

Static Electricity

Mark Scheme

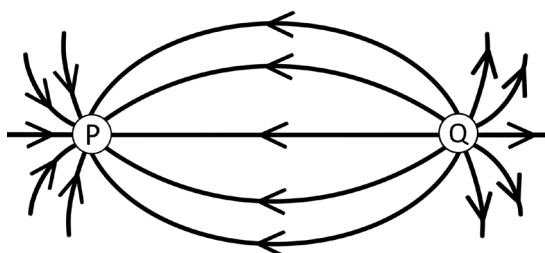


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1. Static electricity is the build-up of electrical charge on the surface of insulating materials.

For each of the following questions **circle** the letter of the correct answer.

- a) The figure below shows an electric field between the two objects, P and Q.
What is the electric charge of P and Q.



A – is the only correct answer.	1 mark
	Total: 1 mark

- b) Which subatomic particle is transferred between objects to create a static electrical charge?

C – is the only correct answer.	1 mark
	Total: 1 mark

- c) Static charge only builds up significantly on materials that do not allow electrical charge to flow easily through them. Which of the following materials is most likely to build up a static charge?

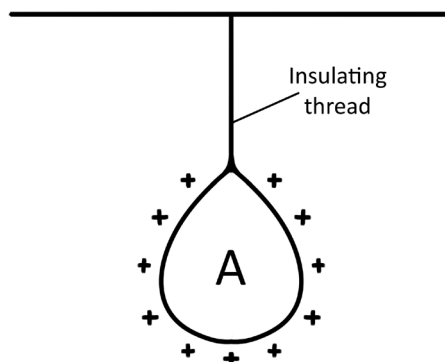
B – is the only correct answer.	1 mark
	Total: 1 mark

- d) As an aircraft flies, friction with the air causes it to build up a massive static charge.
Before it is refuelled on the ground, a copper wire is attached from the aircraft to the earth.
Why is this done?

C – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 4 marks)

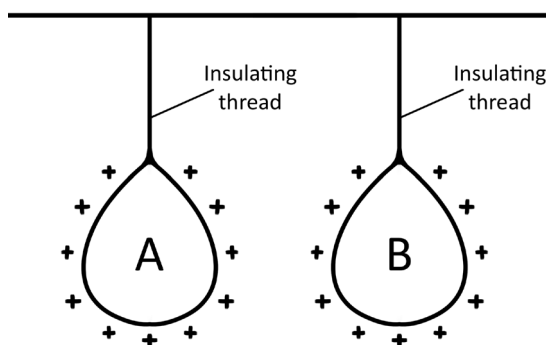
2. A teacher uses a rubber balloon in a practical to show the effect of static charges. The figure below shows the balloon hanging down from the ceiling in the practical.



- a) The balloon has a positive charge. Explain, in terms of electrons how the balloon got this charge.

An explanation to include the following:	
The balloon has lost electrons.	1 mark
Due to friction (with another material).	1 mark
Allow: electrons were transferred/rubbed off the balloon.	
	Total: 2 marks

- b) The teacher brings a second balloon near to balloon B. The second balloon is also positively charged.



Describe and explain what will happen to balloon B.

A description to include the following:	
They will repel / move apart / balloon B swings away.	1 mark
An explanation to include the following:	
Because like charges repel / both balloons have a positive charge.	1 mark
	Total: 2 marks

The teacher touches balloon B with her bare hand. The balloon becomes uncharged (neutral).

- c) Explain how the balloon becomes uncharged. You should refer to electrons in your answer.

Any three of the following points:	
- Electrons flow from the earth / through the person's body / from the hand. - Onto the balloon. - Because the balloon has a positive charge / a deficit of electrons (attracting them). - Until the charges balance / the balloon becomes neutral.	
	Total: 3 marks

When a car is being refuelled at a petrol station, static electricity can be dangerous.

The image shows a person refuelling a car at a petrol station.



- d) Explain how a static charge builds up during refuelling, the danger this poses, and how this danger is prevented. In your answer you should refer to the movement of electrons.

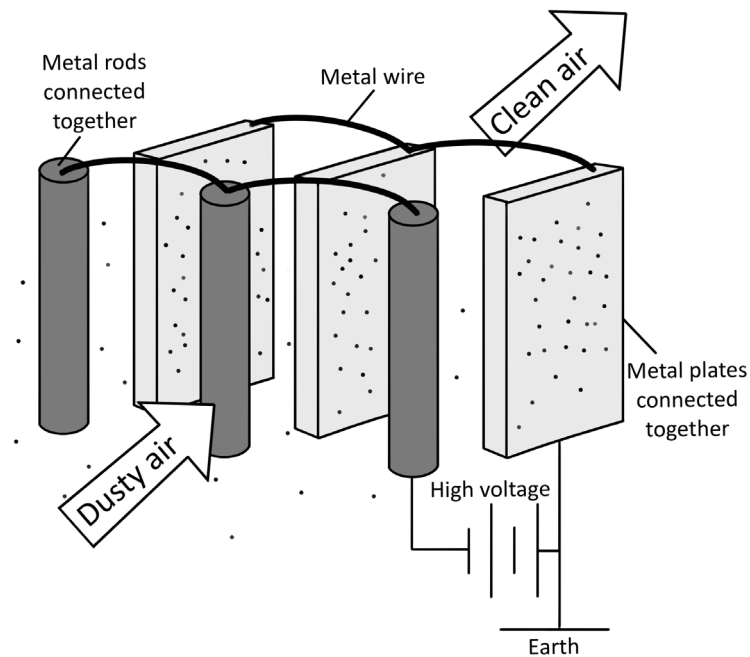
Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Simple, isolated statements are made. For example, "it can blow up" or "they use a wire to stop it." Reference to electron movement is weak, incorrect, or missing.
Level 2	3 - 4	A relevant explanation that addresses at least two areas of the prompt (e.g., explains the friction and the spark, but forgets the prevention, or explains earthing and the spark but misses the electron transfer). The explanation may lack detailed physics terminology.
Level 3	5 - 6	A detailed, coherent, and logically structured explanation that correctly uses physics terminology (e.g., friction, electrons, potential difference). The student addresses all three parts of the prompt: how the charge builds up, the specific danger (spark igniting vapour), and the prevention method (earthing).

Indicative content	
Build-up of charge: - Fuel flows rapidly through the pipe/hose. - This causes friction between the fuel and the pipe. - Electrons are transferred between the fuel and the pipe. - This causes a build-up of static charge / a large potential difference to develop between the nozzle and the car (or earth). The danger: - If the potential difference becomes too high, a spark can jump across the gap (between the nozzle and the fuel tank). - Fuel vapours are highly flammable. - The spark could ignite the fuel vapour, causing a fire or explosion. The prevention: - A bonding line / earthing wire (a conductor) is connected between the aircraft/car and the earth (or the fuel pump). - This provides a path of low resistance for the electrons to flow to/from the earth. - This discharges the vehicle / neutralises the charge, preventing a spark from forming.	
	Total: 6 marks

(Total for Question 2 is 13 marks)

3. The figure below shows how an electrostatic filter traps dust.

Dusty air is blown through a system of metal rods and plates. A high voltage supply is used to maintain a large potential difference across the rods and plates.



a) Identify the charge of the metal rods and the metal plates.

Metal rods: <u>Negative</u>	1 mark
Metal plates: <u>Positive</u>	1 mark
	Total: 2 marks

b) Using the diagram, explain how the electrostatic air filter removes dust particles from the air.

You should refer to the charges on the metal rods and metal plates in your answer.

Any four of the following logically sequenced points:	
- The dust particles pass the negatively charged rods. - The dust particles gain electrons / become negatively charged. - The dust particles are then repelled by the (negatively charged) rods. - The dust particles are attracted to the positively charged plates. - Opposite charges attract. - The dust particles stick to the plates (and are therefore removed from the air).	
	Total: 4 marks

(Total for Question 3 is 6 marks)

4. A manufacturer uses an electrostatic spray gun to paint metal car doors.

As the paint droplets leave the nozzle of the spray gun, they pass over a high-voltage electrode and gain a negative electrical charge. The figure below shows a person painting a car door.



- a) The negatively charged paint droplets spread out rapidly as they leave the nozzle, forming a very fine, wide mist. Explain why the paint droplets spread out.

The paint droplets all have the same charge (negative).	1 mark
Therefore they repel each other (causing them to spread out).	1 mark
	Total: 2 marks

- b) The metal car door is attached to the positive terminal of the power supply, giving it a positive charge. Explain **two** advantages of using this electrostatic method compared to using a normal, uncharged spray.

Award 2 marks for each advantage explicitly explained:	
Advantage 1: even coat. Explanation: - The paint droplets repel each other. - Which produces a very fine / even / uniform layer of paint on the car.	
Advantage 2: less waste. Explanation: - The (negative) paint is attracted to the (positive) car door. - Meaning less paint is wasted this saves money/paint.	
Advantage 3: reach hidden areas. Explanation: - The paint is attracted to the car door. - So it will wrap around / reach the back / coat hidden edges that the spray gun wasn't pointed directly at.	
	Total: 4 marks

The car door is held up using a metal frame.

- c) Explain why the frame is made of a conducting material, rather than an insulating material like wood.

A conducting frame allows electrons/charge to flow through it.	1 mark
This maintains the positive charge on the car door / completes the circuit / prevents a dangerous build-up of static charge on the frame.	1 mark
	Total: 2 marks

(Total for Question 4 is 8 marks)

5. During a thunderstorm, a massive build-up of static electricity occurs inside clouds. This can result in a lightning strike. The figure below shows a thundercloud above a tall building.



- a) Inside the thundercloud, particles of ice and water move around and rub against each other rapidly. Explain how this causes the bottom of the cloud to become negatively charged.

Friction (between the ice and water particles).	1 mark
Causes electrons to be transferred / rubbed off.	1 mark
These electrons gather / build up at the bottom of the cloud.	1 mark
	Total: 3 marks

- b) The bottom of the cloud is highly negatively charged. Explain how the roof becomes positively charged, even though the cloud does not touch it.

The negative charge on the bottom of the cloud repels electrons (on the roof of the building).	1 mark
The electrons move away (down into the building/earth), leaving the roof with a net positive charge.	1 mark
Allow: like charges repel, so the electrons in the roof move downwards.	
	Total: 2 marks

- c) A lightning flash is a very large spark. State the condition required for a spark to jump across the air gap between the cloud and the building.

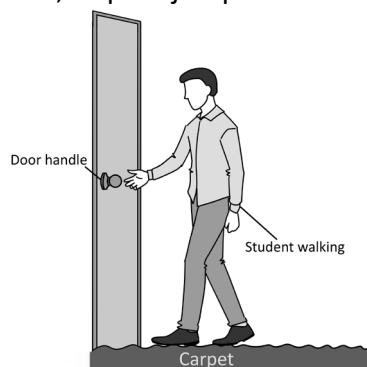
A very high potential difference / voltage (between the cloud and the building).	1 mark
Allow: the electric field strength exceeds the breakdown voltage of air.	
	Total: 1 mark

- d) The lightning conductor protects the building from damage if it is struck by lightning. Explain how the copper strip and its connection to the ground keep the building safe.

Any four of the following logically sequenced points:	
- Copper is a very good electrical conductor. - It provides a path of low resistance to the earth. - If lightning strikes, the huge current / electrons will flow through the copper. - Rather than flowing through the building structure / the people inside. - This safely dissipates the charge / earths the strike (preventing fire or structural damage).	
	Total: 4 marks

(Total for Question 5 is 10 marks)

6. A student walks across a nylon carpet and builds up a static electrical charge. When they reach for a metal door handle, a spark jumps between their finger and the metal.



- a) As the student walked across the carpet they became negatively charged. Explain how they became negatively charged.

Friction (between their shoes/socks and the carpet).	1 mark
Transferred electrons from the carpet to the student (so the student gained electrons).	1 mark
Allow: electrons were rubbed off the carpet onto the person for both marks.	
	Total: 2 marks

- b) When the student reached for the door handle they caused the door handle to become positively charged. Explain how the student caused the door handle to become positively charged.

The student's negative charge repelled the electrons in the metal door handle.	1 mark
(Because like charges repel), leaving the part of the handle near the finger with a net positive charge.	1 mark
	Total: 2 marks

The student has the following information about their static shock.

- The spark transfers 4.8 mJ of energy.
- The potential difference between the student and the door handle is 3000 V.
- The spark lasts for 0.2 ms (milliseconds).

- c) Calculate the current in the spark.

Energy = 0.0048 (J) or 4.8×10^{-3} Time = 0.0002 (s) or 0.2×10^{-3}	1 mark
$E = V \times I \times t$	
$0.0048 = 3000 \times I \times 0.0002$	1 mark
$I = 0.0048 \div (3000 \times 0.0002)$	1 mark
$I = 0.008 \text{ A}$	1 mark
	Total: 4 marks

(Total for Question 6 is 8 marks)