Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/42**

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

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the March 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

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)	$+\Delta U$ <u>increase</u> in internal energy $+q$ heat (energy) transferred <u>to</u> the system / heating of system $+w$ work done <u>on</u> 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 $pV = nRT$ and $N = nN_A$	**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 and 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* $E_K = ½ m v^2$ and $v = \omega x_0$	**C1**
	$= ½ m (4.0/m) (3.0 \times 10^{-2})^2$	**C1**
	$= 1.8 \times 10^{-3}\,\text{J}$	**A1**

Question	Answer	Marks
3(d)	new $x_0 = \sqrt{[(1.8\times10^{-3}\ /\ 2)\times(2\ /\ m\times(m\ /\ 4.0))]}$ *or* ($E_K \propto x_0^2$ so) new $x_0 = \sqrt{[½\times(3.0\times10^{-2})^2]}$	**C1**
	$= 2.12\times10^{-2}$ 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 and 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**
	$\Delta R = 306.0 - 300.0 = 6.0\ (\Omega)$	**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**
	$N_S = (52 / 150) \times 1200$ $= 416$ 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)**
	$R = 36.8^2/1.2$ $= 1100\,\Omega$	**(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 and an arrow between –3.40 eV and –0.85 eV	**B1**
	all arrows shown point 'upwards'	**B1**
10(b)(iii)	$E = hc / \lambda$ *or* $E = hf$ and $c = f\lambda$	**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**