JECRC Foundation

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem. – B. Tech I year, Sem.-I
Subject –Engineering Chemistry
Unit – II
Presented by – Dr. Seema Joshi
Designation - Professor
Department - Chemistry

VISION OF INSTITUTE

To become a renowned centre of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

MISSION OF INSTITUTE

❖**Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.**

❖**Identify, based on informed perception of Indian, regional and global needs, the areas of focus and provide platform to gain knowledge and solutions.**

❖**Offer opportunities for interaction between academia and industry.**

❖**Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders may emerge.**

Engineering Chemistry: Course Outcomes

Students will be able to:

CO1: Explain the impurities of water (mainly hardness) and boiler troubles.

CO2: Describe processing technologies of fuel with numerical aspects of combustion of fuel.

CO3: Describe the engineering material (cement, glass and lubricant) with respect to their manufacturing, composition, classification & properties.

CO4: Explain corrosion with its controlling measures, organic reaction mechanism and synthesis of drugs (Aspirin & Paracetamol) with their properties and uses.

JECRC
Department of Applied Sciences
Lecture Plan (Session- 2020-2021)

Course Name: Engineering Chemistry **Year/Semester: 1st Year/ Semester- I**

Course code: 1FY2-03 **No. of Lecture Req. /(Avl.): /(40/44)**

Semester starting: 21 Sept. 2020 **Semester Ending: 24 Dec. 2020**

Unit No./ Total Lect. Req.	Topics	Lect. No.	Date of Delivery	Book Referred	Pg. No.
Unit-I 10	Introduction to syllabus, Common natural impurities, hardness, Degree of hardness,	1		Engg. Chemistry (New Age International)	2-12
	Units of hardness, Determination of hardness by complexometric (EDTA method).	2		Engg. Chemistry (Jain & Jain)	
	Municipal water supply, Requisite of drinking water, purification of water, Sedimentation,	3			
	Filtration, disinfection, Breakpoint chlorination.	4			
	Boiler troubles: Scale and Sludge formation, Internal treatment Methods	5			
	Priming and Foaming, Boiler corrosion and caustic embrittlement	6			
	Water softening: Lime-Soda process	7			
	Water softening: Zeolite (Permutit) process, Demineralization process.	8			
	Numerical problems based on Hardness, EDTA,	9			
	Numerical problems based on Lime-Soda and Zeolite process.	10			

Unit-II 10	**2.Organic Fuels: Solids fuels: Coal, Classification of Coal, Proximate analysis of coal and its significance**	**11**		**Engg. Chemistry (Jain & Jain)**	**116-117**
	Ultimate analysis of coal and its significance,	12		Engg. Chemistry (Jain & Jain)	117-118
	Gross and Net Calorific value, Determination of Calorific value of coal by Bomb Calorimeter.	13			
	Metallurgical coke, Carbonization processes; Otto-Hoffmann byproduct oven method.	14			
	Liquid fuels : Advantages of liquid fuels, Mining, Refining and Composition of petroleum, Cracking	15			
	Synthetic petrol, Reforming, Knocking, Octane number, Anti-knocking agents, Cetane number	16			
	Gaseous fuels; Advantages, manufacturing, composition and Calorific value of coal gas and oil gas	17			
	Determination of calorific value of gaseous fuels by Junker's calorimeter, Numerical problems based on Junkers calorimeter	18			
	Numerical problems based on determination of calorific value bomb calorimeter, /Dulongs formula, proximate & ultimate Analysis.	19			
	Numerical problems based on combustion of fuel.	20			

Unit-III 3	**3.Corrosion and its control: Definition and significance of corrosion, Mechanism of chemical (dry) corrosion**	**21**			
	Mechanism of electrochemical (wet) corrosion, galvanic corrosion, concentration corrosion and pitting corrosion.	22			
	Protection from corrosion; protective coatings- galvanization and tinning, cathodic protection, sacrificial anode and modifications in design.	23			

Unit-IV 10	**4.Engineering Materials: Portland Cement; Definition, Manufacturing by Rotary kiln.**	**24**			
	Chemistry of setting and hardening of cement. Role of Gypsum.	25			
	Glass: Definition, Manufacturing by tank furnace, significance of Annealing	26			
	Types and properties of soft glass, hard glass	27			
	Borosilicate glass, glass wool, safety glass.	28			
	Lubricants: Classification	29			
	Lubricants: Mechanism	30			
	Properties; Viscosity and viscosity index	31			
	Flash and fire point, cloud and pour point.	32			
	Emulsification and steam emulsion number.	33			

Unit-V 7	**5. Organic reaction mechanism and introduction of drugs: Organic reaction mechanism: Substitution; SN1, SN2.**	**34**			
	Electrophilic aromatic substitution in benzene, free radical halogenations of alkanes,	35			
	Elimination: elimination in alkyl halides, dehydration of alcohols,	36			
	Addition: electrophilic and free radical addition in alkenes, nucleophilic addition in aldehyde and ketones	37			
	Rearrangement: Carbocation and free radical rearrangements	38			
	Drugs : Introduction, Synthesis, properties and uses of Aspirin	39			
	Drugs : Introduction, Synthesis, properties and uses of Paracetamol, Revision	40			

Lecture-12(Unit-II) Ultimate analysis of coal and its significance

CONTENTS:

- Introduction,
- Determination of Carbon and Hydrogen
- Determination of nitrogen
- Determination of Sulphur
- Determination of ash
- Determination of oxygen

Introduction

The ultimate analysis determines all coal component elements, solid or gaseous and it needs properly equipped laboratory with skilled chemists. It is useful in determining the quantity of air required for combustion and the volume and composition of the combustion gases.

Introduction

This is an elemental analysis of coal. It involves the determination of percentage of carbon, hydrogen, oxygen, sulphur, nitrogen and ash in the coal. Each element is estimated separately as follows

- Determination of Carbon and Hydrogen
- Determination of nitrogen
- Determination of Sulphur
- Determination of ash
- Determination of oxygen

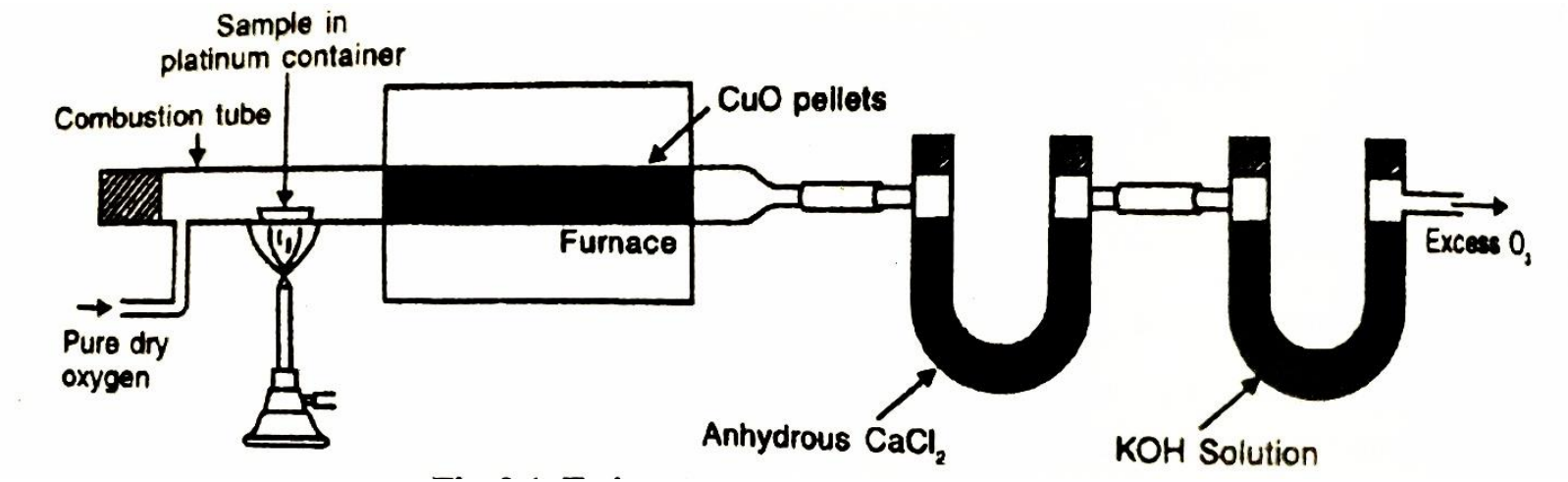
Determination of C & H

A known weight of coal sample is burnt in a stream of pure and dry oxygen in combustion apparatus. C&H present in the sample is converted into CO2 and H2O respectively. The products obtained from the combustion are then passed through two bulbs which are already weighed.

Determination of C & H

One of the bulb is containing anhydrous calcium chloride and second bulb is contains KOH. CO_2 and H_2O are absorbed in KOH and $CaCl_2$ tubes of known weight respectively. Increased weight of KOH and $CaCl_2$ gives the amount of CO_2 and H_2O formed as a result of combustion.

Determination of Carbon and Hydrogen



Determination of Carbon and Hydrogen

- Amount of hydrogen and carbon can be estimated as follows

(a) $C + O_2 \rightarrow CO_2$

$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$

$$\% \text{ of } C = \frac{\text{Increase in weight of KOH tube} \times 100 \times 12}{\text{Weight of coal sample taken} \times 44}$$

(b) $2H_2 + O_2 \longrightarrow 2H_2O$

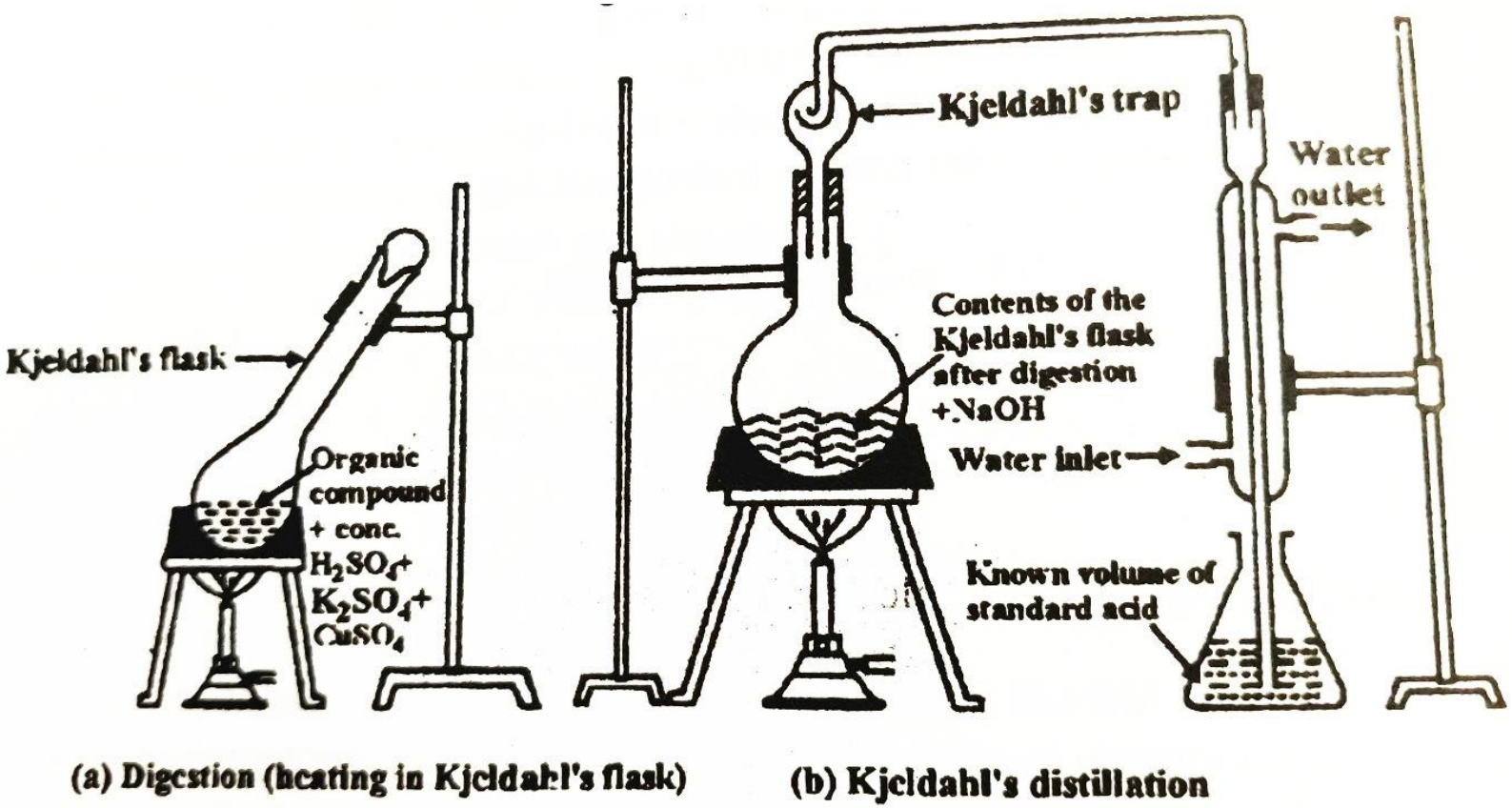
$CaCl_2 + H_2O \longrightarrow CaCl_2.7H_2O$

$$\% \text{ of } H = \frac{\text{Increase in weight of CaCl2 tube} \times 2 \times 100}{\text{Weight of coal sample taken} \times 18}$$

Determination of Nitrogen

A known weight of coal sample is heated with concentrated H_2SO_4, K_2SO_4 & $CuSO_4$ in a special long necked flask known as kjeldahl's flask. When the solution becomes clear it is transferred in a distillation flask and treated with excess of NaOH. The liberated ammonia is distilled over and absorbed in a known volume of the standard acid solution.The amount of unused acid is determined by back titration with standard NaOH solution and the % of Nitrogen is calculated.

Determination of Nitrogen



(a) Digestion (heating in Kjeldahl's flask) (b) Kjeldahl's distillation

Determination of Nitrogen

In kjeldahl's flask

Nitrogen in coal+H_2SO_4 $\longrightarrow$ $(NH_4)_2SO_4$

In distillation flask

$(NH4)_2SO_4$ + 2 NaOH $\longrightarrow$ $Na_2SO_4 + 2NH_3 + 2H_2O$

In conical flask

$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$

Determination of Nitrogen

The percentage of ammonia is calculated as follows:

Observations:

Weight of coal sample taken = W g

Volume of standard acid solution of N_1 Normality = V ml.

Volume of standard alkali solution of N_1 normality required for titration of excess acid (unused)=v ml

Both acid and alkali are in same normality (N_1) and neutralize in equivalent amounts.

Determination of Nitrogen

Calculations

Volume of acid solution of normality N_1 used for neutralizing ammonia = (V-v) ml

Or X ml of N_1 acid solution = X ml of N_1 NH3 Solution

And according to the definition of normal solution

1000 ml of 1N NH_3 solution= 17 g of NH_3 =14 g of nitrogen

Hence

$$\text{X ml of } N_1 \text{ } NH_3 \text{ solution} = \frac{14 \times X \times N1}{1000} \text{ g of Nitrogen}$$

Determination of Nitrogen

Calculations

$$\% \text{ of Nitrogen} = \frac{14 \times X \times N1 \times 100}{1000 \times W} -$$

$$\text{Or } \% \text{ of Nitrogen} = \frac{1.4 \times X \times N1}{W}$$

$$\% \text{ of Nitrogen} = \frac{1.4 \times \text{volume of acid consumed} \times \text{Normality of acid}}{\text{weight of coal sample taken}}$$

Determination of sulphur:

It is determined from the washings obtained from the known weight of coal sample; used in a bomb calorimeter for the determination of calorific value. During this determination, sulphur is converted into sulphate. The washings are heated with barium chloride solution and barium sulphate (BaSO4) is precipitated. The precipitate is filtered, washed and dried to constant weight.

$$S + O_2 \rightarrow SO_2$$

$$SO_2 + 1/2\ O_2 \rightarrow SO_3$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

$$H2SO4 + BaCl2 \rightarrow BaSO4\downarrow + 2HCl$$

Determination of sulphur:

$$\% \text{ of sulphur} = \frac{\text{Weight of barium sulphate obtained} \times 32 \times 100}{\text{Weight of coal sample taken} \times 233}$$

Determination of Ash

It is carried out by heating a known weight of coal sample in a crucible and weighing the residue (that is ash). It is determined same as in proximate analysis.

Determination of oxygen

It is obtained as below

% of oxygen = 100 – [% C +% H+% N+% S +%ash]

Significance of ultimate analysis

Each constituent element has its own importance.

- Carbon and hydrogen: - If percentage of carbon and hydrogen available for combustion increases, the quality of coal also improved, as its calorific value also increases.
- Nitrogen: - Nitrogen has no calorific value so it is undesirable. So nitrogen content should be low for a good coal.

Significance of ultimate analysis

- Sulphur: - Sulphur contributes heating value to coal but at the same time it produces Sulphur dioxide which causes atmospheric pollution and also corrodes equipments. So sulphur is undesirable in coal.
- Oxygen:-oxygen content decreases the calorific value because it is present in the form of moisture and volatile matter. So it is also undesirable in coal.
- Ash: - Ash is useless non combustible matter and reduces the calorific value of coal hence lesser amount of ash will improve the ranking of coal.

Question Bank

Q1.What do you mean by fuel?

Q2.Write down all the reactions involved in combustion of fuel.

Q3. How many types of fuels are there ?

Q4. What are the units of calorific value?.

Q5. How many types of coal are there?

Q6.Write down all the reactions involved in combustion of fuel.

Q7.Write down all the formulae of proximate analysis in proper sequence.

Q8. Write down all the reactions of Kjeldahl's analysis

Q9.Write down reactions and formula for estimation of sulphur in fuel analysis

Q10.Write down reactions and formula involved in estimation of carbon and hydrogen in fuel.

Practice Questions

1.The calorific value of solid or non volatile liquid fuel can be determined by:
(a)Gas calorimeter (b) Bomb calorimeter
(c) Calorimeter (d) By one
2.Ash content of the fuel should be as low as possible, because it is:
(a)Useful (b) Useless
(c) Increase combustion (d) No effect
3.The amount of volatile matter determined mainly depends on:
(a) Pressure (b) Volume
(c) Temperature (d) None
4.Proximate analysis play an important role in assessing:
(a) Quantity of coal (b) Analysis of coal
(c) Quality of coal (d) Grading of coal
5.A fuel have high calorific value, means it should produce:
(a) Large amount of heat (b) less amount of heat
(c) Medium amount of heat (d) No heat
6.Estimation of nitrogen is carried out in:
(a) Round bottom flask (b) Flat bottom flask
(c) Conical flask (d) Kjeldahl's flask
7.During nitrogen estimation by kjeldahl's method, nitrogen present in coal gets converted to:
(a) Ammonium Sulphate (b) Ammonium Nitrate
(c) Ammonium chloride (d) Ammonia
8.In ultimate analysis, sulphur is estimated by the washings of:
(a) Bomb calorimeter (b) Junkers calorimeter
(c) Calorimeter (d) Orsats apparatus
9.To estimate sulphur the washings of Bomb calorimeter are treated with:
(a) $BaCl_2$ (b) $CaCl_2$
(c) NaCl (d) KCl

Suggested links from NPTEL & other Platforms:

- https://nptel.ac.in/content/storage2/courses/101104014/pdf_lecture/lecture3.pdf
- https://nptel.ac.in/content/storage2/courses/113104058/mme_pdf/Lecture2.pdf
- https://nptel.ac.in/content/storage2/courses/113104058/mme_pdf/Lecture3.pdf

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