8.1 Electric Charge and Electric Force

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS conserved • superposition • coulomb's law • electric charge • gravitational force

Objective

Build the skills to answer exam questions on **electric charge and electric force**.

You must be able to:

- describe **electric charge** as **quantized** in multiples of e and **conserved**
- apply **Coulomb's law** $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$
- use the **superposition principle** to find the net force from several charges
- compare the electrostatic force with the **gravitational force**

1 Key knowledge and worked examples

Study these first. Each one shows the method for a question type used later.

Coulomb's law

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = k\frac{q_1 q_2}{r^2}$, with $k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9$ N m^2 C^{-2}.

Superposition

The net force on a charge is the **vector sum** of the Coulomb forces from every other charge.

Charge is quantized and conserved

Any charge is a whole multiple of $e = 1.6 \times 10^{-19}$ C, and total charge is conserved. The electric force vastly exceeds gravity between two charged particles.

2 Practice

2.1 Two $+2.0\ \mu$C charges are 0.30 m apart. Find the force between them. [2]

2.2 State which is stronger for two charged particles: the electrostatic force or the gravitational force. [1]

2.3 An object carries a charge of 8.0×10^{-19} C. Find the number of elementary charges. [2]

3 Exam-style questions

3.1 The Coulomb force between two point charges is proportional to [1]

- ☐ **A** r
- **B** $1/r$
- **C** $1/r^2$
- **D** r^2

3.2 To find the net force on a charge from several others, you use [1]

- ☐ **A** only the nearest charge
- **B** vector superposition of all the forces
- **C** the average of the forces
- **D** the largest force only

3.3 Charges of $+3.0\ \mu\text{C}$ sit at $x = 0$ and $x = 0.20$ m. A $+1.0\ \mu\text{C}$ charge is placed at the midpoint $x = 0.10$ m.

(a) Find the force on the middle charge from **one** of the outer charges. [2]

(b) State the net force on the middle charge, and explain why. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $F = k\frac{q_1 q_2}{r^2} = 8.99 \times 10^9 \times \frac{(2.0 \times 10^{-6})^2}{(0.30)^2} = 0.40$ N

2.2

- the electrostatic force (by far)

2.3

- $N = \frac{8.0 \times 10^{-19}}{1.6 \times 10^{-19}} = 5$

3.1 C

- $1/r^2$.

3.2 B

- vector superposition of all the forces.

3.3

(a)

- $F = 8.99 \times 10^9 \times \frac{(3.0 \times 10^{-6})(1.0 \times 10^{-6})}{(0.10)^2} = 2.7$ N

(b)

- zero – the two outer charges push the middle charge with equal forces in opposite directions, which cancel