A. PHYSICAL CHEMISTRY

1. FUNDAMENTAL CONCEPTS:

In this topic, student should be able to:

a) Define relative atomic, molecular and formula masses, based on the ^{12}C scale and concept of isotopes.
b) Explain mole in terms of the Avogadro's constant.
c) Apply mass spectrometric technique in determining the relative atomic mass of an element using the mass spectral data provided.
d) Calculate empirical and molecular formulae, using combustion data.
e) Understand stoichiometric calculations using mole concept involving.
   i) Reacting masses
   ii) Volume of gases
   iii) Percentage yield
f) Describe and explain following concentration units of solutions:
   i) Percentage composition
   ii) Molarity
   iii) Mole fraction

2. STATES OF MATTER:

In this topic, student should be able to:

a) Understand gaseous state with reference to:
   i) Postulates of kinetic molecular theory
   ii) Gas laws: Boyle's law, Charles' law, Avogadro's law and gas equation (PV=nRT) and calculations involving gas laws.
   iii) Deviation of real gases from ideal behaviour at low temperature and high pressure'
   iv) Conditions necessary for gasses to approach ideal behavior.
b) Discuss liquid state with reference to:
   Evaporation, vapour pressure, boiling and hydrogen bonding in water.
c) Explain the lattice structure of a crystalline solid with special emphasis on:
   i) Giant ionic structure, as in sodium chloride.

ii) Simple molecular, as in iodine.

iii) Giant molecular, as in diamond; silicon (IV) oxide.

iv) Hydrogen-bonded, as in ice.

d) Outline the importance of hydrogen bonding to the physical properties of substances, including NH_3, H_2O, C_2H_5OH and ice.

e) Suggest from quoted physical data the type of structure and bonding present in a substance.

3. ATOMIC STRUCTURE:

In this topic, student should be able to:

a) Identify and describe the proton, neutron and electron in terms of their relative charges and relative masses.

b) Discuss the behaviour of beams of protons, neutrons and electrons in electric fields.

c) Calculate the distribution of mass and charges within an atom from the given data.

d) Deduce the number of protons, neutrons and electrons present in both atoms and ions for a given proton and nucleon numbers/charge.

e)

i) Describe the contribution of protons and neutrons to atomic nuclei in terms of proton number and nucleon number.

ii) Distinguish between isotopes on the basis of different numbers of neutrons present.

f) Describe the number and relative energies of the s, p and d orbitals for the principal quantum numbers 1, 2 and 3 and also the 4s and 4p orbitals.

g) Describe the shapes of s, p and d-orbitals.

h) State the electronic configuration of atoms and ions given, the proton number/charge for period 1, 2, 3 and 4 (hydrogen to Krypton).

i) Explain:

i) Ionization energy.

ii) The factors influencing the ionization energies of elements.

iii) The trends in ionization energies across a Period and down a Group of the Periodic Table.

j) Explain and use the term Electron Affinity.

4. CHEMICAL BONDING:

In this topic, student should be able to:

a) Characterize electrovalent (ionic) bond as in sodium chloride and calcium oxide.

b) Use the 'dot-and-cross' diagrams to explain:

i) Covalent bonding, as in hydrogen(H_2); oxygen(O_2); chlorine(Cl_2); hydrogen chloride; carbon dioxide; methane and ethane.

ii) Co-ordinate (dative covalent) bonding, as in the formation of the ammonium ion in $H_3N^+ - {}^-BF_3$ and H_3O^+.

c) Describe the shapes and bond angles in molecules by using the qualitative model of Valence Shell Electron-Pair Repulsion (VSEPR) theory up to 4 pairs of electron including bonded electron pair and lone pair around central atom.

d) Describe covalent bonding in terms of orbital overlap, giving and bonds.

e) Explain the shape of and bond angles in ethane, ethene and benzene molecules in terms of and bonds.

f) Describe hydrogen bonding, using ammonia and water as simple examples of molecules containing N-H and O-H groups.

g) Explain the terms bond energy, bond length and bond polarity (electronegativity difference) and use them to compare the nature of covalent bonds i.e. polar and non-polar.

h) Describe intermolecular forces (Van der Waal's forces), based on permanent and induced dipoles, as in HCl, $CHCl_3$, Halogens and in liquid noble gases.

i) Describe metallic bonding in terms of positive ions surrounded by mobile electrons (sea of electrons).

j) Describe, interpret and/or predict the effect of different types of bonding (ionic bonding; covalent bonding; hydrogen bonding; Van der Waal's forces and metallic bonding) on the physical properties of substances.

k) Deduce the type of bonding present in a substance from the given information.

5. CHEMICAL ENERGETICS:

In this topic, student should be able to:

a) Understand concept of energy changes during chemical reactions with examples of exothermic and endothermic reactions.

b) Explain and use the terms:

   i) Enthalpy change of reaction and standard conditions, with particular reference to: formation; combustion; solution; neutralization and atomization.

   ii) Bond energy (ΔH positive, i.e. bond breaking).

   iii) Lattice energy (ΔH negative, i.e. gaseous ions to solid lattice).

c) Find heat of reactions/neutralization from experimental results using mathematical relationship i.e. $\Delta H = mc\Delta T$

d) Explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of lattice energy.

e) Apply Hess's Law to construct simple energy cycles, and carry out calculations involving such cycles and relevant energy terms, with particular reference to:

   i) Determining enthalpy changes that cannot be found by direct experiment, e.g. an enthalpy change of formation from enthalpy change of combustion.

   ii) Born-Haber cycle of NaCl (including ionization energy and electron affinity).

6. ELECTROCHEMISTRY:

In this topic, student should be able to:

a) Describe and explain redox processes in terms of electron transfer and/or of changes in oxidation number.

b) Define the terms:

   Standard electrode (redox) potential and Standard cell potential.

c) Describe the standard hydrogen electrode as reference electrode.

d) Describe methods used to measure the standard electrode potentials of metals or non-metals in contact with their ions in aqueous solution.

e) Calculate a standard cell potential by combining two standard electrode potentials.
f) Use standard cell potentials to:
    i) Explain/deduce the direction of electron flow in the external circuit.
    ii) Predict the feasibility of a reaction.
g) Construct redox equations using the relevant half-equations.
h) State the possible advantages of developing the H_2/O_2 fuel cell.
i) Predict and to identify the substance liberated during electrolysis from the state of electrolyte (molten or aqueous), position in the redox series (electrode potential) and concentration e.g. $H_2SO_{4(aq)}$ and $Na_2SO_{4(aq)}$.

7. CHEMICAL EQUILIBRIUM:

In this topic, student should be able to:

a) Explain, in terms of rates of the forward and reverse reactions, what is meant by a reversible reaction and dynamic equilibrium.
b) State Le Chatelier's Principle and apply it to deduce qualitatively the effects of changes in temperature, concentration or pressure, on a system at equilibrium.
c) Deduce whether changes in concentration, pressure or temperature or the presence of a catalyst affect the value of the equilibrium constant for a reaction.
d) Deduce expressions for equilibrium constants in terms of concentrations; Kc, and partial pressures; Kp
e) Calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data.
f) Calculate the quantities present at equilibrium, given appropriate data.
g) Describe and explain the conditions used in the Haber process.
h) Understand and use the Bronsted-Lowry theory of acids and bases.
i) Explain qualitatively the differences in behaviour between strong and weak acids and bases and the pH values of their aqueous solutions in terms of the extent of dissociation.
j) Explain the terms pH; Ka; pKa; Kw and use them in calculations.
k) Calculate $[H^+(aq)]$ and pH values for strong and weak acids and strong bases.
l) Explain how buffer solutions control pH.

m) Calculate the pH of buffer solutions from the given appropriate data.

n) Show understanding of, and use, the concept of solubility product, Ksp.

o) Calculate Ksp from concentrations and vice versa.

p) Show understanding of the common ion effect.

8. REACTION KINETICS / CHEMICAL KINETICS:

In this topic, student should be able to:

a) Explain and use the terms: rate of reaction; activation energy; catalysis; rate equation; order of reaction; rate constant; half-life of a reaction; rate-determining step.

b) Explain qualitatively, in terms of collisions, the effect of concentration changes on the rate of a reaction.

c) Explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy.

d) Describe enzymes as biological catalysts which may have specific activity.

e) Construct and use rate equations of the form

$$\text{Rate} = k[A]^m[B]^n$$

with special emphasis on:

i) Zero order reaction

ii) 1^{st} order reaction

iii) 2^{nd} order reaction

f) Show understanding that the half-life of a first-order reaction is independent of initial concentration and use the half-life to calculate order of reaction.

g) Calculate the rate constant from the given data.

h) Name a suitable method for studying the rate of a reaction, from given information.

B. INORGANIC CHEMISTRY

1. PERIODS:

In this topic, student should be able to:

Discuss the variation in the physical properties of elements belonging to period 2 and 3 and to describe and explain the periodicity in the following physical properties of elements.

a) Atomic radius.
b) Ionic radius.
c) Melting point.
d) Boiling point.
e) Ionization energy.

2. GROUPS:

In this topic, student should be able to:

Describe and explain the variation in the properties of group II and VII elements from top to bottom with special emphasis on:

a) Reactions of group-II elements with oxygen and water.
b) Properties of halogens and uses of chlorine in water purification and as bleaching agent.
c) Reaction of chlorine with sodium hydroxide (disproportionation reactions of chlorine).
d) Uses of Nobel gases (group VIII).

3. TRANSITION ELEMENTS:

In this topic, student should be able to:

Discuss the chemistry of transition elements of 3-d series with special emphasis on:

a) Electronic configuration.
b) Variable oxidation states.
c) Use as a catalyst.
d) Formation of complexes.
e) Colour of transition metal complexes.

4. Compounds of Nitrogen and Sulphur:

In this topic, student should be able to:

a) Describe the inertness of Nitrogen.

b) Manufacture of Ammonia by Haber's process.

c) Discuss the uses of nitrogenous fertilizers.

d) Describe the presence of Sulphur dioxide in the atmosphere which causes acid rain.

e) Describe only manufacturing of Sulphuric acid by contact method.

C. ORGANIC CHEMISTRY

1. FUNDAMENTAL PRINCIPLES:

In this topic, student should be able to:

a) Classify the organic compounds.

b) Suggest how cracking can be used to obtain more useful alkanes and alkenes of lower masses.

c) Discuss the types of reagents; nucleophile, electrophile and free radicals.

d) Explain isomerism; structural and cis-trans.

e) Discuss the functional group and nomenclature of organic compounds with reference to IUPAC names of Alkanes, Alkenes, Alcohols, Haloalkanes and Carboxylic acids.

2. HYDROCARBON:

In this topic, student should be able to:

Describe the chemistry of Alkanes with emphasis on:

a) Combustion.

b) The mechanism of free radical substitution reaction of methane with particular reference to the initiation, propagation and termination.

Discuss the chemistry of Alkenes with emphasis on:

a) Preparation of alkenes by elimination reactions:

   i) Dehydration of alcohols.

   ii) Dehydrohalogenation of Alkyl halide.

b) Reaction of Alkenes such as:
    i) Catalytic hydrogenation.
    ii) Halogenation (Br_2 addition to be used as a test of an alkene).
    iii) Hydration of alkenes.
    iv) Reaction with HBr with special reference to Markownikoff's rule.
    v) Oxidation of alkenes using cold alkaline or acidic $KMnO_4$ (Bayer's reagent) and using hot concentrated acidic or alkaline $KMnO_4$ for cleavage of double bond in 2-butene.
    vi) Polymerization of ethene.

Discuss chemistry of Benzene with examples

a) Structure of benzene showing the delocalized -orbital which causes stability of benzene.
b) Electrophilic substitution reactions of benzene including mechanism of:
    i) Nitration
    ii) Halogenation (chlorination and bromination)
    iii) Friedel Craft's reaction (Alkylation and acylation)
c) Hydrogenation of benzene ring to form cyclohexane ring.
d) Side chain oxidation of methyl benzene (toluene) and ethyl benzene.
e) Directive influence of substituents on the benzene ring by 2,4 directing and 3,5 directing groups (orientation in Electrophilic Substitution reactions of Benzene).

3. ALKYL HALIDES:

In this topic, student should be able to:

a) Discuss importance of halogenoalkanes in everyday life with special use of CFCs, halothanes, CCl_4, $CHCl_3$ and Teflon.
b) Reaction of alkyl halides such as:
    i) S_N-reactions, (Reactions of Alkyl halides with aqueous KOH, Alcoholic / aqueous KCN and Alcoholic / aqueous NH_3).
    ii) Describe SN1 and SN2 Mechanisms for tertiary butyl chloride and methyl bromide respectively using aqueous KOH.
    iii) Elimination reaction with alcoholic KOH to give alkenes.

4. ALCOHOLS AND PHENOLS:

In this topic, student should be able to:

Discus Alcohols with reference to:

a) Classification of alcohols into primary, secondary and tertiary.

b) Preparation of ethanol by hydration of ethene using conc. H_2SO_4 or conc. H_3PO_4

c) Reaction of alcohol with:

   i) $K_2Cr_2O_7 + H_2SO_4$ (oxidation).

   ii) PCl_5.

   iii) Na-metal.

   iv) Alkaline aqueous Iodine (Iodoform Test).

   v) Carboxylic acid (Esterification).

d) Dehydration of alcohol to give alkene.

Phenols

a) Discuss reactions of phenol with:

   i) Bromine ii) HNO_3 iii) NaOH

b) Explain the relative acidity of water, ethanol and phenol.

5. ALDEHYDES AND KETONES: In this topic, student should be able to:

a) Describe the structure of aldehyde and ketones.

b) Discuss preparation of aldehydes and ketones by oxidation of alcohols.

c) Discuss following reactions of aldehydes and ketones:

   i) Common to both;

      - 2,4-DNPH to detect the presence of carbonyl group
      - HCN to show mechanism of nucleophilic addition reaction
      - Reduction with $NaBH_4$ or $LiAlH_4$

   ii) Reactions in which Aldehydes differs from ketones i.e. Oxidation with Tollen's reagent and Fehling's solution.

   iii) Reaction which show presence of CH_3CO- group in aldehydes and ketones Triiodomethane test (Iodo form test) using alkaline aqueous iodine.

6. CARBOXYLIC ACID:

In this topic, student should be able to:

a) Show preparation of ethanoic acid by oxidation of ethanol or by acidic hydrolysis of Ethane nitrile (CH_3CN).

b) Discuss the reactions of ethanoic acid with emphasis on:

   i) Salt formation.

   ii) Esterification.

   iii) Acid chloride formation (acyl chloride).

   iv) Amide formation.

c) Describe the strength of organic acids relative to chloro substituted acids.

d) Explain the relative acidic strength of carboxylic acids, phenols and alcohols.

7. AMINO ACIDS:

In this topic, student should be able to:

a) Describe the general structure of -amino acids found in proteins.

b) Classify the amino acids on the basis of nature of R-group.

c) Describe Acid base properties of amino acids and formation of Zwitter ions.

d) Understand peptide bond formation.

8. MACROMOLECULES:

In this topic, student should be able to describe and explain

a) Formation and uses of Addition polymers such as polyethene, polystyrene and polyvinylchloride (PVC).

b) Formation and uses of Condensation polymers such as polyesters (terylene), polyamide (Nylon-6,6).

c) Structure of proteins i.e. primary and secondary structures.

d) Structure and function of nucleic acid (DNA).

9. ENVIRONMENTAL CHEMISTRY:

In this topic, student should be able to:

a) Describe air pollutants.

b) Understand the chemistry and cause of Acid Rain.

c) Depletion of Ozone layer by chlorofluorocarbons (CFCs).

Table of Specification (ToS) (CHEMISTRY-2018)

(For F.Sc. and Non-F.Sc.)

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B. Inorganic Chemistry	
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C. Organic Chemistry	
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PHYSICS

STRUCTURE OF THE SYLLABUS (2018)

For F.Sc. and Non-F.Sc.

TABLE OF CONTENTS

1. Measurement:

Learning outcomes:

In this topic the student should be able to:

a) Define Physical quantities and understand that all physical quantities consist of numerical magnitude and a unit.

b) Define International System of Units and understand SI base units of physical quantities and their derived units.

c) Use prefixes and symbols to indicate decimal, submultiples or multiples of both base and derived units: pico (p), nano (n), micro ( ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T).

d) Understand Errors and uncertainties including:

- systematic error and random error.
- fractional uncertainty and percentage uncertainty.
- assessment of total uncertainty in the final results.

2. Motion and Force

Learning outcomes:

In this topic the student should be able to:

a) Understand the concept of displacement, distance, speed, velocity and acceleration.

b) Understand velocity–time graph.

c) Review equations of motion.

d) Recall Newton's Laws of motion.

e) Define momentum and describe law of conservation of momentum.

f) Derive and explain the relation between the force and rate of change of momentum.

g) Define impulse and understand the concept of $I = F\,t = mv_f - mv_i$

h) Understand projectile motion and its applications.

i) Define moment of force or torque and use of torque due to force.

j) Define the equilibrium, its conditions and use it to solve problems.

3. Work, Energy and Power

Learning Outcomes:

In this topic the student should be able to:

a) Understand the concept of work in terms of the product of a force and displacement in the direction of the force.

b) Understand the concept of kinetic energy $K.E.$ $\frac{1}{2}mv^2$.

c) Understand the concept of potential energy $P.E.$ mgh.

d) Explain the Interconversion of kinetic energy and potential energy in gravitational field.

e) Define power in terms of work done per unit time and use power as product of force and velocity $P = \frac{W}{t}$ and $P = FV$.

4. Circular Motion

Learning outcomes:

In this topic the student should be able to:

a) Describe angular motion with the concept of angular displacement, angular velocity and use relation between angular and linear velocity to solve problems.

b) Define centripetal force and use equations $F = mr^2$, $F = \frac{mv^2}{r}$ and centripetal acceleration equations $a = r^2$ and $a = \frac{v^2}{r}$.

c) Understand geostationary orbits.

5. Oscillations

Learning outcomes:

In this topic the student should be able to:

a) Define and explain simple harmonic motion with examples.

b) Define and use the terms amplitude, frequency, angular frequency, phase difference. Express the time period in terms of both frequency and angular frequency.