Exercise walk-through

Electric Potential Energy ▪ 10.4

eXercise

You must be able to

- define **electric potential energy 电势能** as the work done to assemble a charge configuration
- calculate the potential energy of two point charges, $U = k\frac{q_1 q_2}{r}$
- relate changes in potential energy to **work** done by the electric force
- apply **conservation of energy** to charges moving in a field

Method — Potential energy of two charges

$U = k\dfrac{q_1 q_2}{r}$ — **positive** for like charges (they store energy as they are pushed together) and **negative** for unlike charges.

Method — Work and energy

Work done by the field $= -\Delta U$. A charge released from rest gains kinetic energy equal to the drop in U.

Method — Example

A $+1.0\ \mu$C and a $+2.0\ \mu$C charge 0.10 m apart:

$$U = 8.99 \times 10^9 \times \frac{(1.0 \times 10^{-6})(2.0 \times 10^{-6})}{0.10} = 0.18 \text{ J}.$$

Practice 2.1 ▪ 2 marks

Find the electric potential energy of a $+2.0$ μC and a $+3.0$ μC charge 0.50 m apart ($k = 8.99 \times 10^9$).

Solution 2.1

Method: Example

Worked steps

$$U = 8.99 \times 10^{9} \times \frac{(2.0 \times 10^{-6})(3.0 \times 10^{-6})}{0.50} = 0.11 \text{ J}$$ M1 A1.

Practice 2.2 ▪ 1 mark

State the sign of the potential energy for two opposite charges.

Solution 2.2

Method: Potential energy of two charges

Worked steps

negative B1.

Practice 2.3 ▪ 1 mark

A charge is released and its potential energy falls by 5.0 J. State the kinetic energy it gains.

Solution 2.3

Method: Work and energy

Worked steps

5.0 J (energy is conserved) 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 two charges

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 electric potential energy of two unlike charges is

A positive

B negative

C zero

D infinite

Solution 3.2

Method: Potential energy of two charges

A positive

B negative ✓

C zero

D infinite

Worked steps

B.

Exam-style 3.3 ▪ 3 marks

Two $+4.0\ \mu$C charges are held 0.20 m apart.
(a) Find the electric potential energy of the pair.
(b) State what happens to this energy if the charges are released.

Solution 3.3

Method: Potential energy of two charges

Worked steps

(a) $U = 8.99 \times 10^9 \times \dfrac{(4.0 \times 10^{-6})^2}{0.20} = 0.72$ J M1 M1 A1. (b) it is converted into kinetic energy as the like charges fly apart B1.