TEACHER BACKGROUND INFORMATION

(*Basic Chemistry*)

A. ATOMIC STRUCTURE:

All matter is made up of small particles known as atoms. Identical atoms can bond together (like a gold bar), and different atoms can bond together to create new molecules. For example, table salt consists of a sodium atom bonded with a chlorine atom. The result is neither sodium nor chlorine but a new type of matter known as sodium chloride or salt. Some molecules are made up of many different atoms. For example, a sugar molecule is made up of 12 carbon, 22 hydrogen and 11 oxygen atoms.

Atoms are made up of three main subatomic particles: protons, neutrons and electrons. There are even smaller pieces moving around in atoms, for example quarks. Protons and neutrons make up the nucleus (center) of an atom, while electrons orbit outside the nucleus (Fig. 1). It was once thought that electrons orbit the nucleus in a fixed path much like planets orbit the sun. While this model may be visually pleasing, it is quite inaccurate. More recently, scientists believe that electrons do not orbit the nucleus in a well-defined path, but rather that they may occupy many positions around the nucleus. For this reason, scientists represent atoms with the electrons' positions drawn as indistinct clouds around the nucleus.

Protons have a positive charge, electrons have negative charges and neutrons have no charge. Just like magnets with opposite charges, the protons and electrons are attracted to each other. This attraction keeps the electron close to the nucleus. The number of protons and electrons determines the overall electrical charge of an atom. For example, an atom with more protons than electrons is positive, the reverse would yield a negative atom and if there is no difference in the number of protons and electrons the atom is said to be neutral. Atoms with a charge are called **ions**. Changing the number of neutrons in an atom does not affect its electrical charge. Atoms that have the same number of protons but different number of neutrons are called **isostopes**.

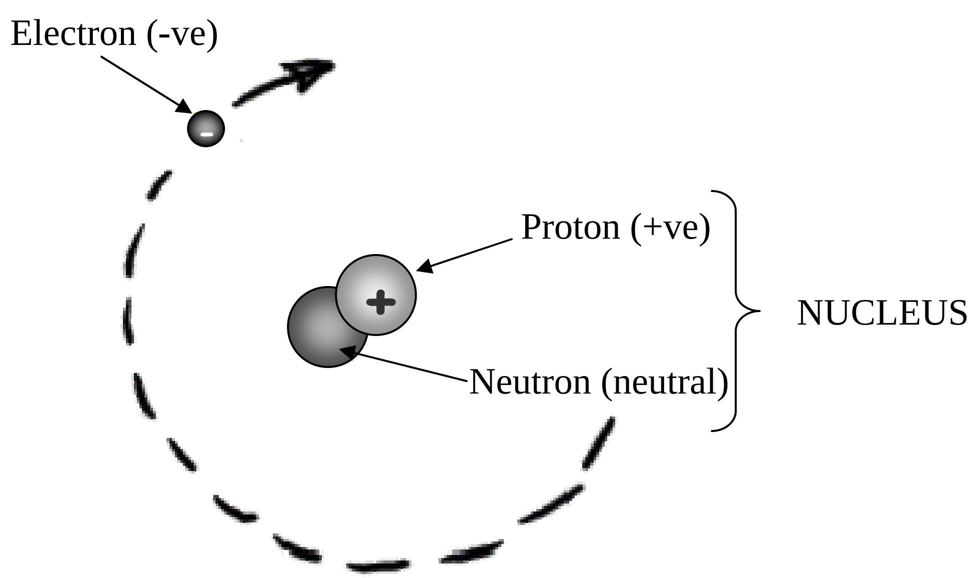

Figure 1 – Atom showing positive proton and neutral neutron in nucleus, and positive electron outside nucleus.

Atoms are very small. Most atoms are only about one ten-billionth of a meter in diameter. That means you could fit about 100 million atoms along a 1 cm long line. The protons, neutrons, and electrons that make up an atom are much smaller than the whole atom. There is a lot of “empty” space between the protons and neutrons in an atom’s nucleus and the electrons attached to the atom. In fact, most of the volume of an atom is empty space.

Most of an atom's mass is in its nucleus. The mass of a proton is about 2000 times the mass of an electron. Protons and neutrons have similar masses.

B. <u>ELEMENTS AND COMPOUNDS</u>:

<u>Elements</u>:

An **element** is a substance which cannot be separated into simpler substances by a chemical change, e.g. gold. It is important to note that all atoms of an element have the same number of protons (**atomic number**), but not necessarily the same number of electrons and neutrons. Let's use the element Lithium as an example to demonstrate what was just stated. Lithium atoms generally have 3 protons, 3 neutrons and 3 electrons.

- If we remove or add a neutron from a Lithium atom, it is still Lithium but with a different number of neutrons (**isotopes)**.
- If we remove or add an electron from a Lithium atom, it is still Lithium but with a different number of electrons (**ions**).
- If we remove a proton from a Lithium atom, it is no longer Lithium but rather it has become a Helium atom.

It is important to know that the atoms of most elements do not occur alone. They combine/bond with the same kind of atom or different kinds to form molecules. For example Oxygen in the atmosphere is not found as single atoms of Oxygen, but rather as a molecule of two bonded Oxygen atoms (O_2) or sometimes even three bonded Oxygen atoms (O_3).

Scientists have discovered more than 100 elements (~ 92 naturally occurring) in our world so far and created many of them in a lab. These elements have been organized and arranged into a periodic table according to their properties. The **Periodic Table** uses symbols (e.g. Sodium is Na) and organizes elements in order of atomic number. The table is also organized so that elements with similar properties are in the same group of columns. These groups include metals, nonmetals, and metalloids (See Table 1).

Table 1 – Characteristics of metals, nonmetals and metalloids.

Group in Periodic Table	**Example**	**Characteristics**
Metals	Gold (Au)	• Shiny metallic appearance • Solid at room temperature (except Mercury) • Ductility (ability to be shaped into a duct/pipe) • Malleability (ability to be pounded into a thin sheet) • Thermal/heat conductor • Electrical conductor
Nonmetals	Carbon (C)	• Little or no metallic luster • Brittle solids • Poor thermal conductors • Poor electrical conductors
Metalloids	Silicon (Si)	• Some are shiny • Possess characteristics of both metals and nonmetals • Often make good semi-conductors

<u>**Compounds**</u>:

Compounds are composed of two or more elements, and thus contain two or more kinds of atoms. Water is one of the most common compounds on earth. Each water molecule is made up of two Hydrogen atoms bonded to one Oxygen atom. The chemical formula for water is H_2O.

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When two elements join to form a compound, they undergo a chemical change. The properties of the compound are different from the properties of the elements in it.

Elements and compounds are considered to be **pure substances**, or just substance for short, meaning they each have a fixed composition and a unique set of physical and chemical properties.

C. MIXTURES AND SOLUTIONS:

Mixtures:

Mixtures are combinations of two or more substances such as elements or compounds. Each substance keeps its own individual properties in a mixture. Whereas pure substances have a fixed composition, the compositions of mixtures can vary, e.g. a cup of coffee can contain a little bit of sugar or a lot. Solids, liquids, and gases can all be mixed together. A carbonated drink is a mixture of a liquid and a gas (carbon dioxide). Tap water is a mixture of pure water, and very small trace amounts of calcium, magnesium, fluorine, and other solid elements and compounds. The substances of a mixture do not chemically combine, and can be physically separated through filtering, heating, and other methods.

Mixtures can be classified as **heterogeneous** (hetero- different), or **homogeneous** (homo- same). Both types of mixtures can be separated into the substances that make them up.

- In a **heterogeneous** mixture, individual substances can be seen, such as pulp in orange juice or oil in vinegar. The components of a heterogeneous mixture are not mixed evenly. One way to separate heterogeneous mixtures is called **filtration**. This process basically requires pouring a heterogeneous mixture through a piece of paper, which lets the liquid pass through but retains the solid.

- In a **homogeneous** mixture, the individual substances are not visible. Homogeneous mixtures are uniform throughout. For example, sea water is a homogeneous mixture of water and salts. Homogeneous mixtures cannot be separated by filtration. Examples of techniques used to separate homogeneous mixtures include:
  - **Distillation**- a process that takes advantage of differences in boiling points. For example, in a mixture of two liquids, the liquid with the lower boiling point will change into a gas first. This gas can be changed into a liquid and collected. The other liquid will remain liquid until its boiling point is reached.
  - **Crystallization**- a process that forms crystals. For example, if seawater is allowed to evaporate partially, crystals of salt will form. It is not limited to liquid mixtures. Gemstones are crystals that formed as the earth slowly cooled.
  - **Chromatography**- a process that takes advantage of the cohesive and adhesive properties of a liquid or gas to a medium such as paper. For example, the pigments in an ink solution can be separated by passing it through a piece of paper. Some pigments will move up the paper, while others will be held back.

Solutions:

Homogeneous mixtures are called **solutions**. Examples of solutions include the air we breathe, fluids in our bodies, brass in jean buttons, and seawater. A solution is formed when one substance disperses uniformly throughout another, making it practically impossible to visually distinguish between the two of them.

Solutions may be gases, liquids, or solids. Each substance in a solution is called a **component** of the solution. In a solution, the component present in the greatest amount is called the **solvent** and the other components are called **solutes**. A solution is formed when a solute is dissolved in a solvent. For example, salt (solute) can be dissolved in water (solvent) to make a solution of seawater. Solutions can be categorized according to the physical state of the solution: solid solutions, gaseous solutions, and liquid solutions (See Table 2).

Table 2- Different types of solutions in different physical states.

Solute	Solvent	Example
Gas	Gas	• Air (Oxygen in Nitrogen)
Gas	Liquid	• Seltzer (carbon dioxide in water)
Liquid	Liquid	• Antifreeze (ethylene glycol, a type of alcohol in water)
Solid	Liquid	• Ocean water (salt in water)
Gas	Solid	• Charcoal filter (poisonous gases in liquid)
Liquid	Solid	• Dental filling (mercury in silver)
Solid	Solid	• Sterling silver (copper in silver)

Sometimes a mixture may look like a solution, but in fact it is not. For example milk may look like a solution but it consists of tiny particles of fat and protein that are suspended in water. Hence, milk is a mixture of particles and liquid. This is an example of a colloid. Other examples include smoke and fog, which are colloids occurring in air.

A **colloid** is a mixture where the components are very small, and cannot be seen, but are larger than the solvent molecules. This difference in particle size between the solute and the solvent makes a colloid non-homogeneous. However, the particles do not settle as they would in a heterogeneous mixture. Colloids are a dividing line between solutions (homogeneous mixtures) and heterogeneous mixtures. Like solutions, colloids can be gases, liquids, or solids (See Table 3). Although colloid particles are very small, they are large enough to scatter light. Consequently, most colloids appear cloudy or opaque unless they are very dilute. Milk is actually a colloid. Because colloidal particles scatter light, a light beam can be seen as it passes through a colloidal solution. This scattering of light by colloidal particles, known as **Tyndall effect**, makes it possible to see the light beam from a car on a dusty road.

Table 3- Types of colloids.

Phase of Colloid	**Dispersing (Solvent-like) Substance**	**Dispersed (solutelike) Substance**	**Colloid Type**	**Example**
Gas	Gas	Liquid	Aerosol	• Fog or hairspray
Gas	Gas	Solid	Aerosol	• Smoke
Liquid	Liquid	Gas	Foam	• Whipped cream
Liquid	Liquid	Liquid	Emulsion	• Milk
Solid	Solid	Gas	Solid Foam	• Marshmallow
Solid	Solid	Liquid	Solid	• Butter or mayonnaise