

Thoughts for the Day
CH301H Fall 2010
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Chapter 3

Models

We will cover a number of different models for Chemical Bonding. Each getting a bit more complicated than the rest. This is not to teach you things and then tell you that they are “wrong” and make life more difficult. It is to explore a range of models of chemical bonding ranging from empirical classical ideas to full blown quantum mechanics. With more approximations we move farther from “reality” but we have the ability to have more physical insight and intuition.

Things to remember about models.

1. Models are all made up by people and thus they are never “real”.
2. Since they are made up, they can (and will) fail.
3. We can learn as much from the failures as their success. If we always keep in mind what assumptions (approximations) the model had made.

Periodic Trends

It is all the electrons. The periodic table was arranged by properties (and atomic mass), but we know now that we can think of it as being arranged by electronic structure. It’s all about the electrons. To stay on the same page in chemistry language we need to all know the following.

Period, group, main group, transition metal, lanthanide, actinide, alkali metal, alkali earth metal, chalcogen, halogen, noble gas.

Classical Mechanics Vs. Quantum Mechanics

Classical mechanics is the physics of the macroscopic world around us that we know and love. Newton’s Laws, Coulomb’s Law, gravity... Quantum mechanics deals with the forces on objects of very small mass (like the electron or an atom). In QM things behave in ways that seem “odd” as they are by their nature not following the “rules” of classical mechanics.

First we will explore the idea of chemical bonding from a classical perspective.

The most important concepts that we will use again and again (even in quantum) are ideas of electrostatics.

Coulomb's Law tells us about the force between two charged particles. From this we can derive the potential energy.

IMPORTANT IDEA: We define as a starting point the place where the potential energy is zero. For two charged particles we choose this point to be when the two particles are at a distance of infinity.

Based on this, if two particles have a negative potential energy, their energy is lower when they are closer than when they are far apart. This is an attractive coulomb potential and occurs of oppositely charged particles. Or they the potential is positive and the potential is repulsive.

We can also examine the potential, kinetic, and total energy. We invoke the virial theorem for coulomb's law to show how changes in potential energy could be related to changes in total energy and in kinetic energy.

Next time we will look at ionization energies, electron affinity, and electronegativity along with the shell model for the atom and empirical ideas about chemical bonds.

Thompson's experiment

Use a cathode ray tube to show electrons were negatively charged and measured their mass to charge ratio.

How?

Used a beam of electrons (cathod rays) and deflected them with an electric field. However, this could not be used to figure out the mass/charge ratio as the velocity of the electrons passing through the plates was unknown. A perpendicular magnetic field was applied to offset the force from the electric field. The mass/charge ratio of the electron could then be found from the ratio of the applied electric and magnetic fields.

Milliken's oil drop

Showed that charge is quantized (comes in fixed amounts). Measured the charge on the electron thus yielding the electron mass.

How.

Ionized oil drops and watched them fall. First examined drop in falling at a terminal velocity without an electric field. He measured both the size of the particle and how fast it was falling. The size allowed him to quantify both the mass as well as the drag on the particle. Then he repeated the experiments with an applied field to determine the extra force from the electric field. From this is found the charge on many oil drops. He then used this data to deduce the smallest unit of charge possible to explain all of the data and concluded this was the charge on the electron. KEY IDEA: charge comes in tiny units of the charge on the electron

Rutherford's scattering experiments

Showed that nucleus of an atom is very small compared to the internuclear spacing and that the mass to charge ratio is extremely large. Essentially measured the size, spacing, mass, and charge of the nucleus.

How.

Shot a beam of alpha particles (He nuclei) at a thin metal foil. A small number were deflected and a much smaller number were scattered backwards. Using some

Other random thoughts tossed out today.

Atoms are all about 1\AA in size (give or take)

Pb is denser than Al because Pb atoms are more massive

Things to keep in mind for the future. When you eventually work on electrochemistry you have to remember which electrode has the oxidation reaction and which electrode has the reduction. Reduction is the gaining of electrons. I always remember this is happening at the cathode as this is the electrode that the electrons come flying off of (the source of the cathode rays).