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)*

2

(b) $m = 4\pi r^3 \rho / 3$ and $mg = 6\pi\eta rv$ 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 $r = 9.7 \times 10^{-7}$ m ✔

> *Do not allow backward calculation*
>
> *Can be seen by substitution.*
>
> *Can be seen in single equation:*
>
> *$4\pi r^3 \rho g/3 = 6\pi\eta rv$*
>
> *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

[8]

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) ≤ 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 <u>atoms</u> 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

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

or $\frac{e}{m} = \frac{v}{Br}$ or $\frac{e}{m} = \frac{v^2}{2V}$ ✓

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

✓

> *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 $\frac{e}{m} = \frac{2 \times 320}{(1.5 \times 10^{-8})^2 \times 0.040^2}$

And answer 1.8×10^{11} ✓

Answer to 2 sig figs ✓

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 ✓

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 ✓

> *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.

2

[7]

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*
> *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 <u>mass</u> 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

[8]