

Mark schemes

1.

- (a) Weight/gravitational force AND electric/electrostatic force ✓

Equal (magnitudes) and opposite directions,

AND one direction at least specified ✓

The second mark is conditional on the first.

First mark is for naming the two forces.

Condone 'electromagnetic' for 'electric'

Do not allow field or potential for force.

Allow "force due to electric field"; "force due to magnetic field"

Penalise additional forces in MP2.

The second mark is for the relationship between them. Must include idea of size and direction.

e.g. weight down equals E force up/towards positive plate/away from negative plate.

Do not allow 'balanced' or 'in equilibrium' for equals

The forces can be in the form of formulae for MP1 and MP2 (e.g. Eq , EV/d , mg)

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- (b) $m = 4\pi r^3 \rho / 3$ and $mg = 6\pi \eta r v$ seen ✓

$r^2 = 18 \eta v / 4 \rho g$ is seen in in some form, in symbols or through substituted data, ✓

Correct use of equations to obtain $r = 9.7 \times 10^{-7} \text{ m}$ ✓

Do not allow backward calculation

Can be seen by substitution.

Can be seen in single equation:

$$4\pi r^3 \rho g / 3 = 6\pi \eta r v$$

Do not award if v and V confused

Do not condone 1sf answer.

Must be clear answer refers to r , not r^2 for example.

If no other mark given MP1 can be awarded if F used for mg , and/or volume AND density equations seen separately

3

- (c) The number of excess electrons on the droplet is 3 ✓

In order for each half to remain stationary, the charge would have to split equally
OR

Due to the quantisation of charge, the charge cannot split equally ✓

It is not possible for both droplets to remain stationary / the student is wrong ✓

May be seen in terms of values of charge or e

Award for idea that charge would have to be $1.5e$

Evidence for MP1 and MP2 may be seen together. E.g. charge on drops are e and $2e$, OR 1.6×10^{-19} and 3.2×10^{-19}

Ignore reference to particles repelling each other

3

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2.

- (a) Filament / metal is heated due to the current through it ✓

OR

Temperature of the filament rises due to the current through it

(Free / conduction) electrons gain sufficient/enough (kinetic) energy to leave (the metal surface)

OR

Work function (defines work function) $\leq$ energy supplied to an electron/electron energy ✓

Thermionic emission ✓

Not

Electrons are heated

Not heated due to the pd across it

Allow

By electrical power or electrically heated

Not allowed

Reference to electrons leaving atoms or ionisation

Allow

Energy supplied sufficient to overcome the work function

3

- (b) Use one of $\frac{1}{2}mv^2 = eV$ and $r = \frac{mv}{Be}$ or $\frac{mv^2}{r} = Bev$

To arrive at

$$\frac{Bev}{m} = v \text{ or } v = \sqrt{\frac{2eV}{m}} \text{ or } v^2 = \frac{2eV}{m}$$

$$\text{or } \frac{e}{m} = \frac{v}{Br} \text{ or } \frac{e}{m} = \frac{v^2}{2V} \quad \checkmark$$

Substitution in the other equation and manipulates correctly and clearly to give $\frac{e}{m} = \frac{2V}{B^2 r^2}$
 $\checkmark$

Condone q for e

Substitution in other equation and correct manipulation

NB this is a show that so mark is not simply for stating the equation given

I presented such that v (velocity) and V (voltage) are indistinguishable in manipulation then award only first mark

2

- (c) Correct substitution $\frac{e}{m} = \frac{2 \times 320}{(1.5 \times 10^{-3})^2 \times 0.040^2}$

And answer 1.8×10^{11} $\checkmark$

Answer to 2 sig figs $\checkmark$

Allow for incorrect answer following incorrect substitution in equation

As answer is on the data sheet must see correct substitution with all correct powers of ten

2

- (d) The specific charge of the cathode rays/the particles was(much) larger/greater than the hydrogen ion/proton $\checkmark$

This provided evidence that cathode rays were composed of electrons/particles which have a (very) small mass / have a high (negative) charge

OR

Mass (much) smaller than the mass of a hydrogen (ion)/proton $\checkmark$

Not higher

If mark 1 not given then 0 for the question

Not lightest as substitute for mass

2

[9]

3.

- (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.

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4.

(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

$$\text{e.g. } F_M = Bqv$$

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.

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[8]