

Charges, coulomb's law and electric potential

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Marks are awarded for a correct formula, a correct conversion to base units, a clear substitution and a final answer with its unit. Allow answers within rounding error and award method marks if an earlier slip is carried forward consistently.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB D.2

Question 1 Defining field strength (2 marks)

Electric field strength is the **force per unit positive charge** acting on a small test charge placed at the point, $E = F / q$. A unit is **N/C** (or V/m).

Marking: 1 mark for the definition, 1 mark for the unit.

Question 2 Two charged spheres (3 marks)

- a. $F = kQ_1Q_2 / r^2 = (8.99 \times 10^9 \times 5.0 \times 10^{-9} \times 3.0 \times 10^{-9}) / (0.060)^2 = \mathbf{3.7 \times 10^{-5} \text{ N}}$.
b. It is **attractive** because the charges have opposite signs.

Marking: (a) 1 mark for the substitution with r in metres, 1 mark for the answer. (b) 1 mark.

Question 3 Changing the distance (2 marks)

The distance triples, so the force falls by a factor of $3^2 = 9$: $F = 1.8 \times 10^{-3} / 9 = \mathbf{2.0 \times 10^{-4} \text{ N}}$.

Marking: 1 mark for the inverse square factor, 1 mark for the answer.

Question 4 Field between plates (3 marks)

- a. $E = V / d = 900 / 0.030 = \mathbf{3.0 \times 10^4 \text{ V/m}}$.
b. $F = qE = 1.5 \times 10^{-9} \times 3.0 \times 10^4 = \mathbf{4.5 \times 10^{-5} \text{ N}}$.

Marking: (a) 1 mark. (b) 1 mark for the formula, 1 mark for the answer.

Question 5 Field lines (2 marks)

The field at any point has only one direction. If lines crossed, the field would have two directions at the crossing point, which is impossible. Lines that are closer together show a **stronger field**.

Marking: 1 mark for the single direction argument, 1 mark for spacing meaning strength.

Question 6 Electron gun (3 marks)

a. $KE = eV = 1.60 \times 10^{-19} \times 2500 = \mathbf{4.0 \times 10^{-16} \text{ J}}$.

b. $v = \sqrt{2 KE / m} = \sqrt{(2 \times 4.0 \times 10^{-16} / 9.11 \times 10^{-31})} = \mathbf{3.0 \times 10^7 \text{ m/s}}$.

Marking: (a) 1 mark. (b) 1 mark for the formula, 1 mark for the answer.

Question 7 Potential between plates (2 marks)

The field is uniform, so the potential changes linearly: $V = 80 \times (1.0 / 4.0) = \mathbf{20 \text{ V}}$ at P. The field is $E = 80 / 0.040 = \mathbf{2.0 \times 10^3 \text{ V/m}}$.

Marking: 1 mark for the potential at P, 1 mark for E.

Question 8 Potential of a point charge (3 marks)

a. $V = kQ / r = (8.99 \times 10^9 \times 5.0 \times 10^{-9}) / 0.25 = \mathbf{180 \text{ V}} \approx \mathbf{1.8 \times 10^2 \text{ V}}$.

b. $W = eV = 1.60 \times 10^{-19} \times 179.8 = \mathbf{2.9 \times 10^{-17} \text{ J}}$.

Marking: (a) 1 mark for the formula, 1 mark for the answer. (b) 1 mark.