AQA A-LEVEL PHYSICS · 7408

PHYSICS



EXAM QUESTION PACK

3.12.1 THE DISCOVERY OF THE ELECTRON

SCORE	PERCENTAGE
/47	%

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner reports in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

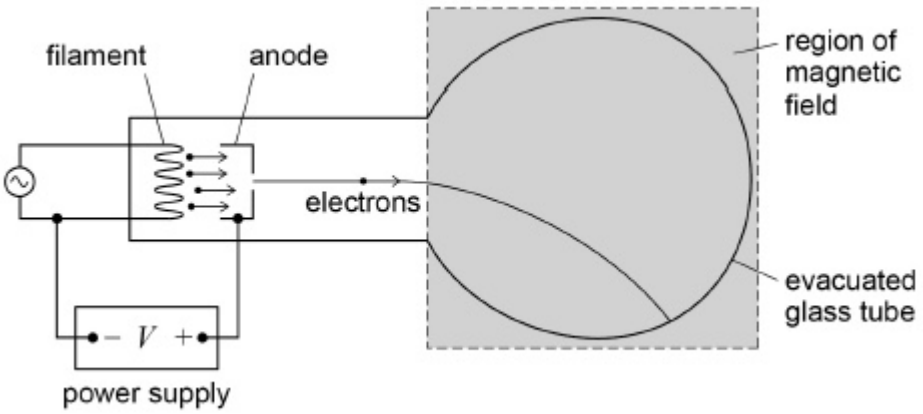
Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

The diagram shows apparatus which can be used to determine the specific charge of an electron.



Electrons are emitted from the filament and accelerated by a potential difference between the filament and anode to produce a beam. The beam is deflected into a circular path by applying a magnetic field perpendicular to the plane of the diagram.

(a) Describe the process that releases the electrons emitted at the filament.

(3)

(b) The table shows the data collected when determining the specific charge of the electron by the method shown in the diagram.

potential difference V that accelerates the electrons	320 V
radius r of circular path of the electrons in the magnetic field	4.0 cm
flux density B of the applied magnetic	1.5 mT

STEMUP.CO.UK

field	

Show that the specific charge of the electron is given by the expression $\frac{2V}{B^2r^2}$

(2)

(c) Using data from the table, calculate a value for the specific charge of the electron. Give your answer to an appropriate number of significant figures.

specific charge of the electron = _____ C kg^{-1}

(2)

(d) At the time when Thomson measured the specific charge of the particles in cathode rays, the largest specific charge known was that of the hydrogen ion.

State how Thomson's result for the specific charge of each particle within a cathode ray compared with that for the hydrogen ion and explain what he concluded about the nature of the particles.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

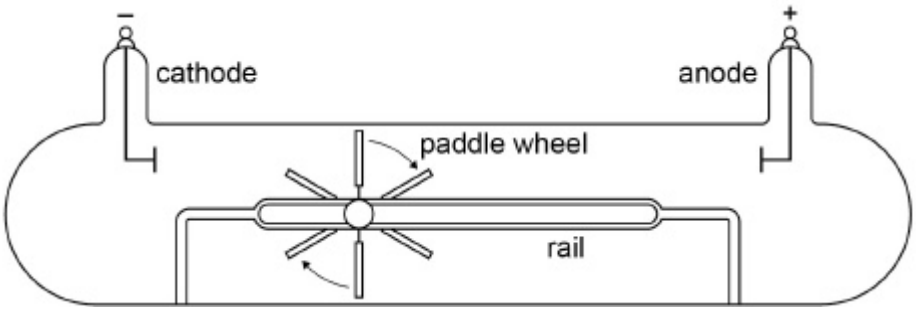
(Total 9 marks)

Q2.

The diagram shows a gas discharge tube devised by William Crookes in one of his investigations.

When a large potential difference is applied between the cathode and anode the paddle wheel is seen to rotate and travel along the rail towards the anode.

STEMUP.CO.UK



(a) Explain how this experiment led Crookes to conclude that cathode rays are particles and that these particles caused the movement of the paddle.

(2)

(b) Later experiments showed that cathode rays are electrons in motion.

Explain how cathode rays are produced in a gas discharge tube.

(3)

(c) In a particular gas discharge tube, air molecules inside the tube are absorbed by the walls of the tube.

Suggest the effect that this absorption may have on the motion of the paddle wheel.

Give a reason for your answer.

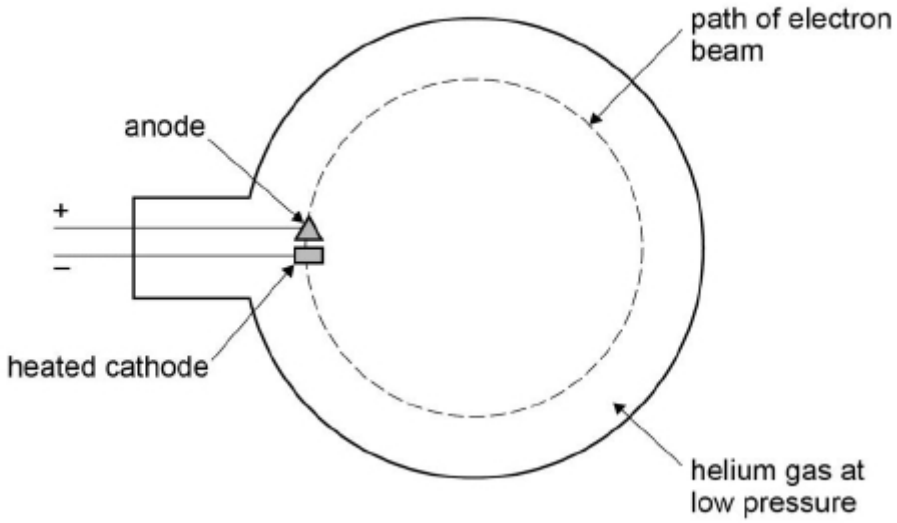
STEMUP.CO.UK

(2)

(Total 7 marks)

Q3.

The diagram below shows part of an apparatus used to determine the specific charge of an electron.



Electrons are emitted by the cathode by thermionic emission. They are accelerated by the potential difference between the cathode and anode. The tube contains helium gas at a low pressure and the gas emits light to show the path of the electron beam.

The beam is bent into a circular path by applying a magnetic field perpendicular to the plane of the diagram.

(a) Explain how light is emitted as the electrons travel through the helium gas.

(3)

(b) In one experiment the potential difference between the cathode and anode is 2.5 kV.

STEMUP.CO.UK

Show that the speed of the electrons is about 3.0×10^7 m s^{-1}.

_____

_____

(2)

(c) When the flux density of the magnetic field is 3.1 mT the diameter of the path of the beam is 0.114 m.

Calculate the value for the specific charge of an electron from the data in this experiment.

specific charge _____ C kg^{-1}

(3)

(d) In practice the path of the electron beam is not a perfect circle.

Discuss how the presence of the gas affects the path of the electrons.

_____

_____

_____

_____

_____

_____

(3)

(Total 11 marks)

Q5.

(a) J J Thomson devised the first experiments to determine the specific charge for cathode rays produced in discharge tubes. He found that the value did not depend on the gas in the tube. He also discovered that particles emitted by a heated filament and particles emitted in the photoelectric effect had the same specific charge.

State **two** conclusions that were drawn from Thomson's experiments.

1. _____

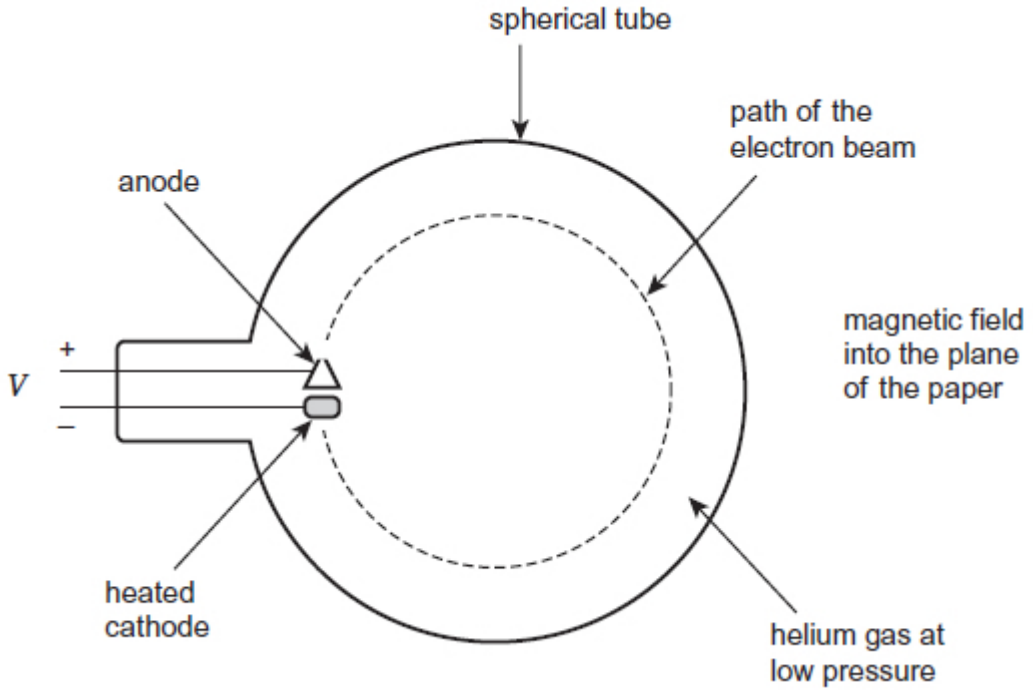
_____

2. _____

STEMUP.CO.UK

(2)

(b) The diagram shows a spherical tube, filled with low-pressure helium gas, that is used in an experiment to determine the specific charge of an electron.



Electrons are accelerated by a potential difference (pd) V applied between the cathode and anode. A magnetic field of known flux density B, directed into the plane of the diagram, causes the electrons to move in a circular path.

(i) Explain the process that causes the low-pressure helium gas to emit light so that the path of the electron beam can be seen.

(3)

(ii) In one experiment using the apparatus in the diagram, the accelerating pd is 1.6 kV and the flux density of the magnetic field is 2.2 mT. The path of the electron beam has a radius of 0.059 m.

Determine a value for the specific charge of an electron using these data. State an appropriate unit for your answer.

STEMUP.CO.UK

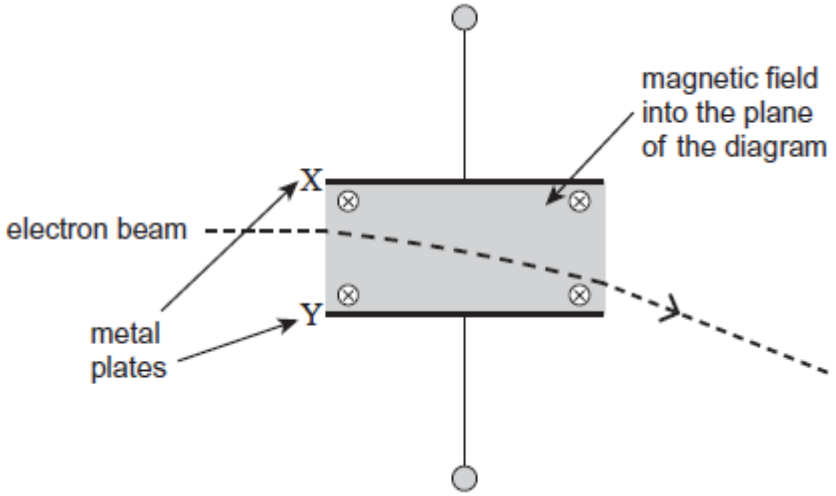
specific charge = _____ unit = _____

(4)

(Total 9 marks)

Q6.

The diagram below shows part of an evacuated tube that is used to determine the specific charge (e / m) for an electron. An electron beam is directed between the two parallel metal plates, X and Y. In the region between the plates, a magnetic field is applied perpendicularly into the plane of the diagram. An electric field can be applied in this region by applying a potential difference (pd) between the plates.



(a) The diagram shows the path of the electron beam when the magnetic field is applied and the pd between X and Y is zero.

(i) Explain why the path followed by the electron beam in the magnetic field is a circular arc.

_____

_____

_____

_____

(2)

(ii) Show that the speed v of the electrons is given by $v = \frac{Ber}{m}$

where r is the radius of the path of an electron in the magnetic field and B is the flux density of the magnetic field.

STEMUP.CO.UK

(1)

(iii) A pd V is now applied between X and Y without changing the flux density of the magnetic field. V is adjusted until the electron beam is not deflected as it travels in the region between the plates.

Determine an expression for the speed v of the electrons in terms of V, B and the separation d of the metal plates.

(1)

(b) Use the equation given in part (ii) and your answer to part (iii) to show that the specific charge for the electron = $\frac{V}{B^2 r d}$

(1)

(c) If the charge on an electron is known then its mass can be determined from the specific charge. Describe how Millikan's experiment with charged oil droplets enables the electronic charge to be determined.

Include in your answer:

- the procedures used to determine the radius of a droplet and the charge on a droplet
- how the measurements made are used
- how the electronic charge can be deduced.

The quality of your written communication will be assessed in your answer.

STEMUP.CO.UK

(6)
(Total 11 marks)

STEMUP.CO.UK