Question	Answer	Marks
8(a)(i)	constant gain for all frequencies	**B1**
8(a)(ii)	unchanged	**B1**
8(b)(i)	(open loop) gain of op-amp is infinite	**B1**
	feedback loop ensures $V^+ \approx V^-$ **or** any difference between V^+ and V^- results in saturated output	**B1**
	non-inverting input is 0 V so inverting input also at 0 V	**B1**
8(b)(ii)	input = (40 × 1.5) / (40 + 110)	**C1**
	= 0.40 V	**A1**
8(b)(iii)	gain = (–) (100 + 230) / 150 **or** feedback current = 0.40 / (150 × 10^3) (A)	**C1**
	p.d. = [(100 + 230) / 150] × 0.40 = 0.88 V	**A1**
8(c)	(magnitude of) gain decreases	**M1**
	voltmeter reading decreases	**A1**

Question	Answer	Marks
9(a)(i)	force is downwards/down the page **or** current is (right) to left	**B1**
	by left-hand rule, field is into plane of paper	**B1**
9(a)(ii)	magnetic force provides the centripetal force	**C1**
	$Bqv = mv^2 / r$	**C1**
	$v = Bqr / m$ $= (8.0 \times 10^{-4} \times 1.60 \times 10^{-19} \times 6.4 \times 10^{-2}) / (9.11 \times 10^{-31})$ $= 9.0 \times 10^{6}\ \mathrm{m\,s^{-1}}$	**A1**
9(b)(i)	arrow showing field direction down the page	**B1**
9(b)(ii)	$Bqv = Eq$ **or** $v = E / B$	**C1**
	$E = 9.0 \times 10^{6} \times 8.0 \times 10^{-4}$ $= 7.2 \times 10^{3}\ \mathrm{N\,C^{-1}}$	**A1**
9(c)	straight line/undeviated	**B1**
	condition for no deflection depends only on *v* **or** condition for no deflection does not depend on *m* or *q*	**B1**

Question	Answer	Marks
10(a)	(induced) electromotive force is proportional to rate	**M1**
	of change of (magnetic) flux (linkage)	**A1**
10(b)(i)	to change magnitude of potential difference	**B1**
10(b)(ii)	magnitude of e.m.f. varies as rate of change of flux changes	**B1**
	direction of e.m.f. changes when direction of change of flux reverses/when flux changes from increasing to decreasing	**B1**
	flux is continuously increasing and decreasing, so polarity of e.m.f. is continuously switching	**B1**
10(b)(iii)	to reduce energy/power losses **or** to reduce eddy currents	**B1**

Question	Answer	Marks
11(a)	conduction band and valence band overlap	B1
	number (density) of charge carriers does not vary	B1
	increase in temperature gives rise to increased lattice vibrations	B1
	(lattice) vibrations hinder movement of charge carriers so resistance increases	B1
11(b)	$mv = h / \lambda$	C1
	$v = (6.63 \times 10^{-34}) / [(2.6 \times 10^{-11}) \times (9.11 \times 10^{-31})]$ $(= 2.80 \times 10^{7}\ \text{m s}^{-1})$	C1
	$qV = ½mv^2$	C1
	$V = [9.11 \times 10^{-31} \times (2.80 \times 10^{7})^2] / [2 \times 1.60 \times 10^{-19}]$ $= 2.2 \times 10^{3}\ \text{V}$	A1

Question	Answer	Marks
12(a)	difference between mass of nucleus and mass of (constituent) nucleons	**M1**
	where nucleons are separated to infinity	**A1**
12(b)(i)	$E = mc^2$	**C1**
	$= 1.66 \times 10^{-27} \times (3.00 \times 10^8)^2 / (1.60 \times 10^{-13}) = 934$ MeV	**A1**
12(b)(ii)	mass defect = $2 \times (1.007276 + 1.008665) - 4.001506$ (= 0.030376)	**B1**
	binding energy per nucleon = $(0.030376 \times 934) / 4 = 7.09$ MeV	**A1**
12(c)	binding energy per nucleon is much greater	**M1**
	so would require a large amount of energy to separate the nucleons in helium	**A1**
	or	
	amount of energy released in forming hydrogen isotopes	**(M1)**
	is less than energy required to break apart helium nucleus	**(A1)**