

Exercise walk-through

10.7

Conservation of Electric Energy

AP Physics 2

Conservation of electric energy

A charge **accelerated** through a potential difference turns field work into kinetic energy:

Accelerating a charge

$$\Delta KE = q \Delta V = \frac{1}{2}mv^2$$

A capacitor stores $\frac{1}{2}CV^2$, then hands it back – energy borrowed, not lost.

Worked example

An electron through 200 V:

$$\begin{aligned}\Delta KE &= (1.6 \times 10^{-19})(200) \\ &= 3.2 \times 10^{-17} \text{ J}\end{aligned}$$

$$v = \sqrt{\frac{2\Delta KE}{m}} \approx 8.4 \times 10^6 \text{ m/s}$$

Exam tips

- **Coulomb's law** and the point-charge field are **inverse-square** – doubling the separation makes the force (or field) four times smaller.
- Use magnitudes for the size of a force and decide direction from the **signs**; the field points the way a **positive** test charge would move.
- **Potential (V) is a scalar so potentials from several charges simply add; the field (E) is a vector and must be added by direction.**
- For a charge accelerated through a voltage use energy conservation $qV = \frac{1}{2}mv^2$.
- Capacitor relations: $C = Q/V$ (capacitance is fixed by geometry) and energy $U = \frac{1}{2}CV^2$.

Exercises 2.1-2.3

2.1 A charge of $5.0 \times 10^{-6} \text{ C}$ moves through a potential difference of 200 V. Find the kinetic energy it gains. [2]

2.2 State the energy conversion when a charge accelerates through a potential difference. [1]

2.3 An electron ($q = 1.6 \times 10^{-19} \text{ C}$) is accelerated through 100 V. Find the kinetic energy it gains. [2]

Exercises 2.1·2.3

2.1 A charge of 5.0×10^{-6} C moves through a potential difference of 200 V. Find the kinetic energy it gains. [2]

2.1

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

2.2 State the energy conversion when a charge accelerates through a potential difference. [1]

2.2

- electric potential energy is converted into kinetic energy

2.3 An electron ($q = 1.6 \times 10^{-19}$ C) is accelerated through 100 V. Find the kinetic energy it gains. [2]

2.3

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

Exercises 3.1-3.2

3.1 A charge q accelerated through a potential difference ΔV gains kinetic energy [1]

☐

A $q \Delta V$

B $q/\Delta V$

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

D $\Delta V/q$

3.2 As a positive charge moves from high to low potential, its kinetic energy [1]

☐

A decreases

B increases

C stays constant

D becomes zero

Exercises 3.1-3.2

3.1 A charge q accelerated through a potential difference ΔV gains kinetic energy [1]

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A $q \Delta V$

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3.1 A

- $q \Delta V$.

3.2 As a positive charge moves from high to low potential, its kinetic energy [1]

☐

A decreases

B increases

C stays constant

D becomes zero

3.2 B

- increases.

Exercise 3.3 (a)

3.3 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.

[2]

Exercise 3.3 (a)

3.3 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.

[2]

(a)

- $\Delta KE = q \Delta V = (1.6 \times 10^{-19})(1000) = 1.6 \times 10^{-16}$ J

Exercise 3.3 (b)

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

(b) Find its final speed.

[2]

Exercise 3.3 (b)

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

(b) Find its final speed.

[2]

(b)

$$\bullet \quad \frac{1}{2}mv^2 = 1.6 \times 10^{-16} \Rightarrow v = \sqrt{\frac{2(1.6 \times 10^{-16})}{1.67 \times 10^{-27}}} = 4.4 \times 10^5 \text{ m s}^{-1}$$