
PHYSICS

9702/41

Paper 4 A Level Structured Questions

October/November 2018

MARK SCHEME

Maximum Mark: 100

Published

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This document consists of **12** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

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- marks are not deducted for omissions
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GENERIC MARKING PRINCIPLE 4:

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Question	Answer	Marks
1(a)(i)	work done per unit mass	B1
	work done moving mass from infinity (to the point)	B1
1(a)(ii)	(near Earth's surface change in) height $\ll$ radius or height <u>much</u> less than radius	B1
	potential inversely proportional to radius and radius approximately constant (so potential approximately constant)	B1
1(b)	initial kinetic energy = (–) potential energy (at surface) or $\frac{1}{2}mv^2 = GMm/r$	B1
	$v^2 = (2 \times 6.67 \times 10^{-11} \times 7.4 \times 10^{22}) / (0.5 \times 3.5 \times 10^6)$	C1
	$v = 2.4 \times 10^3 \text{ ms}^{-1}$	A1

Question	Answer	Marks
2(a)	sum of potential and kinetic energies (of molecules/atoms/particles)	B1
	(energy of) molecules/atoms/particles in random motion	B1
2(b)(i)	final temperature = initial temperature	B1
	no change in internal energy	B1
2(b)(ii)	1. work done on gas (P→Q): 0	A1
	increase in internal energy (P→Q): (+)97.0 J	A1
	2. increase in internal energy (Q→R): –42.5 J	A1
	3. increase in internal energy (R→P): –54.5 J	A1
	thermal energy supplied (R→P): –91.5 J	A1

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Question	Answer	Marks
3(a)	$\omega^2 = 2g / L$	C1
	$T = 2\pi / \omega$	C1
	$\omega^2 = (2 \times 9.81) / 0.19$	A1
	$\omega = 10.2 \text{ (rad s}^{-1}\text{)}$	
	$T = 2\pi / 10.2$	
	$= 0.62 \text{ s}$	
3(b)(i)	e.g. viscosity of liquid/friction within the liquid/viscous drag/friction between walls of tube and liquid	B1
3(b)(ii)	(maximum) $\text{KE} = \frac{1}{2}mv_0^2$ and $v_0 = \omega x_0$ or energy = $\frac{1}{2}m\omega^2 x_0^2$	C1
	change = $\frac{1}{2} \times 18 \times 10^{-3} \times 103 \times [(2.0 \times 10^{-2})^2 - (0.95 \times 10^{-2})^2]$	C1
	$= 2.9 \times 10^{-4} \text{ J}$	A1

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Question	Answer	Marks
4(a)	pulses (of ultrasound from generator)	B1
	reflected at boundaries (between media)	B1
	time delay (between transmission and receipt) gives information about depth	B1
	intensity of reflected pulse gives information about nature (of tissues)/type (of tissues)/boundary	B1
	Any two from: • (reflected pulses) detected by the (ultrasound) generator • gel used to minimise reflection at skin/maximise transmission into skin • degree of reflection depends upon impedances of two media (at boundary)	B2
4(b)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
4(b)(ii)	Z_1 about equal to Z_2 results in negligible/no reflection	B1
	$Z_1 \gg Z_2$ (or $Z_1 \ll Z_2$) results in mostly reflection	B1

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Question	Answer	Marks
5(a)	Any two reasonable suggestions e.g.: - noise can be eliminated/(signal/data) can be regenerated - bits can be added to correct for errors - data compression/multiplexing (is possible) - signal can be encrypted/better security	B2
5(b)	sketch: series of seven steps	B1
	each step width 2 ms	B1
	correct levels in correct order (2, 5, 14, 4, 9, 11, 7) <i>(1 mark for 6 levels correct, 2 marks for 7 levels correct)</i>	A2
5(c)(i)	step width reduced or higher frequencies can be reproduced	B1
5(c)(ii)	step height reduced or smaller <u>changes</u> in signal (intensity) can be reproduced	B1

Question	Answer	Marks
6(a)(i)	work done per unit charge	B1
	work done moving positive charge from infinity (to the point)	B1
6(a)(ii)	field strength = potential gradient	M1
	‘–’ sign included or directions discussed	A1
6(b)(i)	gain in kinetic energy (= loss in potential energy) = charge $\times$ p.d. or $qV = \frac{1}{2}mv^2$	M1
	so v is independent of separation (because separation not in expressions)	A1

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Question	Answer	Marks
6(b)(ii)	(at $x = 0.40\text{ cm}$), potential = $(-) 75 \times 0.40 / 1.2$ (= $(-) 25\text{ V}$)	C1
	$\frac{1}{2}mv^2 = qV$ $\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 = 2 \times 1.60 \times 10^{-19} \times 25$	C1
	or	
	$a = Vq/dm$ and $v^2 = 2as$	(C1)
	$v^2 = (2 \times 75 \times 2 \times 1.60 \times 10^{-19} \times 0.40 \times 10^{-2}) / (1.2 \times 10^{-2} \times 4 \times 1.66 \times 10^{-27})$	(C1)
	$v = 4.9 \times 10^4\text{ ms}^{-1}$	A1

Question	Answer	Marks
7(a)(i)	gain is constant	M1
	for all frequencies	A1
7(a)(ii)	no time delay between input (voltage) and output (voltage)	B1
	clear reference to <u>change</u> (s) in input and/or output (voltages)	B1
7(b)	diagram: V_{IN} connected to V^+ only	B1
	midpoint between resistors R_1 and R_2 connected to V^- only	B1
7(c)(i)	-3.6 V	A1
7(c)(ii)	$(+)5.0\text{ V}$	A1

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Question	Answer	Marks
8(a)	region where there is a force	M1
	experienced by a current-carrying conductor/moving charge/(permanent) magnet	A1
8(b)(i)	single path, deflection in 'upward' direction	B1
	acceptable circular arc in whole field	B1
	no 'kinks' at start or end of curvature, and straight outside region of field	B1
8(b)(ii)	force (on particle) is normal to velocity/direction of motion/direction of speed	B1
8(c)	magnetic force provides/is the centripetal force	B1
	$Bqv = mv^2/r$ or $r = mv/Bq$	C1
	(if q is doubled), new speed = $2v$	A1

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Question	Answer	Marks
9(a)	(induced) e.m.f. proportional/equal to <u>rate</u>	M1
	of change of (magnetic) flux (linkage)	A1
9(b)(i)	induced e.m.f. = $(\Delta B)AN/\Delta t$ = $(2 \times 0.19 \times 1.5 \times 10^{-4} \times 120)/0.13$	C1
	= 0.053 V	A1
9(b)(ii)	reading on voltmeter connected to coil C/V: 0 0.053 0 (all three values required)	A1
	reading on voltmeter connected to Hall probe/V: zero in middle column	B1
	final column correct sign (negative)	B1
	final column correct magnitude (0.20)	B1

Question	Answer	Marks
10	Any five points from: • as temperature rises electrons gain energy • electrons enter conduction band • (positively charged) holes left in valence band • more charge carriers (so resistance decreases) • (as temperature rises,) lattice vibrations increase • effect of increase in number of electrons or holes or charge carriers outweighs effect of increased lattice vibrations (so resistance decreases)	B5

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Question	Answer	Marks
11(a)	discrete amount/quantum/packet of <u>energy</u>	M1
	of electromagnetic radiation	A1
11(b)(i)	energy = hc/λ	C1
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^8)/(0.51 \times 10^6 \times 1.60 \times 10^{-19})$ $= 2.4 \times 10^{-12} \text{ m}$	A1
11(b)(ii)	$p = h/\lambda$ $= (6.63 \times 10^{-34})/(2.44 \times 10^{-12})$ or $p = E/c$ $= (0.51 \times 1.60 \times 10^{-13})/(3.00 \times 10^8)$	C1
	$p = 2.7 \times 10^{-22} \text{ N s}$	A1
11(c)(i)	$E = c^2 \Delta m$	C1
	$\Delta m = (0.51 \times 1.60 \times 10^{-13})/(3.00 \times 10^8)^2$ $= 9.1 \times 10^{-31} \text{ kg}$	A1
11(c)(ii)	(momentum is conserved so) nucleus must have momentum in opposite direction to photon	B1

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Question	Answer	Marks
12(a)	unstable nucleus	B1
	emission of particles/photons	B1
	emission is spontaneous or (particles/radiation) are ionising	B1
12(b)(i)	tangent drawn and gradient calculation attempted	B1
	activity = 1.3×10^6 Bq (1 mark for answer within $\pm 0.2 \times 10^6$ Bq, 2 marks for answer within $\pm 0.1 \times 10^6$ Bq)	A2
12(b)(ii)	$A = \lambda N$	C1
	$\lambda = (1.3 \times 10^6) / (3.05 \times 10^{10}) = 4.3 \times 10^{-5} \text{ s}^{-1}$ ($\approx 4 \times 10^{-5} \text{ s}^{-1}$)	A1
12(c)	$A = A_0 e^{-\lambda t}$ $1.0 \times 10^3 = 4.6 \times 10^3 \exp(-5.5 \times 10^{-7} \times t)$	C1
	$\ln(4.6) = 5.5 \times 10^{-7} \times t$	C1
	$t = 2.78 \times 10^6 \text{ s}$ $= 32 \text{ days}$	A1

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Question	Answer	Marks
1(a)(i)	force per unit mass	B1
1(a)(ii)	acceleration = F/m , field strength = F/m , so equal	B1
1(b)	smooth curve between R and $4R$ with negative gradient of decreasing magnitude	B1
	line passing through $(R, 1.00g)$ and $(2R, 0.25g)$	B1
	line ending at $(4R, 0.0625g)$	B1
1(c)	$M = (4/3 \times \pi R^3)\rho$	C1
	$g = GM/(2R)^2$	C1
	$g = \frac{1}{3} \times 6.67 \times 10^{-11} \times \pi \times 3.4 \times 10^6 \times 4.0 \times 10^3$ $= 0.95 \text{ ms}^{-2}$	A1

Question	Answer	Marks
2(a)	gas that obeys equation $pV = \text{constant} \times T$	M1
	symbols p , V and T explained	A1
2(b)(i)	$pV = \frac{1}{3} Nm\langle c^2 \rangle$ and $M = Nm$ (and so) $p = \frac{1}{3}\rho\langle c^2 \rangle$	C1
	$2.12 \times 10^7 = \frac{1}{3} \times [3.20 / (1.84 \times 10^{-2})] \times \langle c^2 \rangle$	C1
	$c_{\text{r.m.s.}} = 605 \text{ m s}^{-1}$	A1
2(b)(ii)	1. $pV = nRT$ and $T = (22 + 273)\text{K}$	C1
	$n = (2.12 \times 10^7 \times 1.84 \times 10^{-2}) / (8.31 \times 295)$ $= 159 \text{ mol}$	A1
	2. mass = $3.20 / (159 \times 6.02 \times 10^{23})$ or mass = $[2 \times (3/2) \times 1.38 \times 10^{-23} \times 295] / 605^2$	C1
	mass = $3.34 \times 10^{-26} \text{ kg}$	A1
2(c)	$A = (3.34 \times 10^{-26}) / (1.66 \times 10^{-27})$ $= 20$	A1

Question	Answer	Marks
3(a)	(thermal) energy per unit mass (to cause change of state)	B1
	(energy transfer during) change of state between solid and liquid at constant temperature	B1
3(b)(i)	Any one from: • rate of increase in mass (of beaker and water) is constant • level of water rises at a constant rate • volume of water (in beaker) increases at a constant rate • constant time between drops • constant rate of dripping	B1
3(b)(ii)	(electrical power supplied =) 12.8×4.60 (= 58.9 W)	C1
	(rate of transfer to ice =) $[(185.0 - 121.5) \times 332] / [5.00 \times 60]$ (= 70.3 W)	C1
	1. rate = 70.3 W	A1
	2. rate = 70.3 – 58.9 = 11.4 W	A1

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Question	Answer	Marks
4(a)	(defining equation of s.h.m. is) $a = -kx$ where k is a constant or $a \propto -x$	B1
	g and L are constant (so $a \propto -x$ and hence s.h.m.)	B1
4(b)	$T = 0.50\text{ s}$ and $T = 2\pi/\omega$	C1
	$\omega^2 = 2g/L$	C1
	$L = (2 \times 9.81 \times 0.50^2)/4\pi^2$ $= 0.12\text{ m}$	A1
4(c)(i)	Any one from: - viscosity of liquid - friction within the liquid - viscous drag - friction/resistance between walls of tube and liquid	B1
4(c)(ii)	(maximum) $\text{KE} = \frac{1}{2}mv_0^2$ and $v_0 = \omega x_0$ or energy = $\frac{1}{2}m\omega^2 x_0^2$	C1
	ratio = $(1.3/2.0)^2$ $= 0.42$	A1

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Question	Answer	Marks
5(a)	amplitude of carrier (wave) varies	B1
	variation in synchrony with displacement of information signal	B1
5(b)(i)	wavelength = $(3.0 \times 10^8)/(900 \times 10^3)$ = 3.3×10^2 m	A1
5(b)(ii)	amplitude varies (continuously) between a maximum and a minimum	B1
	variations repeat 5000 times each second or variations repeat every 0.2 ms or variations above and below 4.0 V	B1
5(b)(iii)	10000 Hz	A1
5(c)(i)	Any two from: • (orbit is) above the Equator • (orbit is) from west to east/same direction as Earth's rotation • orbit is circular/orbit has a particular radius	B2
5(c)(ii)	1. minimal reflection/absorption/attenuation by <u>atmosphere</u> or maximum penetration of/transmission through <u>atmosphere</u>	B1
	2. uplink signal is greatly attenuated/must be greatly amplified	B1
	prevents downlink signal swamping the uplink signal	B1

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Question	Answer	Marks
6(a)(i)	work done per unit charge	B1
	work done moving positive charge from infinity (to the point)	B1
6(a)(ii)	field strength = potential gradient	M1
	negative sign included or directions discussed	A1
6(b)	horizontal straight lines, at non-zero potential, within the spheres	B1
	magnitude of potential greater at surface of sphere A than at surface of sphere B	B1
	concave curve between A and B, with a minimum nearer to B	B1
	lines show V <u>positive</u> all the way from 0 to D	B1

Question	Answer	Marks
7(a)	$R/R_T = 2.4/1.8$ or at 4.0°C , $R_T = 3.2\text{ k}\Omega$	C1
	hence $R/3.2 = 2.4/1.8$ $R = 4.3\text{ k}\Omega$	A1
7(b)	$R_T = 3.37\text{ k}\Omega$ or R_T is greater (than $3.2\text{ k}\Omega$)	B1
	$V^+ > V^-$	M1
	hence output is $+5.0\text{ V}$	A1

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Question	Answer	Marks
7(c)	correct LED symbol	B1
	two diodes shown connected, in parallel and with opposite polarities, between V_{OUT} and earth	M1
	diodes labelled to show correct polarities consistent with (b) (G pointing from V_{OUT} to earth and B pointing from earth to V_{OUT} if (b) correct)	A1

Question	Answer	Marks
8(a)	force per unit current	B1
	force per unit length (of wire)	B1
	current normal to (magnetic) field	B1
8(b)(i)	forces (on PQ and RS) are horizontal	B1
	(hence they create) no moment about the pivot	B1
	or	
	forces (on PQ and RS) are equal and opposite	(B1)
	(hence there is) no <u>net</u> force (on the two sections)	(B1)
8(b)(ii)	realisation of the need to apply moments	C1
	$BILx = mgy$	C1
	$B \times 2.7 \times 1.2 \times 10^{-2} \times 7.5 = 45 \times 10^{-6} \times 9.81 \times 8.8$	
	$B = 1.6 \times 10^{-2} \text{ T}$	A1

Question	Answer	Marks
9(a)	$0 \rightarrow t_1$ horizontal straight line at non-zero value of V_H and $t_3 \rightarrow t_4$ horizontal straight line at different non-zero V_H	B1
	$t_1 \rightarrow t_3$ straight diagonal line with negative gradient and graph line starts at $(0, V_0)$ and ends at $(t_4, -2V_0)$	B1
9(b)	$E = 0$ for $0 \rightarrow t_1$ and $t_3 \rightarrow t_4$	B1
	E is non-zero at all points between $t_1 \rightarrow t_3$	M1
	E has constant magnitude between $t_1 \rightarrow t_3$	A1

Question	Answer	Marks
10(a)	$V_0 = \sqrt{2} \times V_{\text{r.m.s.}} = \sqrt{2} \times 9.9 (= 14 \text{ V})$ and $\omega = 2\pi f = 2\pi \times 50 (= 314 \text{ rad s}^{-1})$	C1
	$V = 14 \sin 314t$	A1
10(b)	enables (resonating) nuclei to be located	B1
	resonant frequency depends on magnetic field strength	B1
	Any one from: • non-uniform field is (accurately) calibrated • (non-uniform) field may be varied to enable detection in different positions • unique (magnetic) field strength/frequency at each point	B1
10(c)	$I = I_0 \exp(-\mu x)$	C1
	$I = I_0 [\exp(-\mu x)_{\text{bone}} \times \exp(-\mu x)_{\text{soft tissue}}]$	C1
	$I = I_0 [\exp(-2.9 \times 0.40) \times \exp(-0.92 \times 1.4)]$	
	$I/I_0 = 0.0865$	C1
	ratio/dB = $10 \lg 0.0865$ = -11 dB	A1

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Question	Answer	Marks
11(a)	discrete amount/quantum/packet of <u>energy</u>	M1
	of electromagnetic radiation	A1
11(b)	mostly dark/dark background	B1
	coloured lines	B1
11(c)(i)	6	A1
11(c)(ii)	1. maximum photon energy = $13.6 - 0.85$ $(= 12.75 \text{ eV})$	C1
	maximum kinetic energy = $(13.6 - 0.85) - 5.6$ $= 7.2 \text{ eV}$	A1
	2. energy = hc / λ	C1
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^8) / [(13.6 - 0.85) \times 1.60 \times 10^{-19}]$	C1
	$= 9.8 \times 10^{-8} \text{ m}$	A1

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Question	Answer	Marks
12(a)	fusion: two nuclei <u>combine</u> to form a (single) nucleus	B1
	fission: a (single) large nucleus <u>divides</u> to form (smaller) nuclei	B1
	Any one from: • fusion is initiated by (very) high temperatures • fission is initiated by neutron bombardment • resulting nuclei in fission are of similar size • (both processes) release energy • binding energy per nucleon increases • total binding energy increases • fission involves release of neutrons	B1
12(b)(i)	neutron	B1
12(b)(ii)	1. zero	A1
	2. $(4 \times 11.3290 \times 10^{-13}) - (2 \times 1.7813 \times 10^{-13}) - (3 \times 4.5285 \times 10^{-13})$	C1
	energy change = $45.316 \times 10^{-13} - 17.148 \times 10^{-13}$ $= 2.82 \times 10^{-12} \text{ J}$	A1
12(b)(iii)	1.0 mol or N_A nuclei of each energy = $2.817 \times 10^{-12} \times 6.02 \times 10^{23}$ $= 1.7 \times 10^{12} \text{ J}$	A1

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	potential inversely proportional to radius and radius approximately constant (so potential approximately constant)	B1
1(b)	initial kinetic energy = (–) potential energy (at surface) or $\frac{1}{2}mv^2 = GMm/r$	B1
	$v^2 = (2 \times 6.67 \times 10^{-11} \times 7.4 \times 10^{22}) / (0.5 \times 3.5 \times 10^6)$	C1
	$v = 2.4 \times 10^3 \text{ ms}^{-1}$	A1

Question	Answer	Marks
2(a)	sum of potential and kinetic energies (of molecules/atoms/particles)	B1
	(energy of) molecules/atoms/particles in random motion	B1
2(b)(i)	final temperature = initial temperature	B1
	no change in internal energy	B1
2(b)(ii)	1. work done on gas (P→Q): 0	A1
	increase in internal energy (P→Q): (+)97.0 J	A1
	2. increase in internal energy (Q→R): –42.5 J	A1
	3. increase in internal energy (R→P): –54.5 J	A1
	thermal energy supplied (R→P): –91.5 J	A1

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Question	Answer	Marks
3(a)	$\omega^2 = 2g / L$	C1
	$T = 2\pi / \omega$	C1
	$\omega^2 = (2 \times 9.81) / 0.19$	A1
	$\omega = 10.2 \text{ (rad s}^{-1}\text{)}$	
	$T = 2\pi / 10.2$	
	$= 0.62 \text{ s}$	
3(b)(i)	e.g. viscosity of liquid/friction within the liquid/viscous drag/friction between walls of tube and liquid	B1
3(b)(ii)	(maximum) $\text{KE} = \frac{1}{2}mv_0^2$ and $v_0 = \omega x_0$ or energy = $\frac{1}{2}m\omega^2 x_0^2$	C1
	change = $\frac{1}{2} \times 18 \times 10^{-3} \times 103 \times [(2.0 \times 10^{-2})^2 - (0.95 \times 10^{-2})^2]$	C1
	$= 2.9 \times 10^{-4} \text{ J}$	A1

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Question	Answer	Marks
4(a)	pulses (of ultrasound from generator)	B1
	reflected at boundaries (between media)	B1
	time delay (between transmission and receipt) gives information about depth	B1
	intensity of reflected pulse gives information about nature (of tissues)/type (of tissues)/boundary	B1
	Any two from: • (reflected pulses) detected by the (ultrasound) generator • gel used to minimise reflection at skin/maximise transmission into skin • degree of reflection depends upon impedances of two media (at boundary)	B2
4(b)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
4(b)(ii)	Z_1 about equal to Z_2 results in negligible/no reflection	B1
	$Z_1 \gg Z_2$ (or $Z_1 \ll Z_2$) results in mostly reflection	B1

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Question	Answer	Marks
5(a)	Any two reasonable suggestions e.g.: • noise can be eliminated/(signal/data) can be regenerated • bits can be added to correct for errors • data compression/multiplexing (is possible) • signal can be encrypted/better security	B2
5(b)	sketch: series of seven steps	B1
	each step width 2 ms	B1
	correct levels in correct order (2, 5, 14, 4, 9, 11, 7) <i>(1 mark for 6 levels correct, 2 marks for 7 levels correct)</i>	A2
5(c)(i)	step width reduced or higher frequencies can be reproduced	B1
5(c)(ii)	step height reduced or smaller <u>changes</u> in signal (intensity) can be reproduced	B1

Question	Answer	Marks
6(a)(i)	work done per unit charge	B1
	work done moving positive charge from infinity (to the point)	B1
6(a)(ii)	field strength = potential gradient	M1
	‘–’ sign included or directions discussed	A1
6(b)(i)	gain in kinetic energy (= loss in potential energy) = charge $\times$ p.d. or $qV = \frac{1}{2}mv^2$	M1
	so v is independent of separation (because separation not in expressions)	A1

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Question	Answer	Marks
6(b)(ii)	(at $x = 0.40\text{ cm}$), potential = $(-) 75 \times 0.40 / 1.2$ (= $(-) 25\text{ V}$)	C1
	$\frac{1}{2}mv^2 = qV$ $\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times v^2 = 2 \times 1.60 \times 10^{-19} \times 25$	C1
	or	
	$a = Vq/dm$ and $v^2 = 2as$	(C1)
	$v^2 = (2 \times 75 \times 2 \times 1.60 \times 10^{-19} \times 0.40 \times 10^{-2}) / (1.2 \times 10^{-2} \times 4 \times 1.66 \times 10^{-27})$	(C1)
	$v = 4.9 \times 10^4\text{ ms}^{-1}$	A1

Question	Answer	Marks
7(a)(i)	gain is constant	M1
	for all frequencies	A1
7(a)(ii)	no time delay between input (voltage) and output (voltage)	B1
	clear reference to <u>change</u> (s) in input and/or output (voltages)	B1
7(b)	diagram: V_{IN} connected to V^+ only	B1
	midpoint between resistors R_1 and R_2 connected to V^- only	B1
7(c)(i)	-3.6 V	A1
7(c)(ii)	$(+)5.0\text{ V}$	A1

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Question	Answer	Marks
8(a)	region where there is a force	M1
	experienced by a current-carrying conductor/moving charge/(permanent) magnet	A1
8(b)(i)	single path, deflection in 'upward' direction	B1
	acceptable circular arc in whole field	B1
	no 'kinks' at start or end of curvature, and straight outside region of field	B1
8(b)(ii)	force (on particle) is normal to velocity/direction of motion/direction of speed	B1
8(c)	magnetic force provides/is the centripetal force	B1
	$Bqv = mv^2/r$ or $r = mv/Bq$	C1
	(if q is doubled), new speed = $2v$	A1

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Question	Answer	Marks
9(a)	(induced) e.m.f. proportional/equal to <u>rate</u>	M1
	of change of (magnetic) flux (linkage)	A1
9(b)(i)	induced e.m.f. = $(\Delta B)AN/\Delta t$ = $(2 \times 0.19 \times 1.5 \times 10^{-4} \times 120)/0.13$	C1
	= 0.053 V	A1
9(b)(ii)	reading on voltmeter connected to coil C/V: 0 0.053 0 (all three values required)	A1
	reading on voltmeter connected to Hall probe/V: zero in middle column	B1
	final column correct sign (negative)	B1
	final column correct magnitude (0.20)	B1

Question	Answer	Marks
10	Any five points from: • as temperature rises electrons gain energy • electrons enter conduction band • (positively charged) holes left in valence band • more charge carriers (so resistance decreases) • (as temperature rises,) lattice vibrations increase • effect of increase in number of electrons or holes or charge carriers outweighs effect of increased lattice vibrations (so resistance decreases)	B5

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Question	Answer	Marks
11(a)	discrete amount/quantum/packet of <u>energy</u>	M1
	of electromagnetic radiation	A1
11(b)(i)	energy = hc/λ	C1
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^8)/(0.51 \times 10^6 \times 1.60 \times 10^{-19})$ $= 2.4 \times 10^{-12} \text{ m}$	A1
11(b)(ii)	$p = h/\lambda$ $= (6.63 \times 10^{-34})/(2.44 \times 10^{-12})$ or $p = E/c$ $= (0.51 \times 1.60 \times 10^{-13})/(3.00 \times 10^8)$	C1
	$p = 2.7 \times 10^{-22} \text{ N s}$	A1
11(c)(i)	$E = c^2 \Delta m$	C1
	$\Delta m = (0.51 \times 1.60 \times 10^{-13})/(3.00 \times 10^8)^2$ $= 9.1 \times 10^{-31} \text{ kg}$	A1
11(c)(ii)	(momentum is conserved so) nucleus must have momentum in opposite direction to photon	B1

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Question	Answer	Marks
12(a)	unstable nucleus	B1
	emission of particles/photons	B1
	emission is spontaneous or (particles/radiation) are ionising	B1
12(b)(i)	tangent drawn and gradient calculation attempted	B1
	activity = 1.3×10^6 Bq (1 mark for answer within $\pm 0.2 \times 10^6$ Bq, 2 marks for answer within $\pm 0.1 \times 10^6$ Bq)	A2
12(b)(ii)	$A = \lambda N$	C1
	$\lambda = (1.3 \times 10^6) / (3.05 \times 10^{10}) = 4.3 \times 10^{-5} \text{ s}^{-1}$ ($\approx 4 \times 10^{-5} \text{ s}^{-1}$)	A1
12(c)	$A = A_0 e^{-\lambda t}$ $1.0 \times 10^3 = 4.6 \times 10^3 \exp(-5.5 \times 10^{-7} \times t)$	C1
	$\ln(4.6) = 5.5 \times 10^{-7} \times t$	C1
	$t = 2.78 \times 10^6 \text{ s}$ $= 32 \text{ days}$	A1