Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/43**

Paper 4 A Level Structured Questions **May/June 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)	(F =) GMm / x^2, where G is the (universal) gravitational constant	**B1**
1(b)(i)	$GMm / x^2 = mv^2 / x$ **or** $v^2 = GM / x$	**C1**
	$v^2 = (6.67 \times 10^{-11} \times 7.5 \times 10^{23}) / (3.4 \times 10^6 + 240 \times 10^3)$ so $v = 3.7 \times 10^3$ m s^{-1}	**A1**
1(b)(ii)	potential energy = $(–)GMm / x$	**C1**
	$E_A = (–)(6.67 \times 10^{-11} \times 7.5 \times 10^{23} \times 650) / (3.64 \times 10^6)$ **or** $E_B = (–)(6.67 \times 10^{-11} \times 7.5 \times 10^{23} \times 650) / (5.00 \times 10^7)$	**M1**
	correct substitution and subtraction $E_B – E_A$ shown, leading to $\Delta E_p = 8.3 \times 10^9$ J	**A1**
	or	
	$\phi = (–)GM / x$ **and** potential energy = $m\phi$	**(C1)**
	$\Delta\phi = (6.67 \times 10^{-11} \times 7.5 \times 10^{23}) \times [(1 / (3.64 \times 10^6)) – (1 / (5.00 \times 10^7))]$ $(= 1.27 \times 10^7$ J kg^{-1})	**(M1)**
	$\Delta E_p = 1.27 \times 10^7 \times 650$ $= 8.3 \times 10^9$ J	**(A1)**
1(c)	kinetic energy <u>or</u> potential energy decreases	**B1**
	kinetic energy <u>and</u> potential energy decrease so total energy decreases	**B1**

Question	Answer	Marks
2(a)(i)	$pV = nRT$	**C1**
	$n = (3.0 \times 10^5 \times 210 \times 10^{-6}) / (8.31 \times 270)$	**C1**
	$= 0.028$ mol	**A1**
2(a)(ii)	$V \propto T$ **or** $T = pV / nR$ with value of n from **(i)**	**C1**
	$T = (140 / 210) \times 270$ **or** $T = (3.0 \times 10^5 \times 140 \times 10^{-6}) / (8.31 \times 0.028)$ $= 180$ K	**A1**
2(a)(iii)	$W = p\Delta V$ $= 3.0 \times 10^5 \times (210 - 140) \times 10^{-6}$	**C1**
	$= 21$ J	**A1**

Question	Answer	Marks
2(b)	$\Delta U = w + q$	**C1**
	$= 21 - 53$	**C1**
	or	
	$\Delta U = (nN_A) \times (3/2)k\Delta T$	**(C1)**
	$= (0.0281 \times 6.02 \times 10^{23}) \times (3/2) \times 1.38 \times 10^{-23} \times (180 - 270)$	**(C1)**
	or	
	$\Delta U = (3/2)nR\Delta T$	**(C1)**
	$= (3/2) \times 0.0281 \times 8.31 \times (180 - 270)$	**(C1)**
	$\Delta U = (–)32$ J	**A1**

Question	Answer	Marks
3(a)(i)	amplitude = 0.020 m	A1
3(a)(ii)	T = 0.60 s	C1
	f = 1 / T = 1.7 Hz	A1
3(a)(iii)	$a = (–)\omega^2 x$ **and** [$\omega = 2\pi f$ **or** $\omega = 2\pi / T$]	C1
	$a = (4\pi^2 / 0.60^2) \times 2.0 \times 10^{-2}$ $= 2.2\ \text{m s}^{-2}$	A1
3(b)	$1.67 = (1 / 2\pi) \times [(24 \times 10^{-4} \times \rho \times 9.81) / 0.23]^{1/2}$	C1
	$\rho = 1.1 \times 10^3\ \text{kg m}^{-3}$	A1
3(c)	wave starting with a peak at (0,6)	B1
	wave with same period (or slightly greater)	B1
	peak height decreasing successively	B1

Question	Answer	Marks
4(a)(i)	loss of (signal) power/amplitude/intensity	**B1**
4(a)(ii)	unwanted/random signal	**B1**
	superposed on (transmitted) signal	**B1**
4(b)	noise can be eliminated (from digital signals) **or** signal can be regenerated (from digital signals)	**B1**
4(c)(i)	010<u>1</u>	**A1**
4(c)(ii)	1000 at *t* = 4.0 ms	**B1**
	0110 at *t* = 5.0 ms **and** 0100 at *t* = 6.0 ms	**B1**
4(d)	series of equally-spaced steps of width 1 ms	**B1**
	each step in correct time interval (0–1 ms, 1–2 ms, 2–3 ms, 3–4 ms)	**B1**
	correct step heights (2, 6, 4 and 5)	**B1**

Question	Answer	Marks
5(a)	force per unit charge	**B1**
	(force on) positive charge	**B1**
5(b)(i)	field changes <u>direction</u> (between A and B)/field is zero at a point (between A and B)	**M1**
	so charges have same sign	**A1**
5(b)(ii)	Any one from: • field is (also) influenced by charge B • charge A is not isolated/is not the only charge present • field is due to two/both charges • field is the resultant of two fields	**B1**
5(b)(iii)	$E = Q / (4\pi\varepsilon_0 x^2)$	**C1**
	at x = 10 cm, $E_A = E_B$	**C1**
	$Q_A / 10^2 = Q_B / 5^2$ $Q_A / Q_B = 4.0$	**A1**

Question	Answer	Marks
6(a)	Any valid two points e.g.: • to store (electrical) energy • smoothing/reduce ripple (on direct voltages/currents) • to block d.c. • timing/time delay (circuits) • in oscillator (circuits) • in tuning (circuits) • to prevent arcing/sparks	**B2**
6(b)	clear indication of equal charge on each capacitor	**B1**
	$E = V_1 + V_2 + V_3$ **and** $V = Q / C$	**M1**
	completion of algebra leading to $1 / C = 1 / C_1 + 1 / C_2 + 1 / C_3$	**A1**
6(c)(i)	three capacitors connected in parallel	**B1**
6(c)(ii)	parallel combination of three capacitors connected in series with one capacitor	**B1**

Question	Answer	Marks
7(a)(i)	(amplifier) gain is very large/infinite	**B1**
	for amplifier not to saturate, $V^+ = V^-$ **or** feedback (loop) ensures $V^+ = V^-$	**B1**
	V^+ is at earth/0 V so V^- is (almost) at earth/0 V	**B1**
7(a)(ii)	gain = (–)5200 / 800 **or** (–)5.2 / 0.80	**C1**
	= –6.5	**A1**

Question	Answer	Marks
7(b)	(at saturation,) V_{OUT} = 5 V	**C1**
	p.d. across R = 5 – 2.3 = 2.7 (V)	**C1**
	resistance = 2.7 / (30 × 10^{-3}) = 90 Ω	**A1**
	or	
	R_{diode} = 2.3 / 0.030 = 77 Ω R_{total} = 5.0 / 0.030 = 167 Ω	**(C1)**
	$R_{resistor}$ (= 167 – 77) = 90 Ω	**(A1)**
	or	
	R_{diode} = 2.3 / 0.030 = 77 Ω 77 / ($R_{resistor}$ + 77) × 5 = 2.3	**(C1)**
	$R_{resistor}$ = 90 Ω	**(A1)**
	or	
	R_{diode} = 2.3 / 0.030 = 77 Ω $R_{resistor}$ = 77 × (2.7 / 2.3)	**(C1)**
	$R_{resistor}$ = 90 Ω	**(A1)**

Question	Answer	Marks
8(a)(i)	region where a force is exerted on: a magnetic pole **or** a moving charge **or** a current-carrying wire	**B1**
8(a)(ii)	arrow on axis of solenoid pointing downwards labelled P	**B1**
8(b)(i)	direction of induced e.m.f./current	**M1**
	(tends to) oppose the change causing it	**A1**
8(b)(ii)	magnetic field in solenoid is increasing	**B1**
	field in coil in opposite direction to oppose increase	**B1**
	arrow inside or just above small coil pointing in opposite direction to P	**B1**
8(c)	e.m.f. $= N\Delta\phi / \Delta t$	**C1**
	$= (75 \times 1.4 \times 10^{-3} \times 2 \times 7.0 \times 10^{-4}) / 0.12$	**C1**
	$= 1.2 \times 10^{-3}$ V	**A1**

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

Question	Answer	Marks
10(a)	V_{MAX} = 15 V	A1
10(b)	210 = 2π / T	C1
	T = 0.0299 s	C1
	($t_2 - t_1$) = 0.060 s	A1

Question	Answer	Marks
11(a)	Any three points from: • (max) energy of emitted electrons depends on frequency • (max) energy of emitted electrons does not depend on intensity • rate of emission of electrons depends on intensity (at constant frequency) • existence of frequency below which no emission of electrons • instantaneous emission of electrons • increasing the frequency at constant intensity decreases the rate of emission of electrons	B3
11(b)(i)	photon energy $= hc / \lambda$	C1
	$= (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (380 \times 10^{-9})$ $(= 5.23 \times 10^{-19}$ J)	C1
	$= 3.3$ eV	A1
11(b)(ii)	photon energy must be greater than work function (energy)	B1
	so sodium and calcium	B1
11(c)	$\lambda = h / p$	C1
	$p = (6.63 \times 10^{-34}) / (380 \times 10^{-9})$ $= 1.74 \times 10^{-27}$ N s	C1
	force $= 1.74 \times 10^{-27} \times 7.6 \times 10^{14}$ $= 1.3 \times 10^{-12}$ N	A1

Question	Answer	Marks
12(a)(i)	$\Delta N / \Delta T$	B1
12(a)(ii)	$\Delta N / N$	B1
12(a)(iii)	$\Delta N / (N\,\Delta T)$	B1
12(b)(i)	**1.** mass change = 5.60×10^{-3} u	A1
	2. energy = $(\Delta)mc^2$	C1
	$= 5.6 \times 10^{-3} \times 1.66 \times 10^{-27} \times (3.0 \times 10^8)^2$ $(= 8.36 \times 10^{-13}$ J)	C1
	= 0.84 pJ	A1
12(b)(ii)	kinetic energy (of recoil) of lead (nucleus)	B1
	energy of γ-ray photon	B1