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PHYSICS **9702/42**

Paper 4 A Level Structured Questions **February/March 2025**

MARK SCHEME

Maximum Mark: 100

Published

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This document consists of **14** printed pages.

Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
^	information missing or insufficient for credit
AE	arithmetic error
BOD	benefit of the doubt given
CON	contradiction in response, mark not awarded
✗	incorrect point or mark not awarded
ECF	error carried forward applied
I	ignore the response

Annotation	Meaning
MO	mandatory mark not awarded
POT	power of ten error
SEEN	blank page seen
SF	error in number of significant figures
TE	transcription error
✔	correct point or mark awarded
XP	incorrect physics

Question	Answer	Marks
1(a)	arrow vertically downwards labelled 'weight' <u>and</u> arrow perpendicular to cone, inwards and upwards, labelled 'normal contact force'	**B1**
1(b)	vertical component of contact force = weight (so no resultant force vertically)	**B1**
	horizontal component of contact force is resultant force towards centre (of circle)	**B1**
1(c)	$a = v^2 / r$	**C1**
	$a = g \tan 52°$	**C1**
	$9.81 \times \tan 52° = v^2 / 0.15$ leading to $v = 1.4\ \text{m s}^{-1}$	**A1**
1(d)	$v = r\omega$ <u>or</u> $a = r\omega^2$	**C1**
	$\omega = 1.4 / 0.15$ or $\sqrt{(9.81 \times \tan 52° / 0.15)}$ $= 9.3\ \text{rad s}^{-1}$	**A1**
1(e)	same resultant force / same acceleration so v^2 is proportional to r (so if speed increases radius must also increase)	**A1**

Question	Answer	Marks
2(a)	<u>sketch:</u> line from $x = R$ to $x = 4R$ entirely in the negative ϕ region	**B1**
	curve with continuously decreasing magnitude and with gradient of continuously decreasing magnitude, starting at $(R, \pm\phi)$	**B1**
	line passing through $(2R, \pm\frac{1}{2}\phi)$ <u>and</u> $(4R, \pm\frac{1}{4}\phi)$	**B1**
2(b)	horizontal straight line from $t = 0$ to $t = 24$ hours	**B1**
	line starting at $(0, -\phi)$	**B1**

Question	Answer	Marks
2(c)	straight line with non-zero gradient from 0 to d	**B1**
	line with negative gradient from $(0, V)$ to $(d, 0)$	**B1**

Question	Answer	Marks
3(a)(i)	(P and Q are at the) same temperature	**B1**
	no <u>net</u> transfer of thermal energy (between P and Q)	**B1**
3(a)(ii)	$Q = mc\Delta T$	**C1**
	$24 \times 10^3 = (0.54 \times 390 \times \Delta T) + (0.37 \times 910 \times \Delta T)$	**C1**
	$\Delta T = 44\,\text{K}$	**A1**
3(b)(i)	work done $= p\Delta V$	**C1**
	$= (1.6 \times 10^5) \times (0.18 - 0.32)$	**C1**
	$= -2.2 \times 10^4\,\text{J}$	**A1**
3(b)(ii)	$pV = NkT$	**C1**
	$N = (1.6 \times 10^5 \times 0.18) / (1.38 \times 10^{-23} \times 273)$ $= 7.6 \times 10^{24}$	**A1**
3(b)(iii)	$\tfrac{1}{2}m\langle c^2\rangle = (3/2)kT$	**C1**
	r.m.s. speed $= \sqrt{[(3 \times 1.38 \times 10^{-23} \times (210 + 273) / (4.7 \times 10^{-26})]}$ $= 650\,\text{m s}^{-1}$	**A1**

Question	Answer	Marks
4(a)	$\omega = 2\pi / T$	C1
	$= 2\pi / (0.15 \times 10^{-6}) = 4.2 \times 10^{7}$ rad s^{-1}	A1
4(b)	$a_0 = \omega^2 x_0$	C1
	$= (4.2 \times 10^{7})^2 \times 40 \times 10^{-6}$ $= 7.1 \times 10^{10}$ m s^{-2}	A1
4(c)	$E = ½ m\omega^2 x_0^2$	C1
	$= ½ \times 2.4 \times 10^{-4} \times (4.2 \times 10^{7})^2 \times (40 \times 10^{-6})^2$	C1
	= 340 J	A1
4(d)(i)	apply alternating p.d. (to / across crystal)	B1
	applying p.d. to / across crystal causes it to distort	B1
4(d)(ii)	$Z = \rho c$ $Z_m = 1100 \times 1600$ (= 1.76×10^{6}) $Z_b = 1900 \times 4100$ (= 7.79×10^{6})	C1
	intensity reflection co-efficient= $[(7.79 – 1.76) / (7.79 + 1.76)]^2$ = 0.40 or 40%	C1
	percentage transmitted = 60%	A1

Question	Answer	Marks
5(a)	$Q = Q_1 = Q_2$ <u>and</u> $V = V_1 + V_2$	**M1**
	$V = Q / C$ so: $Q / C = Q / C_1 + Q / C_2$ <u>leading to</u> $1 / C = 1 / C_1 + 1 / C_2$	**A1**
5(b)	total capacitance = $C + ½C = (3 / 2)C$	**C1**
	total capacitance = gradient = $400 \times 10^{-6} / 6.0$	**C1**
	either: $C = (2 \times 400 \times 10^{-6}) / (3 \times 6.0) = 4.4 \times 10^{-5}$ F = 44 μF *or*: $C = (2 \times 400) / (3 \times 6.0) = 44$ μF	**A1**
5(c)(i)	$\tau = RC$	**C1**
	$= 54 \times 10^3 \times (3/2) \times 44 \times 10^{-6}$ = 3.6 s	**A1**
5(c)(ii)	$0.15 = \exp(-t / 3.6)$	**C1**
	t = 6.8 s	**A1**

Question	Answer	Marks
6(a)	$F_B = F_E$	**B1**
	either: $Bqu = qE$ and $E = V / d$ <u>leading to</u> $u = V / Bd$ *or*: $Bqu = qV / d$ <u>leading to</u> $u = V / Bd$	**B1**

Question	Answer	Marks
6(b)	$E_K = ½mu^2$	C1
	$u = \sqrt{[(2 \times 4.1 \times 10^{-17}) / (3.2 \times 10^{-27})]}$ $= 1.6 \times 10^5 \text{ms}^{-1}$	C1
	$B = 980 / (3.6 \times 10^{-2} \times 1.6 \times 10^5)$ $= 0.17\,\text{T}$	A1
6(c)	expression is independent of mass and charge	A1
6(d)	*either*: electric <u>force</u> is downwards so magnetic force is upwards *or*: no resultant <u>force</u> so magnetic force is upwards	B1
	(positive ions so) current is from left to right	B1
	from (Fleming's) left-hand rule, magnetic field is into the page	B1
6(e)	curved path inside plates with consistent direction of curvature and with no discontinuity at entry or in curvature	B1
	direction of deflection is upwards	B1

Question	Answer	Marks
7(a)	(induced) e.m.f. is (directly) proportional to rate	M1
	of change of (magnetic) flux (linkage)	A1
7(b)(i)	(uniform acceleration so) velocity is (directly) proportional to time	M1
	(Fig. 7.2 shows) e.m.f. is (directly) proportional to time so E is proportional to v.	A1

Question	Answer	Marks
7(b)(ii)	($v = at$ so) distance moved in time $\Delta t = at\Delta t$	**C1**
	$\Phi = BA$	**C1**
	$E = (\Delta\Phi / \Delta t) = B \times L \times (at\Delta t) / \Delta t = BLat$	**A1**
7(b)(iii)	$B = (0.30 \times 10^{-3}) / (0.45 \times 7.8 \times 2.0)$	**C1**
	$= 4.3 \times 10^{-5}$ T	**A1**

Question	Answer	Marks
8(a)	• quantum of energy	**M1**
	• of electromagnetic radiation	**A1**
8(b)(i)	$(\Delta)E = hc / \lambda$	**C1**
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (1.96 \times 1.60 \times 10^{-19})$	**C1**
	$= 6.3 \times 10^{-7}$ m	**A1**
8(b)(ii)	number per unit time = power / energy per photon $= (1.0 \times 10^{-2}) / (1.96 \times 1.60 \times 10^{-19})$ $= 3.2 \times 10^{16}$ s^{-1}	**A1**

Question	Answer	Marks
8(b)(iii)	*either*: force = rate of change of momentum *or*: $F = \Delta p / t$	**C1**
	$p = E / c$	**C1**
	half the photons have change in momentum p, the other half have change in momentum $2p$	**C1**
	$F = [(1.96 \times 1.60 \times 10^{-19}) / (3.00 \times 10^{8})] \times 3.2 \times 10^{16} \times [(2 + 1) / 2]$ $= 5.0 \times 10^{-11}$ N	**A1**

Question	Answer	Marks
9(a)(i)	*either*: cannot predict when a (particular) nucleus will decay *or*: cannot predict which nucleus will decay next	**B1**
9(a)(ii)	not affected by external / environmental factors	**B1**
9(b)	time for activity to halve	**B1**
9(c)	energy = (189 × 7.826) + (4 × 7.074) – (193 × 7.774)	**C1**
	= 7.03 eV	**A1**
9(d)(i)	decay constant	**A1**
9(d)(ii)	decay constant / magnitude of gradient = 1.4 / 0.84	**C1**
	half-life = ln2 / (1.4 / 0.84) = 0.42 ms	**A1**
9(e)(i)	positrons collide with electrons and annihilate	**B1**
9(e)(ii)	long enough to have time to conduct investigation, not so long as to cause patient <u>unnecessary</u> exposure to radiation	**B1**

Question	Answer	Marks
10(a)(i)	total power of radiation emitted (by the star)	B1
10(a)(ii)	standard candle has known luminosity	B1
	measure the radiant flux intensity	B1
	use $F = L / (4\pi d^2)$ to calculate d	B1
10(b)(i)	$v = 2\pi R / T$	C1
	$v = 3.00 \times 10^8 \times (656.2877 - 656.2831) / 656.2831$	C1
	$R = [3.00 \times 10^8 \times (656.2877 - 656.2831) / 656.2831] \times (2.07 \times 10^6) / 2\pi = 6.93 \times 10^8$ m	A1
10(b)(ii)	Z is moving towards Earth	M1
	so observed wavelength is less than the emitted wavelength	A1
10(b)(iii)	$L = 4\pi\sigma r^2 T^4$ $3.8 \times 10^{26} = 4\pi \times 5.67 \times 10^{-8} \times (6.93 \times 10^8)^2 \times T^4$	C1
	$T = 5800$ K	A1