

**Electric Potential Energy**

- Change in \_\_\_\_\_ due to \_\_\_\_\_
  - Force of gravity is \_\_\_\_\_
  - $F_G = G \frac{m_1 m_2}{r^2}$
  - $W = mgh_0 - mgh_f = PE_0 - PE_f$
- Change in \_\_\_\_\_ due to \_\_\_\_\_
  - Electrical Force is \_\_\_\_\_
  - $F_E = k \frac{q_1 q_2}{r^2}$
  - $W = PE_0 - PE_f$

**Electric Potential (or Potential)**

$$V = \frac{EPE}{q_0}$$

- Unit: \_\_\_\_\_ (V = J/C)

$$V_f - V_0 = \frac{PE_f}{q_0} - \frac{PE_0}{q_0} = -\frac{W}{q_0}$$

$$\Delta V = \frac{\Delta PE}{q_0} = -\frac{W}{q_0}$$

- V and EPE can only be measured in \_\_\_\_\_

Electric force moves a charge of  $2 \times 10^{-10} \text{ C}$  from point A to point B and does  $5 \times 10^{-6} \text{ J}$  of work. What is the difference in potential energies of A and B ( $PE_A - PE_B$ )?

What is the potential difference between A and B ( $V_A - V_B$ )?

**Electric Potential Difference and Charge Sign**

- Positive Charge
  - Moves from \_\_\_\_\_ electrical \_\_\_\_\_ toward \_\_\_\_\_ electrical potential
- Negative Charge
  - Moves from \_\_\_\_\_ to \_\_\_\_\_ electrical potentials

Points A, B, and C are evenly spaced on a line. A positive test charge is released from A and accelerates towards B, from B it decelerates, but doesn't stop at C. What happens when a negative charge is released at B?

**Batteries**

- Even though it is the \_\_\_\_\_ electrons that actually \_\_\_\_\_, tradition says that we talk about \_\_\_\_\_ charges
- Positive charge \_\_\_\_\_ by \_\_\_\_\_ terminal
- Moves through light bulb and \_\_\_\_\_ to heat
- By the time the \_\_\_\_\_ charge reaches the \_\_\_\_\_ terminal, it has no \_\_\_\_\_ energy left

**Volts and Energy**

$$V = \frac{EPE}{q_0}$$

$$EPE = q_0 V$$

- Use this when solving \_\_\_\_\_ of energy problems
- Unit for \_\_\_\_\_ energy is \_\_\_\_\_ (eV)

$$eV = (1.60 \times 10^{-19} C)(1 V) = 1.6 \times 10^{-19} J$$

When lightning strikes, the potential difference can be ten million volts between the cloud and ground. If an electron is at rest and then is accelerated from the ground to the cloud, how fast will it be moving when it hits the cloud 0.5 km away (ignore relativity effects)?

**Homework**

- Voltage is the common word for potential difference. Which term is more descriptive, voltage or potential difference?
- If the voltage between two points is zero, can a test charge be moved between them with zero net work being done? Can this necessarily be done without exerting a force? Explain.
- What is the relationship between voltage and energy? More precisely, what is the relationship between potential difference and electric potential energy?
- Voltages are always measured between two points. Why?
- How are units of volts and electron volts related? How do they differ?
- The drawing shows three possibilities for the potentials at two points, *A* and *B*. In each case, the same positive charge is moved from *A* to *B*. In which case, if any, is the most work done on the positive charge by the electric force? Account for your answer.
- Find the ratio of speeds of an electron and a negative hydrogen ion (one having an extra electron) accelerated through the same voltage, assuming non-relativistic final speeds. Take the mass of the hydrogen ion to be  $1.67 \times 10^{-27}$  kg. (OpenStax 19.1) **42.8**
- An evacuated tube uses an accelerating voltage of 40 kV to accelerate electrons to hit a copper plate and produce x-rays. Non-relativistically, what would be the maximum speed of these electrons? (OpenStax 19.2)  **$1.17 \times 10^8$  m/s**
- A bare helium nucleus has two positive charges and a mass of  $6.64 \times 10^{-27}$  kg. (a) Calculate its kinetic energy in joules at 2.00% of the speed of light. (b) What is this in electron volts? (c) What voltage would be needed to obtain this energy? (OpenStax 19.3)  **$1.20 \times 10^{-13}$  J,  $7.50 \times 10^5$  eV,  $3.75 \times 10^5$  V**
- The temperature near the center of the Sun is thought to be 15 million degrees Celsius ( $1.5 \times 10^7$  °C). Through what voltage must a singly charged ion be accelerated to have the same energy as the average kinetic energy of ions at this temperature? (OpenStax 19.5)  **$1.9 \times 10^3$  V**
- A lightning bolt strikes a tree, moving 20.0 C of charge through a potential difference of  $1.00 \times 10^2$  MV. (a) What energy was dissipated? (b) What mass of water could be raised from 15 °C to the boiling point and then boiled by this energy? (c) Discuss the damage that could be caused to the tree by the expansion of the boiling steam. (OpenStax 19.7)  **$2.00 \times 10^9$  J, 766 kg, BOOM!**

$\overset{A}{\bullet}$ $\overset{B}{\bullet}$ 150 V    100 V Case 1	$\overset{A}{\bullet}$ $\overset{B}{\bullet}$ 25 V    -25 V Case 2	$\overset{A}{\bullet}$ $\overset{B}{\bullet}$ -10 V   -60 V Case 3
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