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MARK SCHEME

Maximum Mark: 100

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Question	Answer	Marks
1(a)(i)	direction or rate of transfer of (thermal) energy or (if different,) not in thermal equilibrium/energy is transferred	B1
1(a)(ii)	uses a property (of a substance) that changes with temperature	B1
1(b)	- temperature scale assumes linear change of property with temperature - physical properties may not vary linearly with temperature - agrees only at fixed points <i>Any 2 points.</i>	B2
1(c)(i)	$Pt = mc(\Delta)\theta$	C1
	$95 \times 6 \times 60 = 0.670 \times 910 \times \Delta\theta$	M1
	$\Delta\theta = 56^\circ\text{C}$ so final temperature = $56 + 24 = 80^\circ\text{C}$	A1
	or	
	$95 \times 6 \times 60 = 0.67 \times 910 \times (\theta - 24)$	(M1)
	so final temperature or $\theta = 80^\circ\text{C}$	(A1)

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

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

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	C1
	= 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	C1
	$f = \sqrt{60}/2\pi$ = 1.2 Hz	A1

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

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

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Question	Answer	Marks
4(a)	- acts as 'return' (conductor) for signal - shielding from noise/crosstalk/interference <i>Two sensible suggestions, 1 mark each.</i>	B2
4(b)	- small bandwidth (there is) noise/interference/crosstalk - large attenuation/energy loss - reflections due to poor impedance matching <i>Two sensible suggestions, 1 mark each.</i>	B2
4(c)	attenuation = $190 \times 14 \times 10^{-3}$ (= 2.66 dB)	C1
	ratio/dB = $(-10 \lg(P_2/P_1))$	C1
	$2.66 = -10 \lg(P_{\text{OUT}}/P_{\text{IN}})$ $P_{\text{OUT}}/P_{\text{IN}} = 0.54$	C1
	fractional loss = $1 - (P_{\text{OUT}}/P_{\text{IN}}) = 1 - 0.54$ $= 0.46$	A1
	or	
	$2.66 = 10 \lg(P_{\text{IN}}/P_{\text{OUT}})$ $P_{\text{IN}}/P_{\text{OUT}} = 1.85$	(C1)
	fractional loss = $(P_{\text{IN}} - P_{\text{OUT}})/P_{\text{IN}} = (1.85 - 1)/1.85$ $= 0.46$	(A1)

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

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

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

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

Question	Answer	Marks			
9(a)	image of one slice/section	(B1)			
	images (of one slice) taken from different angles	(M1)			
	to give 2D image (of one slice)	(A1)			
	(repeated for) many slices	(M1)			
	to build up 3D image (of whole body/structure)	(A1)			
	Max. 4 marks total	4			
9(b)	evidence of subtraction of background (–26)	C1			
	evidence of division by three	C1			
	<table><tr><td>7</td><td>11</td></tr><tr><td>6</td><td>2</td></tr></table>	7	11	6	2
7	11				
6	2				

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Question	Answer	Marks
10(a)	heating depends on current ² / I^2	B1
	and current ² / I^2 is always positive	B1
	or	
	a.c. changes direction (every half cycle)	(B1)
	but heating effect is independent of current direction	(B1)
	or	
	voltage and current are always in phase in a resistor	(B1)
	so $V \times I$ is always positive	(B1)
	or	
	sketch graph drawn showing power against time	(B1)
	comment that power is always positive	(B1)
10(b)(i)	for same power (transmission, higher voltage) → lower current	B1
	lower current → less power loss in (transmission) cables	B1
10(b)(ii)	- voltage can be (easily) stepped up/down - transformers only work with a.c. - generators produce a.c. - easier to rectify than invert <i>Two sensible suggestions, 1 mark each.</i>	B2

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

Question	Answer	Marks
12(a)	• emission from radioactive daughter products • self-absorption in source • absorption in air before reaching detector • detector not sensitive to all radiations • window of detector may absorb some radiation • dead-time of counter • background radiation <i>Any two points.</i>	B2
12(b)(i)	curve is not smooth or curve fluctuates/curve is jagged	B1
12(b)(ii)	clear evidence of allowance for background	B1
	half-life determined at least twice	B1
	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>	A2
12(c)	1. half-life: no change	M1
	because decay is spontaneous/independent of environment	A1
	2. count rate (likely to be or could be) different/is random/cannot be predicted	B1