

J: Explain Voltage Subatomically

Level 5

Prerequisite: Explain Current Subatomically

Points To:

Objectives:

The overall goal of this quiz and ‘Explain Current Subatomically’ is to explain using the theories of electrons and nuclei how and why electric circuits work as they do.

These questions are addressed by this quiz:

- Where do they come from? How did electrons get into the electric circuit at all?
- Why do the electrons move around the circuit?
- How do they know where to go? Why do they move only through a wire, and not anything else?

When I ask these questions to new physics students, most of them think of answers that are logical, but incorrect. Truly understanding these concepts means that you should be able to address these common misconceptions. In addition to knowing the correct answer, you should be able to explain why *common wrong answers is wrong*.

- You should be able to draw a diagram showing how a battery works.

Part 1: Review of basic vocabulary

Voltage
The <i>push</i> that moves electrons around a circuit.
Potential Difference
Another, more precise, term for voltage. Potential difference refers to the amount of potential energy that is released when electrons move around a circuit.
Battery
The battery is the part of the circuit that releases voltage (potential difference).

Part 2: Where does potential difference (voltage) come from?

Electrochemistry basics

What a battery does: A battery uses a chemical reaction to create a POTENTIAL DIFFERENCE (voltage), which is the energy that allows a circuit to work.
A battery can be created whenever a) there is an exothermic reaction between two metals (releases energy). the most common example is zinc and copper b) the reaction involves the exchange of an electron from one metal to the other (called a <i>oxidation-reduction reaction</i>)
A battery is used up when this reaction is completed!

Battery vocabulary:

- the two metals are called the electrodes
- the positive electrode (which receives electrons...oxidizes) is called a cathode and the negative electrode (which gives electrons...reduces) is called the anode
- positive ions need to be able to travel between the electrodes, typically through a liquid called an <i>electrolyte</i> in a wet cell battery or a solid material in a dry cell battery

How charges move:

- if a wire connects the two electrodes, then the electrons can travel *through that wire* in order for the reaction to occur
- this is why only chemical reactions that involve electron exchange (oxidation-reduction reactions) can be converted into batteries.
- as the electrons move across the wire from anode to cathode, positive ions *also* move from anode to cathode through the electrolyte....so in fact the charge is moving both ways and the reaction is electrically neutral

Energy in batteries:

- because the reaction between anode and cathode is *exothermic*, that electron is able to release energy as it travels
- when the electron is on the anode, it has potential energy (electrochemical potential energy)
- as it moves across the wire, that electrochemical potential energy converts into kinetic energy (called *electrical energy*)...just like a ball rolling down a hill
- however, in an Ohmic electric circuit, that electron's kinetic energy (electrical energy) is *always* immediately released into some other type of energy (like light or heat energy)
- the ability to release potential energy into another type of energy creates a situation called a *potential difference*! (which is also called *voltage*)!

Types of batteries

Wet cell battery

The electrolyte is a liquid substance.
Car batteries are wet cell batteries.

Dry cell battery

The electrolyte is a solid substance.
Most batteries you use are dry-cell.

Lemon battery

A typical school project, in turning a lemon or potato into a battery.
In this lemon battery, however, the energy *does not* come from the lemon!
Energy comes from the electrodes: the zinc and copper materials pushed into the lemon.
The lemon juice is the electrolyte!

A lemon battery is really a primitive *wet cell* battery.

Vocabulary Exercise:

Match each word or phrase to the proper definition

1. Electrochemical potential Energy	A. physicists say that current is going positive to negative, even though it is really opposite
2. Conventional Current	B. charged particle that moves in an electric circuit
3. Electric Field	C. force affecting charged particles from a distance
4. Conductor	D. to gain electrons in a chemical reaction
5. Electron	E. material that allows positive charges to move and complete a battery reaction
6. Oxidize	F. a material containing electrons that are free to move amongst atoms
7. Electrolyte	G. to lose electrons in a chemical reaction
8. Reduce	H. energy contained within two chemicals that react in an exothermic, oxidation-reduction reaction
9. Cathode	I. net motion of electric charge
10. Battery	J. a chemical within a battery that gives up electrons
11. Current	K. a device which creates a potential difference across a wire
12. Electron Drift	L. a tiny charged particle moves

	randomly, but slightly more in one direction
13. Kinetic Theory of Matter	M. a chemical within a battery that accepts electrons
14. Potential Difference	N. matter is made of small particles that are always moving randomly
15. Anode	O. energy released when a charged particle moves around a circuit