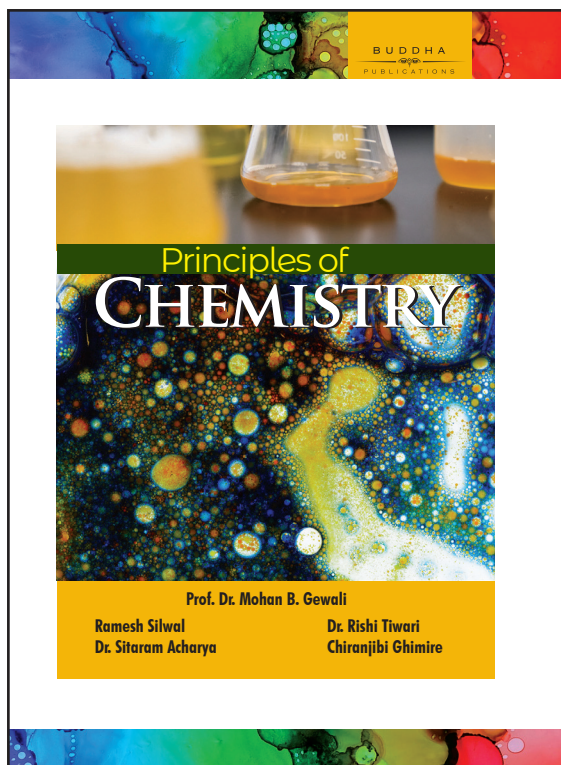


# Principles of CHEMISTRY - I

## GRADE XI



**Prof. Dr. Mohan B. Gewali**  
**Ramesh Silwal**  
**Dr. Rishi Tiwari**  
**Dr. Sitaram Acharya**  
**Chiranjibi Ghimire**



# SYLLABUS

## Chemistry

### GENERAL AND PHYSICAL CHEMISTRY

- |  |          |   |          |
|--|----------|---|----------|
| <b>1. Foundation and Fundamentals</b>  | <b>2</b> |   |          |
| 1.1 General introduction of chemistry  |          |   |          |
| 1.2 Importance and scope of chemistry  |          |   |          |
| 1.3 Basic concepts of chemistry (atoms, molecules, relative masses of atoms and molecules, atomic mass unit (amu), radicals, molecular formula, empirical formula) |          |   |          |
| 1.4 Percentage composition from molecular formula  |          |   |          |
| <b>2. Stoichiometry</b>  | <b>8</b> |   |          |
| 2.1 Dalton's atomic theory and its postulates  |          |   |          |
| 2.2 Laws of stoichiometry  |          |   |          |
| 2.3 Avogadro's law and some deductions   |          |   |          |
| 2.3.1 Molecular mass and vapour density  |          |   |          |
| 2.3.2 Molecular mass and volume of gas   |          |   |          |
| 2.3.3 Molecular mass and no. of particles  |          |   |          |
| 2.4 Mole and its relation with mass, volume and number of particles  |          |   |          |
| 2.5 Calculations based on mole concept   |          |   |          |
| 2.6 Limiting reactant and excess reactant  |          |   |          |
| 2.7 Theoretical yield, experimental yield and % yield  |          |   |          |
| 2.8 Calculation of empirical and molecular formula from % composition (Solving related numerical problems)   |          |   |          |
| <b>3. Atomic Structure</b>   | <b>8</b> |   |          |
| 3.1 Rutherford's atomic model  |          |   |          |
| 3.2 Limitations of Rutherford's atomic model   |          |   |          |
| 3.3 Postulates of Bohr's atomic model and its application  |          |   |          |
| 3.4 Spectrum of hydrogen atom  |          |   |          |
| 3.5 Defects of Bohr's theory   |          |   |          |
| 3.6 Elementary idea of quantum mechanical model: de Broglie's wave equation  |          |   |          |
| 3.7 Heisenberg's Uncertainty Principle   |          |   |          |
| 3.8 Concept of probability   |          |   |          |
| 3.9 Quantum Numbers  |          |   |          |
| 3.10 Orbitals and shape of s and p orbitals only   |          |   |          |
| 3.11 Aufbau Principle  |          |   |          |
| 3.12 Pauli's exclusion principle   |          |   |          |
| 3.13 Hund's rule and electronic configurations of atoms and ions (up to atomic no. 30)   |          |   |          |
| <b>4. Classification of Elements and Periodic Table</b>  | <b>5</b> |   |          |
| 4.1 Modern periodic law and modern periodic table  |          |   |          |
| 4.1.1 Classification of elements into different groups, periods and blocks   |          |   |          |
| 4.2 IUPAC classification of elements   |          |   |          |
| 4.3 Nuclear charge and effective nuclear charge  |          |   |          |
| 4.4 Periodic trend and periodicity   |          |   |          |
|  |          | 4.4.1 Atomic radii  |          |
|  |          | 4.4.2 Ionic radii   |          |
|  |          | 4.4.3 Ionization energy   |          |
|  |          | 4.4.4 Electron affinity   |          |
|  |          | 4.4.5 Electronegativity   |          |
|  |          | 4.4.6 Metallic characters (General trend and explanation only)  |          |
|  |          | <b>5. Chemical Bonding and Shapes of Molecules</b>  | <b>9</b> |
|  |          | 5.1 Valence shell, valence electron and octet theory  |          |
|  |          | 5.2 Ionic bond and its properties   |          |
|  |          | 5.3 Covalent bond and coordinate covalent bond  |          |
|  |          | 5.4 Properties of covalent compounds  |          |
|  |          | 5.5 Lewis dot structure of some common compounds of s and p block elements  |          |
|  |          | 5.6 Resonance   |          |
|  |          | 5.7 VSEPR theory and shapes of some simple molecules ( $\text{BeF}_2$ , $\text{BF}_3$ , $\text{CH}_4$ , $\text{CH}_3\text{Cl}$ , $\text{PCl}_5$ , $\text{SF}_6$ , $\text{H}_2\text{O}$ , $\text{NH}_3$ , $\text{CO}_2$ , $\text{H}_2\text{S}$ , $\text{PH}_3$ ) |          |
|  |          | 5.8 Elementary idea of Valence Bond Theory  |          |
|  |          | 5.9 Hybridization involving s and p orbitals only   |          |
|  |          | 5.10 Bond characteristics:  |          |
|  |          | 5.10.1 Bond length  |          |
|  |          | 5.10.2 Ionic character  |          |
|  |          | 5.10.3 Dipole moment  |          |
|  |          | 5.11 Vander Waal's force and molecular solids   |          |
|  |          | 5.12 Hydrogen bonding and its application   |          |
|  |          | 5.13 Metallic bonding and properties of metallic solids   |          |
|  |          | <b>6. Oxidation and Reduction</b>   | <b>5</b> |
|  |          | 6.1 General and electronic concept of oxidation and reduction   |          |
|  |          | 6.2 Oxidation number and rules for assigning oxidation number   |          |
|  |          | 6.3 Balancing redox reactions by oxidation number and ion-electron (half reaction) method   |          |
|  |          | 6.4 Electrolysis  |          |
|  |          | 6.4.1 Qualitative aspect  |          |
|  |          | 6.4.2 Quantitative aspect (Faradays laws of electrolysis)   |          |
|  |          | <b>7. States of Matter</b>  | <b>8</b> |
|  |          | 7.1 Gaseous state   |          |
|  |          | 7.1.1 Kinetic theory of gas and its postulates  |          |
|  |          | 7.1.2 Gas laws  |          |
|  |          | 7.1.2.1 Boyle's law and Charles' law  |          |
|  |          | 7.1.2.2 Avogadro's law  |          |

- 7.1.2.3 Combined gas equation
- 7.1.2.4 Dalton's law of partial pressure
- 7.1.2.5 Graham's law of diffusion
- 7.1.3 Ideal gas and ideal gas equation
- 7.1.4 Universal gas constant and its significance
- 7.1.5 Deviation of real gas from ideality (Solving related numerical problems based on gas laws)
- 7.2 Liquid state
  - 7.2.1 Physical properties of liquids
    - 7.2.1.1 Evaporation and condensation
    - 7.2.1.2 Vapour pressure and boiling point
    - 7.2.1.3 Surface tension and viscosity (qualitative idea only)
  - 7.2.2 Liquid crystals and their applications
- 7.3 Solid state

- 7.3.1 Types of solids
- 7.3.2 Amorphous and crystalline solids
- 7.3.3 Efflorescent, Deliquescent and Hygroscopic solids
- 7.3.4 Crystallization and crystal growth
- 7.3.5 Water of crystallization
- 7.3.6 Introduction to unit crystal lattice and unit cell

- 8. **Chemical Equilibrium** 3
- 8.1 Physical and chemical equilibrium
- 8.2 Dynamic nature of chemical equilibrium
- 8.3 Law of mass action
- 8.4 Expression for equilibrium constant and its importance
- 8.5 Relationship between  $K_p$  and  $K_c$
- 8.6 Le Chatelier's Principle (Numericals not required)

## INORGANIC CHEMISTRY

- 9. **Chemistry of Non-metals** 4
- 9.1 Hydrogen
  - 9.1.1 Chemistry of atomic and nascent hydrogen
  - 9.1.2 Isotopes of hydrogen and their uses
  - 9.1.3 Application of hydrogen as fuel
  - 9.1.4 Heavy water and its applications
- 9.2 Allotropes of Oxygen
  - 9.2.1 Definition of allotropy and examples
  - 9.2.2 Oxygen: Types of oxides (acidic, basic, neutral, amphoteric, peroxide and mixed oxides)
  - 9.2.3 Applications of hydrogen peroxide
  - 9.2.4 Medical and industrial application of oxygen
- 9.3 Ozone
  - 9.3.1 Occurrence
  - 9.3.2 Preparation of ozone from oxygen
  - 9.3.3 Structure of ozone
  - 9.3.4 Test for ozone
  - 9.3.5 Ozone layer depletion (causes, effects and control measures)
  - 9.3.6 Uses of ozone
- 9.4 Nitrogen 5
  - 9.4.1 Reason for inertness of nitrogen and active nitrogen
  - 9.4.2 Chemical properties of ammonia [Action with  $\text{CuSO}_4$  solution, water,  $\text{FeCl}_3$  solution, Conc.  $\text{HCl}$ , Mercurous nitrate paper,  $\text{O}_2$ ]
  - 9.4.3 Applications of ammonia
  - 9.4.4 Harmful effects of ammonia
  - 9.4.5 Oxy-acids of nitrogen (name and formula)
  - 9.4.6 Chemical properties of nitric acid [ $\text{HNO}_3$  as an acid and oxidizing agent (action with zinc, magnesium, iron, copper, sulphur, carbon,  $\text{SO}_2$  and  $\text{H}_2\text{S}$ )
  - 9.4.7 Ring test for nitrate ion
- 9.5 Halogens 5
  - 9.5.1 General characteristics of halogens
  - 9.5.2 Comparative study on preparation (no diagram and description is required),

- 9.5.2.1 Chemical properties [with water, alkali, ammonia, oxidizing character, bleaching action] and uses of halogens ( $\text{Cl}_2$ ,  $\text{Br}_2$  and  $\text{I}_2$ )
- 9.5.3 Test for  $\text{Cl}_2$ ,  $\text{Br}_2$  and  $\text{I}_2$
- 9.5.4 Comparative study on preparation (no diagram and description is required), properties (reducing strength, acidic nature and solubility) and uses of haloacids ( $\text{HCl}$ ,  $\text{HBr}$  and  $\text{HI}$ )
- 9.6 Carbon 3
  - 9.6.1 Allotropes of carbon (crystalline and amorphous) including fullerenes (structure, general properties and uses only)
  - 9.6.2 Properties (reducing action, reaction with metals and nonmetals) and uses of carbon monoxide
- 9.7 Phosphorus
  - 9.7.1 Allotropes of phosphorus (name only)
  - 9.7.2 Preparation (no diagram and description is required), properties (basic nature, reducing nature, action with halogens and oxygen) and uses of phosphine
- 9.8 Sulphur 8
  - 9.8.1 Allotropes of sulphur (name only) and uses of sulphur
  - 9.8.2 Hydrogen sulphide (preparation from Kipp's apparatus with diagram,) properties (Acidic nature, reducing nature, analytical reagent) and uses
  - 9.8.3 Sulphur dioxide its properties (acidic nature, reducing nature, oxidising nature and bleaching action) and uses
  - 9.8.4 Sulphuric acid and its properties (acidic nature, oxidising nature, dehydrating nature) and uses
  - 9.8.5 Sodium thiosulphate (formula and uses)
- 10. **Chemistry of Metal** 5
- 10.1 Metals and Metallurgical Principles
  - 10.1.1 Definition of metallurgy and its types (hydrometallurgy, pyrometallurgy, electrometallurgy)

- 10.1.2 Introduction of ores
- 10.1.3 Gangue or matrix, flux and slag, alloy and amalgam
- 10.1.4 General principles of extraction of metals (different processes involved in metallurgy) – concentration, calcination and roasting, smelting, carbon reduction, thermite and electrochemical reduction
- 10.1.5 Refining of metals (poling and electro-refinement)
- 10.2 Alkali Metals 5
  - 10.2.1 General characteristics of alkali metals
  - 10.2.2 Sodium [extraction from Down's process, properties (action with Oxygen, water, acids nonmetals and ammonia) and uses]
  - 10.2.3 Properties (precipitation reaction and action with carbon monoxide) and uses of sodium hydroxide
  - 10.2.4 Properties (action with  $\text{CO}_2$ ,  $\text{SO}_2$ , water, precipitation reactions) and uses of sodium carbonate

- 10.3 Alkaline Earth Metals
  - 10.3.1 General characteristics of alkaline earth metals
  - 10.3.2 Molecular formula and uses of (quick lime, bleaching powder, magnesia, plaster of paris and epsom salt)
  - 10.3.3 Solubility of hydroxides, carbonates and sulphates of alkaline earth metals (general trend with explanation)
  - 10.3.4 Stability of carbonate and nitrate of alkaline earth metals (general trend with explanation)

## 11. Bio-inorganic Chemistry 3

- 11.1 Introduction
- 11.2 Micro and macro nutrients
- 11.3 Importance of metal ions in biological systems (ions of Na, K, Mg, Ca, Fe, Cu, Zn, Ni, Co, Cr)
- 11.4 on pumps (sodium-potassium and sodium-glucose pump)
- 11.5 Metal toxicity (toxicity due to iron, arsenic, mercury, lead and cadmium)

## ORGANIC CHEMISTRY

## 12. Basic Concept of Organic Chemistry 6

- 12.1 Introduction to organic chemistry and organic compounds
- 12.2 Reasons for the separate study of organic compounds from inorganic compounds
- 12.3 Tetra-covalency and catenation properties of carbon
- 12.4 Classification of organic compounds
- 12.5 Alkyl groups, functional groups and homologous series
- 12.6 Idea of structural formula, contracted formula and bond line structural formula
- 12.7 Preliminary idea of cracking and reforming, quality of gasoline, octane number, cetane number and gasoline additive

## 13. Fundamental Principles of Organic Chemistry 10

- 13.1 IUPAC Nomenclature of Organic Compounds (upto chain having 6-carbon atoms)
- 13.2 Qualitative analysis of organic compounds (detection of N, S and halogens by Lassaigne's test)
- 13.3 Isomerism in Organic Compounds
- 13.4 Definition and classification of isomerism
- 13.5 Structural isomerism and its types: chain isomerism, position isomerism, functional isomerism, metamerism and tautomerism
- 13.6 Concept of geometrical isomerism (cis & trans) & optical isomerism (d & l form)
- 13.7 Preliminary Idea of Reaction
  - 13.7.2 Electrophiles, nucleophiles and free-radicals
  - 13.7.3 Inductive effect: +I and –I effect
  - 13.7.4 Resonance effect: +R and –R effect Mechanism
- 13.7.1 Homolytic and heterolytic fission

## 14. Hydrocarbons 8

- 14.1 Saturated Hydrocarbons (Alkanes)
  - 14.1.1 Alkanes: Preparation from haloalkanes (Reduction and Wurtz reaction), Decarboxylation, Catalytic hydrogenation of alkene and alkyne
  - 14.1.2 Chemical properties: Substitution reactions (halogenation, nitration & sulphonation only), oxidation of ethane
- 14.2 Unsaturated hydrocarbons (Alkenes & Alkynes)
  - 14.2.1 Alkenes: Preparation by Dehydration of alcohol, Dehydrohalogenation, Catalytic hydrogenation of alkyne
    - 14.2.1.1 Chemical properties: Addition reaction with HX (Markovnikov's addition and peroxide effect),  $\text{H}_2\text{O}$ ,  $\text{O}_3$ ,  $\text{H}_2\text{SO}_4$  only
- 14.3 Alkynes: Preparation from carbon and hydrogen, 1,2 dibromoethane, chloroform/iodoform only
  - 14.3.1 Chemical properties: Addition reaction with ( $\text{H}_2$ , HX,  $\text{H}_2\text{O}$ ), Acidic nature (action with Sodium, ammoniacal  $\text{AgNO}_3$  and preparation of alkane, alkene and alkynes ammoniacal  $\text{Cu}_2\text{Cl}_2$ )
- 14.4 Test of unsaturation (ethene & ethyne): bromine water test and Baeyer's test
- 14.5 Comparative studies of physical properties of alkane, alkene and alkyne
- 14.6 Kolbe's electrolysis methods for the preparation of alkane, alkene and alkynes

## 15. Aromatic Hydrocarbons 6

- 15.1 Introduction and characteristics of aromatic compounds

- 15.2 Huckel's rule of aromaticity
- 15.3 Kekule structure of benzene
- 15.4 Resonance and isomerism
- 15.5 Preparation of benzene from decarboxylation of sodium benzoate, phenol, and ethyne only
- 15.6 Physical properties of benzene
- 15.7 Chemical properties of benzene: Addition reaction:

hydrogen, halogen, Electrophilic substitution reactions: orientation of benzene derivatives (o, m & p), nitration, sulphonation, halogenations, Friedal-Craft's reaction (alkylation and acylation), combustion of benzene (free combustion only) and uses

## APPLIED CHEMISTRY

### 16. Fundamentals of Applied Chemistry 4

- 16.1 Fundamentals of Applied Chemistry
- 16.1.2 Chemical industry and its importance
- 16.1.3 Stages in producing a new product
- 16.1.4 Economics of production
- 16.1.5 Cash flow in the production cycle
- 16.1.6 Running a chemical plant
- 16.1.7 Designing a chemical plant
- 16.1.7 Continuous and batch processing
- 16.1.8 Environmental impact of the chemical industry

### 17. Fundamentals of Applied Chemistry 11

- 17.1 Modern Chemical Manufactures (principle and flow sheet diagram only)
- 17.1.1 Manufacture of ammonia by Haber's process,
- 17.1.2 Manufacture of nitric acid by Ostwald's process,
- 17.1.3 Manufacture of sulphuric acid by contact process,
- 17.1.4 Manufacture of sodium hydroxide by Diaphragm Cell
- 17.1.5 Manufacture of sodium carbonate by ammonia soda or Solvay process
- 17.2 Fertilizers (Chemical fertilizers, types of chemical fertilizers, production of urea with flow-sheet diagram)



# CONTENTS

## GENERAL AND PHYSICAL CHEMISTRY

### CHAPTER 1 FOUNDATION OF FUNDAMENTALS

1.1	General Introduction of Chemistry	2	1.3.9	Valency	11
1.2	Importance and Scope of Chemistry	3	1.3.10	Radicals/Ions	12
1.3	Basic Concept of Chemistry	5	1.3.11	Chemical Formula	14
1.3.1	Pure and Impure Substances and Chemical Changes	5	1.3.12	Empirical Formula	17
1.3.2	Classification of Substances	5	1.3.13	Chemical Equation: Significance and Limitation	17
1.3.3	Classification of Substances	6	1.3.14	Balancing Chemical Equations	21
1.3.4	Elements	6	1.3.15	Types of Chemical Reactions	23
1.3.5	Atoms	7	1.3.16	Atomic Mass and Molecular Mass	25
1.3.6	Compounds	7	1.4	Determination of Percentage Composition	29
1.3.7	Molecules	8		Questions for Practice	31
1.3.8	Symbols and Formulae	8		Project Work	34

### CHAPTER 2 STOICHIOMETRY

2.1	Dalton's Atomic Theory	36	2.4.3	Mole in Terms of Volume	52
2.2	Laws of Stoichiometry	36	2.5	Stoichiometric Calculations Based on Mole Concept	55
2.2.1	Law of Conservation of Mass	37	2.5.1	Mass and Mass Relationship	56
2.2.2	Law of Constant Composition	38	2.5.2	Mass and Volume Relationship	56
2.2.3	Law of Multiple Proportions	40	2.5.3	Volume and Volume Relationship	57
2.2.4	Law of Reciprocal Proportions	42	2.6	Concept of Limiting Reactants	58
2.2.5	Gay-Lussac's Law of Gaseous Volumes	44	2.7	Calculation of Percentage Yield	60
2.3	Avogadro's Hypothesis	45	2.8	Determination of Empirical and Molecular Formula	60
2.4	Concept of Mole	51		Questions for Practice	64
2.4.1	What is Mole?	51		Project Work	70
2.4.2	Mole in Terms of Gram	51			

### CHAPTER 3 ATOMIC STRUCTURE

3.1	Introduction	72	3.2.1	Evidence for the Electrical Nature of Atoms	72
3.2	Fundamental Particles of an Atom	72			

3.2.2	Discovery of Electrons	72	3.6	Elementary Idea of Wave Mechanical Model of an Atom	87
3.2.3	Charge and Mass of an Electron	73	3.6.1	Dual Nature of an Electron: de Broglie's Equation	87
3.2.4	Discovery of Proton	74	3.6.2	de Broglie's Equation	87
3.2.5	The Charge and Mass of the Particles Constituting Anode Rays	75	3.6.3	Bohr's Theory versus de Broglie's Concept	88
3.2.6	Discovery of Neutrons	76	3.6.4	Heisenberg's Uncertainty Principle	89
3.2.7	Concept of Atomic Number and Mass Number	76	3.6.5	Probability Concept	91
3.2.8	Isotopes	77	3.7	Atomic Orbital	92
3.2.9	Isobars	78	3.7.1	Shapes of Orbitals	92
3.3	Thomson's Atomic Model	78	3.8	Quantum Numbers	94
3.4	Rutherford's Atomic Model	79	3.8.1	Principal Quantum Number (n)	95
3.4.1	Alpha Rays Scattering Experiment	79	3.8.2	Azimuthal Quantum Number (l)	95
3.4.2	Observations	79	3.8.3	Magnetic Quantum Number (ml)	96
3.4.3	Conclusions	80	3.8.4	Spin Quantum Number (ms)	97
3.4.4	Shortcomings of Rutherford's Atomic Model	81	3.9	Pauli's Exclusion Principle	99
3.5	Bohr's Atomic Model	82	3.10	Hund's Rule	100
3.5.1	Absorption and Emission Spectra	83	3.10.1	Significance of Hund's Rule	101
3.5.3	Interpretation of Hydrogen Spectra in Light of Bohr's Theory	84	3.11	Aufbau Principle	101
3.5.4	Limitations of Bohr's Theory	86	3.12	Electronic Configuration	102
				Questions for Practice	106
				Project Work	109

## CHAPTER 4 CLASSIFICATION OF ELEMENTS AND PERIODIC TABLE

4.1	Introduction	111	4.3.6	Trivial Name of a Specific Group	119
4.2	Mendeleev's Periodic Table	111	4.3.7	Classification of Elements Based on Certain Properties	120
4.2.1	Description	113	4.4	Nuclear Charge and Effective Nuclear Charge	121
4.2.2	Zero Group Elements	113	4.4.1	Shielding Effect (Screening Effect)	122
4.2.3	Contributions of Mendeleev's Periodic Table	113	4.4.2	Factor Affecting Effective Nuclear Charge	122
4.2.4	Shortcomings of Mendeleev's Periodic Table	114	4.5	Important Properties and their Periodic Trends	123
4.3	Modern Periodic Law	114	4.5.1	Atomic Radii	123
4.3.1	Cause of Periodicity	115	4.5.2	Ionization Energy	126
4.3.2	Description of the Modern Periodic Table	115	4.5.3	Electron Affinity	129
4.3.3	Advantages of the Modern Periodic Table	116	4.5.4	Electronegativity	131
4.3.4	Classification of Elements into s, p, d and f-Blocks	117	4.5.5	Metallic Character	133
4.3.5	Latest IUPAC Classification of Elements	118	4.5.6	Diagonal Relationship	134
				Questions for Practice	134
				Project Work	136

## CHAPTER 5 CHEMICAL BONDING AND SHAPES OF MOLECULES

5.1	Electronic Theory of Valency	138	5.10	Ionic Character of Covalent Bonds	167
5.2	Chemical Bond and Lewis Structure	139	5.11	Bond Length	172
5.3	Covalent Bond	141	5.12	Intermolecular Bonding in Molecular Solids	173
5.4	Properties of Covalent Compounds	143	5.13	Hydrogen Bonding	174
5.5	Coordinate Covalent Bond	145	5.14	Metallic Bond	177
5.6	Resonance	147	5.15	Bonding in Sodium Chloride (Ionic Solid)	178
5.7	Valence Shell Electron Pair Repulsion (VSEPR) Theory	150		Questions for Practice	179
5.8	Valence Bond Theory	153		Project Work	184
5.9	Concept of Hybridization	158			

## CHAPTER 6 OXIDATION AND REDUCTION

6.1	Classical Concept of Oxidation and Reduction	186	6.6	Electrolysis and Redox Reaction	199
6.2	Electronic Concept of Oxidation and Reduction	186	6.7	Electrolytic Cell and Electrolytes	200
6.3	Oxidation Number and Its Assignment	188	6.7.1	Qualitative Aspect of Electrolysis	201
6.4	Redox Reaction	190	6.7.2	Quantitative Aspect of Electrolysis	202
6.5	Balancing a Redox Reaction	191		Questions for Practice	206
				Project Work	210

## CHAPTER 7 STATES OF MATTER

7.1	Gaseous State	212	7.3.2	Classification of Solids	238
7.1.1	Postulates of Kinetic Theory of Gas	212	7.3.3	Crystal Lattice and Unit Cell	240
7.1.2	Gas Laws	213	7.3.4	Seven Types of Crystal System	240
7.1.3	Deviation of a Gas from Ideal Behaviour and van der Waals Equation	230	7.3.5	Water of Crystallization	243
7.2	Liquid State of Matter	232	7.3.6	Polymorphism and Isomorphism	244
7.2.1	Properties of Liquids	232	7.3.7	Fractional Crystallization	244
7.2.2	Liquid Crystal	236	7.3.8	Efflorescence, Hygroscopy and Deliquescence	244
7.3	Solid State of Matter	237		Questions for Practice	248
7.3.1	Introduction	237		Project Work	253



## CHAPTER 8 CHEMICAL EQUILIBRIUM

8.1 Reversible and Irreversible Reactions	255	8.8 Law of Mass Action	260
8.2 State of Equilibrium	255	8.9 Expressions for Equilibrium Constant for Some Reactions	262
8.3 Equilibrium Involving Physical Changes	256	8.10 Relationship between $K_p$ and $K_c$	264
8.4 Dynamic Nature of Equilibrium	257	8.11 Le Chatelier's Principle	266
8.5 Characteristics of a Chemical Equilibrium	258	Questions for Practice	274
8.6 Types of Equilibrium	259	Project Work	278
8.7 Active Mass and Molarity	260		

## INORGANIC CHEMISTRY

### CHAPTER 9 CHEMISTRY OF NON-METALS

9.1 Hydrogen	280	9.4.3 Properties of Ammonia	296
9.1.1 Introduction	280	9.4.4 Uses of Ammonia	299
9.1.2 Position of Hydrogen in the Periodic Table	280	9.4.5 Harmful Effect of Ammonia	299
9.1.3 Types of Hydrogen	281	9.4.6 Properties of Nitric Acid	299
9.1.4 Isotopes of Hydrogen	283	9.4.7 Uses of Nitric Acid	304
9.1.5 Heavy Water	284	9.4.8 Test for Nitric Acid & Nitrates (Ring Test)	305
9.2 Oxygen	285	Questions for Practice 9.2	306
9.2.1 Periodic Position	286	9.5 Halogens	308
9.2.2 Medical and Industrial Application of Oxygen	286	9.5.1 Periodic Position	308
9.2.3 Oxides	287	9.5.2 General Characteristics of the Family	308
9.2.4 Application of Hydrogen Peroxide	288	9.5.3 Occurrence of Halogens	310
9.3 Ozone	289	9.5.4 Preparation of Halogens	310
9.3.1 Introduction	289	9.5.5 Properties of Halogens	314
9.3.2 Occurrence of Ozone	289	9.5.6 Test for Halogens	318
9.3.3 Preparation of Ozone	289	9.5.7 Uses of Halogens	319
9.3.4 Properties of Ozone	290	9.5.8 Halogen Acids	319
9.3.5 Test for Ozone	290	Questions for Practice 9.3	329
9.3.6 Depletion of Ozone Layer	290	9.6 Carbon	332
9.3.7 Uses of Ozone	291	9.6.1 Periodic Position	332
9.3.8 Structure of Ozone	292	9.6.2 Allotropes of Carbon	332
Questions for Practice 9.1	292	9.6.3 Oxides of Carbon	336
9.4 Nitrogen	295	9.7 Phosphorus	339
9.4.1 Stability of Nitrogen Molecule	295	9.7.1 Periodic Position	339
9.4.2 Position in Periodic Table	295	9.7.2 Occurrence of Phosphorus	339

9.7.3 Allotropes of Phosphorus	339	9.8.5 Allotropes of Sulphur	347
9.7.4 Phosphine (PH <sub>3</sub> )	339	9.8.6 Hydrogen Sulphide (H <sub>2</sub> S)	349
<b>Questions for Practice 9.4</b>	<b>342</b>	9.8.7 Sulphur Dioxide (SO <sub>2</sub> )	354
9.8 Sulphur	346	9.8.8 Sulphuric Acid (H <sub>2</sub> SO <sub>4</sub> )	359
9.8.1 Position in the Periodic Table	346	9.8.9 Sodium Thiosulphate or Hypo (Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> )	364
9.8.2 Comparison of Oxygen and Sulphur	346	<b>Questions for Practice 9.5</b>	<b>367</b>
9.8.3 Structure of Sulphur (S <sub>8</sub> ) Molecule	346	<b>Project Work</b>	<b>369</b>
9.8.4 Uses of Sulphur	346		

## CHAPTER 10 CHEMISTRY OF METALS

10.1 Metals and Metallurgical Principles	371	10.2.3 Extraction of Sodium	396
10.1.1 Distinction between Metals and Non-metals	371	10.2.4 Uses of Sodium and Potassium	398
10.1.2 Metalloids	372	<b>Questions for Practice 10.2</b>	<b>404</b>
10.1.3 Alloys and Amalgams	372	10.3 Alkaline Earth Metals	406
10.1.4 Abundance of Elements	373	10.3.1 Periodic Position	406
10.1.5 Occurrence of Metals	373	10.3.2 General Properties of Alkaline Earth Metals	406
10.1.6 Occurrence of Metals in Nepal	374	10.3.3 Some Compounds of Magnesium and Calcium	407
10.1.7 Minerals and Ores	376	10.3.4 Solubility of Compounds of Alkaline Earth Metals	415
10.1.8 General Metallurgical Operations	376	10.3.5 Stability of Compounds of Alkaline Earth Metals	416
<b>Questions for Practice 10.1</b>	<b>390</b>	<b>Questions for Practice 10.3</b>	<b>417</b>
10.2 Alkali Metals	393	<b>Project Work</b>	<b>418</b>
10.2.1 General Characteristics of Alkali Metals	393		
10.2.2 Occurrence of Sodium and Potassium	396		

## CHAPTER 11 BIO-INORGANIC CHEMISTRY

11.1 Introduction	420	11.4 Ion Pumps	423
11.2 Macro and Micronutrients	421	11.5 Metal Toxicity	425
11.3 Importance of Metal ions in Biological System	422	<b>Questions for Practice</b>	<b>428</b>
		<b>Project Work</b>	<b>428</b>

# INORGANIC CHEMISTRY

## CHAPTER 12 BASIC CONCEPT OF ORGANIC CHEMISTRY

12.1 Introduction	430	12.6 Importance of Organic Chemistry	433
12.2 Origin of Organic Compounds (Vital Force Theory)	430	12.7 Classification of Organic Compounds	434
12.3 Modern Concept of Organic Compounds	430	12.8 Functional Group and Homologous Series	436
12.4 General Properties of Organic Compounds	431	12.9 Idea of Different Types of Formula	439
12.5 Sources of Organic Compounds	433	12.10 Sources of Hydrocarbons	441
		Questions for Practice	448
		Project Work	450

## CHAPTER 13 FUNDAMENTAL PRINCIPLES OF ORGANIC CHEMISTRY

13.1 Nomenclature of Organic Compounds	452	Breakage of a Covalent Bond	485
13.2 Qualitative Analysis of Organic Compounds	474	Electrophiles and Nucleophiles	486
13.3 Isomerism in Organic Compounds	478	Electronic Effects	487
Types of Isomerism	478	Electromeric Effect	488
13.4 Stereoisomerism	482	Resonance (Mesomeric Effect)	488
Types of Stereoisomerism	482	13.6 Types of Organic Reactions	489
13.5 Preliminary Concept of Reaction Mechanism	484	Questions for Practice	491
		Project Work	494

## CHAPTER 14 HYDROCARBONS

14.1 Introduction	496	14.8 Properties of Alkenes	515
14.2 Nomenclature, Structure and Isomerism of Alkanes	496	14.9 Uses of Alkenes	521
14.3 General Methods of Preparation of Alkanes	499	14.10 Alkynes	522
14.4 Properties of Alkanes	503	14.11 General Methods of Preparation of Alkynes	524
14.5 Uses of Alkanes	508	14.12 Properties of Alkynes	526
14.6 Alkenes	509	14.13 Uses of Ethyne	530
14.7 General Methods of Preparation of Alkenes	512	14.14 Unsaturation Test Hydrocarbon	531
		Question for Practice	532
		Project Work	534

## CHAPTER 15 AROMATIC HYDROCARBONS

15.1 Introduction	536	15.5 Aromatic Disubstitution	541
15.2 Structure of Benzene	536	15.6 Methods of Preparation of Benzene	543
15.3 Aromaticity (Aromatic Character)	538	Question for Practice	548
15.4 Isomerism in Arenes	541	Project Work	550

## APPLIED CHEMISTRY

## CHAPTER 16 FUNDAMENTALS OF APPLIED CHEMISTRY

16.1 Chemical Industry and its Importance	552	16.6 Designing a Chemical Plant	558
16.2 Stages in Producing a New Product	554	16.7 Environmental Impact of Chemical Industry	560
16.3 Economics of Production	555	Question for Practice	561
16.4 Cash Flow in Production Cycle	556	Project Work	562
16.5 Running a Chemical Plant	557		

## CHAPTER 17 MODERN CHEMICAL MANUFACTURES

17.1 Manufacture of Ammonia by Haber's Process	564	17.4 Manufacture of NaOH (Diaphragm Cell)	570
17.2 Manufacture of Nitric Acid	565	17.5 Manufacture of Sodium Carbonate	571
17.3 Manufacture of Sulphuric Acid by Contact Process	567	17.6 Fertilizers	573
		Question for Practice	577
		Project Work	578