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)

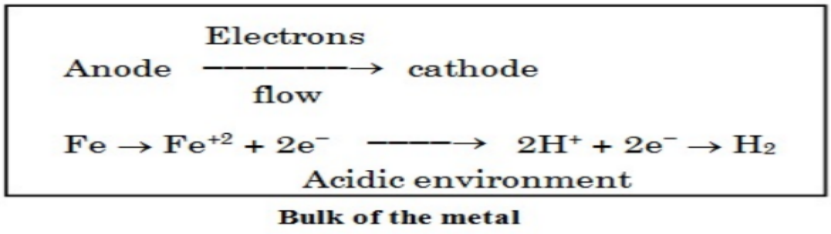
Solution:-

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.

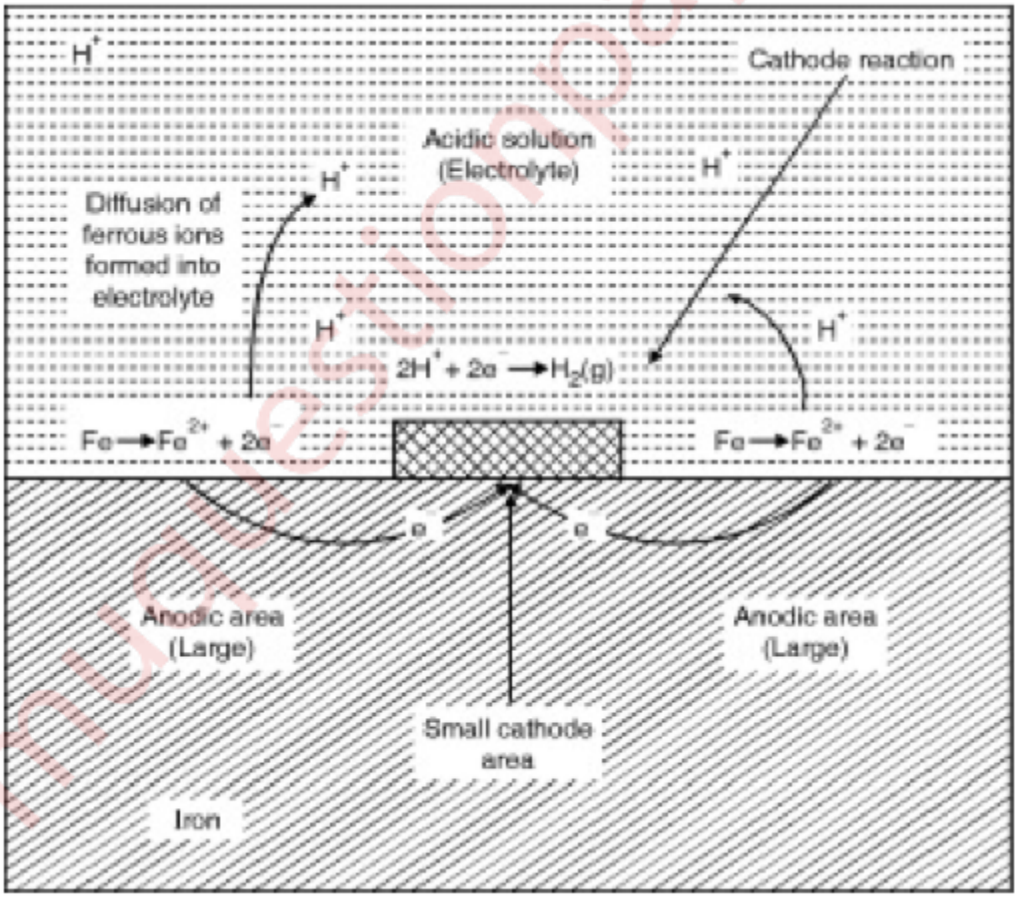
The following reaction occurs



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

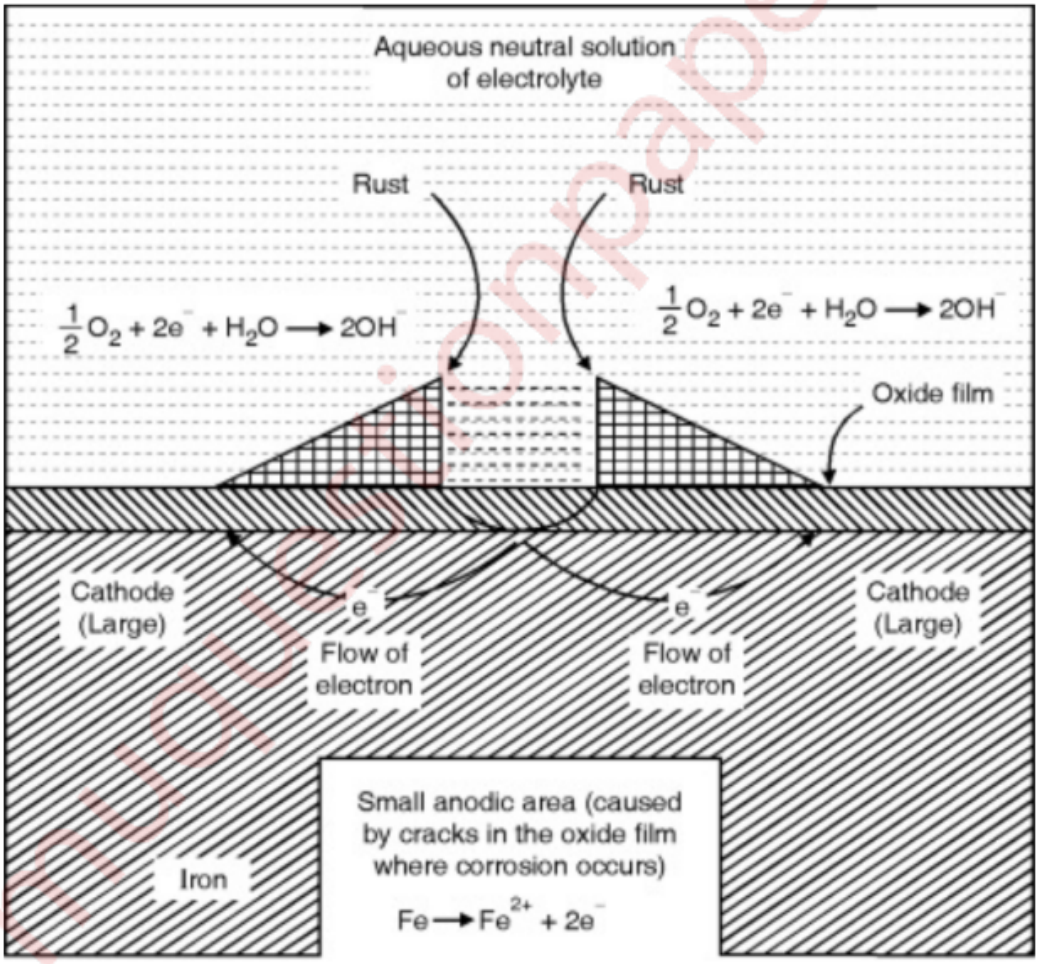
Rusting of iron in neutral aqueous solution of electrolytes in the presence of atmospheric oxygen is the most common example of this type of corrosion (mechanism).

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)

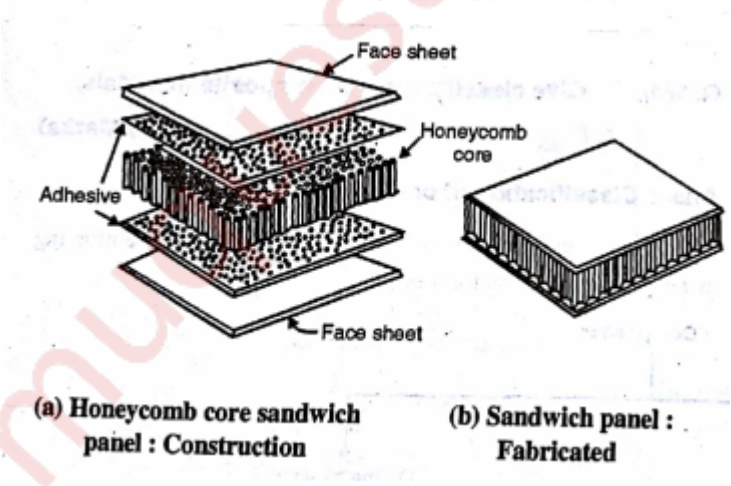
Solution:-

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:

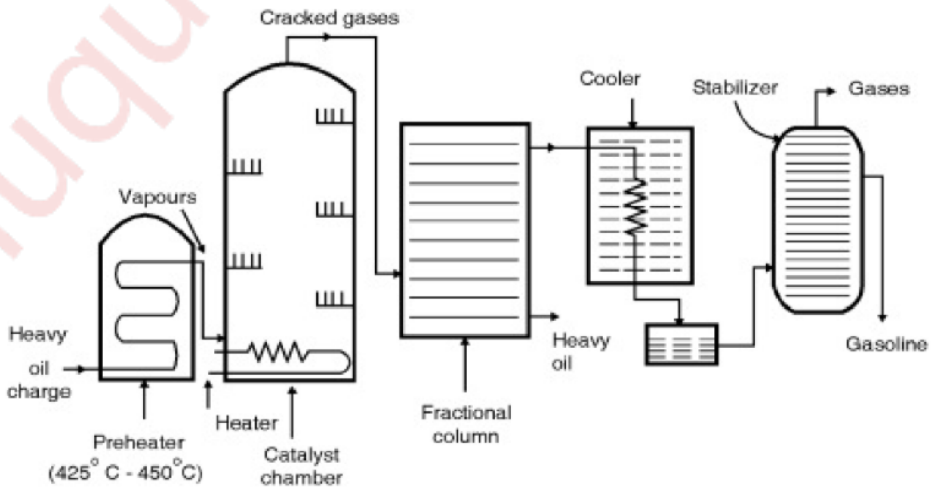
$$C_{12}H_{26} \xrightarrow{heat/catalyst} C_7H_{16} + C_5H_{10}$$

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

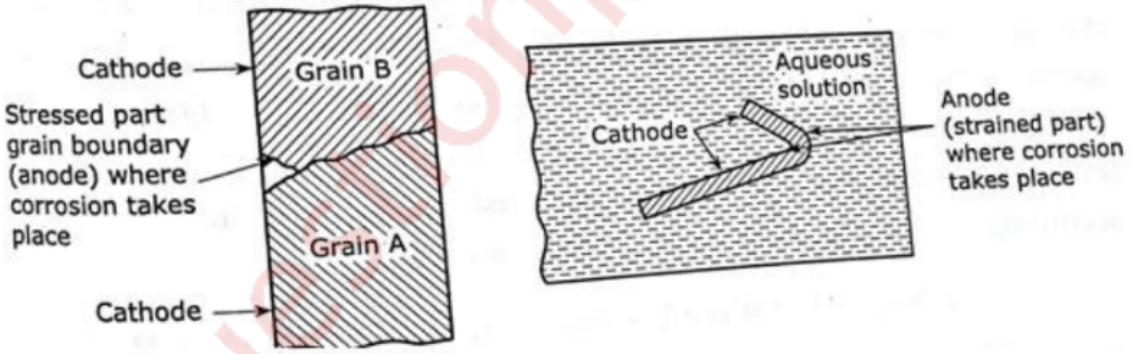
The corrosive agents are highly:

- 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

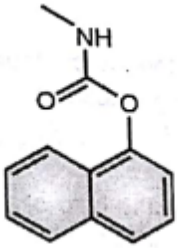
- In this type of cracking the catalyst is in the form of granules or pellets and the beds of these catalyst are fired in catalyst towers.
- Oil vapours to be cracked are passed through the beds at the cracking temperature unhl the catalyst becomes carbonized.
- Gasoline , vapour are cooled and condensed 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)

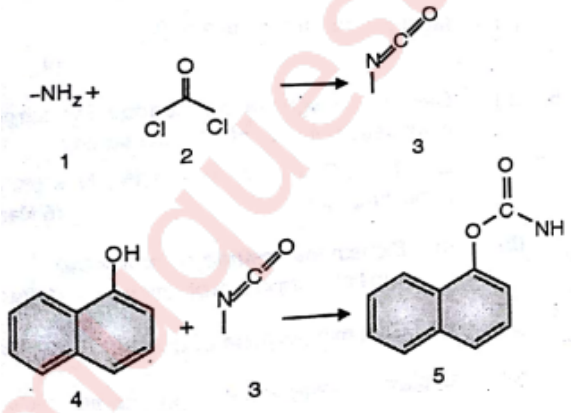
Solution:-

Structure of Carbaryl



(1) Traditional route

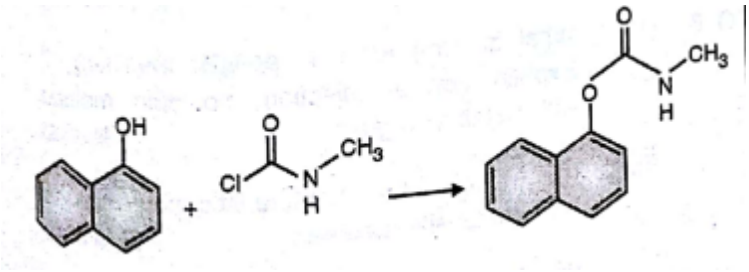
Carbaryl is prepared on large scale by treating methyl-isocyanate with 1-naphthol, Amine is treated with Phosgene to get methyl-isocyanate. Carbaryl is produced by treating methyl isocyanate with 1-naphthol.



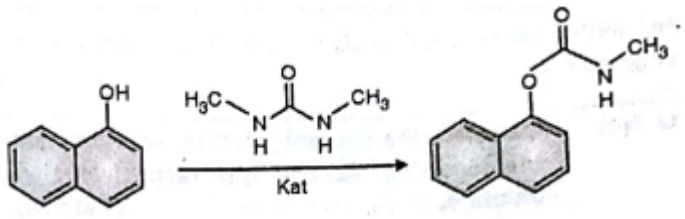
(2)With using naphthol-1 and methylcarbamoyl chloride:

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

phosgene ,methyl isocyanate and methylcarbamoyl chloride are used.

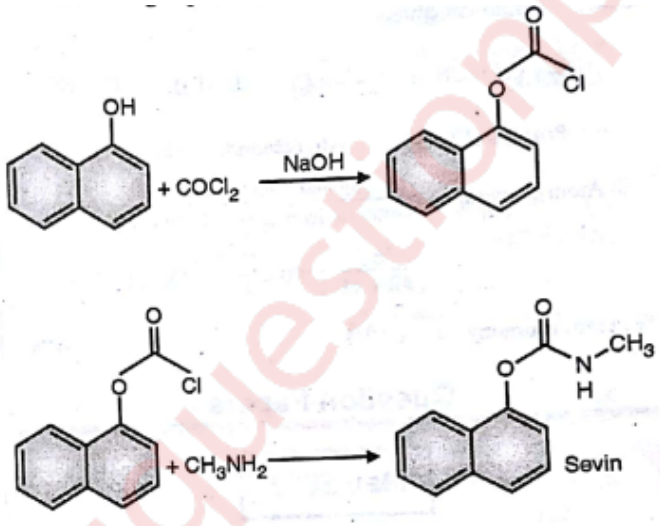


We have developed a new and cost-effective approach to seven synthesis without using of toxic reagents:



Routes of seven synthesis:

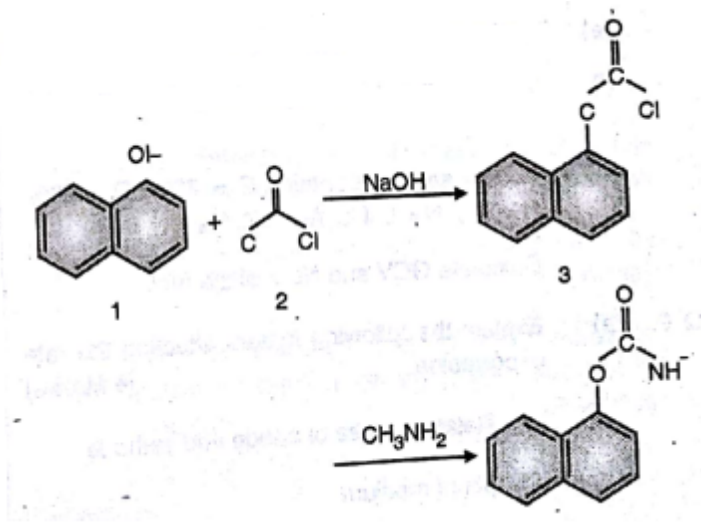
1) With using naphthol-1 and phosgene



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:-

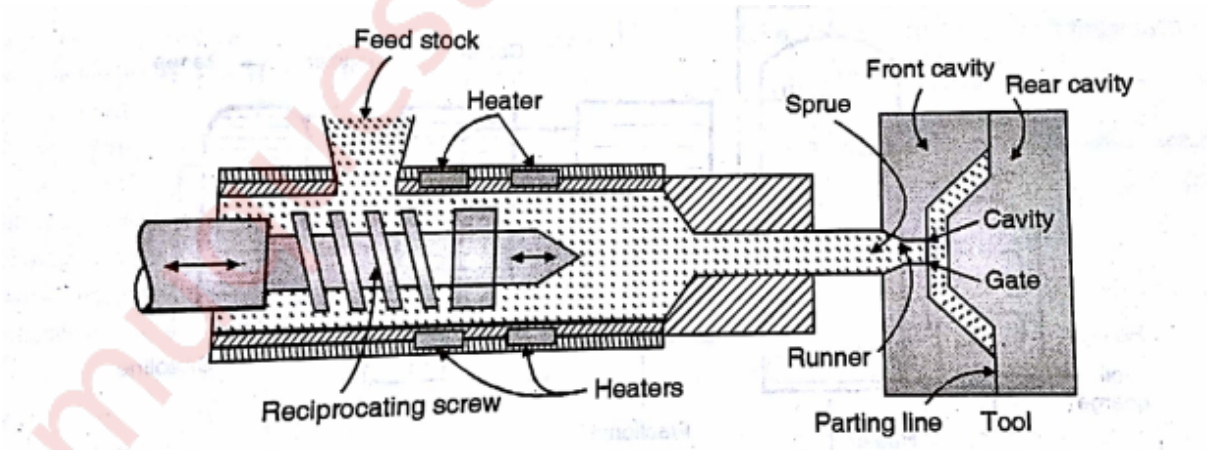
Powder metallurgy has some disadvantages which limits its applications in some of the situations.

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.
