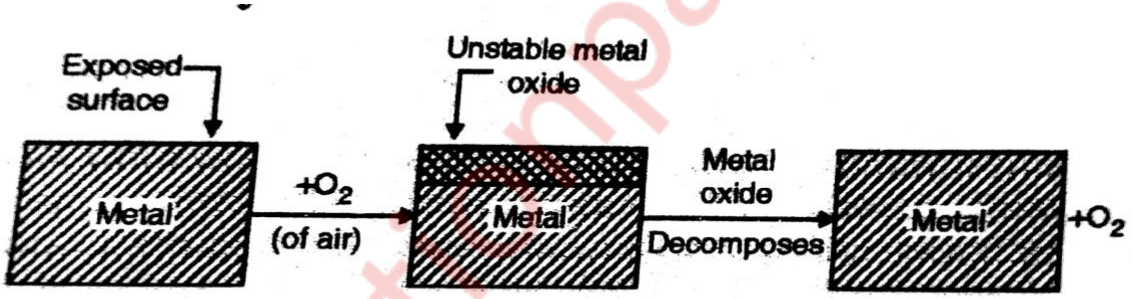
Chemistry-II

Q.1)Answer any five of following: (15 Marks)

a)Gold does not get corroded due to oxidation.Why?

Gold forms an **unstable oxide film** on metal surface.They get **decomposed** on metal **surfaces back to metal & oxygen**.Consequently,oxidation corrosion is not possible such a case.**Thus Pt,Au and Ag don't go under corrosion**

Metal+Oxygen →Metal oxide →Metal+Oxygen.



b) Give the composition,propoerties and uses of Duralumin.

- **Element Composition of Duralumina**
  - Al=95%
  - Cu=4%
  - Mn=0.5%
  - Mg=0.5%
- **Properties of Duralumina**
  - It is light weighted

- Highly ductile
- Easily castable
- Good conductor of heat and electricity
- Its tensile strength can be increased by heat treatment
- **It approaches steel in strength and yet its density is one third that of steel.**

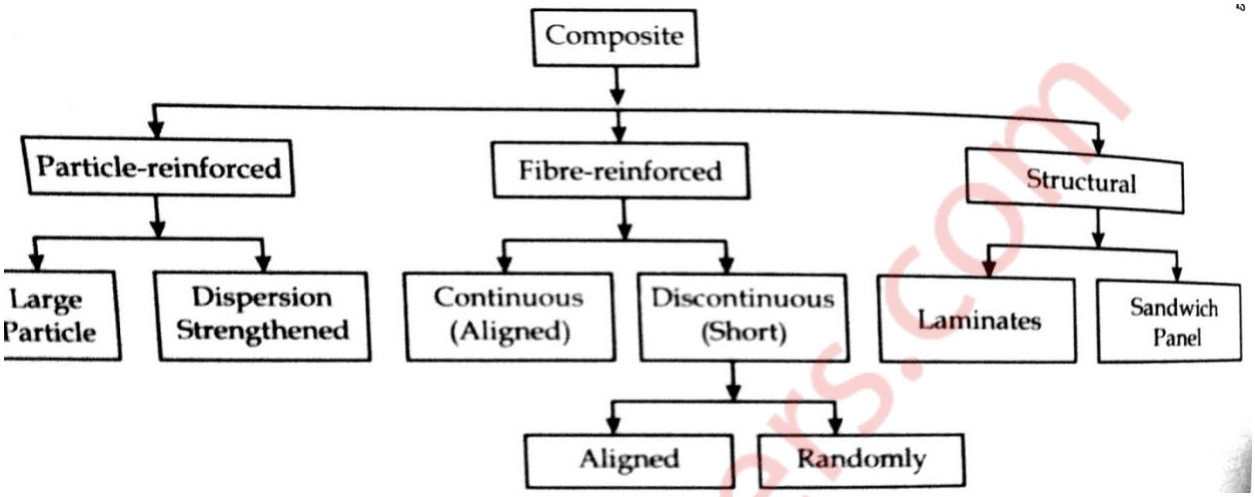
➢ **Uses**

- It is also used in making surgical instruments,cables,fluorescent tube caps etc.
- It is also used in making automobile and locomotive parts because of its high ductility and good electrical conductivity.

c)Define octane number and cetane number.

- **Octane No:-**The octane number can be defined as the **proportion by volume of isooctane** in a **mixture** of i**sooctane and n-heptane** which **shows** the **same knocking property** as the fuel under test.
- **Cetane No:**-The **percentage by volume of cetane** in a **mixture** of **cetane and α-methylnaphthalene** which just **matches** the **knocking characteristics of diesel oil** under test is called as cetane number.

- **d)Give classification of composite materials.** The composites are classified on the basis of reinforcing material or structure as follows:



e)List any Six principles of Green Chemistry.

1. Prevention of waste.
2. Non-hazardous chemicals.
3. Auxiliary substances.
4. Renewable feedstocks.
5. New analytical methods.
6. Safer chemicals.

f)Explain the advantages of galvanizing over tinning.

Metallic coatings are either anodic or cathodic depending upon the electrode potential of base method & coating metal.**They are used for the prevention of corrosion of metals**.Metallic coatings can be divided into anodic and cathodic coating.**Galvanising is a coating of Zinc over iron,here zinc acting as anode and exposed area of iron acting as cathode**.***It means area of anode is larger***.Comparatively **in tinning coating of tin is acting as cathode(large area)and exposed area of iron(small) acting as anode**.Here a***rea of anode is small therefore***

corrosion will be faster in tinned article as compared to galvanized article.Therefore,*galvanizing is more preferred than tinning.*

g)A coal sample contains C=70%,O=23%,H=5%,N=0.4%,Ash=0.1%.Calculate GCV and NCV of the fuel.

HCV=$\frac{1}{100}$[8080C+3500(H-O/8)+2240S)

=$\frac{1}{100}$[8080X70+34500(5-23/8)+2240X0)

=$\frac{1}{100}$[565600+73312.5]

=6389.12Kcal/kg.

LCV=[HCV-$\frac{9}{100}$ X H X 587]

=[6389.12-$\frac{9}{100}$ X 5 X 587]

=[6389.12-264.15]

=6124.97 Kcal/kg.

Q.2)a)Explain the following factors affecting the rate of corrosion.(15 marks)

i)Relative areas of anode and cathode:If the **anodic area** is **very small** as compared to **cathodic area**,**corrosion occurs**.The **reason** is **current density** at a **smaller anodic** area is **much greater** and the demand for electron by the cathodic area.

ii)Effect of pH:**Acidic mediums** are **more corrosive** than **neutral or alkaline mediums**.All the metals have a **particular pH value** at which it

has highest corrosion resistance,**below and above that value** it **corrodes** faster.

iii)Purity of Metal:**If** metals are **impure**,then **impurities** present in them **cause heterogeneity** which **gives rise to small electro chemical cells** at the sites where **metal & impurities are exposed** top environment,& **thus corrosion starts affecting the entire metal**.

b)i)0.5gm of coal sample was burnt in Bomb Calorimeter experiment produced 0.06gm of $BaSO_4$.Calculate percentage of sulphur.

Data:

Weight of $BaSO_4$=0.06gm

Weight of coal=0.5gm

To find: %S

Solution:

$$\%S=\frac{\text{Weight of BaSO4 X 32 X 100}}{\text{Weight of coal X 233}}$$

$$=\frac{0.06\ X\ 32\ X\ 100}{0.5\ X\ 233}$$

=1.64%

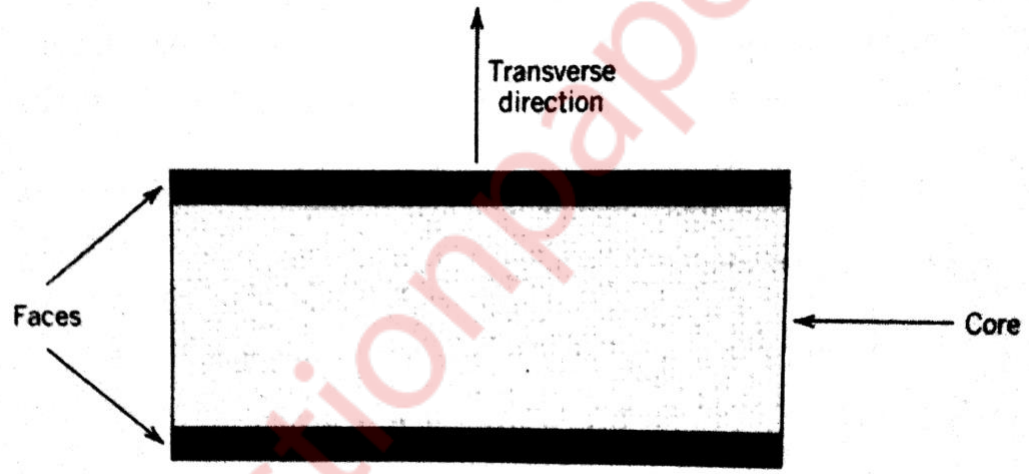
b)ii)What is supercritical CO_2?Give one application of it.

Supercritical Fluids:- **A fluid heated to above the critical temperature and compressed to above critical pressure is known as supercritical fluid**.Supercritical carbon dioxide is **non-flammable,non toxic and inexpensive**.As the **solubility** of **most of the solute changes** near the

critical point,they can be **recovered from** the **solvent** by **reducing** the **pressure/temperature to below critical point**.

c)Write a note on sandwich panel type layered composites.

Sandwich Panels:Sandwich panels are designed to be light-weight beams or panels **having relative high stiffness and strengths**.A sandwich panel **consists of two outer sheets or faces** that are separated by and adhesively binded to a thicker core.**Faces are made of a relatively stiff and strong material,typically aluminium alloys,fiber-reinforced plastics,titanium,steel or plywood.**



Schematic diagram showing cross section of a sandwich panel

Functions:

i)**They impart high stiffness and strength** to the **structure**.

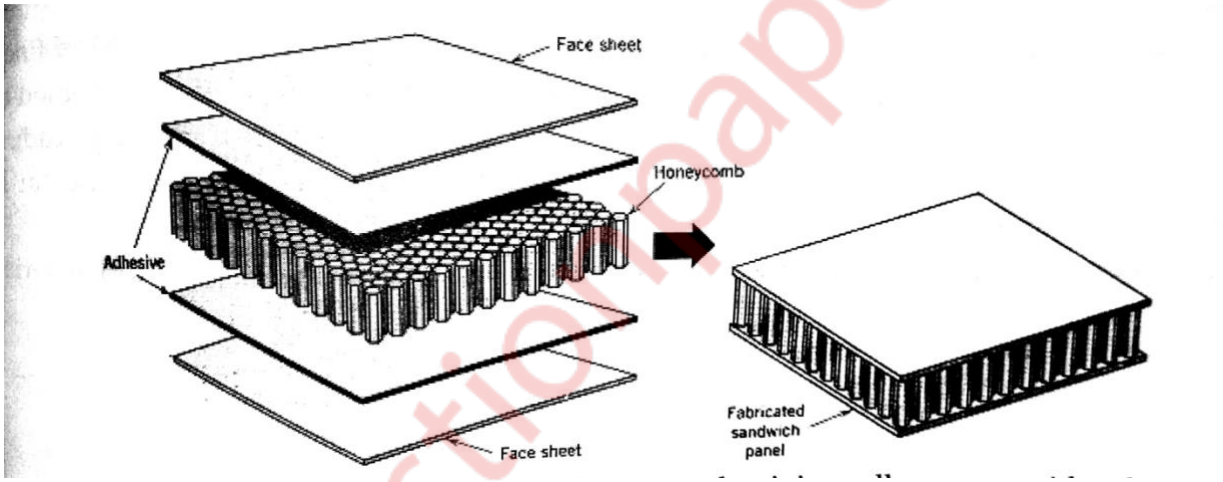
ii)They **must** be **thick** enough **to withstand tensile and compressive stresses** that result from loading.The **core** material is **light-weight** has a **low modulus of elasticity**.Typical "core" materials include **synthetic rubbers**,**formed polymers,balsa wood and inorganic cements**.

Core servers the following two structural functions:

i)It **separates the "faces"** and **provides continuous support** fit the faces.

ii)They **resist** any **deformations perpendicular to the face plane**.

iii)It **provides** a certain **degree of shear rigidity** along the planes **which are perpendicular** to the **"faces"**.**Another** popular **core** consists of a **"honeycomb" structure** thin foils that have been formed into **interlocking hexagonal cells**,with axes oriented perpendicular to the face plane.

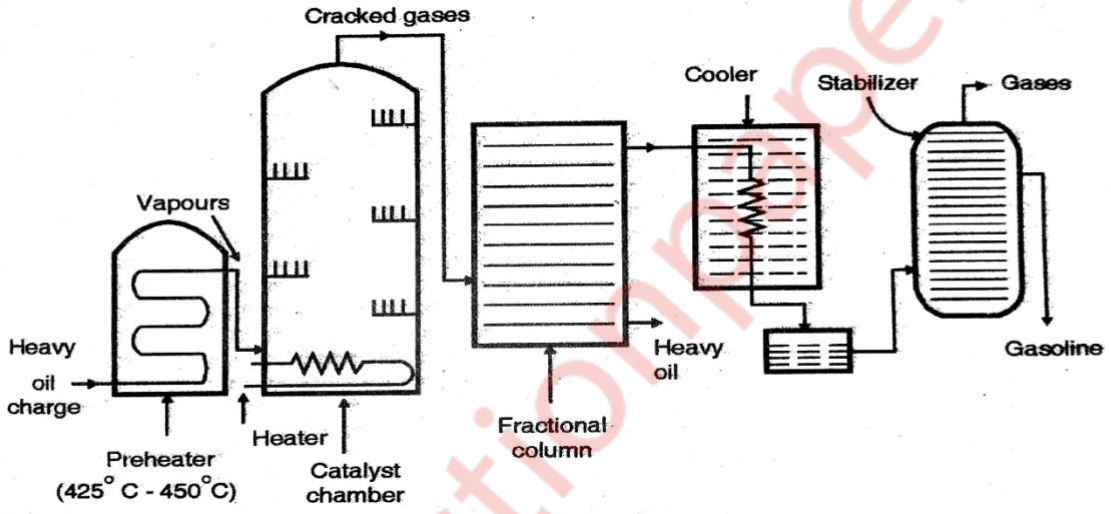


The **honeycomb material** is normally either an **aluminium alloy or aramid polymer**.**Strength and stiffness** of **honeycomb structures depend** on **cell size,cell wall thickness,and the material** from which the honeycomb is made.

Sandwich panels are **used** in a wide variety of applications including **roofs,floors,and walls of buildings,and in aeroplanes and aircraft(i.e for wings,fuselage and tailplane skins.)**

Q.3)a)With neat and labeled diagram explain fixed bed catalytic cracking.(15 marks)

Fixed Bed catalytic cracking: **Heavy oil** is **vapourised** by **heating in an electrical heater**.The **vapors** are **passed** over a series of trays containing **catalysts** such as **crystalline aluminium silicate,silicate benzoate,bauxite and zeolites.**The reaction chamber is maintained at **425° C to 540^{0}C** and **under pressure of 1.5kg/cm^2**.The cracked gases **are taken out** from **the top of the reaction chamber** and **allowed to pass into fractionating tower**.



b)i)Write short note on atomization.

In this method,**liquid metal** is forced through a **small orifice** and **jet of liquid** is broken down by blast of compressed gas.Now a days in advanced/modified atomization process,**the metal is atomized by striking a rapidly rotating disc**

ii)What is pigment?Give its two functions. I

PigmentsPigments:Pigments are the **inorganic materials** which **produces color to the materials**.

Functions:

a) It imparts an **aesthetic appeal to the film**.
b) It imparts **strength to the paint film**.
c) It gives **opacity and color to the film**.
d) It protects the film by **reflecting the destructive U.V. light**.

3)c)Calculate the percentage atom economy for the following reaction.

$CH_3NH_2+COCL_2 \rightarrow CH_3N=C=O+2HCL$

Solution:

CH_3NH_2 + $COCL_2 \rightarrow CH_3N=C=O$ + 2HCL
(41) (99) (57)

$$\%\text{Atom Economy} = \frac{\text{Molecular weight of the product}}{\text{Total molecular weight of reactant}} X100$$

$$= \frac{57X100}{41+99}$$

= 43.86%

CH_3NH_2=12+13+14+2
=41
$COCL_2$=12+16+2X35.5
=99

CH_3=C=O=12+3+14+16

=57

Q.4)a)Explain with the help of diagram wet corrosion in neutral medium.(15 marks)

Electrochemical corrosion occurs:

i)**When conducting liquid** is in **contact** with **metal**.

ii)Two dissimilar metals or alloys are dipped in electrolyte.

- The **corrosion** can **take place by H_2** evolution mechanism or **O_2 absorption,mechanism**.
- **The wet corrosion in neutral medium takes place by O_2 absorption mechanism.**

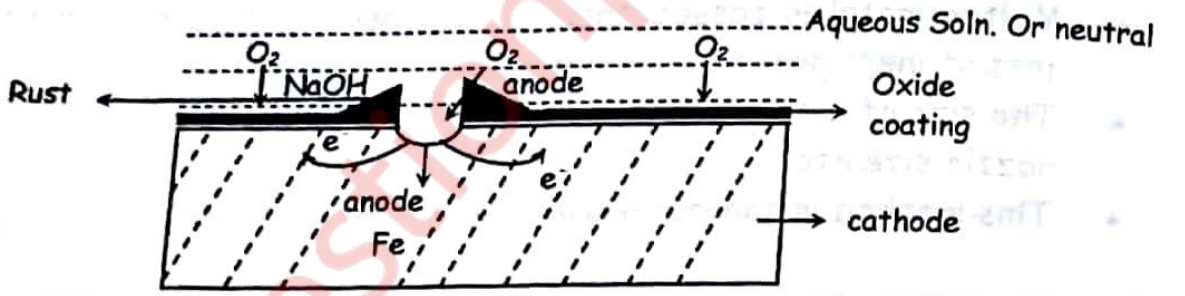


Fig. : Wet corrosion by absorption of Oxygen

Take an example of Fe in contact with water.

- **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 the water as Fe^{2+} ions.
  $Fe \rightarrow Fe^{2+}+2e^-$

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

$\frac{1}{2}O_2H_2O+2e^- \rightarrow 2OH^-$

$Fe^{2+}+2OH^-$ combine to form $Fe(OH)_2$ & further precipitates

$Fe(OH)_2$ Ferric hydroxide.

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

$Fe(OH)_2+\frac{1}{2}O_2H_2O \rightarrow 2Fe(OH)_2\downarrow$

Ferric Hydroxide

Q.4)b)

i)Explain the green chemistry principle "prevention of waste".

- **The ability of chemists to redesign chemical transformations to minimize the generation of hazardous waste is an important step in pollution prevention.**
- By **preventing** waste **generation** we **minimize** hazards associated with **waste storage,transportation & treatment**.
- **Greener route of indigo creates very less wastage due to renewable feedstock and enzymes used in conventional synthesis such as aniline,chloroacetic acid are avoided**.Overall atom economy increases.
- Other **example** include green synthesis of **Ibuprofen & adipic acid**.

ii)Write a note on 'Matrix phase' of composite material

- **Composite materials are combination of two or more materials with significantly different properties than the original materials.**
- Composites are **made** up of **Matrix & Reinforcement**.
- **Matrix** is a **continuous phase** which holds the reinforcement.

- Matrix is **more ductile,soft phase**.
- It **holds dispersed phase and share load**.
- It phases the stress to reinforcement via interface but protects the reinforcement fibers.
- **Ex.Concrete**:Where **cement is matrix** and **sand,stones** are the **dispersed phase**.

Q.4)c)Mention four drawbacks of plain carbon steel.

1) **Increase in C content decreases ductility and increases brittleness**.
2) **Carbon steel cannot be deep hardened**.
3) At **high temperatures PCS lose their hardness and mechanical properties deteriorate at higher temperatures**.
4) They do **not** have **corrosion resistance**.

Q.5)a)Calculate weight of air needed for complete combustion of 2kg of coal containing C=70%,H=10%,O=10%,N=5% and remaining ash.(15 marks)

1kg of coal contains 0.7kg C,0.1kg H & 0.1kg O_2

Combustion reactions	Weight of O_2 required(kg)
1) $C + O \rightarrow CO_2$	$0.7 \times \frac{32}{12}=1.86$
2) $H_2+\frac{1}{2}O_2 \rightarrow H_2O$	$0.1\times \frac{16}{2}=0.8$

Weight of O_2=1.86+0.8=2.66

Available O_2=0.10

Total O_2=2.56

Air contains 23% O_2 by weight

∴Min quantity of air required=$2.56\times \frac{100}{23}$

=11.13 kg.

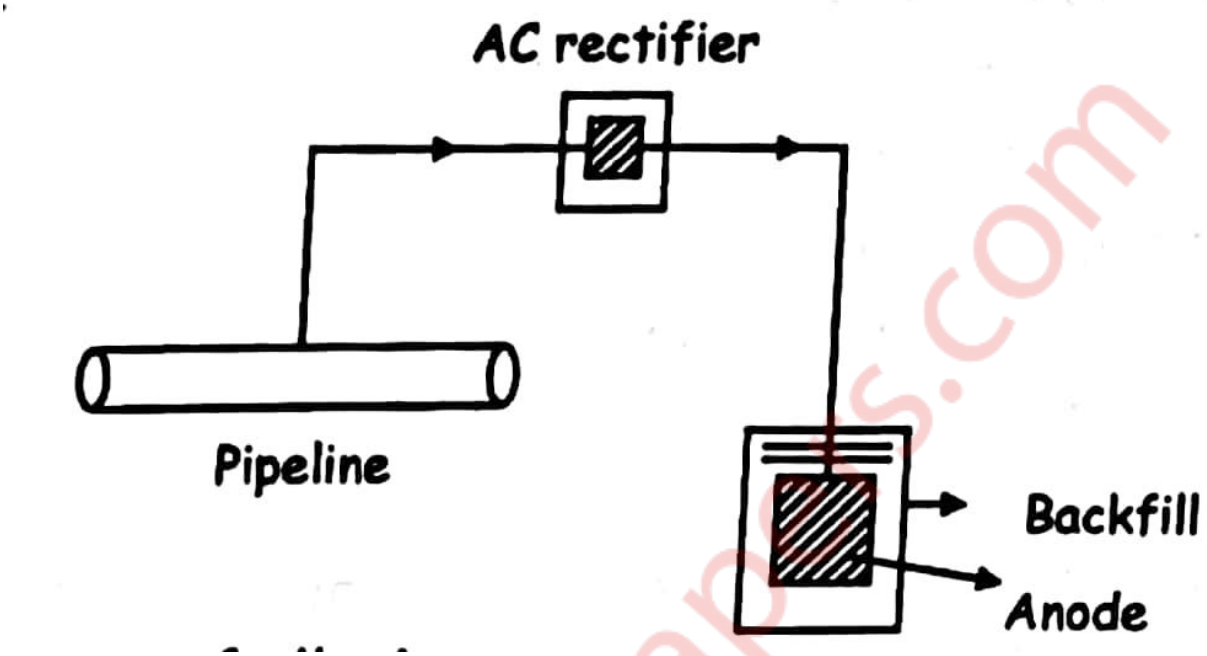
For 2kg of coal air needed=11.32×2

=22.26kg.

b)i)Explain the method of impressed current cathodic protection.

i)Impressed current cathodic protection is to convert anode to cathode by **nullifying the rate of corrosion**.The structure is connected to D.C.

- This is **done by rectifying a.c ensuring the connection between anode and new electrode.**
- **Anode** used **is** an **inert material such as graphite,pt etc**.
- **Anode** is **buried** in **backfill** such as **gysum to increase the electrical contact between soil and metal.**
- This protection is used for underground structures like water tanks,pipelines,transmission towers etc.
- The method is better and more efficient than sacrificial anode method.



ii)Give two purposes of alloying

1) **To enhance the hardness of metal.**

Ex.Pure Fe is soft but PCS is hard

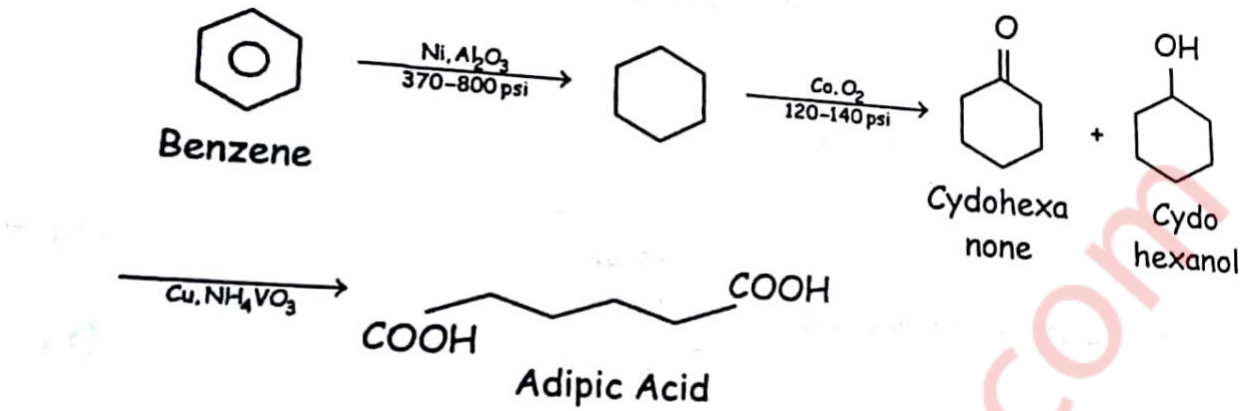
2)**To lower melting point**

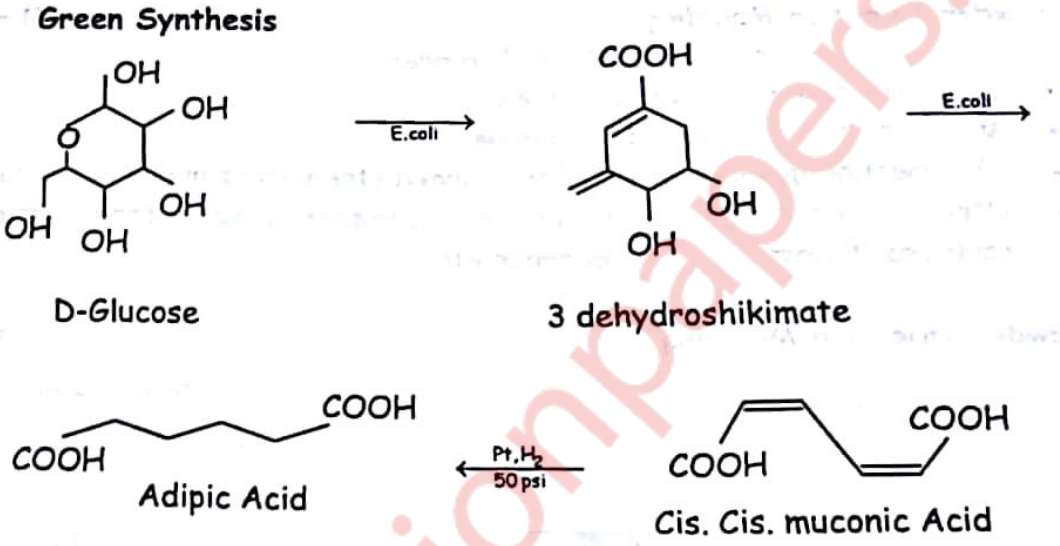
Wood's metal (Bi,Sn,Cd,Pb have high melting pointer but wood's metal has m-p-71^{o}C that's why used to make safety fuses.)

C)Explain conventional and green route of manufacturing of Adipic acid.

The traditional starting material for adicpic acid synthesis is benzene & green synthesis uses D-glucose.

Conventional Synthesis:





Q.6)a)What is compaction in powder metallurgy?(15 marks)
Explain powder injection moulding method with suitable diagram.

Compacting is the operation of obtaining object produced by the compression of a metal powder generally while confined in a die.

- **Compaction is done without the application of heat**.
- Loose powders are converted into required shape with sufficient strength to withstand ejection from tools and sintering process.
- In case like **cemented carbide,hot compaction is done followed by sintering.**

- Methods of compacting

a) **Cold pressing.**
b) **Powder injection moulding.**
c) **Hot compaction.**

a)***Cold pressing***

The powder with lubricant or binder and compacted in rigid dies by axially loaded punch.

b)***Powder injection moulding***

The powder is mixed with 30-40% binder and moulding is done by injection into mould by screw.

c)***Hot compaction***

Hot compaction mechanism is activated by higher processing temperatures and external pressure.

- The hot compaction include Axial & Isotactic hot pressing,hot forging,hot extrusion etc.
- The compact obtained by any above processes is known as green compact & further sintered.

Powder Injection Moulding

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

Powder Injection Moulding

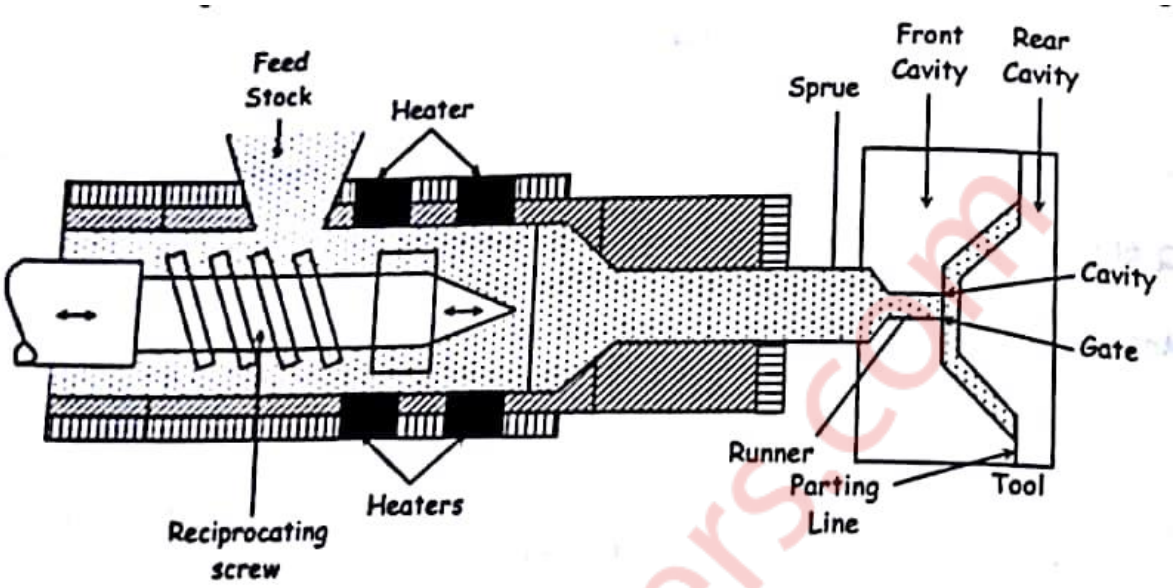


Fig. B : Schematic representation of PIM equipment

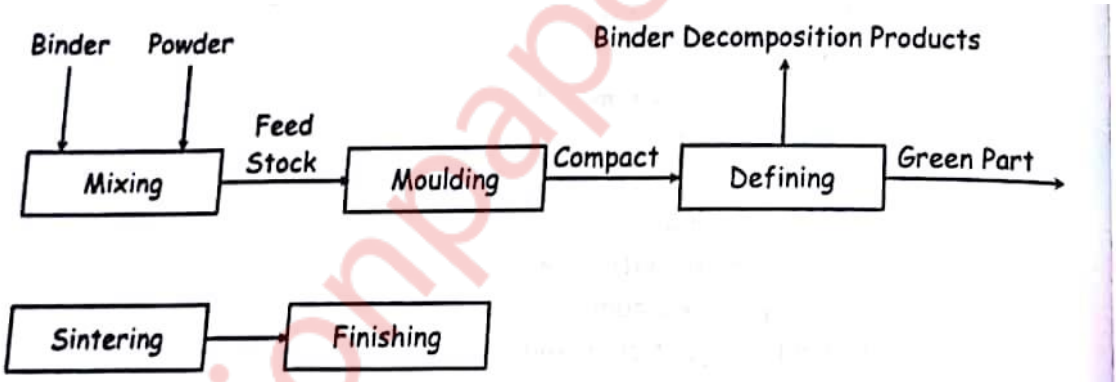


Fig. A : Flow chart of PIM process

Q.6)b)i)Mention the characteristic properties of composite materials.

i)Properties of composites

- ***Stronger & stiffer than metals.***
  -for same strength,lighter than steel by 80% & Al by 60%.
- ***Highly corrosion resistant***
- **Tailorablethermal** expansion properties.
  Can be compounded to closely match surrounding structures to minimize thermal stress.
- **Exceptional Formability**

Composites can be formed into many complex shapes during fabrication

- **Stealth property**
  It can be made low observable by radar by seeding appropriate materials.

ii)Distinguish between Cathodic Protection and Anodic Protection

	Cathodic Protection	Anodic Protection
i)	This can be applied to **all metals**.	This can be applied to the metals **showing the active passive behaviour.**
ii)	This does **not required** use if **electricity**	This **requires electricity**.
iii)	Standard & Simple	Can be used under server condition and specific

Q.6)c)Define fuel.Give the characteristics of good fuel.

Definition:

A fuel is a substance which generates energy when burnt & can be used for various purposes.

Characteristics of a good fuel:

- A good fuel should **have high calorific value**.
- A good fuel should **have moderate ignition temperature.**
- A good fuel should **have good availability,easy to store and handle.**
- A good fuel should **have moderate velocity of combustion**
- It should have **low S, low ash and high C & H content**.

APPLIED CHEMISTRY II

1. Answer any five from the following (15 M)

a. Select the compound which possesses highest octane number and highest cetane number out of n-heptane, n-octane and isooctane.

Ans:

Octane number:
n-heptane → 00
n-octane → 60
isooctane → 100

Cetane number:
n-heptane → 100
n-octane → 00
isooctane → 60

∴ The highest octane number is of n-heptane and highest octane number is of isooctane.

b. Iron does not rust even if the zinc coating is broken in a galvanized iron pipe. Give reasons.

Ans:

1. Anodic coating type of coating protect base metal "sacrificially". Corrosion of iron does not enhance even on breaking "anodic coating" as it heals its film.
2. The iron, coating metal is at lower electrode potential than zinc base metal.
3. Galvanizing is a process of coating iron with thin coat of zinc to protect them from rusting.
4. The iron sheets are cleaned with dilute H_2SO_4 i.e. pickling to remove impurities. In this process, NH_4Cl flux is used.
5. Molten zinc is maintained at 425-430^{0}C and it becomes the reason of iron and rusting even of zinc coating is broken in a galvanized iron pipe.

c. Calculate the higher and lower calorific values of coal sample contains 84% carbon, 1.5% sulphur, 0.6 Nitrogen, 5.5% hydrogen and 8.4% oxygen.

Ans:

Dulong Formula

$G.C.V = 1/100[8080C + 34500(H\text{-}O/8) + 2240S]$ kcal/kg

$= 1/100[8080*84+34500*(5.5 – 8.4/8) + 2240*1.5]$kcal/kg

$= 1/100[678720+153525+3360]$

$= 1/100[835605]$

$= 8356.05$ kcal/kg

$\therefore$ G.C.V $= 8356.05$ kcal/kg

Net calorific value $=$ G.C.V $-$ [9H/100 *587]kcal/kg

$= 8356.05 - [9*5.5/100*587]$

$= 8356.05 - 290.57$

$\therefore$ N.C.V $= 8065.48$ kcal/kg

d. What are drawbacks of plain carbon steel

Ans:

1. With increasing percentage of carbon the ductility decreases and brittleness increases.
2. Plain carbon steel cannot be deep hardened on heat treatment, because due to effect of heat, only surface of steel get hardened while the inner layer of the steel remains soft.
3. During the use the mechanical properties of plain carbon steels get deteriorated at higher temperature. Thus the use of plain carbon steel to make various machine parts has limitations of temperature.
4. The corrosion resistance of plain carbon steel has limited use in manufacturing various machine parts, though strengths and welding characteristics may be suitable.

e. Explain the principle 'Prevention of waste' in green chemistry.

Ans:

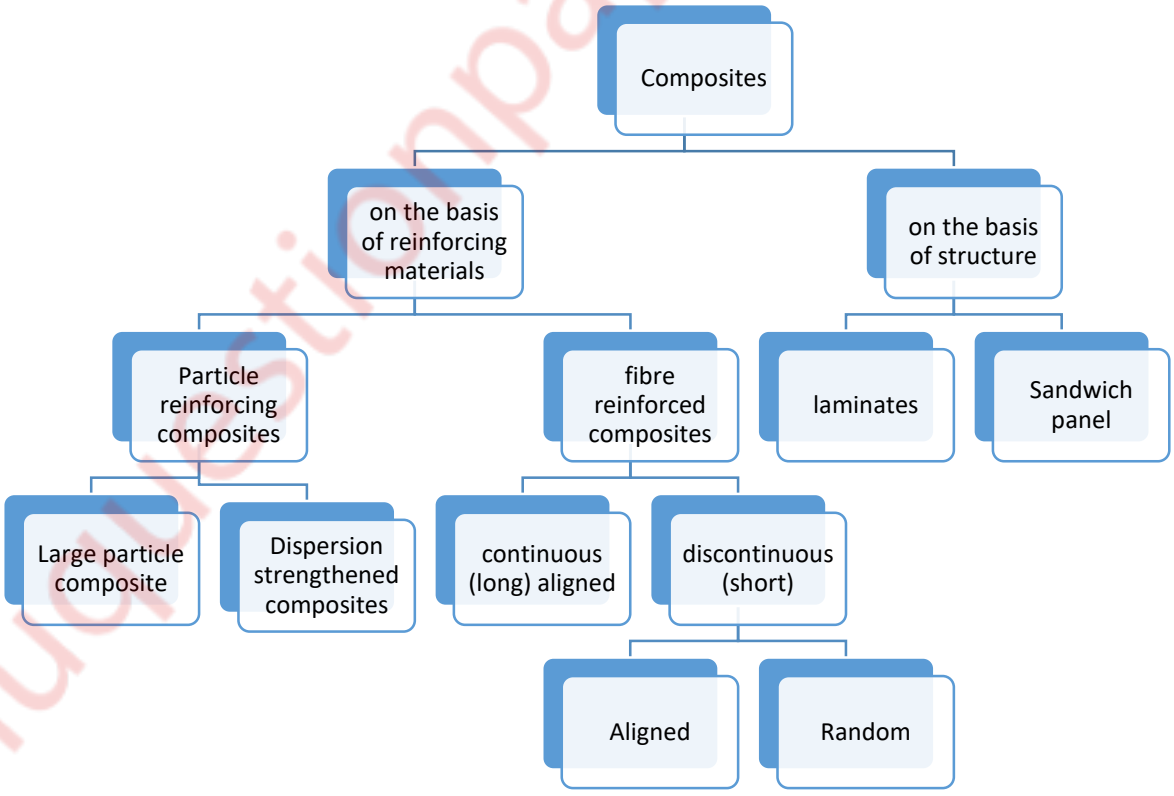
1. It is better to prevent waste than to treat and clean up waste after it is formed.
2. It has been a common practice to dump waste on land or in water or release in air. This resulted in soil, water and air pollution.

3. This made the legislation to be stringent on industries and hence there was compulsion to have waste treatment and disposal units attached to the manufacturing plants. Thus the cost of process increased considerably.
4. Thus green chemistry, involves to design chemical synthesis in such a way that the process involving pathway to give products, leaving no waste to treat or clean up.

f. Define and classify composite materials.

Ans:

1. Composite is defined as "A multiphase product made by two or more existing materials which exhibits properties of its constituents as well as shows certain unique properties of its own".
2. The composite materials are classified on the basis of reinforcing materials or structure as follows:



g. Mention three functions of thinner in paint.

Ans:

Functions of thinner in paint are:

1. To adjust viscosity and formulation in plant.
2. It helps in drying of the paint.
3. It suspend the pigment and dissolve film forming material.

Q.2.a) Define corrosion of metals. Explain the electrochemical theory of wet corrosion, giving its mechanism. (6 M)

Ans:

1. Any process of destruction and deterioration of any material is known as corrosion.
2. When metal is in immediate contact of aqueous /acidic/alkaline/natural/electrolytic solutions, the short circuited galvanic cells get set all along the surface of metal. This gives rise to corrosion which proceeds by electrochemical principles.
3. Wet corrosion is more common than dry corrosion.
4. The co-ordinating metals behave like galvanic cells thereby the parts of metal acting as an anode is consumed while the other part which is acting as cathode remains unchanged.

Mechanism:

Corrosion, by this mechanism occurs usually if environment to the metal is acidic.

Example:

Pipe lines made of iron metal get corroded if industrial waste material, or solutions of non-oxidising acids is transported through them.

The following reaction occurs:

$$Anode \xrightarrow{e-} Cathode$$

$$Fe \rightarrow Fe^{+2} + 2e^{-} \rightarrow 2H^{+} + 2e^{-} \rightarrow H_2$$

From above reactions, we can say that the flow of electrons take place from anode to cathode. These electrons are gained by cathodic reaction, and at cathodic H^+ ions are eliminated as H^2 gas. The overall mechanism can be represented as

$$Fe + 2H^{+} \rightarrow Fe^{+2} + H^2$$

Thus displacement of H^2 ions from acidic solutions by metal ions takes place. Thus all metals have tendency to get dissolved in acidic solution with simultaneous equations of the H^2 gas.

Q.2.b.i) 1.56g of coal sample was kjeldahlished and NH_3 gas thus evolved was absorbed in 50ml of 0.1N H_2SO_4. After absorption to excess (residual) acid requires 6.25ml of 0.1N NaOH for exact neutralisation. Calculate the percentage of N in the coal sample. (3 M)

Ans: Calculation of Nitrogen percentage

Weight of coal = 1.56gm

Volume of H_2SO_4 = 50 ml

Volume of NaOH = 6.25 ml

Normality of H_2SO_4 and NaOH = 0.1 N

H_2SO_4 consumed = 50-6.25 = 43.75 ml

Equivalent of H_2SO_4 = 43.75*0.1

= $4.375 * 10^{-3}$ milli equivalent

$N_2 = 4.375 * 10^{-3} * 14$

= wt. of nitrogen / wt. of coal sample * 100

= $4.375 * 10^{-3} *14 / 1.56 *100$

= 3.93 %

Q.2.b.ii) What is supercritical CO_2? Why is it considered a green solvent. (2 M)

Ans:

1. Supercritical fluids possesses properties of gases and liquids in an intriguing manner, which could after a range of applications in both synthetic and analytical chemistry.
2. **The green solvents:** A newer concept involves the technology which has been popularly preferred over conventional solvents extraction process because of environment concerns, such as the need to organic solvents and to find appropriate technologies for their disposal. **Eg.** Ionic liquid CO_2, propylene glycol, etc.

Q.2.c) Write a short note on Particle reinforced composites. (4 M)

Ans:

The size of the particle is in dispersed phase are of nearly the same in all directions.

Large particle composites:

In this sub type of composites, particulate phase should have following characteristics:

1. Stiffer and harder as compared to matrix phase.
2. It acts as reinforcing material.
3. It restrains the movement of matrix surrounding to itself.
4. The bond strength between two phases governs mechanical properties of composites.

Q.3.a) What is cracking? Explain in detail – fixed bed catalytic cracking. (6 M)

Ans:

1. Cracking is a process of converting heavy oil with higher molecular weight hydrocarbons to the oil with lower molecular weight hydrocarbons which is known as gasoline.
2. Generally on cracking a mixture of hydrocarbons is obtained which is allowed to undergo fractional condensation to separate gasoline.

Thermal Cracking:

a. Liquid phase thermal cracking: By this any type of oil can cracked. In this method the oil is pumped into the coil kept at 420^0C to 550^0C under pressure of 15 to 100 kg/cm^2 .
b. Vapour phase thermal cracking: in this method the heavy is treated at 400^0c to convert it into the vapour and then these vapours are passed to the reaction chamber.

Catalytic cracking:

a. It is a process in which heavy is oil is heated in presence of catalyst. Generally used catalyst are crystalline substances.

Eg: bauxite, zeolite, crystalline alumina silicate, etc.

Fixed bed catalytic cracking:

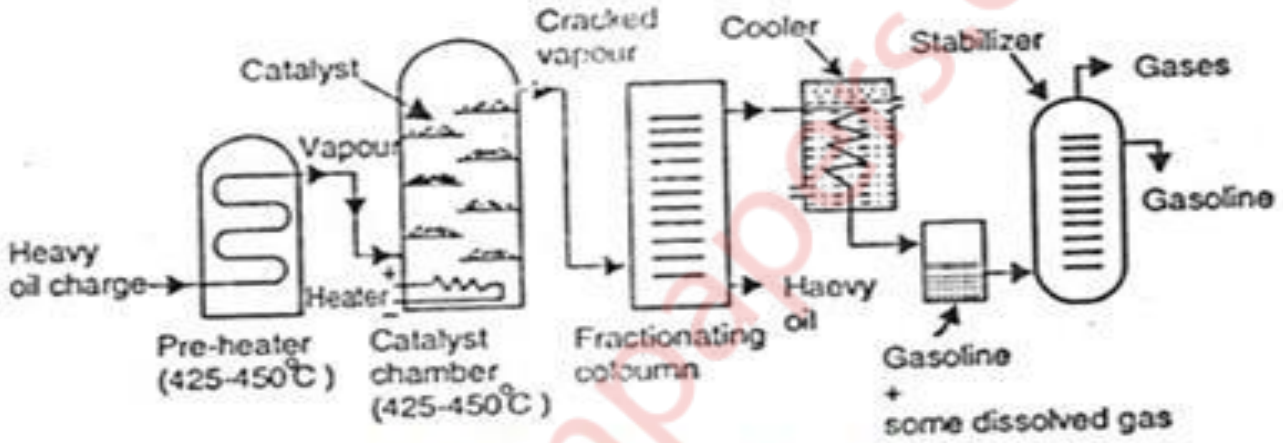


Fig.4. Fixed-bed catalytic cracking.

1. In this method vapours of heavy oil is treated in the presence of catalyst due which a better yield of petrol is obtained.
2. In this method heavy oil is vapourised by heating in an electrical heater. Then the vapours are passed over a series of trays containing catalyst. Generally the catalyst used are crystalline alumino-silicate, bauxite and zeolite.
3. The reaction chamber is maintained at 425^0c to 450^0c and under pressure of 1.5 kg/cm^2.
4. The cracked gases are taken out from the top of the reaction chamber and are allowed to pass in the fractionating tower, where gasoline fraction is collected. The octane value of this gasoline is about 80-85.
5. During the cracking, free carbon is also formed which deposits in catalyst, then the flow of vapours of heavy oil is passed over the second set of reaction chamber and catalyst in earlier chamber in regenerated by burning the carbon deposits with help of air.

Q.3.b.i) Write a note on heat resistant steel (3 M)

Ans:

These are steels which are exposed to high temperatures during proportion of equipment.
Heat resistance is obtained by adding specific metals in appropriate proportion.
Following metals are used/added in stainless steel in order to make them heat resisting.
Molybdenum: 3.5% addition of this metal improves heat resistance of steel.

Chromium: though this is the component in steel, but it is added more than 12%, it imports high grade heat resistance to steel. Such a steel is called as 'nichrome'.
Uses:
For making equipment facing high temperature i.e. gas turbines, retorting, parts of boilers, steam – linings, aero engine valves, etc.

Q.3.b.ii) A metal rod half immersed in water starts corroding at the bottom. Give reasons. (2 M)

Ans:

A metal rod when partially dipped in water or dilute solution of salt; like Nacl and if solution is not agitated properly then the parts of the strip above and closely adjacent to the water line are more strongly aerated, because they have more strongly aerated, and have more supply of oxygen while remaining parts of rod which is immersed to greater depth have less supply of oxygen and these are poorly aerated and show lower oxygen concentration and hence a metal rodhalf immersed in water starts corroding at the bottom.

Q.3.c) Calculate the percentage of atom economy for the following reaction with respect to allyl chloride. CH_3-CH=CH_2+Cl_2 → Cl-CH_2-CH=CH_2+HCl (4 M)

Ans:

CH_3-CH=CH_2+Cl_2 → Cl-CH_2-CH=CH_2+HCl

Prpene (42) (71) Allyl chloride (76.5) (36.5)

% Atom economy = molecular weight of product/total mol. Weight of reactants * 100

=76.5/42+71 * 100

=76.5/113 * 100

= 67.7%

% Atom economy = 67.7%

Q.4.a) Explain how the following factors affect the rate pf corrosion (6 M)

i) pH

Ans: In acidic pH the rate of corrosion is higher, because the mechanism of electrochemical corrosion proceeds by evolution of hydrogen gas at cathode. On the contrary, in alkaline or neutral electrolytic medium the electrochemical corrosion occurs by following the mechanism of absorption of oxygen, thereby forming as oxide film as a cathodic product. Such a film gets adhered to the surface of the metal and further rate of corrosion is governed by nature of corrosion product which is discussed as above.

ii) Ratio of anode to cathode areas.

Ans:

1. If two dissimilar metals are in contact one forming anode while another cathode, then the corrosion of the anodic metal is directly proportional to the ratio of the areas occupied by cathode and anode.
   Thus, corrosion at anode
   α = area of cathodic part / area of anodic part

2. Hence, if cathode is large and anode is small, then corrosion at anode is higher and vice – versa.

iii) Position of metal in galvanic series.

Ans:

1. This is the major factor for corrosion of metals are in corroding environment, the metal having higher electrode potential in the galvanic series undergoes corrosion, i.e. it act as a anode.

Q.4.b.i) Write a brief note on products obtained from natural materials. (3 M)

Ans:

1. Plants have been playing an important role in the field of pharmacy, not only in ancient time but also in arena of modern drug discovery.
2. The chemical diversity of plant gives the important dew for synthesis of different efficient pharma cophore in pharmaceutical during design.
3. Example like merpidine, pentazoine, are totally synthetic drugs for which opiates such as morphine and codeine were the models
4. Japanese research group has recently isolated stilbane derivatives from the bark of a shorea hemsleyana and roots of cyphostomma bainessi.
5. The active compounds identified is hemsleyanol – D is potent anti-bacterial agent methicillin resistance staphylococcus aurous responsible for variety of human diseases.

Q.4.b.ii) Define structural composites. (2 M)

Ans: A structural composites consists of both homogenous and composites materials. Their properties of the constituent materials as well as the geometric design. Structural composites are of two types such as,

a) Laminar composites: eg. Plywood
b) Sandwich composites: eg. Honeycomb core.

Q.4.c) Define shape memory alloys and mention its applications. (4 M)

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

Applications:

1. Orthopaedic applications:
   - Microstents simon filter micro wrapper.
2. cardiovascular applications are:
   - microsurgery
   - reinforcing week blood vessels
   - microstents.
3. Intravascular therapy:
   - Micro assembly for MEMS devices
   - Facilitates access to intricate regions of the body
   - Grab tiny foreign objects for removal from the body

Q.5.a) A sample of coal was found to contain the following constituents. C = 81%, O = 8%, S = 1%, H = 5%, N = 1% and Ash = 4%. Calculate the minimum weight and volume of an required for the complete combustion of 1kg of coal. (6 M)

Ans:

Let us calculate the 0_2 required for 1kg of coal first

Weight of carbon = 81 / 100 * 1 = 0.81 kg

Weight of hydrogen = 5 / 100 * 1 = 0.05 kg

Weight of sulphur = 1 / 100 * 1 =0.01 kg

Weight of oxygen = 8 / 100 * 1 = 0.08 kg

Calculation of O_2 needed for 1 kg of coal

CO_2 = 0.81 * 32 /12 = 2.16 kg

$2H_2O$ = 0.05 * 32 / 12 = 0.4 kg

SO_2 = 0.01 * 32 / 12 =0.01 kg

Total O_2 required = 2.57 kg

Less O_2 available = -0.08

Net O_2 required = 2.49 kg

Weight of air required = weight of O_2 / 23 *100

= 2.49 / 23 *100

= 10.82 kg of air

Volume of air:

$\therefore 28.94$ kg of air $= 22400$ ml volume at NTP

$\therefore 10.82$ kg of air $= 22400 * 10.82 / 28.94$

$= 8374.84$ ml

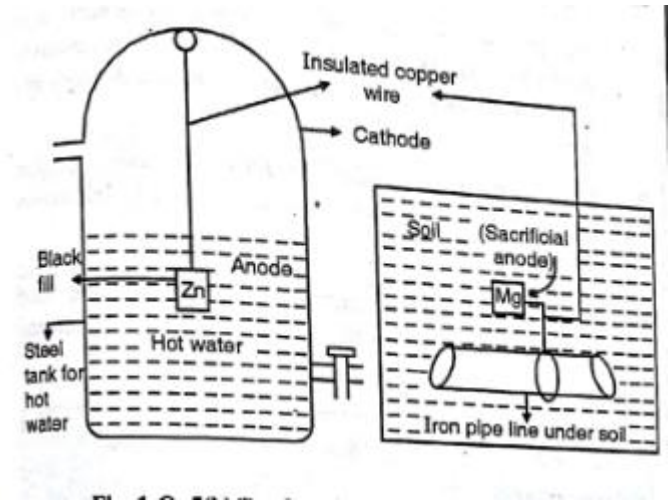
air $= 8.375$ litres of air

Weight of air requires $= 10.28$ kg

Volume of air required $= 8.375$ Litres.

Q.5.b.i) Discuss in brief sacrificial anode method of corrosion protection. (3 M)

Ans:



1. To achieve protection by sacrificial anode method, the metal to be protected from corrosion is connected by a wire to another piece of metal which is more reactive than the base metal itself.
2. This results in the corrosion of the piece of metal, connected thereby saving base metal.
3. Since the more active metal sacrifices itself, by undergoing corrosion and saving the base metal the method is named as sacrificial anode or auxiliary anode method.
4. The metal normally used are Mg, Zn or Al.
5. The method is generally used to protect cable or iron pipelines, by connecting them to Mg blocks, and in case of marine structures, ships are protected by suing Zn plates as sacrificial anode. Even water tanks, boilers are protected by using Zn metal.

Q.5.b.ii) What is powder metallurgy? Mention any two advantages and two limitations of powder metallurgy. (2 M)

Ans:

1. Powder metallurgy is the process which deals with the product of useful components from fine metal powders, from individual, mixed or alloyed with or without the inclusion of non-metallic constituents.
2. In this process,
   - Metal is obtained powder form
   - Powdered metal is mixed with other elements in powder form
   - It is then subjected to high pressure so s to get compressed into desired shape
   - The shaped is then finished finished into final form various combinations with metal and non-metals are possible.

Advantages:

1. By PM, materials can be made using, metal or non-metal in any desirable composition
2. Dimensional accuracy and finish of the materials are excellent.

Limitations:

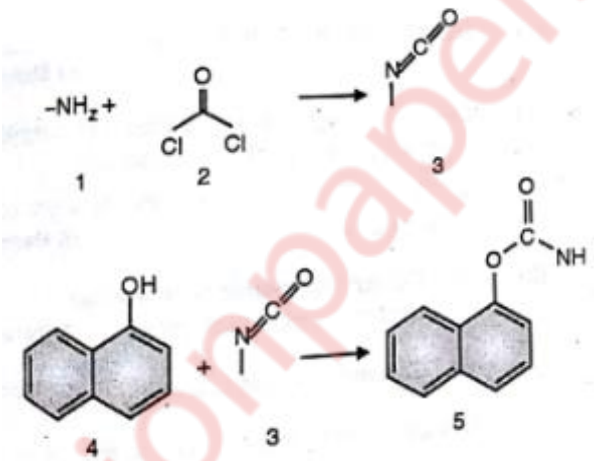
1. Storage of metal powder requires precautions, because powder metals get oxidised in air if exposed. This cause wastage.
2. Process is not suitable to produce large size components because process available for compaction are of limited capacity.

Q.5.c) Explain with suitable equations conventional and green synthesis of carbaryl. Also mention the principle of green chemistry involved. (4 M)

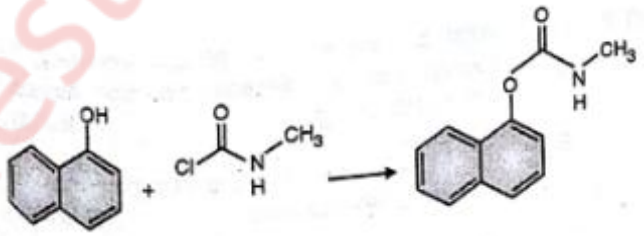
Ans:

Conventional route:

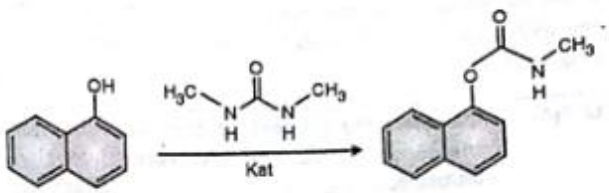
Carbonyl is prepared on large scale by treating methyl-isocynate with 1-napthol, anine is treated with phosgene to get methyl-isocynate. Carbaryl is produced by treating methyl isocynte with 1-napthol



- With using napthol-1 methylcarbomoyl chloride:

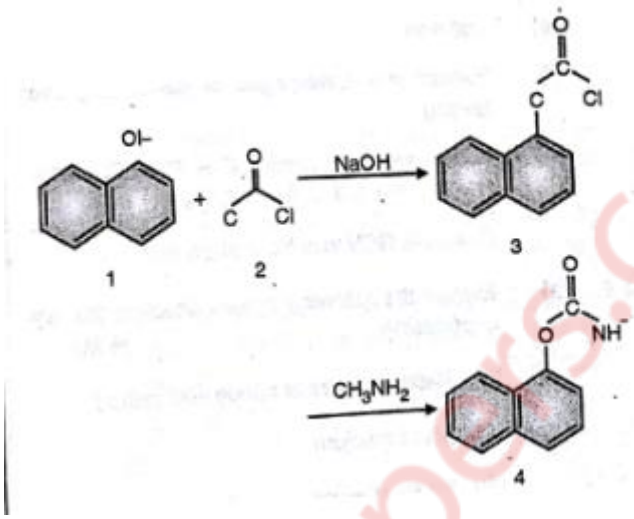


- In these route of synthesis of carbaryl highly toxic substance such as phosgene, methyl isocynate and methylcarbamoyl chloride are used.



Green route:

1. Napthol treated directly with equal quantity of phosgene is alkaline medium to get chloroformate which is then treated with methylamine to give carbary alternatively, 1-napthol is first converted to its chloroform, which is then treated with methylamine to give desired product.



2. Greener route synthesis also uses exactly the same reagent, but these are taken in different sequence. Hence, this sequence avoids the proportion of methyl isocynate. But use of phosgene and methyl amine is still needs to be avoided.

Q.6.a) Mention the composition, properties and uses of (6 M)

i. Duralumin:

Compositon:

Aluminium (Al) = 95%

Copper (cu) = 4%

Manganese (mn) = 0.5%

Magnesium (mg) = 0.5%

Properties:

1. It is light weighted, tough, highly, ductile, easily, castable, good conductor of heat and electricity and corrosion resistant.
2. It can easily be worked as it possesses high machinability. Its tensile strength can be raised by heat treatment, up to about 2000 kg-cm^2 without affecting its ductility. It approaches steel in strength and yet its density is one third of steel.

Uses:

Due to high strength with low density, it finds extensive use in aircraft industry in the form of a 'clad'. It is also used in making surgical instruments, cables, fluorescent tube caps etc. It is also used in making automobile and locomotive parts because off its high ductility and good electrical conductivity.

Q.6.a.ii) German silver

Ans:

Composition:

Cu = 25 -50%

Zn = 10 – 35%

Sn = 5 – 35%

Properties:

Possesses good strength, high corrosion resistance to electrolyte, high ductility, malleability, appears like silver.

Uses:

Decorative articles, utensils, table wares, ornaments, cutlery etc.

Q.6.a.iii) Gun metal

Ans:

Composition:

Cu = 85%

Zn = 4%

Sn = 8%

Pb = 3%

Properties:
High strong, can resist explosion, hard, tough.

Uses:

For hydraulic fittings, high pressure steam, plant marine, pumps, water fillings etc.

Q.6.b.i) Mention the advantages of composite materials (3 M)

Ans:

The composite materials find variety of applications in all these areas where, high mechanical strength, dimension stability, thermal stability, corrosion, resistance, abrasion resistance etc. is desirable. They find application in following industries.

a) Construction.
b) Electrical and electronics and telecommunication
c) Transportation
d) Agriculture
e) Sport goods
f) Automobile
g) Aviation industry
h) Mobiles

Composites, in short are extremely useful and more research work is going on to develop newer materials to cater to various industries.

Q.6.b.ii) Distinguish between anodic and cathodic coating (2 M)

Ans:

Anodic coating	Cathodic Coating
1. This type of coating protect base metal sacrificially.	1. This type of coating protect the base metal because of high corrosion resistance and noble behaviour
2. The coating metal is at lower electrode potential than base metal.	2. The coating metal is at higher electrode potential than base metal.
3. Corrosion of base metal does not enhance even on breaking "anodic coating" as it heals its film	Corrosion of base metal enhances, if there is a small cut in coating
4. Eg. Galvanising i.e. Zn coating on iron/steel	Eg. Tinning i.e. tin coating on iron/steel/copper/brass.

Q.6.c) What is biodiesel? Discuss the method to obtain biodiesel. What are the advantages of biodiesel? (4 M)

Ans:

1. Chemically biodiesel is the methyl esters of long chain carboxylic acids.
   Method to obtain biodiesel are:
   1. Filter cheap or waste vegetable oil/fat/
   2. Heat it at 110^0C with stirring to remove any water from it.
   3. Prepare sodium methoxide from sodium metal and methanol. Add the sodium methoxide about 2% by weight to the vegetable oil or fat.
   4. Add methanol about 20% by volume to the, mixture.
   5. Heat the mixture with stirring for 30 minutes.
   6. Cool and mix sufficient water, stir well. The glycerol and soap dissolve in water phase.
   7. Separate the water insoluble phase from water phase
   8. Add antioxidants to biodiesel to avoid it to become gummy due to oxidation and polymorphism.

   Advantages:

   1. Biodiesel is cheaper
   2. It has high cetane numbers 46 to 54 and high c.v. of about 40 kJ/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 use provides good market to vegetable oils and reduces over dependence for diesel on foreign countries, saving currency.
   7. It is clean to use biodiesel in diesel engines.

APPLIED CHEMISTRY- II (MAY-2018 SOLUTION)

Q.1. Attempt any 5 of the following: [3 M x 5 Q= 15 M]

Q.1. (a) Define Power Alcohol. Give any two advantages of power alcohol.

Ans:

Power Alcohol:

When ethyl alcohol is used as fuel in internal combustion engine, it is called as power alcohol.

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

Advantages:-

1) Addition of ethyl alcohol to petrol increases its octane number.
2) Power alcohol is cheaper than petrol.

Q.1. (b) Explain why cathodic coating is preferred over anodic coating for manufacturing of containers to store food stuffs.

Ans:

1) Cathodic Coating is used for storing any foodstuff as it is nontoxic.
2) It protects the metal from corrosion and avoids any food poisoning.
3) E.g.:- Tinning.

Q.1. (c) A sample of coal has the following composition:-

C= 70% O=23% H=5% S=1.5% N=0.4% Ash=0.1%

Calculate GCV of this fuel.

Ans:

Given: - C= 70% **O**=23% **H**=5% **S**=1.5% **N**=0.4% **Ash**=0.1%

Required: - GCV=?

Formula: GCV$= \frac{1}{100}[8080C + 34500\left(H - \frac{O}{8}\right) + 2240S]$

Calculations:

GCV$=\frac{1}{100}[8080 \times 70 + 34500\left(5 - \frac{23}{8}\right) + 2240 \times 1.5]$

GCV= 6422.725 kcal/kg

Q.1. (d) Give the composition, properties and uses of high phosphorous bronze.

Ans:

High Phosphorous bronze

Composition:

Sn = 10-13% **P** = 0.4-1% **Cu** = Rest%

Properties:

1) Good Strength and resistance to corrosion under sea water.
2) It can be rolled or drawn into wires.
3) Abrasion resistant
4) Hard
5) Brittle
6) Low coefficient of friction.

Uses:

1) For springs, turbine blades, pumps, boiler fitting, bearing plates, spindle, for valves.

2) For gear wheels, side, valves, bearing, taps, bushes springs, turbine blades etc.

Q.1. (e) Why is it essential to design safer chemicals and products wrt green chemistry principle? Explain with an example.

Ans:

1) The synthetic method should be designed wherever possible to use and generate substances having little or no toxicity to human health and the environment.
2) The starting material selected should be least toxic.
3) The reactions in which intermediates or reagents or products are toxic should not be followed. Instead alternative pathways should be used for synthesis.
4) Bhopal Gas Tragedy led to lots of deaths.
5) Thus, green chemistry recommends the design of synthesis to use and generate substances with little or no toxicity to humans and the environment.

Q.1. (f) What is matrix phase and particle phase in concrete? Give any two properties of concrete.

Ans:

Concrete

Matrix Phase = Cement

Particulate Phase= Sand and Gravels

Properties:

1) It is harder than ordinary cement.
2) Sets well on surface thereby holding structures.

Q.1. (g) Porous Film is also called as 'Non protective Film'. Explain with an example.

Ans:

In porous film, the volume of metal oxide formed is less than the volume of the metal from which it is formed. Hence this film possesses pores or cracks in the structure. Through these pores, atmospheric oxygen can enter and attack the metal. Hence it is non protective oxide film. Examples: Such type of oxide film is formed in alkali metals like Li, K, Na and alkaline metals like Ca, Sr, and Mg.

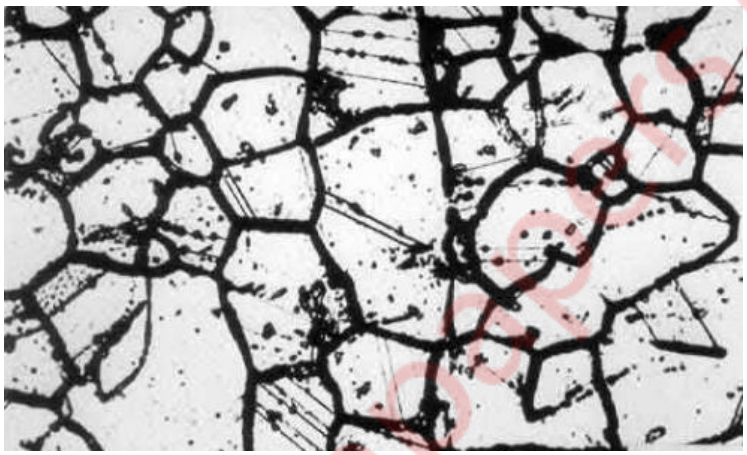
Q.2. (a) Define Electrochemical Corrosion. Explain Intergranular Corrosion with a neat diagram. [6 M]

Ans:

The corrosion which is brought about through ionic reactions in the presence of moisture or solution as a conducting medium when two dissimilar metals are in contact with each other is called electro chemical corrosion. It also occurs when the metal surface is in immediate contact with aqueous acidic/alkaline/neutral/electrolytic solutions forming the short circuited galvanic cells.

- Intergranular corrosion (IGC), also known as intergranular attack (IGA), is a form of corrosionwhere the boundaries of crystallites of the material are more susceptible to corrosion than their insides. (Cf. transgranular corrosion.)
- This situation can happen in otherwise corrosion-resistant alloys, when the grain boundaries are depleted, known as grain boundary depletion, of the corrosion-inhibiting elements such as chromium by some mechanism.
- In nickel alloys and austeniticstainless steels, where chromium is added for corrosion resistance, the mechanism involved is precipitation of chromium carbide at the grain boundaries, resulting in the formation of chromium-depleted zones adjacent to the grain boundaries (this process is called sensitization).

- Around 12% chromium is minimally required to ensure passivation, a mechanism by which an ultra thin invisible film, known as passive film, forms on the surface of stainless steels. This passive film protects the metal from corrosive environments.
- The self-healing property of the passive film make the steel stainless. Selective leaching often involves grain boundary depletion mechanisms.



Q.2. (b) i) 1.95 gm of coal sample was taken for nitrogen estimation by Kjeldahis's method. The ammonia liberated required 9.5 ml of 0.4 N H_2SO_4 for neutralization. Calculate the percentage of nitrogen in coal sample. [3 M]

Ans.

Given:

Weight Of Coal= 1.95 gm **Normality of H_2SO_4=** 0.4 N

Volume of H_2SO_4= 9.5 ml

Required: % N=?

Formula: %N=$\frac{vol\ of\ H2SO4 \times Normality \times 1.4}{wt\ of\ coal}$

Calculations:

%N=$\frac{9.5 \times 0.4 \times 1.4}{1.95}$

%N= 2.72%

Q.2.(b) (ii) Write a note on Green Solvents. [2 M]

Ans.

The green solvent is newer concept involves technology which has been popularly preferred over conventional solvent extraction process because of environmental concerns, such as the need to eliminate organic solvents and to find appropriate technologies for their disposal e.g. Ionic liquids CO2,Propylene Glycol etc. Super critical fluid possesses properties of gases and liquids in an intriguing manner, which could offer range of applications/possibilities in both synthetic and analytical chemistry. Supercritical ionic liquid carbon dioxide has found to be an energy conserving, selective and waste reducing alternatives to organic solvents and therefore is viewed as promising environmentally benign solvents. In addition supercritical fluids can lead to reaction, which are difficult or even impossible to achieve conventional solvents Supercritical ionic extraction is relatively new technology with a large potential for application in industry.

Q.2. (c) Explain structural Composition of plywood. [4 M]

Ans.

Adjacent wood sheets in plywood are aligned with the grain direction at right angles to each other. Laminar composites are constructed using the same materials such as cotton, paper or woven glass fibers.

It possesses high strength in a number of direction in the 2-D planes.

Q.3. (a) Define Fuel Cell. Explain Hydrogen Oxygen Fuel Cell with a neat diagram. [6 M]

Ans.

A cell capable of generating an electric current by converting the chemical energy of a fuel directly into electrical energy is known as fuel cell.

Q.3. (b) i) Define Shape Memory Alloys. Give its properties and uses. [3 M]

Ans.

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

Properties:

1) Excellent corrosion resistance.
2) High fatigue strength.

Uses:

1) Microsurgery
2) Reinforce weak blood vessels.

Q.3. (b) ii) Define bio-diesel and give its advantages. [2 M]

Ans.

Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil.
Chemically biodiesel is the methyl ester of long of long chain carboxylic acids. It is also called as 'Green Fuel'.

Advantages of Biodiesel:

1. Cheaper
2. High cetane numbers 45 to 54 & high CV of @ 40KJ/gm.
3. Regenerative & environmental friendly. It causes less pollution.
4. It has certain extent of lubricity.
5. Clean to use in diesel engine.

Q.3. (c) Calculate the % atom economy for the following reaction with respect to acetophenone. [4 M]

C6H6+CH3COCL = C6H5COCH3+HCL

Ans.

Given:

Molecular weight of Products= 12x6+1x5+12+16+12+1x3= 120

Molecular Weight of Reactants= 12x6+1x6+12+1x3+12+16+35.5= 156.5

Required: %Atom economy= ?

Formula: %Atom economy= $\frac{molecular\ weight\ of\ the\ product}{total\ molecular\ weight\ of\ the\ reactants} \times 100$

%Atom economy=$\frac{120}{156.5} \times 100$

%Atom economy= 76.677

Q.4. (a) What is cathodic protection? Explain impressed current cathodic protection with the applications. [6 M]

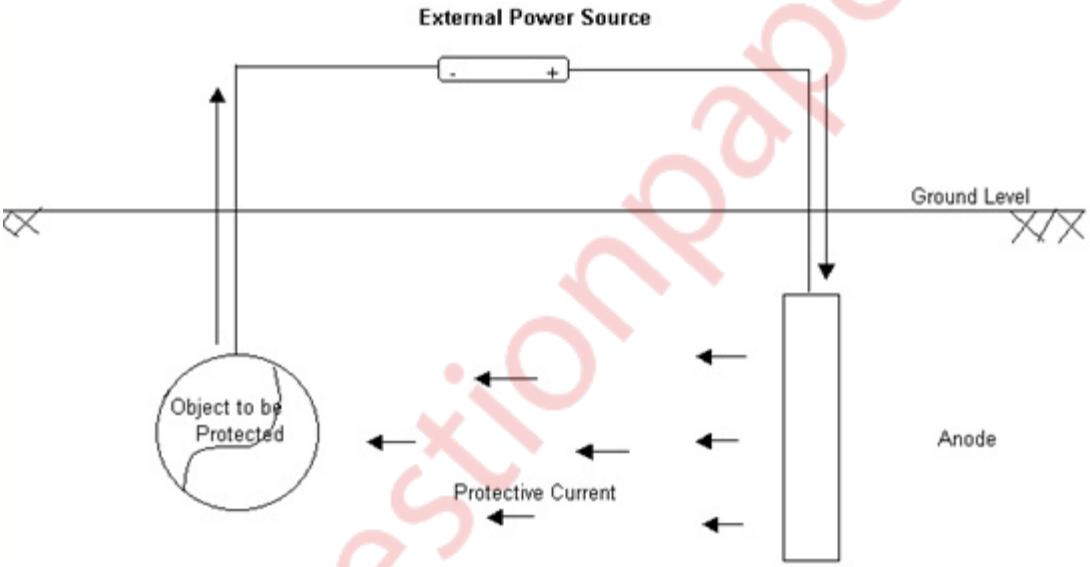
Ans.

Cathodic protection:

In this process base metal is forced to behave like a cathode either by connecting it with some more active metal or by using impressed current in order to protect it from corrosion. It can be explained by considering the corrosion of metal M in acid environment.

Impressed Current Cathodic Protection

In this method, a current is applied in the opposite direction to that of the corrosion current there by nullifying its effect on the base metal i.e. converting the base metal to cathode from anode. The impressed current is obtained by using a D.C. source such as a wet battery or a dry cell along with an insoluble anode such as platinum, stainless steel, graphite etc. which is embedded underground and to this, impressed current is applied. The whole assembly is connected to the metallic structure to be protected. The anode can be single fora small structure like water tank or there can be many series connected such anodes if the structure to be protected is big like long pipeline, oil-rig platforms on the sea etc. The insoluble anode is kept inside back-fill made up of mostly gypsum which increases the electrical contact with the soil.



Advantages:

This method can protect very large and long structures. Further its maintenance is easy.

Disadvantage:

The anode needs frequent replacement.

Applications:

Protection from soil corrosion of underground pipelines, cables, protection from seawater corrosion of cables ship bulls, piers.

Q.4. (b) (i) What is green chemistry? Give its significance. [3 M]

Ans.

Green Chemistry

Environment friendly chemical synthesis which reduces the use and generation of hazardous substance/pollutants is known as Green chemistry.

Significance of Green chemistry:

1) A novel approach that blends the application of chemistry with economic growth and environmental preservation.
2) To develop strategy for sustainable chemical process industries.
3) Achieve conservation of limited resources through cost effectiveness and pollution prevention.
4) Therefore basic axiom of Green chemistry is to design product and processes that reduce or eliminate the generation of all wastes.

Q.4. (b) (ii) Define Composite. Give any two applications of composite materials. [2 M]

Ans.

Composite materials can be defined as 'A multiphase product made using two or more existing materials which exhibits properties of its constituents as well as shows certain unique properties of its own'. Thus, composites are engineered materials, comprising of metals, ceramics, glasses and polymers.

Applications:

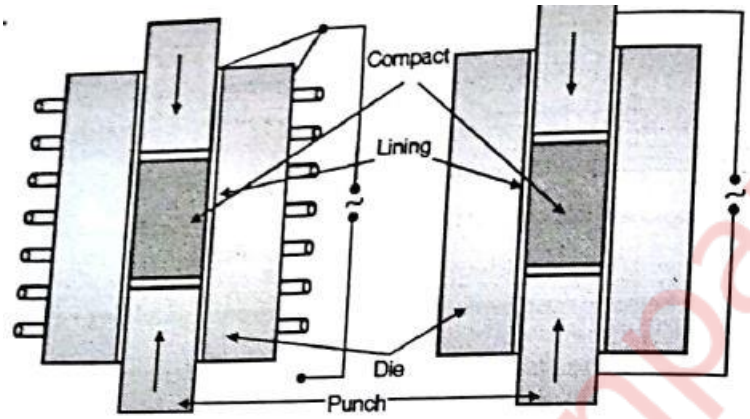
1) Construction
2) Transportation
3) Electrical and electronics and telecommunication
4) Agriculture

Q.4. (c) What is powder metallurgy? Explain hot compaction method with a neat labelled diagram. [4 M]

Powder metallurgy 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.

Hot Compaction Method:

The equipment used is similar to that used in cold compaction.



(A) By induction heating (B) by direct current heating

Fig. 2.9.5 : Tooling for axial hot

But the process is operated at higher temperature, and pressure. The ceramic powder with the binder are fed into die and pressed at high temperature and pressure into article, followed by sintering and finishing. The temperature can be raised by direct current of induction current.

Uses:

Process is used for making tools such as metal bonded diamond tools, or carbide compacts.

Q.5. (a) A gaseous fuel contains H_2=50% CH_4=30% N_2=2% CO=7% C_2H_4=3% C_2H_6=5% and water vapours=3%. Calculate weight and volume of air for 2m^3 of the gas. [6 M]

Ans.

Given:

H2=50% **CH4=**30% **N2=**2% **CO=**7% **C2H4=**3% **C2H6=**5% **water vapors=**3%

Required: Vol. and weight for complete combustion of 2 m3 of fuel.

	Constituents	Volume		Reaction	Vol. of oxygen required
		%	m3		
(i)	H_2	50	0.5	$H_2+\frac{1}{2}O_2=H_20$	0.5X0.5=0.25
(ii)	CH_4	30	0.3	$CH_4+2O_2=CO_2+H_2O$	0.3X2=0.6
(iii)	CO	7	0.07	$CO+\frac{1}{2}O_2=CO_2$	0.07X0.5=0.035
(iv)	C_2H_4	3	0.03	$C_2H_4+3O_2=2CO_2+2H_2O$	0.03X3=0.15
(v)	C_2H_6	5	0.05	$C_2H_6+3.5O_2=2CO_2+3H_2O$	0.05X3.5=0.175

Total Volume of O2 Required= 0.25+0.6+0.035+0.15+0.175= **1.21**

Vol. of air required=1.21x2 m^3=**2.420m3**

22.4 m^3 of air weighs 28.949 kg

2.420 m^3 of air will weigh =$\frac{2.420}{22.4} \times 28.949 = \mathbf{3.12}\boldsymbol{kg}$

Wt. of air required=3.12kg.

Q.5.(b) (i) List the three main constituents of paint and give functions of each. [3 M]

Ans.

Paints are formed by using various ingredients which are listed below. Each ingredients is mixed for a particular function.

1) Drying oils /medium/ vehicle.
2) Pigments
3) Thinners
4) Driers

Constituent - Drying oils or vehicle

Examples - Linseed oil, soya bean oil, dehydrated castor oil, neem oil, fish oil, etc.

Functions - They help pigments to be held on surface. They provide dried film by oxidation or polymerization. They provide durable water resistant film of paint.

Constituent - Pigments

Examples - White pigments: White lead, ZnO, Titanium oxide, Coloured pigments Red lead, Fe_2O_3, chrome red, etc.

Functions - Provide opacity, colour strength, and protection. Provide resistance against abrasion. Minimize shrinkage and cracking caused on drying.

Constituent - Thinners

Examples - Turpentine, spirits, benzene, naphtha, xylol, kerosene, methylated naphthalene etc.

Functions - Adjust viscosity of formulation. Help in drying of the paint. Suspend the pigments and dissolve film forming material.

Constituent - Driers

Examples - Oxygen carrying catalyst, Linoleates of Co, Mn, Zn, etc

Functions - Improve drying process. Act as catalyst in drying process.

Q.5. (b) (ii) Explain the effect of the following alloying elements on steel. [2 M]

Ans.

Chromium

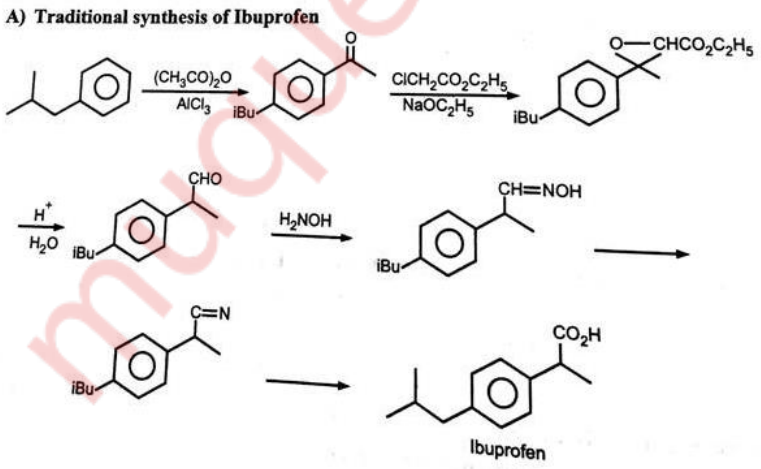
Improves tensile strength , hardness, wear resistance, and toughness. Imparts high corrosion resistance.

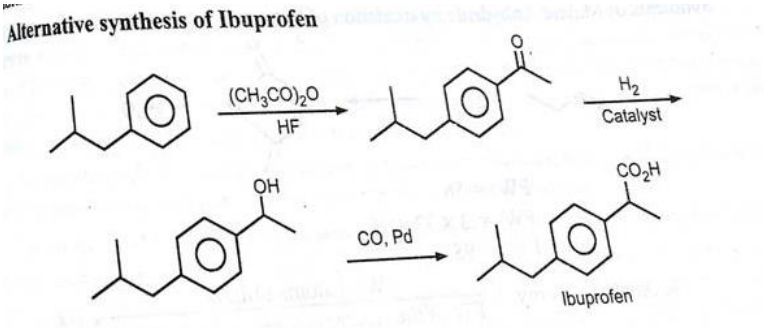
Tungsten

Improves red hardness, toughness, abrasion resistance and shock resistance.

Q.5. (c) Explain conventional and green chemistry route for production of Ibuprofen. Highlight the green chemistry principle involved. [4 M]

Ans.





Q.6. (a) Write short notes on:-

a) Computing b) Sintering [6 M]

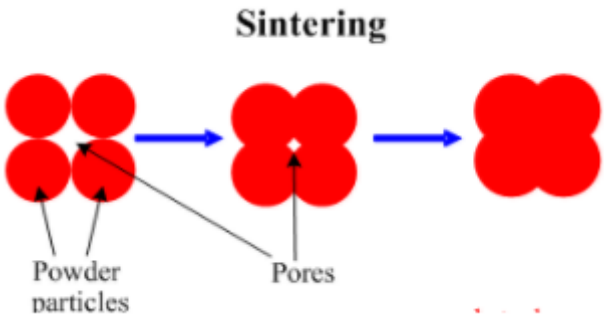
Ans.

(i) Compaction:

- A controlled amount of the mixed powder is introduced into a precision die and then it is pressed or compacted at a pressure in the range 100 MPa to 1000 MPa.
- The compacting pressure required depends on the characteristics and shape of the particles, the method of mixing, and on the lubricant used.
- This is generally done at room temperature. In doing so, the loose powder is consolidated and densified into a shaped model.
- The model is generally called “green compact.” As is comes out of the die, the compact has the size and shape of the finished product.
- The strength of the compact is just sufficient for in – process handling and transportation to the sintering furnace.

(ii) Sintering:

- During this step, the green compact is heated in a protective atmosphere furnace to a suitable temperature, which is below the melting point of the metal.
- Typical sintering atmospheres are endothermic gas, exothermic gas, dissociated ammonia, hydrogen, and nitrogen.
- Sintering temperature varies from metal to metal; typically these are within 70 to 90% of the melting point of the metal or alloy.



- Sintering is a solid state process which is responsible for producing physical and mechanical properties in the PM part by developing metallurgical bond among the powder particles.
- It also serves to remove the lubricant from the powder, prevents oxidation, and controls carbon content in the part.
- The structure and porosity obtained in a sintered compact depend on the temperature, time, and processing details.
- It is not possible to completely eliminate the porosity because voids cannot be completely closed by compaction and because gases evolved during sintering.
- Porosity is an important characteristic for making PM bearings and filters.

Q.6. (b) (i) What are fiber reinforced composite? [3 M]

Ans.

Fibre reinforced composite material:

- Fibre reinforced composite can be made from metals, ceramics, glasses or fibre that have been turned into graphite which is known as carbon fibre.
- These composites are very expensive as reinforcement of fibre into matrix is difficult.
- Fibre pull is possible and while increasing or decreasing length bond breaking is observed.
- In time trial racing bicycle frame carbon fibre is used along with matrix phase which is made up of thermosetting plastic.
- In racing car glass fibre is used along with thermosetting plastic.
- There are 2 types of fiber reinforced composites:

i) Continuous & aligned composite

ii) Discontinuous fibre reinforced composite

Q.6. (b) (ii) Explain how areas of cathode and anode affect the rate of corrosion. [2 M]

Ans.

Relative areas of the Anodic and Cathodic Parts:

When 2 dissimilar metals are in contact, the corrosion of the anodic part is directly proportional to the ratio of areas of the cathodic part and anodic part. Thus, mathematically,

$$Rate\ of\ Corrosion \propto \frac{Acathode}{Aanode}$$

This is because when the cathode area is larger than the anodic area, then the demand for electrons by the cathodic area will be more which can only be met by the anodic area by undergoing faster corrosion. Thus, smaller the area of the anode, faster is the rate of corrosion. Thus,

$$Corrosion \propto \frac{1}{Anode\ Area}$$

Q.6. (c) Explain the determination of % moisture and % volatile matter in a coal sample. [4 M]

Ans.

% Moisture:

- A known weight of powdered and air dried coal sample is taken in a crucible and it is placed in preheated oven for 1 hour at 110 C. Then the coal is cooled in a dessicator and weighed out.

- If the initial weight of the coal is m gms and final weight is m1 gms.
- Then the loss in weight corresponds to moisture in coal.
- Moisture %= $\frac{loss\ in\ weight}{weight\ of\ coal\ sample} \times 100 = \frac{m-m1}{m} \times 100$

% Volatile Matter:

- Moisture free coal left in the crucible in the first experiment is covered with a lid loosely. Then it is heated at 925 C in a furnace for 7 minutes.
- The crucible is taken out and cooled in a dessicator. Then it is weighed again. The loss in weight is due to loss of volatile matter in the m gms of the coal sample.
- % volatile matter = $\frac{weight\ of\ volatile\ matter}{weight\ of\ air\ dried\ coal} \times 100 = \frac{m1-m2}{m} \times 100$
- The volatile matter % can also be determined by taking the fresh weight of the air dried coal but the loss in weight at 925 C, will be due to loss of moisture and volatile matter both.
- If w is he weight of air dried coal and w2 is the mass of coal left at 925 C heating then,
- % Volatile Matter= $\frac{loss\ in\ weight\ due\ to\ moisture\ and\ V.M.}{Weight\ of\ coal\ sample} \times 100$

APPLIED CHEMISTRY 2

(CBCGS DEC 2018)

Q1] a) Define Fuel. Why a good fuel must have low ash content? (3)

Solution:-

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.” This definition does not include nuclear fuel because it cannot be used easily by a common man. The various fuels used economically are wood, coal, kerosene, petrol, diesel gasoline, coal gas, producer gas, water gas, natural gas etc. the fossil fuels such as wood , vegetables oils etc., which burns to produce heat are called as chemical fuels.

A fuel should have less amount of ash content because ash content is considered as the waste. It reduces the calorific value of the fuel. Hence a good fuel should have low ash content.

Q1] b) Name the different methods of applications of metallic coatings. Explain metal cladding. (3)

Solution:-

The different methods of applications of metallic coatings are as follows:-

- Electroplating
- Electroless plating
- Zinc Coatings
- Pack cementation
- Cladding
- Thermal spraying
- Physical vapor deposition
- Inorganic coatings

METAL CLADDING:-

Cladding is the bonding together of dissimilar metals. It is different from fusion welding or gluing as a method to fasten the metals together. Cladding is often achieved by extruding two metals through a die as well as pressing or rolling sheets together under high pressure.

Metal cladding is a type of protective coating, where the protective material such as metal powder or foil is bonded to a substrate by applying heat and/or pressure. The study of metal cladding is significant because this method of corrosion protection and wear protection is generally very reliable and cost-effective. In addition, the process parameters can be optimized for different metals and composites in various critical applications.

Q1] c) A sample of coal contains C = 66%, O = 28%, H = 4%, S = 1.5%, N = 0.8% and ash = 0.2%. Calculate the G.C.V and N.C.V of the coal. (3)

Solution:-

Given:- C = 66% O = 28% H = 4% S = 1.5% N = 0.8% ash = 0.2%

To find:- GCV and NCV

$$GCV = \frac{1}{100}\left[8080\times C+34500\left(H-\frac{O}{8}\right)+2240\times S\right] \text{ kCal/kg}$$

$$= \frac{1}{100}\left[8080\times 66+34500\left(4-\frac{28}{8}\right)+2240\times 1.5\right]$$

$$= \frac{1}{100}[533280+17250+3360]$$

$$= \frac{1}{100}[533280+17250+3360]$$

GCV = 5538.9 kCal/kg

$$NCV = GCV - \left[\frac{9H}{100}\times 587\right]$$

$$= 5538.9 - \left[\frac{9\times 4}{100}\times 587\right]$$

NCV = 5327.58 kCal/kg

Q1] d) Give the composition, properties and uses of Gun metal. (3)

Solution:-

Element composition (gun metal)	Properties	Uses
Cu = 85% Zn = 4% Sn = 8% Pb = 3%	highly strong, can resist explosion, hard, tough.	For hydraulics fittings, high pressure steam plants marine pumps, water fillings.

Q1] e) Explain 'Design for Energy Efficiency' principle of Green chemistry. (3)

Solution:-

The aim of green chemistry is to increase the energy efficiency of a chemical process by proper design which includes:

1. Use of catalysts and by avoiding the use of fossil or gaseous fuels which release solid or gaseous pollutants.

   For this, we can substituents like solar energy, microwave radiations, ultra sound etc.

2. Carrying out the synthetic methods at the ambient temperature and pressure.
3. Proper heat transfer.
4. Minimum wastage of energy during the process.
5. Using fermentation process requiring very low energy and also the products are less harmful.

Q1] f) Give the functions of matrix phase (3)

Solution:-

Functions of matrix phase are as follows

1. To bind reinforcing particle / fibre strongly
2. It acts as medium for distribution of applied load to the dispersed phase.
3. It keeps the reinforcing fibre I proper orientation for the high strength development
4. It prevents propagation of cracks due to its plasticity

Q1] g) State the characteristics of a good paint (3)

Solution:-

1) Its power to cover the surface should be as high as possible.

2) Its consistency should be adequate so that it can be spread easily.

3) On drying it should be able to give strong, uniform, highly adherent and impervious film.

4) The layer should not be cracked, peeled or blistered on drying.

5) The layer should be washable and durable.

6) Its colour should not be changed on prolonged exposure to air.

7) Its corrosion resistance should be high.

8) The texture of the dried coat should be smooth, uniform and glossy.

Q2] a) With a suitable diagram explain electrochemical mechanism of rusting of iron in neutral aqueous medium (6)

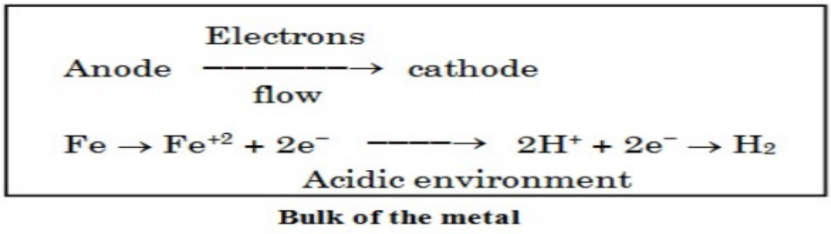
Solution:-

Evolution of Hydrogen type

Corrosion, by this mechanism occurs usually if environment, surrounding to the metal is acidic.

Example : Pipe lines made from iron metal get corroded if industrial waste material, or solutions of non-oxidising acids, is transported through them.

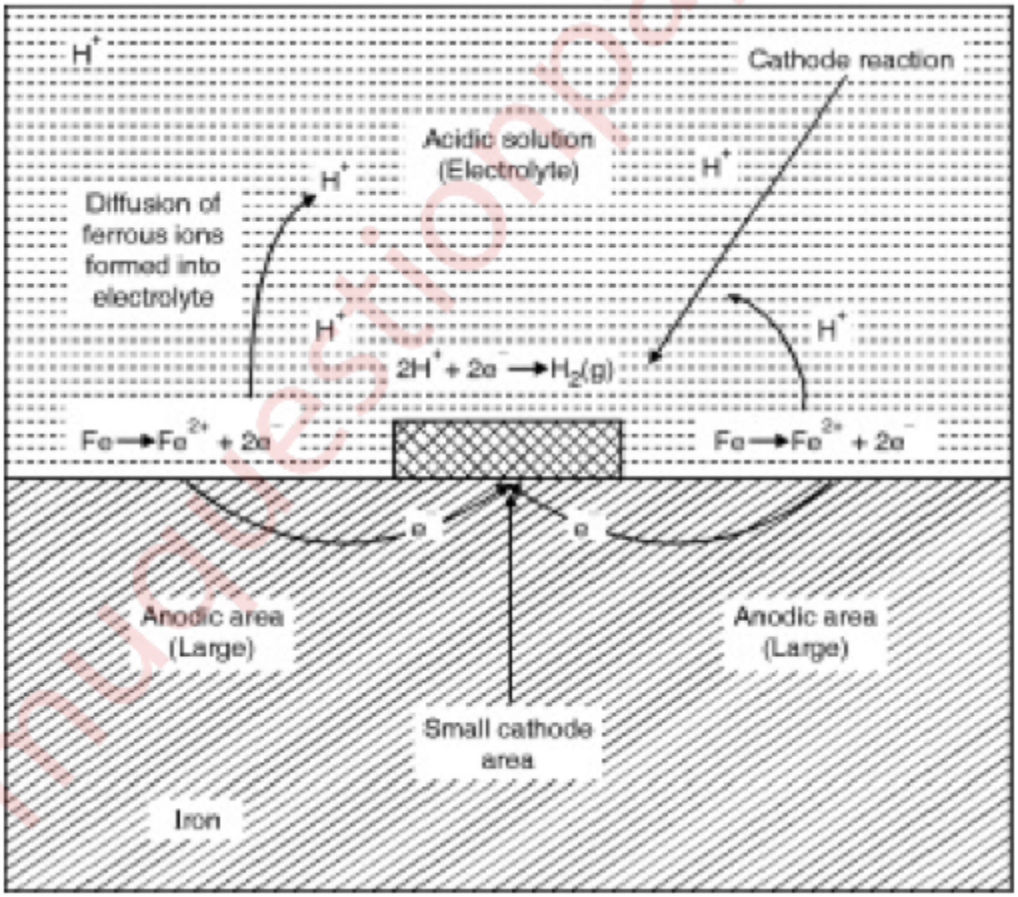
The following reaction occurs



From above reactions, we can say that the flow of electrons takes place from the anode to the cathode. These electrons are gained by cathodic reaction, and at cathode H+ ions are eliminated as H2 gas. The overall mechanism can be represented as

$$Fe + 2H^{+} \rightarrow Fe^{2+} + H_2$$

Thus displacement of H2 ions from acidic solution by metal ions takes place.



Thus, all metals have tendency to get dissolved in the acidic solution with

simultaneous evolution of H_2 gas.

Absorption of oxygen type

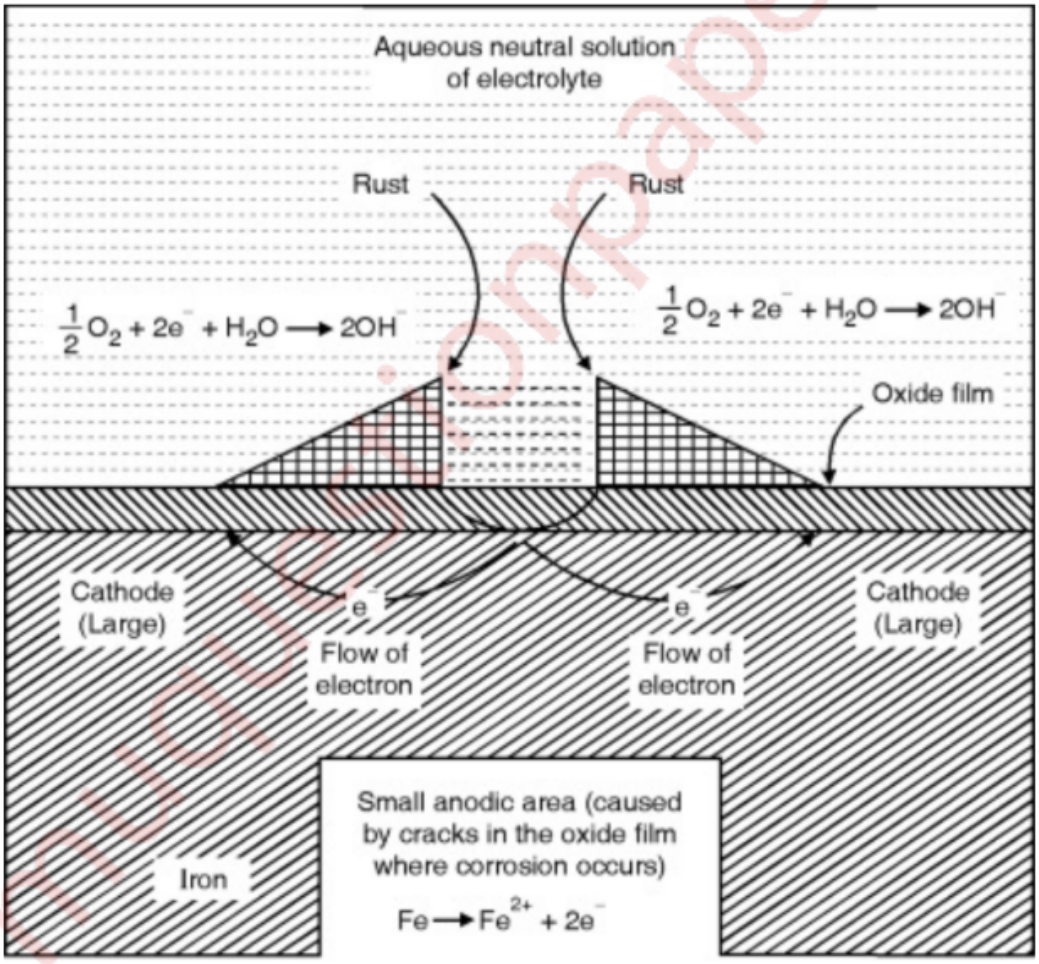
Rusting of iron in neutral aqueous solution of electrolytes in the presence of atmospheric oxygen is the most common example of this type of corrosion (mechanism).

Thus, iron metal in such cases is always with a coat of thin film of iron oxide (Fe2O3). Since, the film is porous in nature, the surface of iron exposed to atmosphere acts as an anode while rest of surface acts as a cathode.

Anodic reaction

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

Thus, at anode iron dissolves as ferrous ions with liberation of electrons.



Cathodic reaction

The liberated electrons flow through iron metal from anode to the cathode, where electrons are intercepted by the dissolved oxygen as

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

If the supply of oxygen is limited, the product formed may be Ferroso-ferric hydroxide.

If oxygen supply is increased, cathodic reaction is influenced forming more number of OH– ions, and subsequently anodic reaction is also influenced, eliminating more number of electrons, thereby increasing the rate of corrosion.

Q2] b) (i) 0.5 gm of coal sample was burnt in Bomb Calorimeter experiment produced 0.06 gm of $BaSO_4$. Calculate percentage of sulphur. (3)

(ii) What are Green Solvents? Give two industrial applications of Green solvents. (2)

Solution:-

1. Given :- weight of coal sample = 0.5 gm weight of $BaSO_4$ = 0.06 gm

$$\% S = \frac{\text{weight of } BaSO_4 \text{ ppt}}{\text{weight coal sample}} \times \frac{32}{233} \times 100$$

$$\% S = \frac{0.05}{0.6} \times \frac{32}{233} \times 100 = \frac{1.6}{139.8} \times 100 = 1.14\%$$

$$\% S = 1.14\%$$

2) Supercritical CO_2 is the substances which exists as a vapour and liquid at critical

temperature and pressure. It's a fluid state of CO_2. Supercritical CO_2 is green solvent as it does not produce any hazardous waste. It has low toxicity and can be used at relatively low temperature.

APPLICATIONS:-

1. Decaffeination
2. It is used as dry cleaning solvent.
3. It is used as the extraction solvent for creation of essential oils.

Q2] c) Write a short note on 'Sandwich Panel'. Mention their applications. (4)

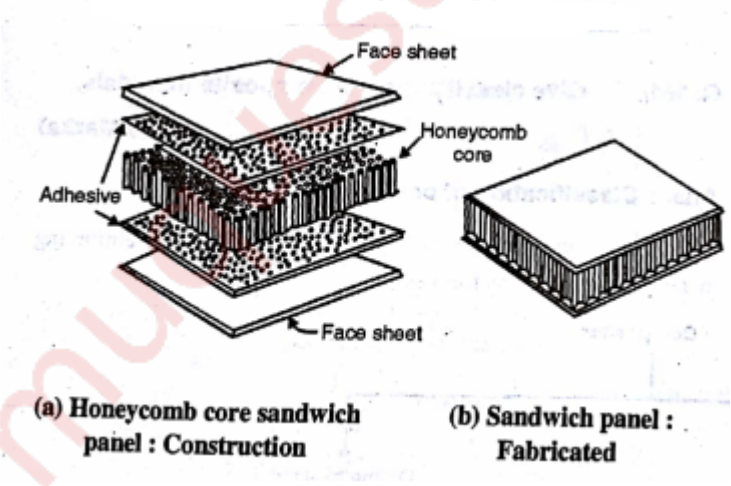
Solution:-

Sandwich panel

This is a type of layered composite. It consists of :

(1) "Faces" are formed by two outer sheets, e .g . Titanium , steel , aluminium alloys , plywood , fibre reinforced plastic material.

(2) "Core" which is layer of less dense material l. e . g . Synthetic rubbers , foamed polymers, inorganic cementing material etc.



(a) Honeycomb core sandwich panel : Construction (b) Sandwich panel : Fabricated

All above three layers are joint together adhesive. In these "faces" are capable of

bearing transverse bending stresses. The 'core' performs functions related to functional properties.

(i) Separation of faces from each other.

(ii) Resisting deformations perpendicular to the face plane.

(iii) Providing certain degree of shear rigidity along above planes which are perpendicular to the ' faces ' .

With increase in thickness of core, its stiffness increases. ' honeycomb' structure which contain thin foils forming interlocked hexagonal cells with their axes oriented at right angles in the direction of face sheet.

Properties

These have following properties:

1) Excellent dimensional stability
2) Resistant to abrasion and corrosion
3) High tensile strength
4) Low density
5) High elasticity modulus

Application

These are used in:

1) Aircraft for wing, fuselage and skins of tailpane.
2) In roofs, walls and floor of building.

Q3] a) What is Cracking. With the help of diagram explain Fixed Bed Catalytic cracking. (6)

Solution:-

Cracking is the process of breaking of higher molecular weight high boiling fraction

into lower molecular weight low boiling fraction. The equation below show such cracking:

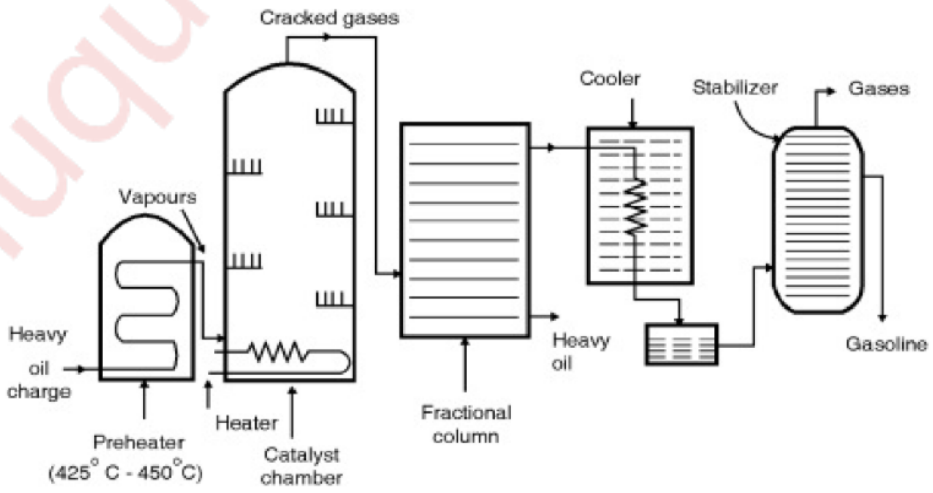
$$C_{12}H_{26} \xrightarrow{heat/catalyst} C_7H_{16} + C_5H_{10}$$

Dodecane heptane pentane

FIXED BED CATALYTIC CRACKING:

It is a type of catalytic cracking carried out in presence of a catalyst at high temperature and low moderate or no applied pressure.

- In this type of cracking the catalyst is in the form of granules or pellets and the beds of these catalyst are fired in catalyst towers.
- Oil vapours to be cracked are passed through the beds at the cracking temperature unhl the catalyst becomes carbonised.
- Burning off the deposited carbon then regenerates the catalyst.
- During reactivation of catalyst oil vapours are transferred through the second catalyst chamber.
- 30.40% of charge is converted into low molecular weight and about 4% Cis formed.
- In fired bed catalyst process charge is passed through a heater and heated there to cracking temperature vapours are passed over a series of tray containing catalyst.



- Generally catalyst used are crystalline alumina silicate bentonite, bauxite and zeolite. The reaction chamber is maintained at 425° C with a pressure of 1.5 /cm^2.
- The cracked gases are taken out from top of the reaction chamber and allowed to pass into fractioning tower where gasoline fraction is collected.
- Gasoline vapours are cooled and condensed in condenser and gasoline is sent to stabilizer where certain gases are removed.
- The octane value of this gasoline is about 80-85.

Q3] b) i) Differentiate between Brass and Bronze (3)

ii) Define Stress corrosion with an example (2)

Solution:-

i)

BRASS	BRONZE
1. Brass contains Cu and Zn	1. Bronze contains Cu and Sn
2. Higher malleability	2.lower malleability
3. Yellow	3.redish brown
4. Used for decorative 10 w friction applications	4.used in ship fittings,propellers
5. Corrosion resistant	5.It is resistance to sea water
6. Not as hard as steel	6.Better conductor of electricity and heat than steels

ii)Stress Corrosion:

Stress cracking it is combine effect of static tensile stress and the corrosion environment on the metal. Stress corrosion is characterize by a highly localized attack occurring when over all corrosion is negligible.

For stress corrosion to occur, the presence of tensile stress specific corrosive environment are necessary

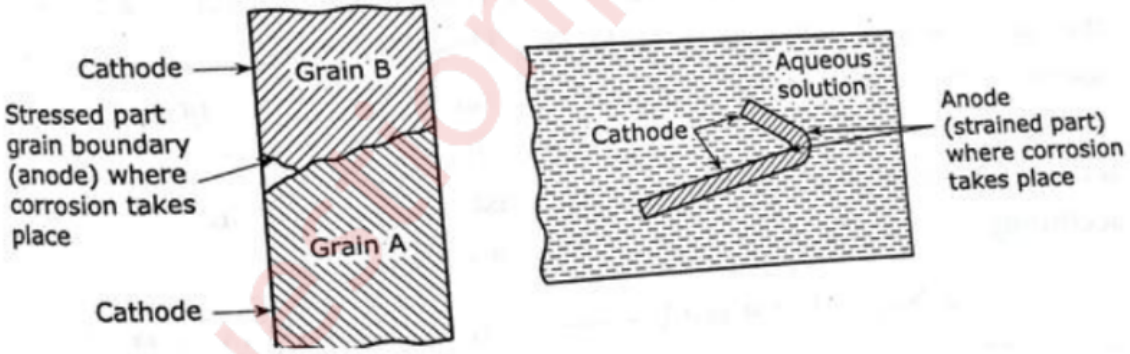
The corrosive agents are highly:

- Caustic alkalis and storing nitrate for mild steel.
- Traces of ammonia for brass.
- Acid chloride selection for stainless steel

This type of corrosion is seen in fabricated articles of certain alloys like high zinc brasses and nickel brasses due to the presence of stresses caused by heavy working like rolling drawing or insufficient annealing pure metal are relatively immure to stress corrosion.

It is generally believed that stress corrosion involves in localized electrochemical corrosion occurring along the narrow path, forming anodic area with respect to larger cathodic areas of the metal surface. Presence of stress produces strain which result in localized zone of higher electrical potential. Theses become so chemically active that they are attacked even by mild corrosive environment resulting the formation of crack.

Under sufficiently high tensile stress and specific environment nearly alloys are susceptible to corrosion.



Q3] c) Calculate the % atom economy of the following reaction w.r.t the product Allyl Chloride (4)

$$CH_3 - CH = CH_2 + Cl_2 \rightarrow Cl - CH_2 - CH = CH_2 + HCl$$

Solution:-

$$CH_3 - CH = CH_2 + Cl_2 \longrightarrow Cl - CH_2 - CH = CH_2 + HCl \quad 36.5$$

Propene 42 71 Allyl chloride (76.5)

$$\% \text{ Atom economy} = \frac{\text{Molecular weight of product}}{\text{Total molecular wt. of reactants}} \times 100$$

$$= \frac{76.5}{42 + 71} \times 100 = \frac{76.5}{113} \times 100 = 67.7\ \%$$

Ans. : *% Atom economy = 67.7%*

Q4] a) How do the following factors affect the rate of corrosion (6)

i) **Passive character of metal**

ii) **pH of medium**

iii) **purity of metal**

Solution:-

Passive character of metal

Nature of metal depends upon its position in galvanic series and potential difference.

The rate of corrosion is inversely proportional to the areas of anode.

$$\text{Rate of corrosion } \alpha \frac{1}{\text{area of anode}}$$

If cathodic area is large then demand of e^{-s} from anode is more. The more e^- are shed and anode is oxidised more. The rate od corrosion increase with the increase of cathodic area.

pH of medium

- lesser than pH = 7 the medium is acidic and in acidic media the rate of

corrosion is highest.

- More than pH = 7 the medium is alkaline and the rate of corrosion is less. The alkalinity also helps to bring mineral acidity down and thus corrosion reduces.
- However if oxygen is absorbed in alkaline or neutral medium then rate of corrosion increases due to oxygen absorption mechanism.

Purity of metal

- Higher the purity of metal, the rate of corrosion is less.
- The impurities in metal are non metal and other metals hence in case of cell formation electrolyte the rate of corrosion increases incredibly.

Purity of Zn	Rate of corrosion
1. 99.999	1
2. 99.99	2650
3. 99.95	5000

Q4] b) i) What is Green Chemistry. Give its significance (3)

ii) Define the following : a) Matrix Phase b) Dispersed phase (2)

Solution:-

Green Chemistry

It is defined as invention design and application of chemical products and process to reduce or to eliminate the use and generation of hazardous substances.

Principles and significance of Green Chemistry :

1. prevention
2. catalysis
3. atom economy
4. less hazardous chemical synthesis

5. design for degradation
6. energy efficiency.

Matrix Phase

Matrix material should have the properties such as:

1. It should have adequate ductility.
2. It should possess lower elastic modules as compared to that of the fibre used.
3. It should get bonded to fibre very strongly, but with minimum pull out of fibre.

The matrix material is selected on the basis of the properties mentioned in combination of the fibre. The proper choice of matrix and fibre gives bonding and ultimately a good composite material.

Example:- metals such as Al, Cu which shows high ductility bonded to the polymers such as thermoplastics and thermosets are most widely used as matrix material.

Dispersed phase

It is the structure constituent which, determines the internal structure of composite. The dispersed phase comprises of fibres. Normally with small diameter preferred of bulk ones . Whiskers are special type of fibres, which are very thin single crystals.

Q4] c) Write a short note on Shape memory alloy. (4)

Solution:-

SHAPE MEMORY ALLOY

Shape memory alloys (SMAS) are a unique class of metal alloys that can recover apparent permanent strains when they are heated above a certain temperature. The SMAS has two stable phase the high temperature phase called austenite and the low temperature phase , called martensite.

Application:

(i) 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 the 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 fracture.

(ii) Piping : The first consumer 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.

(iii) 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.

Q5] a) Calculate weight and volume of air required for complete combustion of 1m^3 of gaseous fuel which possess by volume ; CH_4 = 35%, C_2H_4= 5% , CO= 15% , H_2= 40% , N_2= 1% , watervapour = 4%. (Molecular Weight of air = 28.949) **(6)**

Solution:-

component	reaction	Volume of O_2
CH_4 = 0.35 m^3	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	$0.35 \times 2 = 0.7\ m^3$
$C_2H_4 = 0.05\ m^3$	$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$	$0.05 \times 3 = 0.15\ m^3$
$CO = 0.15\ m^3$	$CO + \frac{1}{2}O_2 \rightarrow CO_2$	$0.15 \times \frac{1}{2} = 0.075\ m^3$
$H_2 = 0.4\ m^3$	$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$	$0.4 \times \frac{1}{2} = 0.2\ m^3$

Volume of total O_2 required = 1.125 m^3

O_2 available In fuel = 0.00

Net O_2 required = 1.125m^3

Volume of air required = $1.125 \times \frac{100}{21}\ m^3$ = 5.357 m^3 = 5357 Ltrs.

Weight of air

22.4 litres = 28.94 kg air

5357 litres = 5357 × 28.94/22.4 kg of air = 6921 kg of air.

Volume of air = 5.357 m^3 or 5357 litres

Weight of air = 6921 kg

Q5] (b) (i) Explain Galvanic corrosion with a neat labelled diagram. (3)

(ii) What is meant by cracking of petroleum. (2)

Solution:-

a. The name of this type of corrosion is indicative that there must be formation of a galvanic cell on metal surface causing corrosion. Such cells get set up all along the surface of metal when it faces the electrolytic environment and two dissimilar metals in contact.

b. For example, in ships floating on the sea water, the portion of it in contact with marine water gets corroded, if there is a difference in the materials used in assembling the ship.If metal iron or brass alloy is used together to join various parts, due to difference in potential, a galvanic cell gets set, leading to corrosion.

c. In such cases all along the surface of metal small galvanic cells are set up, where area of high potential acts as an anode and the one with lower potential acts as a cathode.

d. The portion of metal acting as anode, deteriorates and at cathode the cathodic product gets evolved/deposited,depending upon the environment, and mechanism of the corrosion, i.e. by absorption of oxygen or evolution of hydrogen, as the case may be.

e. The case where the former type of mechanism takes place is seen in electrolytic/alkaline environment while the latter type is seen in acidic environment.

f. The rate of corrosion is obviously very high in latter type. In former one, for iron metal generally three types of iron oxides are formed in succession with the increasing valency of iron. For example : FeO, Fe2O3 and Fe3O4.

g. In such type of environment, on metal surface small anodic and cathodic areas are formed. Here, cathodic area is slightly larger and hence rate of corrosion is comparatively higher. The mechanism of corrosion in slightly alkaline medium, proceeds as, At anode

$$\text{At cathode} \quad \frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^-$$

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

To avoid the formation of galvanic cells,

a) The metals should be pure.

b) The materials used to assemble the different parts

should be of same potentials.

c) Moisture and other electrolytic/aqueous medium, if

present, other corrosion controlling methods may be

used.

Cracking is the process of breaking of higher molecular weight high boiling fraction into lower molecular weight low boiling fraction.

The equation below show such cracking:

$$C_{12}H_{26} \xrightarrow{\text{heat/catalyst(cracking)}} C_7H_{16} + C_5H_{10}$$

Dodecane Heptane Pentane

- Fixed bed catalytic cracking :

  It is a type of catalyte cracking carried out in presence of catalyst at high temperature and low moderate or no applied pressure

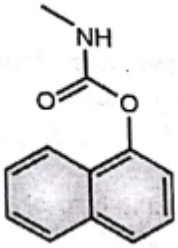
- In this type of cracking the catalyst is in the form of granules or pellets and the beds of these catalyst are fired in catalyst towers.
- Oil vapours to be cracked are passed through the beds at the cracking temperature unhl the catalyst becomes carbonized.
- Gasoline , vapour are cooled and condensed and condensed in a condenser and gasoline is sent to the stabilizer ,where certain gases are removed .

- The octane value of this gasoline is about 80- 85.

Q5] (c) Explain Convectional and Green route of manufacturing of Carbaryl. By this reaction which principle of Green chemistry is shown.(4)

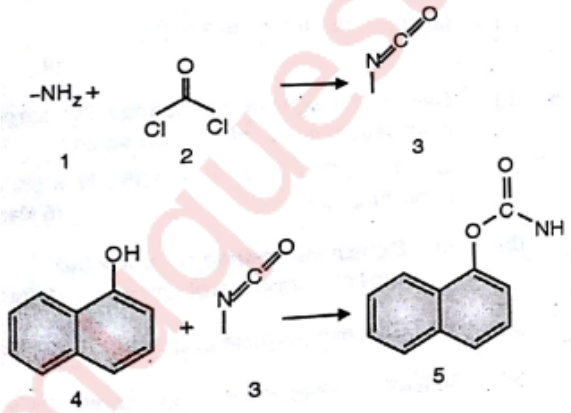
Solution:-

Structure of Carbaryl



(1) Traditional route

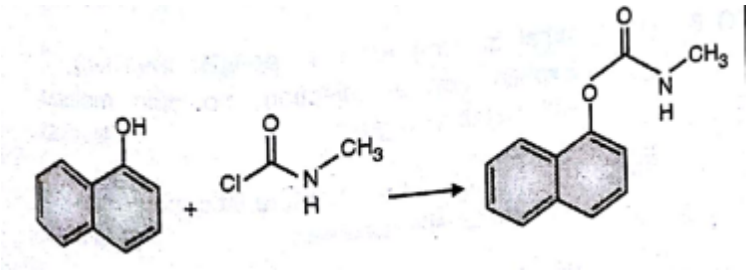
Carbaryl is prepared on large scale by treating methyl-isocyanate with 1-naphthol, Amine is treated with Phosgene to get methyl-isocyanate. Carbaryl is produced by treating methyl isocyanate with 1-naphthol.



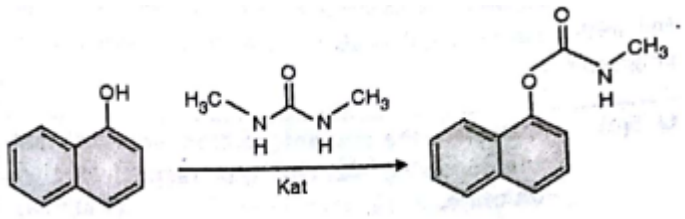
(2)With using naphthol-1 and methylcarbamoyl chloride:

In these routes of synthesis of Carbaryl highly roxic substances such as

phosgene ,methyl isocyanate and methylcarbamoyl chloride are used.

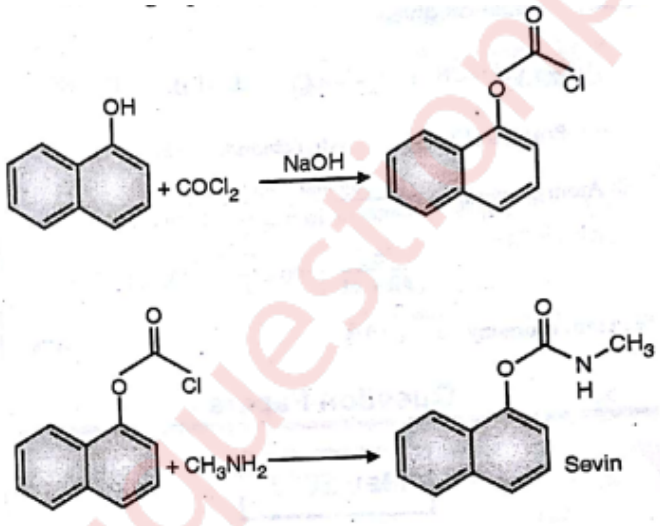


We have developed a new and cost-effective approach to seven synthesis without using of toxic reagents:



Routes of seven synthesis:

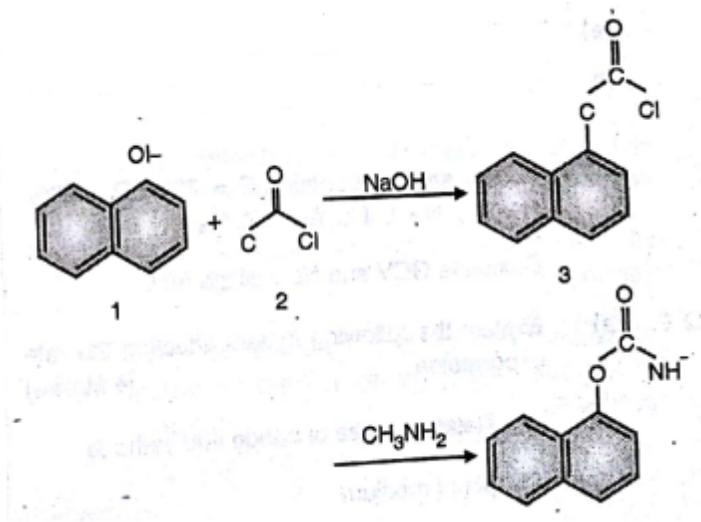
1) With using naphthol-1 and phosgene



2) Green route

1-naphthol treated directly with equal quantity of phosgene in alkaline medium to get chloroformate , which is then treated with methylamine to give carbaryl

Alternatively , 1-naphothol is first converted to its chloroformate which is then treated with methylamine to give the desired product.



Greener route synthesis also uses exactly the same reagents, but these are taken in a different sequence. Hence this synthesis avoids the preparation of methyl isocyanate. But use of phosgene and methyl amine is still needs to be avoided. Research is in progress.

Q6] (a) What is powder metallurgy? Explain Injection moulding method of compaction. (6)

Solution:-

Powder metallurgy is a process which deals with the product of useful components from fine metal powders from individuals mixed or alloyed with or without the inclusion of non-metallic constituents.

The blended and mixed metal powders are then fed into suitable dies to give them desired shape. This process requires specific pressure. This is an important step in powder metallurgy, because proper shape of finished product governs many properties.

Advantages:-

1. Dimensional accuracy and finish of the materials are excellent.
2. Porosity of material can be controlled; along with control over size, shape and distribution of pores, to achieve desired properties.
3. By PM it is possible to produce materials with properties similar to the parent metals unlike in typical alloying.

Disadvantages:-

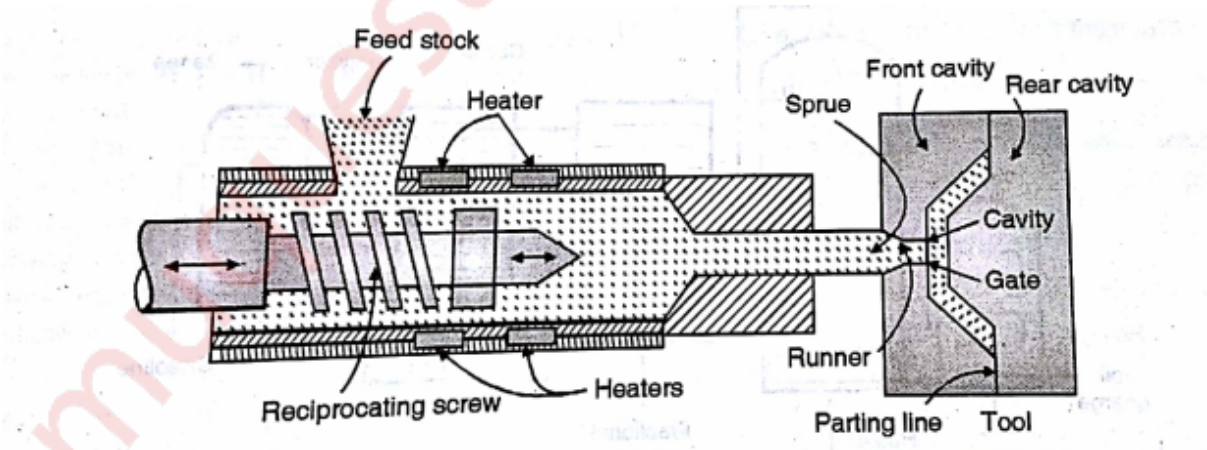
Powder metallurgy has some disadvantages which limits its applications in some of the situations.

The disadvantages or drawbacks of P.M. can be summarized as:

1. The process is not suitable for manufacture of small number of components, because of high initial investment on tooling and die cast and other equipment.
2. The process does not suit for forming components from metals like Mg, Al,Zr ,Ti etc. this is because such metals in powder from may explode and cause fire hazards when they come in contact with air.
3. Storage of metal powders requires precautions, because powder metals get oxidised in air if exposed. This causes wastage.

Powder injection moulding(PIM)

The metal / ceramic powder is converted into suitable feed stock. Then it is mixed with a chemical compound which acts as binder . The role of binder is to impact flow properly to feed stock which enable to be mouldable under conditions of temperature . The feed is heated , to melt and then is forced through sprue and runner channel .



Q6] (b) (i) Explain characteristics of composite materials. (3)

(ii) Define paint? Give any 2 functions of Thinners. (2)

Solution:-

i) Stronger and sniffer than metals

For same strength, lighter than steel by 80% and Al by 60%

ii) Highly corrosion resistant

iii) Tailorable thermal expansion properties.

Can be compounded to closely match surrounding structures to minimise thermal stress

iv) Exceptional formability

Composites can be formed into many complex shapes during fabrication.

v) Stealth property

It can be made low observable by radar by seeding appropriate materials.

ii) Paints can be defined as: "A liquid solution of **pigment** and **solvent**, which is applied on different surfaces for decorative or protective reasons."

It can also be defined as: " Dispersion of **pigment** in a suitable drying oil in the presence of a **solvent** (*paint thinner*) is known as paint."

Functions of thinner in paint are as follows:-

1. They suspend pigments in the paint
2. They increase elasticity of the paint film
3. They evaporate easily and help the drying of the film.

Q6] (c) Explain the determination percentage of Moisture content in the coal Sample. Give its significance. (4)

Solution:-

1. **Total Moisture:** The coal which has been exposed to contact with water in the seam or in a washery, or coal wetted by rain, may carry free or visible water. This water plus the moisture within the material, is referred to as to as total moisture.

2. **Surface or Free Moisture:** Free moisture is that quantity of water which is physically adhering to coal. This is that quantity of water which is more than the moisture holding capacity of a coal.

Determination:

1. **Total Moisture:**

The total moisture is determined in two stages:

a. Stage One (Air drying): 1 Kg of coal sample crushed to pass a square mesh of 12.5 mm is delivered in a sealed container. The sample and the container is accurately weighed to nearest 0.5 g. The sample weight is measured as difference in weight of sample with container and the weight of the container. The material is then transferred to tray and is sample is air dried at atmospheric temperature in a well-ventilated place free from dust. The drying is taken to be complete when the change in mass during an hour is less than 0.1 percentage of the sample. The changed mass of sample is recorded.

b. Stage two (oven drying): An empty weighing vessel is heated at 108±2 °C and weighed after cooling for 20 min. The air-dried material is crushed to pass 2.9 mm IS sieve. About 10 g of the crushed material is then spread uniformly in the weighing vessel and weighed. The uncovered vessel is heated in the drying oven at a temperature of 108±2 °C. until there is no further loss in mass. This normally takes 1.5 to 3 h. The cover is replaced and cooled in a desiccator for 20 min and then weighed.

Total moisture =X+Y*(1-X/100),

Where,

X: percentage loss in mass of original in air-drying,

Y: percentage loss in mass of air dried sample on oven drying.

2. Free/Surface Moisture:

The free moisture is determined from total moisture and moisture at 96 % relative humidity and 40 °C using the below formula:

Free Moisture: A-((100-A))/((100-B))*B

Where,

A= Total Moisture as determined as described above,

B= Moisture at 96 % relative humidity and 40 °C.

SIGNIFICANCE

The amount of moisture content should be less in fuel.

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

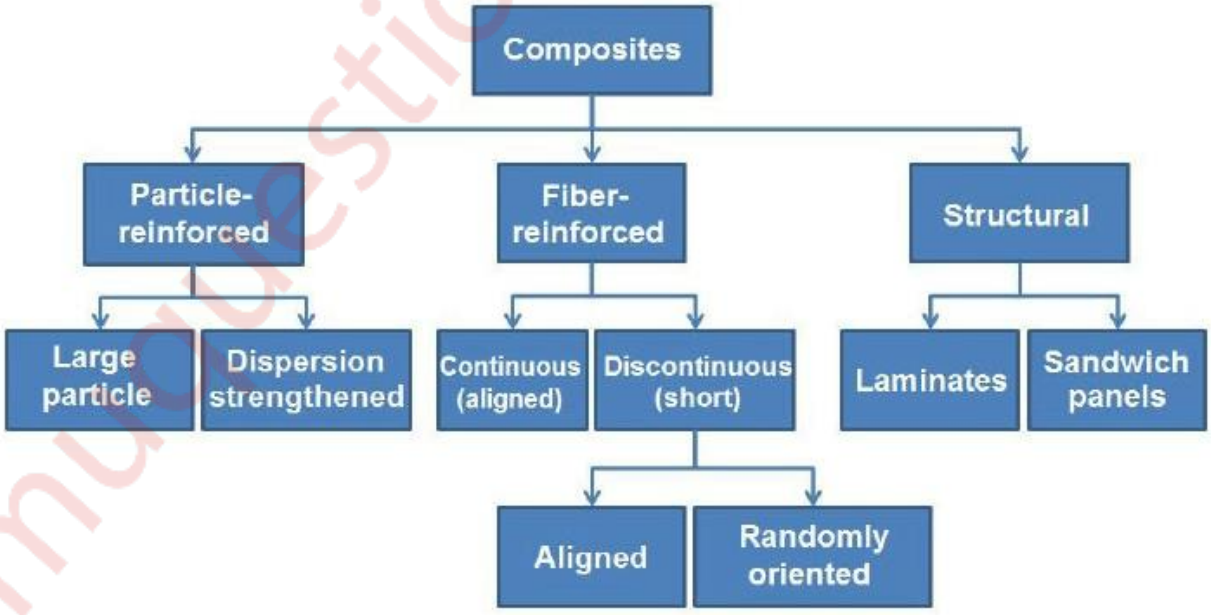
1. used in Architectural metal works.
2. It is used in jewelry.
3. Widely used in hardware's
4. It is also used to make screws, forgings, rivets & costume jewelry etc.

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

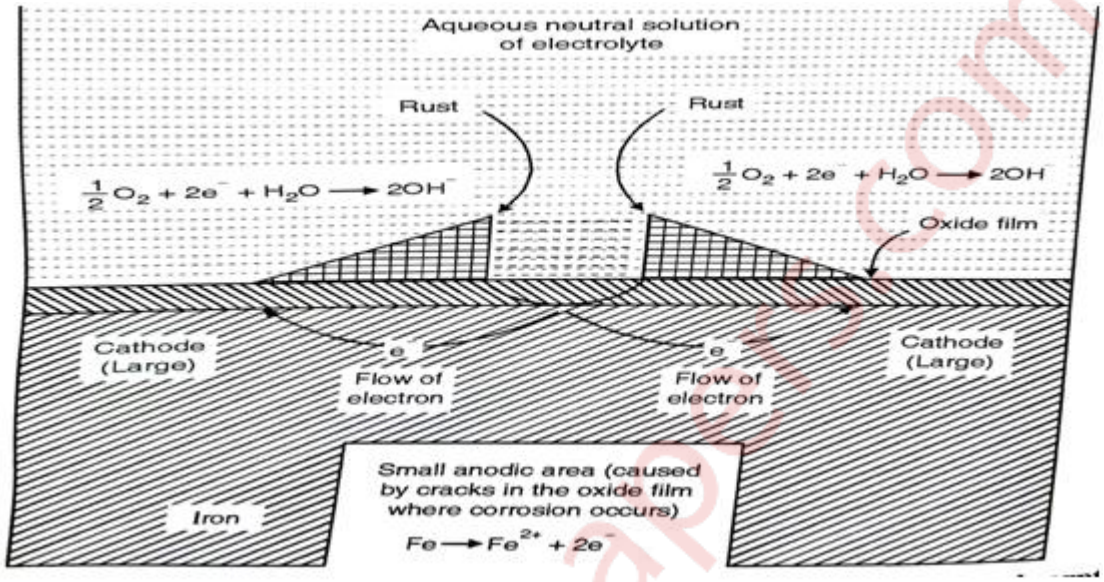
a) Define corrosion. Explain the mechanism of wet corrosion with respect to neutral and alkaline media. (6)

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

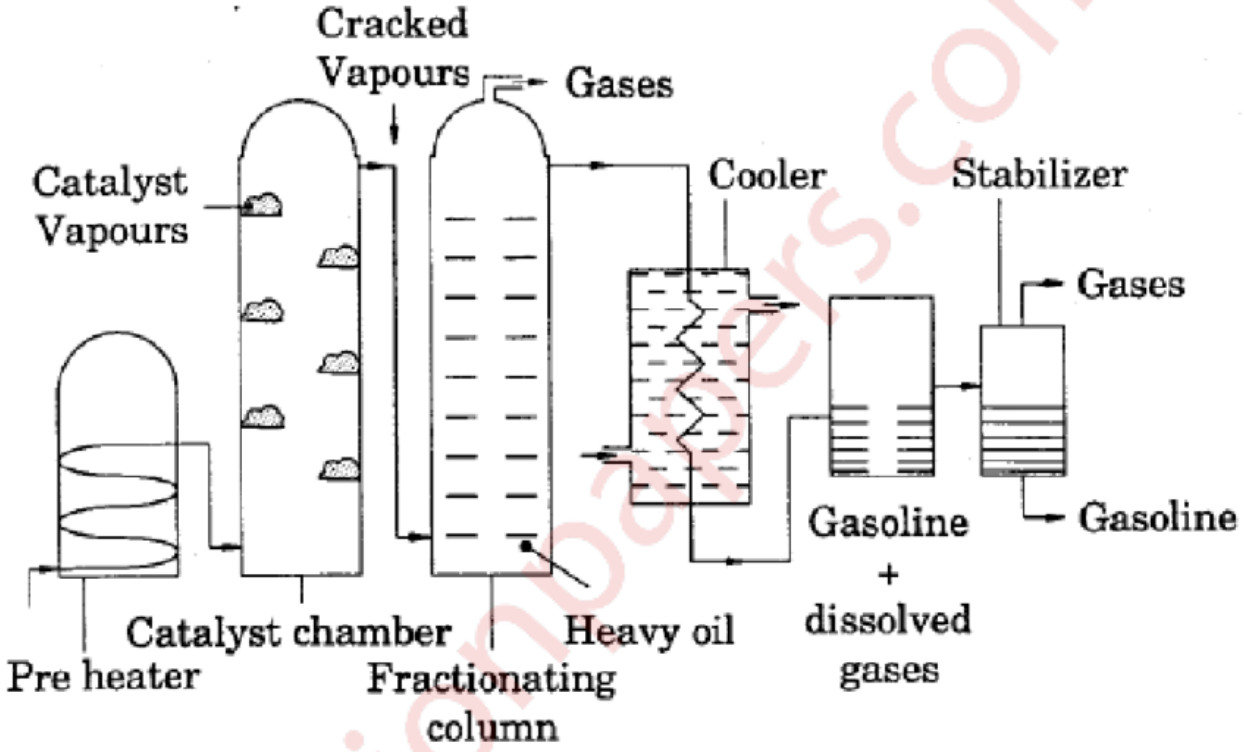
- In this method, vapors of the heavy oil are heated in the presence of catalyst due to which better yield of petrol is obtained.
- Heavy oil is vaporized by heating in an electrical heater. Then the vapours are passed over a series of trays containing catalyst. Generally catalysts used are bauxite, 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

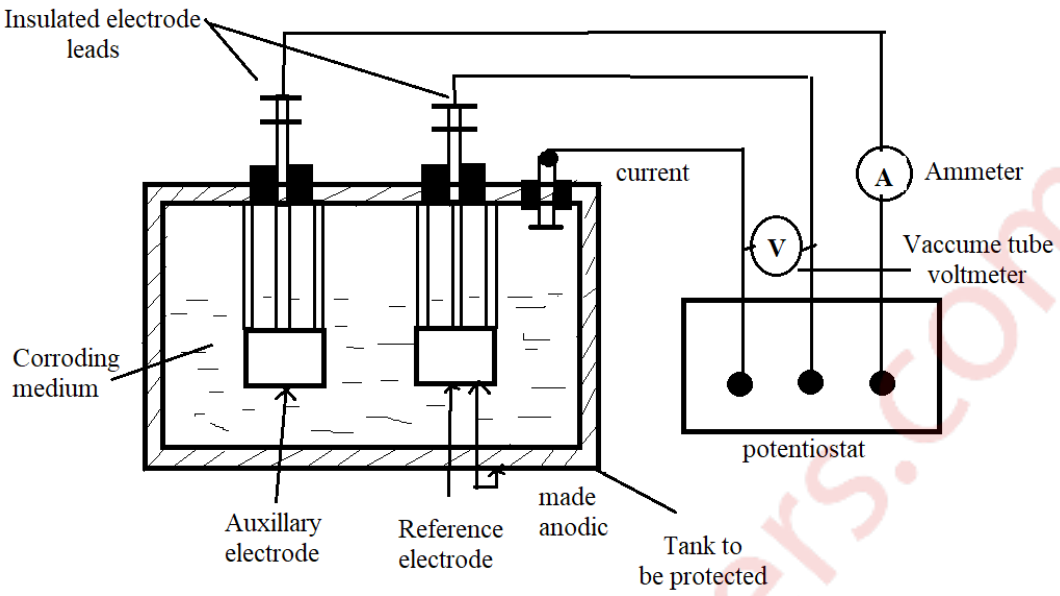
- Anodic protection is based on the formation of protection film by external applied anodic current.
- If carefully controlled anodic protection current is applied to Ni, Fe, Cr, Ti and their alloys they are passivated and the rate of metal dissolution is decreased.

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.

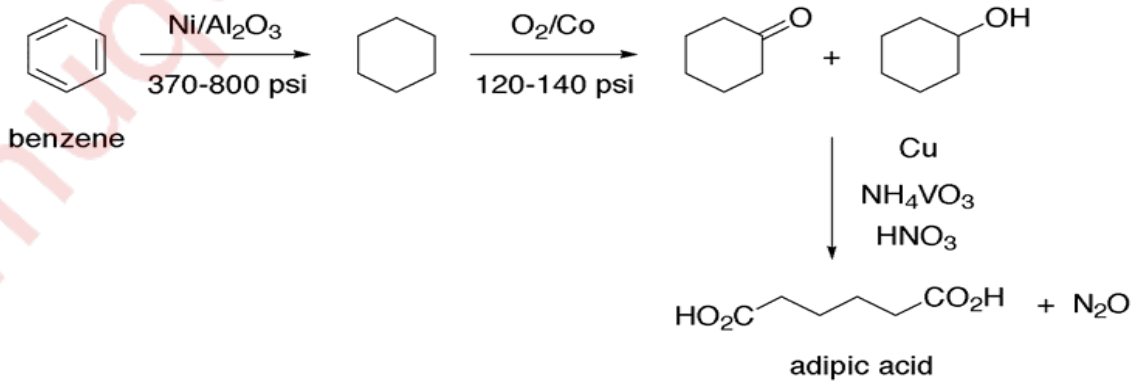
ii) What are the applications of fuel cell? (2)

- 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)

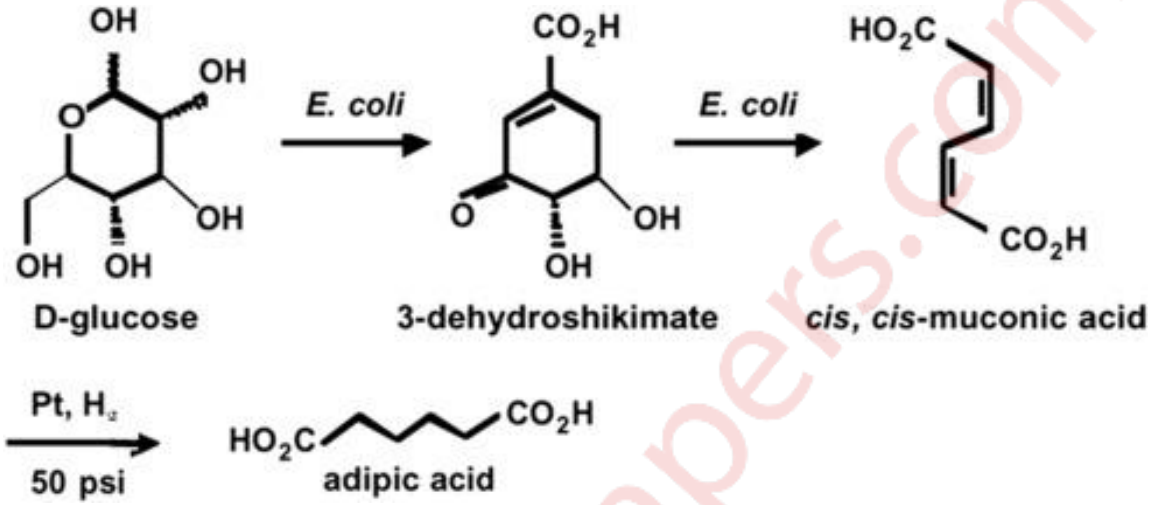
- The commercial method makes use of benzene for synthesis whereas green synthesis use D-glucose.
- It is used in preparation of Nylon-66 & other reagents.

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

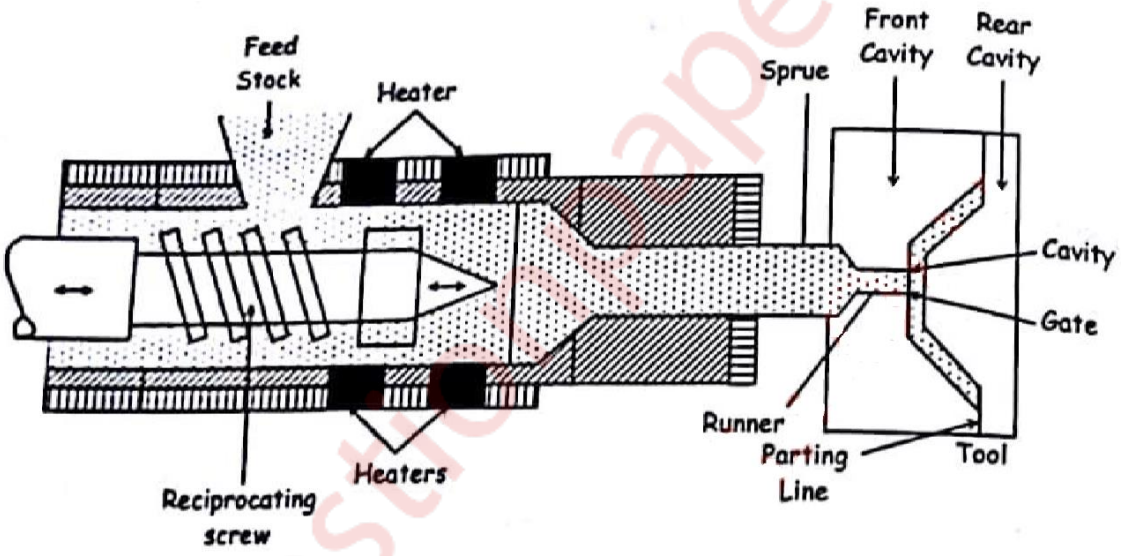
- Metal is obtained in powder form.
- Powder metal is mixed with other element in powder metal.
- It is then subjected to high pressure so to get compressed into desired shape.
- The shaped is then finished into final form various combinations with metal and non-metals are possible.

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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Applied Chemistry II
(Dec 2019)

Q.P. Code – 67598

Q 1 Answer any 5 of the following **15M**

a. What is passivity? With an example explain how it affects the rate of corrosion.

- "Phenomenon in which a metal or an alloy exhibits a much higher corrosion resistance than expected from its position in the electrochemical series".
- Passivity is the result of the formation of highly protective but very thin and quite invisible film on the surface of metal or of an alloy, which make it noble.
- Such film is considered to be insoluble, nonporous and of "Self heating nature" that when broken will repair itself.
- Examples of passive metals and alloys are: Ti, Al, Cr, stainless steel containing Cr.
- This material exhibit corrosion resistance in oxidizing environments, but in reducing environment they become active

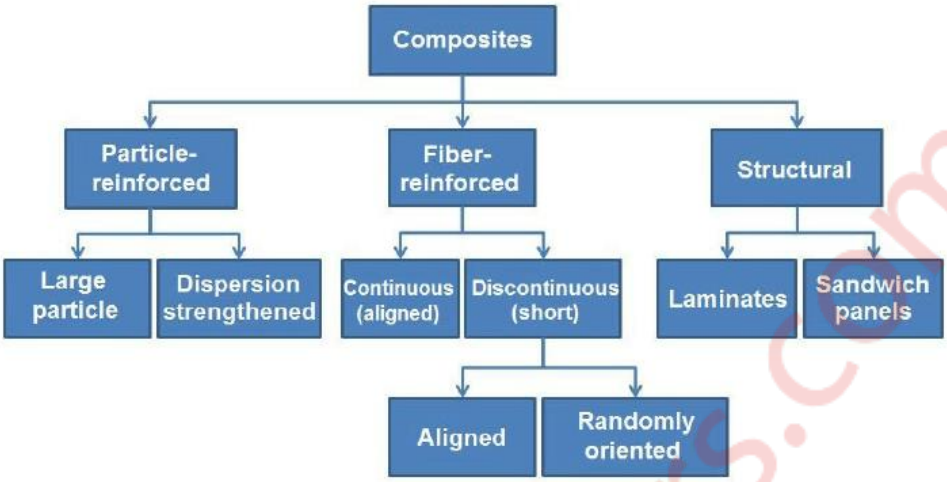
b. Name a Green Solvent and explain its properties.

The solvents which are not harmful to the environment are called green solvents.

- **Super critical fluid** possesses properties of gases and liquids in an intriguing manner, which could offer range of applications/possibilities in both synthetic and analytical chemistry.
- **PEG (polyethylene glycol)** is rightfully called a green chemical, because it is inflammable, non-volatile, non-toxic to humans, animals and aqueous environment. Additionally, the polymer is biodegradable by bacteria found in sewage and soil.
- **Supercritical CO_2** is a fluid heated above the critical temperature and compressed to above critical temperature is known as super critical fluid. Supercritical CO2 is non-toxic, non-flammable and inexpensive.
- **Supercritical ionic liquid carbon dioxide** has found to be an energy conserving, selective and waste reducing alternatives to organic solvents and therefore is viewed as promising environmentally benign solvents. In addition, supercritical fluids can lead to reaction, which are difficult or even impossible to achieve conventional solvents.
- Some green solvent is also Ethanol, diethyl ether, toluene, etc.

c. Give the detailed classification of composites with Example.

- 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.
- Composites material are classified into 3 types particle reinforced, Fiber reinforced and Structural as shown below.
- 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 panel

d. A coal sample was found to contain the following constituents: C=81%, H=6%, S=1%, N=2%, Ash=4% and rest is oxygen. Calculate the minimum weight of air requested at STP for complete combustion of 1 kg of the coal sample.

O% = 100 – [C% + H% + S% + N% + Ash%]
= 100 – [81 + 6 + 1 + 2 + 4]
= 100 – 94
O% = 6%

Constituents	% by weight	Weight per kg
C	81	0.81
H	6	0.06
S	1	0.01
N	2	0.02
Ash	4	0.04
O	6	0.06

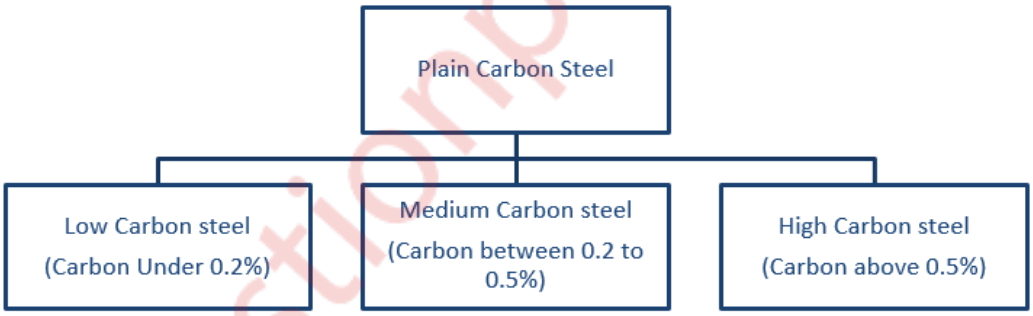
Weight of Air = $\frac{100}{23}$ [2.67 C + 8 H + S - O]
= $\frac{100}{23}$ [2.67 X 0.81 + 8 X 0.06 + 0.01 – 0.06]
Weight of Air = 11.27 kg

e. State and explain the Pilling Bedsworth rule.

- Pilling-Bedworth rule: According to it "an oxide is protective or non-porous, if the volume of the oxide is at least as great as the volume of the metal from which it is formed".
- On the other hand, "if the volume of the oxide is less than the volume of metal, the oxide layer is porous (or non-continuous) and hence, non-protective, because it cannot prevent the access of oxygen to the fresh metal surface below".
- Thus, alkali and alkaline earth metals (like Li, K, Na, Mg) form oxides of volume less than the volume of metals.
- Consequently, the oxide layer faces stress and strains, thereby developing cracks and pores in its structure. Porous oxide scale permits free access of oxygen to the underlying metal surface (through cracks and pores) for fresh action and thus, corrosion continues non-stop.
- Metals like Aluminum forms oxide, whose volume is greater than the volume of metal.
- Consequently, an extremely tightly-adhering non-porous layer is formed. Due to the absence of any pores or cracks in the oxide film, the rate of oxidation rapidly decreases to zero.
-

f. Give the classification and composition of plain carbon steels.

Plain Carbon steels are classified into three types as shown below:



1. Low Carbon Steel:

- It contains carbon under 0.2%
- It contains Sulphur and phosphorous of 0.055%.
- It is also known as mild carbon steel.
- They undergo corrosion and they are tough and ductile.
- It is used in roof covering, railway tracks, cranes, etc.

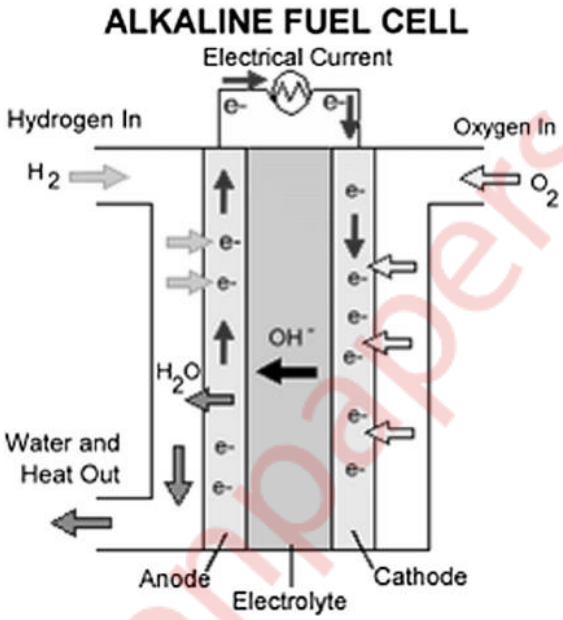
2. Medium Carbon Steel:

- It contains carbon between 0.2% to 0.5%
- It is shock resistance.
- It is tough and hard then mild steel.
- It is used in wheel gears, wires, wire ropes, etc.

3. High Carbon Steel:

- It contains carbon above 0.5%
- It is also known as hard steel.
- It is resistance to wear.
- It is tough and hard.
- It is used in blades, hammer, screw driver, etc.

g. Draw the diagram of the alkaline fuel cell, and write the reactions taking place at the anode and cathode.



Chemical Reaction

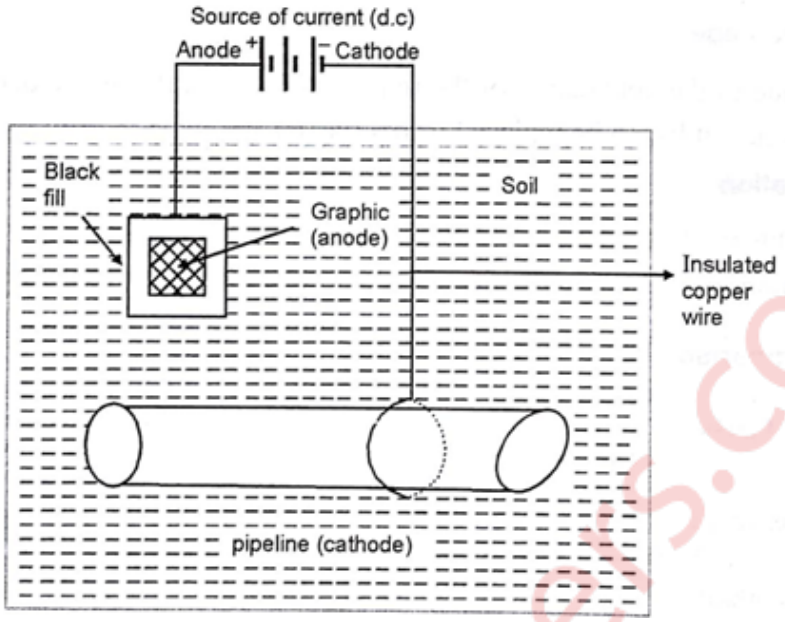
Anode: $2H_2 + 4OH \rightarrow 4H_2O + 4e^-$
Cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
Net Cell: $2H_2 + O_2 \rightarrow 2H_2O$

Q 2.a. Explain the impressed current cathode protection method with the help of following points: -

1) **Principle and diagram** **6M**
2) **Explanation of process**
3) **Application**

Principle and diagram

Impressed Cathodic protection is a means to prevent corrosion by applying a flow of electrical current from an external source (anode) through the environment and on to the metallic structure that is being protected. This protective current changes the environment around the metal thus halting the corrosion reaction.



Explanation of process

- Current is applied in opposite direction to that of the corrosion current, thereby nullifying the effect of the later one on the base metal i.e. converting the base metal to cathode from an anode.
- Such impressed current obtained by using dc source such as battery or dry cell along with an insoluble anode such as platinum, stainless steel, graphite, etc.
- In this method as shown in figure the insoluble metal used is normally embedded underground to this with the help of dc current source.
- The impressed current is applied and whole of this assembly is connected to the metallic structure to be protected. The connection is done by using wires.
- The insoluble anodes are kept inside backfill made up of gypsum or any such material which can help in increasing.
- The electrical contact with soil such an anode can be single if the area of the metallic structure to be protected is small or there can be many such anodes which can be connected in series if the area of the metallic structure to be protected is wider i.e. a long pipeline.
- Due to application of impressed current anode deteriorates and hence it is to be replaced from time to time. Application of this method are seen in care of water tanks, buried pipelines, carrying water or oil condenser and transmission lines and ships.
- This method is highly useful because it can protect the long length structure for longer time. Thereby reducing the frequency if monitoring as well as maintenance cost. This both method is widely used because protection provided to the base metal is long term and maintenance is easy.

Application

- Pipelines
- Boat hulls
- Storage tank

b. i) 1.5gm of coal sample was kjeldahlised and the ammonia evolved was absorbed in 49ml N/10 H_2SO_4. After absorption the access H_2SO_4 required 32.5ml of 0.1N NaOH for neutralization. 0.5gm of the same coal sample was burnt in a bomb calorimeter and on treatment with $BaCl_2$ produced 0.08gm of $BaSO_4$. Calculate the percentage of nitrogen and Sulphur in the given coal sample. 3M

$$\text{Percentage of Nitrogen} = \frac{Volume\ of\ H_2SO_4 + NH_2SO_4 \ \ X\ 1.4}{Weight\ of\ coal}$$

$$= \frac{(49 - 32.5)\ \text{X}\ 0.1 \ \ X\ 1.4}{1.5}$$

$$= \frac{16.5\ \text{X}\ 0.1 \ \ X\ 1.4}{1.5}$$

Percentage of Nitrogen = 1.54 %

$$\text{Percentage of Sulphur} = \frac{Weight\ of\ BaSO_4\ \text{X}\ 32 \ \ X\ 100}{Weight\ of\ coal\ X\ 233}$$

$$= \frac{0.08\ \text{X}\ 32 \ \ X\ 100}{0.5\ X\ 233}$$

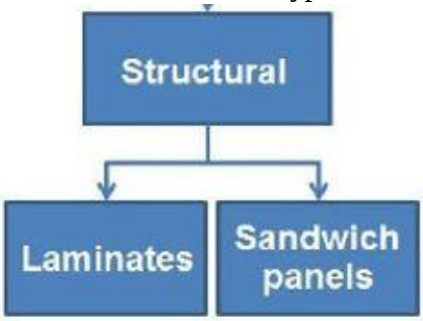
Percentage of Sulphur = 2.197 %

ii) Give an example to explain why it is beneficial to prevent waste formation in chemical processes rather than treat waste? 2M

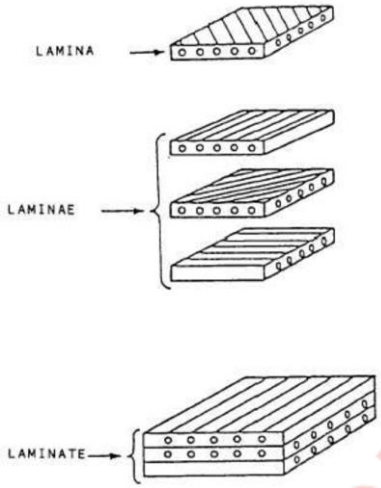
- It is best to prevent waste rather than to clean the waste after it is formed,
- It is best to design a new path to reduce or avoid the waste by doing new chemical synthesis.
- The waste treatment & disposal cost is added to the total cost production.
- The disposal of harmful gases, chemical into the atmosphere like flue gases, CO_2, etc. Which affects human health, birds, fishes, etc.
- The fertility od land is also decreased.
- Hence, the prevention of waste is must as we know, prevention is better than cure.
- Example – In synthesis of biodiesel waste formed is glycerin. One can convert glycerin into propylene glycol which is useful.

c. Classify structural composites and explain their properties and uses along with diagram. 4M

- Structural Composites are classified into two types as shown below:



- **Laminates**: Laminates are layers of materials joined by an organic adhesive.

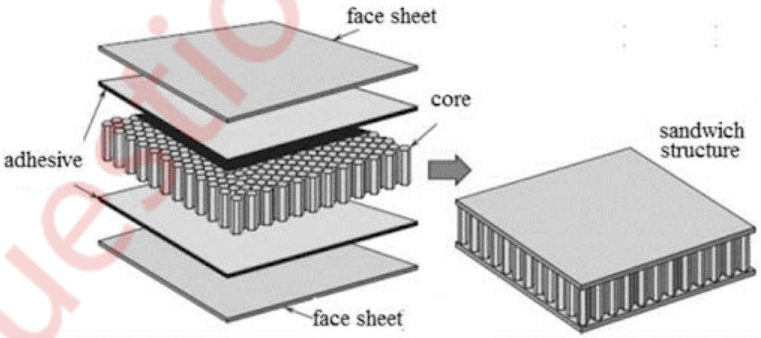


Properties:

- Resistance to creep, Have low coefficient of thermal expansion, High thermal conductivity.

Uses:

- Cladding - A laminar composite produced when a corrosion-resistant or high-hardness layer of a laminar composite formed onto a less expensive or higher-strength backing.
- Bimetallic - A laminar composite material produced by joining two strips of metal with different thermal expansion coefficients, making the material sensitive to temperature changes.
- **Sandwich:** sandwich is layered structure in which one layer is sandwich by other two.



Properties:

- Light weight, low density, hard

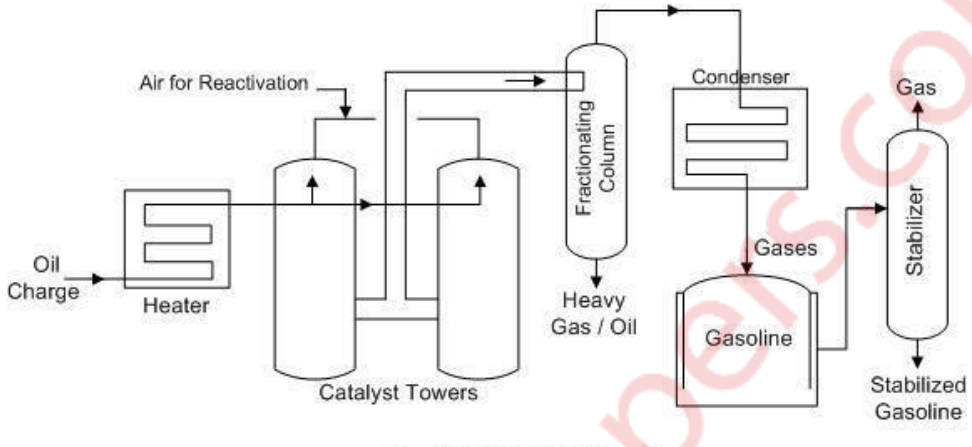
Uses:

- Aircraft: used in outer covering of rocket, aero plane, etc. due to its light weight.
- Transportation applications: including cars, subway cars and trains with an aim of reducing weight, emissions, and to integrate details for reduced manufacturing costs, acoustical and thermal insulation.

Q.3.a. Explain fixed bed catalytic cracking with the help of the following points: -
i) Principle ii) Labelled Diagram iii) Flow chart of process. 6M

Principle: The process of less volatile higher hydrocarbon molecule into more volatile lower molecular weight hydrocarbon by the application of fixed catalyst is called as fixed bed catalytic cracking.

Labelled Diagram



Fixed Bed Catalytic Cracking

Flow chart of process

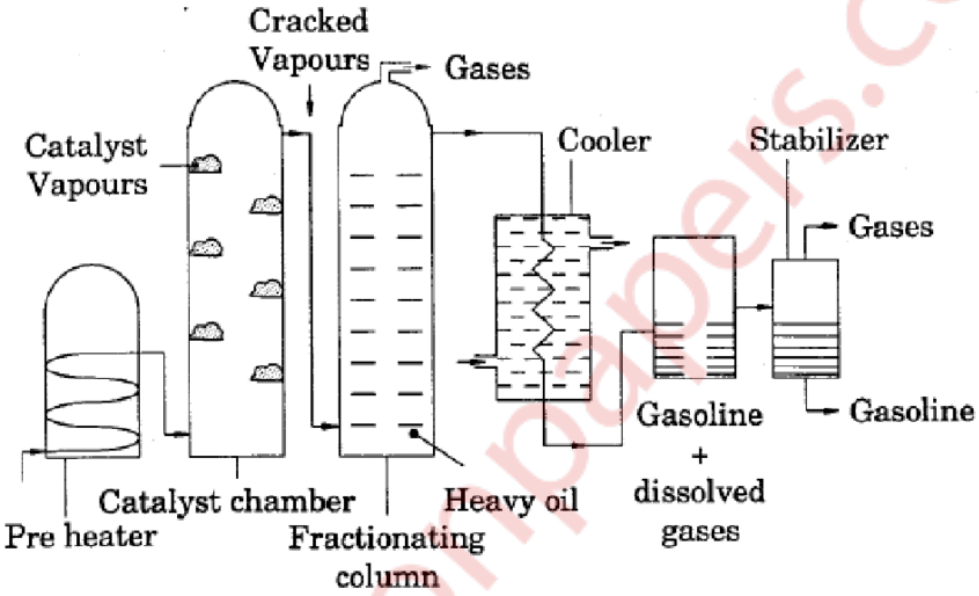
Fixed bed cracking

- 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 vapors 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 425-4500C. the resulting vapours oil is charge is then forced through the catalytic chamber.
- The catalytic chamber is maintained at a temperature of 425-4500C and 1-5 kg/cm2pressure. 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 vapor's containing heavy oil as well as cracked gasoline pass into the fractionating column where heavy oil condenses.

- The uncondensed vapor containing the cracked fraction is led to the coolers where some of the vapor 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 5000C 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 special steels? Explain the properties and applications of any one type of special steel. 3M

- Special steel is a unique alloy or chemical composition formed via distinct and superior production process. It possesses higher strength, more toughness, better physical & chemical properties, biocompatibility, and performance compared to ordinary steel.
- Different type of special steels is heat resisting steel, Nichrome, stainless steel, non-heat treatable stainless steel, non-magnetic, etc.
- Heat Resisting Steel: (Mo=3.5%, Cr=12%, C=0.5%)
  Properties: - Heat resistance
  - tougher and harder
  Application: - manufacturing of equipment's boiler part, furnace part and gas turbine.
- Nichrome: (Ni=60%, Cr=12%)
  Properties: - High resistance to oxidation.
  - high bearing ability.
  Application: - manufacturing of dental instrument and surgical instrument.

ii) Name the type of microscopic corrosion affecting Alpha brass and explain the conditions under which it occurs. 2M

- Dezincification can be caused by water containing sulfur, carbon dioxide, and oxygen. Stagnant or low velocity waters tend to promote dezincification. To combat this, arsenic or tin can be added to brass, or gunmetal can be used instead.

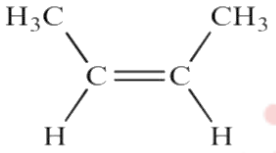
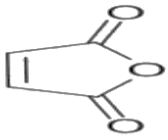
Condition

- The service conditions generally present where dezincification occurs include: Water with high levels of oxygen and carbon dioxide (uniform attack). Stagnant or slow moving waters (uniform attack). Slightly acidic water, low in salt content and at room temperature (uniform attack).
- Dezincification can be caused by water containing Sulphur, carbon dioxide, and oxygen. Stagnant or low velocity waters tend to promote dezincification. To combat this, arsenic or tin can be added to brass, or gunmetal can be used instead.

c. Calculate the percentage atom economy of the following reactions with respect to the target product maleic anhydride and state which is the greener reaction. 4M

a) $C_6H_6 + 4.5\ O_2 \rightarrow$  $+ 2\ H_2O + 2CO_2$

Maleic Anhydride

b)  $+ 3O_2 \rightarrow$  $+ 3\ H_2O$

Maleic Anhydride

a) % Atom economy = $\frac{\text{Molecular weight of desired product}}{\text{Total molecular weight of reactant}} \boldsymbol{X\ 100}$

Molecular weight of desired product (Maleic Anhydride) = 98 g/mol

Total molecular weight of reactant = $C_6H_6 + 4.5\ O_2$

= 12 X 6 + 1 X 6 + 4.5(16 X 2)

= 72 + 6 + 144

= 222 g/mol

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

$= \frac{98}{222} \boldsymbol{X\ 100}$

% Atom economy = 44.14%

b) % Atom economy = $\frac{\text{Molecular weight of desired product}}{\text{Total molecular weight of reactant}} \boldsymbol{X\ 100}$

Molecular weight of desired product (Maleic Anhydride) = 98 g/mol

Total molecular weight of reactant = C_4H_8(cis-2-butene) + 3 O_2

= 12 X 4 + 1 X 8 + 3(16 X 2)

= 48 + 8 + 96

= 152 g/mol

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

= $\frac{98}{152} \boldsymbol{X\ 100}$

% Atom economy = 64.47 %

Q.4.a. How do the following factors affect the rate of corrosion:
i) Conductance of corroding medium ii) Relative area of anode and cathode iii) temperature **6M**

- **Conductance of corroding medium**

Metals with higher conductivity corrode easily. The increase in conductance of the medium leads to increase in the diffusion rate. which again leads to an increase in the corrosion rate. The noble metals like gold, platinum and silver whereas the metals with lower reduction potentials readily undergo corrosion. Example= Zn, Mg, Al etc.

$$\text{Rate of Corrosion } \alpha \text{ conductance of the corroding medium}$$

- **Relative area of anode and cathode**

When 2 dissimilar metals are in contact, the corrosion of the anode part is directly proportional to the ratio of areas of the cathodic part and anodic part.

$$\text{Rate of Corrosion } \alpha \frac{cathode}{Anode}$$

This is because when the cathode area is larger than the anode area, then the demand for electrons by the cathode area will be more which can only be met by the anodic area by undergoing faster corrosion. Thus smaller the area of the anode, faster the rate of corrosion.

- **Temperature**

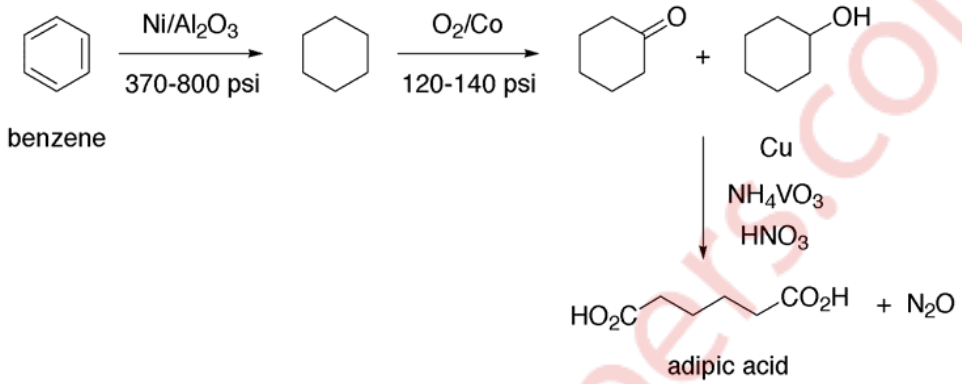
Rate of corrosion increases with increase in temperature. This due to the increase in conductance of the medium with increase in temperature and hence an increase in the diffusion rate. As a consequence, corrosion progresses faster at higher temperatures. In some cases, rise in temperature decreases passivity, which again leads to an increase in the corrosion rate.

$$\text{Rate of Corrosion } \alpha \text{ Temperature}$$

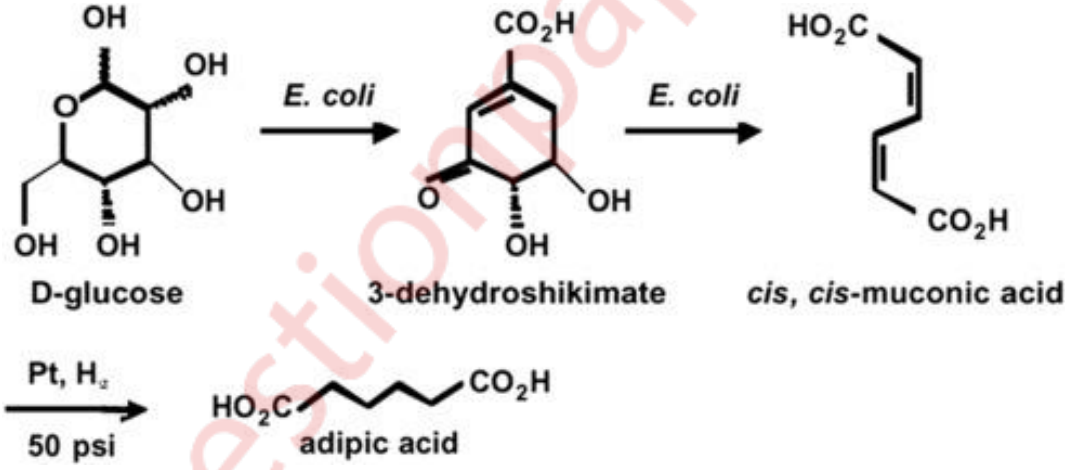
b. i) Give the traditional and green synthesis of adipic acid and compare the starting materials used. 3M

- 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 / traditional



Green Chemistry Routes



- Benzene is used as starting compound in traditional route which is carcinogenic (Cancer causing substance) and carbon monoxide is poisonous gas to avoid this green chemistry routes are used. In which D-glucose is used as stating compound which is not dangerous.

ii) What are the properties of composites which make them popular engineering material. 2M

Properties of Composites

- Tensile strength of composites is 4-6 times greater than that of conventional materials like steel, aluminum, etc.
- Improved torsion stiffness and impact properties.
- Higher fatigue endurance limit (up to 60% of the ultimate tensile strength)

- 30-40% lighter than aluminum structures designed for the same functional requirements.
- Lower embedded energy.
- Composites are less noisy while in operation and provide lower vibration transmission.
- Composites are more versatile and can be tailored to meet performance needs and complex design requirements.

c. Give the composition and properties of any two:
i) German Silver ii) Magnalium iii) Woods Metal **4M**

i) German Silver
- Composition – Cu = 25-50%, Zn = 10-35%, Sn = 5-35%.
- Properties – Possesses good strength, high resistance to electrolyte, high ductility, malleability, appears like silver.
- Uses – Decorative articles, utensils, table wares, ornaments, cutlery etc.

ii) Magnalium
- Composition – Al = 70-90%, Mg = 10-30%.
- Properties – It is strong, tough, lighter than duralumin.
- Uses – scientific instruments, aeroplane parts.

iii) Woods Metal
- Composition – Bi = 50%, Pb = 25%, Sn = 12.5%, Cd=12.5%.
- Properties – Stable, low Melting Point, density 9.7, harmful by inhalation.
- Uses – useful as a low melting solder, casting metal, repairing antiques, etc.

Q.5.a. A gas has following composition by volume: H_2=10%, C_2H_6=25%, CO=16%, H_2O=20%, C_2H_2=15%, CH_4=4%, O_2=4% and the rest is CO_2. Calculate the volume of air to be supplied at STP per 2m^3 of the gas. (Average molar mass of air at STP = 28.94gm) **6M**

Sr No.	Constituents	% by weight	Weight per kg
1	H_2	10	0.1
2	C_2H_6	25	0.25
3	CO	16	0.16
4	H_2O	20	0.2
5	C_2H_2	15	0.15
6	CH_4	4	0.04
7	O_2	4	0.04
8	CO_2	6	0.06

1) $H_2 + \frac{1}{2} O_2 \rightarrow H_2O$
   1 volume of H_2 = 0.5 volume of O_2
   0.1 volume of H_2 = 0.05 volume of O_2
   O_2 for H_2 = 0.05 m^3

2) $C_2H_6 + 3.5\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$
   1 volume of C_2H_6 = 3.5 volume of O_2
   0.25 volume of C_2H_6 = 0.875 volume of O_2
   O_2 for C_2H_6 = 0.875 m^3

3) $CO + \frac{1}{2} O_2 \rightarrow CO_2$
   1 volume of CO = 0.5 volume of O_2
   0.16 volume of CO = 0.08 volume of O_2
   O_2 for CO = 0.08 m^3

4) Not Applicable
5) $C_2H_2 + 2.5\ O_2 \rightarrow 2\ CO_2 + 1\ H_2O$
   1 volume of C_2H_2 = 2.5 volume of O_2
   0.15 volume of C_2H_2 = 0.375 volume of O_2
   O_2 for C_2H_2 = 0.375 m^3

6) $CH_4 + 2\ O_2 \rightarrow CO_2 + 2H_2O$
   1 volume of CH_4 = 2 volume of O_2
   0.04 volume of CH_4 = 0.08 volume of O_2
   O_2 for CH_4 = 0.08 m^3

7) O_2 Already present
8) Not Applicable

Total O_2 required = 0.05 + 0.875 + 0.08+ 0.375 + 0.08
= 1.46 m^3
O_2 already present = 0.04 m^3
Actual O_2 required = Total O_2 required – already O_2 present
= 1.46 – 0.04
= 1.42 m^3

Volume of air
As we know, 1000 m^3 of air = 21 m^3 of O_2

2 m^3 of air = 0.42 m^3 of O_2
Volume of air = 1.42 m^3

$$\text{Volume of air} = \frac{1.42\ X\ 2}{0.42}$$

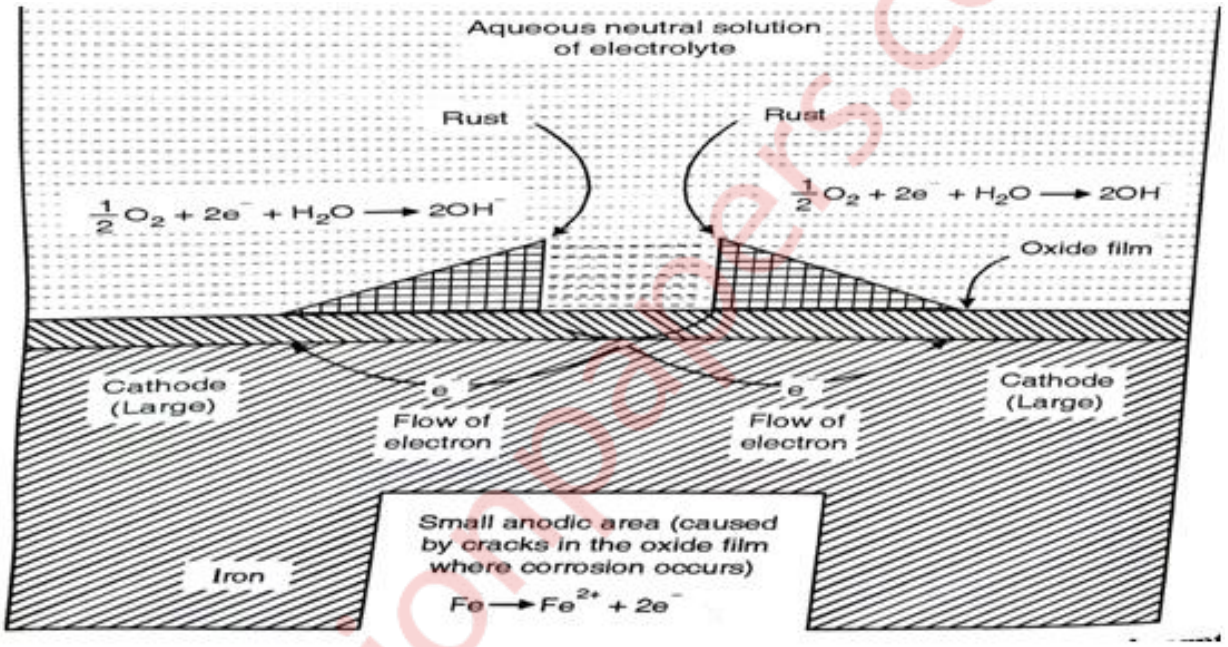
Volume of air = 6.76 m^3

b. i) Part of an iron nail corrodes inside a piece of wood. Identify the type of corrosion and explain the mechanism with a labelled diagram and reactions. 3M

- Wood is a hygroscopic material.
- hygroscopic means the material which absorb and release water.
- Thus, iron nail inside the wood is continuously in contact with water which leads to corrosion.
- This type of corrosion is called wet corrosion.

Wet Corrosion

- The wet corrosion in neutral and alkaline media take place by O2 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.

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

ii) What is shape memory effect? 2M

- Shape memory effect (SME) is a phenomenon, in which a material recovers to its original size and shape when heated above a certain characteristic transformation temperature.
- This phenomenon results from a crystalline phase change known as thermoplastics martensitic transformation.
- At temperatures below the transformation temperature, shape memory alloys are martensitic. In this condition, their microstructure is characterized by self-accommodating twins.
- The martensitic is soft and can be deformed quite by de-twinning.
- Heating above the transformation temperature recovers the original shape and converts the material to its high strength, austenitic, condition.

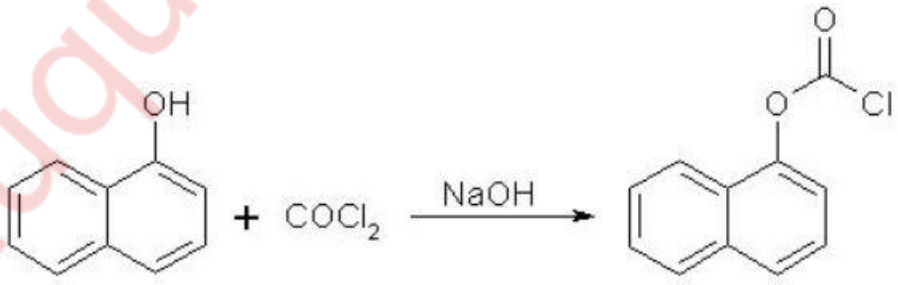
c. The Bhopal gas tragedy was one of the worst industrial disasters. With reactions explain the synthesis of the intermediate which caused the tragedy and the final product. Also give the alternative route of synthesis of the final product explaining the green chemistry principle being adhered to. 4M

Traditional Method

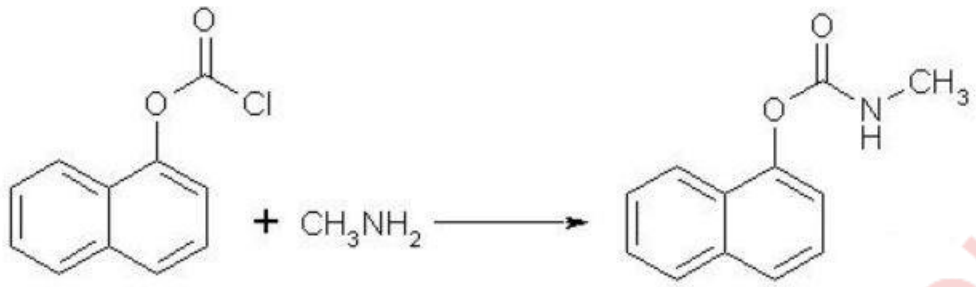
Methylamine phosgene Methyl isocyanate

1-naphthol Methyl isocyanate carbaryl

Green Chemistry Method



naphtol-1 phosgene 1-naphthalenyl chloroformate



1-naphthalenyl chloroformate Carbaryl

- Chemical products should be designed in such a way that it should not harm the environment.
- In traditional method Methylamine and phosgene is used which are dangerous. To avoid these methylamine is replaced by naphtol-1 in green chemistry which is not dangerious.
- Thus green chemistry emphasizes to design chemical products to be fully effective, yet have little or no toxicity.

Q.6.a. What are the steps involved in powder metallurgy? Name the different moulding techniques used. Explain any one method of moulding with detailed diagram. 6M

Steps involved in Powder Metallurgy

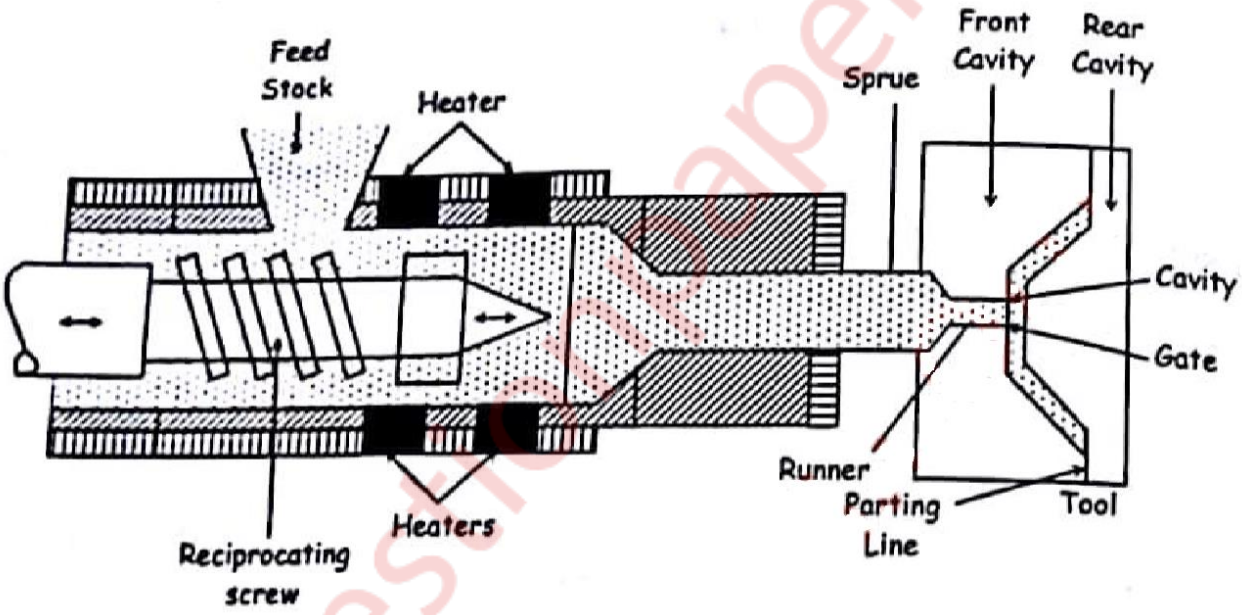
1. **Metallic powders**: Metals are converted in fine powder.
2. **Blending powders**: The fine powders are mixed along with a lubricant. The lubricant helps in imparting good fluidity to the powders.
3. **Filling Mould with mixture:** The mould is filled with above mixture of powder and lubricant.
4. **Compacting**: The blended powder is compacted in a mold or die.
5. **Sintering:** The compacted mass is sintered at a high temperature in a furnace in a controlled atmosphere.
6. **Sizing:** The sintered component is passed in a mold or dies to trim the component and achieve high dimensional accuracy.
7. **Machining:** If required final machining is done on some specific locations including drilling very small holes.
8. **Treatment:** Parts are subjected to deburring and tumbling to remove any small projections and other treatments like oil impregnation tec., are given.
9. **Inspection**: Finally, parts are inspected to check the quality.

Different Moulding Techniques are

- Cold Pressing
- Hot compaction
- Powder Injection Moulding.

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) How are particle reinforced composite different from fiber reinforced composite? **3M**

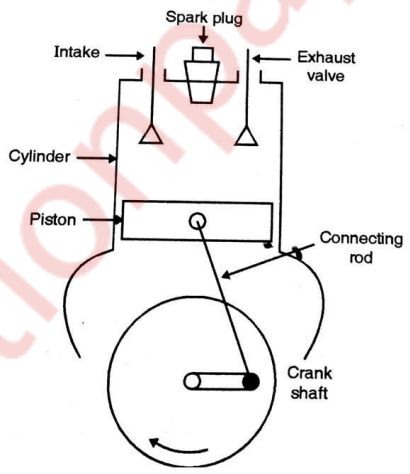
- Particle reinforced composites are less effective in strengthening the material than Fiber reinforced composites.
- Particle reinforced composites are usually used where high levels of wear resistance is required whereas this is not the case with fiber reinforced composites.
- Particle reinforced composites are cheaper and easy to produce than fiber reinforced composites.
- Particulate reinforced composites achieve gains in stiffness primarily, but also can achieve increases in strength and toughness.

ii) Distinguish between galvanizing and tinning. **2M**

Galvanizing	Tinning
1) Zn coating on iron/steel.	1) Tin coating on iron/steel/brass/copper.
2) In Galvanizing, Water bath is required.	2) In Tinning, Water bath is not required.
3) It cannot be used in acidic food stuff.	3) It can be used in acidic food stuff.
4) Galvanizing is cheaper.	4) Tinning is more expensive.
5) Highly effective for corrosion.	5) Less effective for corrosion.
6) They have high toughness. It cannot be moulded into machine.	6) They can be mechanized easily.

c. What is knocking? Explain the role of antiknocking agents. **4M**

- Knocking: A sharp metallic sound produces in the internal combustion engine due to immature (impurity) ignition of the air-gasoline mixture is called as knocking.
- In certain circumstances due to the compression the fuel air mixture heated to higher temperature their ignition temperature so that there is a spontaneous combustion & large portion fuel air mixture produce explosive sound is known as knocking.



- An antiknock agent is a chemical that, when added to gasoline, raises the octane value of the gasoline which, in turn, raises the temperature and pressure at which gasoline will auto-ignite. It allows the gasoline/air mixture to wait until the spark plug ignites the fuel, reducing pre-detonation which can be harmful to the engine.
- The octane rating of many fuel can be increased by adding certain antiknock agents to petrol. These compound which are added to vehicular or aviation petrol to improve their knocking property are called antiknock agents. The commonly used antiknock agents are Tetraethyl lead, Tetra methyl lead, etc.

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