

8.1 Electric Charge and Electric Force

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS conserved 守恒 • superposition 叠加 • coulomb's law 库仑定律 • electric charge 电荷
• gravitational force 引力

Objective

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

You must be able to:

- describe **electric charge** 电荷 as **quantized** in multiples of e and **conserved** 守恒
- apply **Coulomb's law** 库仑定律 $F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$
- use the **superposition principle** 叠加原理 to find the net force from several charges
- compare the electrostatic force with the **gravitational force** 引力

1 Worked examples

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

■ Coulomb's law

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} = k \frac{q_1 q_2}{r^2}, \text{ with } k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}.$$

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

2 Practice

2.1 Two $+2.0\ \mu\text{C}$ charges are $0.30\ \text{m}$ 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 $8.0 \times 10^{-19}\ \text{C}$. 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
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3.3 Charges of $+3.0\ \mu\text{C}$ sit at $x = 0$ and $x = 0.20\ \text{m}$. A $+1.0\ \mu\text{C}$ charge is placed at the midpoint $x = 0.10\ \text{m}$.

(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

2.1 $F = k \frac{q_1 q_2}{r^2} = 8.99 \times 10^9 \times \frac{(2.0 \times 10^{-6})^2}{(0.30)^2} = 0.40 \text{ N}.$

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.

3.2 B.

3.3 (a) $F = 8.99 \times 10^9 \times \frac{(3.0 \times 10^{-6})(1.0 \times 10^{-6})}{(0.10)^2} = 2.7 \text{ N}.$ (b) zero — the two outer charges push the middle charge with equal forces in opposite directions, which cancel.