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**PHYSICS**

**9702/41**

Paper 4 A Level Structured Questions

**October/November 2017**

MARK SCHEME

Maximum Mark: 100

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**Published**

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Question	Answer	Marks
1(a)(i)	direction or rate of transfer of (thermal) energy <b>or</b> (if different,) not in thermal equilibrium/energy is transferred	<b>B1</b>
1(a)(ii)	uses a property (of a substance) that changes with temperature	<b>B1</b>
1(b)	<ul style="list-style-type: none"> <li>• temperature scale assumes linear change of property with temperature</li> <li>• physical properties may not vary linearly with temperature</li> <li>• agrees only at fixed points</li> </ul> <i>Any 2 points.</i>	<b>B2</b>
1(c)(i)	$Pt = mc(\Delta)\theta$	<b>C1</b>
	$95 \times 6 \times 60 = 0.670 \times 910 \times \Delta\theta$	<b>M1</b>
	$\Delta\theta = 56^\circ\text{C}$ so final temperature = $56 + 24 = 80^\circ\text{C}$	<b>A1</b>
	<b>or</b>	
	$95 \times 6 \times 60 = 0.67 \times 910 \times (\theta - 24)$	<b>(M1)</b>
	so final temperature or $\theta = 80^\circ\text{C}$	<b>(A1)</b>

Question	Answer	Marks
1(c)(ii)	1. sketch: straight line from (0,24) to (6,80)	<b>B1</b>
	2. temperature drop due to energy loss = $(80 - 64) = 16^{\circ}\text{C}$	<b>C1</b>
	energy loss = $0.670 \times 910 \times (80 - 64) = 9800 \text{ J}$	<b>A1</b>
	<b>or</b>	
	energy to raise temperature to $64^{\circ}\text{C} = 0.670 \times 910 \times (64 - 24)$	<b>(C1)</b>
	$= 24400 \text{ J}$ loss = $(95 \times 6 \times 60) - 24400 = 9800 \text{ J}$	<b>(A1)</b>

Question	Answer	Marks
2(a)	(angular frequency =) $2\pi \times \text{frequency}$ <b>or</b> $2\pi/\text{period}$	<b>B1</b>
2(b)(i)	1. displacement = 2.0 cm	<b>A1</b>
	2. amplitude = 1.5 cm	<b>A1</b>
2(b)(ii)	reference to displacement of oscillations <b>or</b> displacement from equilibrium position <b>or</b> displacement from 2.0 cm	<b>B1</b>
	straight line indicates acceleration $\propto$ displacement	<b>B1</b>
	negative gradient shows acceleration and displacement are in opposite directions	<b>B1</b>

Question	Answer	Marks
2(b)(iii)	$\omega^2 = (-)1/\text{gradient}$ or $\omega^2 = (-)\Delta a/\Delta s$ or $a = (-)\omega^2 x$ <u>and</u> correct value of $x$	<b>C1</b>
	= e.g. (1.8/0.03) or (0.9/0.015) or (1.2/0.02) etc. or $0.9 = \omega^2 \times 0.015$ = 60	<b>C1</b>
	$f = \sqrt{60}/2\pi$ = 1.2 Hz	<b>A1</b>

Question	Answer	Marks
3(a)	force per unit mass	<b>B1</b>
3(b)	changes in height <u>much</u> less than radius of Earth	<b>M1</b>
	so (radial) field lines are almost parallel or $g = GM/R^2 \approx GM/(R+h)^2$	<b>A1</b>

Question	Answer	Marks
3(c)	gravitational force provides/is centripetal force	<b>B1</b>
	$GMm/r^2 = mv^2/r$	<b>C1</b>
	$v = (2\pi \times 1.5 \times 10^{11}) / (3600 \times 24 \times 365) = 2.99 \times 10^4 \text{ (ms}^{-1}\text{)}$	<b>C1</b>
	$6.67 \times 10^{-11}M = 1.5 \times 10^{11} \times (2.99 \times 10^4)^2$	<b>C1</b>
	$M = 2.0 \times 10^{30} \text{ kg}$	<b>A1</b>
	<b>or</b>	
	$GMm/r^2 = mr\omega^2$	<b>(C1)</b>
	$\omega = 2\pi / (3600 \times 24 \times 365) = 1.99 \times 10^{-7} \text{ (rads}^{-1}\text{)}$	<b>(C1)</b>
	$6.67 \times 10^{-11}M = (1.5 \times 10^{11})^3 \times (1.99 \times 10^{-7})^2$	<b>(C1)</b>
	$M = 2.0 \times 10^{30} \text{ kg}$	<b>(A1)</b>
	<b>or</b>	
	$T^2 = 4\pi^2 r^3 / GM$	<b>(C2)</b>
	$M = 4\pi^2 \times (1.5 \times 10^{11})^3 / \{(3600 \times 24 \times 365)^2 \times 6.67 \times 10^{-11}\}$	<b>(C1)</b>
	$= 2.0 \times 10^{30} \text{ kg}$	<b>(A1)</b>

Question	Answer	Marks
4(a)	<ul style="list-style-type: none"> <li>acts as 'return' (conductor) for signal</li> <li>shielding from noise/crosstalk/interference</li> </ul> <i>Two sensible suggestions, 1 mark each.</i>	<b>B2</b>
4(b)	<ul style="list-style-type: none"> <li>small bandwidth</li> <li>(there is) noise/interference/crosstalk</li> <li>large attenuation/energy loss</li> <li>reflections due to poor impedance matching</li> </ul> <i>Two sensible suggestions, 1 mark each.</i>	<b>B2</b>
4(c)	attenuation = $190 \times 14 \times 10^{-3}$ (= 2.66 dB)	<b>C1</b>
	ratio/dB = $(-10 \lg(P_2/P_1))$	<b>C1</b>
	$2.66 = -10 \lg(P_{OUT}/P_{IN})$ $P_{OUT}/P_{IN} = 0.54$	<b>C1</b>
	fractional loss = $1 - (P_{OUT}/P_{IN}) = 1 - 0.54$ $= 0.46$	<b>A1</b>
	<b>or</b>	
	$2.66 = 10 \lg(P_{IN}/P_{OUT})$ $P_{IN}/P_{OUT} = 1.85$	<b>(C1)</b>
	fractional loss = $(P_{IN} - P_{OUT})/P_{IN} = (1.85 - 1)/1.85$ $= 0.46$	<b>(A1)</b>

Question	Answer	Marks
5(a)(i)	force proportional to <u>product</u> of charges and inversely proportional to <u>square</u> of separation	<b>A1</b>
5(a)(ii)	curve starting at $(R, F_C)$	<b>B1</b>
	passing through $(2R, 0.25F_C)$	<b>B1</b>
	passing through $(4R, 0.06F_C)$	<b>B1</b>
5(b)	graph: $E = 0$ when current constant (0 to $t_1$ , $t_2$ to $t_3$ , $t_4$ to $t_5$ )	<b>B1</b>
	stepped from $t_1$ to $t_2$ and $t_3$ to $t_4$	<b>B1</b>
	(steps) in opposite directions	<b>B1</b>
	later one larger in magnitude	<b>B1</b>

Question	Answer	Marks
6(a)(i)	$1/T = 1/(2C) + 1/C$	<b>C1</b>
	$T = \frac{2}{3}C$ or $0.67C$	<b>A1</b>
6(a)(ii)	same charge on Q as on combination	<b>B1</b>
	so p.d. is 6.0 V	<b>B1</b>
6(b)	P: p.d. will decrease (from 3.0V)	<b>B1</b>
	to zero	<b>B1</b>
	Q: p.d. will increase (from 6.0V)	<b>B1</b>
	to 9.0V	<b>B1</b>

Question	Answer	Marks
7(a)(i)	gain of amplifier is very large	<b>B1</b>
	$V^+$ is at earth (potential)	<b>B1</b>
	for amplifier not to saturate	<b>M1</b>
	difference between $V^-$ and $V^+$ must be very small <b>or</b> $V^-$ must be equal to $V^+$	<b>A1</b>
	<b>or</b>	
	if $V^- \neq V^+$ then feedback voltage	<b>(M1)</b>
	acts to reduce gap until $V^- = V^+$ when stable	<b>(A1)</b>
7(a)(ii)	input impedance is infinite	<b>B1</b>
	(so) current in $R_1$ = current in $R_2$	<b>B1</b>
	$(V_{IN} - 0) / R_1 = (0 - V_{OUT}) / R_2$	<b>B1</b>
	(gain =) $V_{OUT} / V_{IN} = - R_2 / R_1$	<b>B1</b>
7(b)	graph: correct inverted shape (straight diagonal line from (0,0) to a negative potential, then a horizontal line, then a straight diagonal line back to the $t$ -axis at the point where $V_{IN} = 0$ )	<b>B1</b>
	horizontal line at correct potential of (-)9.0V	<b>B1</b>
	both ends of horizontal line occur at correct times (coinciding with when $V_{IN} = 2.0V$ )	<b>B1</b>



Question	Answer	Marks
8(a)	DERQ and CFSP	<b>B1</b>
8(b)(i)	force (on charge) due to magnetic field = force due to electric field <b>or</b> $Bqv = Eq$ <b>or</b> $v = E/B$	<b>B1</b>
	$E = V_H/d$	<b>B1</b>
	$V_H = Bvd$	<b>B1</b>
8(b)(ii)	use of $I = nAqv$ <b>and</b> $A = dt$	<b>M1</b>
	algebra clear leading to $V_H = BI/ntq$	<b>A1</b>
8(c)	(in metal,) $n$ is very large	<b>M1</b>
	(therefore) $V_H$ is small	<b>A1</b>

Question	Answer	Marks			
9(a)	image of one slice/section	<b>(B1)</b>			
	images (of one slice) taken from different angles	<b>(M1)</b>			
	to give 2D image (of one slice)	<b>(A1)</b>			
	(repeated for) many slices	<b>(M1)</b>			
	to build up 3D image (of whole body/structure)	<b>(A1)</b>			
	<i>Max. 4 marks total</i>	<b>4</b>			
9(b)	evidence of subtraction of background (–26)	<b>C1</b>			
	evidence of division by three	<b>C1</b>			
	<table border="1" data-bbox="322 740 624 842"> <tbody> <tr> <td data-bbox="322 740 472 791">7</td> <td data-bbox="472 740 624 791">11</td> </tr> <tr> <td data-bbox="322 791 472 842">6</td> <td data-bbox="472 791 624 842">2</td> </tr> </tbody> </table>	7	11	6	2
7	11				
6	2				

Question	Answer	Marks
10(a)	heating depends on current <sup>2</sup> / $I^2$	<b>B1</b>
	and current <sup>2</sup> / $I^2$ is always positive	<b>B1</b>
	<b>or</b>	
	a.c. changes direction (every half cycle)	<b>(B1)</b>
	but heating effect is independent of current direction	<b>(B1)</b>
	<b>or</b>	
	voltage and current are always in phase in a resistor	<b>(B1)</b>
	so $V \times I$ is always positive	<b>(B1)</b>
	<b>or</b>	
	sketch graph drawn showing power against time	<b>(B1)</b>
comment that power is always positive	<b>(B1)</b>	
10(b)(i)	for same power (transmission, higher voltage) → lower current	<b>B1</b>
	lower current → less power loss in (transmission) cables	<b>B1</b>
10(b)(ii)	<ul style="list-style-type: none"> <li>• voltage can be (easily) stepped up/down</li> <li>• transformers only work with a.c.</li> <li>• generators produce a.c.</li> <li>• easier to rectify than invert</li> </ul> <p><i>Two sensible suggestions, 1 mark each.</i></p>	<b>B2</b>

Question	Answer	Marks
11(a)	packet/quantum of energy of electromagnetic/EM radiation	<b>B1</b>
11(b)(i)	$E = hf$ $1.1 \times 10^6 \times 1.60 \times 10^{-19} = 6.63 \times 10^{-34} \times f$	<b>C1</b>
	$f = 2.7 \times 10^{20} (2.65 \times 10^{20}) \text{ Hz}$	<b>A1</b>
11(b)(ii)	$p = h/\lambda = hf/c$ $= (6.63 \times 10^{-34} \times 2.65 \times 10^{20}) / (3.00 \times 10^8)$ <b>or</b> $p = E/c$ $= (1.1 \times 1.60 \times 10^{-13}) / (3.00 \times 10^8)$	<b>C1</b>
	$p = 5.9 \times 10^{-22} (5.87 \times 10^{-22}) \text{ N s}$	<b>A1</b>
11(c)	$123 \times 1.66 \times 10^{-27} \times v = 5.87 \times 10^{-22}$	<b>C1</b>
	$v = 2.9 \times 10^3 \text{ m s}^{-1}$	<b>A1</b>

Question	Answer	Marks
12(a)	<ul style="list-style-type: none"> <li>• emission from radioactive daughter products</li> <li>• self-absorption in source</li> <li>• absorption in air before reaching detector</li> <li>• detector not sensitive to all radiations</li> <li>• window of detector may absorb some radiation</li> <li>• dead-time of counter</li> <li>• background radiation</li> </ul> <p><i>Any two points.</i></p>	<b>B2</b>
12(b)(i)	<p>curve is not smooth <b>or</b> curve fluctuates/curve is jagged</p>	<b>B1</b>
12(b)(ii)	clear evidence of allowance for background	<b>B1</b>
	half-life determined at least twice	<b>B1</b>
	half-life = 1.5 hours <i>(1 mark if in range 1.7–2.0; 2 marks if in range 1.4–1.6)</i>	<b>A2</b>
12(c)	<b>1.</b> half-life: no change	<b>M1</b>
	because decay is spontaneous/independent of environment	<b>A1</b>
	<b>2.</b> count rate (likely to be or could be) different/is random/cannot be predicted	<b>B1</b>