ENGINEERING CHEMISTRY

ENSH 153

Lecture : 3 **Year : I**
Tutorial : 1 **Part : II**
Practical : 3

Course Objectives:
To develop the basic concepts of physical chemistry, inorganic chemistry, analytical chemistry, environmental chemistry, green and sustainable chemistry, nano chemistry, polymer chemistry and organic chemistry relevant to the different disciplines of engineering.

1 Electrochemistry and Buffer (8 hours)

1.1 Electrochemistry
- 1.1.1 Introduction
- 1.1.2 EMF of galvanic cell, Nernst equation
- 1.1.3 Polarization and overpotential
- 1.1.4 Butler-Volmer equation and Tafel plots

1.2 Electrode processes and mechanisms (Qualitative only)
- 1.2.1 Charge transfer processes at electrodes
- 1.2.2 Mass transfer and diffusion in electrochemical systems

1.3 Industrial and applied electrochemistry
- 1.3.1 Batteries: Lead acid and lithium ion
- 1.3.2 Solar-photovoltaic cell (With typical examples), fuel cell
- 1.3.3 Corrosion

1.4 Buffer, buffer range, buffer capacity and buffer solution (Henderson-Hasselbalch equation) and its applications

2 Catalyst and Catalysis (4 hours)

2.1 Definition and types

2.2 Design and criteria
- 2.2.1 Structure-activity relationships
- 2.2.2 Selection criteria of catalyst

2.3 Photocatalysis and electrocatalysis

2.4 Catalysis for energy and environmental applications
- 2.4.1 Catalytic conversion of fossil fuels
- 2.4.2 Renewable energy catalysts
- 2.4.3 Catalyst for pollution control

3 Analytical Techniques and their Applications (6 hours)

- 3.1 Chromatography
- 3.2 Mass spectroscopy
- 3.3 X-ray diffraction (XRD)
- 3.4 UV-visible spectroscopy
- 3.5 Infrared-spectroscopy (IR)
- 3.6 Nuclear magnetic resonance spectroscopy (NMR)

4 Metal Complexes, Rare Earth Elements and Metal alloys (6 hours)

- 4.1 Complexes
  - 4.1.1 Introduction and Werner's theory
  - 4.1.2 Geometry of complex by VBT and its applications
  - 4.1.3 Crystal field theory: Principle and applications
- 4.2 Rare earth elements: Introduction and applications
- 4.3 Metallic alloys and applications

5 Sustainable Chemistry (7 hours)

- 5.1 Green chemistry: Introduction and principles
- 5.2 Water chemistry
  - 5.2.1 Importance of water quality standards
  - 5.2.2 Degree of hardness, scale formation in boiler and softening of hard water
  - 5.2.3 Water pollution with reference to turbidity, COD, BOD, heavy metals, radioactive substances, and plastic
  - 5.2.4 Industrial wastewater and its treatment
- 5.3 Air pollution: Particulate matter, SOx, NOx, GHGs, VOCs, their impacts and remedies
- 5.4 Waste management
  - 5.4.1 Segregation and management of solid waste
  - 5.4.2 Management of biodegradable waste into energy
  - 5.4.3 E-waste and its management

6 Nanoscience and Nanotechnology (3 hours)

- 6.1 Introduction and types of nano materials (0-, 1-, 2-, and 3- dimensional)
- 6.2 Nanoparticles, nanofibers, nanowires, carbon nanotubes, graphene, mxene, quantum dots, and their uses
- 6.3 Preparation of nanomaterials

7 Engineering Materials (7 hours)

- 7.1 Polymers
  - 7.1.1 Natural and synthetic, organic and inorganic, conducting and non-conducting

7.1.2 Types of polymerizations: Addition and condensation polymerization
7.1.3 Preparation and applications of epoxy resin, polyurethane, Kevlar, polycarbonate, polymethyl methacrylate, polyacrylonitrile, silicones; Phosphorus based polymer, Sulphur based polymer
7.1.4 Conducting polymers: Synthesis and application
7.1.5 Composite: Fiber reinforced polymer
7.1.6 Natural polymers: Cellulose, chitin, chitosan, collagen
7.2 Cement: Hydration and setting chemistry of cement

8 Explosives, Lubricants and Paints (4 hours)

8.1 Explosives
8.1.1 Types of explosives: Primary, low and high explosives
8.1.2 Preparation and applications of TNT, TNG, Nitrocellulose and plastic explosives
8.2 Lubricants: Introduction, function and classification
8.3 Paints
8.3.1 Introduction, requisites, types and applications
8.3.2 Environmental and health impact

Tutorial (15 hours)

1. Introduction to cells, electroplating, EMF, electric double layer, problems related to buffer and Nernst equations
2. Types of catalyst and types of catalysis
3. Electromagnetic radiation, electromagnetic spectrum, electromagnetic wave, principles of spectroscopy, types of molecular spectra
4. Complexes, ligands, postulates, compounds with coordination number 4 and 6, splitting of octahedral and tetrahedral complexes and rare earth elements
5. Application of green chemistry and industrial waste management
6. Application of nanomaterials in pollution minimization
7. Introduction and stabilization of free radicle, carbocation and carbanion.
8. Exothermic reaction of cement and its applications
9. Introduction of and applications of explosives, lubricants and paints

Practical (45 hours)

10. Determination of total, temporary and permanent hardness of water sample using complexometric titration
11. Determination of the alkalinity of water sample A and B by double indicator titration
12. Estimation of the amount of residual chlorine in water by iodometric titration
13. Preparation of the standard buffer solution (Acidic or basic) and measure the approximate pH of given unknown solution by using Universal Indicator

14. Comparison of the cleansing power of two sample of detergents by determining the reduction they cause in surface tension of water
15. Construction of Daniell cell and study of the variation of cell potential with concentration
16. Separation of the pigments through the process of paper / thin layer chromatography
17. Determination of total iron in ground water using spectrophotometer technique
18. Determination of amount of copper and iron in a given mixture solution by K2Cr2O7 titration
19. Preparation of cross – linked polymer by condensation polymerization method
20. Standardize potassium permanganate solution and use it to estimate the amount of Iron and determine the percentage purity in the sample of ferrous salt solution
21. Preparation of Ni-DMG complex and estimation of the amount of nickel

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks Distribution*
1	8	10
2	4	5
3	6	5
4	6	10
5	7	10
6	3	5
7	7	10
8	4	5
Total	45	60

*There may be minor deviation in mark distribution

References

1. Maron, S. H., Prutton, C. F. (1965). Principles of Physical Chemistry (Latest Edition). Macmillan.
2. Lee, J.D. (2007). Concise Inorganic Chemistry. John Wiley & Sons.
3. Madan, R.D., Prakash, S. (1994). Inorganic Chemistry (Latest Edition). S. Chand & Company Ltd.
4. Bahl, S., Tuli, G.D., Bahl, A. (2009). Essentials of Physical Chemistry. S. Chand & Co. Ltd.
5. Bhagi, A. K., Morrison, G. R. T., Boyd, R. N. (2008). Organic Chemistry. Prentice-Hall of India.
6. Morrison, R. T., Boyd, R. N. (2008). Organic Chemistry. Prentice-Hall of India.

7. Vogel. (2008). Vogel's Textbook of Quantitative Chemical Analysis. Pearson Education.
8. Murthy, B. S., Shankar, P., Baldev, R., Rath, B. B., Murday, J. (2012). Textbook of nanoscience and nanotechnology. Universities Press.
9. Chatwal, G.R. (2023). Textbook of Environmental Chemistry. Himalaya Publishing House.