WEST BENGAL STATE UNIVERSITY

SYLLABUS IN CHEMISTRY (HONOURS)

INORGANIC CHEMISTRY PORTION

UNDER CBCS

SEMESTER 1, 3 AND 5

(This is the modified syllabus only for the academic session 2020-21 for the above-mentioned semesters in view of the COVID pandemic as per resolution taken in the UGBOS meetings of the Department of Chemistry)

This document contains a total of 10 pages

CEMACOR06T: **INORGANIC CHEMISTRY-II**

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Marks: 50

Chemical Bonding-I

(24 Lectures) Marks: 20

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. ~~Packing of ions in crystals~~. Born-Landé equation ~~with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant,~~ Born-Haber cycle and its application, Solvation energy. ~~Defects in solids (elememetary idea). Solubility energetics of dissolution process~~.

(ii) *Covalent bond:* Polarizing power and polarizability, ionic potential,Fazan's rules. ~~Lewis structures, formal charge~~. Valence Bond Theory. ~~The hydrogen molecule (Heitler-London approach),~~ directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, Dipole moments, VSEPR theory, shapes of

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molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding (σ and π bond approach).

Chemical Bonding-II

(24 Lectures) Marks: 20

(i) Molecular orbital concept of bonding (The approximations of the theory, Linear combination of atomic orbitals (LCAO)) (elementary pictorial approach): sigma and pibonds and delta interaction, multiple bonding. Orbital designations: *gerade*, *ungerade,* HOMO, LUMO. Orbital mixing,. MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, NO^+, CN^-, HF, CO_2 ~~BeH_2, CO_2 and H_2O~~. Bond properties: bond orders, bond lengths.

(ii) *Metallic Bond:* ~~Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.~~

(iii) *Weak Chemical Forces:* van der Waals forces, ~~ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Intermolecular forces:~~ Hydrogen bonding ~~(theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points~~.

Radioactivity

(12 Lectures) Marks: 10

Nuclear stability and nuclear binding energy. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): ~~Concept of nuclear quantum number~~, magic numbers. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and ~~spallation.~~ Nuclear energy ~~and power generation. Separation and~~ uses of isotopes. Radio chemical methods: principles of determination of age of rocks and minerals, radio carbon dating, ~~hazards of radiation and safety measures~~.

Reference Books

1. Lee, J. D. *Concise Inorganic Chemistry, 5th Ed.,* Wiley India Pvt. Ltd., 2008.
2. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles ofStructure and Reactivity 4th Ed.,* Harper Collins 1993, Pearson, 2006.
3. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970.
4. Porterfield, H. W., *Inorganic Chemistry,* Second Edition, Academic Press, 2005.
5. Purecell, K.F. and Kotz, J.C., *An Introduction toInorganic Chemistry*, Saunders: Philadelphia, 1980.
6. Cotton, F.A., Wilkinson, G., & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India.
7. Gillespie, R. J. and Hargittai, I., The VSEPR Model of Molecular Geometry, Prentice Hall (1992).
8. Albright, T., *Orbital interactions in chemistry,* John Wiley and Sons (2005).
9. Mingos, D.M.P., *Essential trends in inorganic chemistry*. Oxford University Press (1998).

10. Miessler, G. L., Fischer, P. J., Tarr, D. A., *Inorganic Chemistry,* Pearson, 5th Edition.
11. Kaplan, I., *Nuclear Physics,* Addison-Wesley Publishing Company Inc. London, 1964.
12. Friedlander, G., Kennedy, J. W., Macias, E. S. And Miller, J. M., *Nuclear and Radiochemistry*, Wiley, 1981.

CEMACOR06P: INORGANIC CHEMISTRY-II LAB
60 (Lectures/Contact Hours) Marks: 25

Iodo-/ Iodimetric Titrations

1. ~~Estimation of Cu(II)~~
2. Estimation of Vitamin C
3. ~~Estimation of (i) arsenite and (ii) antimony in tartar emetic iodimetrically~~
4. Estimation of available chlorine in bleaching powder. **Estimation of metal content in some selective samples**

1. Estimation of Cu in brass.
2. ~~Estimation of Cr and Mn in Steel~~.
3. Estimation of Fe in cement.

Reference Books

1.Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* 6th Ed., Pearson, 2009.

CEMACOR11T: **INORGANIC CHEMISTRY-IV**

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures Marks: 50

Coordination Chemistry-II
(36 Lectures) Marks: 30

VB description and its limitations. Elementary Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn-Teller distortion. Octahedral site stabilization energy (OSSE). Metalligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples). Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only); d-d transitions; L-S coupling; ~~qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea).~~

Chemistry of d- and f- block elements
(24 Lectures) Marks: 20

Transition Elements:
~~General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry~~.

Lanthanoids and Actinoids:
General Comparison on Electronic configuration, oxidation states, colour, spectral and magnetic properties; lanthanide contraction, separation of lanthanides (ion-exchange method only).

Reference Books

1. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles ofStructure and Reactivity 4th Ed.,* Harper Collins 1993, Pearson,2006.

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2. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, ButterworthHeinemann. 1997.
3. Cotton, F.A., Wilkinson, G., Murrillo, C. A., Bochmann, M., *Advanced Inorganic Chemistry 6th Ed. 1999.*, Wiley.
4. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).
5. Purecell, K.F. and Kotz, J.C., *An Introduction toInorganic Chemistry*, Saunders: Philadelphia, 1980.
6. Sinha, S. P., Ed., Lanthanide and Actinide Research (Journal, Vol. 1, 1986).
7. Wulfsberg, G., Principles of Descriptive Inorganic Chemistry, Brooks/Cole: Monterey, CA, 1987.

CEMACOR11P: INORGANIC CHEMISTRY-IV LAB

(60 Lectures/Contact Hours) Marks: 25

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

1. Ni (II) and Co (II)
2. ~~Fe (III) and Al (III)~~

Gravimetry

1. Estimation of Ni(II) using Dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN.
3. ~~Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)$_3$ (aluminium oxinate~~).
4. ~~Estimation of chloride.~~**Spectrophotometry**~~:~~

Spectrophotometry

1. Measurement of 10Dq by spectrophotometric method.
2. ~~Determination of λ_{max} of [Mn(acac)$_3$] and [Fe(acac)$_3$] complexes~~.

Reference Books

1.Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* 6th Ed., Pearson, 2009.

CEMADSE02T: **ANALYTICAL METHODS IN CHEMISTRY**
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures Marks: 50

Qualitative and quantitative aspects of analysis:
(05 Lectures) Marks: 06

Sampling, evaluation of analytical data, errors, accuracy and precision, ~~methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.~~

Optical methods of analysis:
(25 Lectures) Marks: 16

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source,monochromator and detector) for single and double beam instrument;
Basic principles of quantitative analysis: estimation of metal ions from aqueous solution,~~geometrical isomers, keto-enol tautomers~~. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method. *Infrared Spectrometry:* Basic principles of instrumentation (choice of source, monochromator& detector) for single and double beam instrument; sampling techniques.

~~Structural illustration through interpretation of data, Effect and importance of isotope substitution~~.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation(choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; ~~Method of background~~

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correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Thermal methods of analysis:
(05 Lectures) Marks: 06

Theory of thermogravimetry (TG), basic principle of instrumentation.

Techniques for quantitative estimation of Ca and Mg from their mixture.

Electroanalytical methods:
(10 Lectures) Marks: 08

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Separation techniques:
(15 Lectures) Marks: 14

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Role of computers in instrumental methods of analysis.

Reference Books

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson,

CEMADSE02P: ANALYTICAL METHODS IN CHEMISTRY LAB

(60 Lectures/Contact Hours) Marks: 25

I. Separation Techniques

Chromatography:

(a) Separation of mixtures

Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

(b) ~~Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.~~

~~(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC~~

I. Solvent Extractions:

To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, ~~and determine its concentration by spectrophotometry~~.

Analysis of soil:

(i) Determination of pH of soil.

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(ii) ~~Estimation of calcium, magnesium, phosphate~~

Ion exchange:

Determination of exchange capacity of cation exchange resins and anion exchange resins.

III. Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.
2. Determination of chemical oxygen demand (COD).
3. ~~Determination of Biological oxygen demand (BOD).~~

Reference Books

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & AlliedMethods*, Elles Harwood Ltd. London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, New York, 1974.