Chapter 2

List the basic assumptions of Dalton's atomic theory.

The basic assumptions of Dalton's atomic theory are: atoms are very tiny particles. All matter is composed of atoms. Atoms of a given element are alike; they have the same properties. The atoms of a different element have different masses and different properties. Atoms are not created or destroyed in a chemical reaction. Atoms combine in small whole number ratios to form compounds. A given compound always has the same number and types of atoms independent of source.

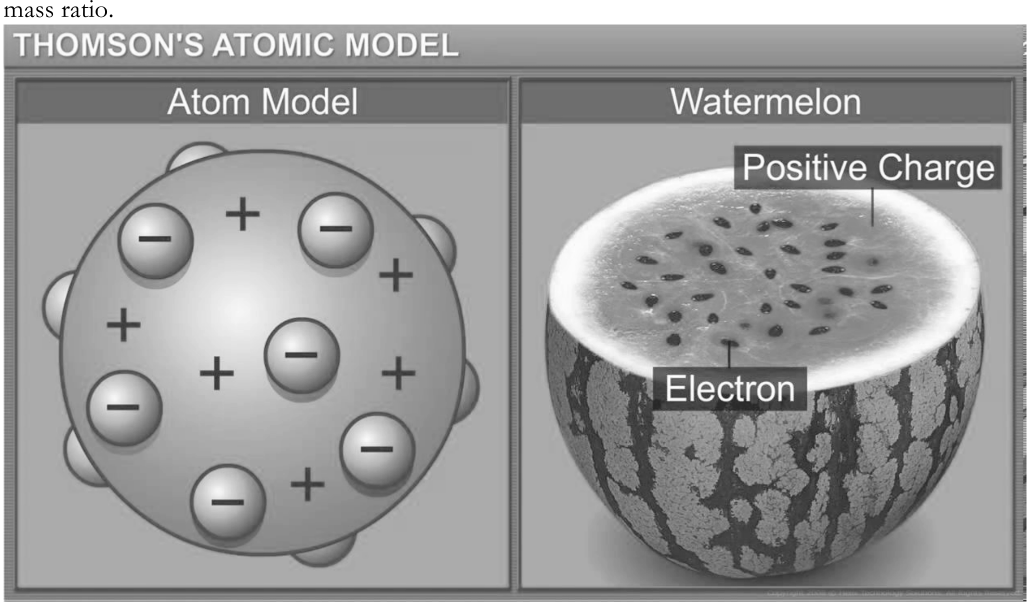
List some of the characteristic properties of cathode rays and anode (canal) rays

Cathode rays travel in a straight line; they travel from the cathode when current flows in the tube; they are deflected away from a negatively charged field; the properties of the ray are independent of current source, tube material, cathode material, and the gas that filled the tube; they are invisible but can be observed when they strike glass, which is coated with phosphorescent material; the particles in the ray have mass.

Canal rays (anode rays) form when electrons are knocked out of neutral atoms. Anode rays consist of positive ions or cations. The properties of an anode ray are: they travel in a straight line like cathode rays. They travel toward the cathode when current flows and are deflected as if positively charged. The behavior of the ray depends on the gas that filled the tube. The particles in the ray have mass. Anode rays are not fundamental particles since their properties are not the same under all circumstances but depend on the gas that originally filled the tube. The behavior and properties of these rays lead to the concept that the atom is composed of positive and negative portions and the negative portions are easily removed.

Describe Thomson's e/m experiment, Millikan's oil drop experiment, and Rutherford's gold foil experiment. Explain the significance of each experiment.

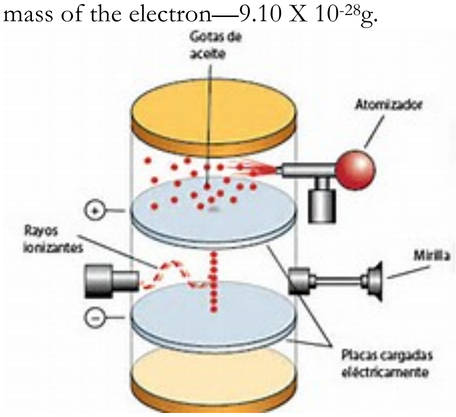
Thomson made a cathode ray tube with a fluorescent screen so that he could observe the ray. In the experiment, he adjusted the magnetic and electric fields and studied how the beam curved. The radius of the curve depended on the energy of the electrons, the mass of the electrons and the strength of the magnetic field. The energy of the electrons in turn depends of their charge. Thomson knew the magnetic field strength but neither the mass nor the charge of the electron. Thomson adjusted the magnetic field that bent the ray of electrons one direction and the electrical field that bent the ray of electrons in another direction. When the two were balanced, he found the charge to mass ratio.



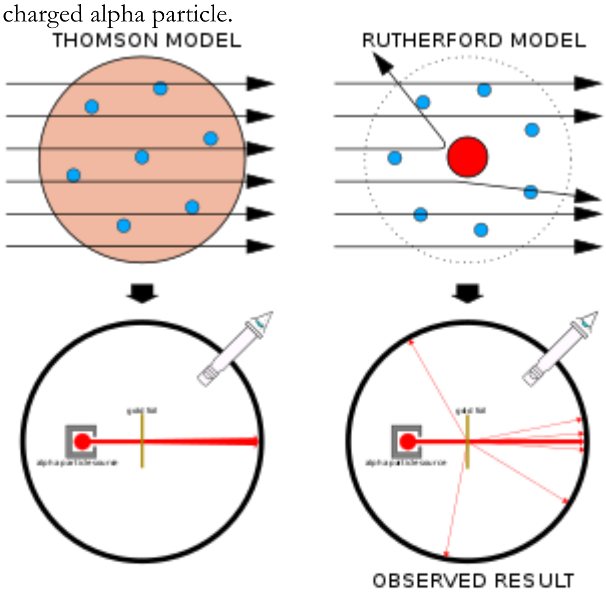
An analogy. Attach a weight to a strip of rubber and, holding the other end of the strip, whirl the weight over your head. You should observe that the rubber strip makes an arc. The radius of the arc will depend on the mass of the mass of the weight, the speed of the weight, and the elasticity of the rubber strip. To make the radius of the arc bigger, you can increase the weight, increase the speed, or use a more elastic rubber. In Thomson experiment, the mass is the mass of the electron, the speed is analogous to the energy of the electron, and the spring is the magnetic field strength. Using this data, Thomson calculated the charge-to-mass ratio of the electron, which is 1.76 X 10^8 Coulomb/g.

The arc depends on	to make radius curve greater:	Thomson's experiment
mass of weight	increase weight	electron mass
speed of weight	increase speed	electron energy
stiffness of spring	use a slacker spring	magnetic field strength

Millikan's designed his experiment to measure the charge on an electron. He designed a device that would allow him to observe oil drops free falling in space. The oil drops were ionized and allowed to fall between two charged plates. The charge on each drop can be found by varying the voltage between the plates until the electrical force felt by the charged drop just balances the force of gravity. Then the drop stands still. The charge on each drop is always found to be an exact multiple of 1.602×10^{-19} coulomb, the charge on an electron. From this data, he was also able to calculate the mass of the electron—9.10×10^{-28}g.



Geiger and Marsden, working in Rutherford's lab, beamed alpha particles at thin gold foil. Alpha particles are high-energy particles that are identical to helium-4 nucleus and are radioactive. Geiger and Marsden were trying to determine the shape of the atom. The experiment is similar to observing a knife thrower at a circus. The knife thrower tries to outline his assistant with knifes. The size and shape of the assistant can be determined from the outline. The experiment had some surprising results. Most of the particles passed straight through but some were deflected, a few right back at the alpha source. This is like having a bullet bounce off a piece of tissue paper and head back toward the shooter. Rutherford used this data to conclude that the atom is composed of mostly empty space. Most of the mass of the atom is in the nucleus, the center of the atom. The nucleus is positively charged because it repelled the positively charged alpha particle.



Describe the differences between Rutherford's nuclear atom and Thomson's model of the atom.

The Rutherford model of the atom consists of a very small nucleus (0.1 pm in diameter), which contains all of the positive charge and more than 99.9% of the mass, surrounded by a cloud of electrons. The electrons possess all of the negative charge, less than 0.1% of the mass, and fill most of the space of the atom.

Thomson's' model lacks the small dense nucleus. The negative electrons are embedded in a uniform sphere of positive charge. This would look like a ball of chocolate chip cookie dough.

Explain the symbolism $^{A}_{Z}X^{C}$. Describe what each part means in the symbol.

The compete symbol for an atom or ion consist of the elemental symbol surrounded by subscripts and superscripts. The subscripts are Z and y; the super scripts are A and w. A and Z are used for describing information about atomic species. W is used for ions, and y is used for writing formulas of compounds.
The superscript A is the mass number. This is the number of protons and neutrons combined.
The subscript Z is the atomic number or the proton number. As the name implies it is the number of protons. Often it is omitted since the elemental symbol determines the atomic number, but we will include it for emphasis.
The superscript w is the charge on the species or the number of protons minus the number of electrons. The sign (+ or -) always must be included. The number zero is used for a neutral atom, but the zero is written only for emphasis. For example,

$$^{203}_{80}W^{2+}$$

, A is 203 amu, Z is 80, W is +2, and y is 2.

Discuss the relationships between the mole, the Avogadro constant and the molar mass of an element.

The atomic mass (the term weight is used interchangeabley) of an element is the decimal number appearing in the elements block in the periodic table. For example, the atomic mass of carbon is 12.011 amu. This atomic mass represents a weighted average atomic mass of the individual isotopes of that element. The atomic mass is a non-integral number, whereas the atomic mass number (A) is considered a whole number consisting of the sum of the protons and neutrons in the nucleus.

When we work with a small group of atoms, we use the unit amu–atomic mass unit. This is a very small amount and not very practical when working n the lab. We want a value that is tangible, and based on the gram. For larger amounts of matter, we use the molar mass, which is related to a larger counting quantity—Avogadro's number of atoms. If the atomic mass of an element is expressed in grams, that mass—the molar mass— will contain an Avogadro's number of atoms of that element.

Avogadro's number is truly huge—6.022 X 10^{23}. The number is so large that if one million workers attempt to move 6.022 X 10^{23}grains of sand with shovels, the task would require 450 years, assuming 10 shovel full per worker each minute and 250 million grains of sand (about 15 pounds) per shovel full. An Avogadro's number of grains of sand is 602.214X 10^{21}grains of sand, 602 septillion grains of sand. Instead of counting atoms, we weigh out an amount of material and use the mass of Avogadro's number of atoms, the molar mass, to determine how many atoms are present.

Usually, we are not concerned with how many atoms are present. We simply need to know that there are enough atoms of each element for a particular chemical reaction, which we can determine by mass. Hence, we speak of moles of atoms. A mole of an element contains Avogadro's number of atoms. The abbreviation for mole is mol. A molecule is simply a cluster of atoms bound together.

Moles, molar mass, and the number of moles are related to each other as cookies in a cookie package. Look at a package of Pepperidge Farm Shortbread cookies. The package holds 12 cookies and has a total mass of 156g. If I need 144 cookies, I could either ask for 12 packages, 1872 g, or 144 cookies. The package is like the unit the mole; the number of cookies is like Avogadro's number; the mass of the package is like the molar mass.

Moles represent a set number of items. If we know the mass of that set number for each material that is used in the experiment, we can use a scale to count atoms instead of actually counting them (something next to impossible for a general lab to do).

Distinguish between a mole of atoms and a mole of molecules

A mole of atoms is 6.022 X 10^{23}atoms, but the mole can apply to anything small we wish to count. A molecule is simply a cluster of atoms bound together. Atoms are the building blocks of molecules. For example, look at water. A mole of water molecules would contain 6.022 X 10^{23} water molecules. Each water molecule contains 2 hydrogen atoms and 1 oxygen atom. There would be 2 moles of hydrogen and one mole of oxygen in a mole of water. Therefore, there are 1.2044 X 10^{24} and 6.022 X 10^{23} of oxygen in a mole of water.

Distinguish between formula unit and molecule, empirical formula and molecular formula, and formula mass and molecular mass.

A molecule is a group of atoms bound together to form discrete units. The bonds that hold a molecule together are called covalent bonds (CH9). The species in a formula unit are not bound together in the same manner. Formula units represent the simplest form of a larger collection of ions or atoms that are not bound together in discrete units. They might be networks of atoms, metallic bonds, or ionic compounds.

A molecular formula accounts for the type and number of each atom in the compound. The empirical formula expresses the smallest combining ratio of atoms in the compound. Peroxide has 2 hydrogen atoms and 2 oxygen atoms in its molecular formula; its empirical formula has 1 hydrogen and 1 oxygen.

The molar mass of a compound is the sum of all of the molar masses of the atoms in the compound; likewise, the formula mass in grams is the mass of a mole of formula units, and the molecular mass in grams is the mass of a mole of molecules. It is okay to refer to any one of these three masses as the molar mass.

We can determine the molar mass of a compound by adding up each mass component of the formula. Each subscript is interpreted as the number of moles of each element in a mole of the compound. Hydrogen peroxide H_2O_2 has a molar mass of 34.02 g/mol (16.00 X 2 + 1.01 X 2). Notice that the value 34.02 is the same whether we speak of amu as the unit or g/mol. The amu represents a smaller amount (1 molecule) of peroxide than the g/mol (1 mole).