1)What is green chemistry

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle of a chemical product, including its design, manufacture, use, and ultimate disposal

2)What are the use of green chemistry

Green chemicals either degrade to innocuous products or are recovered for further use. Plants and animals suffer less harm from toxic chemicals in the environment. Lower potential for global warming, ozone depletion, and smog formation.

Less chemical disruption of ecosystems

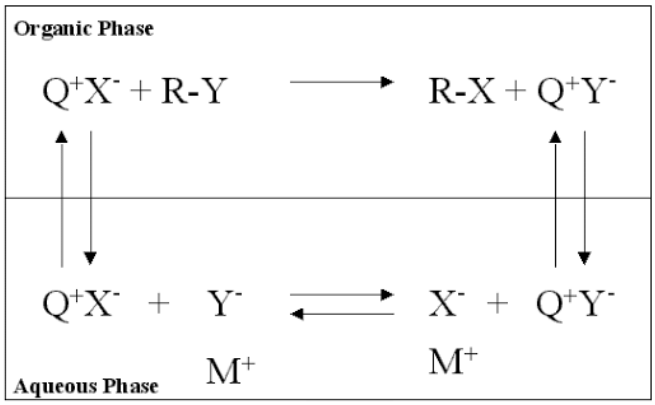
3) What is green synthesis? Give the example for aqueous phase method

green synthesis technology is environment-friendly by eliminating the use and generation of chemical hazardous and utilization of renewable raw materials.

Give the example for aqueous phase method?

4) what is phase transfer catalyst and its examples?

phase-transfer catalyst or PTC is a catalyst that facilitates the migration of a reactant from one phase into another phase where reaction occurs. Phase-transfer catalysis is a special form of heterogeneous catalysis. Ionic reactants are often soluble in an aqueous phase but insoluble in an organic phase in the absence of the phase-transfer catalyst.



5) What is ultra sound method?

ultrasound in chemical reactions in solution provides specific activation based on a physical phenomenon

ultrasound is very effective in cleaning, and is also responsible for rate acceleration in multiphasic reactions, since surface cleaning and erosion lead to improved mass transport.

6)what is microwave method?

Microwave method consists of an electromagnetic radiation and lies between radio waves and infrared frequencies, and relative wavelength spans from 1 mm to 1 m

7)Write the applications of green synthesis?

8)Define fuel and write characterisitics of good fuel

Fuels can be defined as substances which undergo combustion in the presence of air to produce a large amount of heat that can be used economically for domestic and industrial purpose. e.g. wood, coal, kerosene, petrol, diesel, coal gas, producer gas, natural gas, LPG, water gas, etc.

Characteristics of a good fuel: -

1. High Calorific value
2. High efficiency
3. Moderate ignition temperature
4. Moderate velocity of combustion
5. Low moisture content
6. Low non-combustible matter content
7. Low cost & low storage cost
8. Should not pollute the atmosphere
9. Should not undergo spontaneous combustion 10 Easy to handle, store & transport

9) significance of moisture and volatile matter in coal?

The most common **volatile matter in coal** is water, carbon dioxide, and sulfur dioxide. ... High-**volatile matter** may also be associated with spontaneous combustion, especially in low-rank **coals**

Moisture content is an **important** parameter in **coal** analysis. It is needed for determining the calorific (heating) value and handling properties of a **coal**

10) Compare solid fuels and liquid fuels.

Liquid fuels generally provide more energy than solid fuels and are easier to control. Liquid fuel engines can be throttled up and down during a flight. Solid fuels are easier to handle. They do not give off toxic vapors or require extreme cooling during storage and pre-launch operations.

11) How sulphur is determined by ultimate analysis of a coal?

ultimate analysis of coal involves determination of the weight percent carbon as well as sulfur, nitrogen, and oxygen (usually estimated by difference).

Total **sulfur** in the **ultimate analysis** is the measured weight percent of **sulfur** in the **coal**.

a **coal** sample is combusted in an **ultimate** analyzer, which measures the weight percent of carbon, hydrogen, nitrogen, **sulfur**, and ash from a **coal** sample

12) Why gaseous fuels are more advantageous than solid fuels?

The higher the calorific value of a fuel, the more is its efficiency.The calorific value of gaseous fuels are more.When a gaseous fuel burns, it gives off a great deal of energy. And unlike other solid and liquid fuels it does not leaves any ash. and it produces very little air pollution.

13) Write the significance of fixed carbon and ash content in coal.

the **fixed carbon** represents the portion of the **coal** that must be burned in a solid state. Knowledge of **fixed carbon** helps in the selection of combustion equipment, since its form and hardness are an indication of the caking properties of a fuel.

The **ash content** of **coal** is a crucial parameter for the coking process. Compacting of high-**ash coals** improves the coke quality. ... Because of the higher density of mineral matter in the **coal**, stamping **coals** with higher **ash content** should result in a higher cake density.

14)What is CNG? Give the composition CNG.

CNG is made by compressing natural gas, which is mainly composed of methane (CH_4), to less than 1% of the volume it occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 20–25 MPa (2,900–3,600 psi), usually in cylindrical or spherical shapes.

15) Compare liquid fuels and gaseous fuels?
Most liquid fuels are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust. The fumes of the liquid fuel are flammable instead of the liquid.

Advantages:

Higher calorific value per unit mass.
Burn without ash, clinkers, etc.
Controlling the combustion is easier.

Gaseous fuels occur in nature, besides being manufactured from solid and liquid fuels. Most gaseous fuels are composed of hydrocarbons, carbon monoxide, hydrogen or a mixture of them all.

Advantages:

- Transportation through pipes is easy.
- Sparking combustion is really easy.
- They have a higher heat content.

16) What is meant by calorific value of a fuel? Mention its units.

Calorific value is the amount of **heat energy** present in food or **fuel** and which is determined by the complete combustion of specified quantity at constant pressure and in normal conditions. It is also called **calorific** power. The **unit** of **calorific value** is kilojoule per kilogram i.e. KJ/Kg.

Fuel: Calorific Value Of Fuel(Approximately)

Kerosene: 45000

17) What is LPG? Give its composition and applications

LPG is a highly flammable mixture of these hydrocarbon gases which is widely used as a fuel in household cooking applications. It is also used as a fuel in some automobiles. The most active components of LPG are propane and butane

Apart from being used as a domestic **fuel** for cooking and heating, It is also widely used for various commercial and industrial applications like Hotels, Restaurants, Bakeries, Ceramics, Metallurgical, Steel & Iron, Textiles, Tea, Poultry as well as specialised applications that include Food Processing and Aerosol ..

18) Write the classification of fuels with suitable examples

19)Compare gross calorific value and net calorific value of fuel.
Gross calorific value (**GCV**) is the **amount** of **heat** released by the complete combustion of a unit of natural **gas**. ... **Net Calorific Value** (**NCV**) also known as **lower heating value** (**LHV**) or **lower calorific value** (LCV) is determined by the subtracting the **heat** of vaporization of the water vapour from the higher **heating value**.

20) Compare solid, liquid and gaseous fuels.
On the basis of their physical state, fuels are classified into solid fuels, liquid fuels and gaseous fuels.
Solid fuels: Fuels which exist in the solid state are called solid fuels.
Examples of solid fuels are- wood, coal, charcoal,coke and paraffin.
Liquid fuels: Fuels which exist in the liquid state at room temperature are called liquid fuels.
Examples of liquid fuels are- kerosene, petrol and diesel. These are obtained by the refining petroleum.
Gaseous fuels: Fuels which exist in the gaseous state at room temperature are called gaseous fuels.
Examples of gaseous fuels are-hydrocarbons such as natural gas, butane and propane.

PART - B (Long Answer Questions)

1) What is green synthesis? Explain about aqueous phase method.

Ans:

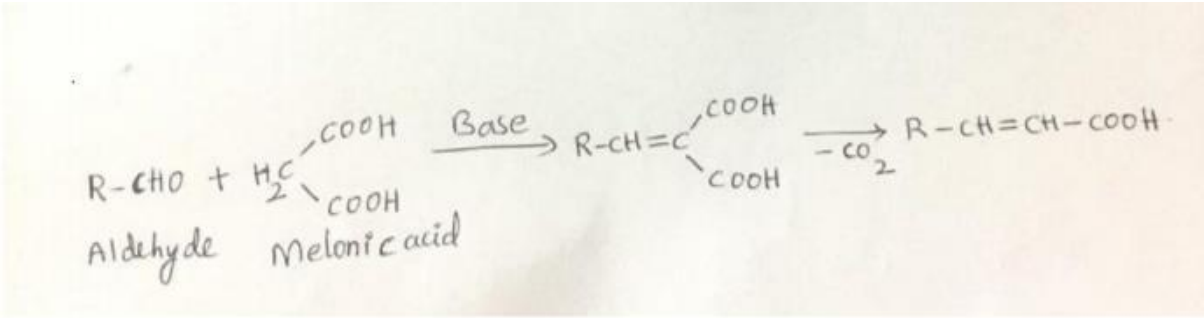
Methods of Green Synthesis or Green Reactions:

Chemistry plays an important role to develop our quality life and achieving sustainability on earth. All over the world using advanced knowledge to develop new synthetic conditions like aqueous phase, solvent free, microwave induced, etc. These are produced pollution free environment. Following are given some of the methods for greener synthesis:

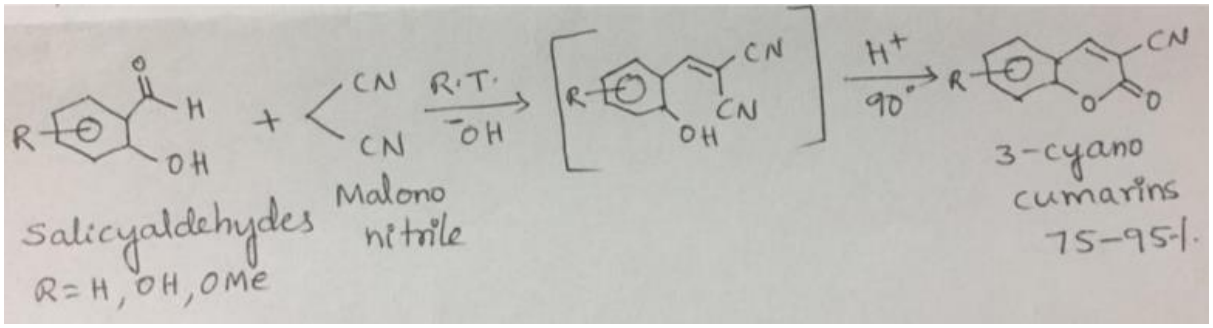
1. Aqueous Phase Method for Green Synthesis: Environmental pollution is mainly caused by organic solvents. So now all over the world have been trying to carry out organic reaction in aqueous phase. The advantages of using water as a solvent is its low cost, non-flammable, devoid of any carcinogenic effects, high specific heat resistance, unique enthalpic and entropic properties and easily handling.

Example: Knoevenagel reactions.

The condensation of carbonyl compounds with active methylene compounds in presence of weak base like ammonia/amine/pyridine is known as Knoevenagel reaction.



The Knoevenagel reaction has been carried out in water medium between aromatic aldehydes and acetonitrile.



APPLICATIONS:

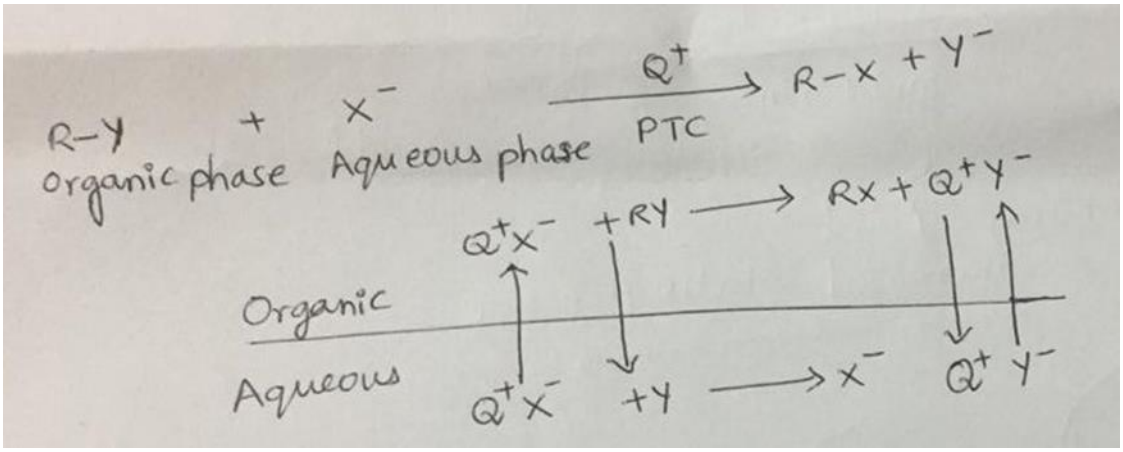
- Environmental pollution is mainly caused by organic solvents. So now all over the world have been trying to carry out organic reaction in aqueous phase. The advantages of using water as a solvent is its low cost, non-flammable, the avoid of any carcinogenic effects, high specific heat resistance, unique enthalpic and entropic properties and easily handling.
- In recent year, **aqueous phase** system has become a proven tool used in separation and purification technology.
- The **application** of APSs in clarification, partitioning and partial purification of biomolecules and bioproducts had showed the rapid development.

2) Describe the phase transfer catalyst method with example.

Ans:

⦿ Phase transfer catalyst is heterogeneous catalyst, which is used to solubilize salts which are insoluble in organic phase solvent. The PTC catalyst can facilitate the migration of the reactants from one phase into another phase where reaction occurs.

• By using PTC, one can achieve faster reactions obtained higher yield by convection of products, make less by products to eliminate the need of expensive and dangerous solvents. So, PTC is especially need for green chemistry. For example, quaternary ammonium salts like benzyl tri methyl ammonium chloride, phosphonium salts like Hexa decyl tri butyl phosphonium bromide and crown ethers. Involvement of PTC in reactions given below,



Example:

Aqueous NaCN solution reaction with 1-bromo octane does not readily occur due to poor solubility of 1-bromo octane in aqueous phase, but by the addition of small amount of hexadecyl tributyl phosphonium bromide (PTC), a rapid reaction occurs to give nonyl nitrile.

⦿ CH_3-$(CH_2)_6$-CH_2-Br + NaCN → CH_3-$(CH_2)_6$-CH_2-CN + NaBr + R_4 P Br (PTC)

1-bromo octane Sodium cyanide Nonyl nitrile

3) Explain briefly about microwave method with example.

Ans:

Microwave Induced Method for Green Synthesis:

Microwaves have wavelength range from 1 cm to 1 m in the electromagnetic spectrum and are located between the infrared and radio/radar-frequencies.

- The main purpose of microwaves is used for heating.
- According to Planck's law (E=hv), the quanta energy involved can be evaluated to 0.3cal/mole. This energy is too low to induce a molecule for extraction of any reaction. The main source to exposure ahead under microwaves is microwave interactions.
- Polar molecules can involve in selective absorption of electromagnetic microwaves but non polar molecules are being inert to microwaves.
- In the absence of electric field, the dipoles are oriented randomly; in the presence of electric field dipoles are oriented in same direction.

Advantages:

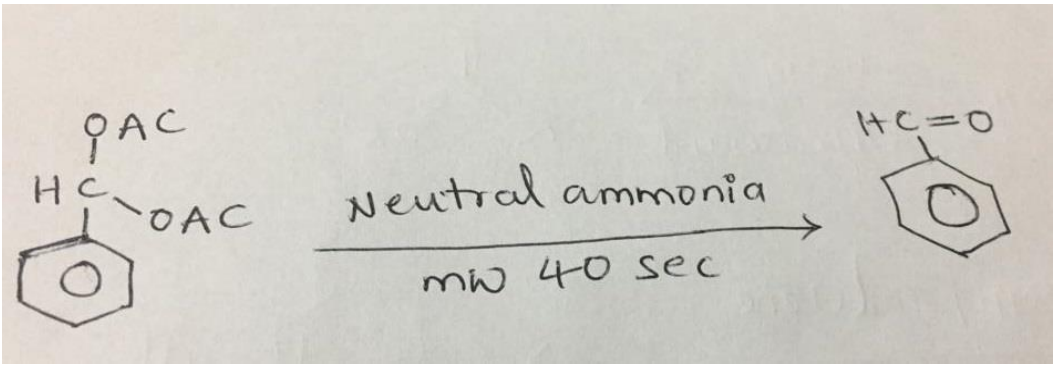
1. It is a clean, economical, efficient and safe procedure, which can lead to substantial saving in money, time and products.

2. Better yields are obtained.

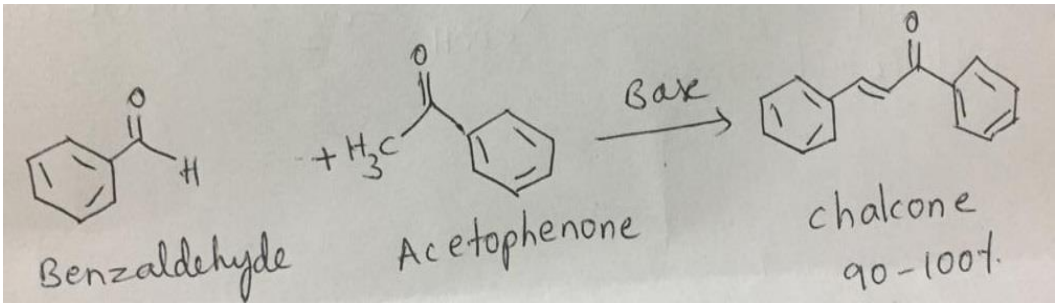
Unlike conventional methods for heating the reaction, it is possible to activate processes by physical methods such as ultrasonic sounds, pressure or microwaves. The reactions can be carried out under microwaves method. Whether in solvent medium or non-solvent medium. Limited reactions in solvent medium, and most of the reactions in solvent free medium. There are three different types in using microwave reactions.

(i) Microwave solvent-free reactions (solid state reactions): Solvent free technique hold a strategic position as a solvent is very often toxic, expressive and problematic to use and to remove. It is the main reason for development of such

modern technologies. These approaches can also enable experiments avoiding the use of strong safety and pollution problems. These acids can be replaced by solid recyclable acids such as clays. These types of reactions are known as solid state reactions.

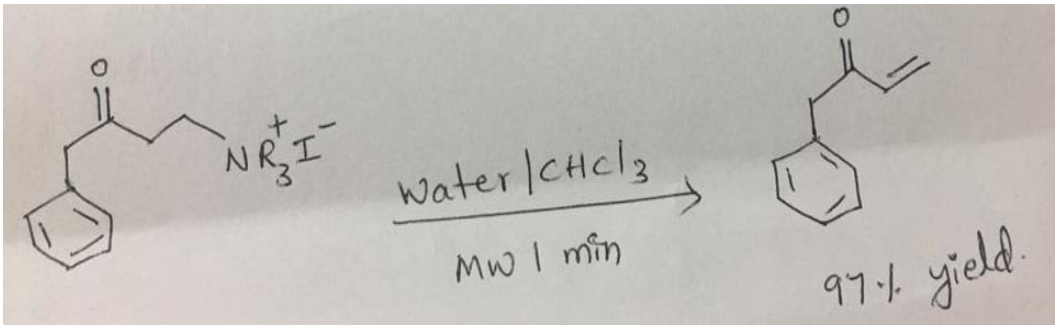


(ii) Microwave-assisted reaction in organic solvents: Microwaves have been used for synthesis of chalcones and related enones in presence of organic solvents.



(iii) Microwave assisted reactions in aqueous phase Hoffman elimination reactions: In normal method quaternary ammonium salts are heated at high temperature and the yield of the products is low. Use of microwave irradiation has led to high yielding synthesis of a thermal sensitive

Hoffman elimination product in water-chloroform system.



4) Describe the ultra sound method with a neat diagram.

Ans:

Ultrasound Assisted Method for Green Synthesis:

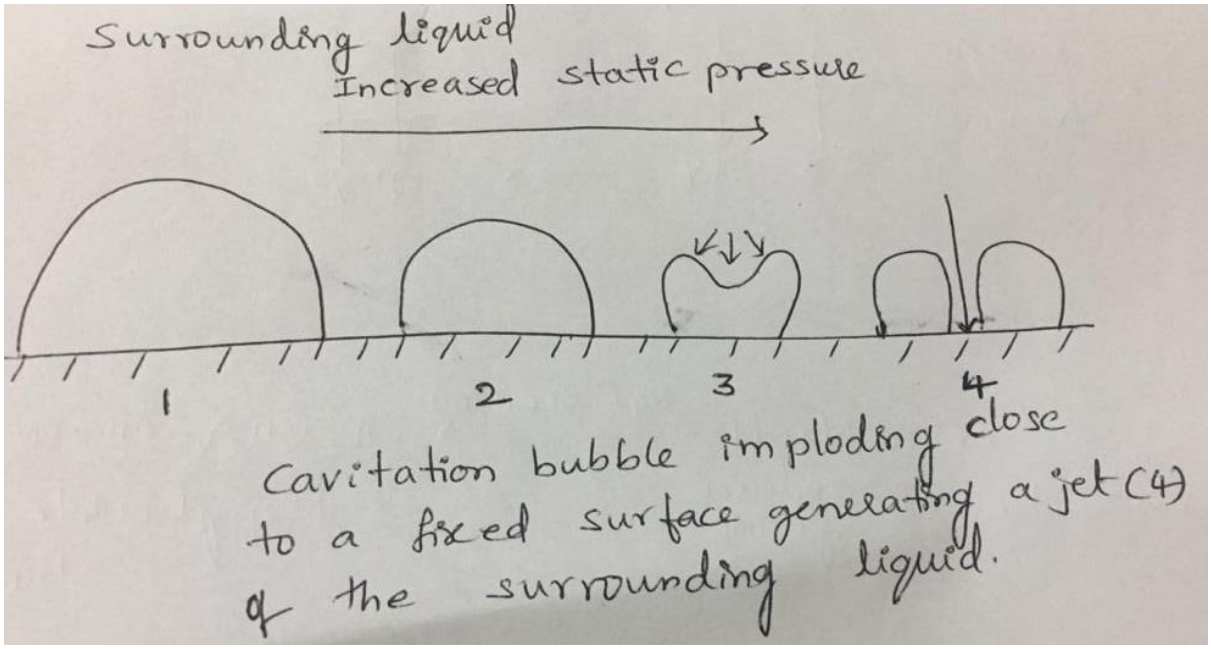
Sound waves having high frequencies are known as ultrasound waves. (about 20-100 kHz). The ultrasound is generated with an instrument having an ultrasonic transducer, a device by which electrical or mechanical energy can be converted into sound energy. Commonly used ultrasonic transducer is “quartz” but in modern ultrasonic equipment, ceramic impregnated barium titanate used as transducer which converts. Over 95% of electrical energy into ultrasound.

These are worked based on the “piezoelectric effect” it is nothing but an equal and reversing charges are applied to opposite faces of the transducer resulted generation of vibrations by expansion and contraction of transducer which emits ultrasonic waves. The term sonochemistry is used to describe the effect of ultrasound waves on chemical reactivity. This depends upon phenomenon of “sonic cavitations or acoustic cavitations”.

Upon irradiation with high intensity sound or ultrasound waves, which are propagated a series of compressing refraction cycles; pass through a liquid medium results oscillation of molecules takes place. Under appropriated condition, the attractive forces of

the molecules may be overcome, causing formation of bubbles, growth and collapsed which is due to great internal forces in the bubbles.

Bubble collapse in liquid produces enormous amount of energy from the conversion of K.E. of the liquid into heating the contents of the bubble. Experimental results have shown that these bubbles have temperature around 5000K, pressure of roughly 1000 atm and heating, coling rates above 1010 K/s.



Advantages:

1. It can enhance chemical reactivity.

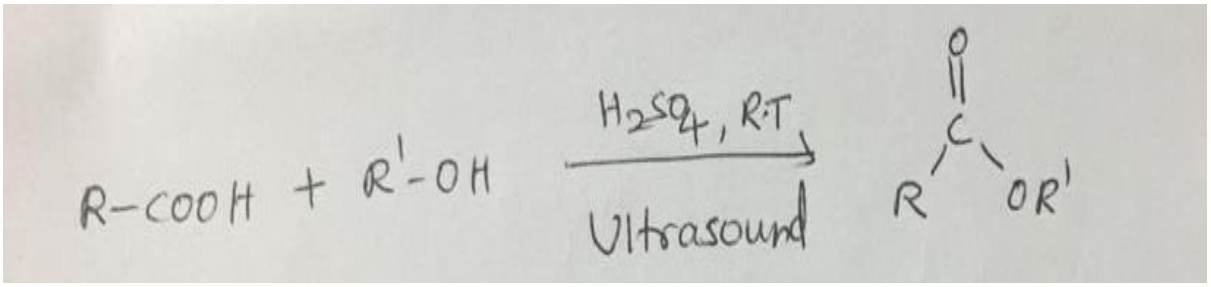
2. It can effectively activate the catalyst by excitation of the atomic and molecular modes of the system.

3. It can increase solid surface area of the system through cavitation, it increases the observed rate of reaction.

Example:

1. Esterification: This is generally carried out in presence of acid catalyst like H2 SO4, gives low yield and takes longer time. But by using ultrasound it gives high yield and takes short

time.



5) What are fuels? Give complete classification of fuels with suitable examples.

Ans:

- A fuel is a combustible substance which on proper burning produces a large amount of heat energy. The heat evolved during combustion can be used economically for industrial and other uses.
- For example, coal is used in locomotives and as reducing agent in blast furnace. Petrol is mainly used in internal combustion engines and for doing mechanical work. There are solid, liquid, and gaseous fuels that are available for firing in boilers, furnaces, and other combustion equipment. Right type of fuel can be selected depending on various factors such as storage, availability, handling, pollution, and landed cost of fuel. Combustion is the process of chemical reaction between fuel and oxygen.
- Classification of fuels is based on two factors.

  1. Occurrence (andpreparation)

  2. The state ofaggregation

On the basis of occurrence, the fuels are further divided into two types. A

- **Natural Fuels (Primary Fuels)**

These are called natural fuels, e.g. wood, coal,natural gas and petroleum.

- **Artificial Fuels (Secondary Fuels)**

  The fuels that are derived from natural fuels (primary) are called

  artificial or secondary fuels, e.g. petrol, producer gas and charcoal.

The second classification is based upon their state of aggregation like:

a) Solid fuels

b) Liquid fuels

c) Gaseous fuels

	Solid	Liquid	Gas
1.	Cheap and easily available.	Costly and available only in a few countries and obtained from mines.	More costly than solid fuels.
2.	As it does not burn spontaneously, its storage, transportation and use is easy.	Transportation is easy and storage needs care.	Transportation is easy but storage is risky. Very large storage tanks are needed.
3.	Low risk of fire hazards.	More risky as they are highly inflammable.	High risk of fire hazards.
4.	Slow combustion.	Quick combustion.	Very fast combustion due to uniform mixing of air and fuel.
5.	Ash content is more.	No ash content.	No ash content.
6.	Causes more pollution.	Less pollution.	Least pollution due to uniform mixing of air and fuel.
7.	Low calorific value and low thermal efficiency.	Higher calorific value.	Higher calorific value.
8.	More oxygen is required for combustion and burn with clinker formation.	Less oxygen is required for combustion than solid fuels.	Least oxygen is required for combustion.
9.	It cannot be used in vehicles as fuel.	Mainly used in vehicles (IC engines) as fuel.	Also used as fuel for vehicles. (IC engines).

10.	Combustion process of solid fuels cannot be controlled easily.	Combustion process can be easily controlled by regulating the flow of liquid fuels.	Combustion can be readily controlled for changes in demand like oxidizing or reducing atmosphere, length of flame, temperature, etc.
11.	The products of combustion escaping into atmosphere as flue gases are associated with ash and soot.	The products of combustion are relatively clean, free from dust, soot, etc.	Complete combustion occurs without pollution due to uniform mixing of air and fuel.

6) Explain the proximate analysis of coal.

i. Moisture

ii. Volatile matter

iii. Ash content

iv. Fixed carbon

Ans:

Proximate Analysis

- Proximate analysis gives information regarding the practical utility of coal. In this analysis, the percentage of carbon is indirectly determined. This analysis includes percentage of moisture, volatile substance, ash content and carbon.
- **Moisture**: A known mass of finely powdered air-dried coal is taken in a crucible. It is heated upto 110°C for an hour and cooled to room temperature in desiccator. The moisture is removed as water vapour and the process is repeated. The weight of coal is reported on moisture% basis till the constant weight is obtained.

% of moisture = (Loss of weight in coal/weight of coal taken)x100

- **Volatile matter:** Dried sample of coal left in the crucible is covered with a lid and placed in a muffle furnace maintained at 950°C exactly for 7 minutes. The crucible is then taken out, cooled in the air and then in desiccator and weighed. The loss in weight is reported as the percentage of volatile matter

  Percentage of volatile matter= Loss in weight due to removal of volatile matter/Weight of coal taken×100

- **Ash content:** Coal, free from moisture and volatile matter, is heated in a crucible at about 700°C in a mufflef urnance in the presence of air. It undergoes combustion and results in the formation of ash. Crucible is cooled to room temperature and weighed. Heating, cooling, weighing is repeated to get constant weight of the residue. The residue is reported as ash. The mass of ash is then determined.

  Percentage of ash=Mass of ash × 100/Mass of coal

- **Carbon:** Since the main component of coal is carbon, it can be determined by subtracting the sum of the percentage of moisture, volatile substance and ash content from 100.

  Carbon % = 100 – (% of moisture + % of volatile matter + % of ash)

Significance of proximate analysis: Proximate analysis provides following valuable information‟s in assessing the quality of coal.

1. Moisture:
   Moisture is coal evaporates during the burning of coal and it takes some of the liberated heat in the form of latent heat of

evaporation. Therefore, moisture lowers the effective calorific value of coal. Moreover over, it quenches the fire in the furnace, hence, lesser, the moisture content, better the quality of coal as a fuel. However, presence of moisture, up to 10%, produces a more uniform fuel-bed and less of“fly-ash”.

2. Volatile matter:
   a high volatile matter content means that a high proportion of fuel will distil over as gas or vapour, a large proportion of which escapes un-burnt, So, higher volatile content in coal s undesirable. A high volatile matter containing coal burns with a long flame, high smoke and has low calorific value. Hence, lesser the volatile matter, better the rank of thecoal.
3. Ash:
   Ash is a useless, non-combustible matter, which reduces the calorific value of coal. Moreover, ash causes the hindrance to the flow of air and heat, thereby lowering the temperature. Also, it often causes trouble during firing by forming clinkers, which block the interspaces of the grate, on which coal is being burnt. This in-turn causes obstruction to air supply; thereby the burning of coal becomes irregular. Hence, lower the ash content, better the quality of coal. The presence of ash also increases transporting, handling and storage costs. It also involves additional cost in ash disposal. The presence of ash also causes early wear of furnace walls, burning of apparatus and feeding mechanism.
4. Fixed carbon:
   Higher the percentage of fixed carbon, greater is it‟s calorific and betters the quality coal. Greater the percentage of fixed carbon, smaller is the percentage of volatile matter. This also represents the quantity of carbon that can be burnt by a primary current of air drawn through the hot bed of a fuel. Hence, high percentage of fixed carbon is desirable. The percentage of fixed carbon helps in designing the furnace and

the shape of the fire-box, because it is the fixed carbon that burns in the solidstate.

7) Explain how the percentage of carbon, hydrogen, sulphur and oxygen is estimated by ultimate analysis of coal.

Ans:

Ultimate analysis: This is the elemental analysis and often called as qualitative analysis of coal. This analysis involves the determination of carbon and hydrogen, nitrogen, suphur and oxygen.

Carbon and hydrogen determination: A known mass of carbon is taken and burnt in combustion apparatus in a current of oxygen. The carbon changes to CO_2 and hydrogen changes to H_2O. The vapours of CO_2 and H_2O are then passed through KOH and $CaCl_2$ tubes of known weight. The CO_2 is absorbed by KOH in the tube while H_2O is absorbed by $CaCl_2$. Because of the absorption, the weight of KOH and $CaCl_2$ increases, which is then measured. 12 parts by mass of carbon gives 44 parts by mass of CO_2. 2 parts by mass of H_2 gives 18 parts by mass of water.

$$C_{12} + O_2 \xrightarrow{\text{Ignition}} CO_2$$

$$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$

$$H_2 + \frac{1}{2}O_2 \xrightarrow{\text{Ignition}} H_2O$$

$$OCaCl_2 + 7H_2O \rightarrow CaCl_2 \cdot H_2O$$

$$\text{Percentage of carbon} = \frac{\text{Increase in weight of KOH tube}}{\text{Weight of coal}} \times \frac{12}{44} \times 100$$

$$\text{Percentage of hydrogen} = \frac{\text{Increase in weight of } CaCl_2 \text{ tube}}{\text{Weight of coal}} \times \frac{2}{18} \times 100$$

Significance: They directly contribute to the CV of coal. The higher the percentage of carbon and hydrogen, the better is the quality of coal and higher its calorific value. The percentage of carbon helps in assessing the rank of coal.

Nitrogen:

About 1 gram of accurately weighed powdered coal is heated with concentrated H_2SO_4 along with K_2SO_4 (catalyst) in a long-necked Kjeldahl's flask. After the solution becomes clear, it is treated with excess of KOH and the liberated ammonia is distilled over and absorbed in a known volume of standard acid solution. The unused acid is then determined by back titration with standard NaOH solution. From the volume of acid used by ammonia liberated, the percentage of N in coal is calculated as follows:

$$\text{Percentage of N} = \frac{\text{Volume acid X Normality of acid X\_1.4}}{\text{Weight of coal taken}}$$

Sulphur:

Sulphur is determined from the washings obtained from the known mass of coal ,used in bomb calorimeter for determination of a calorific value. During this determination, Sulphur is converted into Sulphate. The washings are treated with Barium chloride solution, when Barium-sulphate is precipitated. This precipitate is filtered, washed and heated to constant weight.

$$\%\text{ of Sulphur} = \frac{\text{Weight of } BaSO_4 \text{ obtained X 32 X 100}}{\text{Weight of coal sample taken in bomb X 233}}$$

Ash:

The residual coal taken in the crucible and then heated without lid in a muffle furnace at 700 $\pm$ 50^0c for half-an-hour. The crucible is then taken out, cooled first in air, then in desiccators and weighed. Hearing, cooling and weighing are repeated, till a constant weight is obtained. The residue is reported as ash on percentage-basis.

Thus,

Percentage of ash = $\frac{\text{Weight of ash left X 100}}{\text{Weight of coal taken}}$

Oxygen: It is determined indirectly by deducting the combined percentage of carbon, hydrogen, nitrogen, sulphur and ash from 100.

% of Oxygen = 100 – percentage of (C + H + S + N + Ash)

8) Explain the refining of petroleum by giving its composition, boiling ranges and uses of various fractions obtained during refining.

Ans:

Refining of petroleum:

- Refining can be defined as the process by which petroleum is made free of impurities, division of petroleum into different fractions having different boiling points and their further treatment to impart specific properties.

Refining of petroleum is done in different stages:

- **Removal of solid impurities:**

The crude oil is a mixture of solid, liquid and gaseous substances. This is allowed to stand undisturbed for some time, when the heavy solid particles settle down and gases evaporate. The supernant liquid is then centrifuged where in the solids get removed.

- **Removal of water (Cottrell's process):**

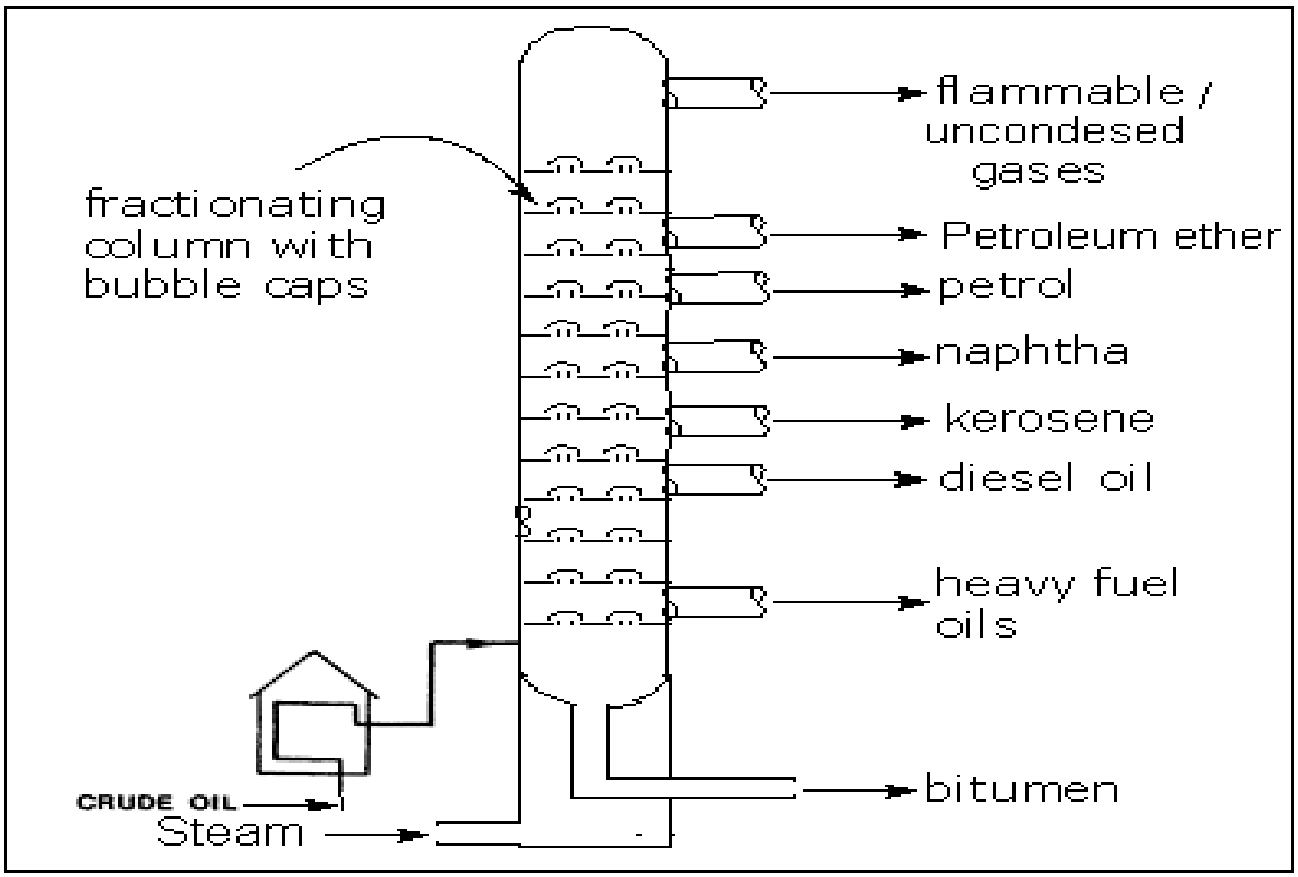
The crude oil emulsion of oil obtained from the earth's crust is in the form of stable and brine. This mixture when passed between two highly charged electrodes will destroy the emulsion films and the colloidal water droplets coal escape into bigger drops and get separated out from the oil.

- **Removal of harmful impurities:**

In order to remove sulphur compounds in the crude oil. It is treated with copper oxide. The sulphur compounds get converted to insoluble copper sulphide, which can be removed by filtration. Substances like NaCl and $MgCl_2$ it present will corrode the refining equipment and result in scale formation. These can be removed by techniques like electrical desalting and dehydration.

- **Fractional distillation:**

Heating of crude oil around 400^0C in an iron retort, produces hot vapor which is allowed to pass through fractionating column. It is a tall cylindrical tower containing a number of horizontal stainless trays at short distances and is provided with small chimney covered with loose cap. As the vapours go up they get cooled gradually and fractional condensation takes place. Higher boiling fraction condenses first later the lower boiling fractions.



9) Explain the composition, properties and applications of LPG and CNG.

Ans:

LPG (Liquefied Petroleum Gas):

The gas is obtained from natural gas or as a byproduct in refineries during cracking of heavy petroleum products. Nowadays LPG has been a common fuel for domestic work and also in most of the industries.

The main components of LPG are n-butane, isobutane, butylenes and propane (traces of propene and ethane). The hydrocarbons are in gaseous state at room temperature and 1 atmospheric pressure but can be liquefied under higher pressure.

LPG is kept in metallic cylinder attached with burner through pipe. It has two stoppers, one at the cylinder and other at burner.

LPG has special odour due to the presence of organic sulphides which are added specially for safety measure.

Characteristics of LPG:

- 1. It has high calorific value: 27800 kcal/m^3.
- 2. It gives less CO and least unburnt hydrocarbons. So it causes least pollution.
- 3. It gives moderate heat which is very good for cooking.
- 4. Its storage is simple. It is colourless.
- 5. It has the tendency to mix with air easily.
- 6. Its burning gives no toxic gases though it is highly toxic.
- 7. It neither gives smoke nor ash content.

- 8. It is cheaper than gasoline. It burns with little air pollution and leaves no solid residue. Hence, it is used as fuel in auto vehicles also.
- 9. It is dangerous when leakage is there. It is highly knock resistant.
- 10. LPG can be extracted from natural gases and also from refining of crude oil. Cryogenic process is best for the extraction for natural gas.

Applications:

1. In Food industry: LPG is widely used in the food industry like hotels, restaurants, bakeries, Canteens etc. Low sulphur content and controllable temperature makes LPG the most Preferred fuel in the food industry.

2. In Glass & Ceramic: The use of a clean fuel like LPG enhances the product quality thereby reducing technical problems related to the manufacturing activity of glass and ceramic products.

3. In Building Industry: LPG being a premium gaseous fuel makes it ideal for usage in the Cement manufacturing process.

4. In Automotive Industry: The main advantage of using automotive LPG is, it is free of lead, Very low in sulphur, other metals, aromatics and other contaminants.

5. In Farming industry: LPG in the farming industry can be used for the following:

- Drying of crops
- Cereal drying
- Curing of tobacco and rubber
- Soil conditioning

- Horticulture etc 84

6. LPG is used in metal industry, aerosol industry, textile industry and it can also be used in Steam rising.

❖ *Advantages of LPG:*

- 1. LPG is used as domestic fuel and as a fuel for

internal combustion engines.

- 2. It is used as feedstock for the manufacture of

various chemicals and olefins by

pyrolysis.

- 3. LPG in used in industries as portable blow lamps,

welding, annealing, hardening, steel cutting, etc.

❖ *Disadvantages of LPG:*

- 1. It is difficult to handle asfuel.
- 2. Engines working at low compression ratio cannot

use LPG as fuel.

CNG (Compressed Natural Gas):

Natural gas contains mainly CH4. When natural gas is compressed at high pressure (1000atm) or cooled to -160oC, it is converted to CNG. It is stored in cylinder made of steel. It is now replacing gasoline as it releases less pollutant during its combustion. In some of the metro cities, CNG vehicles are used to reduce pollution.

Characteristics of CNG:

1. Natural Gas being lead/sulphur free, its use substantially reduces harmful engine emissions.

2. Natural gas being lighter than air, will rise above ground level and disperse in the atmosphere, in the case of a leakage.

3. Natural Gas in the gaseous state, and is colourless.

4. Predominantly Methane is available in the lean gas, hence CNG contains mostly methane.

Applications:

1. It was used to generate electricity, heat buildings, fuel vehicles, power industrial furnaces and Air conditioners.

2. Natural gas is also consumed in homes for space heating and for water heating

3. It is used in stoves, ovens, clothes dryers and other appliances.

4. In some of the metro cities, CNG vehicles are used to reduce pollution.

Advantages:

- Green Fuel. Commonly referred to as the green fuel because of its lead and Sulphur free character, CNG reduces harmful **emissions**.
- Safe Fuel. The properties of CNG make it a safe fuel.
- High auto ignition temperature.
- Low operational **cost**.
- Dual facility.
- Increased life of oils.

Disadvantages:

- Higher purchasing cost.
- Limited Availability.
- Reduced storage space.
- Lowered performance
- Engine injector issues.
- Lesser fuel range.

10) Explain the ultimate analysis of coal.

i. Carbon and hydrogen

ii. Nitrogen

iii. Sulphur

iv. Oxygen

Ans:

For percentage estimation refer question 7. Significance is given here

Significance:

Carbon and Hydrogen: Greater the percentage of carbon and hydrogen better is the coal in quality and calorific value. However, hydrogen is mostly associated with the volatile mater and hence, it affects the use to which the coal is put.

Nitrogen: Nitrogen has no calorific value and hence, its presence in coal is undesirable. Thus, a good quality coal should have very little Nitrogen content.

Sulphur: Sulphur, although contributes to the heating value of coal, yet on combustion produces acids like SO_2, SO_3, which have harmful effects of corroding the equipments and also cause atmospheric

pollution. Sulphur is, usually, present to the extent of 0.5% to 0.3% and derived from ores like iron, pyrites, gypsum, etc., mines along with the coal. Presence of sulphur is highly undesirable in coal to be used for making coke for iron industry. Since it is transferred to the iron metal and badly affects the quality and properties of steel. Moreover, oxides of sulphur pollute the atmosphere and leads to corrosion.

Oxygen: Oxygen content decreases the calorific value of coal. High oxygen-content coals are characterized by high inherent moisture, low calorific value, and low coking power. Moreover, oxygen is a combined form with hydrogen in coal and thus, hydrogen available for combustion is lesser than actual one. An increase in 1% oxygen content decreases the calorific value by about 1.7% and hence, oxygen is undesirable. Thus, a good quality coal should have low percentage of oxygen.

11)What is a crude oil? Describe the refining of petroleum with various fractions obtained during refining and mention uses of each fraction.

Ans:

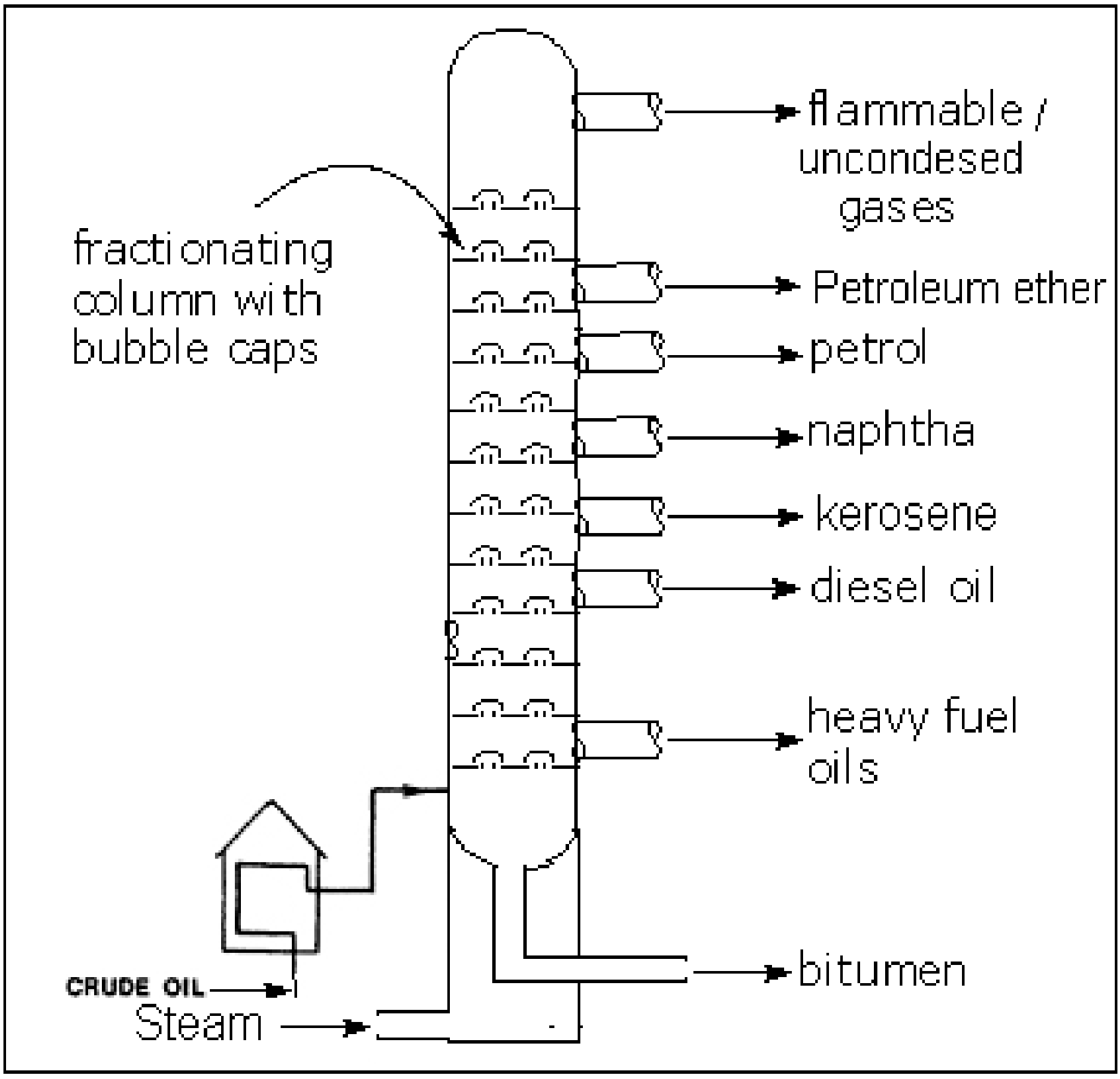
Petroleum or crude oil is a dark greenish brown, viscous oil found deep in the earth crust. Crude oil is a source of many liquid fuels that are in current use. The composition of crude petroleum approximately is C = 80-85%, H= 10-14% S= 0.1-3.5% and N=0.1-0.5%.

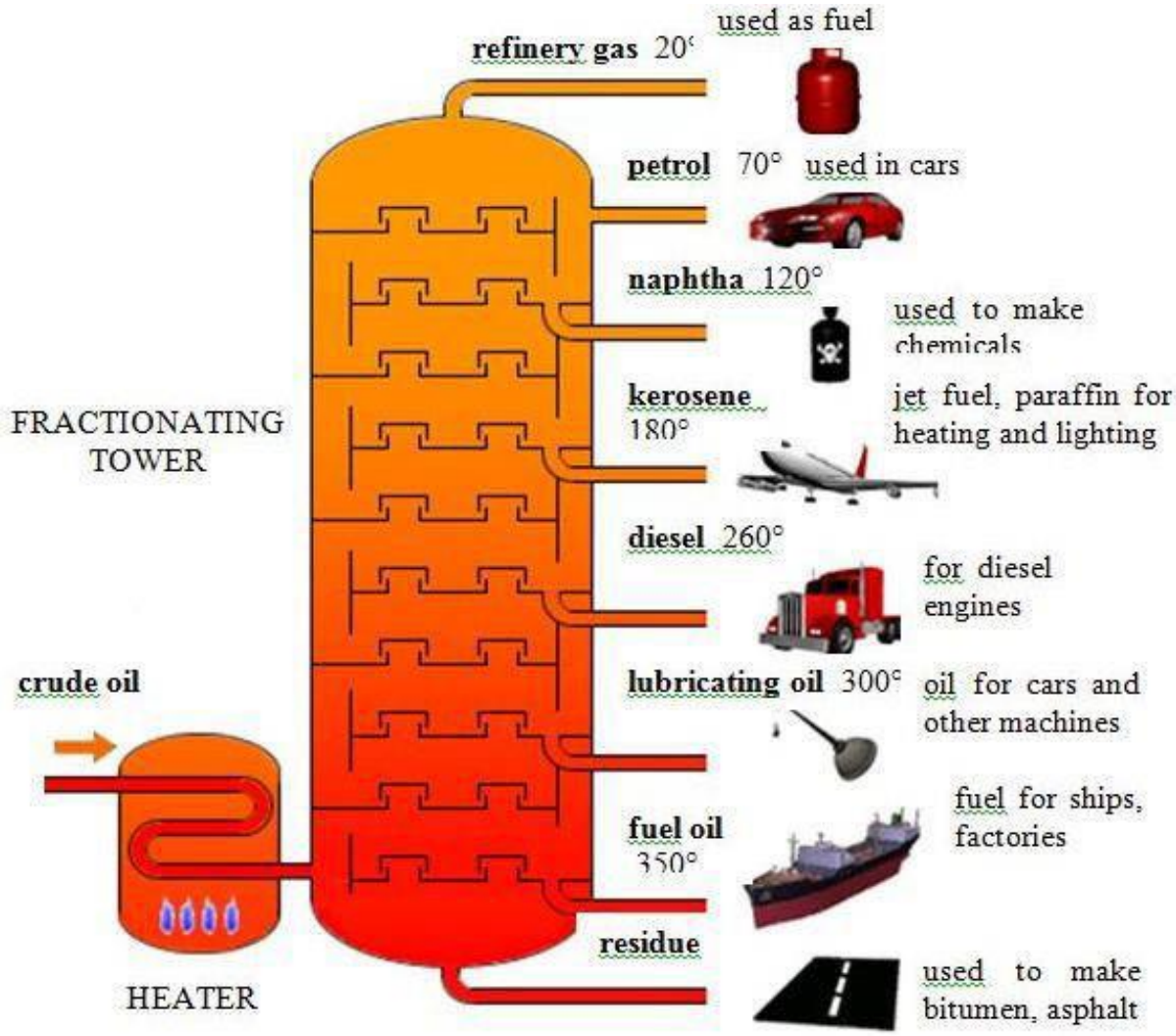
Refining of Petroleum: Crude oil obtained from the mine is not fit to be marked. It contains a lot of soluble and insoluble impurities which must be removed. Previously the purification of crude oil is done by simple fractional distillation. Further treatment of the products is done by refining. Refining can be defined as the process by which

petroleum is made free of impurities, division of petroleum into different fractions having different boiling points and their further treatment to impart specific properties. 81 Refining of petroleum is done in different stages:

a. Removal of solid impurities:
   The crude oil is a mixture of solid, liquid and gaseous substances. This is allowed to stand undisturbed for some time, when the heavy solid particles settle down and gases evaporate. The supernant liquid is then centrifuged where in the solids get removed.
b. Removal of water (Cottrell‟s process):
   The crude oil obtained from the earth‟s crust is in the form of stable emulsion of oil and brine. This mixture when passed between two highly charged electrodes will destroy the emulsion films and the colloidal water droplets coalesce into bigger drops and get separated out from the oil.
c. Removal of harmful impurities:
   In order to remove sulphur compounds in the crude oil. It is treated with copper oxide. The sulphur compounds get converted to insoluble copper sulphide, which can be removed by filtration. Substances like NaCl and $MgCl_2$ it present will corrode the refining equipment and result in scale formation. These can be removed by techniques like electrical desalting and dehydration.
d. Fractional distillation:
e. Heating of crude oil around 4000C in an iron retort, produces hot vapor which is allowed to pass through fractionating column. It is a tall cylindrical tower containing a number of horizontal stainless trays at short distances and is provided with small chimney covered with loose cap. As the vapors go up they get cooled gradually and fractional condensation takes

place. Higher boiling fraction condenses first later the lower boiling fractions.





12) Distinguish the solid, liquid and gaseous fuels with its advantages and disadvantages.

Ans:

The difference between solid liquid and gaseous fuels is given below:

	Solid	Liquid	Gas
1.	Cheap and easily available.	Costly and available only in a few countries and obtained from mines.	More costly than solid fuels.
2.	As it does not burn spontaneously, its storage, transportation and use is easy.	Transportation is easy and storage needs care.	Transportation is easy but storage is risky. Very large storage tanks are needed.
3.	Low risk of fire hazards.	More risky as they are highly inflammable.	High risk of fire hazards.
4.	Slow combustion.	Quick combustion.	Very fast combustion due to uniform mixing of air and fuel.
5.	Ash content is more.	No ash content.	No ash content.
6.	Causes more pollution.	Less pollution.	Least pollution due to uniform mixing of air and fuel.
7.	Low calorific value and low thermal efficiency.	Higher calorific value.	Higher calorific value.
8.	More oxygen is required for combustion and burn with clinker formation.	Less oxygen is required for combustion than solid fuels.	Least oxygen is required for combustion.
9.	It cannot be used in vehicles as fuel.	Mainly used in vehicles (IC engines) as fuel.	Also used as fuel for vehicles. (IC engines).
10.	Combustion process of solid fuels cannot be controlled easily.	Combustion process can be easily controlled by regulating the flow of liquid fuels.	Combustion can be readily controlled for changes in demand like oxidizing or reducing atmosphere, length of flame, temperature, etc.
11.	The products of combustion escaping into atmosphere as flue gases are associated with ash and soot.	The products of combustion are relatively clean, free from dust, soot, etc.	Complete combustion occurs without pollution due to uniform mixing of air and fuel.

13) Define the terms Calorific value, High calorific value (HCV) and Low calorific value(LCV) and explain the their relation between HCV and LCV.

Ans:

Calorific value:

Calorific value of fuel may be defined as “the total quantity of heat liberated, when a unit mass (or volume) of a fuel is burnt completely”.

“Calorific value is the amount of heat liberated by the complete combustion of a unit weight of the fuel and in usually expressed as cal gm^{-1} or kcal gm^{-1} or B.Th.U.

(Or)

The calorific value of a fuel can be defined as “the total quantity of heat liberated when a unit mass of the fuel is completely burnt in air or oxygen”.

Higher calorific value (HCV) or gross calorific value is defined as the total amount of heat liberated, when unit mass or unit volume of the fuel has been burnt completely and the products of combustion are cooled down to 60 ^{0}F or 15 ^{0}C.

Net calorific value or lower calorific value (LCV): lower calorific value is defined as “the net heat produced, when unit mass or unit volume of the fuel is burnt completely and the combustion products are allowed to escape.

Relation:

Net calorific value is the gross calorific value excluding the latent heat of condensation of water (the weight of water formed is nine times the weight of hydrogen in the fuel).

Therefore,

LCV or NCV = HCV – Latent heat of water vapour formed Net calorific value = Gross calorific value – (Mass of hydrogen per weight of fuel burnt x 9 x latent heat of vaporization of water).

Latent heat of steam is 587 kcal/g.

Net calorific value = Gross calorific value – 52.83 x %H Where % H = percentage of hydrogen.

14) Differentiate the following

i. HCV and LCV

ii. CNG and LPG

Ans:

i. **Higher calorific value** (HCV) or gross calorific value is defined as the total amount of heat liberated, when unit mass or unit volume of the fuel has been burnt completely and the products of combustion are cooled down to 60 ^{0}F or 15 ^{0}C.

Net calorific value or lower calorific value (LCV): lower calorific value is defined as "the net heat produced, when unit mass or unit volume of the fuel is burnt completely and the combustion products are allowed to escape.

ii. Refer answer 9 for differences between CNG and LPG. 😊

15) Explain how the percentage of Moisture, Volatile matter, Ash content and Fixed carbon by proximate analysis of coal.

Ans:

Refer answer 6 for proximate analysis. 😀

16) Define natural fuel and artificial fuel and write the characteristics of a good fuel.

Ans:

Natural Fuels (Primary Fuels)

- Some fuels are found in nature and are used in the same form. These are called natural fuels, e.g. wood, coal,natural gas and petroleum.

Artificial Fuels (Secondary Fuels)

- The fuels that are derived from natural fuels (primary) are called
- artificial or secondary fuels, e.g. petrol, producer gas and charcoal.

A good fuel has the following features:

- 1. It should be cheap and easily available.
- 2. It should be dry and should have less moisture content. Dry fuel increases its calorific value.
- 3. It should be easily transportable, otherwise cost of fuel will increase.
- 4. It must have high calorific value.
- 5. It must leave less ash after combustion. In case of more ash, the fuel gives less heat.
- 6. The combustion speed of a good fuel should be moderate, other wise it will not solve the problem of heating.
- 7. It must have moderate ignition temperature. Low (burning)/ignition temperature can cause fire accident.
- 8. It should not burn spontaneously to avoid fire hazards.
- 9. It should not give harmful gases after combustion.

- 10. Its handling should be easy.
- 11. The combustion of a good fuel should not be explosive.
- 12. The combustion of a good fuel should not result in the release of toxic gases such as CO, CO_2, CH_4,etc

17) Explain the significances of proximate analysis and ultimate analysis.

Ans:

Significance of ultimate analysis:

Carbon and Hydrogen: Greater the percentage of carbon and hydrogen better is the coal in quality and calorific value. However, hydrogen is mostly associated with the volatile mater and hence, it affects the use to which the coal is put.

Nitrogen: Nitrogen has no calorific value and hence, its presence in coal is undesirable. Thus, a good quality coal should have very little Nitrogen content.

Sulphur: Sulphur, although contributes to the heating value of coal, yet on combustion produces acids like SO_2, SO_3, which have harmful effects of corroding the equipments and also cause atmospheric pollution. Sulphur is, usually, present to the extent of 0.5% to 0.3% and derived from ores like iron, pyrites, gypsum, etc., mines along with the coal. Presence of sulphur is highly undesirable in coal to be used for making coke for iron industry. Since it is transferred to the iron metal and badly affects the quality and properties of steel. Moreover, oxides of sulphur pollute the atmosphere and leads to corrosion.

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Significance of proximate analysis:

1. Moisture:
   Moisture is coal evaporates during the burning of coal and it takes some of the liberated heat in the form of latent heat of evaporation. Therefore, moisture lowers the effective calorific value of coal. Moreover over, it quenches the fire in the furnace, hence, lesser, the moisture content, better the quality of coal as a fuel. However, presence of moisture, up to 10%, produces a more uniform fuel-bed and less of“fly-ash”.
2. Volatile matter:
   a high volatile matter content means that a high proportion of fuel will distil over as gas or vapour, a large proportion of which escapes un-burnt, So, higher volatile content in coal s undesirable. A high volatile matter containing coal burns with a long flame, high smoke and has low calorific value. Hence, lesser the volatile matter, better the rank of thecoal.
3. Ash:
   Ash is a useless, non-combustible matter, which reduces the calorific value of coal. Moreover, ash causes the hindrance to the flow of air and heat, thereby lowering the temperature. Also, it often causes trouble during firing by forming clinkers, which block the interspaces of the grate, on which coal is being burnt. This in-turn causes obstruction to air supply; thereby the burning of coal becomes irregular. Hence, lower the ash content, better the quality of coal. The presence of ash also increases transporting, handling and storage costs. It also

involves additional cost in ash disposal. The presence of ash also causes early wear of furnace walls, burning of apparatus and feeding mechanism.

4. Fixed carbon:
   Higher the percentage of fixed carbon, greater is it‟s calorific and betters the quality coal. Greater the percentage of fixed carbon, smaller is the percentage of volatile matter. This also represents the quantity of carbon that can be burnt by a primary current of air drawn through the hot bed of a fuel. Hence, high percentage of fixed carbon is desirable. The percentage of fixed carbon helps in designing the furnace and the shape of the fire-box, because it is the fixed carbon that burns in the solid state.

18) Explain about composition, properties and applications of compressed natural gas.

Ans:

CNG (Compressed Natural Gas):

Natural gas contains mainly CH_4. When natural gas is compressed at high pressure (1000atm) or cooled to -160oC, it is converted to CNG. It is stored in cylinder made of steel. It is now replacing gasoline as it releases less pollutant during its combustion. In some of the metro cities, CNG vehicles are used to reduce pollution.

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Advantages:

- Green Fuel. Commonly referred to as the green fuel because of its lead and Sulphur free character, CNG reduces harmful **emissions**.
- Safe Fuel. The properties of CNG make it a safe fuel.
- High auto ignition temperature.
- Low operational **cost**.
- Dual facility.
- Increased life of oils.

Disadvantages:

- Higher purchasing cost.
- Limited Availability.
- Reduced storage space.

- Lowered performance
- Engine injector issues.
- Lesser fuel range.

19) Explain the significances of analysis of coal.

Ans:

Refer answer 17😊

20) Explain about composition, properties and applications of liquefied petroleum gas.

Ans:

LPG (Liquefied Petroleum Gas):

The gas is obtained from natural gas or as a byproduct in refineries during cracking of heavy petroleum products. Nowadays LPG has been a common fuel for domestic work and also in most of the industries.

The main components of LPG are n-butane, isobutane, butylenes and propane (traces of propene and ethane). The hydrocarbons are in gaseous state at room temperature and 1 atmospheric pressure but can be liquefied under higher pressure.

LPG is kept in metallic cylinder attached with burner through pipe. It has two stoppers, one at the cylinder and other at burner.

LPG has special odour due to the presence of organic sulphides which are added specially for safety measure.

Characteristics of LPG:

- 1. It has high calorific value: 27800 kcal/m^3.

- 2. It gives less CO and least unburnt hydrocarbons. So it causes least pollution.
- 3. It gives moderate heat which is very good for cooking.
- 4. Its storage is simple. It is colourless.
- 5. It has the tendency to mix with air easily.
- 6. Its burning gives no toxic gases though it is highly toxic.
- 7. It neither gives smoke nor ash content.
- 8. It is cheaper than gasoline. It burns with little air pollution and leaves no solid residue. Hence, it is used as fuel in auto vehicles also.
- 9. It is dangerous when leakage is there. It is highly knock resistant.
- 10. LPG can be extracted from natural gases and also from refining of crude oil. Cryogenic process is best for the extraction for natural gas.

Applications:

1. In Food industry: LPG is widely used in the food industry like hotels, restaurants, bakeries, Canteens etc. Low sulphur content and controllable temperature makes LPG the most Preferred fuel in the food industry.

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