Question	Answer	Marks
7(a)(i)	non-inverting (amplifier)	**B1**
7(a)(ii)	$\text{gain} = \frac{R_f}{R} + 1$ $\text{gain} = \frac{3.6}{0.72} + 1 = 6.0$	**B1**
7(a)(iii)	straight line from (0,0) to (T / 2, 3)	**B1**
	line from origin to 3.0 V then horizontal line at 3.0 V to T	**B1**
7(a)(iv)	ldr / light dependent resistor replaces one of the two resistors	**B1**
7(b)(i)	relay coil	**B1**
7(b)(ii)	relay coil between op-amp and earth	**B1**
	diode with correct polarity (pointing away from output) connected between output and device and no other connections or diode with correct polarity (pointing towards earth) between device and earth and no other connections	**B1**
	switch connected to high voltage circuit	**B1**

Question	Answer	Marks
8(a)(i)	at least one anticlockwise arrow and no clockwise arrows	**B1**
8(a)(ii)	(force is to the) left	**B1**
8(a)(iii)	force is the same	**B1**
	Newton's third law (of motion) *or* force depends on the product of the two currents	**B1**

Question	Answer	Marks
8(b)(i)	frequency of radio waves is equal to natural frequency of protons	**B1**
	resonance of protons occurs / protons absorb energy	**B1**
8(b)(ii)	in between pulses / when pulse stops	**B1**
	Any 1 from: • protons de-excite • protons emit r.f. pulses • emitted (r.f.) pulse (from proton) detected	**B1**

Question	Answer	Marks
9(a)	(magnetic) flux density × area × number of turns	**M1**
	area is perpendicular to (magnetic) field	**A1**
9(b)	use of $t = 1.2\,\text{s}$	**C1**
	$\varepsilon = \frac{\Delta BAN}{\Delta t}$ $= \frac{0.250 \times \pi \times 0.030^2 \times 540}{1.2}$	**C1**
	$= 0.32V$	**A1**
9(c)(i)	light damping	**B1**

Question	Answer	Marks
9(c)(ii)	sheet cuts (magnetic) flux and causes induced emf	**B1**
	(induced) emf causes (eddy) currents (in sheet)	**B1**
	either currents (in sheet) cause resistive force or currents (in sheet) dissipate energy	**B1**
	smaller currents in Y or larger currents in X, so dashed line is X	**B1**

Question	Answer	Marks
10(a)	**230** V	**A1**
10(b)	$\omega = 100\pi$ $T = \frac{2\pi}{\omega} = \frac{2\pi}{100\pi}$	**C1**
	$= 0.020\,s$	**A1**
10(c)(i)	half-wave (rectification)	**B1**
10(c)(ii)	sinusoidal half waves in positive V only or negative V only, peak at 320 V	**B1**
	line at zero for second half of cycle	**B1**
	two time periods shown, each of 0.020 s	**B1**
10(c)(iii)	capacitor added in parallel with resistor	**B1**

Question	Answer	Marks
11(a)(i)	electrons decelerate (on hitting target) so X-ray photons produced	**B1**
	range of decelerations	**B1**
	photon energy depends on (magnitude of) deceleration	**B1**
11(a)(ii)	$eV = \frac{hc}{\lambda}$	**C1**
	$\lambda = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{1.6\times10^{-19}\times15000}$	**C1**
	$= 8.3\times10^{-11} m$	**A1**
	or $E = hf$ and $c = f\lambda$ and electron energy = eV *or* $E = hc / \lambda$ and electron energy = eV electron energy = $1.6 \times 10^{-19} \times 15000$ $= 2.4 \times 10^{-15}$	**(C1)**
	$\lambda = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{2.4\times10^{-15}}$	**(C1)**
	$\lambda = 8.3\times10^{-11} m$	**(A1)**
11(b)(i)	μ = – gradient *or* ln $(I / I_o) = -\mu x$	**C1**
	(e.g. 2.08 / 10.0) = **0.21** cm^{-1}	**A1**

Question	Answer	Marks
11(b)(ii)	$\ln(0.05) = -\mu x$	**C1**
	$x = \dfrac{\ln 0.05}{-\mu}$ *e.g.* $x = 14\,cm$	**A1**

Question	Answer	Marks
12(a)	1 not affected by external factors	**B1**
	2 cannot predict when a (particular) nucleus will decay *or* cannot predict which nucleus will decay (next)	**B1**
12(b)(i)	Number of atoms = $\dfrac{1.0\times10^{-9}}{90\times1.66\times10^{-27}}$ *or* $\dfrac{1.0\times10^{-9}\times6.02\times10^{23}}{90\times10^{-3}}$ $= 6.693\times10^{15}$	**C1**
	$A = \lambda N$ $\lambda = \dfrac{5.2\times10^{6}}{6.693\times10^{15}}$	**C1**
	$\lambda = 7.8\times10^{-10}\ s^{-1}$	**A1**
12(b)(ii)	daughter nucleus is unstable	**B1**