# Unit 1: Matter & Qualitative Analysis

Text sections: 1.1 - 1.17 Pages 1 - 70

### What Is Chemistry?

**Chemistry** is the study of the composition, structure, properties and transformations of matter

Matter is defined as anything that has mass and takes up volume (space).

There ar	e two	types	of	chemistry:

SCHHL  $H \perp U$ **Applied Chemistry** Pure Chemistry - The **study** of principles of - The **use** of chemistry for practical purposes (i.e. chemistry developing useful products) - Involves the search for - Involves the use of scientific knowledge scientific knowledge - Involves the technological - Involves the scientific method method Areas of Study? Areas of Study? -Structure of Matter -Atomic Energy - Biochemistry of Blood - Medicines -Types of Viruses -Vaccines

### Pure vs Applied Chemistry

#### Pure chemists study:

•Composition and structure of substances

•Properties of substances

•Conditions under which substances can be changed into new substances

### Applied chemists use the knowledge gained by pure chemists to:

•Solve societal problems eg. diseases

•Improve standards of living eg. development of new materials: rubber, clothing, food

**Technology** refers to the use of basic scientific knowledge to develop useful products.

FIELDS OF	APPLIED CHEMISTRY
AGRICULTURE	- Study of soils, fertilizers, pesticides, herbicides
ENVIRONMENTAL	- Effect of human activity on chemistry of air, land, water
FOOD CHEMISTRY	<ul> <li>Chemical composition of foods &amp; food additives</li> </ul>
MARINE	- Study of chemical compounds in marine life and sea water
NUCLEAR	- Study of atomic nucleus
BIOCHEMISTRY	- Study of processes and physical properties of living organisms

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### <u>Observation, Inference & Empirical</u> <u>& Theoretical Knowledge</u>

Term	Definition
Qualitative Analysis	Determining the composition of a sample of matter from its physical and chemical properties Careers: Forensics
Observation	A statement based on your <u>five</u> senses (see, hear, touch, taste, and smell)
Inference	A judgment or opinion that is based on observations and/or conclusions from testing Example: "The ground is wet (Obs). It must have rained last night (I)"
Empirical Knowledge	Knowledge coming <b>directly</b> from observations. <b>Example:</b> a thermometer placed in water that reads 100°C indicates water changing from liquid to gas
Theoretical Knowledge	Knowledge based on <b>ideas</b> that are created to explain observations. <b>Example:</b> <i>Kinetic Molecular Theory is used to</i> <i>explain water changing from liquid to gas</i>
Theory	An explanation of a large number of observations
Model	A representation of a theoretical concept <b>Example:</b> A vibrating box that contains marble to demonstrate the kinetic molecular theory

### The Electromagnetic Spectrum

A wave has maximum and minimum values called crests and troughs. The distance between 2 crests or 2 troughs is called the **wavelength** (figure 1). Wavelength of visible light is usually measured in nanometers (nm = 10<sup>-9</sup>m).



**Electromagnetic energy**: light energy that travels in the form of waves. The **frequency** of a light wave is the number of cycles that pass a point in one second. The electromagnetic spectrum consists of light waves of different frequencies and wavelengths (figure 2).



The electromagnetic spectrum encompasses an enormous range of wavelengths and energies. Waves in the X-ray range are 10<sup>11</sup> times more energetic than waves in the radio range. The special band of light waves that the human eye can detect

is called the visible spectrum (400nm - 700nm).

### <u>The Electromagnetic Spectrum</u> <u>Cont'd</u>

Term	Definition
Continuous Spectrum	Uninterrupted pattern of colours that is observed when a narrow beam of white light passes through a prism <b>Example:</b> A rainbow
Line Spectrum	Discontinuous spectrum that is produced when light emitted by an element is directed through a prism or a diffraction grating.

e moving in atoms

			nnqnn	u u u u u u u u	man		11111
400	460	500	550	600	650	700	750
		v	isible spec	trum, λ (nn	n)		
figure	2 3)		•				

Analyzing the spectrum of a sample is one way to distinguish between different types of matter.



(figure 4)

\*\* An element's line spectrum is analogous to a human's fingerprint, therefore, using a spectroscope can identify the chemical composition of an unknown sample \*\*

### The Bohr Model of The Atom

In the Bohr model of the atom, electrons orbit the nucleus as the planets orbit the Sun. Only certain orbits are allowed, however, and an electron in each orbit has a specific energy.



Bohr suggested that electrons revolve around the atom's nucleus in orbits of fixed energy. These orbits are similar to the fixed orbits of the planets as they revolve around the Sun.

The electrons are restricted to certain energy levels. Electrons must posses specific amounts "quanta" of energy at each energy level (fig. 3)



When the hydrogen atom's electron falls back to its original position, it releases the same amount of energy it absorbed in order to reach the higher energy level. If the electron is found in the lowest possible energy level, it is said to be in its **ground state** (figures 4 and 5) An electron dropping from a higher energy level to a lower energy level is like a ball bouncing down a staircase. The bottom stair = ground state of the electron in an atom.





(a) An electron gains a quantum of energy and jumps to a higher energy level.



(b) An electron loses a quantum of energy and drops to a lower energy level.

#### Conductivity & Ions

Term	Definition
Conductivity	The ability of a substance to conduct electricity; a physical property



Figure 1: Electrolytes vs. non-electrolytes

The majority of elements on the face of the Earth exist as compounds. This is because elements desire to achieve a **STABLE OCTET**. In order to do this, elements gain and lose electrons to fill their **VALENCE SHELL** to 8.



### Dot Diagrams & Ionic Compounds

Term	Definition
Lewis Symbol	A diagram showing both the chemical symbol and dots indicating the # of valence electrons

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Н٠							He:
			IV	v	VI	VII	
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\*\* Review names of polyatomic ions p.33 Table 1\*\*

Term	Definition
Ionic Bond	Bonds that form between a metal and a non- metal due to an attraction between 2 oppositely charged ions
Ionic Compound	A compound that consists of cations and anions held together by ionic bonds.
Formula Unit	The smallest amount of a substance having the composition given by its chemical formula
Dissociate	Separate into positive and negative ions when placed in water 9

## <u>Covalent Bonds</u>

Term	Definition
Covalent Bond	Two non-metal atoms <b>share</b> one or more pairs of electrons between them. The shared electron pairs attracted to the nuclei of both atoms.
Molecule	Two or more atoms joined by covalent bonds
Lewis Structure	Representation of covalent bonding using Lewis diagrams with shared electron pairs shown as <b>lines</b> and <b>lone pairs</b> shown as dots
Lone Pair	Pair of valence electrons that is not involved in bonding.

Read the SAMPLE PROBLEM p. 36 - 39 & Answer p. 39 # 1-4

### Polarity & Bonding

Term	Definition
Electronegativity	A measure of an atom's ability to attract a shared pair of elecctrons within a covalent bond.



Term	Definition
Polar Molecule	Slightly positive end & slightly negative end
Non-polar Molecule	No charged ends

Polarity of molecules depends on two characteristics:

- 1. The presence of polar covalent bonds
- 2. The three dimensional shape (geometry) of the molecule



### Intermolecular bonds

Туре	Description	Example
Dipole- Dipole Force (DDF)	Attraction that forms between the slightly positive end of one polar molecule and the slightly negative end of an adjacent polar molecule	HCI - HCI
London Dispersion Forces (LDF)	Attraction that forms between atoms of neighbouring molecules as a result of a temporary imbalance in the position of the atoms' electrons; can form between polar and non-polar molecules. BIG MOLECULES!	C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> - C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>
van der Waals Forces	Attraction between molecules: include DDF and LDF	

### Types of Reactions

SYNTHESIS = 2 or more little bits form a larger bit

 $\begin{array}{c} \mathsf{A} + \mathsf{B} & \Longrightarrow & \mathsf{A}\mathsf{B} \\ \mathsf{2} \ \mathsf{H}_{2(\mathsf{I})} + \mathsf{O}_{2(\mathsf{g})} & \Longrightarrow & \mathsf{2} \ \mathsf{H}_{2}\mathsf{O}_{(\mathsf{g})} \end{array}$ 

COMBUSTION = Elements combine rapidly with  $O_{2(g)}$  to form more complex molecules by burning

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$$
  
 $S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$ 

DECOMPOSITION = One big bit breaks into two or more bits  $AB \longrightarrow A + B$  $2H_2O_{2(l)} \longrightarrow O_{2(g)} + 2H_2O_{(l)}$ 

SINGLE DISPLACEMENT = a reaction of an element with a compound to produce a new element and a new compound.

 $A + BC \implies AC + B$  $Zn_{(s)} + Pb(NO_3)_{2(aq)} \implies Pb_{(s)} + Zn(NO_3)_{2(aq)}$ 

DOUBLE DISPLACEMENT = the anions and cations from the two compounds switch places, forming two new compounds.

$$AB + CD \longrightarrow AD + BC$$
  

$$2AgNO_{3(aq)} + CaCl_{2(aq)} \implies 2AgCl_{(s)} + Ca(NO_3)_{2(aq)}$$

### Solubility Rules

- (a) Determine the products (if any) when a solution of sodium chloride is mixed with a solution of silver nitrate. If a reaction occurs, summarize the reaction as a balanced chemical equation.
- Step 1: Identify Type of Reaction and Possible Products

- Step 2: Look up Solubility of Both Products
- Step 3: Indicates States of Reactants and Products

Step 4: Write Chemical Equation for Reaction

Step 5: Balance Equation

### Total Ionic & Net Ionic Equations

Term	Definition
Net Ionic Equation	Equation that depicts <b>only</b> the ions that are involved in a chemical reaction
Total Ionic Equation	Equation that illustrates <b>all</b> soluble ionic compounds in their ionic form
Spectator Ion	An ion that is present during a chemical reaction but does <b>not</b> participate in the reaction.

e.g. aqueous sodium chloride and aqueous lead (II) nitrate

- Write the double displacement reaction as a word equation
- Using the solubility rules, determine whether the products of the reaction have high or low solubility in water.
- Using this information, indicate the states of the reactants and products
- Write a chemical equation for the reaction.
- Balance the equation.
- Rewrite the equation, with all the ionic compounds that are soluble in water separated into their respective ions. Cancel identical amounts of identical ions that appear on both the reactant and product sides of the equation.
  - Write the net ionic equation, reducing coefficients if necessary.

### Separating Ions

Term	Definition
Centrifuge	Lab equipment that spins solutions at very high speeds, to separate the different particles form each other based on their densities
Supernate	Part of a centrifuged solution that does not settle to the bottom of the centrifuge top

