Exercise walk-through

Electric Potential Energy ▪ 9.1

eXercise

You must be able to

- define **electric potential energy 电势能** as the work to assemble a charge configuration
- calculate the potential energy of two point charges, $U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$, with its sign
- find the total potential energy of a system by summing over all **pairs**
- relate the work done by the electric force to $W = -\Delta U$

Method — Potential energy of a pair

$U = k\dfrac{q_1 q_2}{r}$ — **positive** for like charges, **negative** for unlike.

Method — System of charges

Add U over every **distinct pair** of charges.

Method — Work and a conservative force

The electric force is **conservative**, so $W = -\Delta U$ and the energy depends only on position.

Practice 2.1 ▪ 2 marks

Find the potential energy of a $+3.0\ \mu$C and a $-2.0\ \mu$C charge 0.40 m apart ($k = 8.99 \times 10^9$).

Solution 2.1

Method: Potential energy of a pair

Worked steps

$$U = k\frac{q_1 q_2}{r} = 8.99 \times 10^9 \times \frac{(3.0 \times 10^{-6})(-2.0 \times 10^{-6})}{0.40} = -0.13 \text{ J}$$ M1 A1.

Practice 2.2 ▪ 1 mark

State the sign of the potential energy of two like charges.

Solution 2.2

Method: Potential energy of a pair

Worked steps

positive B1.

Practice 2.3 ▪ 1 mark

The electric force does $+6.0$ J of work on a charge. State the change in its potential energy.

Solution 2.3

Method: Work and a conservative force

Worked steps

$\Delta U = -6.0$ J **B1**.

Exam-style 3.1 ▪ 1 mark

The electric potential energy of two point charges is

A $k\frac{q_1 q_2}{r^2}$

B $k\frac{q_1 q_2}{r}$

C qE

D $\frac{1}{2}CV^2$

Solution 3.1

Method: Potential energy of a pair

A $k\frac{q_1 q_2}{r^2}$

B $k\frac{q_1 q_2}{r}$ ✓

C qE

D $\frac{1}{2}CV^2$

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

The work done by the electric force equals

A $+\Delta U$

B $-\Delta U$

C ΔU^2

D zero always

Solution 3.2

Method: Work and a conservative force

A $+\Delta U$

B $-\Delta U$ ✓

C ΔU^2

D zero always

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

Three $+2.0\ \mu$C charges sit at the corners of an equilateral triangle of side 0.30 m.
(a) Find the potential energy of **one** pair.
(b) State the total potential energy of the system.

Solution 3.3

Method: Potential energy of a pair

Worked steps

(a) $U = k\dfrac{q^2}{r} = 8.99 \times 10^9 \times \dfrac{(2.0 \times 10^{-6})^2}{0.30} = 0.12$ J **M1** **A1**. (b) three identical pairs, so $U_{\text{total}} = 3 \times 0.12 = 0.36$ J **M1** **A1**.