

10.1 Electric Charge and Electric Force

Name: _____ Class: _____ Date: _____ **Total: 10 marks****KEY WORDS** coulomb's law 库仑定律 • electric charge 电荷 • charge quantization 电荷量子化

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 a conserved property in positive and negative types
- state that like charges repel and unlike charges attract
- apply **Coulomb's law** 库仑定律 $F = k \frac{q_1 q_2}{r^2}$
- explain **charge quantization** 电荷量子化 — charge in whole multiples of e

1 Worked examples

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

■ Charge and force

Charge comes in two types; **like repel, unlike attract**, and total charge is conserved.

■ Coulomb's law

 $F = k \frac{q_1 q_2}{r^2}$ with $k = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$ — an inverse-square law like gravity.

■ Quantization

Charge is always a whole multiple of $e = 1.6 \times 10^{-19} \text{ C}$.

■ Example

Two $+2.0 \mu\text{C}$ charges 0.10 m apart: $F = 8.99 \times 10^9 \times \frac{(2.0 \times 10^{-6})^2}{(0.10)^2} = 3.6 \text{ N}$ (repulsive).

2 Practice

2.1 State whether two negative charges attract or repel. [1]

2.2 Two point charges are moved twice as far apart. State the factor by which the force between them changes. [1]

2.3 Find the force between a $+3.0 \mu\text{C}$ and a $-3.0 \mu\text{C}$ charge 0.20 m apart ($k = 8.99 \times 10^9$). [2]

3 Exam-style questions

3.1 The Coulomb force between two point charges varies with their separation as [1]

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

3.2 An object carries a charge of $-4.8 \times 10^{-19} \text{ C}$. The number of excess electrons is [1]

- **A** 1
- **B** 2
- **C** 3
- **D** 4

3.3 Two point charges, $+5.0 \mu\text{C}$ and $+2.0 \mu\text{C}$, are 0.30 m apart.

(a) Find the force between them. [3]

(b) State whether the force is attractive or repulsive. [1]

Solutions

2.1 repel.

2.2 it becomes one quarter as large ($1/2^2$).

2.3 $F = 8.99 \times 10^9 \times \frac{(3.0 \times 10^{-6})^2}{(0.20)^2} = 2.0 \text{ N}$, attractive.

3.1 B.

3.2 C — $4.8 \times 10^{-19} / 1.6 \times 10^{-19} = 3$.

3.3 (a) $F = 8.99 \times 10^9 \times \frac{(5.0 \times 10^{-6})(2.0 \times 10^{-6})}{(0.30)^2} = 1.0 \text{ N}$. (b) repulsive (both charges positive).