
PHYSICS

9702/41

Paper 4 A Level Structured Questions

October/November 2017

MARK SCHEME

Maximum Mark: 100

Published

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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)

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)

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

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 border="1"><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				

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

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

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1(a)	<u>force</u> proportional to <u>product</u> of masses and inversely proportional to square of separation	B1
	idea of <u>force</u> between <u>point</u> masses	B1
1(b)	mass of Jupiter (M) = $(4/3)\pi R^3 \rho$	B1
	$\omega = 2\pi/T$ or $v = 2\pi nR/T$	B1
	$(m)\omega^2 x = GM(m)/x^2$ or $(m)v^2/x = GM(m)/x^2$	M1
	substitution and correct algebra leading to $\rho T^2 = 3\pi n^3/G$	A1
1(c)(i)	$n = (4.32 \times 10^5)/(7.15 \times 10^4)$ or $n = 6.04$	C1
	$\rho \times (42.5 \times 3600)^2 = (3\pi \times 6.04^3)/(6.67 \times 10^{-11})$	C1
	$\rho = 1.33 \times 10^3 \text{ kg m}^{-3}$	A1
1(c)(ii)	Jupiter likely to be a gas/liquid (at high pressure) [allow other sensible suggestions]	B1

Question	Answer	Marks
2(a)	(thermal) energy <u>per</u> (unit) mass (to cause change of state)	B1
	(energy required to cause/released in) change of state at constant temperature	B1
2(b)(i)	1. (work done on/against) the <u>atmosphere</u>	B1
	2. <u>water</u> as it turns from liquid to vapour	M1
	as potential energy of <u>molecules</u> increases	A1
	or	
	<u>surroundings</u> as its temperature rises	(M1)
	as energy is lost/transferred to surroundings	(A1)
2(b)(ii)	$VI - h = M/t \times L$ (where h = power loss) or $L = (VI t - Q)/M$ (where Q = energy loss)	C1
	$(14.2 \times 6.4) - (11.5 \times 5.2) = (9.1 - 5.0) \times L/300$ or $L = [(14.2 \times 6.4) - (11.5 \times 5.2)] \times 300 / (9.1 - 5.0)$	C1
	$L = 2300 \text{ J g}^{-1}$	A1

Question	Answer	Marks
3(a)(i)	angle (subtended) where arc (length) is equal to radius	M1
	(angle subtended) at the centre of a circle	A1
3(a)(ii)	angular frequency = $2\pi \times$ frequency or 2π / period	B1
3(b)(i)	c/ML^3 is a constant so acceleration is proportional to displacement	B1
	minus sign shows that acceleration and displacement are in opposite <u>directions</u>	B1
3(b)(ii)	$c/ML^3 = (2\pi f)^2$	C1
	$c = 4\pi^2 \times 3.2^2 \times 0.24 \times 0.65^3$	C1
	$= 27 \text{ kg m}^3 \text{ s}^{-2}$	A1

Question	Answer	Marks
4(a)	quartz/piezo-electric and crystal/transducer	B1
	p.d. across crystal causes it to distort	B1
	applying <u>alternating</u> p.d. causes oscillations/vibrations	B1
	when applied frequency is natural frequency, crystal resonates	B1
	natural frequency of crystal is in ultrasound range	B1
4(b)	small(er) structures can be resolved/observed/identified	B1

Question	Answer							Marks							
5(a)	<table><tr><td>(0.2 ms)</td><td>8.0 (mV)</td><td colspan="5">1000</td></tr></table>							(0.2 ms)	8.0 (mV)	1000					B1
	(0.2 ms)	8.0 (mV)	1000												
<table><tr><td>(0.8 ms)</td><td>5.8 (mV)</td><td colspan="5">0101</td></tr></table>							(0.8 ms)	5.8 (mV)	0101					B1	
(0.8 ms)	5.8 (mV)	0101													
5(b)	series of steps							B1							
	all (step) changes are at 0.2 ms intervals							B1							
	steps with correct levels at correct times (1 mark if five levels correct; 2 marks if all levels correct)							B2							
	<table><tr><td>level</td><td>0</td><td>8</td><td>10</td><td>15</td><td>5</td><td>8</td></tr></table>								level	0	8	10	15	5	8
	level	0	8	10	15	5	8								
<table><tr><td>time /ms</td><td>0–0.2</td><td>0.2–0.4</td><td>0.4–0.6</td><td>0.6–0.8</td><td>0.8–1.0</td><td>1.0–1.2</td></tr></table>							time /ms	0–0.2	0.2–0.4	0.4–0.6	0.6–0.8	0.8–1.0	1.0–1.2		
time /ms	0–0.2	0.2–0.4	0.4–0.6	0.6–0.8	0.8–1.0	1.0–1.2									
5(c)	smaller step heights (possible)							B1							
	smaller changes (in input signal) can be seen/reproduced/represented or (allows) more accurate <u>reproduction</u> (of the input signal)							B1							

Question	Answer	Marks
6(a)	electric field lines are radial/normal to surface (of sphere)	B1
	electric field lines <u>appear</u> to originate from centre (of sphere)	B1
6(b)(i)	tangent drawn at $x = 6.0$ cm and gradient calculation attempted	C1
	$E = 9.0 \times 10^4 \text{ NC}^{-1}$ (1 mark if in range ± 1.2 ; 2 marks if in range ± 0.6)	A2
	or	
	correct pair of values of V and x read from curved part of graph and substituted into $V = q/4\pi\epsilon_0 x$	(C1)
	to give $q = 3.6 \times 10^{-8} \text{ C}$	(C1)
	(then $E = q/4\pi\epsilon_0 x^2$ and $x = 6$ cm gives) $E = 9.0 \times 10^4 \text{ NC}^{-1}$	(A1)
	or	
	($E = q/4\pi\epsilon_0 x^2$ and $V = q/4\pi\epsilon_0 x$ and so) $E = V/x$	(C1)
	giving $E = 5.4 \times 10^3 / 0.060$	(C1)
	$= 9.0 \times 10^4 \text{ NC}^{-1}$	(A1)
6(b)(ii)	($R =$) 2.5 cm	B1
	potential inside a conductor is constant or field strength inside a conductor zero (so gradient is zero)	B1

Question	Answer	Marks
7(a)(i)	(part of) the output is combined with the input	M1
	reference to potential/voltage/signal	A1
7(a)(ii)	- increased (operating) stability - increased bandwidth/range of frequencies over which gain is constant - less distortion (of output) <i>Any 2 points.</i>	B2
7(b)(i)	1. gain = $3.6 / (48 \times 10^{-3})$	C1
	= 75	A1
	2. gain = $1 + R_F / R$ $75 = 1 + (92.5 \times 10^3) / R$	C1
	$R = 1300 \Omega$	A1
7(b)(ii)	for 68 mV, gain $\times V_{IN} = 5.1$ (V) or output voltage would be greater than the supply voltage	M1
	amplifier would saturate (at 5.0 V) or output voltage = 5.0 (V)	A1

Question	Answer	Marks
8(a)(i)	DERQ and CFSP	B1
8(a)(ii)	charge carriers moving normal to (magnetic) field	B1
	<u>charge carriers</u> experience a <u>force</u> normal to I (and B)	B1
	charge build-up sets up electric field across the slice or build-up of charges results in a p.d. across the slice	B1
	charge stops building up/ V_H becomes constant when $F_B = F_E$	B1
8(b)	V_H inversely proportional to n /number density of charge carriers	B1
	number density of charge carriers (n) lower in semiconductors so V_H larger for semiconductor slice	B1
	or	
	V_H proportional to v /drift velocity	(B1)
	(for same current) drift velocity (v) higher in semiconductors so V_H larger for semiconductor slice	(B1)

Question	Answer	Marks
9(a)	region (of space)	B1
	where an object/particle experiences a force	B1
9(b)	electric and magnetic fields normal to each other	B1
	velocity of particle normal to both fields	B1
	forces (on particle) due to fields are in opposite directions	B1
	<u>forces are equal</u> for particles with a particular speed/for a selected speed/for speed given by $v = E(q)/B(q)$	B1
9(c)(i)	path labelled Q shown undeviated	B1
9(c)(ii)	reasonable curve in field and no 'kink' on entering, labelled V	B1
	deviated 'upwards'	B1

Question	Answer	Marks
10(a)	λ_0 marked and graph line passing through $E_{\text{MAX}} = 0$ at $\lambda = \lambda_0$	B1
	graph line with λ always $< \lambda_0$	B1
	negative gradient with correct concave curvature	B1
10(b)	curve with negative gradient and correct concave curvature	M1
	not touching either axis	A1

Question	Answer	Marks
11(a)(i)	circles drawn only around the top left and bottom right diodes	B1
11(a)(ii)	B shown as (+)ve and A shown as (–)ve	B1
11(b)(i)	$V_{\text{r.m.s.}} (= 5.6 / \sqrt{2}) = 4.0 \text{ V}$	A1
11(b)(ii)	$380 = 2\pi f$ or $f = 60.5 \text{ Hz}$	C1
	number ($= 2f$) = 120	A1
11(c)(i)	peak values (all) unchanged	B1
	(all) minima shown at 4.0 V	B1
	three lines from near peak showing concave curves after leaving dotted line not 'kinked' and not cutting the peak reaching <u>candidate's</u> minimum at the point where the decay meets the next dotted line	B1
	three lines drawn along the dotted lines showing rise in voltage from minima back to peak values	B1
11(c)(ii)	<u>mean</u> p.d. is higher or <u>r.m.s.</u> p.d. is higher or capacitor supplies energy <u>to resistor</u>	M1
	so (mean) power increases	A1

Question	Answer	Marks
12(a)(i)	<u>nucleus</u> emits particles/EM radiation/ionising radiation	B1
	emission/release from unstable <u>nucleus</u> or emission from <u>nucleus</u> is random and/or spontaneous	B1
12(a)(ii)	probability of decay (of a nucleus) or fraction of (number of undecayed) nuclei that will decay	M1
	per unit time	A1
12(b)	energy is shared with another particle	B1
	mention of antineutrino	B1
12(c)(i)	number = $[(1.2 \times 10^{-9}) / 131] \times 6.02 \times 10^{23}$ or number = $(1.2 \times 10^{-3} \times 10^{-9}) / (131 \times 1.66 \times 10^{-27})$ (= 5.51×10^{12})	C1
	$A = \lambda N$	C1
	= $[0.086 / (24 \times 3600)] \times 5.51 \times 10^{12}$ = 5.5×10^6 Bq	A1
12(c)(ii)	$1/50 = \exp(-0.086t)$ or $1/50 = 0.5^n$	C1
	$t = 45$ days	A1

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	$95 \times 6 \times 60 = 0.670 \times 910 \times \Delta\theta$	M1
	$\Delta\theta = 56^\circ\text{C}$ so final temperature = $56 + 24 = 80^\circ\text{C}$	A1
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	2. amplitude = 1.5 cm	A1
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	$f = \sqrt{60}/2\pi$ = 1.2 Hz	A1

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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)

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

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 border="1"><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				

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

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