Sinhgad Institutes

Sinhgad Technical Education Society's

Sinhgad College of Engineering, Pune 41.

First Year Engineering

Subject: Engineering Chemistry

Unit 4: Fuels

Notes (Questions and Answers)

Q. 1 Define Gross and Net Calorific Value and Justify the relationship between GCV and NCV of the fuel. 3M *(Definition-1M each, Justification-1M)*

Ans:

1. **Gross calorific value (GCV):** It is defined as the total amount of heat obtained on complete combustion of unit mass of solid or liquid fuel or unit volume of a gaseous fuel (STP) on cooling the products of combustion to 15^0c.

The GCV is called as Higher calorific value.

2. Net Calorific value (NCV): It is the amount of heat obtained practically on the on complete combustion of unit mass of solid or liquid fuel or unit volume of a gaseous fuel (STP) and the products of combustion are allowed to escape with some heat.

NCV is also called as Lower calorific value.

<u>Relation between GCV and NCV</u>

NCV and GCV are related as

$$\mathrm{G.C.V} = N.C.V + \frac{9\ X\ H\ X\ Latent\ heat\ of\ water}{100}$$

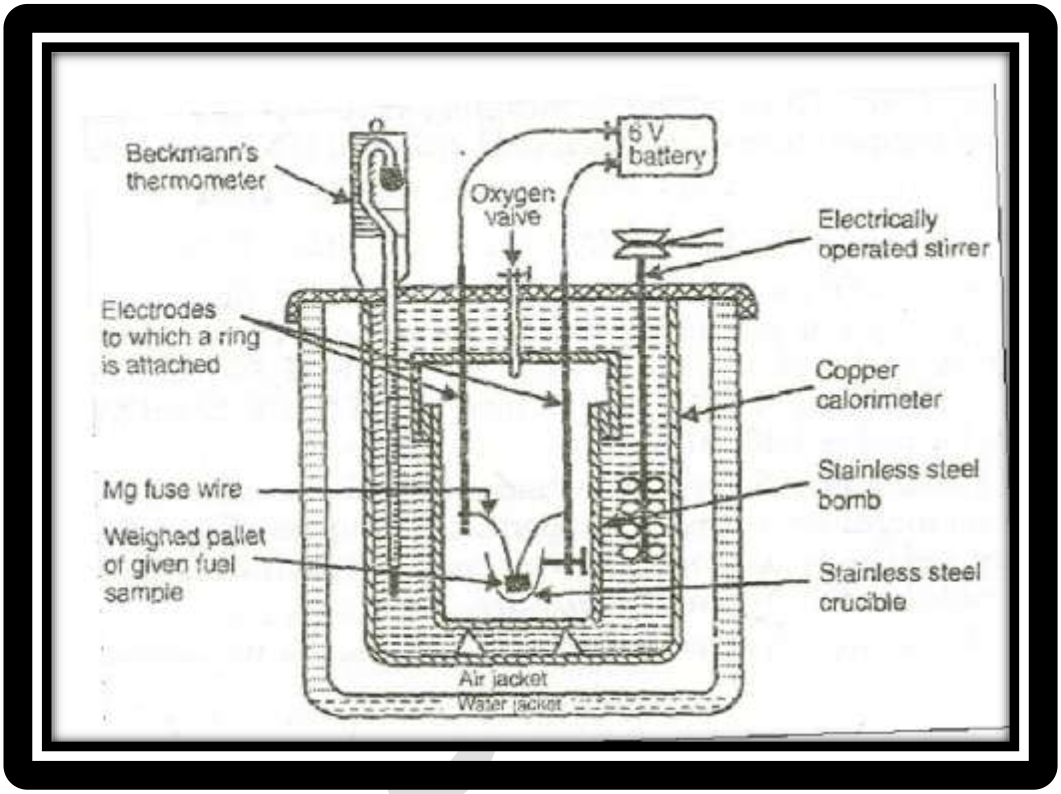
Where

H = Percentage of hydrogen in fuel.

Q. 2 Draw neat labeled diagram of Bomb calorimeter. Give the formula to calculate GCV with and without corrections. 4M *(Diagram-2M, Formula without correction-1M, formula with correction-1M)*

Ans:

Diagram of Bomb Calorimeter



Formula of G.C.V. without corrections:

$G.C.V. = \frac{(W+w)(t2-t1)}{X}$ cal/gm or Kcal/kg

Formula with corrections:

$G.C.V. = \frac{(W+w)(t2-t1+t.dt)-(a+f)}{X}$ cal/gm or Kcal/kg

Where W=mass of water in calorimeter

w = Water equivalent of calorimeter set

(t_2-t_1) = rise in temperature

X = mass of fuel

t.dt = cooling correction

f = fuse wire correction

a = Acid correction

Q. 3 Explain the corrections required in the GCV of Bomb Calorimeter. 3M *(Correction- 1 M each)*

Ans: To get more accurate results, the following corrections should be considered.

i) Fuse wire correction
ii) Acid correction
iii) Cooling correction

i) **Fuse wire correction (f)**: Out of the total heat obtained, little heat is given out by fuse wire when the current is passed for 5-10 sec to start the combustion. Hence **Fuse wire correction must be subtracted.**

ii) **Acid correction (a)**: The S and N in the fuel are oxidized to H2SO4 and HNO3. Formation of H_2SO_4 and HNO_3 are exothermic reaction and the heat measured includes a small share by these acid formation.

$$S + O_2 \rightarrow SO_2 \xrightarrow{O_2} SO_3 \xrightarrow{H_2O} H_2SO_4 \quad \Delta H = -144 \text{ kcal/mol}$$

$$N + O_2 \rightarrow NO_2 \xrightarrow{O_2, H_2O} HNO_3 \quad \Delta H = -57 \text{ kcal/mol}$$

Acid correction must be subtracted.

iii) **Cooling correction (tc):** If the time taken for water in calorimeter to cool from maximum temperature attained to the room temperature is 't' minutes and average cooling rate is dt/min, then the cooling correction to be added to rise in temperature is t.dt.
The actual rise in temperature would have been (t2-t1+ t.dt), had the heat liberated been absorbed by water and calorimeter rapidly and there would have no loss of heat from the set by radiation. **Cooling correction must be added**.

Therefore the accurate formula of GCV is,

$$G.C.V. = \frac{(W+w)(t2-t1+t.dt)-(a+f)}{X} \text{ cal/gm or Kcal/kg}$$

Q. 4 How calorific value of gaseous fuel is determines by using Boy's calorimeter. 4M
(Diagram-1M, Construction-1M, working-1m, Formula-1M)

Ans:

Principle:

A gaseous fuel is burnt at a known constant rate in the calorimeter, so that total amount of heat produced is absorbed by circulating water. From the rise in temperature of water calorific value can be calculated.

Construction:

It consists of following parts

1. **Gas burner**: There is a gas burner in which known volume of gas is burnt at a known pressure. The gas is burnt at the rate of 3-4 litre per minute.

2. **Combustion chamber**: Around the burner there is a combustion chamber which has a copper tubing coiled inside as well as outside of it. Water enters from the top of the outer coil, moves to bottom of chimney and then goes up through the inner coil to the exit at top.

3. **Thermometers:** There are two thermometers to measure temperatures of inlet water and outlet water.

4. **Insulating cover:** The assembly is covered with an insulator to detach combustion chamber from atmosphere. There is a hole on top for exhaust gas, water inlet and condensed steam comes out from bottom outlet.

Diagram:

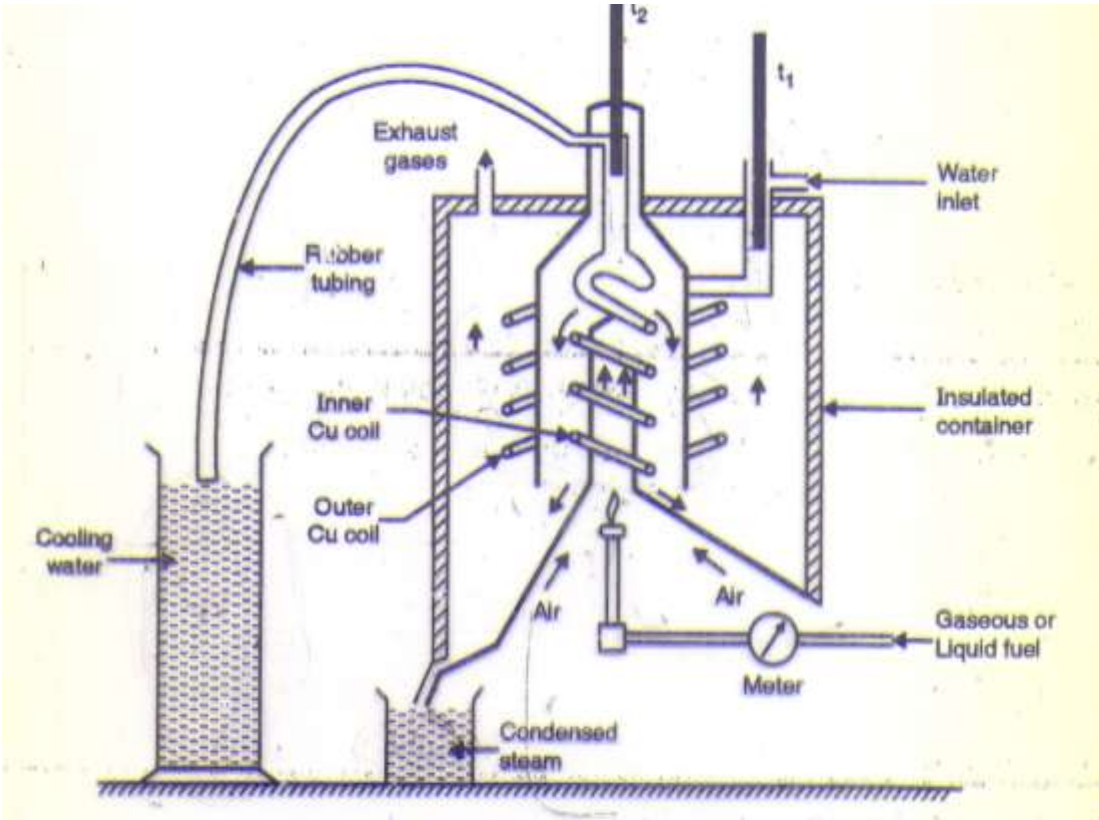


Fig. 1.2 : Boy's gas calorimeter

Working:

1. Burn the gas at suitable pressure & adjust the rate of flow such that the temp, of outgoing water remains constant.
2. After steady conditions note down the following observations

Observations:

(a) Volume of gas burnt at given temp, & pressure in certain time period = V m^3

(b) Quantity of water passed through coil during this period = W

(c) Mass of water condensed from product gas during the period = m kg

(d) Rise in temp of water $(t_2 – t_1)$

(e) GCV of the fuel = L Kcal/m^3

Calculations:

Heat liberated by burning of fuel = Heat absorbed by circulating water

$$VL = W(t_2 - t_1)$$

$$G.C.V.\ (L) = \frac{W(t2-t1)}{V}\ \text{Kcal/m}^3$$

$$N.C.V.\ (L) = \frac{W(t2-t1)}{V} - \frac{m\ X\ 587}{V}\ \text{Kcal/m}^3$$

Where m/v = mass of steam condensed per $m^3$of gas

Q.5 What is proximate analysis? Mention the principle involved in the analysis of each of these constituents. Give the significance. 7M *(Definition-1M, 4 principles-1M each, significances-2M)*

OR

Q.6 What is the proximate analysis? Give methods and formulae for the proximate analysis. *(Definition-1M, Method ½ M each, Formula-1M each)*

(Note: Student should attempt according to the structure of the question)

Ans:

Proximate Analysis: The analysis in which % of Moisture**, Volatile Matter, Ash & Fixed carbon of fuel** can be determined is called as Proximate analysis.

1. **% of Moisture**
   Principle:
   All moisture in coal escapes on heating coal at 110^0c for 1 hour.

   Method: A known weight of powdered and air dried coal sample is taken in a crucible and it is placed in an oven for 1 hr at 110^0c. Then the coal is cooled in a desiccator and weighed out. If the initial weight of the coal is m gms and final weight is m_1 gms . The loss in weight ($m-m_1$) corresponds to moisture in coal.

   Formula:

$$Moisture\ \% = \frac{Weight\ of\ moisture}{Weight\ of\ coal} X\ 100$$

$$= \frac{m - \text{m1}}{m} X\ 100$$

   Significance:

   a. Decrease in calorific value of coal largely as it does not burn and takes away heat in the form of latent heat.
   b. It increases the ignition point of coal.
      Hence a coal with lower moisture % is better quality.

2. % of Volatile matter

Principle:
At 925^0c, coal molecules undergo thermal degradation to produce volatile matter.

Method: Moisture free coal left in the crucible in first experiment (m_1) is covered with a lid loosely. Then it is heated at 925^0c for 7 minutes. The crucible is taken out and cooled in a desiccator. The it is weighed (m_2) gms. The loss in weight (m_1- m_2) gms is due to the loss in volatile matter in the m gms of the coal.

Formula:

$$Volatile\ matter\ \% = \frac{Weight\ of\ V.M}{Weight\ of\ coal} X\ 100$$

$$= \frac{m1 - m2}{m} X\ 100$$

Significance:

a. It decreases calorific value of coal.
b. It elongates flame and decreases flame temperature.
c. It forms smoke and pollutes air.
Overall regarding burning of coal, the coal with lesser V.M. is better quality of coal.

3. % Ash
Principle:
Inorganic matter in the coal gets oxidized to form metal oxides and silica, which is non-combustible and left as ash.

Method: The residual coal in the above experiments is heated and burnt in an open crucible at above 750^0c for half an hour. The coal gets burnt. The ash left in crucible is cooled in desiccator and weighed (m_3 gms).

Formula:

$$Ash\ \% = \frac{Weight\ of\ Ash}{Weight\ of\ coal} X\ 100$$

$$= \frac{m3}{m} X\ 100$$

Significance:
a. Ash reduces the calorific value of coal as ash is non-burning part in coal.
b. Ash disposal is a problem.

c. Ash fuses to form clinker at high temperature, obstructing the air supply to coal burning in furnace.
Hence, lesser the ash %, better is the quality of coal.

4. % fixed carbon

Principle: This is the actual amount of carbon available for combustion, after loss of some carbon in the form of volatile matter.

Formula:

Fixed Carbon = 100 - (% Moisture + % Volatile matter + % Ash)

Significance:

a. Carbon is the burning part in coal and higher the FC%, higher the calorific value. Hence a good quality of coal.

Q.6 Explain in brief the process with diagram for distillation of crude petroleum. Give composition, boiling range and uses of two fractions obtained. 7M *(Diagram-1M, process-1M, Composition-1M each, Boiling Range-1M each, uses of fractions-1/2 M each)*

Ans:

Definition:

The process in which crude oil is separated into various useful fractions by distillation, depending upon their boiling points in a refining tower is known as refining or fractional distillation of crude oil.

Principle:

The fractions of the petroleum are separated on the basis of physical constant i.e Boiling point.

Process:

Petroleum refining involves three steps:

1. Removal of water

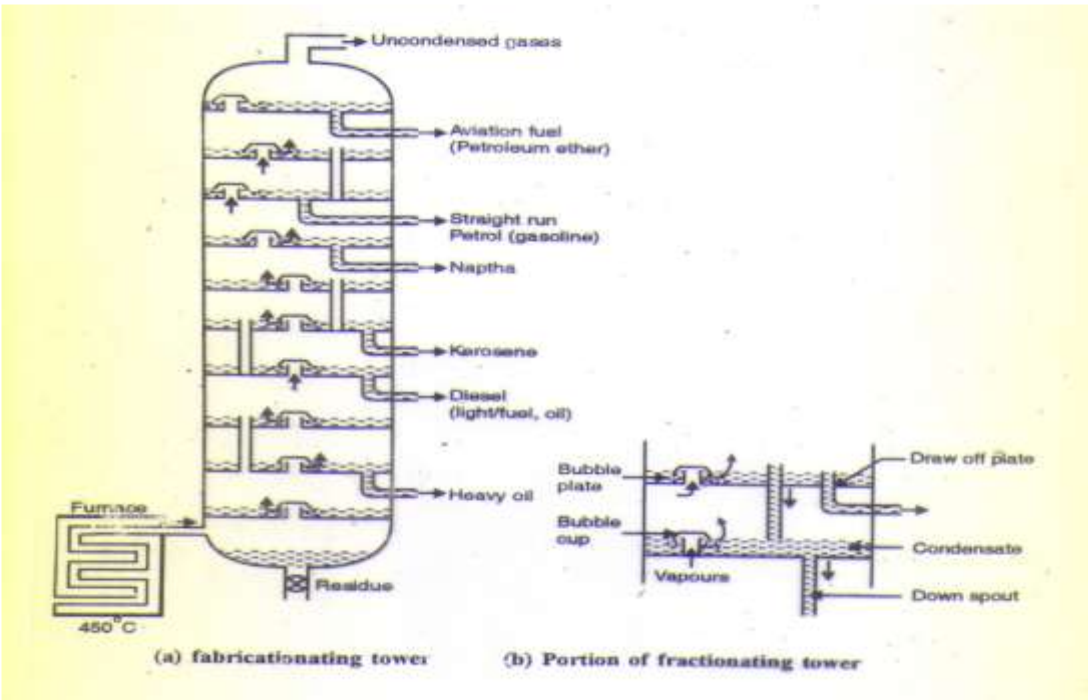
2. Removal of Sulphur

3. Fractional distillation

Working:

1. The crude oil is heated to about 450^{0}C in furnace to form vapors of crude oil, which enter into the fractionating tower from the bottom.
2. Those fractions having high vapour pressure i.e. less boiling point exert more pressure on cup and get condensed at the upper part of tower.
3. While those fractions having less vapour pressure i.e. High boiling points, exert a less pressure on cap and condensed at the bottom of tower and hence fractional distillation takes place in trays at different heights of column.

Diagram:



Petroleum Fractions:

Sr. no.	Name of fraction	Boiling range	Composition of hydrocarbon	Uses
1.	Uncondensed gases	Below 40^{0}c	C1-C4	Domestic and industrial fuel under the name 'LPG'.
2.	Aviation fuel or petroleum ether	400-700c	C5-C7	Fuel for aero plane, helicopters as a solvent

3	Petrol or gasoline	600c-1200c	C5-C8	For the petrol engines, dry cleaning, as solvent
4.	Naphtha or solvent spirit	120-1800c	C7-C10	As a solvent and for dry cleaning, for chemicals

Q.7 What is Power alcohol? Give the manufacturing process with any two merits and demerits of power alcohol. 5M *(Definition-1M, Process-2M, Merits-1M, demerits-1M)*

Ans: Power alcohol: "When ethyl alcohol is used as fuel in internal combustion engine for generation of power is called power alcohol."

Pure ethyl alcohol cannot be used as fuel.

Generally, ethyl alcohol is used as its 5-25% mixture with petrol.

Process: ethyl alcohol is manufactured by fermentation of molasses, starch, carbohydrates on a large scale and cheaply.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Invertase (yeast)}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C6H12\ O6}$$

$$\underset{\text{Glucose/Fructose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} \underset{\text{Ethyl aclcohol}}{2\ C_2H_5OH} + 2CO_2$$

Merits/Advantages of Power Alcohol:

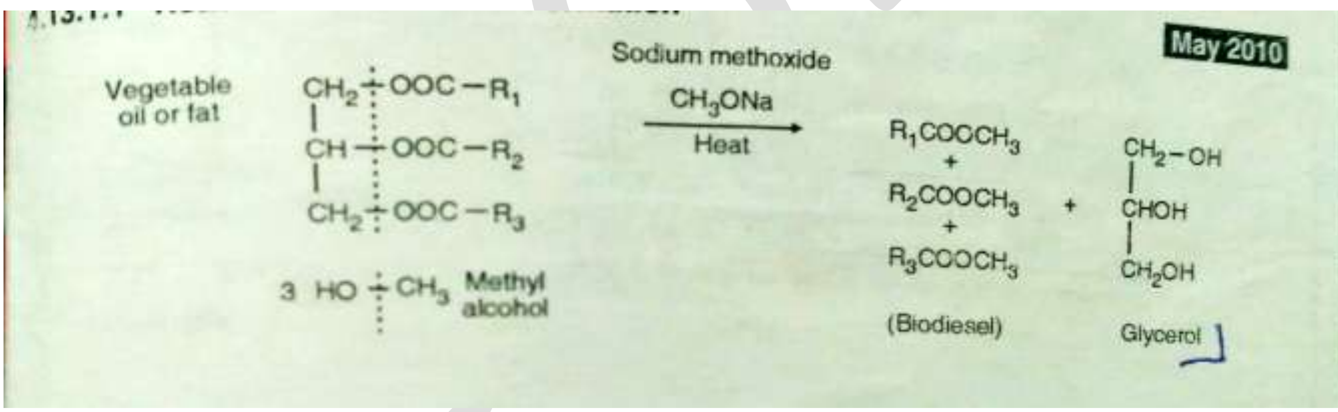
1. It has good antiknocking property and its octane number is 90, while the octane number of petrol is 65. Therefore addition of ethyl alcohol to petrol increases the octane number.
2. Alcohol has property of absorbing any traces of water if present of petrol.
3. Ethyl alcohol contains oxygen atoms which help for complete combustion of power alcohol and polluting emissions of CO, hydrocarbon, particulates are reduced largely.
4. Use of ethyl alcohol in petrol reduces our dependence on foreign countries for petrol and saves foreign currency considerably.
5. Power alcohol is cheaper than petrol.

Disadvantages / Demerits of Power Alcohol

- Ethyl alcohol has C.V. 7000 cal/gm much lower than C.V. of Petrol 11500 cal/gm.
- Ethyl Alcohol has high surface tension and atomization, especially at lower temperature is difficult causing starting trouble.
- Ethyl alcohol undergo oxidation to form acetic acid which corrodes engine parts.
- Ethyl alcohol obtained by fermentation process directly cannot be mixed with petrol. It has to be dehydrated first.
- As the Ethyl alcohol contains 'O' atoms, the amount of air required for the complete combustion of power alcohol is lesser and therefore carburetor and engine needs to be adjusted or modified, when only ethyl alcohol is used as a fuel.

Q.8. Write chemical reactions for production of Biodiesel and give its advantages. 3M
(Chemical reaction-1M, advantages-2M)

Ans: **Chemical reaction of Biodiesel**



Advantages:

1. Biodiesel is cheaper as it is manufactured from cheap, nonedible or waste oil or animal fats.
2. Biodiesel can be used as a good and clean fuel for diesel engines.
3. It has high cetane number 46 to 54 and high CV about 40 KJ/gm.
4. It is regenerative and environmental friendly.
5. It does not give out particulate and COx pollutants.
6. It has certain lubricity due to higher oiliness of the esters.

7. It provides good market to vegetable oils and reduce our dependence on diesel on foreign countries, saving currency.

Q.9 What is Ultimate analysis? Give the significance of each constituent. 7M *(Definition-1M, Significance of six constituents-1M each)*

Ans: Ultimate Analysis:

The analysis in which % of **C, H, N, S, & O from the coal** can be determined is called Ultimate analysis.

1. **Carbon** :

   Significance: Greater the % of carbon in coal, better is the quality and calorific value.

2. **Hydrogen** :

   Significance: Most of the hydrogen in coal is in the form of moisture and volatile matter. Only a small percentage of hydrogen is combustible. Hence it decrease C.V. of coal. Smaller the H% better is the coal quality.

3. **Nitrogen** :

   Significance: Nitrogen does not burn during coal combustion and therefore it has no calorific value. Hence a good quality coal contains negligible N%.

4. **Sulphur:**

   Significance
   : Although sulphur can burn and increases the Calorific value of coal but it causes Sox pollution and causes acid rain, corrosion of metallic equipment. Hence, lower the % of S in coal, better will be the quality.

5. **Oxygen** :

   Significance
   : Most of the Oxygen in coal is in the form of moisture. It decreases Calorific value of coal (1% oxygen in coal decreases calorific value by 1.7%). Hence, lower the % of O, better is the quality of coal.

6. **Ash** :

   Significance:
   a. Ash reduces the calorific value of coal as ash is non-burning part in coal.
   b. Ash disposal is a problem.

c. Ash fuses to form clinker at high temperature, obstructing the air supply to coal burning in furnace.
Hence, lesser the ash %, better is the quality of coal.

Q.10 What is Power alcohol? Give any two merits and demerits of power alcohol. 3M *(Definition-1M, Merits-1M, demerits-1M)*

Ans: Power alcohol: "When ethyl alcohol is used as fuel in internal combustion engine for generation of power is called power alcohol."

Pure ethyl alcohol can not be used as fuel.

Generally, ethyl alcohol is used as its 5-25% mixture with petrol.

(Note: For merits and demerits refer the answer of Q. 6)

Q.11 What is Power alcohol? Give method of preparation of Power alcohol. 4M *(Definition-1M, Prepration-2M, Reactions-1M)*

Ans: (Note: for this refer the answer of Q.6)

Q.12 What is Biodiesel? Write the chemical reaction for the production of biodiesel. 3M *(Definition-1M, Reaction-2M)*

Ans: **Biodiesel** :

Chemically Biodiesel is the methyl esters of long chain carboxylic acids. Biodiesel is obtained by the transesterification of vegetable oil or animal fats with methyl alcohol using catalyst sodium metal or sodium methoxide.

(Note: For the chemical reaction refer answer of Q.7)

Q.13 Give Composition, properties and applications of CNG. 5M *(Composition-2M, Properties-2M, Applications-1M)*

Ans. Composition:

- CH_4 = 88.5%
- C_2 to C_4 Hydrocarbons = 9%
- H_2= 1%
- CO=1%

Properties:

- It has higher ignition point than petrol and it is safer to use.

- It mixes better with air than liquid fuels.
- It's calorific value is about 13000 $kcal/m^{3.}$
- It can be used as a fuel for petrol and diesel engines after modifications in engines.
- It burns completely to give no CO and Sox emissions.
- CNG has higher ignition point than LPG, LNG etc.

Applications:

- It is used as substitute fuel to petrol and diesel. City buses, rickshaws, cars run on CNG in metropolitan cities like Delhi, Mumbai etc. to reduce pollution.
- It can be used as industrial and domestic fuel.
- It is the source of carbon black and hydrogen gas.
- CNG is used as fuel for engines, reduces CO, SOx and particulate pollution.
- It is useful for manufacturing of various petrochemicals like methanol, formic acid, formaldehyde etc.

Q.14 Comment on Hydrogen gas as a future fuel. 3M *(3 comments-1M each)*

Ans: Comments on Hydrogen gas as a future fuel

- Hydrogen gas is going to be the most popular fuel in the 21^{st} century. It is an increasingly important fuel for industries, vehicles, rockets, fuel cells etc.
- Hydrogen gas produces a very high temperature blue flame in combustion and no pollutant is emitted in atmosphere by its combustion. It has high calorific value.
- After shortage of crude oil fractions in the near future, hydrogen is likely to have increased importance as fuel for industrial and transportation purposes.
- It can be used in fuel cell or internal combustion engine to power vehicles or electric devices.
- It can provide motive power for liquid propellant rockets, cars, boats and aero planes.
- Combustion engines in commercial vehicles have been converted to run on a hydrogen-diesel mix where up to 70% of emissions have been reduced during normal driving conditions.

- Minor modifications are needed to the engines a s well as the addition of hydrogen tanks at a compression of 350 bars. It can also be used for heavy duty vehicles where it is expected to run 300km/17kg which means an efficiency better than a standard diesel engine.

Q.15 What is Ultimate analysis? Explain the determination of % of Carbon and Hydrogen with principle, chemical reaction and formulae. 7M *(Definition-1M, Principle-1M each, Chemical reaction-1M each, formulae-1M each)*

Ans : Ultimate Analysis:

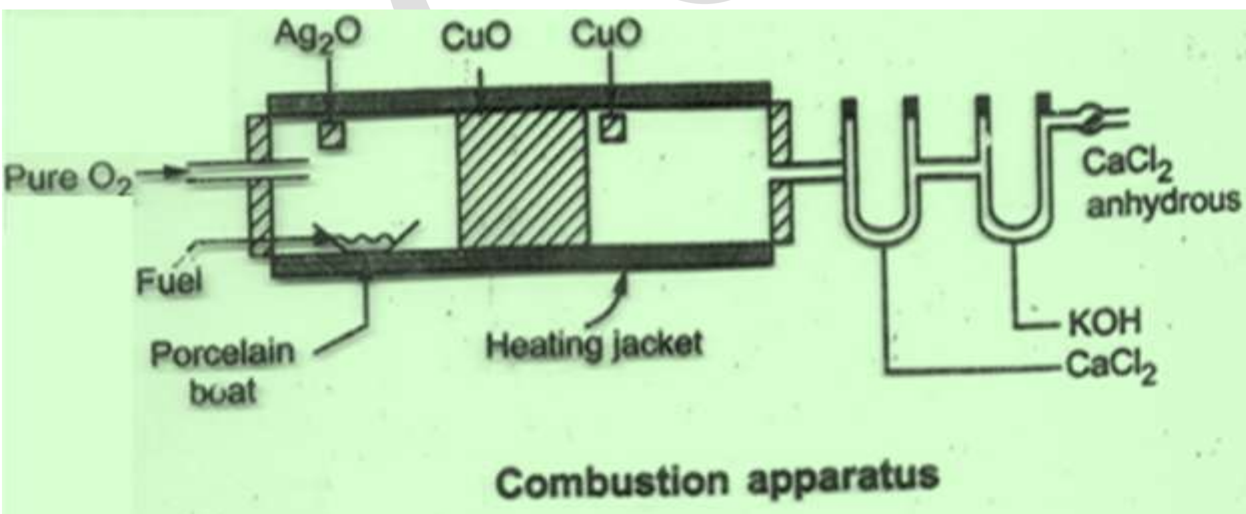
The analysis in which % of C**, H, N, S, & O from the coal** can be determined is called Ultimate analysis.

Determination of % of Carbon and Hydrogen

Principle: On combustion, carbon and hydrogen present in coal are converted to equivalent amount of CO_2 & H_2O as products of combustion, which get absorbed in KOH tube & $CaCl_2$ tube respectively of known weights & from increase in weights of those tubes, % of C & H can be calculated.

a) $C + O2 \rightarrow CO_2$

b) $H_2 + ½ O_2 \rightarrow H_2O$



Combustion apparatus

44 gm CO_2 $\longrightarrow$ 12 gm of C

18 gm H_2O $\longrightarrow$ 2 gm of H

Formulae:

$$\% \; C = \frac{\text{Weight of CO2 X 12 X 100}}{Weight\ of\ Coal\ sample\ X\ 44}$$

$$\% \; H = \frac{\text{Weight of H2O X 2 X 100}}{Weight\ of\ Coal\ sample\ X\ 18}$$

Q.16 Explain Kjeldahl's method for the determination of nitrogen from the coal sample with principle, process, diagram and formula. 4M *(Principle-1M, Process-1M, Diagram-1M, Formula-1M)*

Ans: **Principle:**

Nitrogen in coal, in presence of conc. H_2SO_4 & K_2SO_4 , converted into equivalent amount of ammonia which is distilled in standard acid solution & from acid consumed by ammonia, percentage of nitrogen in coal can be determined.

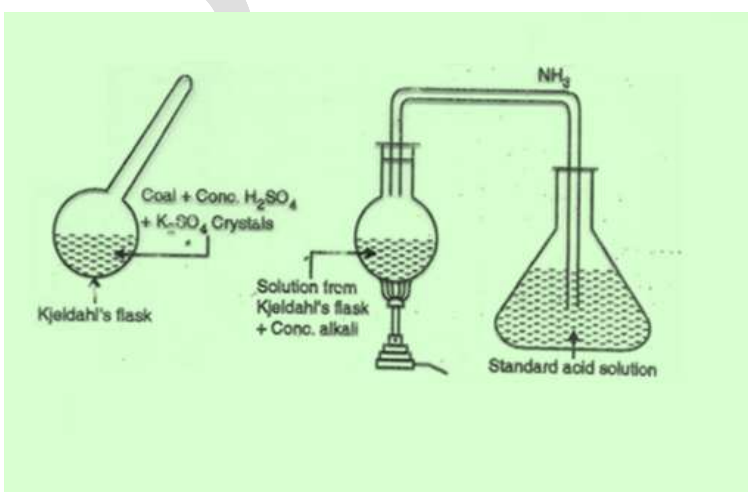
$$\textbf{N (coal)} \xrightarrow[K_2SO_4]{\text{H2SO4, heat}} \mathbf{(NH_4)_2SO_4} \xrightarrow[\text{NaOH}]{\text{alkali, heat}} \mathbf{NH_3} \longrightarrow \mathbf{H_2SO_4 \text{ \& Unused } H_2SO_4 + NaOH}$$

Process: A known weight of powdered and air dried coal is heated with concentrated H_2SO_4 alongwith K2SO4 catalyst in a long necked Kjeldahl's flask.

After the contents become clear, it is treated with alkali solution in a round bottom flask. The ammonia (basic gas) liberated is passed in known volume of standard acid solution.

The unused acid is determined by back titration with NaOH solution.

Diagram:



Formula:

$$N\ \% = \frac{Volume\ of\ acid\ consumed\ X\ Normality\ of\ acid\ X\ 1.4}{weight\ of\ Coal\ sample}$$

Q.17 Give the method of determination of Sulphur. 4M *(Principle-1M, Process-1M, Formula-1M, Reaction-1M)*

Ans: **Principle**

Sulphur on combustion form sulphur oxides. Washings from Bomb calorimeter have sulphuric acid along with nitric acid. Hence estimation of sulphur is done gravimetrically.

$$S \xrightarrow{O_2} SO_2 \xrightarrow{O_2} SO_3 \xrightarrow{H_2O} H_2SO_4 \xrightarrow{BaCl_2} BaSO_4 \downarrow$$

Process: Take about 10 ml of distilled water in the Bomb pot. Burn the known weight of powdered and air dried coal sample in the Bomb calorimeter experiment.

Then collect the washings of the Bomb pot in a beaker. Add $BaCl_2$ solution in it.

Filter the precipitate of $BaSO_4$, dry it and weigh the precipitate of $BaSO_4$, from weight of $BaSO_4$ precipitate, calculate sulphur % as below.

Formula: $S\ \% = \frac{Weight\ of\ BaSO4\ ppt.X\ 32\ X\ 100}{weight\ of\ Coal\ sample\ X\ 233}$

Neumerical

Q.1 Calculate GCV and NCV of a fuel containing 7.5% hydrogen with the following data of Bomb calorimeter experiment. Mass of fuel-0.928 gm, Water equivalent of calorimeter set-850 gm, Mass of water in calorimeter-2050 gm, rise in temperature- 2.78 ^{0}c.

Solution: Given data

X= 0.928 gm, w=850 gm, W=2050 gm t_2-t_1 = 2.78 ^{0}c

$$G.C.V. = \frac{(W+w)(t2-t1)}{X}\ \text{Cal/gm or Kcal/kg}$$

$$= \frac{(850+2050)(2.78)}{0.928}$$

= 8687.5 cal/gm or Kcal/kg

$$\text{G.C.V} = N.C.V + \frac{9\ X\ H\ X\ Latent\ heat\ of\ water}{100}$$

$$\text{N.C.V} = G.C.V - \frac{9\ X\ HX\ Latent\ heat\ of\ water}{100}$$

$$= \ 8687.5 - \frac{9\ X\ 7.5\ X\ 587}{100}$$

= 8291.3 Cal/gm or Kcal/kg

Q.2 Calculate G.C.V. of a liquid fuel if the data in Bomb calorimeter experiment is

Mass of liquid fuel burnt =1.025gm

Rise in temperature of water=3.04^{0}c

Mass of water in calorimeter= 1900 gm

Water equivalent of calorimeter= 770 gm

Cooling correction= 0.07^{0}c

Acid correction = 43.9 calories

Fuse wire correction = 12.8 calorie.

Solution:

Given: X=1.025 gm, t2-t1 = 3.04 0c, W = 1900 gm, w = 770 gm, a = 43.9 cal, f = 12.8 cal, tc = t.dt = 0.07^{0}c

$$G.C.V. = \frac{(W+w)(t2-t1+t.dt)-(a-f)}{X}$$

$$= \frac{(1900+770)(3.04+0/07)-(43.9+12.8)}{1.025}$$

= 8045.8 cal/gm or Kcal/kg

Q.3 Observations in the Boy's gas calorimeter experiment on a gaseous fuel are given below. Find the G. C.V. and N. C. v. of the fuel, volume of gas burnt (STP) = 0.08 m^3. Mass of cooling water used = 29.5 kg. Rise in temperature of circulating water= 9.1^{0}c. Mass of steam condensed=0.04kg.

Solution: Given: W= 29.5 kg, V= 0.08 m3, (t2-t1) = 9.10c, m= 0.04 Kg

$$G.C.V.\ (L) = \frac{W(t2-t1)}{V}\ \text{Kcal/m}^3$$

$$= \frac{29.5\ X\ 9.1}{0.08}\ \text{Kcal/m}^3$$

$$= 3355.6\ \text{Kcal/m}^3$$

$$N.C.V.\ (L) = \frac{W(t2-t1)}{V} - \frac{m\ X\ 587}{V}$$

$$= \text{G.C.V.} - \frac{m\ X\ 587}{V}$$

$$= 3355.6 - \frac{0.04\ X\ 587}{0.08}$$

$$= 3062.1\ \text{Kcal/m}^3$$

Q.4 1 gm of coal loses 0.03 gm at 110^{0}c and then complete combustion leaves 0.08 gm of the same coal looses 0.22 gm at 950^{0}c. Calculate fixed Carbon %.

Solution: Given

Weight of moisture in 1 gm of coal = 0.03 gm

Weight of ash in 1 gm of coal = 0.08 gm

Weight of (moisture + V.M.) in 1 gm of coal = 0.22 gm.

$$Moisture\ \% = \frac{Weight\ of\ moisture}{Weight\ of\ coal} X\ 100$$

$$= \frac{0.03}{1} X\ 100$$

$$= 3\ \%$$

$$Ash\ \% = \frac{Weight\ of\ Ash}{Weight\ of\ coal} X\ 100$$

$$= \frac{0.08}{1} X\ 100$$

$$= 8\ \%$$

$$Volatile\ matter\ \% = \frac{Weight\ of\ (moisture + V.M)}{Weight\ of\ coal} X\ 100 - Moisture\ \%$$

$$= \frac{0.22}{1} X\ 100 - 3$$

= 22-3

= 19 %

Fixed Carbon % = 100- (19+ 3 + 8)

= 70 %

Q.5 a) 2.5 gm of coal on heating at 110^0c, leaves 2.415 gm residue.

b) Then the residue on heating at 950^0c with cover on crucible gives 1.528 gm residue.

c) The 1.528 gm residue on burning gives 0.245 gm residue.

What type of analysis is this? Calculate Percentage results.

Solution: This is the Proximate analysis and Moisture, Volatile Matter, Ash and Fixed Carbon are calculated as below.

a) Weight of coal = 2.5 gm
Weight of moisture = 2.5 - 2.415 = 0.085 gm

$$Moisture\ \% = \frac{Weight\ of\ moisture}{Weight\ of\ coal} X\ 100$$

$$= \frac{0.085}{2.5} X\ 100$$

= 3.4 %

b) Weight of Volatile matter = 2.415- 1.528 = 0.887 gm

$$Volatile\ matter\ \% = \frac{Weight\ of\ V.M}{Weight\ of\ coal} X\ 100$$

$$Volatile\ matter\ \% = \frac{0.887}{2.5} X\ 100$$

= 35.5 %

c) Weight of coal= 2.5 gm
Weight of ash = 0.245 gm

$$Ash\ \% = \frac{Weight\ of\ Ash}{Weight\ of\ coal} X\ 100$$

$$= \frac{0.245}{2.5} X\ 100$$

= 9.8 %

d) Fixed Carbon = 100 - (% Moisture + % Volatile matter + % Ash)
= 100 – (9.8 + 3.4 + 35.5)
= 51.3 %

Q.6 1.6 gm of a coal sample in Kjeldahl's experiment liberated ammonia which was absorbed in 50 ml sulphuric acid. The resultant solution required 14 ml of 0.1 N NaOH for complete neutralization of H_2SO_4 in back titration. The reading for blank titration was 25 ml. Find the % of Nitrogen in coal.

Solution: Weight of Coal = 1.6 gm

Volume of Sulphuric acid consumed by ammonia = Blank titration reading – Back titration reading

= (25-14) ml 0.1 N NaOH

= 11 ml 0.1 N NaOH

$$N\,\% = \frac{Volume\ of\ acid\ consumed\ X\ Normality\ of\ acid\ X\ 1.4}{weight\ of\ Coal\ sample}$$

$$= \frac{11\ X\ 0.1\ X\ 1.4}{1.6}$$

= 0.963 % of nitrogen in coal

Q.7 Calculate S% in coal when 0.55 gm of coal is combusted in Bomb calorimeter. Solution from bomb on treatment with $BaCl_2$ forms 0.025 gm $BaSO_4$.

Solution: **Given**: Coal weight = 0.55 gm, Weight of dry $BaSO_4$ ppt = 0.025 gm

$$S\,\% = \frac{Weight\ of\ BaSO4\ ppt.X\ 32\ X\ 100}{weight\ of\ Coal\ sample\ X\ 233}$$

$$S\,\% = \frac{0.025\ X\ 32\ X\ 100}{0.55\ X\ 233}$$

= 0.62 % Sulphur in coal

Q.8 One gram of coal sample was burnt in Oxygen. Carbon Dioxide was absorbed in KOH and water vapour in $CaCl_2$. The increase in weight of KOH and $CaCl_2$ was 3.157 and 0.504 gm respectively. Determine % C and % H in the sample.

Solution: Given: Weight of CO_2 absorbed in KOH = 3.157 gm

Weight of H_2O absorbed in $CaCl_2$ = 0.504 gm

Weight of coal burnt = 1.0 gm

a) $\% \, C = \frac{\text{Weight of CO2 X 12 X 100}}{Weight\ of\ Coal\ sample\ X\ 44}$

$= \frac{3.157 \text{ X } 12 \text{ X } 100}{1\ X\ 44}$

= 86.1 %

b) $\% \, H = \frac{\text{Weight of H2O X 2 X 100}}{Weight\ of\ Coal\ sample\ X\ 18}$

$= \frac{0.504 \text{ X } 2 \text{ X } 100}{1\ X\ 18}$

= 5.6 %