Question	Answer	Marks
6(a)	work done per unit charge	**B1**
	(work done) moving positive charge from infinity	**B1**
6(b)	straight line with non-zero gradient from $x = 0$ to $x = d$	**B1**
	line with gradient of constant sign and end-points between which $\Delta V = V_0$ and $\Delta x = d$	**B1**
	line passes through (d, 0) and (0, $+V_0$) with negative gradient throughout	**B1**
6(c)	V constant (and non-zero) from $0 \rightarrow R$ and from $(D - R) \rightarrow D$	**B1**
	equal (non-zero) values of (magnitude of) V at R and $(D - R)$.	**B1**
	curve (with a minimum) from R to $(D - R)$ with V always positive	**B1**
	minimum at mid-point of curve	**B1**

Question	Answer	Marks
7(a)	Any five from: • (as temperature rises) energy of electrons increases • electrons (have enough energy to) cross forbidden band • electrons enter conduction band • leaving holes in valence band • both holes and electrons act as charge carriers • more charge carriers results in lower resistance • increased lattice vibrations outweighed by increase in (number of) charge carriers	**B5**
7(b)	(at 10 °C resistance is) 2.55 kΩ	**C1**
	new potential difference = 9.00 × 2.55 / (2.55 + 12.0) = 1.58 V	**C1**
	change in p.d. = 0.58 V	**A1**
7(c)	change of resistance with temperature is not linear	**B1**
	change in potential with resistance is not linear **or** potential divider equation is non-linear	**B1**

Question	Answer	Marks
8(a)(i)	$v_N = 3.4 \times 10^7 \times \sin 30°$ $= 1.7 \times 10^7$ m s^{-1}	A1
8(a)(ii)	$mv^2 / r = Bqv$ **or** $r = mv / Bq$	C1
	$r = (9.11 \times 10^{-31} \times 1.7 \times 10^7) / (3.2 \times 10^{-3} \times 1.60 \times 10^{-19})$	C1
	$= 0.030$ m	A1
8(b)	zero	B1
8(c)	helix/coil	B1

Question	Answer	Marks
9(a)(i)	relay coil shown connected between diode and earth	B1
	switch shown connected across lamp	B1
9(a)(ii)	Any one from: • (for diode to conduct) current flow is into output of op-amp • when earth is at higher potential diode is forward biased • diode blocks current when output positive • diode must conduct	M1
	so V_{OUT} is negative	A1
9(b)(i)	strain gauge	B1
9(b)(ii)	light-dependent resistor	B1

Question	Answer	Marks
10(a)	(induced) e.m.f. proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
10(b)	current in primary coil gives rise to <u>magnetic</u> flux	**B1**
	changing (magnetic) flux in core links with secondary coil	**B1**
	induced e.m.f. (in secondary coil) causes current in load/resistor	**B1**
10(c)	correct application of turns ratio: to peak voltage ratio, giving (V_0 / 220) = (450 / 2700) **or** to r.m.s. voltage ratio, giving ($V_{r.m.s.}$ / 156) = (450 / 2700)	**C1**
	correct application of √2 factor: to peak applied e.m.f., giving 220 / √2 **or** to peak output em.f., giving 37 / √2	**C1**
	$V_{r.m.s.}$ = 26 V	**A1**

Question	Answer	Marks
11(a)	packet/quantum of <u>energy</u>	**M1**
	of electromagnetic radiation	**A1**
11(b)(i)	$E = hc / \lambda$	**C1**
	$1.18 \times 1.60 \times 10^{-13} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda$ $\lambda = 1.05 \times 10^{-12}$ m	**A1**
11(b)(ii)	$\lambda = h / p$ **or** $E = pc$	**C1**
	$p = (6.63 \times 10^{-34}) / (1.05 \times 10^{-12})$ **or** $p = (1.18 \times 1.60 \times 10^{-13}) / (3.00 \times 10^{8})$ leading to $p = 6.3 \times 10^{-22}$ N s	**B1**
11(c)	$6.3 \times 10^{-22} = 60 \times 1.66 \times 10^{-27} \times v$	**C1**
	$v = 6.3 \times 10^{3}$ m s^{-1}	**A1**

Question	Answer	Marks
12(a)	energy required to separate the nucleons (in a nucleus)	**M1**
	to infinity	**A1**
	or	
	energy released when nucleons come together (to form nucleus)	**(M1)**
	from infinity	**(A1)**
12(b)	mass defect = 140.911 – (57 × 1.007) – (84 × 1.009)	**C1**
	= 140.911 – 142.155 = (–)1.244 (u)	**C1**
	energy = $c^2(\Delta)m$	**C1**
	= $(3.00 \times 10^8)^2 \times 1.244 \times 1.66 \times 10^{-27}$ = 1.9×10^{-10} J	**A1**
12(c)(i)	$A = A_0 e^{-\lambda t}$ **and** $\ln 2 = \lambda t_{½}$	**C1**
	$0.40 = \exp(-\ln 2 \times t / 3.9)$	**C1**
	or	
	$(0.5)^n = 0.40$	**(C1)**
	$n = 1.32$ **and** $t = 1.32 \times 3.9$	**(C1)**
	t = 5.2 hours	**A1**
12(c)(ii)	daughter product may be radioactive **or** random nature of decay	**B1**