Cambridge Assessment International Education

Cambridge International AS & A Level

PHYSICS **9702/42**

Paper 4 A Level Structured Questions **February/March 2022**

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 February/March 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>‘List rule’ guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Examples of how to apply the list rule
State **three** reasons…. [3]

A

1. Correct	✓	**2**
2. Correct	✓	
3. Wrong	✗	

B **(4 responses)**

1. Correct, Correct	✓, ✓	**3**
2. Correct	✓	
3. Wrong	ignore	

C **(4 responses)**

1. Correct	✓	**2**
2. Correct, Wrong	✓, ✗	
3. Correct	ignore	

D **(4 responses)**

1. Correct	✓	**2**
2. Correct, CON (of 2.)	✗, (discount 2)	
3. Correct	✓	

E **(4 responses)**

1. Correct	✓	**3**
2. Correct	✓	
3. Correct, Wrong	✓	

F **(4 responses)**

1. Correct	✓	**2**
2. Correct	✓	
3. Correct CON (of 3.)	✗ (discount 3)	

G **(5 responses)**

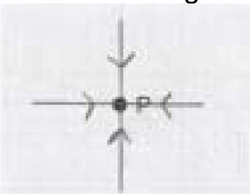
1. Correct	✓	**3**
2. Correct	✓	
3. Correct Correct CON (of 4.)	✓ ignore ignore	

H **(4 responses)**

1. Correct	✓	**2**
2. Correct	✗	
3. CON (of 2.) Correct	(discount 2) ✓	

I **(4 responses)**

1. Correct	✓	**2**
2. Correct	✗	
3. Correct CON (of 2.)	✓ (discount 2)	

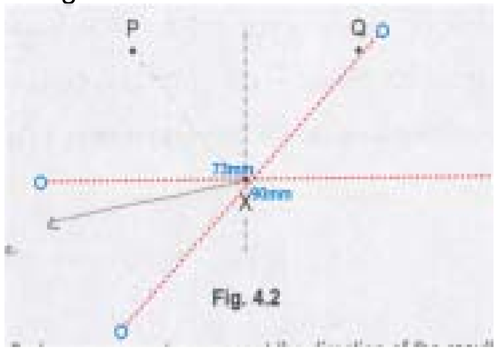
Question	Answer	Marks
1(a)	at least 4 straight radial lines to P 	B1
	all arrows pointing along the lines towards P	B1
1(b)	**Any 2 from:** gravitational force provides the centripetal force (centripetal or gravitational) force has constant magnitude (centripetal or gravitational) force is perpendicular to velocity (of moon) / direction of motion (of moon)	B2
1(c)(i)	$\frac{GMm}{r^2} = mr\omega^2$	M1
	$M = \frac{r^3\omega^2}{G}$ and gradient = $r^3\omega^2$ hence $M = \frac{\text{gradient}}{G}$ or $r^3 = GM \times 1/\omega^2$ so gradient = GM hence $M = \frac{\text{gradient}}{G}$	A1
1(c)(ii)	M = $4.1 \times 10^{23} / (6.0 \times 10^{7} \times 6.67 \times 10^{-11})$ = $\mathbf{1.0 \times 10^{26}}$ kg	B1

Question	Answer	Marks
1(c)(iii)	$\frac{GMm}{r^2}=\frac{mv^2}{r}$ $\frac{GM}{r}=v^2$	C1
	$v^2=\frac{6.67\times10^{-11}\times1.0\times10^{26}}{1.2\times10^{8}}$ $v^2=5.6\times10^{7}\,m\,s^{-1}$	C1
	v =7500 $m s^{-1}$	A1

Question	Answer	Marks
2(a)	0	B1
2(b)	$pV = nRT$ (n =) $1.5 \times 10^5 \times 4.2 \times 10^{-3} / 8.31 \times 540$	C1
	= **0.14** mol	A1
2(c)	missing pressure **1.5** ($\times 10^5$)	B1
	both missing volumes **1.8** ($\times 10^{-3}$)	B1
2(d)(i)	(ΔU:) increase in internal energy (of the system)	B1
	(q:) thermal energy supplied to the system	B1
	(W:) work done on system	B1

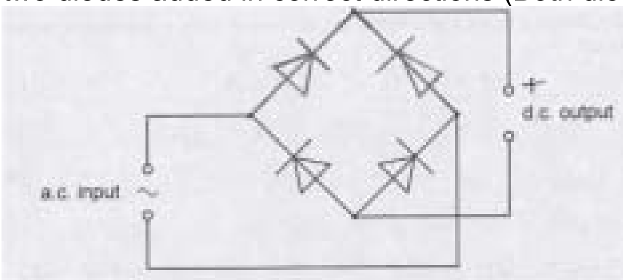
Question	Answer	Marks
2(d)(ii)	volume increases and work is done by the gas	B1
	temperature decreases and internal energy decreases	B1

Question	Answer	Marks
3(a)	upthrust, weight	B1
3(b)	upthrust greater than weight so (resultant force is) upwards	B1
3(c)(i)	*A*, *g* and ρ all constant so $F \propto x$	B1
	minus sign means *F* and *x* are in opposite directions	B1
3(c)(ii)	$(a = \frac{F}{m}$ so) $a = (-)\frac{Ag\rho x}{m}$	M1
	so $\omega^2 = \frac{Ag\rho}{m}$ hence $\omega = \sqrt{\frac{Ag\rho}{m}}$	A1
3(d)(i)	damping due to viscous forces	B1
3(d)(ii)	$(E =)\ \frac{1}{2} m\omega^2 x_0^{\ 2}$	C1
	$\omega^2 = (-)$ gradient	C1
	$(E =)\ \frac{1}{2} m\omega^2 (x_1^{\ 2} - x_2^{\ 2})$ $= \frac{1}{2} \times 0.57 \times (\frac{2.3}{0.020})(0.020^2 - 0.016^2)$ $= 4.7 \times 10^{-3}$ J	A1

Question	Answer	Marks
4(a)	direction of force	B1
	force on a positive charge	B1
4(b)(i)	$V = \frac{Q}{4\pi\varepsilon_o r}$ $\frac{4.0\times10^{-9}}{4\pi\varepsilon_o x} + \frac{-7.2\times10^{-9}}{4\pi\varepsilon_o(0.120 - x)} = 0$ $4(0.120 - x) = 7.2x$	C1
	x = 0.043 m	A1
4(b)(ii)	fields are in the same direction so no	B1
4(b)(iii)	straight arrow drawn leftwards from X in direction between extended line joining Q and X and the horizontal  Fig. 4.2	B1

Question	Answer	Marks
5(a)	(energy stored =) area under line or ½ QV = $\frac{1}{2} \times 8.0 \times 1.2 \times 10^{-4}$	C1
	= **4.8×10^{-4}** J	A1
5(b)(i)	(τ=) RC	C1
	(τ=) $220 \times 10^3 \times (1.2 \times 10^{-4}/8.0)$ = **3.3** s	A1
5(b)(ii)	$E \propto V^2$	C1
	(so time to) $V_o / 3$ $V = V_o e^{-t/RC}$	C1
	$\frac{V_o}{3} = V_o e^{-t/3.3}$ $\frac{1}{3} = e^{-t/3.3}$	C1
	t = 3.6 s	A1
5(c)	(total) capacitance is doubled	M1
	time constant is doubled	A1

Question	Answer	Marks
6(a)	less in smaller solenoid	**B1**
6(b)	greater in smaller solenoid	**B1**
6(c)(i)	<u>direction</u> of (induced) e.m.f.	**M1**
	such as to (produce effects that) oppose the <u>change</u> that caused it	**A1**
6(c)(ii)	change of flux (linkage) in smaller solenoid induces e.m.f. in smaller solenoid	**B1**
	(induced) current in smaller solenoid causes field around it	**B1**
	the two fields (interact to) create an attractive force	**B1**

Question	Answer	Marks
7(a)(i)	two diodes added in correct directions (Both diodes pointing inwards and upwards), correct symbols only 	**B1**
7(a)(ii)	'+' anywhere on upper output wire	**B1**
7(b)(i)	$\omega = 2\pi / T$ $= 2\pi / 2.5$ $= 0.80\,\pi$ or $4\pi / 5$ or 2.5	**C1**
	(V =) **3.5 sin (0.8π *t*)** or 3.5 sin (4π t / 5) or 3.5 sin (2.5 t)	**A1**

Question	Answer	Marks
7(b)(ii)	$(P=)\frac{V^2}{2R}$ or $(P=)\frac{{V_{r.m.s.}}^2}{R}$ $=\frac{3.5^2}{2\times12}$ or $\frac{2.47^2}{12}$	C1
	= 0.51 W	A1

Question	Answer	Marks
8(a)	$\lambda=\frac{h}{p}$ or $\lambda=\frac{h}{mv}$	M1
	where *h* is the Planck constant **and** *p* is the momentum (of particle) / *mv* is the momentum (of particle) / *m* is the mass (of particle) and *v* is the velocity (of particle)	A1
8(b)(i)	(electron) diffraction	B1
8(b)(ii)	moving electrons behave like waves	B1
8(b)(iii)	spacing between atoms ≈ wavelength of electron *or* diameter of atom ≈ wavelength of electron	B1
8(b)(iv)	Any one of: • wavelength has decreased • electron had greater momentum	M1
	so (accelerating) p.d. was increased	A1

Question	Answer	Marks
9(a)	207, 82 for lead	B1
	4, 2 for alpha	B1
9(b)(i)	(half-life found as) 0.52 s or correctly read points substituted into $N = N_0 e^{-\lambda t}$ $\lambda = \frac{0.693}{t_{1/2}}$ $\lambda = \frac{0.693}{0.52}$	C1
	λ = **1.3 s^{-1}**	A1
9(b)(ii)	$A = \lambda N$ $= 1.3 \times 24 \times 10^{12}$ $= 3.1 \times 10^{13}$ Bq	A1
9(b)(iii)	upwards curve of decreasing gradient starting from (0,0)	B1
	passes through (0.52, 12) and (1.2, 18.8)	B1
9(c)(i)	16×10^{12} and 7.2×10^{12}	C1
	$6900 \times 10^3 \times 1.6 \times 10^{-19}$ $(16 \times 10^{12} - 7.2 \times 10^{12}) \times 6900 \times 10^3 \times 1.6 \times 10^{-19}$	C1
	= **9.7 J**	A1

Question	Answer	Marks
9(c)(ii)	lead nuclei have kinetic energy *or* gamma <u>photons</u> are also emitted	**B1**

Question	Answer	Marks
10(a)	energy = mcΔT	**C1**
	energy = ItV $(\Delta T =) \dfrac{0.40 \times 0.020 \times 75\ 000 \times 0.95}{0.015 \times 130}$	**C1**
	=290 K	**A1**
10(b)	$I = I_o e^{-\mu t}$ $0.20 = e^{-0.22t}$	**C1**
	t = 7.3 cm	**A1**

Question	Answer	Marks
10(c)	*either* (linear) attenuation coefficients / μ <u>very</u> different for bone and muscle	**M1**
	(very) different amounts (of X-rays) absorbed so good contrast or (very) different intensities transmitted so good contrast	**A1**
	or (linear) attenuation coefficients / μ similar for blood and muscle	**(M1)**
	similar amounts (of X-rays) absorbed so poor contrast or similar intensities transmitted so poor contrast	**(A1)**

Question	Answer	Marks
11(a)	substance containing radioactive nuclei that is introduced into the body *or* substance containing radioactive nuclei that is absorbed by the tissue being studied	**B1**
11(b)(i)	a particle interacting with its antiparticle so that mass is converted into energy	**B1**
11(b)(ii)	electron(s) and positron(s)	**B1**
11(c)(i)	$E = 2mc^2$ $= 2 \times 9.11 \times 10^{-31} \times 3.00 \times 10^{-82}$ $= 1.64 \times 10^{-13}$ J	**A1**

Question	Answer	Marks
11(c)(ii)	$\lambda = \frac{2hc}{E}$ $= \frac{2 \times 6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{1.64 \times 10^{-13}}$	**C1**
	$= 2.43 \times 10^{-12}$ m	**A1**
11(d)	Any 3 from: • the two gamma photons travel in opposite directions • gamma photons detected (outside body / by detectors) • gamma photons arrive (at detector) at different times • determine location of production (of gamma) • image of tracer concentration in tissue produced	**B3**

Question	Answer	Marks
12(a)	total power of radiation emitted (by the star)	**B1**
12(b)	$F = \frac{L}{4\pi d^2}$ $= \frac{3.83 \times 10^{26}}{4 \times \pi \times 1.51 \times 10^{112}}$	**C1**
	$= 1340$ W m^{-2}	**A1**

Question	Answer	Marks
12(c)	$m = \frac{E}{c^2}$ $= \frac{3.83 \times 10^{26}}{3.00 \times 10^{82}}$ $= 4.26 \times 10^{9}$ kg	A1
12(d)	L = $4\pi\sigma r^2 T^4$ $3.83 \times 10^{26} = 4 \times \pi \times 5.67 \times 10^{-8} \times 6.96 \times 10^{82} \times T^4$ leading to T = 5770 K	B1
12(e)	$\lambda_{(max)} \propto \frac{1}{T}$ $\frac{5.00 \times 10^{-7}}{\lambda} = \frac{9940}{5770}$	C1
	$\lambda = 2.90 \times 10^{-7}$m	A1