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MARK SCHEME

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Question	Answer	Marks
1(a)	force per unit mass	B1
1(b)(i)	$g = GM/r^2$ $= (6.67 \times 10^{-11} \times 1.0 \times 10^{13}) / (3.6 \times 10^3)^2$	C1
	$= 5.1 \times 10^{-5} \text{ N kg}^{-1}$	A1
1(b)(ii)	mass = $(960 / 9.81) \text{ kg}$ weight on comet = $(960 / 9.81) \times 5.1 \times 10^{-5}$	C1
	$= 5.0 \times 10^{-3} \text{ N}$	A1
1(c)	similarity: e.g. both attractive/pointed towards the comet e.g. same order of magnitude	B1
	difference: e.g. radial/non-radial e.g. same (over surface)/varies (over surface)	B1

Question	Answer	Marks
2(a)(i)	mean/average square speed/velocity	B1
2(a)(ii)	$pV = NkT$ or $pV = nRT$	B1
	$\rho = Nm / V$ or $\rho = nN_A m / V$ and $k = nR / N$	B1
	$E_K = \frac{1}{2} m \langle c^2 \rangle$ with algebra to $(3/2)kT$	B1
2(b)(i)	no (external) work done or $\Delta U = q$ or $w = 0$	B1
	$q = N_A \times (3/2)k \times 1.0$	M1
	$N_A k = R$ so $q = (3/2)R$	A1
2(b)(ii)	specific heat capacity = $\{(3/2) \times R\} / 0.028$	C1
	= $450 \text{ J kg}^{-1} \text{ K}^{-1}$	A1

Question	Answer	Marks
3(a)(i)	e.g. period = $6 / 2.5$	C1
	frequency = 0.42 Hz	A1
3(a)(ii)	energy = $\frac{1}{2} m \times 4\pi^2 f^2 y_0^2$	C1
	= $\frac{1}{2} \times 0.25 \times 4\pi^2 \times 0.42^2 \times (1.5 \times 10^{-2})^2$	C1
	= 2.0×10^{-4} J	A1
3(b)(i)	(induced) e.m.f. proportional to rate of change of magnetic flux (linkage)	M1
	or cutting of magnetic flux	A1
3(b)(ii)	coil cuts flux/field (of moving magnet) <u>inducing</u> e.m.f. in coil	B1
	(induced) current in resistor causes heating (effect)	M1
	thermal energy/heat derived from energy of oscillations (of magnet)	A1

Question	Answer	Marks
4(a)	pulse (of ultrasound)	B1
	* produced by quartz crystal/piezo-electric crystal	
	* gel/coupling medium (on skin) used to reduce reflection at skin	
	reflected from boundaries (between media)	B1
	reflected pulse/wave detected by (ultrasound) transmitter	B1
	reflected wave processed and displayed	B1
	* intensity of reflected pulse/wave gives information about boundary	
	* time delay gives information about depth of boundary	
	<i>max. 2 of additional detail points marked *</i>	B2
4(b)	$I_T = I_0 \exp(-\mu x)$	C1
	$2.9 = \exp(4.6\mu)$	C1
	$\mu = 0.23 \text{ cm}^{-1}$	A1

Question	Answer	Marks
5(a)	any two reasonable suggestions e.g. <ul style="list-style-type: none"> • signal can be regenerated/noise removed (not “no noise”) • circuits more reliable • circuits cheaper to produce • multiplexing (is possible) • error correction/checking • easier encryption/better security 	B2
5(b)(i)	samples the analogue signal	M1
	at regular intervals and converts it (to a digital number)	A1
5(b)(ii)	1. smaller step depth	B1
	2. smaller step height	B1

Question	Answer	Marks
6(a)	force proportional to product of charges and inversely proportional to the square of the separation	M1
	reference to point charges	A1
6(b)(i)	(near to each sphere,) fields are in opposite directions or point (between spheres) where fields are equal and opposite or point (between spheres) where field strength is zero	M1
	so same (sign of charge)	A1
6(b)(ii)	(at $x = 5.0 \text{ cm}$,) $E = 3.0 \times 10^3 \text{ V m}^{-1}$ and $a = qE / m$	C1
	$E = (1.60 \times 10^{-19} \times 3.0 \times 10^3) / (1.67 \times 10^{-27})$	C1
	$= 2.9 \times 10^{11} \text{ ms}^{-2}$	A1
6(c)	field strength or E is potential gradient or field strength is rate of change of (electric) potential	M1
	(field strength) maximum at $x = 6 \text{ cm}$	A1

Question	Answer	Marks
7(a)	equal and opposite charges on the plates so no resultant charge	B1
	+ve and –ve charges separated so energy stored	B1
7(b)	charge / potential difference	M1
	reference to charge on one plate and p.d. between plates	A1
7(c)	energy = $\frac{1}{2} CV^2$ or energy = $\frac{1}{2} QV$ and $C = Q / V$	C1
	$(1 / 16) \times \frac{1}{2} CV_0^2 = \frac{1}{2} CV^2$ $V = \frac{1}{4} V_0$	A1

Question	Answer	Marks
8(a)(i)	circle around both diodes	B1
8(a)(ii)	indicates (whether) temperature	M1
	(is) above or below a set value	A1
8(b)(i)	(when resistance of C > R_V ,) $V^- > V^+$ or $V^+ < 3V$ or p.d. across $R_V < \text{p.d. across } R/Y/3V$ or p.d. across C > p.d. across R/ X/3V	M1
	op-amp output is negative	M1
	(only) green	A1
8(b)(ii)	resistance of C becomes less than R_V or $V^- < V^+$	B1
	green (LED) goes out	A1
	blue (LED) comes on	A1
8(c)	changes/determines <u>temperature</u> at which LEDs switch	B1

Question	Answer	Marks
9(a)(i)	Hall voltage depends on thickness of slice	C1
	thinner slice, larger Hall voltage	A1
9(a)(ii)	Hall voltage depends on current in slice	B1
9(b)	sinusoidal wave, one cycle	B1
	at $\theta = 0$ and at $\theta = 360^\circ$, $V_H = V_{MAX}$	B1
	at $\theta = 180^\circ$, $V_H = -V_{MAX}$	B1

Question	Answer	Marks
10(a)	two from: <ul style="list-style-type: none"> • frequency below which electrons not ejected • <u>maximum</u> energy of electron depends on frequency • <u>maximum</u> energy of electrons does not depend on intensity • instantaneous emission of electrons 	B2
10(b)(i)	$(\lambda_0$ is the) threshold wavelength or wavelength corresponding to threshold frequency or maximum wavelength for emission of electrons	B1
10(b)(ii)1.	intercept = $1/\lambda_0 = 2.2 \times 10^6 \text{ m}^{-1}$ $\lambda_0 = 4.5 \times 10^{-7} \text{ m}$ or 450 nm	A1
10(b)(ii)2.	gradient = hc	C1
	gradient = 2.0×10^{-25} or correct substitution into gradient formula	C1
	$h = (2.0 \times 10^{-25}) / (3.0 \times 10^8) = 6.7 \times 10^{-34} \text{ J s}$	A1
10(c)	line: same gradient	B1
	straight line, positive gradient, intercept at greater than 2.2×10^6 when candidate's line extrapolated	B1

Question	Answer	Marks
11(a)	loss of (electric) potential energy = gain in kinetic energy or $qV = \frac{1}{2}mv^2$ or $E_K = p^2/2m = qV$	B1
	$p = mv$ with algebra leading to $p = \sqrt{2mqV}$	B1
11(b)(i)	particle/electron has a wavelength (associated with it)	B1
	dependent on its momentum or when/because particle is moving	B1
11(b)(ii)	$p = (2 \times 9.11 \times 10^{-31} \times 1.60 \times 10^{-19} \times 120)^{1/2}$	C1
	$\lambda = (6.63 \times 10^{-34}) / (5.91 \times 10^{-24})$	C1
	$= 1.12 \times 10^{-10} \text{ m}$	A1
11(c)	wavelength is similar to separation of atoms	M1
	so diffraction observed	A1

Question	Answer	Marks
12(a)	$7\ _{-1}^0\text{e}$	A1
12(b)(i)	$E = mc^2$	C1
	$= 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2$	M1
	$= 1.494 \times 10^{-10}\ \text{J}$	A1
	division by 1.60×10^{-13} clear to give 934 MeV	
12(b)(ii)	$\Delta m = (82 \times 1.00863\text{u}) + (57 \times 1.00728\text{u}) - 138.955\text{u}$	C1
	$= (-) 1.16762\ (\text{u})$	
	energy = 1.16762×934	C1
	energy per nucleon = $(1.16762 \times 934) / 139$	A1
	$= 7.85\ \text{MeV}$	
12(c)	above $A = 56$, binding energy per nucleon decreases as A increases	B1
	U-235 has larger nucleon number	M1
	so less (binding energy per nucleon)	A1
	or	
	fission takes place with uranium	(B1)
	fission reaction releases energy	(M1)
	binding energy per nucleon less (for uranium than for products)	(A1)