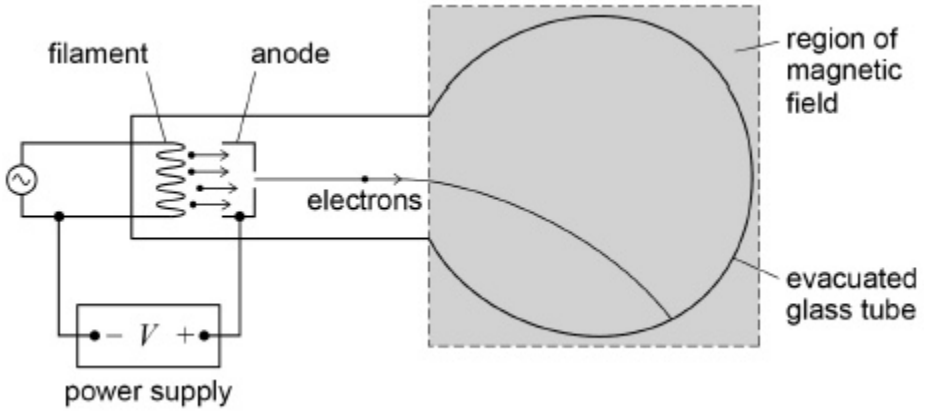
1 The diagram shows apparatus which can be used to determine the specific charge of an electron.



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.

thermiconic emission. Current warms up the element, delocalised electrons gain enough energy to leave the surface of the metal

(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 field	1.5 mT

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

$F = \frac{mv^2}{r} = Bqv \Rightarrow \frac{mv}{r} = Bq \quad \cdots (1) \qquad \frac{1}{2}mv^2 = qV$

$\frac{Bqr}{m} = v \Rightarrow v^2 = \frac{B^2q^2r^2}{m^2}$

(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.

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(2)

(Total 9 marks)

In a particular experiment, muons moving with a velocity 0.990*c* travel a distance of 1310 m through the atmosphere to a detector.

Determine the percentage of muons that reach the detector.

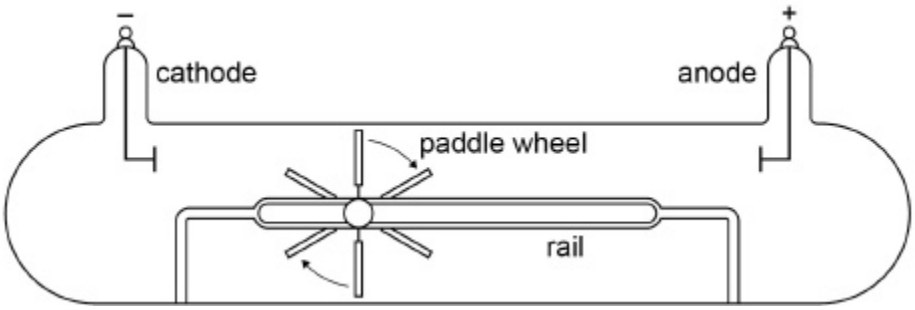
percentage = _____ %

(4)

(Total 12 marks)

5 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.



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

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(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.

(2)

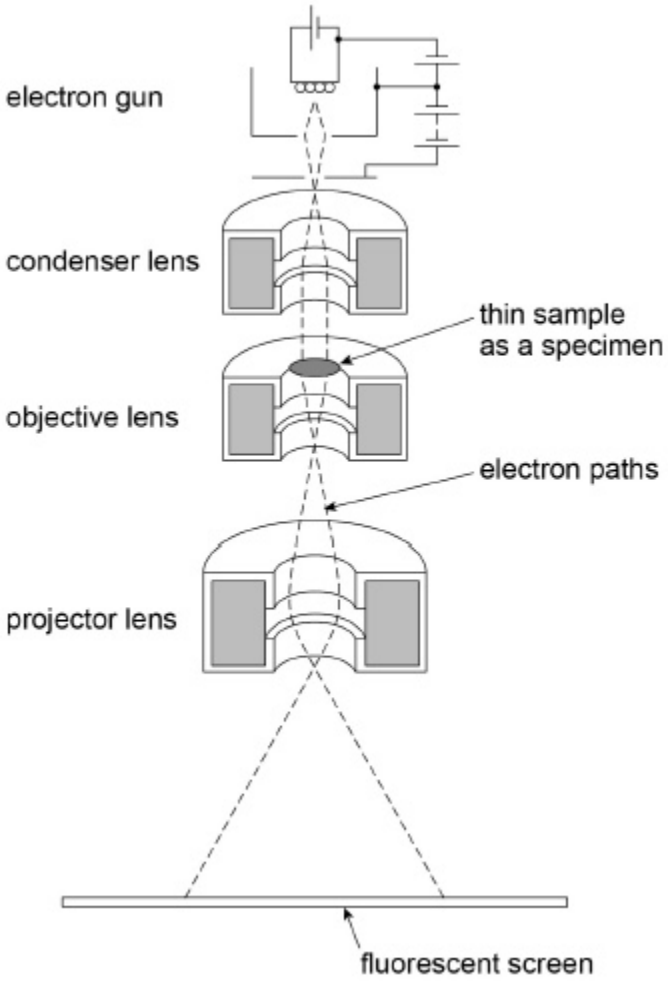
(Total 7 marks)

(d) Explain how the nature of light is implied by Maxwell's theory of electromagnetic waves and Fizeau's result.

(3)

(Total 9 marks)

7 The diagram shows the main parts of a transmission electron microscope (TEM).



(a) What is the process by which electrons are produced in an electron gun?
Tick (✓) the correct box.

Beta particle emission	☐
Electron diffraction	☐
Photoelectric effect	☐
Thermionic emission	☐

(1)

(b) The electrons in a particular TEM have a kinetic energy of 4.1×10^{-16} J.
Relativistic effects are negligible for this electron energy.

Suggest, with a calculation, whether the images of individual atoms can, in principle, be resolved in this TEM.

_____

_____

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_____

(3)

(c) A typical TEM can accelerate electrons to very high speeds and form high resolution images.

Explain:

- the process of image formation, and
- the factors that affect the quality of, and the level of detail in, the image.

(6)

(Total 10 marks)