Cambridge Assessment International Education
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PHYSICS **9702/41**

Paper 4 A Level Structured Questions **May/June 2018**

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 International will not enter into discussions about these mark schemes.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1: Marks must be awarded in line with: • the specific content of the mark scheme or the generic level descriptors for the question • the specific skills defined in the mark scheme or in the generic level descriptors for the question • the standard of response required by a candidate as exemplified by the standardisation scripts.
GENERIC MARKING PRINCIPLE 2: Marks awarded are always **whole marks** (not half marks, or other fractions).
GENERIC MARKING PRINCIPLE 3: Marks must be awarded **positively**: • marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate • marks are awarded when candidates clearly demonstrate what they know and can do • marks are not deducted for errors • marks are not deducted for omissions • answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.
GENERIC MARKING PRINCIPLE 4: Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer	Marks
1(a)	force proportional to product of masses and inversely proportional to square of separation	**B1**
	idea of force between point masses	**B1**
1(b)(i)	velocity changes/direction of motion changes/there is an acceleration/there is a resultant force so not in equilibrium	**B1**
1(b)(ii)1.	gravitational force equals/is centripetal force	**C1**
	$GMm/R^2 = mR\omega^2$ **and** $\omega = 2\pi/T$ **or** $Gm/R^2 = mv^2/R$ **and** $v = 2\pi r/T$ **or** $GMm/R^2 = mR\,(2\pi/T)^2$	**M1**
	convincing algebra leading to $k = GM/4\pi^2$	**A1**
1(b)(ii)2.	correct use of R^3/T^2 for one planet (c gives 3.54×10^{21}; e and g both give 3.56×10^{21})	**C1**
	$3.5(5) \times 10^{21} = (6.67 \times 10^{-11} \times M) / 4\pi^2$ $M = 2.1 \times 10^{33}$ kg	**A1**
	two or three values of R^3/T^2 correctly calculated and used in a valid way to find a value for M based on more than one k	**B1**

Question	Answer	Marks
2(a)(i)	straight line through origin indicates acceleration $\propto$ displacement	B1
	negative gradient shows acceleration and displacement are in opposite directions	B1
2(a)(ii)	$a = -\omega^2 y$ **and** $\omega = 2\pi f$ $4.5 = (2\pi \times f)^2 \times 8.0 \times 10^{-3}$ *(or other valid read-off)*	C1
	$f = 3.8$ Hz	A1
2(b)(i)	maximum displacement upwards/above rest/above the equilibrium position	B1
2(b)(ii)	(just leaves plate when) acceleration = 9.81 m s^{-2}	C1
	$9.81 = (2\pi \times 3.8)^2 \times y_0$ **or** $9.81 = 563 \times y_0$	C1
	amplitude = 17 mm	A1

Question	Answer	Marks
3(a)(i)	sum of potential and kinetic energies (of molecules/atoms/particles)	**B1**
	(energy of) molecules/atoms/particles in random motion	**B1**
3(a)(ii)	(in ideal gas) no intermolecular forces so no potential energy	**B1**
	internal energy is (solely) kinetic energy (of particles)	**B1**
	(mean) kinetic energy (of particles) proportional to (thermodynamic) temperature of gas	**B1**
3(b)	$pV = NkT$	**C1**
	$6.4 \times 10^6 \times 1.8 \times 10^4 \times 10^{-6} = N \times 1.38 \times 10^{-23} \times 298$	**C1**
	or	
	$pV = nRT$ **and** $N = n \times N_A$	**(C1)**
	$6.4 \times 10^6 \times 1.8 \times 10^4 \times 10^{-6} = n \times 8.31 \times 298$ $n = 46.5$ (mol) $N = 46.5 \times 6.02 \times 10^{23}$	**(C1)**
	$N = 2.8 \times 10^{25}$	**A1**

Question	Answer	Marks
4(a)	e.g. microphone weighing scales/pressure sensor lighters/spark generation watches/clocks/regulation of time	**B1**
4(b)	pulses (of ultrasound)	**B1**
	reflected at boundaries (between media)	**B1**
	(reflected pulses) detected by (ultrasound) generator	**B1**
	Any three from: • time delay (between transmission and receipt) gives information about depth (of boundary) • intensity of reflected pulse gives information about (nature of) boundary • gel used to minimise reflection at skin/maximise transmission into skin • degree of reflection depends upon impedances of two media (at boundary)	**B3**

Question	Answer	Marks
5(a)(i)	west to east	B1
5(a)(ii)	above the Equator	B1
5(a)(iii)	value in range $(1–300) \times 10^9$ Hz	A1
5(b)(i)	gain / dB = 10 lg (P_2 / P_1)	C1
	–195 = 10 lg $(P / 3000)$ **or** 195 = 10 lg $(3000 / P)$	C1
	power = 9.5×10^{-17} W	A1
5(b)(ii)	up-link has been (greatly) attenuated (before reaching satellite) **or** down-link signal must be (greatly) amplified (before transmission back to Earth) **or** up-link has (much) smaller intensity/power than down-link	B1
	(different frequency) prevents down-link (signal) swamping up-link (signal)	B1

Question	Answer	Marks
6(a)	force per unit charge	B1
6(b)	$E = Q / (4\pi\varepsilon_0 r^2)$	C1
	$2.0 \times 10^4 = Q / (4\pi \times 8.85 \times 10^{-12} \times 0.26^2)$ charge = 1.5×10^{-7} C	A1
6(c)	charge (= Q [52 / 26]^2) = 4Q	C1
	additional charge = 3Q	A1

Question	Answer	Marks
7(a)	(capacitance =) charge / potential	M1
	charge is (numerically equal to) charge on one plate	A1
	potential is potential difference between plates	A1
7(b)(i)	4.5×10^{-6} C	A1
7(b)(ii)	9.0×10^{-8} C	A1
7(b)(iii)	capacitance = (9.0×10^{-8}) / 120	C1
	= 7.5×10^{-10} F	A1
7(c)	total capacitance is halved	B1
	current is halved	B1

Question	Answer	Marks
8(a)(i)	(fraction of) output is combined with the input	**M1**
	output (fraction) subtracted/deducted from input	**A1**
8(a)(ii)	any two valid points e.g.: • greater bandwidth/gain constant over a larger range of frequencies/greater bandwidth • smaller gain	**B2**
8(b)(i)	gain = (–)9600 / 800	**C1**
	= –12	**A1**
8(b)(ii)	**1.** 1.2 V	**B1**
	2. –6 V	**B1**
8(b)(iii)	replace the 9600 Ω resistor with an LDR	**B1**

Question	Answer	Marks
9(a)	using Fleming's left-hand rule force on wire is upwards	**B1**
	by Newton's third law, force on magnet is downwards	**B1**
9(b)(i)	$F = BIL$	**C1**
	$= 3.7 \times 10^{-3} \times 5.1 \times 8.5 \times 10^{-2}$ $= 1.6 \times 10^{-3}$ N	**A1**
9(b)(ii)	$F = 1.6 \times 10^{-3}$ N	**A1**
9(c)	sketch: sinusoidal wave with two cycles	**B1**
	amplitude 2.3×10^{-3} N	**B1**
	period 0.05 s	**B1**

Question	Answer	Marks
10(a)	induced <u>e.m.f.</u> proportional to rate	**M1**
	of <u>change</u> of (magnetic) <u>flux</u> (linkage) **or** of <u>cutting</u> (magnetic) <u>flux</u>	**A1**
10(b)	current in coil produces flux	**B1**
	(by Faraday's law) changing flux induces e.m.f. in ring	**B1**
	current in ring causes field (around ring)	**B1**
	(by Lenz's law) field around ring opposes field around coil	**B1**

Question	Answer	Marks
11(a)(i)	packet/quantum/discrete amount of energy	M1
	of electromagnetic radiation	A1
11(a)(ii)	(maximum) energy of emitted electrons is independent of intensity **or** no emission of electrons below the threshold frequency regardless of intensity **or** no emission of electrons when photon energy is less than work function (energy) regardless of intensity	B1
11(b)	in darkness: conduction band empty so high resistance	B1
	in daylight: electrons in valence band absorb photons	B1
	in daylight: electrons 'jump' to conduction band	B1
	this leaves holes in valence band	B1
	more charge carriers in daylight so resistance decreases	B1

Question	Answer	Marks
12(a)(i)	$I = I_0 e^{-\mu x}$	C1
	$= I_0 \exp(-0.90 \times 2.8)$ $= 0.080 I_0$	A1
12(a)(ii)	$I = I_0 \exp[(-0.90 \times 1.5) + (-3.0 \times 1.3)]$	C1
	$= 0.0052 I_0$	A1
12(b)(i)	difference in degrees of blackening	M1
	between structures	A1
12(b)(ii)	large difference in intensities so good contrast	B1

Question	Answer	Marks
13(a)	emission of particles/radiation by unstable nucleus	B1
	spontaneous emission	B1
13(b)(i)	use of graph to determine half-life = 14 minutes	B1
	hence $\lambda = \ln 2 / (14 \times 60)$ (s^{-1})	C1
	N at 14 minutes = 4.4×10^7 **and** $A = \lambda N$	C1
	activity $= 4.4 \times 10^7 \times \ln 2 / (14 \times 60)$ $= 3.6 \times 10^4$ Bq	A1
	or	
	correct tangent drawn at time t = 14 minutes	**(B1)**
	magnitude of gradient of tangent identified as activity	**(C1)**
	correct working for gradient leading to activity	**(C1)**
	activity = 3.6×10^4 Bq	**(A1)**
13(b)(ii)	$3.6 \times 10^4 = \lambda \times 4.4 \times 10^7$ **or** $\lambda = \ln 2 / (14.0 \times 60)$	C1
	$\lambda = 8.2 \times 10^{-4}$ s^{-1}	A1