Cambridge International AS & A Level

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PHYSICS **9702/42**

Paper 4 A Level Structured Questions **March 2017**

MARK SCHEME

Maximum Mark: 100

Published

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Question	Answer	Marks
1(a)	work done per unit mass	M1
	bringing (small test) mass from infinity (to the point)	A1
1(b)(i)	$\Delta\phi = (GM/2R) - (GM/5R) = 3GM/10R$	A1
1(b)(ii)	change in GPE = $(3 \times 4.0 \times 10^{14} / 10R) \times 4.7 \times 10^{4}$	C1
	$(3 \times 4.0 \times 10^{14} / 10R) \times 4.7 \times 10^{4} = (1.70 - 0.88) \times 10^{12}$ $R = 6.88 \times 10^{6}$	C1
	distance $= 3 \times 6.88 \times 10^{6}$ $= 2.1 \times 10^{7}$ m	A1

Question	Answer	Marks
2(a)	$+\Delta U$ increase in internal energy $+q$ heat (energy) transferred to the system / heating of system $+w$ work done on system	B2
2(b)(i)	$W = p\Delta V$ $= 5.2 \times 10^{5} \times (5.0 - 1.6) \times 10^{-4}$ (=177 J)	B1
	$\Delta U = q + w$ $= 442 - 177 = 265$ J	A1
2(b)(ii)	no (molecular) potential energy	B1
	internal energy decreases so (total molecular) kinetic energy decreases	B1
	(mean molecular) kinetic energy decreases so temperature decreases	B1

Question	Answer	Marks
2(b)(iii)	$\Delta U + 265 - 313 = 0$ $\Delta U = 48\,\text{J}$	A1
2(b)(iv)	$pV = NkT$ or $pV = nRT$ <u>and</u> $N = nN_A$	C1
	$5.2 \times 10^5 \times 1.6 \times 10^{-4} = N \times 1.38 \times 10^{-23} \times (273 + 227)$ *or* $5.2 \times 10^5 \times 1.6 \times 10^{-4} = n \times 8.31 \times (273 + 227)$ and $n = N / 6.02 \times 10^{23}$ $N = 1.2 \times 10^{22}$	A1

Question	Answer	Marks
3(a)	m is constant *or* k / m is constant <u>and</u> so acceleration / a proportional to displacement / x	B1
	negative sign shows that acceleration / a is in opposite direction to displacement / x *or* negative sign shows acceleration / a is towards fixed point	B1
3(b)	evidence of comparison to expression to $a = -\omega^2 x$	B1
	$\omega^2 = k/m$ *or* $\omega^2 = 4.0/m$ hence $\omega = 2.0/\sqrt{m}$	A1
3(c)	$E_K = ½ m \omega^2 x_0^2$ *or* $E_K = ½ mv^2$ <u>and</u> $v = \omega x_0$	C1
	$= ½m\,(4.0/m)\,(3.0 \times 10^{-2})^2$	C1
	$= 1.8 \times 10^{-3}\,\text{J}$	A1

Question	Answer	Marks
3(d)	new $x_0 = \sqrt{[(1.8 \times 10^{-3} / 2) \times (2 / m \times (m / 4.0))]}$ *or* ($E_K \propto x_0^2$ so) new $x_0 = \sqrt{[½ \times (3.0 \times 10^{-2})^2]}$	**C1**
	= 2.12×10^{-2} m	**A1**
3(e)	flux linked to block changes / flux is cut by block which induces an e.m.f. in block	**B1**
	(eddy) currents induced in block cause heating	**B1**
	thermal / heat energy comes from (kinetic / potential) energy of oscillations / block	**B1**

Question	Answer	Marks
4	piezo-electric / quartz crystal / transducer	**B1**
	alternating p.d. applied across crystal / transducer	**B1**
	causes crystal to vibrate / resonate	**B1**
	crystal resonates at ultrasound frequencies / crystal's natural frequency is in the ultrasound range / alternating p.d. is in ultrasound frequency range	**B1**

Question	Answer	Marks
5(a)	any **three** from: • greater bandwidth • does not suffer from (e.m.) interference / can be used in (e.m.) 'noisy' environments • no / less power / energy radiated / better security / less cross-talk • less attenuation / fewer repeaters / amplifiers needed • less weight / easier to handle / cheaper / occupy less space	**B3**
5(b)(i)	attenuation / gain = 10 log P_1 / P_2	**C1**
	$0.50 \times 57 = 10 \log (15 \times 10^{-3}/P)$ so $P = 2.1 \times 10^{-5}$ W *or* $-(0.50 \times 57) = 10 \log (P/15 \times 10^{-3})$ so $P = 2.1 \times 10^{-5}$ W	**A1**
5(b)(ii)	*either*	
	(calculation of S / N ratio at receiver) S / N ratio = $10 \log (2.1 \times 10^{-5} / 9.0 \times 10^{-7})$ or S/N ratio = 14	**M1**
	14 < 24 or S/N ratio < minimum S/N ratio	**A1**
	so not able to distinguish signal from noise	**A1**
	or	
	(calculation of minimum acceptable power at receiver) $24 = 10 \log (P / 9.0 \times 10^{-7})$ or $P = 2.3 \times 10^{-4}$	**(M1)**
	$2.1 \times 10^{-5} < 2.3 \times 10^{-4}$ or power < minimum power	**(A1)**
	so not able to distinguish signal from noise	**(A1)**

Question	Answer	Marks
6(a)	similarity: lines are radial / greater separation of lines with increased distance from the sphere	B1
	difference: gravitational lines directed towards sphere <u>and</u> electric lines directed away from sphere	B1
6(b)(i)	$E = Q / 4\pi\varepsilon_0 r^2$ or $E = kQ / r^2$ with k defined / substituted in	C1
	$4.1 \times 10^{-5} = [Q / (4\pi \times 8.85 \times 10^{-12} \times 0.025^2)] - [Q / (4\pi \times 8.85 \times 10^{-12} \times 0.075^2)]$	C1
	$Q = 3.2 \times 10^{-18}$ C	A1
6(b)(ii)	smooth curve with gradient decreasing starting at $(0, 4.1 \times 10^{-5})$ to d-axis at (2.5, 0)	B1
	smooth curve with gradient increasing from (2.5, 0) ending at $(5, -4.1 \times 10^{-5})$	B1
6(b)(iii)	acceleration decreases (to zero at mid-point)	B1
	then acceleration increases in the opposite direction / increasing negative acceleration	B1

Question	Answer	Marks
7(a)	correct grid shape (of wire)	B1
	fine wire / foil strip	B1
	plastic / insulating envelope containing the wire	B1
7(b)(i)	2.00 / 6.00 = 153.0 / (R + 153.0) *or* 4.00 / 6.00 = R / (R + 153.0) (so R = 306.0)	C1
	ΔR = 306.0 – 300.0 = 6.0 (Ω)	C1
	so $\Delta L = 8(.0) \times 10^{-5}$ m	A1

Question	Answer	Marks
7(b)(ii)	*R* or ΔR increases	**B1**
	$V^+ < V^-$ or $V_A < 2.00$ or V^+ / V_A decreases	**M1**
	output is negative / –5 V	**A1**
	diode X emits light / is ‘on’	**A1**

Question	Answer	Marks
8(a)	region (of space) where there is a force	**M1**
	produced by / on a magnet / magnetic pole / <u>moving</u> charge / current-carrying conductor	**A1**
8(b)(i)	out of (the plane of) the paper / page	**B1**
8(b)(ii)	the force on the particle is (always) perpendicular to the velocity / perpendicular to the direction of travel / towards the centre of path	**B1**
	no work is done by the force on the particle / there is no acceleration in the direction of the velocity / the acceleration is (always) perpendicular to the velocity	**B1**
8(b)(iii)	$F = Bqv$ or $F = mv^2 / r$	**C1**
	$mv^2 / (d/2) = Bqv$ so $d = 2mv / Bq$	**A1**
8(b)(iv)	time = distance / speed $T_{(F)} = \pi d / 2v$	**C1**
	$T_{(F)} = (\pi / 2v) \times (2mv / Bq)$ $T_{(F)} = \pi m / Bq$ and so $T_{(F)}$ independent of v	**A1**

Question	Answer	Marks
9(a)(i)	increase flux linkage (with secondary coil) / to reduce flux loss	**B1**
9(a)(ii)	e.m.f. (induced only) when flux (in core/coil) is changing	**B1**
	constant / direct voltage gives constant flux / field	**B1**
9(b)(i)	N_S / N_P = V_S / V_P	**C1**
	N_S = (52 / 150) × 1200 = 416 turns	**A1**
9(b)(ii)	0 ms or 7.5 ms or 15.0 ms or 22.5 ms	**A1**
9(c)(i)	*either*	
	mean power = $V^2 / 2R$ and V = 52 (V)	**C1**
	R = $52^2 / (2 \times 1.2)$ = 1100 (1127) Ω	**A1**
	or	
	mean power = V^2 / R and $V = 52 / \sqrt{2}$ (= 36.8 V)	**(C1)**
	R = $36.8^2 / 1.2$ = 1100 Ω	**(A1)**
9(c)(ii)	sinusoidal shape with troughs at zero power	**B1**
	only 3 ‘cycles’	**B1**
	each ‘cycle’ is 2.4 W high and zero power at correct times	**B1**

Question	Answer	Marks
10(a)	packet / quantum of energy	**M1**
	of electromagnetic radiation	**A1**
10(b)(i)	light is re-emitted in all directions / only part of the re-emitted light is in the direction of the beam	**B1**
10(b)(ii)	an arrow between –3.40 eV and –1.51 eV <u>and</u> an arrow between –3.40 eV and –0.85 eV	**B1**
	all arrows shown point 'upwards'	**B1**
10(b)(iii)	$E = hc / \lambda$ *or* $E = hf$ <u>and</u> $c = f\lambda$	**C1**
	$2.60 \times 1.60 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda$	**C1**
	$\lambda = 4.8 \times 10^{-7}$ m	**A1**

Question	Answer	Marks
11	any **five** from: • electrons need energy to enter conduction band (from valence band) • (positively-charged) holes are left in valence band • moving charge carriers / holes / electrons are current • (increase of temperature leads to) more (positive and negative) charge carriers / more holes / more electrons so more current • more charge carriers / holes / electrons gives rise to less resistance • (increase of temperature causes) greater (amplitude of) vibrations of atoms / ions / lattice • effect of more charge carriers/holes/electrons is greater than effect of greater vibrations (and so resistance decreases)	**B5**

Question	Answer	Marks
12(a)	*either*	
	(minimum) energy required / work done to separate the nucleons (in a nucleus)	**M1**
	to infinity	**A1**
	or	
	energy released when nucleons come together (to form a nucleus)	**(M1)**
	from infinity	**(A1)**
12(b)(i)	(total) binding energy of thorium and helium (nuclei) greater than binding energy of uranium (nucleus)	**B1**
12(b)(ii)1	change in mass = 238.05076 – (234.04357 + 4.00260) = 4.59×10^{-3} u	**A1**
12(b)(ii)2	*either*	
	$E = mc^2$ $= 4.59 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$	**C1**
	$= 6.9 \times 10^{-13}$ J	**A1**
	or	
	1u = 931 MeV $E = 4.59 \times 10^{-3} \times 931 \times 10^6 \times 1.6 \times 10^{-19}$	**(C1)**
	$= 6.8 \times 10^{-13}$ J	**(A1)**
12(b)(iii)	Th nucleus / He nucleus / product nucleus has kinetic energy	**M1**
	energy of gamma photon must be less than energy released	**A1**