1

(a) 3×10^8 (ms^{-1}) (Do not allow 'speed of light' / *c*) B1

(b)(i) $v = f\lambda$ C1

$3.0 \times 10^8 = f\lambda$ / $3.0 \times 10^8 = f \times 8.8 \times 10^{-7}$

frequency = 3.41×10^{14} (Hz) $\approx 3.4 \times 10^{14}$ (Hz) A1

(b)(ii) (e.m.f =) $\frac{W}{Q}$, with *W* = energy (transformed to electrical) and *Q* = charge (B1)

Or

Energy transformed by / per unit charge / 1C (from chemical to electrical) B1

(Allow: 'energy gained by / per unit charge / 1C / one coulomb')

(b)(iii) $I = \frac{\Delta Q}{\Delta t}$ Allow any subject, with or without Δ notation B1

(b)(iv) $Q = 1.4 \times 10^{-3} \times 0.20$ C1

charge = 2.8×10^{-4} (C) A1

(b)(v) $W = VQ$ / energy = VQ C1

$W = 3.0 \times 2.8 \times 10^{-4}$

energy = 8.4×10^{-4} (J) (Possible ecf) A1

(c) Radio waves: 1.5×10^3 m B1

Filament lamp: 5.0×10^{-7} m / 8.8×10^{-7} m B1

X-Ray machine: 8.0×10^{-9} m B1

[Total: 12]

2

(a) length B1

(cross-sectional) area (Allow: radius / diameter / thickness / width) B1

(b)(i) $R = \frac{\rho L}{A}$ (Allow any subject)

C1

$$\rho = \frac{0.54 \times [\pi \times (0.135 \times 10^{-3})^2]}{1.8}$$

C1

$\rho = 1.72 \times 10^{-8} \approx 1.7 \times 10^{-8}$ (Deduct one mark for 10^n error) A1

($\rho = 6.87 \times 10^{-8}$ scores 2/3 if 'diameter' is used)

($\rho = 1.72 \times 10^{-5}$ Ωmm scores 4/4)

unit: Ωm B1

(b)(ii) Any <u>four</u> from: (Allow AW)

1. Resistance of the wire increases (as the temperature is increased) B1
2. The current decreases / the ammeter reading falls B1
3. The decrease in current justified in terms of '*I* = *V*/*R*' B1
4. The voltage remains the same / the voltmeter reading remains the same B1
5. The electrons (within the wire) collide <u>more</u> (often with the atoms) / the

atoms vibrate more (Do not allow 'particles' vibrate more) B1
QWC for 'spelling and grammar' B1

[Total: 11]

3

(a) Correct direction of the magnetic field B1
The magnetic field pattern is correct and 'symmetrical' (≥ 2 lines) B1
'Parallel' field lines within the core of the solenoid B1

(b)(i) $(B =)\frac{F}{IL}$ F = force (on conductor), I = current and L = length (in field) (B1)
Or
Force (experienced) per / by unit length of conductor carrying a unit current B1
(Reference to 1m or 1A scores 0/1)
The (magnetic) field is at right angles to the conductor / current B1

(b)(ii) $F = BIL$ (Allow any subject) C1
force = $6F$ / increased by a factor of 6 A1
(Do not allow 'increase by' 6)

[Total: 7]

4

(a) $E = I(R + r)$ or $E = V + Ir$ / $R_T = \frac{1.5}{0.60} = (2.5)$ / $V_R = 1.8 \times 0.6$ C1

$1.5 = 0.60\,(r + 1.8)$ / $r = 2.5 - 1.8$ / $r = \frac{1.5 - 1.08}{0.6}$ C1

$r = 0.70\ (\Omega)$ (Allow 1sf answer) A1

(b)(i) $P = \frac{V^2}{R}$ / $P = VI$ and $V = IR$ C1

$36 = \frac{12^2}{R}$ / $I = 3.0$ (A) hence $R = \frac{12}{3.0}$

resistance = 4.0 (Ω) (Allow 1 sf answer) A1

(b)(ii) $R_{series} = 30\ (\Omega)$ C1

$R = \frac{30 \times 4.0}{30 + 4.0}$ / $\frac{1}{R} = \frac{1}{30} + \frac{1}{4}$ / $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ C1

resistance = $3.53 \approx 3.5\ (\Omega)$ (Possible ecf) A1

(b)(iii) $I_{lamp} = \frac{36}{12}$ or 3.0 (A) / $I_{20\Omega} = \frac{12}{30}$ or 0.40 (A) C1

ratio = 7.5 / ratio = $\frac{30}{4}$ A1

[Total: 10]

5

(a) No current (in circuit) / 'open' circuit / p.d. between **X** and **Y** is 5.0 V B1

(b) $V = \frac{R_2}{R_1 + R_2} \times V_0$ / $\frac{V_1}{V_2} = \frac{R_1}{R_2}$ / $I = \frac{3.4}{168}$ ($= 2.02 \times 10^{-2}$ mA) C1

$3.4 = \frac{168}{168 + R} \times 5.0$ / $\frac{1.6}{3.4} = \frac{R}{168}$ / $R = \frac{1.6}{2.02 \times 10^{-2}}$ C1

resistance ≈ 79 (kΩ) (Total resistance of 250 kΩ scores 2/3) A1

[Total: 4]

6

(a) × ✓ ✓ × B1 × 2

All correct 2 marks; Three correct 1 mark; Two (or less) correct 0 mark

(b) Any six from: (Allow AW)

1. Photoelectric effect is the removal of electrons (from metals) when exposed to light / u.v. /e.m. radiation / photons B1
2. Surface electrons are involved / electrons released from the surface B1
3. A single photon interacts with a single electron B1
4. Energy is conserved (in the interaction) B1
5. Energy of photon = hf or $\frac{hc}{\lambda}$ B1
6. Reference to Einstein's photoelectric equation: $hf = \phi + KE_{(max)}$ C1
7. photon energy = work function (energy) + (maximum) KE (of electron) A1
8. PE effect takes place / electron(s) released when $hf > \phi$ / $hf = \phi$ / frequency is greater / equal to threshold frequency B1
9. The (maximum) KE of electron is independent of intensity when electrons are emitted B1
10. Intensity increases the rate / number of electrons when emission occurs B1
11. PE effect does not take place / no electrons emitted when $hf < \phi$ / frequency < threshold frequency B1
12. Intensity has 'no effect' when there is no emission of electrons B1

QWC for 'organisation' B1

(c)(i)1. $E = hf$ / $E = \frac{hc}{\lambda}$ / $f = 7.5 \times 10^{17}$ (Hz) C1

('$E = hf$' can be secured either in **(c)(i)1.** or **(b)**)

$E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{4.0 \times 10^{-10}}$ / $E = 6.63 \times 10^{-34} \times 7.5 \times 10^{17}$ C1

energy = 4.97×10^{-16} (J) ≈ 5.0×10^{-16} (J) (Allow 1 sf answer here) A1

(c)(i)2. $E = \frac{4.97 \times 10^{-16}}{1.6 \times 10^{-19}}$ (Possible ecf from **(c)(i)**)

energy = 3.1×10^{3} (eV) B1

(c)(ii) The answer to **(c)(i)1.** and 1.4 (W) are used to determine the rate of photons C1

number = $\frac{1.4}{4.97 \times 10^{-16}}$ (Possible ecf) C1

number = 2.8×10^{15} (s^{-1}) (If 3100 eV is used, then allow 2/3 for 4.5×10^{-4}) A1

[Total: 16]