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.

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)

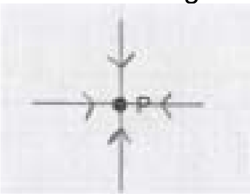
1. Correct	✓	**3**
2. Correct	✓	
3. Correct Correct CON (of 4.)	✓ ignore ignore	

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
	$v^2 = \frac{6.67 \times 10^{-11} \times 1.0 \times 10^{26}}{1.2 \times 10^8}$ $v^2 = 5.6 \times 10^7 \text{ m s}^{-1}$	C1
	$v = 7500 \text{ m s}^{-1}$	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

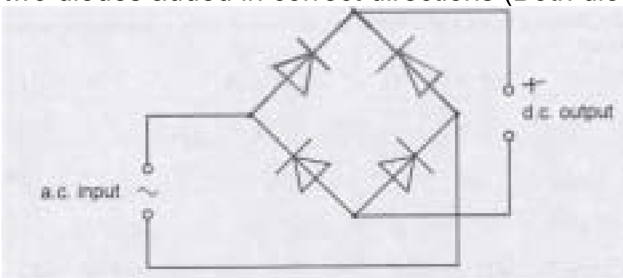
Question	Answer	Marks
2(d)(ii)	volume increases and work is done by the gas	B1
	temperature decreases and internal energy decreases	B1

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)	$V = \dfrac{Q}{4\pi\varepsilon_o r}$ $\dfrac{4.0\times10^{-9}}{4\pi\varepsilon_o x} + \dfrac{-7.2\times10^{-9}}{4\pi\varepsilon_o(0.120 - x)} = 0$ $4(0.120 - x) = 7.2x$	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)	direction of (induced) e.m.f.	**M1**
	such as to (produce effects that) oppose the change 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)	$(P=)\dfrac{V^2}{2R}$ or $(P=)\dfrac{{V_{r.m.s.}}^2}{R}$ $=\dfrac{3.5^2}{2\times 12}$ or $\dfrac{2.47^2}{12}$	**C1**
	= 0.51 W	**A1**

Question	Answer	Marks
8(a)	$\lambda = \dfrac{h}{p}$ or $\lambda = \dfrac{h}{mv}$	**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=λN $= 1.3 \times 24 \times 10^{12}$ $= 3.1 \times 10^{13}$ 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 photons 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)	$\lambda = \dfrac{2hc}{E}$ $= \dfrac{2 \times 6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{1.64 \times 10^{-13}}$	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)	$F = \dfrac{L}{4\pi d^2}$ $= \dfrac{3.83 \times 10^{26}}{4 \times \pi \times 1.51 \times 10^{112}}$	C1
	$= 1340$ W m^{-2}	A1

Question	Answer	Marks
12(c)	$m = \dfrac{E}{c^2}$ $= \dfrac{3.83 \times 10^{26}}{3.00 \times 10^{82}}$ $= 4.26 \times 10^{9}$ 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)	$\lambda_{(max)} \propto \dfrac{1}{T}$ $\dfrac{5.00 \times 10^{-7}}{\lambda} = \dfrac{9940}{5770}$	C1
	$\lambda = 2.90 \times 10^{-7}$m	A1