Electricity Program of Study Content Assessment: Explanations for Current Electricity Items

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Explanations for Items on the Content Assessment about Current Electricity

Questions 1

When we talk about charging objects and the flow of electricity we are talking about the movement of charged particles, called *electrons*. Electrons have a negative charge.

The objects that are easy to charge (balloons, feathers, corks, and combs) do not conduct electricity. We call objects that do not conduct electricity *insulators*. Insulators are materials in which electrons are not free to move around. Since the electric charge is not free to move around, charges can be added and accumulated in that material. Objects made of plastic or glass are examples of insulators.

Objects or materials that conduct electricity well are called *conductors*. In conductors, the electrons are free to move through the material. This is the reason that they are not easy to charge. Charges do not accumulate in the material because they easily flow out of the material. Metals and (some) liquids have the right structure for electric charges to move around easily.

Question 2

For the light bulb to light, the filament of the light bulb must be part of the conductive path that goes from one terminal of the battery to the other. This will allow electricity to flow through the filament of the bulb. The light bulb lights as a result of the movement of electrons through the thin wire that is the filament. As the electrons move through the wire they bump around quite a bit. This motion of particles in the wire causes the material to vibrate and heat up. As it heats up, it gives off light.

Light bulbs are designed such that one end of the filament is connected to the side of the base of the light bulb and the other end of the filament is connected to the bottom of the base of the light bulb. To create a complete path, one connection must be made with the side of the light bulb base to one terminal of the battery, and another connection must be made with the bottom of the light bulb to the other terminal of the battery.

Answers b) and c) are both examples of a complete path – the light bulbs will light in those circuits. In answer choice a), a connection is made to the base of the light bulb, but there is no connection to the other end of the battery. There is no electricity flowing through the filament of the light bulb because the filament is not connected to both ends of the battery. Students will often pick this answer choice because they think of the light bulb as a "receiver" of the energy from the light bulb, such that the electricity only has to flow to the bulb, instead of the scientific view where the electricity must flow *through* the light bulb. Answer choice d) shows the light bulb connected to opposite terminals of two different batteries. The light bulb must be connected to the opposite terminal of the same battery in order for a complete path to exist.

Question 3

As discussed in Question 2, the filaments of a light bulb are connected at one end to the base of the light bulb, and at the other end, to the side of the base of the light bulb. Between the side of the base and the bottom tip is an insulating material that separates them. Because of this, electricity can only flow through the filament. The correct answer, choice d), shows these connections.

Answer choice a) shows both ends of the filament connected to the side of the base of the bulb. Because this part of the light bulb is metal, current would flow through that part of the light bulb, and mostly by-pass the filament, which has more resistance to current flow.

Similarly, by connecting both ends to the base of the light bulb, in answer choice b), the current can flow just though the base of the bulb, and again by-pass the filament. Answer choice c) shows the filaments connected to the insulated part of the light bulb's base. Electricity cannot flow through this part of the light bulb so it will not flow through the filament.

Question 4

In order for the light bulb to light in a circuit, there must be a complete conductive path from one terminal of the battery, through the light bulb and back to the other terminal of the battery. Steel (in the nail) and copper (in the penny) are both conductors will allow electricity to flow through them. So if they are put in a circuit there will still be a complete conductive path.

Electricity does not flow through air. By leaving a gap in the wire, the circuit is no longer complete, so electricity will not flow and the light bulb will not light. Rubber is also not a conductor. Electricity will not flow in a circuit that is interrupted by rubber along any point in its path.

Question 5

The brightness of a light bulb in a circuit depends on how much current is in the circuit. If you increase the current, the filament in the light bulb will heat up more and emit more light. If you decrease the current, the light bulb will emit less light.

The amount of current depends on two things: the amount of voltage and the amount of resistance. If you increase the voltage, you will increase the force on the electrons moving through the circuit, which equals an increase in the current.

If you add more resistance to a circuit, the flow of current through the circuits will be less. Resistance is a property of the materials in the circuit. Some materials have more resistance to current flowing through them than others. The filament of a light bulb creates resistance to the flow of current, and the more light bulbs you have in a circuit, the more resistance in the circuit.

Circuits A and B in Question 5 both have identical batteries, so the voltage is the same in each circuit. But Circuit B has two light bulbs and Circuit A only has one. With two light bulbs in the circuit, Circuit B has more resistance than Circuit A. So with more resistance, Circuit B will have less current flowing than in Circuit A. With less current flowing, both light bulbs in Circuit B will be fainter than the one light bulb in Circuit A. So answer choice a) is correct.

Question 6

Each answer choice in this question represents a different model commonly held by many children. Answer choice c), the correct response, represents the flow of electricity in the scientific model. The electric potential (voltage) created by the battery causes electricity to flow in one direction through the circuit. Answer choice b) shows the "clashing currents" model. Students holding this model think that current is flowing from both terminals of the battery and meets at the light bulb. They will sometimes explain the light in terms of the clash of the currents coming from each end of the battery. Answer choice d) shows the "crossing current" model. Students holding this model believe that current comes from both terminals of the battery, cross at the light bulb, and continue through the circuit to the opposite terminal of the battery. Answer choice a) represents the "unipolar model," where students believe that it is sufficient for electricity to flow from one end of the battery to the light bulb. The students

believe that only one wire is active. They may see the second wire as necessary for the circuit, but still do not believe it plays an active part. The second wire is sometimes regarded as a safety wire.

Question 7

This question is an extension of Question 6. We have observed that some students may appear to hold the scientific model for the flow of electricity when given a circuit with one light bulb, but when presented with a circuit that has two light bulbs their ideas may change. Again, in this question, answer choice c) is the correct answer. The other answer choices show incorrect models of the flow of electricity.

Question 8

Current flows through a complete circuit because the battery has a potential difference or voltage between its two ends. A chemical reaction inside of the battery causes electrons to collect at one end and a deficit of electrons to form at the other end. When the battery is connected in a circuit, the difference in the amount of charge at each end of the battery causes the electrons throughout the circuit (in the wires) to move. The electrons move away from the collection of electrons in the battery and towards the deficit of electrons at the other end of the batteries. This movement of electrons through the wires is the electric current and it occurs instantaneously through out the circuit when the circuit is complete. The amount of current will be the same through out the circuit. Therefore, each light bulb in the circuit will have the same amount of current flowing through them.

The two light bulbs are identical so they will both have the same resistance to the flow of electricity. The filaments in each light bulb will heat up to the same temperature, from the current flowing through them, and therefore give off the same amount of light.
Many students believe that the first light bulb in the circuit will "use up" the electricity before it can reach the second light bulb. This is incorrect - the energy that creates the light in the light bulb is from the motion of the electrons, which is the same through out the entire circuit. The motion of the electrons is the current flow.

Question 9

As discussed in Question 8, the amount of current will be the same through out the circuit so answer choice e) is the correct answer.

Many students have a model of the flow of electric current in which the light bulb is seen as a receiver of energy from the battery, which it then uses up to light the light bulb. Students with this model may expect there to be less or no current in Wire B and Wire C.

Question 10

When a light bulb burns out its filament is broken. This causes the circuit as a whole to be broken, so electricity stops flowing in the circuit. With no electricity flowing in the circuit, Bulb 2 will no longer give off light, so answer choice b) is correct.

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Question 11

As we increase the voltage in a circuit, we increase the current as well. Also, the more current there is in a circuit, the brighter the light bulb will be. Therefore, the light bulb in Circuit B will be brighter because three batteries will provide three times the voltage as one battery. Increasing the voltage in the circuit will increase the motion of the electrons (the current) which will increase the brightness of the light bulb in Circuit B.

Question 12

This is a question about the resistance of wire. A wire with less resistance will allow electricity to flow more easily through it. The thicker the wire, the less resistance it will have to the flow of electricity. So, electricity will flow more easily through Light Bulb 2 because the filament in Light Bulb 2 is thicker than the filament in Light Bulb 1.

Question 13

The brightness of a light bulb in a circuit depends on how much current is flowing in the circuit. The amount of current depends on both the voltage and the resistance. In this question the voltage is the same in both circuits but the circuit with Light Bulb 1 has higher resistance because that light bulb has a thinner filament. Higher resistance in a circuit means it will have less current. So Bulb 2 will be brighter because there will be more current in that circuit.

Question 14

The amount of current in the circuit depends on the sum of the resistance of the two light bulbs. The bulb with the thicker filament has considerably less resistance that the bulb with the thinner filament. So, most of the resistance in the circuit comes from the bulb with the thinner filament. The amount of resistance in the circuit results in a current that is sufficient to light the bulb with the thinner filament, but not enough to light the bulb with the thicker filament. Only the bulb with higher resistance will light.

Question 15

Both Picture A and Picture B show a complete circuit. However, Picture B has an extra wire that is *shorting* the circuit. This means that the extra wire provides a separate path in the circuit that connects to both ends of the battery. Because the wire has less resistance to the flow of electricity, most of the electricity will flow through the extra wire, and not through the light bulb. Electricity follows the path of least resistance.