

Question	Answer	Marks
1(a)(i)	region (of space)	B1
	where a particle experiences a force	B1
1(a)(ii)	force per unit mass	B1
1(b)	$g = GM / R^2$	C1
	$= (6.67 \times 10^{-11} \times 6.42 \times 10^{23}) / (3.39 \times 10^6)^2$	C1
	$= 3.73 \text{ N kg}^{-1}$	A1

Question	Answer	Marks
1(c)	$0.99 \times 3.73 = (6.67 \times 10^{-11} \times 6.42 \times 10^{23}) / r^2$	C1
	$r = 3.41 \times 10^6 \text{ (m)}$	C1
	height = $(r - R)$ $= 2 \times 10^4 \text{ m}$	A1
	or	
	$0.99 \times 3.73 = (6.67 \times 10^{-11} \times 6.42 \times 10^{23}) / (R + h)^2$ $(R + h)^2 = 1.1596 \times 10^{13}$	(C1)
	$R + h = 3.41 \times 10^6 \text{ (m)}$	(C1)
	$h = 2 \times 10^4 \text{ m}$	(A1)
	or	
	$0.99 = (3.39 \times 10^6)^2 / r^2$	(C1)
	$r = 3.41 \times 10^6 \text{ (m)}$	(C1)
	height = $2 \times 10^4 \text{ m}$	(A1)

Question	Answer	Marks															
2(a)	+ q : thermal energy transfer to system	B1															
	+ w : work done on system	B1															
2(b)(i)	($W =$) $2.6 \times 10^5 \times (3.8 - 2.3) \times 10^{-3} = 390 \text{ J}$	A1															
2(b)(ii)	no (total) change (in internal energy)	B1															
	gas returns to its original temperature	B1															
2(c)	A to B row all correct (1370, – 390, 980)	B1															
	B to C row all correct (0, 550, 550)	B1															
	C to A row: ΔU adds to the other two ΔU values to give zero	B1															
	C to A row: $w = 0$ and q adds to w to give ΔU value complete correct answer: <table border="1"><thead><tr><th>change</th><th>q / J</th><th>w / J</th><th>$\Delta U / \text{J}$</th></tr></thead><tbody><tr><td>A to B</td><td>(+)1370</td><td>–390</td><td>(+)980</td></tr><tr><td>B to C</td><td>0</td><td>(+)550</td><td>(+)550</td></tr><tr><td>C to A</td><td>–1530</td><td>0</td><td>–1530</td></tr></tbody></table>	change	q / J	w / J	$\Delta U / \text{J}$	A to B	(+)1370	–390	(+)980	B to C	0	(+)550	(+)550	C to A	–1530	0	–1530
change	q / J	w / J	$\Delta U / \text{J}$														
A to B	(+)1370	–390	(+)980														
B to C	0	(+)550	(+)550														
C to A	–1530	0	–1530														

Question	Answer	Marks
3(a)	acceleration (directly) proportional to displacement	B1
	acceleration in opposite <u>direction</u> to displacement or acceleration (directed) towards equilibrium position	B1
3(b)	$v = \omega(x_0^2 - x^2)^{1/2}$ and $\omega = 2\pi f$ or $v_0 = x_0 \omega$ and $\omega = 2\pi f$	C1
	substitution of any correct point from graph, e.g. for $x = 0$: $0.25 = 2\pi f \times 8.8 \times 10^{-2}$	C1
	$f = 0.45 \text{ Hz}$	A1
3(c)	$1 / 0.45 = 2\pi \times (L / 9.81)^{1/2}$	C1
	$L = 1.2 \text{ m}$	A1
3(d)	ellipse about the origin with same intercepts on x-axis	B1
	ellipse about the origin crossing v-axis inside original loop	B1

Question	Answer	Marks
4(a)	quartz crystal	B1
	alternating p.d. across crystal causes it to vibrate	B1
	resonance occurs when frequency of p.d. matches natural frequency of crystal	B1
	natural frequency of crystal is in ultrasound range	B1
4(b)	$I = I_0 e^{-\mu x}$	C1
	$I / I_0 = e^{-1.2 \times 3.5}$ $= 0.015$	C1
	ratio / dB = $-10 \lg (1 / 0.015)$ or $10 \lg (0.015)$	C1
	$= -18 \text{ dB}$	A1

Question	Answer	Marks
5(a)	work done per unit charge	B1
	(work done on charge) moving positive charge from infinity	B1
5(b)(i)	$(2.0 \times 10^{-9}) / 4\pi\epsilon_0(4.0 \times 10^{-2}) + Q / 4\pi\epsilon_0(8.0 \times 10^{-2}) = 0$	C1
	$Q = 4.0 \times 10^{-9} \text{ C}$	A1
	Q given with negative sign	B1
5(b)(ii)	change = 1200 V	A1
5(c)	$\frac{1}{2}mv^2 = qV$	C1
	$\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 = 2 \times 1.60 \times 10^{-19} \times 1200$	C1
	$v = 3.4 \times 10^5 \text{ m s}^{-1}$	A1

Question	Answer	Marks
6(a)(i)	charge per unit potential (difference)	M1
	charge on one plate <u>and</u> potential difference across the plates	A1
6(a)(ii)	any three points from: <ul style="list-style-type: none"> • smoothing • timing/(time) delay • tuning • oscillator • blocking d.c. • surge protection • temporary power supply 	B3
6(b)	(capacitors in series have combined capacitance =) $8\ \mu\text{F}$	C1
	capacitance = $8 + 24$ = $32\ \mu\text{F}$	A1

Question	Answer	Marks
7(a)	two resistors connected in series between earth and positive of battery and no extra connections	B1
	one resistor and thermistor connected in series between earth and positive of battery and no extra connections	B1
	midpoints of the two potential dividers connected, one each, to the op-amp input terminals	B1
	thermistor in correct place in potential divider circuit (either the upper part of the potential divider leading to V^+ or the lower part of the potential divider leading to V^-)	B1
7(b)(i)	value greater than $1000\ \Omega$	A1
7(b)(ii)	non-zero value less than $1000\ \Omega$	A1

Question	Answer	Marks
8(a)(i)	downwards	B1
8(a)(ii)	PQRS and JKLM	B1
8(b)	(as charge separates) an electric field is created (between opposite faces)	B1
	(maximum value is reached when) electric force (on electron) is equal and opposite to magnetic force (on electron)	B1
8(c)	$V_H = BI / ntq$ $= (4.6 \times 10^{-3} \times 6.3 \times 10^{-4}) / (1.3 \times 10^{29} \times 0.10 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1
	$= 1.4 \times 10^{-12} \text{ V}$	A1
8(d)	semiconductors have a (much) smaller value for n	B1
	V_H for semiconductors is (much) larger so more easily measured	B1

Question	Answer	Marks
9(a)	flux density \times area	M1
	where flux is normal to area	A1
	or	
	flux density \times area $\times \sin \theta$	(M1)
	where θ is angle between flux direction and (plane of) area	(A1)
9(b)(i)	(alternating) current creates changing (magnetic) flux	B1
	core links (magnetic) flux with secondary coil	B1
	changing flux (in secondary) causes induced e.m.f.	B1
9(b)(ii)	rate of change of flux is not constant	B1
	(induced) e.m.f. is proportional to rate of change of flux	B1
9(c)	reduces induced currents in core	B1
	hence reduces energy losses (in core)	B1

Question	Answer	Marks
10(a)	X-rays are used	B1
	section (of object) is scanned	B1
	scans/images taken at many angles/directions or images of each section are 2-dimensional	B1
	(images of (many)) sections are combined	B1
	(to give) 3-dimensional image of (whole) structure	B1
10(b)	<p>K = 6 L = 7 M = 2 N = 9</p> <p>3 marks: all four correct 2 marks: three correct and one incorrect or all correct with two numbers transposed 1 mark: two correct and two incorrect</p>	B3

Question	Answer	Marks
11(a)(i)	quantum of energy	M1
	of electromagnetic radiation	A1
11(a)(ii)	arrow (on Fig. 11.1) pointing upwards and to the right	B1
11(b)(i)	$\lambda = h / p$	C1
	$p = (6.63 \times 10^{-34}) / (544 \times 10^{-9})$	A1
	$= 1.22 \times 10^{-27} \text{ N s}$	
11(b)(ii)	energy = hc / λ	C1
	$= 6.63 \times 10^{-34} \times 3.00 \times 10^8 \times (540^{-1} - 544^{-1}) \times 10^9$	A1
	$= 2.7 \times 10^{-21} \text{ J}$	
11(c)	(smaller wavelength corresponds to) greater photon energy	B1
	any one point from: <ul style="list-style-type: none"> • (deflected) photon loses energy (so not possible) • (deflected) photon would need to gain energy (so not possible) • electron would need to lose energy (so not possible) • initially electron energy is zero (so not possible) 	B1

Question	Answer	Marks
12(a)(i)	unstable nucleus	B1
	emits ionising radiation or decays spontaneously	B1
12(a)(ii)	probability of decay (of a nucleus)	M1
	per unit time	A1
12(b)	$A = \lambda N$	C1
	$560 = 9.9 \times 10^{-7} \times N$	A1
	$N = 5.7 \times 10^8$	
12(c)	$A = A_0 e^{-\lambda t}$	C1
	$170 = 560 \exp(-9.9 \times 10^{-7} \times t)$	
	$t = 1.2 \times 10^6 \text{ s}$	C1
	= 14 days	A1