APPLIED CHEMISTRY II

(MAY 2019)

Q1 Answer any five from the following. 15

a) Define octane number and write its significance (3)

Octane Number: The percentile by volume ratio of iso-octane in mixture of iso-octane & n-heptane which shows the same knocking property as the fule under test is called as octane number.

Significance:

1. It is characteristic of petrol.
2. It can be increased by addition of Tetraethyl lead or Diethyltelluride
3. Petrol containing aromatic have higher octane number.
4. Fuels with high octane numbers are used in high performance gasoline engines.
5. Fuels with low octane number (or high cetane numbers) are used in diesel engines, where fuel is not compressed.

b) What is the difference between Anodic and Cathodic Coating? (3)

Anodic Coating	Cathodic Coating
1. It protects base metal, sacrificially.	1. It protects base metal due to high corrosion resist. & noble behavior
2. Coating metal is at lower, potential than base metal	2. Coating metal is at higher potential than base metal.
3. Corrosion of base metal does not increase even on breaking as it heals its film	3. Corrosion of base metal increases, if there is a break in coating
4. e.g. galvanizing i.e. Zn coating on iron/steel.	4. e.g. Tinning i.e. Tin coating on iron/steel/copper/brass.

c) Calculate Higher Calorific Value of coal sample containing C=85%, H=1%, N=1.5%, O=5%, S=0.4% and remaining being Ash. (3)

The total quantity of heat obtained by combustion of unit weight or unit volume of combustive substance & the product cool down to room temperature is called as High Calorific value(HCV) or Gross calorific value(GCV).

Given: C=85%, H=1%, N=1.5%, O=5%, S=0.4%

To find: HCV=?

Solution:

$$\text{HCV} = \frac{1}{100}\left[8080C + 34500\left(H - \frac{O}{8}\right) + 2400S\right]$$

$$\text{HCV} = \frac{1}{100}\left[8080X85 + 34500\left(1 - \frac{5}{8}\right) + 2400X0.4\right]$$

$$\text{HCV} = 7006.975\ \frac{kcal}{kg}$$

High calorific value of given coal sample is $7006.975\ \frac{kcal}{kg}$.

d) Write the composition, properties and uses of commercial brass. (3)

Brass is an alloy consisting of copper Cu and zinc Zn in variable proportions

Element Composition

It is composition of two metals copper Cu and zinc ZN proportion are mentioned below.

Cu = 90% Zn = 10%

Properties

1. Golden in color
2. harder and stronger than copper
3. High Malleability
4. Corrosion resistance

Uses

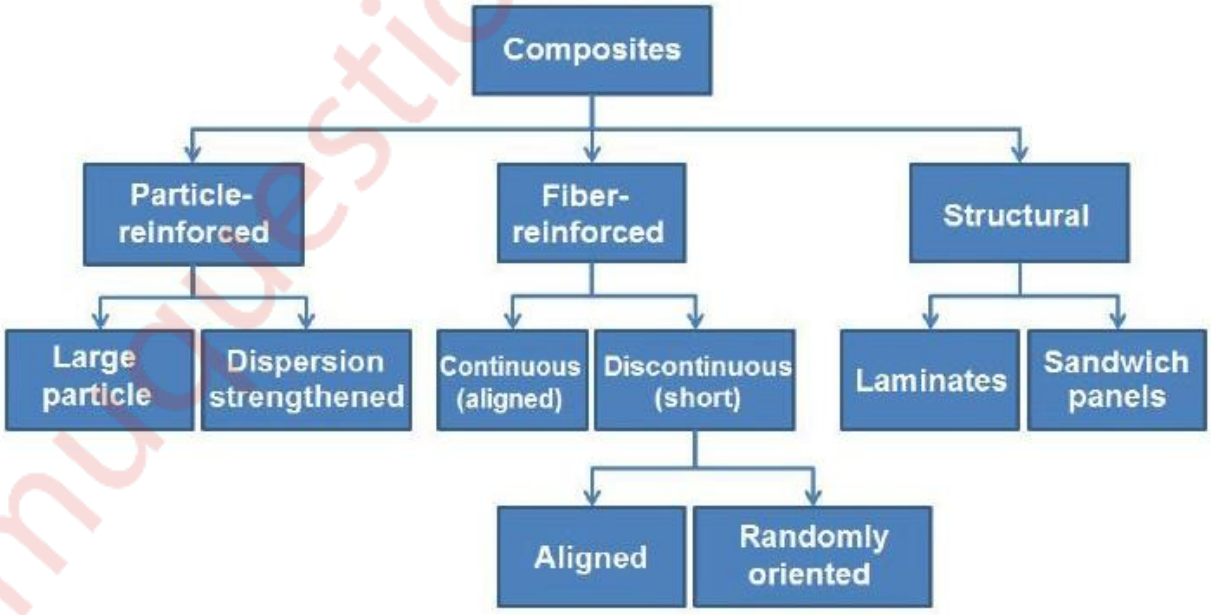
1. used in Architectural metal works.
2. It is used in jewelry.
3. Widely used in hardware's
4. It is also used to make screws, forgings, rivets & costume jewelry etc.

e) Explain the principle "inherently safer chemistry of accidental prevention" in green chemistry. (3)

1. There are 12 principle of Green Chemistry and the last principle is Accidental Prevention.
2. Principle - Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.
3. As the name suggest accidental prevention, the substance used in chemical process should be such that it should prevent the accident such as explosions, fire, etc.
4. This principle is important as it is related to safety purpose.
5. Thus green chemistry, involves to design chemical synthesis in such a way that process to develop the product should prevent accident.

f) Write the classification of composite material. (3)

- Composite Material: It is considered to be any multiphase materials that exhibits a significant proportion of the properties of both constituents of properties is realized.
- Example – Concrete, polymers, etc.
- It is classified as shown below.



- Composites material are classified into 3 types particle reinforced, Fiber reinforced and Structural as shown above.
- Particle reinforced are further classified into 2 sub class that is large particle and Dispersion strengthened.
- Fiber reinforced is further classified into 2 sub class that is continuous which is aligned and discontinuous which is short. Discontinuous are further classified into aligned and random oriented.
- Structural also have 2 types that is laminates and sandwich panels.

g) What are function of pigments in paints? (3)

Pigments are inorganic materials which provide color to the material.

Functions

1. It imparts strength to the paint film.
2. It gives opacity to the film
3. It gives color to the film.
4. It minimizes the cracking.
5. It imparts an aesthetic appeal to the film.
6. It protects the film by reflecting the destructive sun rays.

Q 2

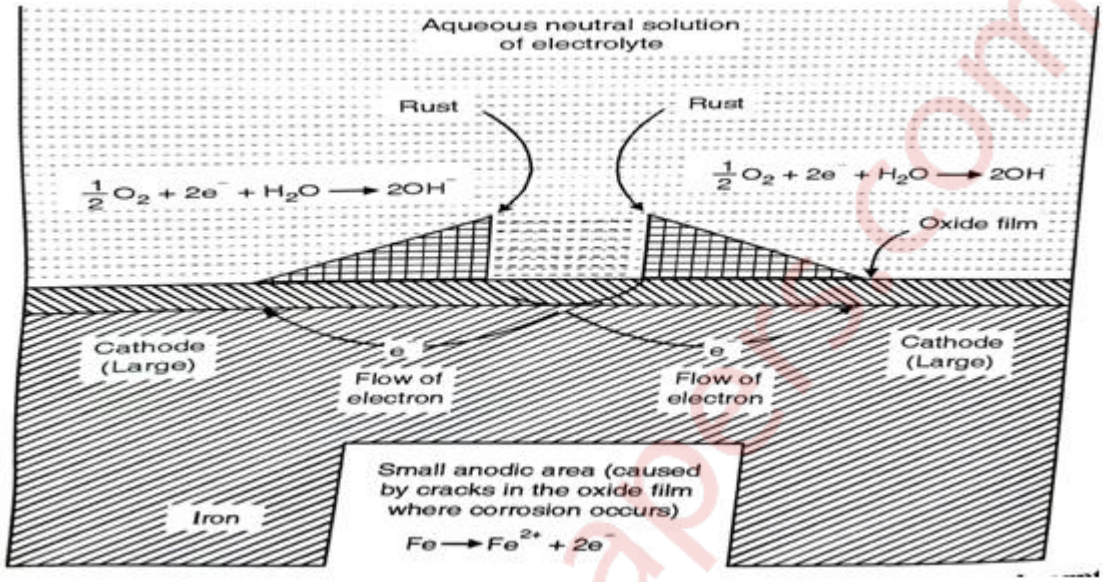
a) Define corrosion. Explain the mechanism of wet corrosion with respect to neutral and alkaline media. (6)

Corrosion:

- It is a process in which metal got destroy or decay when react with the surrounding is called as corrosion.
- There are two types of corrosion dry corrosion and wet corrosion.
- Wet corrosion is more common than dry corrosion.
- Corrosion can take place by H_2 evolution and O_2 absorption mechanism.

Wet corrosion with respect to neutral and alkaline media

- The wet corrosion in neutral and alkaline media take place by O_2 absorption mechanism.



- Fe covered with oxide film acts as cathode and a crack in coating acts as an anode.
- At room temperature the water consists of 8ppm of O_2.
- Being larger area of cathode, protected layer of Fe^{2+} ions.
- At crack, anode Fe sheds e^- & goes into water as Fe^{2+} ions..

At anode (Oxidation)

$$Fe \rightarrow Fe^{2+} + 2e^-$$

- O_2 in water accepts e^- and OH^- is formed.

At Cathode (Reduction)

$$\frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^-$$

- **Net Cell reaction** $H_2O + \frac{1}{2}O_2 + 2e^- \rightarrow Fe^{2+} + 2OH^-$
- $Fe^{2+} + 2OH^-$ combines to form $Fe(OH)_2$ & further precipitates $Fe(OH)_2$ Ferric hydroxide.

$$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$$

b) i) 1.4 gm of coal sample on combustion gave 0.3 gm of barium sulphate precipitate. Calculate the percentage of Sulphur in the sample. (3)

Given: Weight of coal = 1.4 gm

Weight of $BaSO_4$ = 0.3 gm

To Find: % S (Sulphur) =?

Solution:

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

$$= \frac{0.3\ X\ 32\ X\ 100}{1.4\ X\ 233}$$

$$\%S = 2.942\ \%$$

Percentage of Sulphur in the coal sample is 2.942 %

ii) What are the industrial applications of super critical CO_2? (2)

Supercritical Fluid

A fluid heated above the critical temperature and compressed to above critical temperature is known as super critical fluid.

Supercritical CO_2 is non-toxic, non-flammable and inexpensive.

Applications

1. It is used in Food processing industries for extraction.
2. It is also used in materials processing and synthesis.
3. Decaffeination.
4. It is used as dry cleaning solvent.
5. It is used as the extraction solvent for creation of essential oil.

c) What are large particle reinforced Composite material? Explain with the help of example. (4)

Particle reinforced composite: Particles are made from metal powder, mineral powder, ceramic powder & carbon black. Particles increases elasticity modulus & decreases ductility & permeability. It also produces inexpensive composite material. They are of 2 types Large particle composite and dispersed strengthened.

Large particle composite material:

- Material used in developing large particle composite is called as large particle composite material.
- Example:

Material	Matrix	Properties	Uses
1.Concrete	Cement	Harder & stronger than plain cement	Construction purpose
2.Oxide based cermets	Cr	Good strength & good shock resistance properties	Shock resistant equipment
3.Carbide based cermets	Co & Ni	increases surface hardness	Wire drawing, dyes& machine parts
4.Modern rubber	Vulcanized rubber	Enhancement in mechanical properties	Used in automobile industry for making tires
5.Spherodized steel	Iron(ductile)	Ductility of composite decreases	Spherical steel structure for fixing tires

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Q3

a) What is cracking? Explain in detail fixed bed catalytic cracking. (6)

Cracking**:** It is the process of decomposition of bigger hydrocarbon molecules of high boiling point into low boiling hydrocarbon of lower molecular weight. Catalytic cracking is process in which heavy oil is heated in presence of a catalyst. Generally used catalysts are crystalline substances e.g. bauxite, zeolite, crystalline aluminosilicate. And bentonite etc.

The temperature is adjusted apt as where heavy oil gets vaporized. During the process heavy oil gets cracked and form lower hydrocarbon one saturated and one unsaturated and one unsaturated.

$C_{16}H_{34} \rightarrow C_8H_{18}+C_8H_{16}C_{16}H_{34} \rightarrow C_8H_{18}+C_8H_{16}$
Hexadecane → octane + octane

Fixed bed cracking

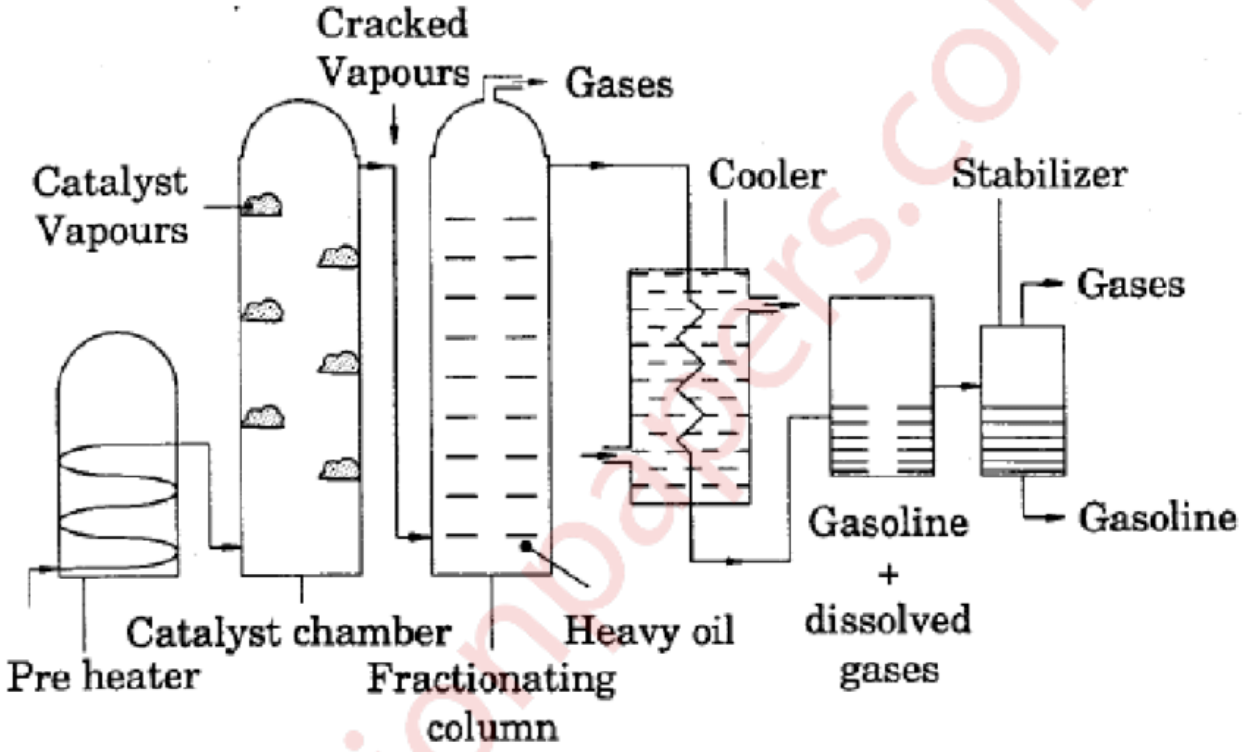
- In this method, vapors of the heavy oil are heated in the presence of catalyst due to which better yield of petrol is obtained.
- Heavy oil is vaporized by heating in an electrical heater. Then the vapours are passed over a series of trays containing catalyst. Generally catalysts used are bauxite, zeolite, crystalline alumina silicate. And bentonite etc.
- The reaction chamber is maintained at –

  TP=425–5400C=1.5 kg/cm2T=425–5400CP=1.5 kg/cm2
- The cracked gases are taken out from the top of the reaction chamber and allowed to pass into fractionating tower, where gasoline fraction is collected. The octane value of Gasoline is about 80-85.
- During the cracking free carbon is also formed which deposits on catalyst then flow of vapors of heavy oil is passed over the second set of reaction chamber and the catalyst in earlier chamber is regenerated by burning the carbon deposits with the help of air and reused.

Detailed Process

- Heavy oil is in preheated to a temperature of about 425-450^{0}C. the resulting vapours oil is charge is then forced through the catalytic chamber.
- The catalytic chamber is maintained at a temperature of 425-450^{0}C and 1-5 kg/cm^{2}pressure. Artificial clay mixed with zirconium oxide is used as a catalyst.
- About 40% of the charge is converted to gasoline and 2-4 is deposited over the catalyst bed as carbon.
- The vapours containing heavy oil as well as cracked gasoline pass into the fractionating column where heavy oil condenses.
- The uncondensed vapour containing the cracked fraction is led to the coolers where some of the vapour condense to form uncondensed gases dissolved in gasoline.
- Gasoline containing dissolved gases is then sent through stabilizer where dissolved gases are removed and pure gasoline is obtained.

- After 8-10 hours of operation, the catalyst gets deactivated and has to be reactivated the catalyst tower is heated to about 500^0C whereby the carbon deposited burns reactivating the catalyst.
- The process can be converted to a continues one by having catalyst towers. While the first tower in operation the second tower is being regenerated and vice-versa.



b) i) What are shape memory alloys? What are their applications? (3)

Shape Memory alloys:

The shape memory alloys are metals alloys undergo deformed at one temperature, but on rising or falling temperature, they return to their original shape.

They have 2 stable phase. The high temperature phase called as austernite and the low temperature phase called as martensite.

Application:

1. Bones – Broken bones can be mended with shape memory alloys. The alloy plate has memory transfer temperature that is close to body temperature and is attached to both ends of broken bone. From the body

heat, the plate wants to construct and retain the original shape. Therefore, existing compression force on the broken bone at the place of facture.

2. Piping – The first consume commercial was a shape memory coupling for piping in oil pipes for industrial application and water pipes and similar type of piping for consumer application.
3. Dentistry - Shape memory alloys are used in as fixation devices for osteptomies in orthopaedic surgery and in dental braces to exert constant tooth moving forces on the teeth.

ii) How does the presence of humidity affect the rate of corrosion? (2)

- Humidity and time-of-wetness play a large role in promoting and accelerating corrosion rates.
- Time-of-wetness refers to the length of time an atmospherically exposed substrate has sufficient moisture to support the corrosion process.
- The wetter the environment, the more corrosion is likely to occur.

Corrosion $\propto$ Humidity

c) Calculate the percentage atom economy of the following reaction with respect to the product allyl chloride (4)

$CH_2{-}CH{=}CH_2{+}C_{12}{\rightarrow}Cl{-}CH_2{-}CH{=}CH_2{+}HCl$ allylchloride

Solution:

$CH_2{-}CH{=}CH_2{+}C_{12}{\rightarrow}Cl{-}CH_2{-}CH{=}CH_2{+}HCl$

Molecular weight of $CH_2{-}CH{=}CH_2$ = 42

Molecular weight of Cl_{12} = 71

Molecular weight of $Cl{-}CH_2{-}CH{=}CH_2$ =76.5

$$\textbf{\% Atom economy} = \frac{\textbf{Molecular weight of desired product}}{\textbf{Total molecular weight of reactant}} \textbf{ X 100}$$

$$= \frac{\textbf{76.5}}{\textbf{42 + 71}} \textbf{ X 100}$$

% Atom economy = 67.7 %

The percentage atom economy of the following reaction with respect to the product allyl chloride is 67.7 %

Q 4

a) What is anodic protection method of corrosion control? Explain with the help of a neat diagram. (6)

Anodic Protection

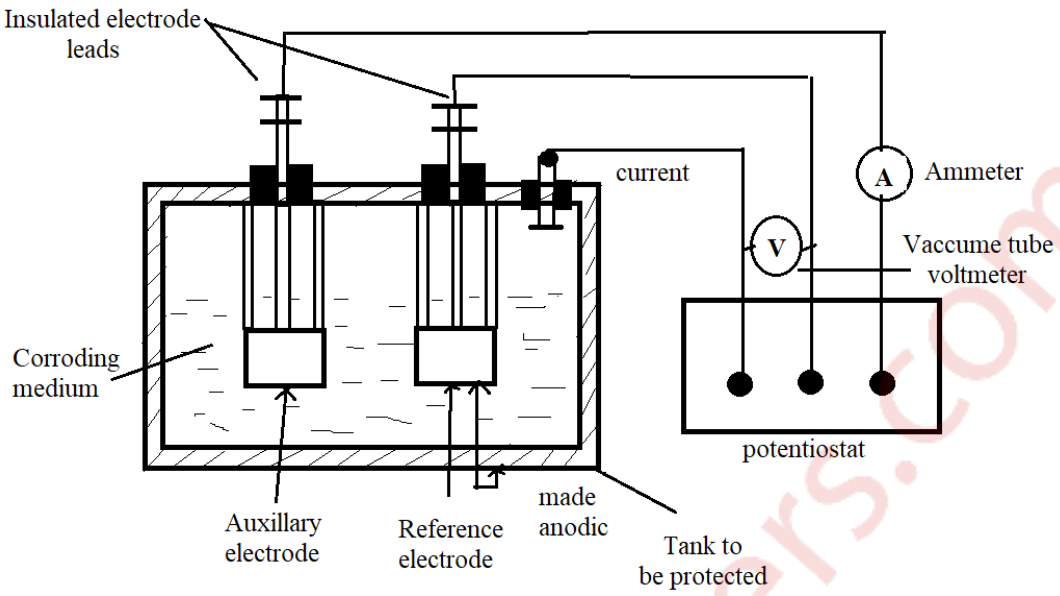
- Anodic protection is based on the formation of protection film by external applied anodic current.
- If carefully controlled anodic protection current is applied to Ni, Fe, Cr, Ti and their alloys they are passivated and the rate of metal dissolution is decreased.

Potentostat

- To anodically protect a structure device is required that is potentiostat
- It is an electronic device that maintain a metal at a constant potential either respect to a reference electrode.
- The figure shows that the potentiostat has the 3 terminals.
- One connected to the tank another to the auxiliary cathode and 3rd to the reference electrode.
- In operation the potentiostat remains constant potential between the tank and reference electrode.
- The optimum potential for protection is measured by electrochemical measurement.

Operations

- Carbon steel in concentrated sulfuric acid exhibits solution potentials in the active corrosion zone.
- An external source of direct current moves the solution potential from the active corrosion zone to the passivation zone where corrosion rates are an order of magnitude lower.



Advantage

- Anodic protection can decrease the corrosion rate substantially.
- The primary advantages of anodic protection are its applicability in extremely corrosive environments and its low current requirement.
- Anodic protection has been most extensively applied to protect equipment used to store and handle sulfuric acid.

Disadvantage

- Failure of electrical supply may be hazardous because of depassivation.
- The requirement for electrical current makes it useless for protection in organic liquid environment.
- And also for component which are not continuously immersed.

b) i) What are the industrial application of the products from natural materials? (3)

1. It is used in wood industries to develop wood from bamboo, bark, etc.
2. It is used in clothing industries to make clothes of silk, wool, cotton, jute, etc.
3. It is widely used in Stone industries to make granite, gems, glass, etc.
4. It is also used in metals industries to make copper, gold, silver, etc.
5. It is used in composite industry for making clay, plasticine, etc.

ii) What are the functions of matrix phase of composite materials? (2)

Functions

1. It binds dispersed phase together.
2. It acts as medium.
3. It prevents cracking.

c) Write a note on heat resisting steel. (4)

- The properties of steel and its yield strength considerably decrease as the steel absorbs heat when exposed to high temperatures.
- Heat resistance means that the steel is resistant to scaling at temperatures higher than 500 °C.
- Heat resistant steels are meant for use at temperatures higher than 500 deg C since they have got good strength at this temperature and are particularly resistant to short and long term exposure to hot gases and combustion products at temperature higher than 500 °C.
- These steels are solid solution strengthened alloy steels. As these steels are used over a certain broad temperature ranges, these steels are usually strengthened by hard mechanism of heat treatment, solid solution and precipitation.
- Heat resisting steels are composed of Molybdenum, Chromium and Carbon in 3.5%, 12% and 0.15% respectively.
- Heat resistant steels are tougher and harder with high heat resistance.
- It is used for the manufacture of equipment boiler parts, furnace part and gas turbines.

Q 5

a) A sample of coal was found to contain C=90%, O=5%, H=1%, S=0.5% and remaining being nitrogen. Calculate weight and volume of air required for complete combustion of 1kg of coal sample (M.W. of air = 29=8.949) (6)

Solution

Constituents	Percentage Weight	Weight per Kg
C	90 %	0.90
O	5 %	0.05
H	1 %	0.01
S	0.5 %	0.005
N	3.5 %	0.035

$$\text{Weight of Air} = \frac{100}{23}\,[2.67\ 'C' + 8\ 'H' + 'S' - 'O']$$

$$\text{Weight of Air} = \frac{100}{23}\,[2.67(0.90) + 8(0.01) + (0.005)\ - (0.05)\ ]$$

Weight of Air = 10.6 kg.

Volume of Air

28.949 kg of air = 22.4 m^3 of air

10.6 kg of air = Volume of air

$$\text{Volume of air} = \frac{22.4\ X\ 10.6}{28.949}$$

Volume of air = 8.202 m^3

weight and volume of air required for complete combustion of 1kg of coal sample is 10.6 kg and 8.202 m^3 respectively.

b) i) "The noble metals do not undergo corrosion" Justify the statement.(3)

- Noble Metals are found as pure metals because they are nonreactive and don't combine with other elements to form compounds.
- Because they are so nonreactive, they don't corrode easily.
- This makes them ideal for jewelry and coins.
- Noble metals include copper, palladium, silver, platinum, and gold.
- Metal oxides formed on the metal surface decompose back to the metals and oxygen.
- Silver (Ag), gold (Au), and platinum (Pt) oxides are highly unstable, and hence they do not undergo oxidation corrosion.
- Hence, the noble metals do not undergo corrosion.

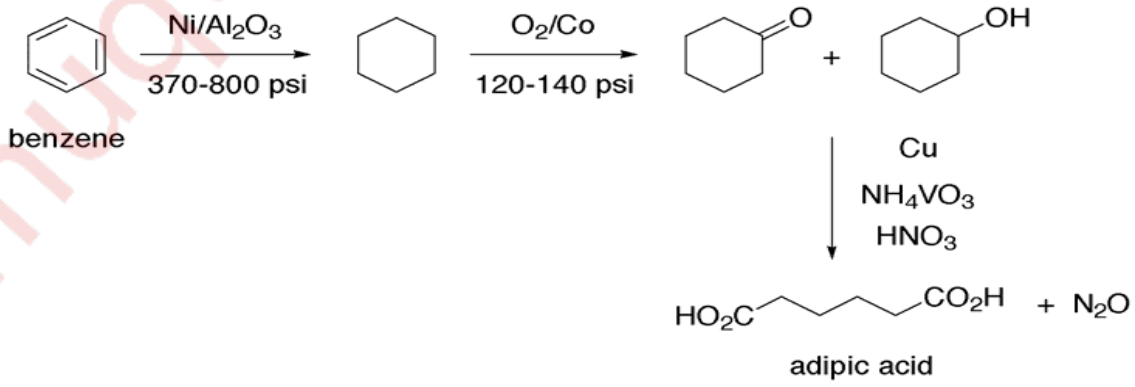
ii) What are the applications of fuel cell? (2)

- Fuel Cell Today categorizes the use of fuel cells into three broad areas: portable power generation, stationary power generation, and power for transportation.
- Portable power generation:
  Portable fuel cells are lightweight, long-lasting, portable power sources that prolong the amount of time a device can be used without recharging. In comparison, secondary (rechargeable) batteries have battery charger system. Example – power bank.
- Stationary power generation:
  Fuel cells for stationary applications have been used commercially for over twenty years. The main difference in these fuel cell systems is the choice of a fuel cell and fuel and the heating and cooling of the stacks. Stationary fuel cells can be used as a primary power source. It is often used to power houses that are not connected to the grid or to provide supplemental power.
- Power for transportation:
  Fuel cells can be used for many transportation applications including automobiles, buses, utility vehicles, and scooters and bicycles.

c) Explain with suitable equation, conventional and green synthesis of adipic acid. (4)

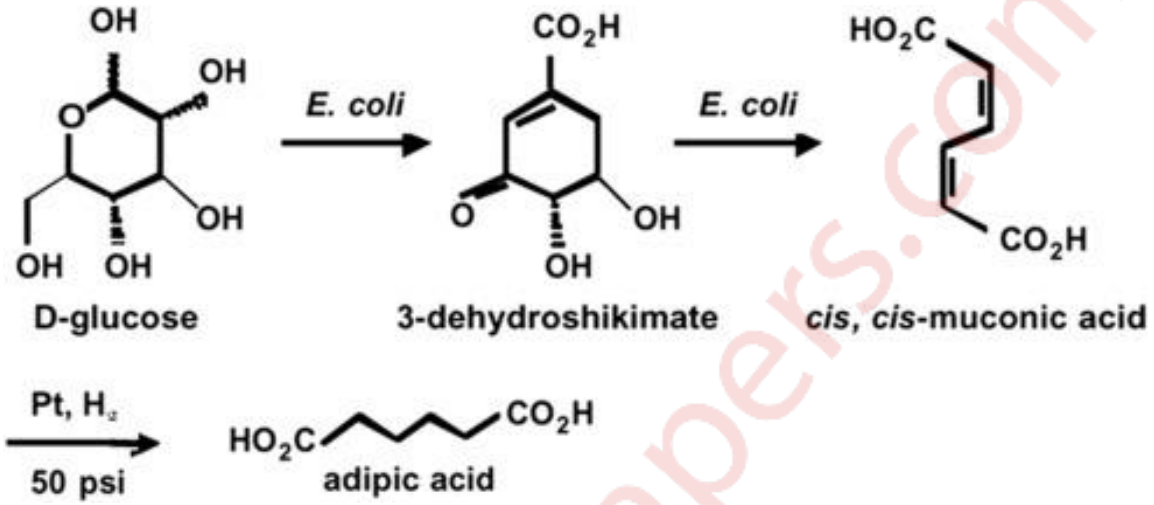
- The commercial method makes use of benzene for synthesis whereas green synthesis use D-glucose.
- It is used in preparation of Nylon-66 & other reagents.

Commercial Routes



- Benzene is used as starting compound which is carcinogenic (Cancer causing substance) and carbon monoxide is poisonous gas to avoid this green chemistry routes are used.

Green Chemistry Routes



Q 6

a) What is powder metallurgy? Explain powder injection moulding method with the help of a neat diagram. (6)

Powder Metallurgy

It is a process which deals with product of useful components from fine metal powders, from individual, mixed or alloyed with or without inclusion of non-metallic constituents.

In this process

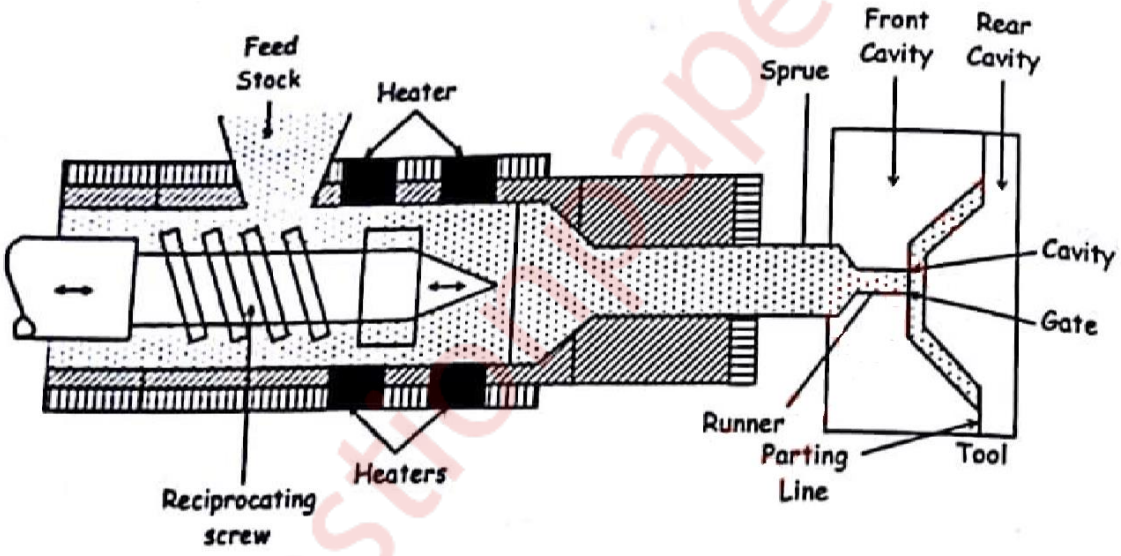
- Metal is obtained in powder form.
- Powder metal is mixed with other element in powder metal.
- It is then subjected to high pressure so to get compressed into desired shape.
- The shaped is then finished into final form various combinations with metal and non-metals are possible.

Method of compacting

1) Cold pressing.
2) Powder injection moulding.
3) Hot compaction.

Powder injection moulding

- The powder is mixed with 30-40 % of binder.
- The mixture is heated up with heater.
- It is injected into mould by screw.
- Mould is cooled and debinding is done.
- This method gives good stability and green strength of moulded product.
- User: This process creates very complex shapes from cemented carbides, tungsten, alloys, ceramics, etc.



b) i) What are the characteristics of composite materials? (3)

- It can be fabricated easily and economically.
- It maintains strength even at high temperature.
- It has better toughness.
- It has good thermal shock resistance.
- It has higher strength and stiffness.

ii) What are the characteristics of a paint film? (2)

- A paint should possess high spreading power and should be durable, tough and resistant to wear on drying.
- It should work smoothly and should not crack, fade or change color.
- Its surface should become dry in 9 hours and hard enough to take another coat in 24 hours.
- We should be able to spread it into a very thin layer and it should provide a smooth and pleasing appearance.

c) What is biodiesel? Write the advantage of biodiesel. (4)

Biodiesel

- Chemically biodiesel is the methyl ester of long chain carboxylic acid.
- Biodiesel is a clean burning renewable fuel made using natural vegetable oil and fats.
- Biodiesel is made through a chemical process which converts oils and fats of natural origin into fatty acids methyl ester (FAME).
- Biodiesel is intended to be used as a replacement for petroleum diesel fuel, or can be blended with petroleum diesel fuel in any proportion.

Advantage

1. Biodiesel is cheaper.
2. It has high cetane number 46 to 54 and high cetane value of about 40 kl/m.
3. It is regenerative and environment friendly.
4. It does not give out particulate and co-pollutants.
5. It has certain extent of lubricity.
6. It is clean to use biodiesel in diesel engine.
7. It uses provides good market to vegetable oils and reduces over dependences for diesel on foreign countries, saving currency.

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