

Science in Focus: Electrons at Play

Investigations

Experiments

Static Electricity

Question 1

For each of the following experiments, choose the correct outcome from the list of three possibilities.

- (a) Comb your hair using a plastic comb; then bring the comb close to your hair.
- (i) The hair flattens.
 - (ii) Nothing happens.
 - (iii) The hair stands on end.
- (b) Tear up a piece of paper into small scraps. Comb your hair again. Place the comb near the scraps of paper.
- (i) Nothing happens.
 - (ii) The paper is attracted to the comb.
 - (iii) The paper scatters.
- (c) Blow up a balloon. Rub the balloon on your clothing; then place it against a wall.
- (i) The balloon falls.
 - (ii) The balloon rises.
 - (iii) The balloon 'sticks' to the wall.
- (d) Turn on a tap so that a thin but steady stream of water flows. Rub a plastic ruler with a cloth. Hold the ruler close to the water.
- (i) The water is attracted to the ruler.
 - (ii) The water is repelled by the ruler.
 - (iii) Nothing happens.

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Question 2

Try to explain the phenomena described in Question 1.

Rubbing a polythene rod with a clean, dry cloth causes the rod to become negatively charged.

If a polythene rod is rubbed with a clean, dry cloth and then suspended so that it moves easily, and another similar polythene rod is then rubbed and brought close to the suspended rod, the suspended rod is repelled.

If a rod made of a different material is rubbed and brought close to the suspended polythene rod, the suspended rod will be repelled, attracted or unmoved depending on the material of the second rod.

Question 3

For each of the following materials, say whether you think the the suspended polythene rod will be (i) repelled, (ii) attracted or (iii) unmoved.

- (a) glass
- (b) aluminium
- (c) cellulose acetate
- (d) zinc
- (e) nylon
- (f) PVC
- (g) Perspex
- (h) ebonite

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Question 4

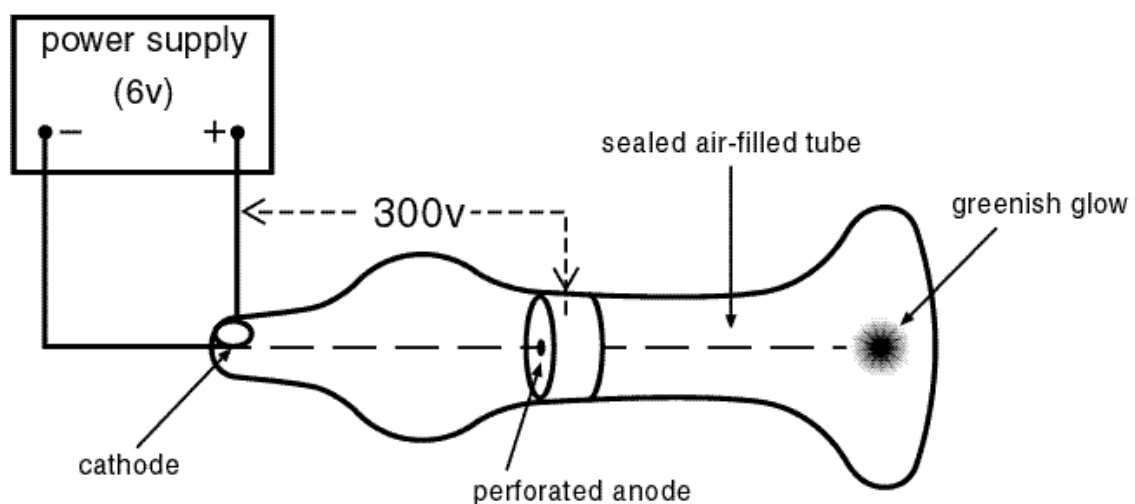
Which of the following statements are supported by the experiments described in Question 3?

- (a) Rubbing the rod makes it magnetic.
- (b) Rubbing the rod makes it charged.
- (c) The charged rod induces an opposite charge on the suspended rod.
- (d) The charged rod induces the same charge on the suspended rod.
- (e) Like charges attract.
- (f) Unlike charges repel.
- (g) Like charges repel.
- (h) Unlike charges attract.

Electrons

The electron was discovered by J J Thomson in 1897. His work was based on earlier attempts by other scientists to understand how an electric current flows through air, which is a poor conductor of electricity.

Thomson's Experiment



Question 5

Describe what happens in Thomson's experiment shown above.

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Question 6

Describe what would happen in Thomson's experiment if the following changes were made:

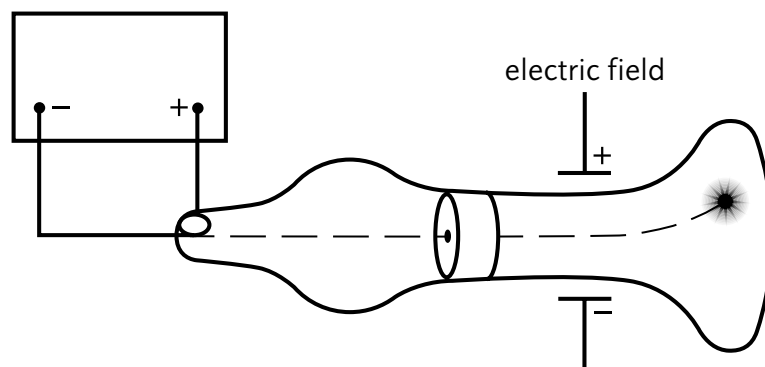
- (a) The air pressure in the tube is increased.
- (b) The air pressure in the tube is decreased.
- (c) The voltage of the power supply is increased.
- (d) The voltage of the power supply is decreased.

Question 7

Which of the following statements are supported by the experiments described in Question 6?

- (a) The flow of current through the tube is affected by the pressure of the air in the tube.
- (b) The flow of current through the tube is affected by the voltage between the anode and cathode.
- (c) Increasing the pressure of the air increases its conductivity.
- (d) Decreasing the pressure of the air increases its conductivity.
- (e) Increasing the voltage between the anode and cathode increases the current.
- (f) Decreasing the voltage between the anode and cathode increases the current.

Thomson set out to determine the nature of the beam that flowed through the tube. Was it radiation or a stream of particles? He tried passing the cathode ray through electric and magnetic fields. In both cases, the beam was deflected. When it passed through an electric field, it was deflected in the direction of the positive plate:



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Question 8

Which of the following statements are supported by Thomson's experiments with magnetic and electric fields?

- (a) Because the beam is affected by magnetic and electric fields, it cannot be a form of radiation.
- (b) Particles are affected by magnetic fields.
- (c) Because the particles are deflected, they must be charged.
- (d) The particles are negatively charged.
- (e) Because they are easily deflected, the particles must be large.
- (f) Because they are easily deflected, the particles must be small.

Electrons and Static Electricity

The basic unit of matter is the *atom*. An atom or group of atoms which is electrically charged is called an *ion*. Atoms or ions may be bound together to form *molecules*. All matter is made up of molecules, atoms or ions.

Every atom possesses a number of *electrons*, which are negatively charged, surrounding a nucleus consisting of *protons*, which are positively charged, and *neutrons*, which have no charge.

Question 9

Use the above ideas to explain how rubbing a polythene rod with a cloth causes it to become negatively charged.

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Question 10

Which of the following statements are true and which are false?

- (a) An electric current is a stream of charged particles passing through a conductive material.
- (b) Most metals are good conductors of electricity.
- (c) Air is a good conductor of electricity.
- (d) The conductivity of air is increased if its pressure is reduced.
- (e) Electrons can be made to flow through air along a cathode ray tube.
- (f) Electrons travel from an anode to a cathode.
- (g) Their speed is increased if the voltage of the power supply is increased.
- (h) The beam of electrons will be deflected if it passes through a magnetic field.
- (i) The beam of electrons will be deflected if it passes through an electric field.
- (j) The beam will be deflected away from the positive plate of the electric field.
- (k) The beam is not affected by gravity.

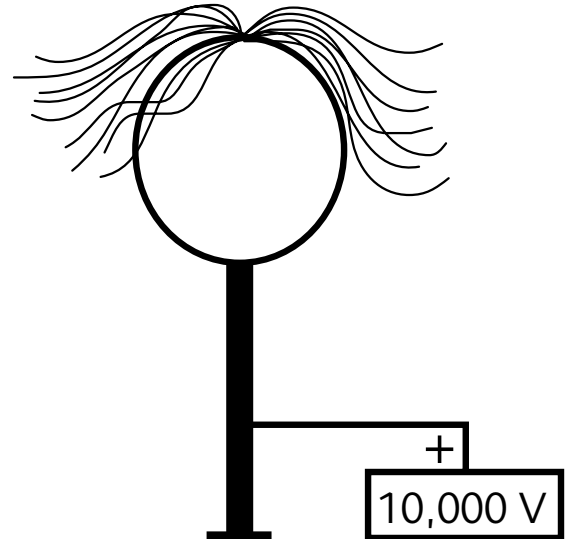
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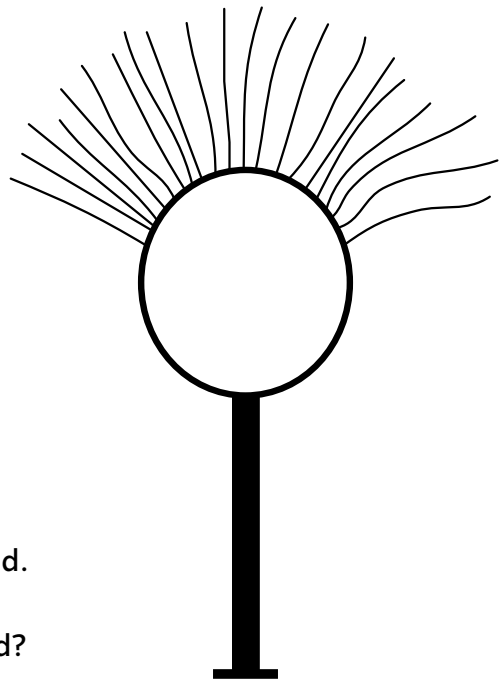
Revision

Question 11

At night you keep your wig on a stand which you keep on the floor in the corner of your room. The stand is made of material that is a good insulator:



A DC supply of $-10,000\text{ V}$ is applied to the stand. This is what happens:



- (a)
 - (i) Explain why the hairs on the wig stand on end.
 - (ii) What type of charge collects on the model?
 - (iii) In which direction have the electrons moved?
- (b) If a DC supply of $-10,000\text{ V}$ were used:
 - (i) What would happen to the hairs of the wig?
 - (ii) In which direction would the electrons move?
- (c) If the stand were made of copper and a DC supply of $+10,000\text{ V}$ were used:
 - (i) What would happen to the hairs?
 - (ii) In which direction would the electrons move?

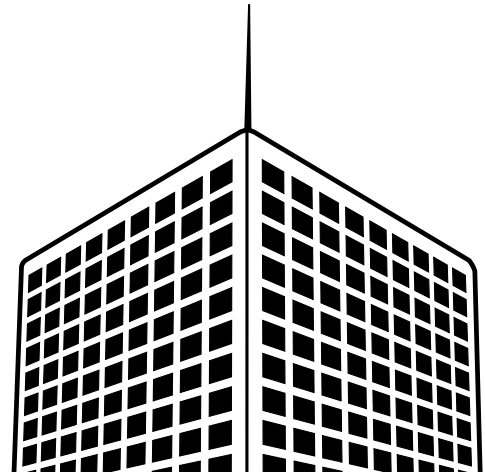
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Question 12

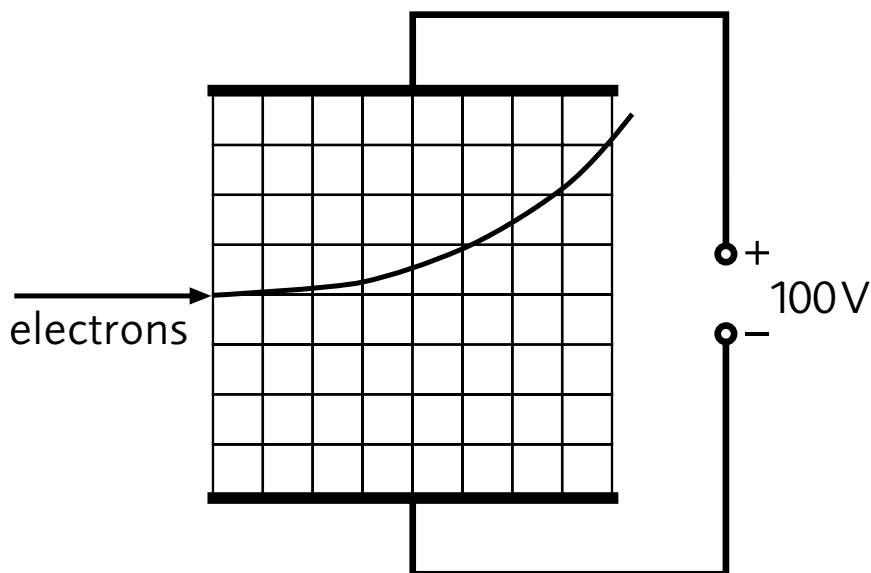
Lightning conductors protect buildings from damage caused by the electrical charge in lightning.



- (a) Of what kind of material is the lightning conductor made?
- (b) Describe what happens to the electrical charge when the spike is struck by lightning.

Question 12

The diagram below shows an electron beam. The beam is deflected as it passes between two metal plates.



- (a) How can you tell from this experiment that the electrons have a negative charge?
- (b) Describe what happens to the path of the electron beam when the voltage between the metal plates is:
 - (i) reversed in polarity
 - (ii) reversed in polarity and increased to 200V