

## **Charge and Electricity- our Model So Far.**

(These are the concepts you can state without justifying them in your explanations.)

### **Kinds of charge, excess charge.**

- Two kinds of charge (positive and negative.)
- Most objects are made of huge numbers of positive and negative charges, but in equal amounts, so they're neutral.
- If an object has fewer positives than negatives, it has an excess negative charge and vice-versa.
- Charge is never created nor destroyed, but can be moved around.

### **Forces between charges.**

- Objects with excess charges of the same sign (like charges) repel each other, and objects with excess charges of the opposite sign attract each other.
- The force between two charged objects is given by Coulombs law  $F=kq_1q_2/r^2$ , which, besides the opposites attract likes repel bit, tells us the force gets weaker the farther the charges are from each other, and that the force depends on the excess charges of both objects. [This is a non-contact force that obeys Newton's laws, as all forces do.]

### **Different materials: flow of charge, acquisition of charge.**

- Materials that let charge flow within them easily are called conductors, and materials that don't let charges flow within them are called insulators. In between these two extremes, materials that will let charge flow but not easily are called resistors (or resistive materials.)
- Any type of material can get an excess charge, since to be charged, some charge simply needs to go on or off the object. It needn't flow, just go on or off! So the different types of materials just have restrictions about flow, *not* about adding charges to a given spot.
- Rubbing often pulls charges apart.
- The ground is like a HUGE conductor. [That's all! Our model does not say the ground makes anything connected to it neutral or anything like that! It's just a big conductor. Think of it like a huge metal house if that helps.]

### **Dipoles**

- A dipole is a pair of opposite charges separated by a distance.
- Although the charge in an insulator can't flow, some insulators have little dipoles that can rotate. [If you combine this with coulomb's law, you'll get that a dipole can exert a force on a charge because it's charges are separated.]

### **Voltage/Pressure**

- Any set of conductors connected to each other will tend to equalize the voltage (pressure) [but not necessarily the charge!]

- Voltage can be thought of as analogous to pressure. [Note: Balancing, Equilibrium of neutral objects, and Stability are not in our model, so if you have these ideas, you must explain why our model says that would be true!]

### Circuit Components: Batteries, bulbs, current

- In a circuit there's the stuff (charge), the flow of stuff (current), and the pressure (the voltage). Also there are wires (things that allow current to flow easily) resistors (including bulbs) (which restrict flow) and batteries (which try to maintain pressure differences.)
- Batteries try to keep the same pressure difference between the two terminals. [Like an air pump that monitors for the pressure difference. It only turns on and pumps to keep, say, a difference of 10 Pa from one side to the other. So if the pressure is 10 Pa different and the valve is closed, for instance, and no air flows, the pump doesn't need to pump and shuts off.]
- The brightness of a bulb is an indicator of the current going through it. More current, brighter bulb. (Actually for each type of bulb, brightness increases with power and power increases with current.)
- Current is not the speed with which something moves, but the amount that passes a certain point in a certain amount of time. (Measured in charge / time,  $q/t$ .)

### Kirchoff's rules.

- **Ohm's law.** Current will only flow through a resistor if there is a voltage difference across it. [Air will only flow through a straw if the pressure at the two ends is different.] The amount of current that flows through a resistor depends on the voltage/pressure difference and the resistance. The equation of this is  $I=\Delta\mathcal{V}/R$ . The same reasoning says the voltage/pressure drop across a resistor depends on the resistance and the current.  $\Delta\mathcal{V}=IR$
- **Loop rule: voltage continuity.** If you sum all these pressure drops and increases around any loop in a circuit, they must sum to zero ( $\Sigma\Delta\mathcal{V}=0$ : You end where you started – continuity of Pressure) When you are moving with the current, you see a pressure drop across a resistor (you're moving from high to low) and a pressure increase across a battery (in the "right" battery direction – you're going from low to high.)
- **Junction rule: current continuity.** At a junction of several wires, the current in must equal the current out (Continuity of current. No leaking, building up, or spontaneous creation allowed.)
- **Conductor rule.** Any wires connected to each other (in junctions or otherwise) must have the same voltage. (See "Voltage/Pressure" above.)

### Other stuff

- **Power.** The power used up in a resistor is given by  $P=\Delta\mathcal{V}I$ .
- **Resistor values.** A resistor is related to its resistivity (density of obstacles), its length, and its cross-sectional area by  $R=\rho l/A$ . Longer resistor, more resistance, wider, less resistance.
- **Electric field.** The electric field is the force per unit charge (or the force on a charge divided by the size of the charge.)  $E=F/q$ .

## Observations

(you can also state observations without justification, but make sure you've got them right! Think about the model!)

- Tapes became charged when pulled off the table, either repelling each other when pulled the same way, or attracting when pulled apart from each other.
- The Van de Graaf builds up a charge slowly, and can shock you (or your professor) if you touch it. We saw that when I was not touching the generator, I only got a shock when I was close and there was enough pressure to ionize the air, which we saw happen with a blue spark.
- Things lose their charge after a while if it's not being replenished. [Air conducts poorly = slowly.]
- The pie plates on the VdG sat there for a while and then one came off, then another, and so one, with a small time between each one.
- The stack Styrofoam plates did not fly off,
- A cylinder of tin foil attracted to the VdG, but repelled when it touched the generator.
- A sphere of Styrofoam attracted to the generator, but weakly. [We said the foam got charged when it was touching, but only in the touching spot, so that wasn't enough to make the repelling force greater than the attracting force.]
- In the balloon demo, the pressures equalized, not the amount of air.
- No current flows in an incomplete circuit.
- Identical bulbs in series are all equally bright.
- Etc., etc. (Make a list and compare against a friend's.)

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## Hints for the Test and for Studying

- Free body diagrams when you need forces!
- Try things as many ways as you can and check them against each other and against the model!
- Don't turn off your common sense when you use a formula. What does the formula mean? How do you picture it in one of our analogies? Is it something you can use in this situation?
- Keeping track - use analogies! Difference between STUFF, FLOW OF STUFF, and PRESSURE.
  - Analogies:
  - Air pressure (boxes with pump, straws)
  - Rope and pullers, pinchers
  - Water in pipes
  - Escalators and stairs in the department store (esc are batteries and stairs are bulbs...Slides would be better than bulbs since you never spontaneously fall UP a slide...)
  - Cars on the beltway, Trains (make sure the trains are continuous, like current.)
- Draw lots of diagrams!
- Try to come up with an argument against your ideas. This will help you find problems, or give you more ideas for approaching a problem.
- Studying: Try to come up with ideas that contradict the model, and arguments against those. Why is the model what we are using? Also study by looking at variations on the problems.