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PHYSICS **9702/42**

Paper 4 A Level Structured Questions **October/November 2024**

MARK SCHEME

Maximum Mark: 100

Published

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Question	Answer	Marks
1(a)(i)	$v = r\omega$	C1
	$= 0.85 \times 140$ $= 120\ \text{m s}^{-1}$	A1
1(a)(ii)	$a = r\omega^2$ **or** $a = v^2 / r$	C1
	$a = 0.85 \times 140^2$ **or** $120^2 / 0.85$ $= 1.7 \times 10^4\ \text{m s}^{-2}$	A1
1(b)(i)	direction of (induced) e.m.f.	M1
	is such as to (produce effects that) oppose the <u>change</u> that caused it	A1
1(b)(ii)	$T = 2\pi / \omega$ $= 2\pi / 140 = 0.045\ \text{s} = 45\ \text{ms}$	A1
1(b)(iii)	$\Phi = BA$	C1
	$= 0.18 \times \pi \times 0.85^2$	C1
	$= 0.41\ \text{Wb}$	A1
1(b)(iv)	$E = \Phi / t$	C1
	$= 0.41 / 0.045$ $= 9.1\ \text{V}$	A1
1(b)(v)	force (on spoke) must be anticlockwise, so current is from A to X (by Fleming's left hand rule), so X is at the higher potential	B1

Question	Answer	Marks
2(a)	force per unit mass	**B1**
2(b)(i)	$g = GM / x^2$	**C1**
	$= (6.67 \times 10^{-11} \times 1.99 \times 10^{30}) / (1.47 \times 10^{11})^2$ $= 6.14 \times 10^{-3}$ N kg^{-1}	**A1**
2(b)(ii)	$E_P = -GMm / x$ $= -(6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 2.63) / (1.47 \times 10^{11})$	**C1**
	$= -2.37 \times 10^9$ J	**A1**
2(c)(i)	$F = L / 4\pi x^2$	**C1**
	($g = GM / x^2$ and so) $x^2 = GM / g$ **and** $x^2 = L / 4\pi F$	**M1**
	elimination of x and subsequent algebra shown leading to $g = 4\pi GMF / L$	**A1**
2(c)(ii)	correct read-off of pair of values of g and F and full substitution of values of g, G, M and F into equation e.g. $L = (4\pi \times 6.67 \times 10^{-11} \times 1.99 \times 10^{30} \times 1.83 \times 10^3) / (8.0 \times 10^{-3})$	**C1**
	$L = 3.8 \times 10^{26}$ W	**A1**
2(c)(iii)	$L = 4\pi\sigma r^2 T^4$ $3.8 \times 10^{26} = (4\pi \times 5.67 \times 10^{-8} \times 5780^4) \times r^2$	**C1**
	$r = 6.9 \times 10^8$ m	**A1**

Question	Answer	Marks
3(a)	(thermal) energy per unit mass (to cause change of state)	**B1**
	(thermal) energy to change state at constant temperature	**B1**
3(b)(i)	$W = p\Delta V$	**C1**
	$= 1.0 \times 10^5 \times 0.017 = 1700$ J = 1.7 kJ	**A1**
3(b)(ii)	$\Delta U = Q + W$	**C1**
	$Q = 17.6 + 1.7$ = 19.3 kJ	**A1**
3(b)(iii)	mass $= 710 \times 7.2 \times 10^{-5}$ (= 0.051 kg)	**C1**
	$L = 19.3 / 0.051$ = 380 kJ kg^{-1}	**A1**
3(c)	fusion involves (much) smaller volume change (than vaporisation)	**B1**
	smaller change in intermolecular spacing so smaller change in internal energy	**B1**
	negligible work done (by substance during fusion) so L_F is less (than L_V)	**B1**

Question	Answer	Marks
4(a)	• molecules are in (constant) random motion • (all) collisions between molecules are (perfectly) elastic • no forces between molecules (except during collisions) • volume of molecules is negligible (compared with volume of gas) • collisions involving molecules are instantaneous *Any three points, 1 mark each*	**B3**
4(b)	• molecules collide with (walls of) container • momentum of molecule changes during collision (with walls) • change in momentum is caused by force on molecule by wall • molecule experiences force from wall so molecule exerts force on wall • many molecules exerting force across the area of the wall leads to pressure (on the wall) *Any three points, 1 mark each*	**B3**
4(c)	*Any three bulleted points from:* • both gases are ideal *Up to 2 points from:* • mass of one molecule of gas X is 3.3×10^{-27} kg • mass of one molecule of gas Y is 6.6×10^{-27} kg • mass of one molecule of gas Y is double mass of one molecule of gas X *Up to 2 points from:* • sample of X contains 0.27 mol / 1.6×10^{23} molecules • sample of Y contains 0.81 mol / 4.9×10^{23} molecules • sample of Y contains treble the amount of gas / number of molecules as sample of X *Up to 2 points from:* • mass of gas X is 5.4×10^{-4} kg • mass of gas Y is 3.2×10^{-3} kg • mass of gas Y is six times mass of gas X	**B3**

Question	Answer	Marks
5(a)	arrow from sphere, perpendicular to string, pointing left and down	**B1**
5(b)(i)	amplitude = 0.016 m	**A1**
5(b)(ii)	angular frequency = $2\pi / T$	**C1**
	$= 2\pi / 0.40$ $= 16$ rad s^{-1}	**A1**
5(b)(iii)	total energy $= ½m\omega^2 x_0^2$	**C1**
	$= ½ \times 0.15 \times 15.7^2 \times 0.016^2$ $= 4.7 \times 10^{-3}$ J	**A1**
5(c)	dome-shaped curve starting and ending on the *x*-axis, with peak at $x = 0$	**B1**
	maximum E_K shown as 4.7×10^{-3} J	**B1**
	minimum *x* shown as –0.016 m and maximum *x* shown as +0.016 m at the ends of the line	**B1**

Question	Answer	Marks
6(a)	(electric) force is (directly) proportional to product of charges	**B1**
	force (between point charges) is inversely proportional to the square of their separation	**B1**
6(b)	at least four straight, radial lines to/from surface of sphere	**B1**
	at least four straight radial lines drawn, approximately equally spaced	**B1**
	arrows pointing away from the surface of the sphere	**B1**
6(c)(i)	radius = 3.2 cm	**A1**
6(c)(ii)	$E = Q / (4\pi\varepsilon_0 x^2)$	**C1**
	Q = e.g. $2.2 \times 10^5 \times 4\pi \times 8.85 \times 10^{-12} \times 0.032^2$	**C1**
	$= 2.5 \times 10^{-8}$ C	**A1**
6(c)(iii)	• the (positive) charge is all the way around the surface • a charge placed inside the sphere is pulled equally in all directions • if the field was not zero, the charges would move (until field is zero) • electric field lines go from positive charge to negative charge, and there are no negative charges inside the sphere *Any point, 1 mark*	**B1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">7(a)</td><td>charge / potential (difference)</td><td>M1</td></tr>
<tr><td>charge is charge on one plate, <u>and</u> potential is p.d. between the plates</td><td>A1</td></tr>
<tr><td rowspan="2">7(b)(i)</td><td>straight line starting at the origin</td><td>B1</td></tr>
<tr><td>line with positive gradient ending at (V, Q)</td><td>B1</td></tr>
<tr><td rowspan="2">7(b)(ii)</td><td>work done is the area under the graph</td><td>B1</td></tr>
<tr><td>$W = ½QV$</td><td>A1</td></tr>
<tr><td rowspan="3">7(c)(i)</td><td>final p.d. shown as $V / 4$ for both capacitors</td><td>B1</td></tr>
<tr><td>final charges add together to give Q</td><td>B1</td></tr>
<tr><td>charge on Y = 3 × charge on X (and both charges shown as a multiple of Q)

Fully correct answer:
<table><tr><th></th><th>X</th><th>Y</th></tr><tr><td>final p.d.</td><td>$V / 4$</td><td>$V / 4$</td></tr><tr><td>final charge</td><td>$Q / 4$</td><td>$3Q / 4$</td></tr></table></td><td>B1</td></tr>
<tr><td>7(c)(ii)</td><td>less than</td><td>B1</td></tr>
</table>

Question	Answer	Marks
8(a)	number of cycles per unit time	**B1**
8(b)(i)	period = 2π / 40π = 0.050 s = 50 ms	**A1**
8(b)(ii)	sinusoidal curve, starting at (0, 0) and initially increasing from there	**B1**
	periodic line showing 2 cycles with period 50 ms from t = 0 to t = 100 ms	**B1**
	all peaks shown at I = +3.5 A and all troughs shown at I = –3.5 A	**B1**
8(b)(iii)	$I_{r.m.s}$ = 3.5 / √2 = 2.5 A	**A1**
8(c)	$P = I^2R$	**C1**
	peak power = $3.5^2 \times 680$ (= 8330 W) **or** mean power = $2.47^2 \times 680$ (= 4170 W)	**M1**
	peak and mean powers both calculated correctly, with supporting working, and compared leading to conclusion that mean power is half the peak power	**A1**

Question	Answer	Marks
9(a)	diffraction is characteristic of wave behaviour so shows that electrons can behave like waves	**B1**
9(b)	$qV = ½mv^2$	**C1**
	$p = mv$	**C1**
	$p = m \times \sqrt{(2qV / m)}$ $= \sqrt{(2qVm)}$	**A1**
9(c)	(electrons have) greater momentum <u>so</u> smaller (de Broglie) wavelength	**B1**
	fringes become closer together	**B1**
9(d)(i)	straight line with positive gradient	**B1**
	line with positive gradient passing through the origin	**B1**
9(d)(ii)	Planck constant	**B1**

Question	Answer	Marks
10(a)(i)	cannot predict when a particular <u>nucleus</u> will decay **or** cannot predict which <u>nucleus</u> will decay next	**B1**
10(a)(ii)	(decay is) not affected by external (environmental) factors	**B1**
10(a)(iii)	fluctuations in (measured) count rate	**B1**
10(b)(i)	• large nuclei undergo fission whereas small nuclei undergo fusion • fission involves one nucleus splitting into two (or more) (smaller) nuclei • fusion involves two nuclei joining together to form one (larger) nucleus • fission is (usually) initiated by neutron bombardment • fusion is (usually) initiated by (very) high temperatures *Any three points, 1 mark each*	**B3**
10(b)(ii)	binding energy <u>per nucleon</u> is greatest for intermediate nucleon numbers (may be shown on sketch graph with axes labelled ‘binding energy <u>per nucleon</u>’ and ‘nucleon number’)	**B1**
	both fusion and fission involve an increase in binding energy (per nucleon)	**B1**