Name _________________________   Section _________________________

Period 10 Activity Sheet:  Electric Charge and Force

Activity 10.1:  How Do Electric Charges Exert Forces?

a)  Evidence of Forces: Give a plastic rod a net negative charge by rubbing it with a piece of foam. Then use the charged rod to exert electrical forces on objects as described below. For each activity, draw + and - charges on the diagrams to show the charges on the objects.

1) Float the Styrofoam ring above the charged rod. Why does the ring float?

   The plastic rod and the Styrofoam ring receive negative charge from the foam. These negative charges repel, exerting a force and causing the ring to float above the rod.

2) Bring the charged rod underneath the pith ball (but not touching the pith ball). Is the pith ball attracted to the rod or repelled by it?

   The neutral pith ball is attracted to the negatively charged rod. The negative charges on the rod repel the negative charges on the pith ball, leaving the side of the pith ball closer to the rod positively charged.

3) Touch the pith ball with the charged rod. Is the pith ball attracted to the rod or repelled by it?

   The pith ball is repelled. When the negatively charged rod touches the neutral pith ball, negative charge flows from the rod to the ball. Now, both the rod and the ball have a negative charge and they repel. The pith ball moves away from the rod.

4) Spin a wooden dowel by holding the charged rod near it.

   The dowel is attracted to the plastic rod. The negative charges in the wooden dowel are repelled by the negatively charged rod. However, the negative charges in wood are not free to flow as they are in metal. The negative charges in the wood's atoms lean away from the negative rod. The more positively charged sides of the atoms are attracted to the negative rod.

b) Electric Force and Gravitational Force:

1) We have learned that the force of gravity is always an attractive force. Is the electrical force always attractive? ___No, it can be repulsive___

2) How do you know? Use the results of the activities in part (a) to explain your answer.

   When the Styrofoam ring floated, the two objects moved apart, indicating a repulsive force between them. But when the wooden dowel spins, the objects moved toward one another, indicating an attractive force.
c) Group Discussion Question: Where does the charge on the plastic rod come from? Do you “create” charge when you rub the rod? What happens to the charge on the piece of foam when you rub the rod with it?

Rubbing the rod with the foam transfers negative electrons in the atoms of the foam onto the rod. Having lost some negative charge, the foam now has a net positive charge. According to the law of Conservation of Charge, the total amount of charge in the universe is constant. You can transfer charge from one object to another, but you cannot create or destroy charge.

d) Electrostatic Oscillator: Rub the dull side of the blue foam briskly with the cloth. Place the electrostatic oscillator on the foam, holding it only by its foam cup. Push the large metal Leyden jar can near to (but not touching) the ball of foil hanging from the plastic straw.

1) Why does the foil ball move away from the pan and toward the metal jar? Draw + and – charges on the diagram to show the charges. Explain why the foil ball moves.

Rubbing the pan transfers negative charge to it. The foil ball receives a negative charge from the negatively charged pan. The negative charges in the pan and the ball repel, and the ball moves away from the pan toward the neutral Leyden jar can.

2) Why does the foil ball move away from the metal jar and toward the pan? Draw + and – charges on the diagram to show the charges. Explain why the foil ball moves.

When the ball touches the neutral jar, its negative charge drains onto the jar and the ball becomes neutral. The negative pan then repels the ball’s negative charges and attracts its positive charges. The positively charged side of the ball is attracted toward the pan.

e) Charge and Voltage

1) Touch the top of the tin can voltmeter to discharge it. Then rub the charged plastic rod across the top of the voltmeter. What voltage do the charges you applied to the voltmeter have? (Hint: each increment of 10 on the scale corresponds to about 1,000 volts.) ____________ What do you think causes the voltmeter needle to move?

The metal voltmeter needle and the Z-shaped metal plate behind it are connected. They both receive negative charge from the plastic rod. Their negative charges repel, pushing the needle away from the plate.

2) Watch the water tank demonstration of voltage. Will two equal amounts of electric charge always have equal amounts of electrical potential energy? ___ No ___ If not, explain how two equal amounts of charge could contain different amounts of potential energy.

Electrical potential energy depends upon the amount of charge and the voltage of that charge. Charge that is held at a higher voltage has more potential energy per charge than charge at a lower voltage.
Activity 10.2: Why Is Separating Charge Useful?

a) Separating Charge on a Can:

1) Charge a plastic rod by rubbing it with foam. Place a charge on an empty metal can by sliding the charged rod along the can. Repeat 5 or 6 times. Hold one wire of a small neon light bulb and touch the other wire to the can. Describe what happens.

   The neon bulb flashes. When the bulb wire touches the can, the negative charge on the can flows through the wire causing the bulb to light briefly.

2) Place the empty can in a glass or plastic beaker. Place a charge on the can by sliding a charged plastic rod along the can. Attach the ground wire to the bottom of the tin can voltmeter. Attach a connecting wire from the top of the voltmeter to the charged can. Describe what happens.

   The needle of the voltmeter moves, measuring the voltage of the charges you have placed on the can.

b) Separating Charge on a Leyden Jar:

A Leyden jar consists of two metal cans separated by an insulating plastic can. Assemble the Leyden jar and connect the outer can to the ground wire. Charge the inner can by touching it with the plastic rod 5 or 6 times. Now disconnect the ground wire from the outer can. Touch one wire of a small neon bulb to the inner can and the other wire to the outer can.

1) Describe what happens.

   The negative charges on the can repel one another. They flow from the can, through the bulb, and into your hand. As they flow through the bulb, they cause it to light. The neon bulb flashes a little more brightly than when you touched it to the can in activity 10.2.a.1. (You may not be able to see much difference in brightness.)

2) How does the brightness of the bulb compare to its brightness using only one charged can in part a) above?

   The bulb flashes more brightly when the plastic jar is placed between the metal cans.

3) Draw a diagram showing the charges on the cans before the bulb is touched to them.

   The outer can has a net positive charge. The inner can and the metal handle have a net negative charge. When the wires of the bulb touch the inner and outer cans, negative charges are attracted to the positive outer can. As the negative charges flow from the inner can to the outer can, they flow through the bulb, lighting it.

4) What is the function of the plastic can?

   The plastic can is an insulator, separating the negative and positive charges.

5) Explain how a Leyden jar separates charges.

   The rod places negative charge on the inner Leyden jar. When the two metal cans and the plastic can are assembled and the outer metal can is connected to ground, the repulsive force from the negative charge on the inner can chases negative charge from the outer can into the ground wire. When you disconnect the ground wire, negative charges cannot flow back to the outer can. The outer can is left with a net positive charge, and the inner can has a net negative charge.
Activity 10.3: How is Charge Stored in Capacitors?

a) **Foil Capacitors:** Examine a torn apart foil capacitor.
   
   1) What is the purpose of the foil and the plastic?
      
      The foil layers store charge and the plastic layer is an insulator, separating the charges on the foil layers.
   
   2) How is the capacitor similar to the Leyden jar?
      
      The capacitor’s two layers of foil separated by plastic act like the two metal cans and plastic liner of the Leyden jar. A capacitor can store more charge in a smaller space than the Leyden jar.

b) **Using Capacitors:** Charge a 1 farad (green) capacitor by connecting it to a battery for about 10 seconds. Connect the charged capacitor to a toy car.
   
   1) Describe what happens. Do you think the car would run longer if it were connected to this capacitor or to a D cell battery?
      
      The car may run for 10 – 20 seconds, then it stops. It could run much longer if powered by a battery.
   
   2) Which stores more energy: the capacitor or a battery? __a battery__

c) **Capacitor Discharge:** Your instructor will demonstrate discharging a large capacitor by connecting it to a light bulb and by touching it with a metal-tipped rod.
   
   1) In which case did the capacitor discharge more quickly? __through the metal rod__
   
   2) In which case is more energy released? __Since the capacitor stored the same amount of charge in both cases, the same amount of energy was released when it discharged through the metal rod or through the light bulb__
   
   3) In which case is more power produced? __through the metal rod__
   
   4) Explain why more power was produced.
      
      Power = Energy/time The same amount of energy was released but over a shorter period of time through the rod and over a longer time through the light bulb. Since the time variable is in the denominator of the power equation, the smaller the value of time, the larger the value of the power.