

^	Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.
SEEN	Indicates that a page has been seen.

Question	Answer	Marks
1(a)	force acting between two masses or force on mass due to another mass or force on mass in a gravitational field	B1
1(b)	arc length = $r\theta$ $d = 1.5 \times 10^{17} \times 1.2 \times 10^{-5} = 1.8 \times 10^{12} \text{ m}$	A1
1(c)(i)	$\omega = 2\pi / T$	C1
	$= 2\pi / (44.2 \times 365 \times 24 \times 3600)$	A1
	$= 4.5 \times 10^{-9} \text{ rad s}^{-1}$	
1(c)(ii)	gravitational forces are equal or centripetal force about P is the same	C1
	$M_1 x \omega^2 = M_2 (d - x) \omega^2$ so $M_1 / M_2 = (d - x) / x$	A1
1(c)(iii)	$x = 0.4d$	C1
	$6.67 \times 10^{-11} \times M_1 = (1.0 - 0.4) \times (1.8 \times 10^{12})^3 \times (4.5 \times 10^{-9})^2$	C1
	$M_1 = 1.1 \times 10^{30} \text{ kg}$	A1

Question	Answer	Marks
2(a)	total potential energy and kinetic energy (of molecules/atoms)	M1
	reference to <u>random</u> motion of molecules/atoms	A1
2(b)	(in ideal gas,) no intermolecular forces	B1
	no potential energy (so change in kinetic energy is change in internal energy)	B1
2(c)	(random) potential energy of molecules does not change	M1
	(random) kinetic energy of molecules does not change	M1
	so internal energy does not change	A1
	or	
	decrease in total potential energy = gain in total kinetic energy	(M1)
	no external energy supplied	(M1)
	so internal energy does not change	(A1)
	or	
	no compression (of ball) so no work done on the ball	(M1)
	no resistive forces so no heating of the ball	(M1)
	so internal energy does not change	(A1)

Question	Answer	Marks
2(c)	or	
	no change of state so potential energy (of molecules) unchanged	(M1)
	no temperature rise so kinetic energy (of molecules) unchanged	(M1)
	so internal energy does not change	(A1)

Question	Answer	Marks
3(a)(i)	amplitude = 4.9 cm	A1
3(a)(ii)	frequency = $2700 / 60$ = 45 Hz	A1
3(a)(iii)	$v_0 = x_0 \omega$ and $\omega = 2\pi f$	C1
	$v_0 = 4.9 \times 10^{-2} \times 2\pi \times 45$ = 14 m s^{-1}	A1
3(a)(iv)	$v = \omega (x_0^2 - x^2)^{1/2}$ = $2\pi \times 45 \times [(4.9 \times 10^{-2})^2 - (2.6 \times 10^{-2})^2]^{1/2}$	C1
	= 12 m s^{-1}	A1

Question	Answer	Marks
3(b)	$F = ma$ and $a_0 = v_0 \omega$ or $a_0 = x_0 \omega^2$	C1
	$F = 0.64 \times 13.9 \times 2\pi \times 45$ or $0.64 \times 4.9 \times (2\pi \times 45)^2$	C1
	$= 2500 \text{ N}$	A1

Question	Answer	Marks
4(a)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
4(a)(ii)	the greater the difference between Z_1 and Z_2 , the closer the ratio is to 1 or if difference between Z_1 and Z_2 large, ratio is close to 1	B1
	the closer together Z_1 and Z_2 , the closer the ratio is to 0 or if difference between Z_1 and Z_2 small, ratio close to 0	B1
4(b)(i)	loss of intensity/amplitude/power (of the wave)	B1
4(b)(ii)	$I = I_0 e^{-\mu x}$	C1
	$0.35 = e^{-0.046\mu}$ $\mu = 23 \text{ m}^{-1}$	A1

Question	Answer	Marks
5(a)	similarity: both are radial or both have inverse square (variations)	B1
	difference: direction is always/only towards the mass or direction can be towards or away from charge	B1
5(b)	field strength = $Q / 4\pi\epsilon_0 x^2$	C1
	$E = Q / 36\pi\epsilon_0 R^2$	A1
5(c)(i)	fields (due to each sphere) are in same direction	B1
5(c)(ii)	charges on spheres attract/affect each other or charge distribution on each sphere distorted by the other sphere or charges on the surface of the spheres move	B1
	spheres are not point charges (at their centres)	B1

Question	Answer	Marks
6(a)(i)	greater information carrying capacity	B1
6(a)(ii)	power/energy is radiated	B1
	signal picked up by adjacent fibre/wire	B1
6(b)	ratio / dB = $10 \lg(P_2 / P_1)$	C1
	$13 = 10 \lg [P / (1.0 \times 10^{-3})]$ and so $P = 20 \text{ mW}$	A1
6(c)	$45 \times 0.18 = 10 \lg (20 / P)$	C1
	$P = 3.1 \text{ mW}$	A1

Question	Answer	Marks
7(a)	output signal proportional to input signal	B1
	output signal has same sign/polarity as input signal	B1
7(b)(i)	$\text{gain} = V_{\text{OUT}} / V_{\text{IN}}$ $= 2.6 / 0.084$ $= 31$	A1
7(b)(ii)	$31 = 1 + (15 \times 10^3) / R$	C1
	$R = 500 \Omega$	A1
7(c)(i)	e.g. cathode-ray oscilloscope/CRO	B1
7(c)(ii)	gain is reduced	B1
	(so) V_{OUT} is smaller	B1

Question	Answer	Marks
8(a)	magnetic field normal to current	B1
	newton per ampere	B1
	newton per metre	B1
8(b)(i)	current in wire QL gives rise to a force or wire QL is perpendicular to the magnetic field	B1
	force on wire QL is vertical	B1
	force does not act through the pivot	B1
8(b)(ii)	forces act through the same line or forces are horizontal	B1
	forces are equal (in magnitude) and opposite (in direction)	B1
8(c)(i)	change = $mg \times (\Delta)L$	C1
	$= 1.3 \times 10^{-4} \times 9.81 \times 2.6 \times 10^{-2} = 3.3 \times 10^{-5} \text{ N m}^{-1}$	A1
8(c)(ii)	change = $B \times (\Delta)I \times L \times x$	C1
	$3.3 \times 10^{-5} = B \times 1.2 \times 0.85 \times 10^{-2} \times 5.6 \times 10^{-2}$	C1
	$B = 0.058 \text{ T}$	A1

Question	Answer	Marks
9(a)(i)	e.m.f. = $(\Delta)B \times AN / t$	C1
	$= 45 \times 10^{-3} \times \pi \times (1.8 \times 10^{-2})^2 \times 350 / 0.20 = 0.080 \text{ V}$	A1
9(a)(ii)	0 to 0.2 s: straight horizontal line at 0.080 V or –0.080 V	B1
	0.2 s to 0.4 s: zero	B1
	0.4 s to 0.8 s: straight horizontal line at 0.040 V or –0.040 V	B1
	opposite polarity to 0 to 0.2 s line	B1
9(b)	either disc cuts flux lines (of the magnet) or there is a changing flux in the disc	B1
	(by Faraday's law) e.m.f. is induced in the disc	B1
	e.m.f. causes (eddy) currents in the disc	B1
	current in the magnetic field (of the magnet) causes force on disc	B1

Question	Answer	Marks
10(a)	• photon gives energy to electron (in an inner shell) or electron (in an inner shell) absorbs a photon • electron moves (from lower) to higher energy level • energy (of photon) is equal to difference in energy levels • electron de-excites giving off photon (of same energy) • photons emitted in all directions <i>Any four points, 1 mark each</i>	B4
10(b)	(in light) photons gives energy to electrons in VB or (in light) electrons in VB absorb photons	B1
	electron crosses FB/jumps to CB	B1
	(positive) holes left/created in VB	B1
	low intensity: few electrons in CB/most electrons in VB or high intensity: more photons so more electrons in CB or electron-hole pairs are charge carriers	B1
	more charge carriers results in lower resistance	B1

Question	Answer	Marks
11(a)(i)	$E = mc^2$	C1
	$= 9.11 \times 10^{-31} \times (3.0 \times 10^8)^2$	A1
	$= 8.2 \times 10^{-14} \text{ J}$	
11(a)(ii)	$p = h / \lambda$ and $E = hc / \lambda$ or $E = pc$	C1
	$p = (8.2 \times 10^{-14}) / (3.0 \times 10^8)$ $= 2.7 \times 10^{-22} \text{ N s}$	A1
11(b)	total momentum (before and after interaction) is zero or momentum must be conserved (in the interaction) or momentum of the photons must be equal and opposite	B1
	(photons emitted in) opposite directions	B1

Question	Answer	Marks
12(a)(i)	time at which a nucleus will decay cannot be predicted or constant probability of decay of a nucleus	B1
12(a)(ii)	decay (of a nucleus) not affected by environmental factors	B1
12(b)	$A = A_0 e^{-\lambda t}$ and $\lambda = \ln 2 / t_{1/2}$	C1
	$= 3.6 \times 10^5 \times \exp [-(2 \times \ln 2) / 1.4]$	C1
	or	
	$A = A_0 \times 0.5^N$	(C1)
	$= 3.6 \times 10^5 \times 0.5^N$ where $N = 2 / 1.4$	(C1)
	$A = 1.3 \times 10^5$ Bq	A1
12(c)(i)	smooth curve, starting at $(0, 3.6 \times 10^5)$ and passing through $(1.4, 1.8 \times 10^5)$ and $(2.0, 1.3 \times 10^5)$	B1
12(c)(ii)	(activity of sample is greater than activity of X so) there must be an additional source of activity	C1
	the decay product (of isotope X) is radioactive	A1