Grade 9 Optional Science, Explained

Unit 14 · Electricity and Magnetism

ANSWER KEY · FOR TEACHERS

Full marks 44

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. test charge → **d.** a small positive charge used to find a field
2. electric field intensity → **a.** the force on a unit positive charge at a point
3. capacitance → **e.** the ratio of the charge on either plate to the potential difference between the plates
4. dielectric → **b.** the insulator between the plates of a capacitor
5. neutral point → **f.** a point where the resultant field is zero
6. angle of declination → **g.** the angle between the geographic meridian and the magnetic meridian

K · 3

Each carries 0.5 mark.

2 Label the diagram

1. metal plate
2. +Q
3. −Q
4. insulator (dielectric)

K · 2

Each carries 0.5 mark.

3 Multiple choice

i. **a.** point straight outward in all directions — K · 1

A positive test charge is pushed directly away from a positive charge, so the lines point radially outward. Electric lines of force never form closed loops round a charge.

ii. **c.** one ninth — A · 1

$F \propto 1/r^2$: tripling r divides F by $3^2 = 9$.

iii. **d.** 60 μC — A · 1

$Q = CV = 10\ \mu\text{F} \times 6\ \text{V} = 60\ \mu\text{C}$. Microfarads times volts give microcoulombs.

iv. **b.** a south pole — U · 1

It attracts the N pole of a compass, and unlike poles attract, so it is a south pole, though it is called the North Magnetic Pole for where it is.

v. **c.** dip circle — K · 1

A dip circle has a needle that turns in a vertical plane in front of a vertical scale. A declinometer measures the declination; a galvanometer measures small currents.

4 Very short answers

a. MARKING SCHEME — U · 1

✓ Halfway between the charges.

b. MARKING SCHEME — K · 1

✓ The highest voltage it can safely take.

c. MARKING SCHEME — U · 1

✓ Plastic doesn't conduct, so the capacitance doesn't change.

d. MARKING SCHEME — K · 1

✓ 0°.

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5 Short answers

a. MARKING SCHEME U · 2

- ✓ The tangent at a point gives the direction of the field there.
- ✓ Two lines crossing would give the field two directions at one point, which is impossible.

b. MARKING SCHEME U · 2

- ✓ The plates are separated by an insulator that charge can't cross.
- ✓ Charge flows only until the capacitor's voltage equals the battery's; then the flow stops.

c. MARKING SCHEME U · 2

- ✓ The magnet's field is equal and opposite to the Earth's horizontal field, so the resultant is zero.
- ✓ With no force to turn it, the needle stays in any direction it is left in.

d. MARKING SCHEME U · 2

- ✓ In the magnetic meridian the needle feels the whole of the horizontal part, so it shows the true dip.
- ✓ In any other plane it feels less of the horizontal part and the same vertical part, so it dips too steeply.

6 Long answers

a. ANSWER A · 4

A neutral point is a point in a magnetic field where the field of a magnet is equal and opposite to the Earth's horizontal field, so the resultant field is zero; a compass there doesn't point in any particular direction.

i. With the N pole pointing north, the neutral points lie east and west of the magnet, on the line through its middle at right angles to it.

ii. With the N pole pointing south, they lie on the axis of the magnet, north and south, beyond its two ends. (the figure in the book shows both.)

MARKING SCHEME

- ✓ A point where the magnet's field is equal and opposite to the Earth's horizontal field, so the resultant is zero.
- ✓ N pole pointing north: the lines of force drawn from N to S, with the Earth's lines beyond them.
- ✓ N pole pointing north: neutral points east and west of the magnet, on the line through its middle.
- ✓ N pole pointing south: neutral points on the axis, beyond both ends.

b. ANSWER K · 4

Level the base of the dip circle with its leveling screws and spirit level. Turn the circle on the horizontal scale until the needle stands vertical: its plane is then at right angles to the magnetic meridian. Turn the circle through exactly 90°, so that the needle swings in the magnetic meridian. Read both ends of the needle on the vertical scale. Turn the circle through 180° and read both ends again. The mean of the readings is the angle of dip.

MARKING SCHEME

- ✓ Level the base with the leveling screws and spirit level.
- ✓ Turn the circle until the needle stands vertical, then through exactly 90°, so that it swings in the magnetic meridian.
- ✓ Read both ends of the needle on the vertical scale.
- ✓ Turn through 180°, read both ends again, and take the mean.

7 Numerical problems

a. ANSWER A · 2

$$F = \frac{9 \times 10^9 \times 5 \times 10^{-6} \times 4 \times 10^{-6}}{(0.30)^2} = \frac{0.18}{0.09} = 2\ \text{N}$$

2 N, an attraction (unlike charges).

MARKING SCHEME

- ✓ $F = 9 \times 10^9 \times 5 \times 10^{-6} \times 4 \times 10^{-6} \div (0.30)^2$, with the distance in meters.
- ✓ 2 N, an attraction.

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b. ANSWER A · 3

$$q^2 = \frac{Fr^2}{k} = \frac{3.6 \times (0.05)^2}{9 \times 10^9} = \frac{9 \times 10^{-3}}{9 \times 10^9} = 10^{-12}\ \text{C}^2$$

q = 10^{-6} C = 1 μC each.

MARKING SCHEME

✓ $q^2 = Fr^2/k$, with r = 0.05 m.
✓ $q^2 = 10^{-12}$ C^2.
✓ q = 10^{-6} C = 1 μC.

c. ANSWER A · 3

$$F = \frac{9 \times 10^9 \times (10^{-7})^2}{(0.03)^2} = \frac{9 \times 10^{-5}}{9 \times 10^{-4}} = 0.1\ \text{N}$$

Weight = $mg = 0.9 \times 10^{-3} \times 10 = 9 \times 10^{-3}$ N.
$F \div W = 0.1 \div 0.009 = 11$. **The electrostatic force is about 11 times the ball's weight**, though each ball carries only a tenth of a microcoulomb. This is why small charged bits of paper jump up to a comb against gravity.

MARKING SCHEME

✓ F = 0.1 N.
✓ Weight = 9×10^{-3} N.
✓ F is about 11 times the weight.

d. ANSWER A · 3

i. $Q = CV = 150 \times 10^{-6} \times 300 = 0.045$ C.

ii. $I = \frac{Q}{t} = \frac{0.045}{1 \times 10^{-3}} = 45$ A.

0.045 C; an average current of 45 A, far more than the camera's small battery could give. The capacitor collects the charge slowly and lets it go all at once.

MARKING SCHEME

✓ Q = $150 \times 10^{-6} \times 300$.
✓ Q = 0.045 C.
✓ I = $0.045 \div (1 \times 10^{-3}) = 45$ A.

8 Think

ANSWER HA · 3

70° is far too steep. A dip needle dips more steeply than the true angle whenever its plane is not in the magnetic meridian, so she has most probably not set the circle in the meridian. To check, she turns the circle slowly on its horizontal scale: the smallest reading, about 45°, is the angle of dip.

MARKING SCHEME

✓ 70° is much steeper than the true dip of about 45°.
✓ The circle isn't in the magnetic meridian.
✓ Turning the circle slowly: the smallest reading is the true angle of dip.

9 Activity: Finding the angle of dip (Practicals 27 and 29)

(not marked)

WHAT STUDENTS SHOULD FIND

In Kathmandu the mean is about 44°, with the N end down, toward the north (a little less in the Terai, a little more in the far west; a home-made needle may be a few degrees off). Turned through 90°, the needle dips close to straight down: it feels none of the horizontal part of the field, only the vertical part. So the needle must be set in the magnetic meridian.

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See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **Static Electricity** (exhibit): Watch the light beads jump and cling: each charged bead feels a force in the electric field of the charges around it.
- **Magnetic Lines of Force** (exhibit): The hanging screws line up along the magnet's lines of force, each screw becoming a small magnet for a while: the field made visible.
- **Earth's Magnetic Field** (exhibit): Find Nepal, where the angle of declination is close to zero, then a place where a compass points far from true north.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	13	11	17	3	**44**