Chemicals and Chemical Change

1. Classifying Pure Substances
    a. A pure substance is one in which all the particles that make up the substance are the same. As a result, the substance has constant properties.
        i. For example, pure water is a clear, colourless substance that freezes at exactly 0°C and boils at 100°C.
    b. Pure substances are classified as elements or compounds.
        i. Elements are pure substances that cannot be broken down into simpler substances.
            1. Oxygen, hydrogen, iron, and mercury are elements because each contains only one kind of atom.
            2. Elements are all listed in the periodic table and each is assigned a chemical symbol. Pure gold (symbol Au) is completely made up of atoms of gold.
            3. Some elements consist of molecules, which are formed when two or more atoms join together; for example, the element oxygen (O) occurs in nature as pairs of oxygen atoms, or molecules of oxygen (O_2).
        ii. Compounds are pure substances that contain two or more different elements in a fixed proportion.
            1. Compounds can be identified with chemical formulas. For example, carbon dioxide (formula CO_2) is a compound. Each molecule of carbon dioxide is composed of one carbon atom and two oxygen atoms.

2. All matter has physical and chemical properties.
    a. A physical property is a characteristic of a substance.
        i. The state of matter at room temperature, hardness, melting and boiling points, odour, solubility, and colour are all physical properties.
            1. For example, baking soda is a pure substance that is a white, crystalline solid at room temperature that dissolves readily in water to form a solution.
            2. A change (such as dissolving or melting) in the size or form of a substance, which does not change the chemical properties of the substance, is called a physical change.
    b. A chemical property is a characteristic behaviour that occurs when a substance changes to a new substance.
        i. The change itself is called a chemical change.
            1. For example, when baking soda is added to acid, a new substance, carbon dioxide gas, is formed. This reaction with acid is a chemical property of baking soda.
            2. When an iron nail is left in contact with water, it undergoes a chemical change: the iron combines with the oxygen in the air to form a new substance, iron(III) oxide (rust).
        ii. The starting materials in a chemical change are called reactants, and the new materials produced are called products. For example, iron and oxygen are reactants and iron(III) oxide is a product.

3. All elements are organized into the Periodic Table.
    a. The periodic table explains and predict physical and chemical properties.
    b. The periodic table is arranged with metals on the left side of the table and nonmetals on the right side of the table.
        i. Notice one exception is hydrogen (H). It behaves as both a metal and a nonmetal.
    c. Chemical families (or groups) are groups of elements in the same vertical column of the periodic table.
        i. They tend to have similar physical and chemical properties.

4. Atoms have a known structure.
    a. All atoms are composed of three types of subatomic particles: protons, neutrons, and electrons.
        i. Protons are heavy, positively charged particles that are found in a dense positive core of the atom called the nucleus.
            1. The number of protons in an atom is equal to the element's atomic number.
        ii. Neutrons are neutral particles that have about the same mass as protons and are also found in the nucleus.
        iii. Electrons are negatively charged particles with almost no mass that move around the nucleus like planets orbiting the sun.
            1. Since atoms are electrically neutral, the number of electrons in an atom equals the number of protons.
    b. The arrangement of electrons in an atom determines how the atom behaves during chemical reactions.
        i. The farther away an electron is from the nucleus, the more likely it is to be involved in a chemical change.
        ii. Electrons in the outer orbit are involved in bonding.
        iii. We can use Bohr diagrams to represent the arrangement of electrons in various orbits.
            1. Each orbit has a definite number of electrons.
            2. The first orbit can have a maximum of two electrons.
            3. The second and third orbits can have no more than eight electrons
            4. The noble gases do not easily form compounds because their outer orbits are already full.
    c. When elements form compounds, changes occur in the arrangement of electrons.
        i. In some compounds, electrons are transferred from one atom to another so that the atoms can have the stable electron arrangements of the closest noble gases (*i.e.*, full outer orbits).
            1. For example, lithium has two electrons in the first orbit and one in the second orbit.
                a. If lithium loses the electron in its outer orbit, it has the same stable electron arrangement as helium: two electrons in the first orbit.
                b. But the lithium atom no longer has a neutral electric charge. It has formed an ion, a charged atom in which the number of electrons is different from the number of protons.
                c. The ionic charge is the numerical value of the electric charge with a plus or minus sign.

i. For example, the lithium ion has an ionic charge of 1+, because it has three positive protons in the nucleus and only two negative electrons. The lithium atom has become a positive lithium ion, Li1+ which is commonly written as Li+.