Engineering Chemistry II
EG1203SH

Year: I **Total: 8 hours /week**
Semester: II **Lecture: 4 hour/week**
Tutorial: 2 hours/week
Practical: hours/week
Lab: 2 hours/week

Course Description*:*
This subject consists of three units related to nonmetals and their compounds, metals and their compounds and organic compounds and polymers.

Course Objectives:
After the completion of this subject, students will be able to

- Know about causes of hardness of water and its remedy.
- Develop the knowledge of physical and chemical properties of different materials.
- Explain about the manufacturing process of ammonia, Nitric acid and sulphuric acid.
- Know about alkali metals, alkaline earth metals and coinage metals and their properties.
- Prepare laboratory method and their properties of different compounds.
- Write IUPAC naming of organic compounds.
- Provide the student's background of basic concepts of chemistry required for understanding and practicing related in engineering works.

Course Content:
Unit 1: Non-metals and their compounds: [30 Hrs.]
1.1 Water: [4 hours]

- Introduction
- Sources of water
- Types of water
- Causes and types of hardness of water
- Methods of removal of temporary hardness by:
  - Boiling and Clark's methods
- Methods of removal of permanent hardness by:
  - Washing soda and permutit process and its advantages
- General concept on Water treatment for domestic and industrial purpose
  - Water for drinking purposes, water for boiler purposes, water for washing purposes
- Conditions of potable water
- Concept of amphoteric and universal solvent of water

1.2 Ammonia: [4 Hrs.]

- Introduction
- Laboratory preparation of ammonia gas
- Manufacture of ammonia by Haber's process (ref. principle, condition for higher yield and process)
- Physical Properties
- Chemical properties:
  - Basic nature, dissociation, auto-ionization
  - Reduction reaction

        - Combustion, catalytic oxidation of ammonia, oxidation of heated copper oxide
    - Action with halogens(chlorine)
    - Action with metals (Na Or K)
    - Action with metallic salts solution like Iron, aluminum, zinc and chromium
    - Formation of complex amines with the salts solutions of d block transitional elements like copper, silver, Nickel and Cobalt
    - Action with Carbon dioxide
    - Action with bleaching powder
- Uses

1.3 Nitric acid: [8 Hrs.]

- Introduction
- Manufacture of nitric acid by Ostwald's process (ref. principle, process and advantages)
- Physical Properties
- Chemical properties:
    - Action of heat
    - Acidic character
    - Oxidizing character
        - action on non-metals like carbon, Sulphur, phosphorus and iodine
        - action on metalloids like arsenic and antimony
        - action on inorganic compounds like Sulphur dioxide, hydrogen sulphide and acidified ferrous sulphates
        - action on metals like Zinc, Magnesium, Iron, copper, mercury and silver
        - action on noble metals like gold and platinum (with aqua regia)
- uses
- Nitrogen cycle (explain with flow chart diagram)
- Nitrogen fixation and it occurs (natural and artificial)
- Fertilizers
    - Types of fertilizers
    - Functions of essentials nutrients
    - Characteristics of fertilizers
    - Classification of chemical fertilizers (ref N,P,K and mix)
- Pollution and pollutant(introduction)
- Oxides of nitrogen and Sulphur as pollutant and acid rain

1.4 Halogens (Chlorine): [3hrs]

- Introduction
- Laboratory preparation of chlorine
    - by applying heat
    - without application of heat
- Physical Properties
- Chemical properties:
    - action with hydrogen
    - action with water
    - action with sodium hydroxide, potassium hydroxide and calcium hydroxide
    - action with ammonia
    - oxidizing character:
        - action of chlorine in presence of water (ref Hydrogen sulphide, Sulphur dioxide, acidified ferrous sulphate)
        - action of chlorine in absence of water (ref, ferrous chloride, stannous chloride)

- Bleaching character
- Action with bromides and iodides
- Action with metals like copper, zinc, aluminum and iron
- Action with metalloids like arsenic and antimony
- Action with non-metals like Sulphur and phosphorus
- Action with organic compounds like methane and ethene

- uses

1.5 Hydrochloric acid: [2 Hrs.]

- Introduction
- Laboratory preparation of HCl gas and aqueous HCl
- Physical Properties
- Chemical properties:
  - acidic character
  - action with ammonia
  - reducing character (action with oxidizing agents)
    - action with manganese dioxide, potassium permanganate and potassium dichromate
  - action with AgNO3
  - formation of aqua regia
  - action with lead acetate
  - action nonmetals
  - action with air
- uses

1.6 Hydrogen sulphide: [2 Hrs.]

- Introduction
- Laboratory preparation of hydrogen sulphide (pure and dry state)
- Physical Properties
- Chemical properties:
  - Acidic character
  - Dissociation
  - Reducing properties
    - action with ferric chloride, halogens, acidified potassium permanganate, acidified potassium dichromate, Sulphur dioxide, sulphuric acid and nitric acid
  - Action with metals
  - Action with lead acetate
  - Precipitation of metals sulphide (acidic and basic medium)
- uses

1.7 Sulphuric acid: [4 Hrs.]

- Introduction
- Manufacture by contact process (ref principle, condition and process)
- Physical Properties
- Chemical properties:
  - action of heat
  - acidic nature
  - precipitation reaction
  - oxidizing agent (ref. nonmetals like Sulphur, carbon, phosphorus, hydrogen halide, hydrogen sulphide, metals
  - dehydrating action, (ref. sugar, starch, formic acid, oxalic acid, alcohol, copper sulphates crystals)

- action with SO3
- uses

1.8 Carbon and its compounds: [3 Hrs.]

- Introduction
- Allotropy
- Allotropic form of carbon (just give flow sheet)
- Structure, properties and uses of diamond and graphite
- Oxides of carbon (Ref. sources of carbon dioxide & carbon mono oxide and its effect)
- Concept of greenhouse effect and global warming

Unit 2: Metals and their compounds [15 Hrs.]

2.1 General study of Metals and their components: [5 Hrs.]

- Introduction
- Distinguish between metals and non-metals (ref. physical and chemical properties: at least any fifteen differences)
- Occurrence of metals
- Definition and types of alloys (ref. ferrous and non-ferrous alloys)
- Purpose of making alloys
- Metalloids
- Amalgam
- Chemistry of metallic carbonate
  - General methods of preparation of metallic carbonate
    - by passing carbon dioxide into oxides or hydroxides
    - by heating bicarbonates
    - by double decomposition (preparation of insoluble carbonates)
  - General properties of metallic carbonates
    - action with water
    - action of heat
    - action with acids
- Chemistry of metallic sulphate
  - General methods of preparation of metallic sulphate
    - by treating metals with sulphuric acid
    - by treating the oxides, hydroxides, carbonates and sulphides of metals with sulphuric acid
    - by double decomposition (preparation of insoluble sulphates)
    - by roasting of sulphides
  - General properties of metallic sulphates
    - action with water
    - action of heat
- Chemistry of metallic chlorides
  - General methods of preparation of metallic chlorides (hydrated)
    - by treating metals with hydrochloric acid
    - by treating the oxides, hydroxides, carbonates and sulphides of metals with hydrochloric acid
    - by double decomposition (preparation of insoluble chlorides)
    - by treating metals with aqua regia
  - General properties of metallic chlorides
    - action with water
    - action of heat

        - action with acid
- Chemistry of metallic nitrate
    - General methods of preparation of metallic nitrate
        - by treating metals with nitric acid
        - by treating the oxides, hydroxides and carbonates of metals with nitric acid
        - by double decomposition
    - General properties of metallic nitrate
        - action with water
        - action of heat

2.2 Alkali metals **[2 Hrs.]**

- Introduction
- Periodic position
- General characteristic properties of alkali metals (ref. physical and chemical properties)
    - Physical properties:
        - Physical appearance, size of atoms, melting and boiling point, oxidation state, metallic character and electronegativity
    - Chemical properties:
        - Action of air, action of water, action with hydrogen, action with halogen
- Sodium
    - Introduction
    - Physical Properties
    - Chemical properties:
        - action with air, water, hydrogen, hydrogen chloride, ammonia, chlorine, Sulphur, carbon dioxide
        - reducing action
    - uses

2.3 Alkaline earth metals **[2 Hrs.]**

- Introduction
- Periodic position
- General characteristic properties of Alkaline earth metals (ref. physical and chemical)
    - Physical properties:
        - Physical appearance, size of atoms, melting and boiling point, oxidation state, metallic character and electronegativity
    - Chemical properties:
        - Action with air, water, hydrogen, nitrogen, halogen, acids, non-metals
        - formation of alloys
- Distinguish between alkali and alkaline earth metals
- Calcium
    - Introduction
    - Physical Properties
    - Chemical properties:
        - action with oxygen, water, hydrogen chloride, sulphuric acid, hydrogen, nitrogen, chlorine, carbon
    - uses

2.4 Coinage metals **[2 Hrs.]**

- Introduction
- Periodic position

- General characteristic properties of coinage metals (ref. physical and chemical properties)
  - Physical properties:
    - Physical appearance, size of atoms, melting and boiling point, malleability, ductility, conductivity, variable valency
  - Chemical properties:
    - Action with air, water and acids
    - Action of salt solution with metals like Zn, Mg, and Fe
    - Formations of alloys
- Copper
  - Introduction
  - Physical properties
  - Chemical properties:
    - action with air, water, acids, ammonia, chlorine, Sulphur
    - reducing action
    - displacement reaction
  - uses

2.5 Aluminum [1 Hr.]

- Introduction
- Physical Properties
- Chemical properties:
  - action with air, water, Nitrogen, chlorine, carbon, Sulphur, acids, sodium hydroxide
- uses

2.6 Zinc [1 Hr.]

- Introduction
- Physical Properties
- Chemical properties:
  - action with oxygen (philosopher's wool), water, sodium hydroxide, acids, chlorine, Sulphur
  - displacement reaction
- uses

2.7 Iron [1 Hr.]

- Introduction
- Physical Properties
- Chemical properties:
  - action with air, water, chlorine, acids, Sulphur, carbon monoxide
  - displacement reaction
- uses

2.8 Lead [1 Hr.]

- Introduction
- Physical Properties
- Chemical properties:
  - action with air, water (plumbosolvency), acids, chlorine, Sulphur, sodium hydroxide, acetic acid
- uses

Unit3: Organic compounds and polymers [15 Hrs.]

3.1Organic compounds [5 Hrs.]

- Introduction
- vital force theory and downfall of vital force theory
- Classification of organic compounds
- Functional groups
- Homologous series
  - Definition
  - Characteristics of homologous series
- Nomenclature of organic compounds
- Concept of word root, suffix and prefix
- IUPAC naming of simple aliphatic compounds:
  - alkane, alkene, alkyne, halogen derivatives (monohalo only), alcohol, (monohydric alcohol only), ethers, aldehydes, ketones, carboxylic acid (mono carboxylic acid), nitroalkane, alkyl cyanides, alkyl isocyanides, amines
- writing the simple structural formula from the name of the compound (IUPAC)

3.2 Alkanes **[2 Hrs.]**

- Introduction
- Hydrocarbon
  - Aliphatic hydrocarbon
    - saturated and unsaturated hydrocarbon
  - aromatic hydrocarbon
- Methane
- Introduction
- Physical properties
- Chemical properties
  - halogenation, nitration, action with air and steam, pyrolysis
- uses

3.3 Alkene **[2 Hrs.]**

- Introduction

Ethylene

- Physical properties
- Chemical properties:
  - addition reaction
    - addition of hydrogen, halogens, hydrogen chloride, water, sulphuric acid,
    - ozonolysis
    - Markonikov's rule and peroxide effect
  - oxidation reaction
    - with alkaline $KMnO_4$, with acidified $KMnO_4$, oxidation by air
  - polymerization
- uses

3.4 Alkyne **[2 Hrs.]**

- Introduction
- Acetylene
- Physical properties
- Chemical properties:
  - Addition reaction
    - addition of hydrogen, halogens, halogens acid water, sulphuric
    - acid, hydrogen cyanides, acetic acid
    - Ozonolysis
  - Substitution reaction

        - action with sodium, ammoniacal silver nitrate, ammoniacal cuprous chloride
    - Oxidation reaction
        - with alkaline KMnO4, with chromic acid, oxidation by air
    - Polymerization
- uses

3.5 Benzene **[3 Hrs.]**

- Introduction
- Distinguish between aliphatic and aromatic compounds
- Aromaticity
- Huckel rule
- Physical properties of benzene
- Chemical properties of benzene:
    - Substitution reaction
        - Halogenations, nitration, Sulphonation, Friedel craft reaction
    - Addition reaction
        - Addition of hydrogen halogens and ozone
    - Oxidation reaction
        - action with air and combustions
- uses

3.6 Polymers **[1Hr]**

- Introduction
- Polymers and polymerization
- Classification of polymer:
    - natural polymer
    - synthetic polymer
- Polythene
    - preparation and uses
- Polyvinyl chloride
    - preparation and uses
- Rubber
    - preparation and uses of natural rubber (ref. isoprene unit) and synthetic rubber (ref. Neoprene rubber)

Tutorial

Unit 1: **[14hrs]**

Practice on causes, types and method of removal of hardness of water, Lab preparation of ammonia, chlorine, hydrogen chloride, hydrogen sulphide, Manufacture of ammonia, nitric acid and sulphuric acid, nitrogen cycle and chemical fertilizers, oxides of nitrogen and Sulphur as pollutant and acid rain, chemical properties of ammonia, nitric acid, chlorine, hydrogen chloride, hydrogen sulphide and sulphuric acid, allotropes of carbon, structure and properties of Diamond.

Unit 2: **[9 Hrs.]**

Practice on difference metals and non-metals, preparation and properties of metallic carbonate, chlorides, sulphate and nitrates, types and purpose of making of alloys, general characteristics of alkali metals, alkaline earth metals and coinage metals, chemical properties of different metals like sodium, calcium, aluminium, copper, Zinc, iron and lead

Unit 3: **[7 Hrs.]**

Practice on homologues series, functional group, IUPAC naming of simple aliphatic compounds, saturated and unsaturated hydrocarbon, chemical properties of methane, alkene,

alkyne and benzene, Huckel's rule, homopolymers and copolymers, preparation and uses of polyethene, polyvinyl chloride and rubber.

Engineering Chemistry Practical II: **[30 Hrs.]**

1. Prepare and study the properties of hydrogen gas. [2hrs]
2. Prepare and study the properties of ammonia gas. [2hrs]
3. Prepare and study the properties of hydrogen Sulphide gas. (This gas should not be prepare individually in woulf bottle but in Kipp's apparatus commonly) [2hrs]
4. Detect the acid radicals (Cl^-, NO_3^{--}, SO_4^{---}, CO_3^{--}) by dry and wet ways. (4hrs)
5. Detect the basic radicals (Cu^{++}, Al^{+++}, Fe^{+++}, Zn^{++}, CO^{++}, Ni^{++}, Ca^{++}, Ba^{++}, Mg^{++}) by wet ways. [6hrs]
6. Detect the acid and basic radicals (complete salt analysis). [6hrs]
7. Investigate the action of acids on some metals (Zn, Mg, Fe, Al, Sn& Cu) (acids: HCl, H_2SO_4(dil.) & HNO_3 (dil.) [2hrs]
8. Compare the hardness of different types of water. [2hrs]
9. Prepare Bakelite (resin) in the laboratory. [2hrs]
10. Determine the condition in which corrosion takes place. [2hrs]

References Books:

1. Foundations of chemistry, Vol-2, M.K. Sthapit and R.R. Pradhananga, Taleju prakashan, Kathmandu
2. A Text book of Engineering Chemistry-vol II, Prakash Paudel, Siddthartha publication, Kathmandu
3. Engineering Chemistry, M.L. Sharma, K.M. Shrestha, P.N. Choudhary, Ekta Book,
4. A Text book of Chemistry, Jha and Guglani, surya publication, India
5. Elementary qualitative analysis, M.K. Sthapit and C.B. Tuladhar, Taleju Prakashan
6. Elementary practical chemistry, MK. Sthapit, Taleju Prakashan
7. Practical engineering chemistry for diploma level, Sumitri Bajracharya, Sabina Shrestha, Kathmandu institute of technology.

Other learning materials:

1. Other references to be selected by the related lecturer(s) from among the texts available in the market that meet the content needs of this subject.
2. The related institute may develop its own textbook and approve from the related authority so as to have a prescribed as a textbook of this subject.

Evaluation Scheme

There will be questions covering all the chapters in the syllabus. The evaluation scheme for the questions will be as indicated as in the table below.

Units	Chapter	Hours	Marks distribution
1	Water	5	4
	Ammonia	4	4
	Nitric acid	8	8
	Halogens (Chlorine),	3	4
	Hydrochloric acid, Hydrogen sulphide	4	4
	Sulphuric acid, Carbon and its compound	7	8
2	General study of metals and their components: Alloys	5	4
	Alkali metals, sodium, Aluminium	3	4
	Alkaline earth metals, calcium, Zinc	3	4
	Coinage metals, copper, Iron, lead	4	4
3	Organic compounds, alkane	6	4
	Alkene, Alkyne	4	4
	Benzene, polymer	4	4
	Total	**60**	**60**