

Mark Scheme for January 2012

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations available in Scoris

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error
	Error in number of significant figures
	Correct response
	Arithmetic error
	Wrong physics or equation

Annotations in detailed mark scheme

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ecf	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

- B** marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.
- M** marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.
- C** marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.
- A** marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

Note about significant figures:

If the data given in a question is to 2 sf, then allow answers to 2 or more significant figures.

(Significant figures are rigorously assessed in the practical skills.)

Question			Answers	Marks	Guidance
1	(a)		electric field strength = force per unit (positive) charge	B1	Allow: force/charge Not: F/Q
	(b)	(i)	$E = V / d$ $3.0 \times 10^6 = V / 1.3 \times 10^{-3}$ $V = 3900 \text{ (V)}$	C1 A1	Note: This mark is for correct substitution Allow: 1 mark if answer is $3.9 \times 10^n \text{ (V)}$, $n \neq 3$ – POT error
		(ii)1	$Q = It$ $Q = 2.7 \times 10^{-9} \times 4.0 \times 10^{-2}$ charge = $1.1 \times 10^{-10} \text{ (C)}$ or $1.08 \times 10^{-10} \text{ (C)}$	C1 A1	Note: This mark is for correct substitution
		(ii)2	number = $1.08 \times 10^{-10} / 1.6 \times 10^{-19}$ number = 6.8×10^8 or 6.75×10^8	B1	Possible ecf from (b)(ii)1
		(iii)	energy = VQ energy = $3900 \times 1.08 \times 10^{-10}$ energy = $4.2 \times 10^{-7} \text{ (J)}$	C1 A1	Note: No credit for using $\frac{1}{2} QV$ Possible ecf from (b)(ii)1
			Total	8	

Question			Answers	Marks	Guidance
2	(a)		torque = one of the forces $\times$ <u>perpendicular</u> distance (between the forces)	B1	
	(b)	(i)	Into (plane of) paper	B1	Not: 'down'
		(ii)1	force = $BIL = 0.060 \times 0.03 \times 0.015$ force = 2.7×10^{-5} (N)	B1	
		(ii)2	torque = $2.7 \times 10^{-5} \times 0.015$ torque = 4.1×10^{-7} (N m) or 4.05×10^{-7} (N m)	C1 A1	Possible ecf from (b)(ii)1 Do not allow 4.0×10^{-7} (N m) - rounding error
	(c)	(i)	$F = BQv$ $2.0 \times 10^{-13} = 0.14 \times Q \times 4.5 \times 10^6$ charge = 3.2×10^{-19} (C) or 3.17×10^{-19} (C)	C1 A1	Allow: Any subject
		(ii)	$F = mv^2 / r$ $2.0 \times 10^{-13} = \frac{2.7 \times 10^{-26} \times (4.5 \times 10^6)^2}{r}$ radius = 2.7 (m) or 2.73 (m)	C1 C1 A1	Allow: Any subject
		(iii)	$BQv = mv^2/r$ Hence, radius $\propto$ mass	B1 B1	Allow: $r \propto m$
			Total	12	

Question			Answers	Marks	Guidance
3	(a)		magnetic flux = (magnetic) flux density $\times$ (cross-sectional) area Idea of (magnetic) field normal to the plane of the area	M1 A1	Allow full credit for magnetic flux = BA , where B = magnetic flux density normal to area and A = (cross-sectional) area
	(b)	(i)	constant rate of change of (magnetic) <u>flux</u> / flux density	B1	Not: 'graph has constant gradient'
		(ii)	e.m.f. = rate of change of flux linkage e.m.f. = $\frac{1.4 \times 10^{-2} \times \pi \times (3.2 \times 10^{-2})^2 \times 180}{2.5}$ e.m.f. = 3.2×10^{-3} (V) or 3.24×10^{-3} (V)	C1 C1 A1	Allow: $E = \frac{\Delta N\phi}{\Delta t}$ Deduct 1 mark if B is misread from the graph and then ecf Allow: 2 marks for an answer 3.24×10^n (if $n \neq -3$) Allow: 2 marks for 1.78×10^{-5} (when 180 has been missed out)
	(c)	(i)	$P = VI$ current in secondary = $15/6$ or 2.5 (A) primary voltage = $6.0 \times$ turn ratio = $6.0 \times 40 = 240$ (V) $V_p = 240$ (V) or $I_s = 2.5$ (A) primary current = $2.5/40$ or $15/240$ input current = 6.3×10^{-2} (A) or 6.25×10^{-2} (A)	C1 A1	The C1 mark is for either of these values
		(ii)	There is no change in <u>flux density</u> / (magnetic) <u>flux</u> / (magnetic) <u>flux</u> linkage	B1	Not: 'There is no change in the magnetic field'
			Total	9	

Question		Answers	Marks	Guidance
4	(a)	capacitance = charge/p.d. or capacitance = charge per (unit) p.d.	B1	Allow: voltage instead of p.d. Note: Do not allow mixture of quantity and unit, e.g. 'charge per (unit) volt'
	(b)	(i) $C_{\text{parallel}} = 240 \text{ (}\mu\text{F)}$ $C_T = (240 \times 120)/(240 + 120)$ or $C_T = (240^{-1} + 120^{-1})^{-1}$ total capacitance = 80 (μF)	C1 C1 A0	Allow :1 mark if C_T is not the subject, e.g: $\frac{1}{C_T} = \frac{1}{240} + \frac{1}{120}$
		(ii) $E = \frac{1}{2} V^2 C$ $E = \frac{1}{2} \times 6.0^2 \times 80 \times 10^{-6}$ energy = 1.4×10^{-3} (J) or 1.44×10^{-3} (J)	C1 A1	Possible ecf Allow: 1 mark for an answer 1.44×10^n ($n \neq -3$)
		(iii)1 6.0/e = 2.2 (V) (as on graph) Or $6.0 \times 0.37 = 2.2$ (V) (as on graph) Or At 20 (s), $V = 2.2$ (V), $2.2/6.0 = 0.37$ (or e^{-1})	B1	Allow: Graph reading within ± 0.2 V
		(iii)2 $CR = 20$ $R = \frac{20}{80 \times 10^{-6}}$ $R = 2.5 \times 10^5$ (Ω)	C1 A1	Allow: Follow through with CR value from (iii)1
		Total	8	

Question		Answers	Marks	Guidance
5	(a)	Same charge / number of protons	B1	Not: 'same chemical property'
	(b)	strong (nuclear force / interaction) gravitational (force)	B1 B1	Allow: 'gravity'
	(c)	(i) ${}_{7}^{15}\text{N}$	B1	
		(ii) $(u\ d\ d) \rightarrow (u\ u\ d)$	B1	Allow: <i>One down quark becomes up quark</i> or $d \rightarrow u$ (+ electron + antineutrino)
	(d)	(i) $0.16\text{ MeV} = 0.16 \times 10^6 \times 1.6 \times 10^{-19}$ $\frac{1}{2} \times 9.11 \times 10^{-31} \times v^2 = 2.56 \times 10^{-14}$ speed = $2.4 \times 10^8\text{ (m s}^{-1}\text{)}$ or $2.37 \times 10^8\text{ (m s}^{-1}\text{)}$	C1 A1	Allow: 1 mark for using 9.8 MeV; answer is equal to $1.86 \times 10^9\text{ (m s}^{-1}\text{)}$
		(ii) The mass of the electron increases / greater than 'rest mass'	B1	
	(e)	(i) $\lambda = 0.693/T$ $\lambda = 0.693/(5560 \times 3.16 \times 10^7)$ $\lambda = 3.9 \times 10^{-12}\text{ (s}^{-1}\text{)}$ or $3.94 \times 10^{-12}\text{ (s}^{-1}\text{)}$	C1 A1	Allow: 1 mark for 1.25×10^{-4} (if 5560 y used)
		(ii) number = $\frac{1.0 \times 10^{-3}}{14} \times 6.02 \times 10^{23}$ number = 4.3×10^{19}	M1 A0	Note: This step must be seen to score 1 mark
		(iii) activity = λN activity = $3.94 \times 10^{-12} \times 4.3 \times 10^{19}$ activity = $1.7 \times 10^8\text{ (Bq)}$ or $1.69 \times 10^8\text{ (Bq)}$	C1 A1	Possible ecf from (e)(i) and (e)(ii)

[illegible]

Question			Answers	Marks	Guidance
6	(a)		(Minimum) energy to separate (all) nucleons / protons <u>and</u> neutrons (of a nucleus)	M1 A1	Alternative: B.E. = mass <u>defect</u> $\times c^2$ M1 mass defect = mass of nucleons – mass of nucleus A1
	(b)	(i)	BE of ${}^2\text{H} = 2 \times 1.8 \times 10^{-13} \text{ (J)}$ or BE of ${}^4\text{He} = 4 \times 1.1 \times 10^{-12} \text{ (J)}$ energy = $(4 \times 1.1 \times 10^{-12}) - 2 \times (2 \times 1.8 \times 10^{-13})$ energy = $3.68 \times 10^{-12} \text{ (J)}$ / $3.7 \times 10^{-12} \text{ (J)}$	C1 C1 A0	Note: Ignore signs
		(ii)1	total surface area = $4\pi \times (1.5 \times 10^{11})^2$ power = $1400 \times (2.83 \times 10^{23})$ power = $3.96 \times 10^{26} \text{ (W)}$ / $4.0 \times 10^{26} \text{ (W)}$	C1 C1 A0	
		(ii)2	number = $4.0 \times 10^{26} / 3.7 \times 10^{-12}$ number = $1.1 \times 10^{38} \text{ (s}^{-1}\text{)}$ or $1.08 \times 10^{38} \text{ (s}^{-1}\text{)}$	C1 A1	Allow: $10^{38} \text{ (s}^{-1}\text{)}$ because the question is about an estimate
			Total	8	

Question		Answers	Marks	Guidance
7	(a)	Any two from: 1. Electrons are accelerated through high voltage 2. (High speed) electron(s) hit metal 3. <u>kinetic</u> energy of electron(s) 'produces' X-ray (photons)	B1×2	Allow: X-rays are produced by (large) deceleration of electrons
	(b)	(i) Packet /quantum of (electromagnetic) <u>energy</u>	B1	Allow: 'particle of (electromagnetic) <u>energy</u> '
		(ii) $E = hc/\lambda$ <u>and</u> X-rays have shorter wavelength Or $E = hf$ <u>and</u> X-rays have higher frequency	B1	
	(c)	(KE of electron =) $1.6 \times 10^{-19} \times 120 \times 10^3$ $eV = \frac{hc}{\lambda}$ $1.6 \times 10^{-19} \times 120 \times 10^3 = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^8}{\lambda}$ wavelength = 1.0×10^{-11} (m) or 1.04×10^{-11} (m)	C1 C1 A1	Allow: 2 marks for $1.0(4) \times 10^{-n}$ (m) ($n \neq 11$ - powers of ten error) Allow: 1×10^{-11} (m)
	(d)	Compton (scattering) Incoming photon collides with an electron, the electron is ejected and the photon is scattered / has lower energy Or Pair production Incoming photon (disappears and) produces electron-positron pair	M1 A1 ----- M1 A1	Must use ticks on Scoris to show where the marks are awarded Allow: (Simple) scatter(ing) M1 The photon is absorbed and re-emitted without change in energy/wavelength/frequency A1
		Total	9	

Question			Answers	Marks	Guidance
8	(a)		No entry into body / no cutting/incision of patient / no surgery Lower risk of infection / less trauma	B1 B1	
	(b)		<u>Radioactive</u> substance that is ingested / injected (into patient) Technetium(-99m) / Iodine(-131) / fluorine(-18)	B1 B1	Not: barium
	(c)		Collimator – gamma (ray photons) travel along the axis of lead tubes or allows parallel gamma (ray photons travel to the scintillator) Having thin / long / narrow (lead) tubes makes the image sharper / less blurred (QWC mark) Scintillator – gamma ray <u>photon</u> produces <u>many/thousands</u> of <u>photons</u> of (visible) light Photomultiplier - An electrical pulse is / electrons are produced from the light (photons) Computer – Signals (from photomultiplier tubes) are used to produce an image	B1 B1 B1 B1	Must use ticks on Scoris to show where the marks are awarded
	(d)	(i)	$v = f\lambda$ $1500 = 2.0 \times 10^6 \times \lambda$ wavelength = 7.5×10^{-4} (m)	C1 A1	
		(ii)	Ultrasound is reflected by (moving) blood (cells) The frequency / wavelength (of ultrasound) is changed (AW) The <u>change</u> of frequency is related to speed of blood / <u>change</u> of wavelength is related to speed of blood / ' Δ frequency $\propto$ speed of blood'	B1 B1 B1	Must use ticks on Scoris to show where the marks are awarded Not: Doppler effect mentioned
			Total	14	

Question		Answers	Marks	Guidance
9	(a)	Any <u>four</u> from: 1. (Sun / star formed from) dust cloud / nebula / (hydrogen) gas 2. <u>Gravitational</u> collapse (AW) 3. Temperature of (dust) cloud increases / KE (of cloud) increases / (cloud) heats up 4. Fusion occurs (when temperature is about 10^7 K) 5. Protons / hydrogen nuclei combine to make helium (nuclei) 6. Stable size star is produced when thermal / radiation pressure is equal to gravitational pressure Steps sequenced correctly – QWC mark	B1 × 4 B1	Must use ticks on Scoris to show where the marks are awarded
	(b)	Any <u>two</u> from: 1. Very dense star 2. Hot star / high surface temperature / low luminosity 3. No fusion reactions take place / leaks away photons (from earlier fusion reactions) 4. Its collapse is prevented by Fermi pressure / mass less than 1.4 solar masses (AW)	B1 × 2	Must use ticks on Scoris to show where the marks are awarded Not: small in size, but <u>allow</u> 'smaller than main sequence star / Sun'
	(c) (i)	Flat or universe will expand towards a (finite) limit or the rate of expansion will become/tend to zero	B1	
	(ii)	Hubble constant = $1/\text{age}$ $H_0 = 1 / 4.4 \times 10^{17} (= 2.273 \times 10^{-18} \text{ s}^{-1})$ $\text{density} = \frac{3H_0^2}{8\pi G}$ $\text{density} = \frac{3H_0^2}{8\pi G} = \frac{3 \times (2.273 \times 10^{-18})^2}{8\pi \times 6.67 \times 10^{-11}}$ density = $9.2 \times 10^{-27} \text{ (kg m}^{-3}\text{)}$ or $9.24 \times 10^{-27} \text{ (kg m}^{-3}\text{)}$ density is about $10^{-26} \text{ (kg m}^{-3}\text{)}$	C1 C1 A1 A0	Allow: 2 marks for a bald $9.24 \times 10^{-27} \text{ (kg m}^{-3}\text{)}$ answer Note: This mark can only be scored if working is shown

Question			Answers	Marks	Guidance
		(iii)	number = $9.24 \times 10^{-27} / 1.7 \times 10^{-27}$ number = 5.4 (Allow 5)	C1 A1	Possible ecf from (c)(ii) Allow: 2 marks for ' $10^{-26} / 1.7 \times 10^{-27} = 5.9$ or 6'
	(d)		$\frac{1}{2}mv^2 = \frac{3}{2}kT$ / speed $\propto \sqrt{T}$ ratio = $\sqrt{\frac{10^8}{2.7}}$ ratio = 6.1×10^3 or 6.09×10^3	C1 A1	
			Total	15	

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