Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/41**

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.

Cambridge International is publishing the mark schemes for the October/November 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

Cambridge Assessment International Education

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)(i)	above the equator	**B1**
	from west to east	**B1**
1(b)(ii)	gravitational force provides/is the centripetal force	**B1**
	$GM / r^2 = r (2\pi / T)^2$	**C1**
	$(6.67 \times 10^{-11} \times M) = \{(4.23 \times 10^7)^3 \times 4\pi^2\} / (24 \times 3600)^2$	**C1**
	$M = 6.0 \times 10^{24}$ kg	**A1**

Question	Answer	Marks
2(a)	(total volume of molecules is) negligible	**M1**
	compared with volume occupied by the gas	**A1**
2(b)(i)	$pV = NkT$	**C1**
	$4.60 \times 10^{5} \times 2.40 \times 10^{-2} = N \times 1.38 \times 10^{-23} \times (273 + 23)$	**C1**
	or	
	$pV = nRT$	**(C1)**
	$4.60 \times 10^{5} \times 2.40 \times 10^{-2} = n \times 8.31 \times (273 + 23)$ $n = 4.49$ (mol) $N = nN_A$ $= 4.49 \times 6.02 \times 10^{23}$	**(C1)**
	$N = 2.7 \times 10^{24}$	**A1**

Question	Answer	Marks
2(b)(ii)	volume of one atom $= d^3$ $(= 2.7 \times 10^{-29}\ \text{m}^3)$	**C1**
	volume of all atoms $= 2.7 \times 10^{-29} \times 2.7 \times 10^{24}$	**C1**
	$= 7 \times 10^{-5}\ \text{m}^3$	**A1**
	or	
	volume of one atom $= (4/3)\pi r^3$ $(= 1.41 \times 10^{-29}\ \text{m}^3)$	**(C1)**
	volume of all atoms $= 2.7 \times 10^{24} \times 1.41 \times 10^{-29}$	**(C1)**
	$= 4 \times 10^{-5}\ \text{m}^3$	**(A1)**
2(c)	numerical comparison between answer to **(b)(ii)** and 2.4×10^{-2} (m^3) showing **(b)(ii)** is <u>much</u> less than 2.4×10^{-2} (m^3)	**B1**

Question	Answer	Marks
3(a)	(thermal) energy per (unit) mass (to change state)	**B1**
	(heat transfer during) change of state at constant temperature	**B1**
3(b)(i)	32 g	**A1**
3(b)(ii)	temperature difference (between liquid and surroundings) does not change	**B1**
3(b)(iii)	$VIt = mL$	**C1**
	$230 \times 1.2 \times 60 \times 10 = (56 \times L) + H$ **or** $190 \times 1.0 \times 60 \times 10 = (32 \times L) + H$	**C1**
	$86 \times 600 = (56 - 32) \times L$	**C1**
	or	
	$230 \times 1.2 = (56 \times L) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times L) / (60 \times 10) + P$	**(C1)**
	$276 - 190 = (24 \times L) / 600$	**(C1)**
	$L = 2200\ \text{J g}^{-1}$	**A1**

Question	Answer	Marks
3(b)(iv)	$230 \times 1.2 \times 600 = (56 \times 2150) + H$ **or** $190 \times 1.0 \times 600 = (32 \times 2150) + H$	**C1**
	$H = 45\,200$ rate $= 45\,200 / 600$ $= 75$ W	**A1**
	or	
	$230 \times 1.2 = (56 \times 2150) / (60 \times 10) + P$ **or** $190 \times 1.0 = (32 \times 2150) / (60 \times 10) + P$	**(C1)**
	rate (= P) = 75 W	**(A1)**

Question	Answer	Marks
4(a)(i)	distance from a (reference) point in a given direction	**B1**
4(a)(ii)	line is not straight **or** gradient is not constant	**B1**
4(b)(i)	0.85–0.90 cm	**A1**
4(b)(ii)	$a = -(2\pi f)^2 x$	**C1**
	e.g. $1.2 = 4\pi^2 \times f^2 \times (0.90 \times 10^{-2})$	**C1**
	$f = 1.8$ Hz	**A1**
4(c)	complete circle/ellipse enclosing the origin	**B1**
	closed shape passing through $(0, \pm v_0)$ and $(\pm x_0, 0)$	**B1**

Question	Answer	Marks
5(a)(i)	provides return for the signal	**B1**
	shields signal from noise	**B1**
5(a)(ii)	e.g. connection between aerial and TV set	**B1**
5(b)(i)	gain / dB = 10 lg (P_1 / P_2)	**C1**
	32 = 10 lg {P_{MIN} / (7.6 × 10^{-6})} P_{MIN} = 0.012 W	**A1**
5(b)(ii)	attenuation per unit length = (1 / *L*) × 10 lg (P_1 / P_2) 6.3 = (1 / *L*) × 10 lg (2.6 / 0.012)	**C1**
	L = 3.7 km	**A1**

Question	Answer	Marks
6(a)	(E =) $Q / 4\pi\varepsilon_0 r^2$	**M1**
	where ε_0 is permittivity (of free space)	**A1**
6(b)(i)	field does not change direction/field does not become zero	**M1**
	so (charges have) opposite (sign)	**A1**
6(b)(ii)	minimum is at the midpoint (between the charges)	**M1**
	so (magnitudes are the) same	**A1**
6(c)	force = field strength × charge **and** force = mass × acceleration **or** acceleration is proportional to field strength	**B1**
	(from x = 3.0 cm) to x = 5.0 cm: acceleration decreases	**B1**
	at x = 5.0 cm: acceleration is a minimum	**B1**
	from x = 5.0 cm (to x = 7.0 cm): acceleration increases	**B1**

Question	Answer	Marks
7(a)(i)	all frequencies are amplified equally	**B1**
7(a)(ii)	no drop in output voltage (when there is a current)	**B1**
7(b)(i)	gain = 1 + R_F / R_{IN} = 1 + (4000 / 800)	**C1**
	= 6.0	**A1**
7(b)(ii)	2.0 / V_{IN} = 6.0 V_{IN} = (+)0.33 V	**A1**
7(b)(iii)	5.0 V	**A1**
7(b)(iv)	V = 5.0 – 2.2 (= 2.8 V)	**C1**
	R = V / I = 2.8 / 0.020 = 140 Ω	**A1**

Question	Answer	Marks
8(a)	concentric circles (around the wire)	**M1**
	at least 3 circles shown, all with increasing separation	**A1**
	direction anticlockwise	**B1**
8(b)(i)	$B = (4\pi \times 10^{-7} \times 6.2) / (2\pi \times 3.1 \times 10^{-2})$	**C1**
	$= 4.0 \times 10^{-5}$ T	**A1**
8(b)(ii)	$F = BIL$ **or** $F / L = BI$	**C1**
	$F / L = 4.0 \times 10^{-5} \times 8.5$ $= 3.4 \times 10^{-4}$ N m^{-1}	**A1**
8(c)	correct application of Newton's 3rd law to the forces **or** F / L is proportional to the product of the two currents	**M1**
	so same magnitude	**A1**

Question	Answer	Marks
9(a)	nuclei precess	**B1**
	precession is about (direction of magnetic) field **or** frequency of precession is in radio-frequency range	**B1**
9(b)	• frequency (of precession) depends on field strength • to locate/find position of (spinning) nuclei • to change region where nuclei are detected *any two points, one mark each*	**B2**

Question	Answer	Marks
10(a)(i)	lower right **and** upper left diodes circled	**B1**
10(a)(ii)	maximum = 7.0√2 = 9.9 V	**A1**
10(b)(i)	correct symbol for capacitor, shown connected in parallel with R	**B1**
10(b)(ii)	**1.** (ripple) decreases	**B1**
	2. (ripple) increases	**B1**

Question	Answer	Marks
11(a)	energy (of photon) required to remove electron	**M1**
	from a surface **or** reference to <u>minimum</u> energy **or** reference to zero <u>kinetic</u> energy	**A1**
11(b)(i)	**1.** photon energy $= hc / \lambda$	**C1**
	$= (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (280 \times 10^{-9})$ $= 7.1 \times 10^{-19}$ J	**A1**
	2. electron energy $= (7.1 - 5.5) \times 10^{-19}$ J	**C1**
	$½ \times 9.11 \times 10^{-31} \times v^2 = (7.1 - 5.5) \times 10^{-19}$	**C1**
	$v = 5.9 \times 10^{5}$ m s^{-1}	**A1**
11(b)(ii)	energy is required to bring electron to the surface	**B1**
11(c)	<table><tr><td>no change</td><td>decreases</td></tr><tr><td>increases</td><td>decreases</td></tr></table>	**B4**

Question	Answer	Marks
12(a)	$E = (3.0 \times 10^8)^2 \times 1.66 \times 10^{-27}$ (= 1.49×10^{-10} J)	M1
	= $(1.49 \times 10^{-10}) / (1.60 \times 10^{-19}) = 9.34 \times 10^8$ = 934 MeV	A1
	or	
	binding energy = 8.443 × 95 [or equivalent using La-139 nucleus]	(M1)
	binding energy / mass defect = (8.443 × 95) / 0.859 = 934 MeV	(A1)
12(b)(i)	binding energy = 1.865 × 934 (= 1741.91 MeV)	C1
	binding energy per nucleon = 1741.91 / 235 = 7.41 (MeV)	A1
12(b)(ii)	less (than)	B1
12(c)	energy = {(1.219 + 0.859) – 1.865)} × 934 **or** energy = (95 × 8.443) + (139 × 8.189) – (235 × 7.412)	C1
	= 199 MeV	A1
12(d)	number of reactions = $1.2 \times 10^{-7} \times 6.02 \times 10^{23}$ = 7.22×10^{16}	C1
	energy release (for one reaction) = $199 \times 1.60 \times 10^{-13}$ (= 3.18×10^{-11} J)	C1
	power = $(7.22 \times 10^{16} \times 3.18 \times 10^{-11}) / (25 \times 10^{-3})$ = 9.2×10^7 W	A1