



A-Level Physics

Cathode Rays

Mark Scheme

Time available: 68 minutes

Marks available: 38 marks

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Mark schemes

1.

(a) 2 From ✓✓

(High) electric field pulls electrons from (gas) atoms/ ionises (gas) atoms

positive ions in tube are accelerated to C/cathode and strike surface/electrons in surface

Electrons (in cathode) emitted and accelerated towards A (and B) (to form cathode ray).

Do not award MP3 if there is a suggestion of a p.d. between A and B

2

(b) Y to X ✓

1

(c) Reference to $v = E/B$ (when path straight) ✓

(Eg Electric force = magnetic force

$$Eq = Bqv$$

$$v = E/B$$

(Therefore for greater v)

Either increase E ✓

Or decrease B . ✓

*For MP2 and MP3 there must be some correct supporting theory
e.g. $F_M = Bqv$*

3

(d) (Magnitude of) specific charge much greater (approximately x 2000) specific charge of hydrogen (ion), (largest then known). ✓

(If charges similar) Cathode rays particles mass much smaller than hydrogen ion and therefore smaller than atom. ✓

Do not condone "he deduced they were electrons"

MP2 cannot be awarded if MP1 is incorrect.

If no other creditable answer given, one mark can be awarded for stating that the sign of the specific charge of cathode ray is opposite to that of hydrogen ion.

2

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2.

- (a) Cathode rays/electrons move from cathode toward anode

Accept move left to right.

1

The paddle wheel has gained energy from cathode rays/electrons.

✓

Accept as alternatives for energy kinetic,

energy/momentum/impulse ✓

Ignore references to force.

Ignore references to applying a magnetic field.

1

- (b) Electrons are pulled out/escape from atoms OR gas atoms are ionised ✓

Condone molecules as alternative to atoms.

1

(Positive ions generated near the cathode are attracted to the cathode causing free) electrons emitted from the cathode. ✓

1

Electrons are accelerated toward the anode (by the potential difference) ✓

Do not accept attraction as an alternative to acceleration.

1

- (c) Reason: Idea of fewer electrons/cathode rays ✓

Effect: Paddle wheel rotates less ✓

Must score the reason mark to score the effect mark.

Ignore references to air resistance.

OR

Reason: Idea of electrons/cathode rays have higher energy/speed /momentum ✓

Effect: Paddle wheel rotates more ✓

If no mark is awarded, one mark can be awarded for the effect of the paddle wheel rotating more where the reasoning is limited to less collisions of electrons with air molecules.

2

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3.

- (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 $\frac{1}{2} m v^2 = eV$ to give $v = (2eV/m)^{1/2}$

1

or correct substitution in equation.

1

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

1

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

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

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4.

(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)**

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

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

4

(iii) specific charge for the electron $\approx 2000 \times$ 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

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