9.2 Electric Potential

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

Objective

Build the skills to answer exam questions on **electric potential**.

You must be able to:

- define **electric potential** 电势 as energy per unit charge, $V = \frac{U}{q}$
- calculate the potential of a point charge, $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$, and use superposition
- relate potential to field through $V = -\int \vec{E} \cdot d\vec{l}$ and $\vec{E} = -\nabla V$
- describe **equipotential surfaces** 等势面 as perpendicular to the field

1 Worked examples

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

■ **Electric potential**

$V = \frac{U}{q}$, in volts. For a point charge $V = k\frac{q}{r}$ —a **scalar**, so potentials just add (superposition).

■ **Field and potential**

$V = -\int \vec{E} \cdot d\vec{l}$, and conversely $\vec{E} = -\nabla V$: the field points **down** the steepest potential drop.

■ **Equipotentials**

Surfaces of constant V are always **perpendicular** to the field lines; no work is done moving a charge along one.

2 Practice

2.1 Find the potential 0.30 m from a +6.0 μC charge ($k = 8.99 \times 10^9$). [2]

2.2 State the relationship between equipotential surfaces and field lines. [1]

2.3 State whether electric potential is a scalar or a vector. [1]

3 Exam-style questions

3.1 The electric potential of a point charge is [1]

- **A** $k\frac{q}{r^2}$
- **B** $k\frac{q}{r}$
- **C** $k\frac{q^2}{r}$
- **D** qE

3.2 Equipotential surfaces are always _____ to the electric field. [1]

- **A** parallel
- **B** perpendicular
- **C** at 45°
- **D** unrelated

3.3 Two +4.0 μC charges are 0.40 m apart.

(a) Find the potential at the midpoint between them. [3]

(b) State why the two potentials can simply be added. [1]

4 Go further

- work through the **9.2 Electric Potential** lesson on the **Learn** page;

- read the **Electric Potential** section of the AP Physics C: E&M handout on the **Know** page.

Solutions

2.1 $V = k\frac{q}{r} = 8.99 \times 10^9 \times \frac{6.0 \times 10^{-6}}{0.30} = 1.8 \times 10^5$ V.

2.2 they are perpendicular to each other.

2.3 a scalar.

3.1 B.

3.2 B.

3.3 (a) each charge is 0.20 m from the midpoint: $V = 2 \times k\frac{q}{r} = 2 \times 8.99 \times 10^9 \times \frac{4.0 \times 10^{-6}}{0.20} = 3.6 \times 10^5$ V. (b) potential is a scalar, so contributions add directly (no direction).