Chemistry Discipline Threshold Learning Outcomes

TLO 2.1 CLAUSES FOR 'PRINCIPLES & CONCEPTS OF CHEMISTRY'

TLO 2.1.1

Stoichiometry, structure and characteristic properties of chemical substances

1. The mole concept is a unifying concept for describing/measuring quantities of substances. It relates the macroscale (mass) to the microscale (atoms, molecules etc.).
2. Stoichiometry is the unique numerical relationship by which atoms, ions and molecules combine together.
3. Electrons, protons and neutrons are the fundamental atomic particles. Distribution of electron density is rationalised using the concept of orbitals.
4. The Periodic Table is a structured presentation of the elements which relates the position of an element in the table to its macroscopic properties and chemical reactivity.
5. Chemical bonds form through the sharing or transfer of electrons between atoms. The nature and quantity of chemical bonds in a chemical species give rise to the shape, structure and microscopic properties of that species.

TLO 2.1.2

Methods of structure determination

1. A variety of experimental (e.g. spectroscopic, spectrometric and diffraction) and theoretical methods can be used to determine molecular structure.
2. Spectroscopic methods are based on transitions between discrete energy levels, spectrometric methods are based on ionisation and diffraction methods are based on scattering from periodic arrangements of atoms.
3. Elemental composition may be determined using techniques such as high resolution mass spectrometry and elemental analysis.
4. Qualitative chemical tests can be used to aid with determination of structure.
5. Separation methods and sample preparation may be required prior to determination of structure.

TLO 2.1.3

Properties of matter in relation to structure

1. The size and location of the constituent atoms within a chemical species influences the shape and hence the chemical and physical properties of that species.
2. Interactions within and between chemical species are essentially electrostatic in nature and influence chemical and physical properties, and with the available energy define the states of matter.
3. The nature and strength of intra- and intermolecular forces / secondary interactions contribute to the macroscopic properties of a chemical species.
4. The properties of a substance can be influenced by both physical and chemical environment.
5. The properties of a mixture can differ from those of the individual components of the mixture.
6. Matter extends beyond the molecular to include metals, crystals, ionic solids and giant covalent complexes.

TLO 2.1.4

Chemical thermodynamics, equilibrium and kinetics

1. Different chemical species have different energies. Most chemical changes are accompanied by a net change of energy of the system.
2. Energy is conserved in chemical changes: breaking chemical bonds requires energy; formation of chemical bonds releases energy.
3. Spontaneity of a chemical change is determined by a balance between energy change, available energy and entropy change.
4. Starting and finishing states are independent of path, and may be predicted.
5. All chemical changes are, in principle, reversible; chemical processes often reach a state of dynamic equilibrium.
6. Thermodynamics provides a detailed capacity to understand energy change at the macroscopic level and to understand equilibrium systems quantitatively.
7. Chemical change can be measured as a function of time and occurs over a wide range of time scales.
8. Most chemical reactions take place by a series of more elementary reactions, called the reaction mechanism.
9. The products obtained from a chemical reaction can be influenced by controlling whether reaction rate or reaction energy plays the key role in the mechanism.

TLO 2.1.5

Reaction processes can transform substances into very different products

1. Reaction processes involve bond breaking and bond making – they neither create nor destroy matter but rearrange already present atoms into new species with chemical properties different to those of the reactants.
2. The outcome of a chemical reaction process is governed by thermodynamic and kinetic factors.
3. Chemical reaction processes can be classified systematically into general types – this allows prediction of outcomes.
4. Reaction processes can be selective depending on reagents and conditions and can be controlled.
5. Reaction processes may be found in a variety of contexts (e.g. industrial, biological etc.).

TLO 2.1.6

Reactions of metal and non-metal compounds including carbon compounds

1. Controlling chemical reactions is a key requirement in the synthesis of new materials. Chemical change can be controlled by choice of reactants and reaction conditions.
2. A range of general reaction types (including but not limited to: acid-base; redox; hydrolysis; addition; substitution; elimination; coordination) can be applied in different contexts to prepare target chemical species.
3. Reaction processes can be understood in terms of mechanism – this provides a means of understanding and predicting outcomes.
4. Chemical reactions may be used in a rational, purposeful way to synthesise desired products using a sequence of well-defined processes.

TLO 2.1.7

Quantifying concentrations and amounts of elements and compounds in simple and complex mixtures

1. Chemical species can be separated on the basis of their chemical and/or physical properties in order to isolate the species for quantification.

2. Chemical species can be quantified using a variety of methods chosen on the basis of the amount of analyte, nature of material and equipment availability/suitability.

3. Quantification is based on measurable chemical and/or physical parameters that are related to the amount of analyte present.

4. A range of factors must be considered when planning a quantitative analysis (e.g. precision vs. accuracy, sources of error and reproducibility, use of calibration curves and standard addition, statistical methods etc.).

5. Quantitative results are reported in appropriate units and are subjected to a critical evaluation in order to determine their validity and reliability.