M1.(a) current heats the wire ✓

1

electrons (in filament) gain sufficient KE (to leave the filament) ✓

1

(b) electrons would collide (or be absorbed or scattered) by gas atoms (or molecules) ✓

1

(c) Rearrange ½ $m v^2 = eV$ to give $v = (2eV / m)^{1/2}$

1

or correct substitution in equation.

1

$$v = \left(\frac{2 \times 1.6 \times 10^{-19} \times 4800}{9.1 \times 10^{-31}} \right)^{\frac{1}{2}} = 4.1 \times 10^{7} \text{ m s}^{-1}$$

1

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 4.1 \times 10^{7}}$$ ✓ $= 1.8 \times 10^{-11}$m✓

1

(d) Increasing the pd increases the speed (or kinetic energy or momentum) of the electrons ✓

1

which decreases their de Broglie wavelength ✓

1

so they are diffracted less so the rings become smaller ✓

1

[10]

M2.(a) (i) electrons pulled out of (gas) atoms so (gas) atoms become (+) ions
OR
ionisation by collision (also) occurs
OR
(+) ions (that) hit cathode causing it to release electrons ✓
conduction due to electrons and positive ions ✓

; Allow 'electrons ionise atoms' as compensation mark (if no marks elsewhere)

2

(ii) ions and electrons (moving in opposite directions) collide (with each other) and recombine and emit photons ✓

Owtte

electrons excite gas atoms (by collision) and photons are emitted when de-excitation occurs ✓

If light not photons given in 1st 2 mark points, 1 max for 1st two mark points

gas needs to be at sufficiently low pressure in order that the particles (or uncharged gas atoms / ions / electrons) in the gas are widely spaced ✓

Owtte

otherwise (+) ions and / or electrons / particles would be stopped by gas atoms OR so that ions / electrons are accelerated (or gain enough ke) to cause excitation ✓

3max

(b) Specific charge = charge / mass (and
charge(s) of ion does not depend on the type of gas) ✓

Mass of ion depends on the type of gas ✓

Accept Q / m in symbols Q / m but not e / m if e / m is specifically stated as specific charge

2

[7]

M3. (a) (i) The number of electrons (per second) in the beam will increase **(1)** because the filament will become hotter and will emit more electrons (per 2 second) **(1)**

2

(ii) the speed (or kinetic energy) of the electrons will increase **(1)**

because the electrons (from the filament) are attracted towards the anode with a greater acceleration (or force) **(1)**

(or gain more kinetic energy in crossing a greater pd)

2

(b) (i) (magnetic) force on each electron in the beam is perpendicular to velocity **(1)**

no work is done on each electron by (magnetic) force so ke (or speed) is constant **(1)**

magnitude of (magnetic) force is constant because speed is constant **(1)**

(magnetic) force is always perpendicular to velocity so is centripetal **(1)**

max 3

(ii) rearranging $r = \frac{mv}{Be}$ gives $\frac{e}{m} = \frac{v}{Br}$ **(1)**

$\frac{e}{m} = \frac{7.4 \times 10^{6}}{6.0 \times 10^{-4} \times 68 \times 10^{-3}}$ = 1.81 × 10^{11} **(1)** C kg^{-1} **(1)**

for correct answer to 2 sf **(1)**

4

(iii) specific charge for the electron ≈ 2000 × specific charge of H^{+} **(1)**

(accept = and accept any value between 1800 and 2000)

which was the largest known specific charge before the specific charge of the electron was determined/measured **(1)**

(or which could be due to a much greater charge or a much smaller mass of the electron)

2

[13]