollution/more environmentally friendly	Or other valid point, eg petrol supplies finite, safety(batteries less of fire hazard), can utilise renewable energy	2
	(b)		$P = VI$ 750 Wh = 750/12 = 62.5 Ah	0/3 for wrong ans no working 0.75/12=0.0625 (2/3) 3/3 for correct ans.	1 1 1
	(c)	(i)	No. of batteries = 960/16 = 60 No of kWh = 0.75 x 60 = 45 kWh = 45 x 1000 x 3600 =162 MJ	-1 for each error 1.62×10^8 MJ (2/3)	1 1 1
		(ii)	Work done = Fd D = $162 \times 10^6/300$ = 540 km	Allow 1sf if working shown	1 1 1
	(d)	(i)	Mass of petrol = 162/50 kg = 3.24 kg Volume = m/ρ(stated or implied) =3.24/700 = 4.6×10^{-3} m^3	Ecf Or equivalent	1 1 1 1
		(ii)	Energy lost/not 100% efficient As heat etc.	General comment + detail	1 1
	(e)		Compare :- • mass, • size, • likely performance of petrol vs batteries, • sensible statement about range Concluding comment	Any 3 from 4	3