Written as per the revised 'G' Scheme syllabus prescribed by the Maharashtra State Board of Technical Education (MSBTE) w.e.f. academic year 2012-2013

BASIC SCIENCE
CHEMISTRY

FIRST YEAR DIPLOMA
SEMESTER - I

First Edition: June 2015

Salient Features

- Concise content with complete coverage of revised G-scheme syllabus.
- Simple and Lucid language.
- Neat, Labelled and Authentic diagrams.
- Illustrative examples showing detailed solution of numericals.
- MSBTE Theory Questions and Numericals from Winter-2006 to Summer-2015.
- MSBTE Question Papers of Summer-2014, Winter-2014 and Summer-2015.
- Three Model Question Papers for practice.
- Important Inclusions: Additional Theory Questions, Practice Problems, Knowledge Bank.

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PREFACE

In the case of good books, the point is not how many of them you can get through, but rather how many can get through to you.

Target's "Basic Science Chemistry" is a complete and thorough book critically analysed and extensively drafted to boost the students' confidence. The book is prepared as per the revised scheme [G-scheme] of MSBTE curriculum effective from June 2012.

Each unit from the syllabus is divided into chapters bearing 'specific objectives' in mind. The sub-topic wise classification of this book helps the students in easy comprehension.

Each chapter includes the following features:

Theory is provided in the form of pointers. Neat labelled diagrams have been provided wherever required. Definitions, statements and laws are specified with italic representation.

Illustrative Examples are provided in relevant chapters in order to understand the application of different concepts and formulae.

Formulae provided for quick recap.

MSBTE Theory Questions covered in separate section to give a clear idea of the type of questions asked. *(Reference of answer to each question is provided.)*

MSBTE Numericals till latest year are included.

Additional Theory Questions to help the student gain insight on the various levels of theory-based questions.

Problems for Practice *(With final answers)* in relevant chapters which covers an array of questions from simple to complex.

Knowledge Bank, Note, etc. to enrich students' knowledge.

Recent **MSBTE Question Papers** are added at the end to make students familiar with the examination. **Model Question Papers** are provided to prepare students for examination.

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.

Please write to us on : mail@targetpublications.org

A book affects eternity; one can never tell where its influence stops.

Best of luck to all the aspirants!

From,
Publisher

SYLLABUS

Topic and Contents	Hours	Marks
Topic 1 - Chemical Bonding **Specific objectives:** ➢ Predict valence electrons and valency of elements. ➢ Draw schematic diagram for formation of molecules. **1.1 Atomic Structure: [8 Marks]** • Definition of atom, Bohr's atomic model, structure of modern atom, characteristics of fundamental particles of an atom, definition of atomic number, atomic mass number and their differences, Isotopes and Isobars: Definitions, examples and distinction, applications of carbon and cobalt isotopes. Orbits: Bohr's energy levels, sub-energy levels, s, p, d, f-orbitals, shapes and description of s-orbital and p-orbital. Distribution of electrons in orbitals: Definition of electronic configuration, Aufbau's principle, Hund's rule, orbital electronic configurations (s, p, d, f) of elements having atomic number 1 to 30. **1.2 Valency: [4 Marks]** • Definitions of valence electrons, valency. • Definition of electrovalency, positive and negative electrovalency, formation of electrovalent compounds - MgO, $CaCl_2$ • Definition of covalency, single, double and triple covalent bonds, formation of covalent compounds - H_2O, CO_2, N_2	**08**	**12**
Topic 2 - Electrochemistry **Specific objectives:** ➢ Describe the mechanism of electrolysis. ➢ Identify the role of electrodes in application of electrolysis. **2.1 Basic Concepts of Electrolysis: [4 Marks]** • Electrolyte, types of electrolyte - strong and weak electrolyte, their difference. • Ionisation and electrolytic dissociation, Arrhenius theory of electrolytic dissociation, degree of ionization, factors affecting degree of ionization. Definitions of electrolytic cell, electrodes - cathode, anode, electrode potential - oxidation potential and reduction potential. **2.2 Electrolysis: [10 Marks]** • Mechanism of electrolysis - Electrolysis, electrochemical series for cations and anions. • Mechanism of electrolysis of $CuSO_4$ solution by using platinum electrodes and copper electrodes. • Applications of electrolysis - Electroplating of silver, electrorefining of blister copper. • Faraday's laws of electrolysis: Faraday's first and second law, relation between electrochemical equivalent and chemical equivalent, Numericals. • **pH and pOH:** Definition of pH, pOH, pH Scale, Numericals.	**10**	**14**

Topic 3 - Metals and Alloys **Specific objectives:** ➢ Identify the properties of metals and alloys related to engineering applications. ➢ Describe the process of extraction of metals. **3.1 Metals: [8 Marks]** • Occurrence of metals in free and combined state, definitions - mineral, ore, gangue, flux and slag, metallurgy. • Metallurgy - Detailed flow chart for extraction of metal. • Important extraction processes: Concentration - gravity separation, electromagnetic separation, froth floatation, calcination and roasting, Reduction - smelting, aluminothermic process, Refining - poling, electrorefining. • Mechanical properties of metals - Hardness, ductility, malleability, tensile strength, toughness, machinability, weldability, forging, soldering, brazing, castability. **3.2 Alloys: [4 Marks]** • Definition, purposes of making alloys with examples. • Preparation methods - Fusion, compression. • Classification of alloys - Ferrous and non-ferrous alloys with examples. • Examples of alloys - Composition, properties and applications of duralumin, Woods metal, babbit metal.	**08**	**12**
Topic 4 - Non-metallic Engineering Materials **Specific objectives:** ➢ Distinguish between thermosoftening and thermosetting plastics. ➢ List the properties of rubber. ➢ State the applications of thermal insulators. **4.1 Polymers (Plastics, Rubber): [8 Marks]** • Plastics: Definitions of plastic, polymer, polymerization, types of polymerization with examples. Types of plastic - thermosoftening plastics and thermosetting plastics and their differences, properties and applications of plastics. • Rubber: Types of rubber. • Natural rubber: Definition, drawbacks of natural rubber, vulcanization of rubber with chemical reaction, applications of vulcanized rubber. Synthetic rubber: Definition, difference between natural and synthetic rubber, examples of synthetic rubber, properties of synthetic rubber like - elasticity, tack and abrasion resistance, their definitions and related applications. **4.2 Thermal Insulators: [4 Marks]** • Thermal Insulators - Definition, characteristics of thermal insulators, classification - organic and inorganic thermal insulators, their examples, preparation, properties and applications of thermocole and glass wool.	**06**	**12**
TOTAL	**32**	**50**

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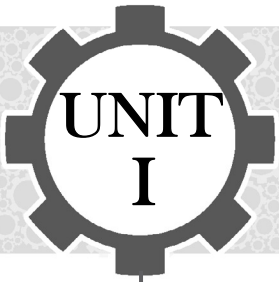


Chemical Bonding

Chapter-1 Atomic Structure

Chapter-2 Valency

Chapter-1 Atomic Structure

1.1 Introduction
1.2 Atoms
1.3 Bohr's atomic model
1.4 Modern atomic structure
1.5 Characteristics of fundamental particles of an atom
1.6 Atomic number and atomic mass number
1.7 Isotopes and isobars
1.8 Energy levels (shells) and sub-energy levels (subshells)
1.9 Atomic orbitals
1.10 Distribution of electrons in orbitals
1.11 Aufbau principle
1.12 Hund's rule of maximum multiplicity
1.13 Orbital electronic configuration of elements having atomic number 1 to 30

Chapter-2 Valency

2.1 Introduction
2.2 Valence electrons
2.3 Valency
2.4 Electrovalency
2.5 Formation of electrovalent compounds
2.6 Covalency
2.7 Formation of covalent compounds

01 Atomic Structure

1.1 Introduction

A Greek philosopher Democritus introduced the term 'atom'. The word 'atom' was derived from Greek word 'a-tomio' meaning indivisible. Maharshi Kanad, an Indian saint and philosopher, first used the term 'Permanu' (A Sanskrit word which means atom) to describe the ultimate particle of matter. Dalton, a British school teacher, in 1808, proposed that matter was made up of extremely small, indivisible particles called atoms.

Modern researches have conclusively proved that atom is no longer an indivisible particle. The works of Sir J. J. Thomson and Ernest Rutherford laid the foundation of the modern picture of the atom. Atom consists of three sub-atomic particles: protons, electrons and neutrons which are known as **fundamental particles.**

1.2 Atoms

1.2.(a) Atoms:

i. *The smallest indivisible particle of an element is called an **atom**.*
ii. Atom takes part in all the chemical changes.
iii. Atoms may or may not exist freely. It possesses all the properties of original element.
iv. Atoms of almost all the elements can react with one another to form compounds.
v. Atom consists of three sub-atomic particles: protons, electrons and neutrons.

1.2.(b) Molecules:

i. *The smallest particle of substance (which can be an element or a compound) is called a **molecule**.*
ii. It possesses all the properties of the original substance.
iii. It has free existence.
iv. The elementary particles which build up a molecule are known as atoms.
v. Molecules are made up of two or more either similar or different kinds of atoms.

Note:

Species	Number of atoms	Examples
Monoatomic element	Contains only one atom	Noble gases, carbon, silicon and metals like sodium, iron, etc.
Diatomic molecule	Contains two atoms per molecule	Hydrogen (H_2), Oxygen (O_2), Nitrogen (N_2), Hydrogen chloride (HCl), etc.
Polyatomic molecule	Contains more than two atoms per molecule	Phosphorus (P_4), Sulphur (S_8), Copper sulphate ($CuSO_4$), etc.

1.3 Bohr's atomic model

1.3.(a) Introduction:

Danish physicist Neils Bohr in 1913 modified Rutherford's model of an atom and proposed a model for the hydrogen atom. The model explained the stability of the atom and the atomic spectrum of hydrogen atom.

1.3.(b) Postulates or assumptions of Bohr's atomic theory:

i. An atom consists of a dense positively charged central part known as 'nucleus' which is at rest and contains protons and neutrons.

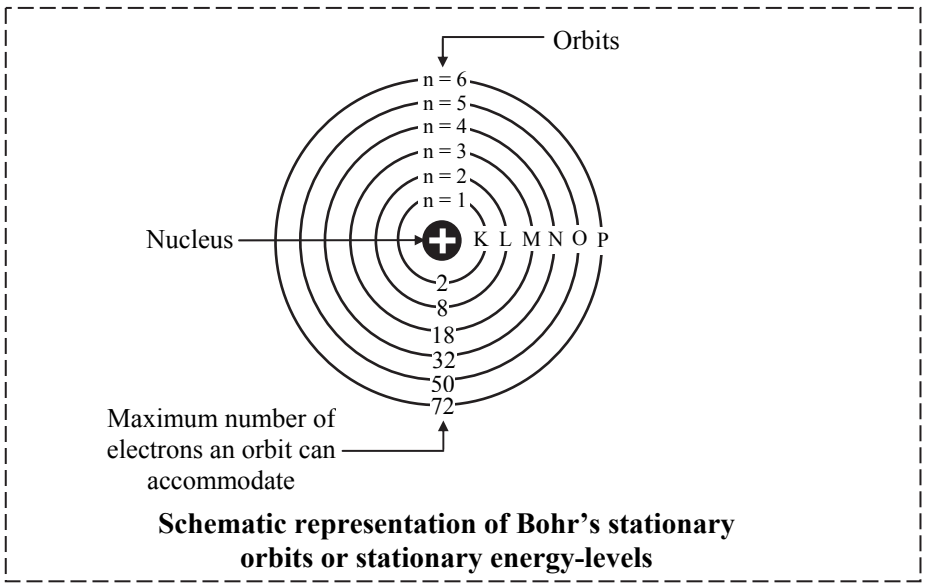
ii. Electrons revolve around the nucleus in concentric circular paths called **orbits or shells** situated at a definite distance from the nucleus. Due to this, the electrostatic force of attraction between the nucleus and electron(s) is exactly balanced by the centrifugal force. Hence, the electrons do not fall into the nucleus and the atom remains stable.

iii. The electron can revolve around the nucleus only in certain permitted orbits which are known as stationary states.

iv. Each stationary state or stationary orbit is associated with a definite amount of energy. Hence, these are also called as energy levels or energy shells.

v. As long as the electrons revolve in these stationary orbits, they do not radiate energy (i.e., the energies of electrons remain constant in stationary orbits).

Different **stationary levels** or **stationary orbits** or **shells** are represented by capital letters **K, L, M, N** with corresponding shell numbers 1, 2, 3, 4, etc.



Schematic representation of Bohr's stationary orbits or stationary energy-levels

vi. An electron can revolve only in those stationary orbits, without radiating energy, for which the angular momentum of an electron is an integral multiple of $h/2\pi$.

$\therefore \quad mvr = n\frac{h}{2\pi}$

Where, m = mass of the electron, v = linear velocity of the electron
r = radius of orbit, h = Planck's constant
n = integral number called Principal quantum number
(n = 1 for K shell
= 2 for L shell
= 3 for M shell
= 4 for N shell, and so on.)

vii. Electrons in the energy level nearest to the nucleus possess lower energy than those at greater distance from the nucleus.

∴ The order of stationary orbits according to the energy associated with them is:
K < L < M < N < O < P

viii. The energy of an electron can change only when it moves from one level to another in the atom. A definite amount of energy or quantum of energy is absorbed when an electron jumps from a lower energy level to the higher energy level. Similarly, a definite amount of energy is given out when an electron jumps from a higher energy level to a lower energy level. The energy absorbed or emitted is the difference between energies of these two energy levels.
This difference in energy (ΔE) between two energy levels is given as,
$\Delta E = h\nu$
where h is Planck's constant and ν is the frequency of radiation of energy.

1.4 Modern atomic structure

i. According to the modern concept of the atom, it is the smallest unit of matter that is composed of three sub-atomic particles: protons, electrons and neutrons.
ii. An atom consists of two parts:
   a. Nucleus: It consists of protons and neutrons.
   b. Extra-nuclear part: It consists of electrons.
iii. The nucleus of an atom is positively charged as the protons present in it are positively charged while the neutrons are neutral in nature.
iv. Protons and neutrons are together known as nucleons while the electrons are called as extra nuclear particles.
v. The electrons are negatively charged and revolve around the nucleus in fixed orbits like planets revolve around the sun in solar system. Hence, the electrons are also called as orbital or planetary electrons.
vi. The number of protons found in the nucleus of an atom equals the number of electrons that surround it. So the positive charge of nucleus is balanced by negative charge. Thus, an atom as a whole is electrically neutral.

Note: In view of the shortcomings of Bohr's model of an atom, efforts were made to develop a new model of atom which could overcome the limitations of Bohr model. The development of new model was mainly based on the following two concepts that had been put forward:
   i. de Broglie concept of dual nature of matter
   ii. Heisenberg uncertainty principle.

1.5 Characteristics of fundamental particles of an atom

Atom consists of particles like protons, electrons and neutrons, which are known as sub-atomic or fundamental particles.

1.5.(a) Protons:

i. Protons were discovered by Eugen Goldstein and are positively charged particles.
ii. A proton is represented by the symbol p or ${}_1^1p$.
iii. The relative mass of a proton is 1.00727 amu (atomic mass unit) i.e., equal to the mass of one hydrogen atom.
iv. The electrical charge of a proton is equal in magnitude and opposite in sign to that of the electron. A proton carries a charge of $+1.6022\times10^{-19}$ coulombs or +1 elementary charge unit.
v. They are present in the nucleus of atom.
vi. As protons are positively charged, they get deflected by electric and magnetic fields.

1.5.(b) Electrons:

i. Electrons were discovered by Sir J. J. Thomson and are negatively charged particles.
ii. An electron is represented by the symbol e^- or $^{0}_{-1}e$.
iii. The relative mass of an electron is 0.00055 amu (atomic mass unit) i.e., $(1/1837)^{th}$ of the mass of hydrogen atom.
iv. The charge on the electron is equal to -1.6022×10^{-19} coulombs or -1 elementary charge unit.
v. Electrons revolve around the nucleus of atom in definite orbits or shells.
vi. As electrons are negatively charged, they get deflected by electric and magnetic fields.

1.5.(c) Neutrons:

i. Neutrons were discovered by James Chadwick.
ii. A neutron is represented by the symbol n or $^{1}_{0}n$.
iii. The relative mass of a neutron is 1.008665 amu (atomic mass unit).
iv. Neutron has no electrical charge i.e., it is electrically neutral.
v. Neutron(s) are present in the nucleus of all atoms (with exception of $^{1}_{1}H$).
vi. As neutrons have no charge, they do not get deflected in electric and magnetic fields.

Knowledge Bank

Atoms are extremely small, hence it is difficult to express their weights in usual units like gram(g). So, a smaller unit known as atomic mass unit (amu) is used.
1 amu (atomic mass unit) = 1.66056×10^{-24} g
Now-a-days, amu has been replaced by 'u' which is known as 'unified mass'.

1.5.(d) Comparison between sub-atomic or fundamental particles:

	Proton	Electron	Neutron
Discovered by	Discovered by Eugen Goldstein.	Discovered by Sir J. J. Thomson.	Discovered by James Chadwick.
Symbol/ representation	Represented as p or $^{1}_{1}p$.	Represented as e^- or $^{0}_{-1}e$.	Represented as n or $^{1}_{0}n$.
Relative mass	Mass = 1.672×10^{-24} g (1.00727 amu).	Mass = 9.108×10^{-28} g (0.00055 amu).	Mass = 1.674×10^{-24} g (1.008665 amu).
Relative charge	Carries unit positive charge equal to $+1.6022 \times 10^{-19}$ C.	Carries unit negative charge equal to -1.6022×10^{-19} C.	Carries no electric charge i.e., neutral.
Location in an atom	Present in nucleus of all atoms.	Present in extra-nuclear part of all atoms.	Present in nucleus of all atoms except $^{1}_{1}H$.

1.6 Atomic number and atomic mass number

1.6.(a) Atomic number:

i. *The number of protons present in the nucleus of an atom of a particular element is called the **atomic number** of that element.*

ii. Atomic number is represented by Z.

∴ Atomic Number (Z) = Number of protons present in the nucleus
= Number of electrons present in the extra-nuclear part of that atom

iii. Atomic number is always a whole number.

1.6.(b) Atomic mass number:

i. *The sum of the total number of protons and neutrons present in the nucleus of an atom is called as* ***atomic mass number*** *of that atom.*

ii. Mass number is represented by A.

∴ Mass number (A) = Number of protons + Number of neutrons
= Number of nucleons

iii. The electrons possess negligible mass. They do not contribute much to the mass of an atom. Hence, the entire mass of an atom is supposed to be present in the nucleus which consists of protons and neutrons.

iv. The atomic number (Z) is written at the left bottom of the symbol of an element while the atomic mass number is written at the left top of the symbol of an element. Hence, an element with symbol X is represented as ${}^{A}_{Z}X$.

1.6.(c) Relationship between atomic number and atomic mass number:

For a neutral atom with atomic mass number A and atomic number Z,
Number of electrons = Z
Number of protons = Z
Number of neutrons = A – Z

e.g. i. ${}^{23}_{11}Na$:

Atomic number (Z)	= 11
Atomic mass number (A)	= 23
Number of electrons	= 11
Number of protons	= 11
Numbers of neutrons	= A – Z
	= 23 – 11
	= 12

ii. ${}^{32}_{16}S$:

Atomic number (Z)	= 16
Atomic mass number (A)	= 32
Number of electrons	= 16
Number of protons	= 16
Number of neutrons	= A – Z
	= 32 – 16
	= 16

Illustrative Examples:

Example 1

Calculate the atomic number and atomic mass number of a neutral atom containing 9 electrons and 10 neutrons.

Solution:

Given: Number of electrons = 9, Number of neutrons = 10

To find: Atomic number (Z) and atomic mass number (A)

Formulae: i. Atomic number (Z) = Number of protons = Number of electrons
ii. Atomic mass number (A) = Number of protons + Number of neutrons

Calculation: Atomic number (Z) = Number of protons = Number of electrons

∴ Atomic number (Z) = **9**

Atomic mass number (A) = Number of protons + Number of neutrons
= 9 + 10 = **19**

Ans: Atomic number (Z) = **9** and atomic mass number (A) = **19**