SLO 1: Fundamentals of Chemistry

1.1 Chemistry And Its Branches

Chemistry
Chemistry is the branch of science which deals with the properties, composition and the structure of substances. It also deals with the physical and chemical changes in matter and the laws or principles which govern these changes.

Analytical Chemistry
This branch of chemistry deals with the analysis of different substances. It involves separation, identification and determination of the concentration of the components present in material things.

Astrochemistry
It is the study of molecules and ions recurring in space and interstellar space. It studies the abundance and reactions of atoms, molecules and ions in the universe and interaction of these species with radiation.

Biochemistry
It is the study of chemical substances and vital processes occurring in living organisms. Biochemistry provides insights into the structure and function of molecules such as proteins, carbohydrates, lipids and nucleic acids.

Environmental Chemistry
It is the scientific study of the sources, reactions, effects and fates of chemical species in the air, soil and water environments. It helps in understanding the causes, effects and solutions of different types of pollution.

Geochemistry
The study of chemical composition of Earth and its sources and minerals is called geochemistry.

Industrial Chemistry
The branch of chemistry which deals with the study of chemical processes involved in the chemical industries for the manufacturing of synthetic products is called Industrial chemistry.

Inorganic Chemistry
The study of the synthesis, composition, properties and structure of elements and compounds that contain little or no carbon such as metals, nonmetals or a mixture of these, salts, acids and bases.

Nuclear Chemistry
Nuclear chemistry deals with radioactivity, nuclear processes and transformation in the nuclei of atoms.

Organic Chemistry
It is the branch of chemistry that deals with the carbon compounds (hydrocarbons and their derivatives) other than its simple salts like carbonates, bicarbonates, oxides and carbides.

Physical Chemistry
This branch investigates how substances behave at atomic and molecular levels. It provides clear explanation as to how fundamental physical laws governing our world cause atoms and molecules to show specific characteristics and in turn react to give huge structures related to life.

Polymer Chemistry
Polymer chemistry focuses on the properties, structure and synthesis of polymers and macromolecules. Proteins, cellulose and nucleic acids are naturally occurring polymers.

1.3 Definitions, Comparisons, Valencies, And Chemical Formulae

1.3.1 Define The Terms:

- Atoms: Atoms are the smallest units of matter that retain the properties of an element.
- Elements: Elements are pure substances made up of only one type of atom.
- Compounds: substances formed when two or more different elements are chemically bonded together.
- Mixtures: combinations of two or more substances are physically combined but not chemically bonded.
- Molecules: Molecules are groups of two or more atoms chemically bonded together. A molecule can consist of the same type of atom (like O_2) or different types (like CO_2).

1.3.2 Differentiate Between

Atoms	Molecules
It is the smallest particle of an element	Two or more atoms bonded together chemically
It can or cannot exist independently and can take part in a chemical reaction	It can exist independently and can take part in a chemical reaction
It is electrically neutral	It is always neutral
Composed of protons, neutrons, and electrons.	Formed by combination of atoms.
Atoms	**Ions**
It is the smallest particle of an element	It is the smallest particle of an ionic compound
It can or cannot exist independently and can take part in a chemical reaction	It cannot exist independently and is surrounded by oppositely charged ions
It is electrically neutral	It has a net charge
Molecules	**Molecular Ions**
Two or more atoms bonded together chemically	It is formed by gain or loss of electrons by molecule
It can exist independently and can take part in a chemical reaction	It cannot exist independently and is surrounded by oppositely charged molecular ions
It is always neutral	It has a net charge
Ions	**Free Radicals**
These are atoms which have some charge	These are atoms that have odd number of electrons
They can exist in solution or in crystal lattice	They can exist in solutions or in air
Their formation is not affected by presence of light	They may form in presence of light
Example: Ammonium ion (NH_4^+), Sulphate ion (SO_4^{2-})	Example: Hydroxyl radical (•OH), Methyl radical (•CH_3)

1.3.3 Differentiate Among Elements, Compounds And Mixtures

Element	Compound	Mixture
Substance made up of same atoms, discovered naturally.	Formed by chemical combination of atoms of the elements.	Formed by the simple mixing of the substances.
Unique properties due to similarity of atoms.	Atoms form a new substance with new properties.	Substances retain their properties in mixture.
All atoms same atomic number.	Fixed composition by mass.	No fixed composition by mass.
Cannot be decomposed	Cannot be physically separated	Can be physically separated.
Represented by symbols	Represented by chemical formula.	Have no chemical formula.
Homogenous composition	Homogenous composition.	Homogenous and heterogeneous
Melting points increase with an.	Sharp and fixed melting points	No sharp and fixed melting points.

1.3.4 Classify The Chemical Species

Term	Charge	Composed of	Example	Key Feature
Atom	Neutral	Single element	H, O	Basic unit of matter
Molecule	Neutral	Two or more atoms	H_2O, O_2	Atoms bonded together
Ion	Charged	Atom or group with charge	Na^+, Cl^-	Gains or loses electrons
Molecular Ion	Charged	Molecule with a net charge	NH_4^+, SO_4^{2-}	Charged group of atoms
Free Radical	Neutral	Atom/molecule with unpaired e^-	•OH, $•CH_3$	Highly reactive

1.3.5 Define The Term Valency.

Valency is defined by the number of electrons an atom can lose, gain, or share to achieve a full outer shell.

- Valency tells you how many bonds an atom can form.
- It is based on the number of electrons in the outermost shell (valence electrons).
- Elements in the same group of the periodic table usually have the same valency.

Examples:

- Hydrogen (H) has 1 electron → valency = 1
- Oxygen (O) needs 2 electrons to fill its shell → valency = 2
- Nitrogen (N) needs 3 electrons → valency = 3
- Carbon (C) can form 4 bonds → valency = 4

1.3.6 Recognize Valencies Of Common Elements And Ions (Radicals) Independently Or In Compounds

Group	Element Type	Valency	Radical (Ion)	Symbol	Valency
1	Alkali metals	1	Ammonium	NH_4^+	1
2	Alkaline earth metals	2	Hydroxide	OH^-	1
13	Aluminium family	3	Nitrate	NO_3^-	1
14	Carbon family	4 or 2	Sulphate	SO_4^{2-}	2
15	Nitrogen family	3 or 5	Carbonate	CO_3^{2-}	2
16	Oxygen family	2	Phosphate	PO_4^{3-}	3
17	Halogens	1	Permanganate	MnO_4^-	1
18	Noble gases	0 (inert)	Methyl	CH_3^-	1

1.3.7 Determine The Formula Of A Compound Based On The Valencies Of Elements And Ions (Radicals)

- Step 1: Write down the symbols of the elements or radicals (polyatomic ions) involved. The positive ion (usually a metal) is written first, followed by the negative ion. Example: **Al** and **O**
- Step 2: Write the valency of each atom or radical beneath its symbol. For simple ions, the valency is often determined by their group number in the periodic table. For radicals, the valency is equal to the net charge on the group. Example: **Al = +3, O = -2**
- Step 3: Criss-cross or swap the valencies of the two combining parts. The valency of the first element becomes the subscript for the second, and vice versa. Example: $\mathbf{Al^{+3}O^{-2} = Al_2O_3}$
- Step 4: If the valencies share a common factor, divide them by their highest common factor to get the simplest ratio. But if the valencies are same, they are not written. 2:3 is simplest in $\mathbf{Al_2O_3}$
- Step 5: Write the final formula using the simplified ratios as subscripts. $\mathbf{Al_2O_3}$
- Use brackets for radicals if the subscript for the entire group is greater than one. $\mathbf{Al_2(SO_4)_3}$