GUJARAT VIDYAPITH: AHMEDABAD
Department of Biogas Research and Microbiology
Faculty of Science and Applied Science, Ahmedabad
SUBJECT: CHEMISTRY
Syllabus for Ph.D. Entrance Test
Part – 1

(Research Methodology) (50%)

---

(1) The Language of Chemical Research

1.1 Analysis, Determination and Measurement
1.2 Techniques, Methods, Procedures and Protocols
1.3 Classifying analytical Techniques
1.4 Selecting an analytical method
- 1.4.1 Accuracy
- 1.4.2 Precision
- 1.4.3 Sensitivity
- 1.4.4 Selectivity
- 1.4.5 Robustness and Ruggedness
- 1.4.6 Scale of operation
- 1.4.7 Equipment, Time and cost
- 1.4.8 Making the final choice

1.5 Developing the procedure
- 1.5.1 Compensating for Interferences
- 1.5.2 Calibration and standardization
- 1.5.3 Sampling
- 1.5.4 Validation

(2) Literature Survey and Obtaining & Preparing Samples for Analysis

2.1 Printed literature: Periodicals, Review serials, Treatises, Textbooks, Monographs, Chemical abstract, Beilstein database.
2.2 Digital literatures: e- journals, e-book, various e-databases, Web resources
2.3 Populations and Samples
2.4 The Importance of Sampling
2.5 Designing a Sampling Plan
- 2.5.1 Where to Sample the Target Population
- 2.5.2 What Type of Sample to Collect
- 2.5.4 How Much Sample to Collect
- 2.5.5 How Many Samples to Collect
- 2.5.6 Minimizing the Overall Variance

2.6 Implementing the Sampling Plan
- 2.6.1 Solutions
- 2.6.2 Gases
- 2.6.3 Solids

(3) Methods of Data Collection

3.1 Qualitative analytical methods

3.2 Quantitative analytical methods

3.3 Classical analytical methods (various methods/techniques with their applications)

3.4 Instrumental analytical methods (various methods/techniques with their applications)

(4) Evaluating Analytical Data-I

4.1 Characterizing Measurements and Results

4.1.1 Measures of Central Tendency

4.1.2 Measures of Spread

4.2 Characterizing Experimental Errors

4.2.1 Accuracy

4.2.2 Precision

4.2.3 Error and Uncertainty

4.3 The Distribution of Measurements and Results

4.3.1 Probability Distributions for Populations

4.3.2 Confidence Intervals for Populations

4.3.3 Probability Distributions for Samples

4.3.4 Confidence Intervals for Samples

4.3.5 Cautionary Statement

(5) Evaluating Analytical Data -II

5.1 Statistical Analysis of Data

5.1.1 Significance Testing

5.1.2 Constructing a Significance Test

5.1.3 One-Tailed and Two-Tailed Significance Tests

5.1.4 Errors in Significance Testing

5.1.5 Correlation and regression

5.2 Statistical Methods for Normal Distributions

5.2.1 Comparing mean to μ

5.2.2 Comparing s^2 to s^2

5.2.3 Comparing Two Sample Variances

5.2.4 Comparing Two Sample Means

5.2.5 Analysis of variance (ANOVA)

(6) Interpretation and Report Writing

6.1 Meaning of Interpretation

6.2 Why Interpretation?

6.3 Technique of Interpretation:

6.4 Precaution in Interpretation

6.5 Significance of Report Writing

6.6 Different Steps in Writing Report

6.7 Layout of the Research Report

6.8 Types of Reports

6.9 Oral Presentation

6.10 Mechanics of Writing a Research Report

6.11 Precautions for Writing Research Reports

6.12 Conclusions

(7) Safety in Academic Chemistry Laboratory

7.1 Your Responsibility for Safety in Laboratories

7.1.1 Personal Protective Equipment (PPE),

7.1.2 Laboratory Protocols: Labeling Chemicals, Cleaning Glassware, Inhaling Harmful Chemicals, Disposal of Chemicals

7.2 Guide to Chemical Hazards

7.2.1 Toxicity: Exposure, Routes of Entry/Exposure, Dose, Duration and Frequency of Exposure, Groups of Chemicals Known to Elicit Toxic Effects

7.2.2 Flammability: Solvents, Flammable Solid*),*

7.2.3 Corrosivity (Corrosives, Acids, Bases)*,*

7.2.4 Reactivity: Oxidizers, Peroxide-Forming Solvents,

7.2.5 Recognizing Chemical Hazards: Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Elements of the GHS (Pictograms, Hazard statements, Precautionary statements, Signal words)

7.3 Safety Equipment and Emergency Response:

7.3.1 Fire Prevention, Prepare to Respond to a Fire, Prepare to Respond to Personal Injuries Involving Fires

7.3.2 Chemical Contamination on Skin, Clothing, and Eyes: Preventing Chemical Contact, Prepare to Respond to Chemical Contact

7.3.3 Other Personal Injury: Preventing Other Personal Injuries, Prepare to Respond to Other Personal Injury Incidents

7.3.4 Chemical Spills: Preventing Chemical Spills, Prepare to Respond to a Chemical Spill

(8) Spectroscopic Methods of Analysis

8.1 Overview of Spectroscopy

8.1.1 What Is Electromagnetic Radiation

8.1.2 Measuring Photons as a Signal

8.2 Basic Components of Spectroscopic Instrumentation

8.2.1 Sources of Energy

8.2.2 Wavelength Selection

8.2.3 Detectors

8.2.4 Signal Processors

8.3 Spectroscopy Based on Absorption

8.3.1 Absorbance of Electromagnetic Radiation

8.3.2 Transmittance and Absorbance

8.3.3 Absorbance and Concentration: Beer's Law

8.3.4 Beer's Law and Multicomponent Samples

8.3.5 Limitations to Beer's Law

8.4 Ultraviolet-Visible and Infrared Spectrophotometry

8.4.1 Instrumentation

8.4.2 Quantitative Applications

8.4.3 Qualitative Applications

8.4.4 Characterization Applications

8.4.5 Evaluation

8.5 Atomic Absorption Spectroscopy
8.5.1 Instrumentation
8.5.2 Quantitative Applications
8.5.3 Evaluation

8.6 Spectroscopy Based on Scattering

8.6.1 Origin of Scattering
8.6.2 Turbidimetry and Nephelometry

(9) Introduction to separation techniques

9.1 Filtration, distillation and solvent extraction
9.2 Chromatography: principle, classification of chromatographic methods
9.3 Paper chromatography: principle, experimental technique
9.4 Column chromatography: principle, experimental technique
9.5 Thin layer chromatography: principle, experimental technique
9.6 Ion exchange chromatography: principle, experimental technique
9.7 Gas chromatography: principle, experimental technique (except types of detector)
9.8 Applications of chromatography in qualitative and quantitative analysis

Reference Books

1. David Harvey, Modern Analytical Chemistry, The McGraw-Hill Companies, Inc (2000).
2. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International Pvt.Ltd, New Delhi (2004)
3. G.H.Jeffery, J Bassett, J Mendham and R C Denney ,Vogel's Textbook of Quantitative Chemical Analysis, LongmanScientific and Technical Ltd.
4. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. *Practical skills in chemistry*. 2nd Ed. Prentice-Hall, Harlow (2011).
5. Hibbert, D. B. & Gooding, J. J. *Data analysis for chemistry*. Oxford University Press (2006).
6. Topping, J. *Errors of observation and their treatment.* Fourth Ed., Chapman Hall, London (1984)
7. Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman Chapters 3-5 (2007)
8. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis.* Cambridge Univ. Press (2001) 487 pages.
9. Safety in Academic Chemistry Laboratory, American Chemical Society, Washington, DC (2017)
10. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, (1992)

****

GUJARAT VIDYAPITH: AHMEDABAD
Department of Biogas Research and Microbiology
Faculty of Science and Applied Science, Ahmedabad
SUBJECT: CHEMISTRY
Syllabus for Ph.D. Entrance Test
Part – 2

(Subject Related) (50%)

ORGANIC CHEMISTRY

1. **IUPAC nomenclature**: IUPAC nomenclature of organic molecules including regio- and stereoisomers.

2. Stereochemistry: Configuration and chirality, optical isomerism, R, S-convention, enantiotopic and diastereotopic groups, methods of resolution, asymmetric synthesis. Geometrical isomerism E, Z-convention. Conformational analysis; effect of conformation on reactivity**.**

3.Organic Reaction Mechanisms: Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Mechanism of nucleophilic substitution (SN1 and SN2) and elimination (E1 and E2).

4.Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.

5.Aromaticity: Huckel's rule and concept of aromaticity: annulenes and heteroannulenes, fullerenes. (C60)

6.Heterocycles: Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline and indole. Skraup synthesis, Fischer indole synthesis.

7.Spectroscopy: Combined applications of mass, UV-VIS, IR and NMR spectroscopy for structural elucidation of compounds.

8. **Biomolecules: (a)**Carbohydrates: Classification, basic chemical structure, general reactions and properties (b) Protein and Poly peptides: Amino acids (Classification, Properties, reactions, rare amino acids), Structural levels of protein (Primary Structure, Secondary structure, Tertiary Structure and Quaternary structure)

INORGANIC CHEMISTRY

1. Periodic Table: Periodic classification of elements and periodicity in properties; general methods of isolation and purification of elements.

2. Chemical bonding and shapes of compounds: Structure and bonding in homo- and heteronuclear molecules, including shapes ofmolecules (VSEPR Theory).

3. Acids and Bases: Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.

4.Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds.

5.Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms.

6.Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications.

7.Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis.

PHYSICAL CHEMISTRY

1.Solutions: Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, Colligative properties, Raolut's law, relative lowering of vapour pressure, molelcular weight determination, Osmosis law of osmotic pressure and its measurement. Elevation of boiling point and depression of freezing point, Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties.

2. Chemical Thermodynamics: Reversible and irreversible processes; First law of thermodynamics and its application to ideal and non-ideal gases; Criteria for spontaneity. Second and third law of thermodynamics. Gibbs and Helmholtz energy; Free energy change and spontaneity

3. Chemical and Phase Equilibria: Law of mass action; Kp, Kc, Kx and Kn; Effect of temperature on K; Ionic equilibria in solutions; pH and buffer solutions; Hydrolysis; Solubility product; Phase equilibria–Phase rule and its application to one-component and two-component systems; Colligative properties.

4. Electrochemistry: Conductance and its applications; Transport number; Galvanic cells; EMF and Free energy; Concentration cells with and without transport

5. Chemical Kinetics: Reactions of various order, Arrhenius equation, Collision theory; Theory of absolute reaction rate; Chain reactions - Normal and branched chain reactions; Enzyme kinetics; Photophysical and photochemical processes; Catalysis.

6.Solid state Chemistry: crystalline and amorphous solids, crystal structure types, unit cell, iller indices, Bragg equation, Bravis lattices, defects in crystals, Frenkel and Schottky defects, Band theory of solids, molecular solids, phosphorescence and fluorescence.

ANALYTICAL CHEMISTRY

1. The Nature of Analytical Chemistry: The Role of Analytical Chemistry, Quantitative Analytical Methods, A Typical Quantitative Analysis, An Integral Role for Chemical Analysis

2.Titrations in Analytical Chemistry: Some Terms Used in Volumetric Titrations, Standard Solutions, Volumetric Calculations, Gravimetric Titrations, Titration Curves

3. Principles of Neutralization Titrations: Solutions and Indicators for Acid/Base Titrations, Titration of Strong Acids and Bases, Titration Curves for Weak Acids, Titration Curves for Weak Bases, The Composition of Solutions During Acid/Base Titrations

4. Complex Acid/Base Systems: Mixtures of Strong and Weak Acids or Strong andWeak Bases, Polyfunctional Acids and Bases, Buffer Solutions Involving Polyprotic Acids

Calculation of the pH of Solutions of NaHA, Titration Curves for Polyfunctional Acids, Titration Curves for Polyfunctional Bases, Titration Curves for Amphiprotic Species Composition of Polyprotic Acid Solutions as a Function of pH

5. **Applications of Neutralization Titrations**: Reagents for Neutralization Titrations, Typical Applications of Neutralization Titrations

6. Complexation and Precipitation Reactions and Titrations: The Formation of Complexes
Titrations with Inorganic Complexing Agents, Organic Complexing Agents, Aminocarboxylic Acid Titrations, Masking and Demasking Agents

****

Reference Books

1. Organic Chemistry (sixth edition), Robert Thornton Morrison and Robert Neilson Boyd, Prentice-Hall of India Pvt. Ltd., New Delhi, (1999)
2. Organic Chemistry (second edition), Paula YurkanisBruice, Prentice-Hall, Inc., New Jersey (1998)
3. Organic Chemistry (third edition), Francis A. Carey, The McGraw-Hill Companies, Inc., New York (1996)
4. Elementary Organic Spectroscopy, Y.R.Sharma, S. Chand & Company Ltd.,Delhi(2007)
5. Basic Inorganic Chemistry (Third edition), F.Albert cotton, Geoffrey Wilkinson and Paul L.Gaus., John Wiley and Sons,Inc.,New York., pp.165-185 (1995) .
6. oncise Inorganic Chemistry (Fifth edition), J.D.Lee., Blackwell Science Ltd.,Oxford., pp.194-236(1996).
7. Text book of Physical Chemistry (second edition), Samuel Glasstone, Macmillan India Ltd., pp.524-556 (1991)
8. Essential of Physical chemistry, Arun Bahl, B.S.Bahl and G.D.Tuli, S.Chand Publishing Co (2006)
9. David Harvey, Modern Analytical Chemistry, The McGraw-Hill Companies, Inc (2000).
10. Vogel′s Text Book of Quantitative Chemical Analysis (fifth edition), Longman Scientific and Technical Publish Group, England, (1991)

11. Data analysis for chemistry, Hibbert, D. B. & Gooding, J. J. Oxford University Press (2006).
12. Errors of observation and their treatment.Topping, J., Fourth Ed., Chapman Hall, London (1984)
13. Quantitative chemical analysis, Harris, D. C., 6th Ed., Freeman (2007).
14.Quantitative analysis (sixth edition), R.A.Day, JR.; A.L.Underwood, Prentice-Hall of India Pvt.Ltd., New Delhi, pp.68-91(2003)

****