Cambridge International AS & A Level

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PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 2019**

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 (gravitational) force between point masses	**B1**
1(b)	gravitational force provides/is the centripetal force	**B1**
	$GM / R^2 = R\omega^2$ **or** $GM / R^2 = v^2 / R$	**M1**
	$\omega = 2\pi / T$ **or** $v = 2\pi R / T$	**M1**
	algebra leading to $R^3/T^2 = GM / 4\pi^2$	**A1**
1(c)	$(6.67 \times 10^{-11} \times M) / 4\pi^2 = (4.38 \times 10^6)^3 / (2.44 \times 3600)^2$	**C1**
	$M = 6.45 \times 10^{23}$ kg	**A1**

Question	Answer	Marks
2(a)(i)	specks of light moving haphazardly	**B1**
2(a)(ii)	(gas) molecules collide with (smoke) particles **or** random motion of the (gas) molecules	**M1**
	<u>causes</u> the (haphazard) motion of the smoke particles **or** <u>causes</u> the smoke particles to change direction	**A1**
2(b)(i)	$pV = nRT$	**C1**
	$n = (3.51 \times 10^5 \times 2.40 \times 10^{-3}) / (8.31 \times 290)$ **or** $n = (3.75 \times 10^5 \times 2.40 \times 10^{-3}) / (8.31 \times 310)$	**C1**
	or	
	$pV = NkT$	**(C1)**
	$n = (3.51 \times 10^5 \times 2.40 \times 10^{-3}) / (1.38 \times 10^{-23} \times 6.02 \times 10^{23} \times 290)$ **or** $n = (3.75 \times 10^5 \times 2.40 \times 10^{-3}) / (1.38 \times 10^{-23} \times 6.02 \times 10^{23} \times 310)$	**(C1)**
	$n = 0.350$ mol **or** 0.349 mol	**A1**
2(b)(ii)	energy transfer = (0.349 **or** 0.35) × 12.5 × (310 – 290)	**C1**
	= 87.3 J **or** 87.5 J	**A1**
2(c)(i)	zero	**A1**
2(c)(ii)	87.3 J **or** 87.5 J	**A1**
	increase	**B1**

Question	Answer	Marks
3(a)	(thermal) energy per unit mass (to change state)	**B1**
	change of state without any change of temperature	**B1**
3(b)(i)	140 g	**A1**
3(b)(ii)	temperature difference (between apparatus and surroundings) does not change	**B1**
3(b)(iii)	$VIt = mL$	**C1**
	$(\{15.1 \times 3.6\} + R) \times 600 = 140 \times L$ **or** $(\{7.3 \times 1.8\} + R) \times 600 = 65 \times L$	**C1**
	$41.22 \times 600 = 75 \times L$	**C1**
	$L = 330\ \text{J g}^{-1}$	**A1**
3(b)(iv)	$15.1 \times 3.6 \times 600 = (140 \times 330) - H$ **or** $7.3 \times 1.8 \times 600 = (65 \times 330) - H$	**C1**
	$H = 13\,600$ rate of gain = 13 600 / 600 = 23 W	**A1**

Question	Answer	Marks
4(a)(i)	loss of energy	**B1**
4(a)(ii)	amplitude (of oscillations) decreases (with time)	**B1**
4(b)(i)	$\omega = 2\pi / T$	**C1**
	$T = 0.80$ s, so $\omega = 2\pi / 0.80$ $\omega = 7.9$ rad s^{-1}	**A1**
4(b)(ii)	$\omega^2 = 2k / M$	**C1**
	$7.9^2 = 2k / 1.2$ $k = 37$ N m^{-1}	**A1**
4(c)(i)	(one) smooth curve, not touching the *f*-axis, with two concave sides meeting at a peak in between them	**B1**
	(one) peak at 1.0ω	**B1**
4(c)(ii)	• lower peak/(whole) line is lower • flatter <u>peak</u>/<u>peak</u> is less sharp • peak at (slightly) lower angular frequency/peak moves to left *any two points, one mark each*	**B2**

Question	Answer	Marks
5(a)(i)	product of density and speed	**M1**
	speed of sound in the medium	**A1**
5(a)(ii)	$Z_B = 1.8 \times 10^3 \times 4.1 \times 10^3$ $= 7.4 \times 10^6$ kg m^2 s^{-1}	**A1**
5(b)	$\alpha = (1.7 - 1.3)^2 / (1.7 + 1.3)^2 = 0.018$ fraction = 0.98	**A1**
5(c)(i)	reduction in power/intensity (of wave)	**M1**
	as the wave passes through the medium	**A1**
5(c)(ii)	**1.** ratio $= e^{-\mu x}$	**C1**
	$= 0.90$	**A1**
	2. ratio = 0.62	**A1**
5(d)	fraction $= 0.898 \times 0.617 \times 0.98$ $= 0.54$	**A1**

Question	Answer	Marks
6(a)	period = 5.0 μs, so frequency = 2.0×10^5 Hz	**A1**
6(b)	sketch: three equally spaced vertical lines sitting on *f*-axis	**B1**
	two outer vertical lines of equal length and central line longer	**B1**
	three vertical lines (and no others) shown at frequencies 190 kHz, 200 kHz and 210 kHz	**B1**

Question	Answer	Marks
7	X-rays are used	**B1**
	section (of object) is scanned	**B1**
	scans/images taken at many angles/directions **or** images of each section are 2-dimensional	**B1**
	images of (many) sections are combined	**B1**
	(to give) 3-dimensional image of (whole) structure	**B1**

Question	Answer	Marks
8(a)	magnitude: (force =) *Bqv*	**B1**
	direction: P→Q **or** E→F **or** S→R **or** H→G	**B1**
8(b)(i)	EHSP and FGRQ	**B1**
8(b)(ii)	PE **or** QF **or** RG **or** SH	**B1**
8(c)(i)	*any one correct starting point from:* • (mass of 1 atom =) $27 \times 1.66 \times 10^{-27}$ • (amount of substance per unit volume =) 2.7 / 27 • 27 g (of substance) contains 6.02×10^{23} atoms • (2.7 g mass contains) 0.1 mol • (1 cm^3 volume contains) 0.1 mol • (1 m^3 volume contains) 10^5 mol	**C1**
	$n = (2.7 \times 10^3) / (27 \times 1.66 \times 10^{-27}) = 6.0 \times 10^{28}$ **or** $n = (2.7 / 27) \times 10^6 \times 6.02 \times 10^{23} = 6.0 \times 10^{28}$	**A1**
8(c)(ii)	$V_H = (0.15 \times 4.6) / (6.0 \times 10^{28} \times 0.090 \times 10^{-3} \times 1.60 \times 10^{-19})$	**C1**
	$= 8.0 \times 10^{-7}$ V	**A1**

Question	Answer	Marks
9(a)	work done per unit charge	**B1**
	(work done) moving positive charge from infinity	**B1**
9(b)(i)	energy $= 4.8 \times 1.60 \times 10^{-13}$ $= 7.7 \times 10^{-13}$ J	**A1**
9(b)(ii)	$E_P = Qq / 4\pi\varepsilon_0 d$	**C1**
	$Q = 79e$ **and** $q = 2e$	**C1**
	$7.68 \times 10^{-13} = (79 \times 2 \times \{1.60 \times 10^{-19}\}^2 / (4\pi \times 8.85 \times 10^{-12} \times d)$	**C1**
	$d = 4.7 \times 10^{-14}$ m	**A1**
9(c)	(diameter must be) less than/equal to 10^{-13} or 10^{-14} m	**B1**

Question	Answer	Marks
10(a)	(as temperature rises) electrons in valence band gain energy	**B1**
	electrons jump to conduction band	**B1**
	holes are left in the valence band	**B1**
	increased <u>number</u> (density) of charge carriers causes lower resistance	**B1**
10(b)(i)	$V^- = V^+$	**C1**
	$1.50 / 1.20 = R_T / 1.76$	**C1**
	$R_T = 2.2$ (kΩ)	**C1**
	temperature = 14 °C	**A1**
10(b)(ii)	(For LED to conduct,) V_{OUT} must be negative	**B1**
	$V^- > V^+$	**B1**
	R_T must be lower so temperature must be above **(b)(i)** value	**B1**

Question	Answer	Marks
11(a)	(induced) e.m.f. proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
11(b)(i)	any two from t_1, t_3, t_5, t_7	**A1**
11(b)(ii)	t_2 **and** t_4 **or** t_4 **and** t_6	**A1**
11(c)	e.m.f. = $N\Delta\Phi / \Delta t$	**C1**
	$= (2 \times 9.4 \times 10^{-4} \times 5.0 \times \pi \times (1.8 \times 10^{-2})^2 \times 63) / (6.0 \times 10^{-3})$	**C1**
	= 0.10 V	**A1**

Question	Answer	Marks
12(a)(i)	(decay is) unpredictable/cannot be predicted	**B1**
12(a)(ii)	probability of decay (of a nucleus)	**M1**
	per unit time	**A1**
12(b)	$A = \lambda N$	**C1**
	(for 1.00 m^3) $A = 0.600 / 4.80 \times 10^{-3}$ (= 125 Bq)	**C1**
	$N = 125 / ([7.55 \times 10^{-3}] / 3600)$ (= 5.96×10^7)	**C1**
	so ratio = $(2.52 \times 10^{25}) / (5.96 \times 10^7)$	**C1**
	or	
	(for 4.80×10^{-3} m^3) N for air = $2.52 \times 10^{25} \times 4.80 \times 10^{-3}$ (= 1.21×10^{23})	**(C1)**
	N for radon = $0.600 / ([7.55 \times 10^{-3}] / 3600)$ (= 2.86×10^5)	**(C1)**
	so ratio = $(1.21 \times 10^{23}) / (2.86 \times 10^5)$	**(C1)**
	ratio = 4.2×10^{17}	**A1**