Exercise walk-through

Conservation of Electric Energy ▪ 10.7

eXercise

You must be able to

- apply **conservation of energy 能量守恒** to a charge accelerated through a potential difference
- relate the kinetic energy gained to the work done by the field, $\Delta KE = q\Delta V$
- analyse energy transfers in systems of charges, fields, and capacitors

Method — Energy from a potential difference

A charge q moved through a potential difference ΔV has work $q\Delta V$ done on it, so $\Delta KE = q\Delta V$ if nothing else acts.

Method — Accelerating a charge

An electron accelerated through ΔV gains kinetic energy $e\Delta V$; setting this equal to $\frac{1}{2}mv^2$ gives its speed.

Method — Example

A $+2.0\ \mu$C charge through 500 V: $\Delta KE = (2.0 \times 10^{-6})(500) = 1.0 \times 10^{-3}$ J.

Practice 2.1 ▪ 2 marks

A charge of 5.0×10^{-6} C moves through a potential difference of 200 V. Find the kinetic energy it gains.

Solution 2.1

Worked steps

$\Delta KE = q\,\Delta V = (5.0 \times 10^{-6})(200) = 1.0 \times 10^{-3}$ J M1 A1.

Practice 2.2 ▪ 1 mark

State the energy conversion when a charge accelerates through a potential difference.

Solution 2.2

Method: Energy from a potential difference

Worked steps

electric potential energy is converted into kinetic energy **B1**.

Practice 2.3 ▪ 2 marks

An electron ($q = 1.6 \times 10^{-19}$ C) is accelerated through 100 V. Find the kinetic energy it gains.

Solution 2.3

Method: Accelerating a charge

Worked steps

$\Delta KE = (1.6 \times 10^{-19})(100) = 1.6 \times 10^{-17}$ J **M1** **A1**.

Exam-style 3.1 ▪ 1 mark

A charge q accelerated through a potential difference ΔV gains kinetic energy

A $q\Delta V$

B $q/\Delta V$

C $\frac{1}{2}q\Delta V^2$

D $\Delta V/q$

Solution 3.1

Method: Accelerating a charge

A $q\Delta V$ ✓

B $q/\Delta V$

C $\frac{1}{2}q\Delta V^2$

D $\Delta V/q$

Worked steps

A.

Exam-style 3.2 ▪ 1 mark

As a positive charge moves from high to low potential, its kinetic energy

A decreases

B increases

C stays constant

D becomes zero

Solution 3.2

A decreases

B increases ✓

C stays constant

D becomes zero

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A proton ($q = 1.6 \times 10^{-19}$ C, $m = 1.67 \times 10^{-27}$ kg) is accelerated from rest through 1000 V.

(a) Find the kinetic energy it gains.

(b) Find its final speed.

Solution 3.3

Method: Accelerating a charge

Worked steps

(a) $\Delta KE = q\,\Delta V = (1.6 \times 10^{-19})(1000) = 1.6 \times 10^{-16}$ J **M1** **A1**. (b) $\frac{1}{2}mv^2 = 1.6 \times 10^{-16} \Rightarrow v = \sqrt{\dfrac{2(1.6 \times 10^{-16})}{1.67 \times 10^{-27}}} = 4.4 \times 10^5$ m s^{-1} **M1** **A1**.