

Static electricity and electric fields

AQA GCSE Separate Physics 8463 | Paper 1 | Foundation and Higher

Worked answers and marking guidance | 27 parts | 50 marks

Specification points covered

8463 4.2.5.1: static charge, electron transfer and non-contact forces

8463 4.2.5.2: electric fields, isolated-sphere patterns and sparking

A manufacturer powder-coats metal panels. Technicians investigate how charged powder behaves, then review a fault that could allow a spark. Each test has the conditions stated in its section.

Original PhysicsUK practice, not an official AQA resource. Credit equivalent scientifically correct reasoning. This topic is Separate Physics only, but is assessed at both tiers. No Coulomb's law or field-strength equation is required.

1 Charging the powder

Initially neutral insulating powder particles rub against an initially neutral insulating liner inside the delivery tube. The powder becomes negatively charged. Treat the powder and liner as an isolated pair during this charging test.

1(a) Name the particle transferred between the insulating surfaces during charging. **[1 mark]**

Answer / mark points: Electrons. [1] Not protons, positive electrons or atoms.

1(b) What is an electric field? **[1 mark]**

Answer / mark points: A region where a charged object experiences an electric force. [1] The force acts without contact.

1(c) Explain how the powder becomes negative and state the resulting charge on the liner. **[2 marks]**

Answer / mark points: Electrons transfer from the liner to the powder, so the powder gains an excess of electrons. [1]
The liner loses electrons and becomes positive. [1] Equal and opposite net charges are produced in this isolated pair.

1(d) A trainee says, "The liner became positive because protons moved into it." Correct this explanation. **[2 marks]**

Answer / mark points: The liner becomes positive by losing electrons. [1]
Protons remain in the atomic nuclei; they do not move between these surfaces during charging. [1]
Positive charge here means an electron deficit, not transferred protons.

1(e) A separate, initially neutral batch gains 6 million electrons. Later, 2 million electrons return to the liner. Calculate the number of excess electrons left on this batch and state its net charge sign. **[2 marks]**

Answer / mark points: Excess electrons = 6 million – 2 million = 4 million. [1]
The batch is still negatively charged. [1] It has not become positive merely because some electrons left.



2 Will the powder reach the panel?

Figure 1 is a separate test: the metal panel is pre-charged positively and rests on an insulating support. It is not earthed. All six powder particles are negative. When considering the panel's force on one particle, ignore forces from the other particles. Compare positions before any particle touches the panel.

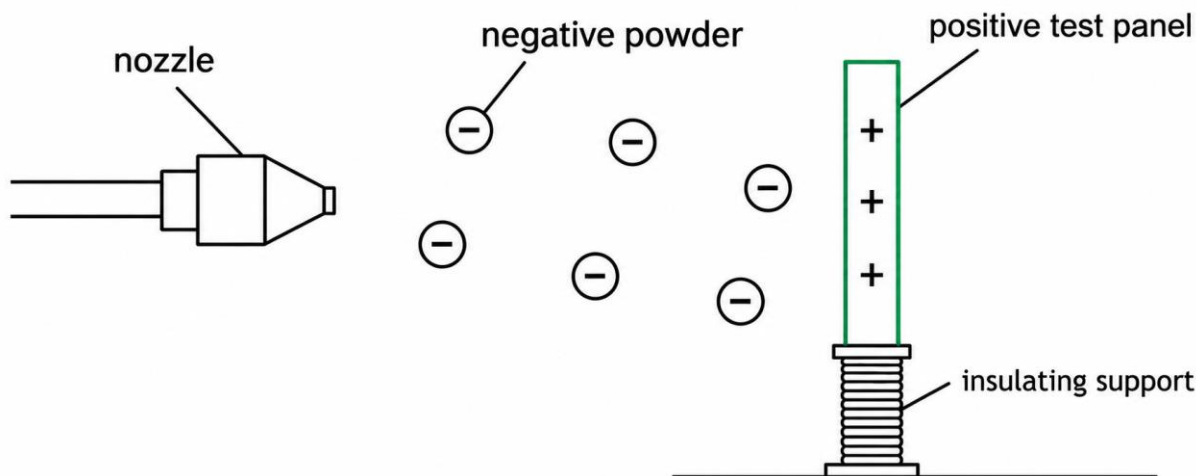


Figure 1

2(a) State the direction of the electric force exerted by the positive panel on a negative powder particle. Explain your answer. **[2 marks]**

Answer / mark points: Towards the panel (to the right in Figure 1). [1]
The panel and particle have opposite charges, so they attract. [1] This asks about the panel's electric force, not the particle's total motion.

2(b) Predict whether two airborne powder particles attract or repel each other. Explain why. **[2 marks]**

Answer / mark points: They repel. [1] Both are negatively charged; like charges repel. [1] Their interaction is separate from their attraction to the panel.

2(c) Suggest how the force between the powder particles can help the coating process. **[1 mark]**

Answer / mark points: Repulsion spreads particles apart/reduces clumping, helping distribute the powder over the panel. [1] It does not guarantee a perfectly uniform coating.

2(d) The same powder particle is tested farther from the panel. The charges are unchanged. State how the panel's electric force changes and explain why. **[2 marks]**

Answer / mark points: The force becomes weaker. [1] The electric field is weaker farther from the charged panel. [1] No quantitative distance law is required.



3 What does attraction prove?

A known negatively charged probe is brought near two freely suspended objects in separate tests. There is no contact or spark. The objects are free to move. Table 1 records the observations.

Table 1

Object tested	Response to the negative probe
X	Repelled
Y	Attracted

3(a) State X's charge sign and explain how the observation supports your answer. **[2 marks]**

Answer / mark points: X is negative. [1]

Repulsion shows it has the same charge sign as the negative probe. [1] Repulsion is evidence of like net charges in this test.

3(b) Does the observation prove that Y is positively charged? Explain. **[2 marks]**

Answer / mark points: No. [1] Y could be a neutral object whose charges redistribute near the probe, producing attraction. [1]

A positive Y is possible, but attraction alone does not establish that. Do not award "Y must be negative".

For 3(c) and 3(d), consider an initially neutral, isolated metal piece. Electrons can move within the metal; positive nuclei remain fixed. There is no contact, spark or earth connection.

3(c) A negative particle approaches one side of the neutral metal piece. Explain how its electrons redistribute and why the piece can be attracted. **[3 marks]**

Answer / mark points: Electrons in the metal are repelled away from the nearer side. [1]

This leaves the nearer side positive and the farther side negative. [1]

The attraction to the nearer positive region is stronger than repulsion from the farther negative region. [1] Accept an equivalent closer/farther force explanation. The terms induction or polarisation are not required.

3(d) After this redistribution, what is the overall charge of the isolated metal piece? Give a reason. **[1 mark]**

Answer / mark points: It remains neutral because no electrons have entered or left it; they have only moved within it. [1 for charge with reason] The positive nuclei remain fixed.



4 Mapping the field

Figure 2 shows two separate tests with isolated spherical charged sensors. A is positive and B is negative. They are not next to each other in the actual tests. P and Q are positions outside B. Any test particle is small enough not to change the source field.

4(a) Draw the electric field pattern around A in Figure 2. Include arrows showing its direction. **[2 marks]**

Answer / mark points: Straight radial lines distributed around the sphere. [1]

Arrows point outwards, away from the positive sphere. [1] Lines begin at the surface, do not cross and do not join A to B. An isolated sphere is shown, not a uniform parallel field.

4(b) Add arrowheads to the field lines around B to show the field direction. **[1 mark]**

Answer / mark points: Arrowheads point inwards, towards the negative sphere, on the radial spokes. [1] Field direction is the force direction on a positive test charge.

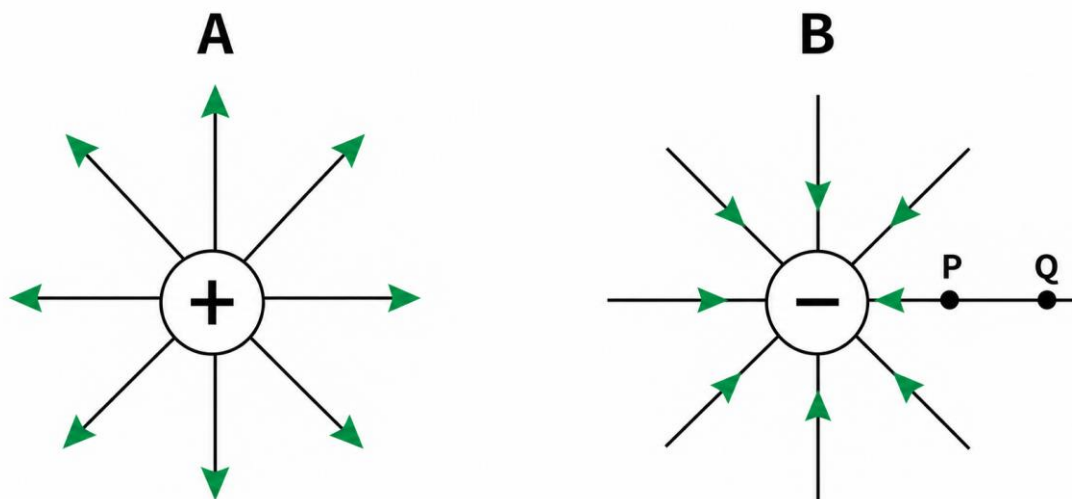


Figure 2

4(c) Compare the field strength at P and Q. Hence compare the force on the same positive test particle placed at each point. **[2 marks]**

Answer / mark points: The field is stronger at P, which is nearer B. [1]

The same positive test particle experiences a greater force at P than at Q. [1] Do not infer a numerical ratio from this schematic.

4(d) At P, state the force direction on a positive test particle and on a negative powder particle. **[2 marks]**

Answer / mark points: Positive particle: towards B (left). [1]

Negative particle: away from B (right). [1] The force on a negative particle is opposite to the field direction.

4(e) B is changed to a positive sphere. A negative powder particle is still at P. State its new force direction and explain why. **[2 marks]**

Answer / mark points: Towards B (left), reversing the previous direction. [1]

The negative powder and positive sphere now have opposite charges and attract. [1] The field itself points away from the positive sphere.



5 When can air conduct?

In a separate test, a negatively charged metal rail is near an earthed conductor. Air is normally an insulator. Table 2 shows the largest gap that allowed a spark at each potential difference (p.d.). In these tests a spark occurred at or below that maximum gap. All other conditions were kept the same. These data are not a universal rule for every air gap.

Table 2

Potential difference / kV	Largest spark gap / mm
10	3.0
20	6.0
30	9.0

5(a) Explain how a spark can pass across the air gap from the negatively charged rail to the earthed conductor. **[3 marks]**

Answer / mark points: A large potential difference/strong electric field exists across the gap. [1]

The air becomes ionised and can conduct. [1]

Electrons move through the air from the negative rail towards the earthed conductor. [1] A spark is a discharge. Do not assume an earthed conductor has a positive net charge.

5(b) At 20 kV, predict whether a spark occurs across a 4.0 mm gap and an 8.0 mm gap. Justify both predictions using Table 2. **[2 marks]**

Answer / mark points: 4.0 mm: a spark occurs because the gap is below the measured maximum of 6.0 mm. [1]

8.0 mm: no spark occurs in these conditions because the gap exceeds 6.0 mm. [1] Each prediction must be linked to the table.

5(c) Use the linear trend in Table 2 to estimate the largest spark gap at 25 kV. **[1 mark]**

Answer / mark points: 25 kV is halfway between 20 and 30 kV, so the estimated gap is halfway between 6.0 and 9.0 mm: 7.5 mm. [1] This is interpolation within these measurements, not a universal field equation.

5(d) Name one condition, other than potential difference, that should be controlled when comparing these maximum spark gaps. **[1 mark]**

Answer / mark points: One of: air humidity, air pressure, air temperature, or electrode shape/size/material. [1] A named relevant air/electrode condition is sufficient. Do not require the gap to remain constant: the maximum gap is what is being measured.

5(e) The rail discharges through a spark. Explain what happens to its excess electrons and its negative charge. **[2 marks]**

Answer / mark points: Excess electrons leave the rail towards the earthed conductor. [1]

The rail becomes less negatively charged as the electron imbalance decreases. [1] Do not insist the discharge removes every excess electron or that electrons become positive.



6 An earthing fault on the coating line

An earth connection is a conducting path to Earth, which can receive or provide electrons. In 6(a) and 6(b), the charging source is disconnected before the metal panel is connected to Earth. In 6(c) and 6(d), powder continues to arrive at the production panel.

6(a) The disconnected metal panel is initially negative. State the direction of electron flow when it is earthed and explain the change in its charge. **[2 marks]**

Answer / mark points: Electrons flow from the negative panel to Earth. [1]
Its excess electrons are removed, so it becomes less negative (neutral when fully discharged). [1]
Protons do not move to Earth.

6(b) The disconnected panel is instead initially positive. In which direction do electrons flow when it is earthed? **[1 mark]**

Answer / mark points: From Earth to the positively charged panel. [1] Earth supplies electrons to reduce the electron deficit; positive charge does not need to flow out as protons.

6(c) A wire touches the production panel, but its other end is not connected to Earth. Will this reliably prevent charge building up as more negative powder arrives? Explain. **[2 marks]**

Answer / mark points: No: there is no conducting connection from the panel-wire system to Earth. [1]
Charge may redistribute along the floating wire, but continuing deposition can still build up excess electrons on the isolated panel-wire system. [1] Do not say electrons cannot move anywhere in the wire.

6(d) A damaged earth connection lets negative charge build up on the production panel near a combustible powder cloud. Explain how restoring a conducting earth connection reduces the spark hazard. Link the charge, potential difference, air and possible consequence. **[4 marks]**

Answer / mark points: Deposited electrons would otherwise build up negative charge and a large potential difference to nearby earthed objects. [1]
A conducting earth path allows excess electrons to leave, reducing charge/potential-difference build-up. [1]
The smaller field across an air gap is less likely to ionise the air and produce a spark. [1]
A spark could ignite the combustible powder cloud, so reducing sparking reduces this ignition hazard. [1] It does not prove the process is risk-free or replace a full safety assessment.

Review and improve

Require the quantity and its change: electrons transfer, charge builds up, field becomes stronger, force changes. Attraction alone does not prove opposite net charges. Timing is estimated, not trialled. No practical-completion or safety-certification claim.

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