Chapter 5

Current

and

Potential Difference

Electric Current

- Whenever electric charges of like signs move, an *electric current* is said to exist
- The current is the **rate at which the charge flows**

$$I \equiv \frac{\Delta Q}{\Delta t}$$

- The SI unit of current is Ampere (A)
  - 1 A = 1 C/s

Electric Current, cont

- The direction of the current is the direction positive charge would flow
  - This is known as *conventional current direction*
    - In a common conductor, such as copper, the current is due to the motion of the negatively charged electrons
- It is common to refer to a moving charge as a mobile *charge carrier*
  - A charge carrier can be positive or negative

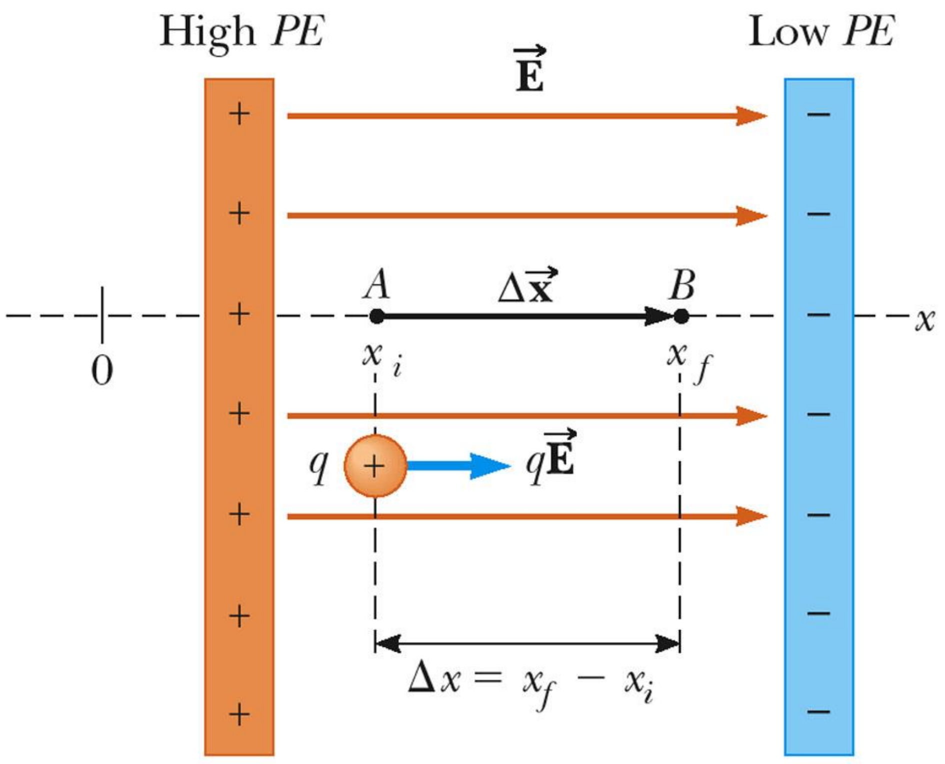
Electric Potential Energy

- The electrostatic force is a conservative force
- It is possible to define an electrical potential energy function with this force
- Work done by a conservative force is equal to the negative of the change in potential energy

Work and Potential Energy

- There is a uniform field between the two plates
- As the charge moves from A to B, work is done on it
- $W = Fd = q\ E_x\ (x_f - x_i)$
- $\Delta PE = -\ W$

  $= -\ q\ E_x\ (x_f - x_i)$
  - only for a uniform field



Potential Difference

- The potential difference between points A and B is defined as the change in the potential energy of (work done on) a charge q moved from A to B divided by the size of the charge
  - $\Delta V = V_B - V_A = \Delta PE / q$
  - IB Version: $V = \frac{W}{q}$
- Potential difference is *not* the same as potential energy

Potential Difference, cont.

- Another way to relate the energy and the potential difference:
  - $\Delta PE = q \, \Delta V$
- Both electric potential energy and potential difference are *scalar* quantities
- Units of potential difference
  - $V = J/C$
- A special case occurs when there is a *uniform electric field*
  - $\Delta V = V_B - V_A = -E_x \, \Delta x$
    - Gives more information about units: $N/C = V/m$

Which **one** of the following is a correct definition of electric potential difference between two points?

A. The power to move a small positive charge between the two points.

B. The work done to move a small positive charge between the two points.

C. The power per unit charge to move a small positive charge between the two points.

D. The work done per unit charge to move a small positive charge between the two points.

The work done on a positive point charge of magnitude 3.0 nC as it is moved at constant speed from one point to another is 12 nJ. The potential difference between the two points is

A. 0.0 V.

B. 0.25 V.

C. 4.0 V.

D. 36 V.

Sources of emf

- The source that maintains the current in a closed circuit is called a source of *emf*
  - Any devices that increase the potential energy of charges circulating in circuits are sources of emf
  - Examples include batteries and generators
- SI units are Volts
  - The emf is the work done per unit charge

Electrical Energy and Power, cont

- The rate at which the energy is lost is the power

$$P = \frac{\Delta Q}{\Delta t}\Delta V = I\Delta V$$

Electrical Energy and Power, final

- The SI unit of power is Watt (W)
  - I must be in Amperes and ΔV in Volts
- The unit of energy used by electric companies is the *kilowatt-hour*
  - This is defined in terms of the unit of power and the amount of time it is supplied
  - 1 kWh = 3.60×10^6 J

The Electron Volt

- The electron volt (eV) is defined as the energy that an electron gains when accelerated through a potential difference of 1 V
  - Electrons in normal atoms have energies of 10's of eV
  - Excited electrons have energies of 1000's of eV
  - High energy gamma rays have energies of millions of eV
- 1 eV = 1.6×10^{-19} J

The electron volt is **defined** as

A. a unit of energy exactly equal to 1.6×10^{-19} J.

B. a fraction $\frac{1}{13.6}$ of the ionization energy of atomic hydrogen.

C. the energy gained by an electron when it moves through a potential difference of 1.0 V.

D. the energy transfer when 1.0 C of charge moves through a potential difference of 1.0 V.

Which of the following is the correct value of the electronvolt, measured in SI Units?

A. 1.6×10^{-19} N

B. 1.6×10^{-19} J

C. 9.1×10^{-31} N

D. 9.1×10^{-31} J