**Short answer questions with solutions**

# Phase Rule

1. **State condensed phase rule and where it is applicable.**
   In two component systems and for minimum one phase the degree of freedom becomes 3 and a three dimensional diagram is not feasible to draw. So the least important variable is kept constant (Pressure) and Gibbs Phase rule equation is reduced by 1 *i.e.*
   F' = C-P+1
2. **Define triple point of water system.**
   It is the point where all the three phases are in equilibrium i.e. 0.0098 °C and 4.58mm of Hg Pressure. The system is invariant at this point.
3. **Define the terms phase and components with respect to phase rule.**
   A homogeneous, physically distinct and mechanically separable portion of the system which is separated from the other parts by definite boundary surfaces.
   The components can be defined as the minimum number of chemical species which are required to define the composition of all the phases present in the system.
   For eg.
   $CaCO_3$ (s) $\longrightarrow$ CaO (s) + $CO_2$ (g)
   In this we have three phases and two components.
4. **What is dry ice.**
   Solid $CO_2$ is known as dry ice.
5. **What is eutectic point?**
   In binary systems where two components are miscible in all possible proportions in molten state but do not react chemically, have a property of lowering each other's freezing points and the minimum freezing point attainable out of the possible mixtures is known as eutectic point.
6. **What are supercritical fluids?**
   Supercritical fluid is a state of matter at a temperature and pressure above its critical point. Beyond this point we cannot differentiate between liquid and gas phase.
7. **What do you understand by metastable equilibrium?**
   Equilibrium which can be attained only from one direction by a careful change of condition. Example super cooling of water.
   Super cooled water $\leftrightarrow$ vapour
8. **Define incongruent m.pt.**
   When a compound is not stable up to its actual m.pt. and decomposes in to a new solid phase and liquid of different composition.
   Solid $\leftrightarrow$ New Solid + Liquid
   For example $Na_2SO_4$-$H_2O$ system.
9. **Define congruent m.pt.**
   When a solid melts sharply in to a liquid having the same composition as that of the solid from which it is formed. Eg Zn-Mg system.

# Catalysis

**1 What is positive and negative catalysis?**

A catalyst can increase as well as decrease the rate of a chemical reaction. The catalyst which increases the rate of a reaction is called positive catalyst and the phenomenon is known as positive catalysis. The catalyst which decreases the rate of a reaction is called negative catalyst and the phenomenon is known as negative catalysis.

Examples:

Vegetable oil+ $H_2 \rightarrow$ Vegetable ghee (Ni is positive catalyst for the reaction)

TEL decreases the knocking of petrol and acts as negative catalyst.

**2 What is homogeneous and hetertogeneous catalysis?**

In a heterogeneous reaction, the catalyst is in a different phase from the reactants. In a homogeneous reaction, the catalyst is in the same phase as the reactants.

e.g. of heterogeneous catalysis

Combination of $N_2$ & $H_2$ in the presence of finely divided iron (Haber's process)

$$N2(g)+3H2(g) \xrightarrow{Fe} 2NH3$$

In this case, the reactants nitrogen & hydrogen are present in the gaseous phase, whereas iron is in the solid phase. Hence the reaction system is heterogeneous.

e.g. of homogeneous catalysis

Oxidation of $SO_2$ into SO by oxygen in the presence of NO (g)

Hydrolysis of an ester in the presence of a mineral acid:

$$RCOOR(l)+H2O(l) \rightarrow C_6H_{12}O_6+C_6H_{12}O_6$$

**3 Explain induced and autocatalysis.**

When a chemical reaction influences the rate of some other reaction which does not occur under ordinary conditions, is called induced catalysis.

e.g. Sodium arsenite solution is ordinarily not oxidized by air. However, if air is passed through a mixture of a solution of sodium arsenite & sodium sulphite, both of them undergo simultaneous oxidation. In fact, in this case, the oxidation of sodium arsenite is catalysed by the oxidation of sodium sulphite.

When the reaction product itself act as catalyst for that reaction is known as autocatalyst and process is called autocatalysis .

e.g. Hydrolysis of ethyl acetate:

$CH_3COOC_2H_5+H_2O \rightarrow CH_3COOH+C_2H_5OH$

**4 What are promoters?**

A promoter itself is not a catalyst but is capable of increasing the catalytic action of a catalyst already used in the reaction.

e.g. In the manufacture of ammonia by Haber's process, iron is used as a catalyst. Its catalytic activity is increased when it is mixed with a small amount of Mo or $Al_2O_3$.

**5 What are poisoners?**

A foreign substance which renders a heterogeneous catalyst ineffective is called as catalytic poisioning.

e.g.The iron catalyst used in the synthesis of ammonia by Haber's process is poisoned by $H_2S$.

**6 What do you mean by optimum temperature and pH for a catalytic reaction?**

The temperature & pH at which enzymatic activity is maximum is known as optimum temp. & pH. The temp. is $37^{\circ}C$& pH is around 5.

**7 Why solid catalyst should be used in finely divided form?**

Ans. Catalytic activity of the solid catalyst increase in finely divided form as it is increase the surface area of the catalyst & the free valancies of the catalyst.

**8 What is cofactor & coenzyme?**

When the prosthetic group of an enzyme is a metal ion, it is called as a cofactor & if the prosthetic group is a small organic molecule, it is known as coenzyme.

# Water and Its Treatment Part I

**1. What is principle of EDTA titration?**

In this method hard water is titrated against EDTA using EBT as indicator in the presence of buffer solution. The $Ca^{2+}$ and $Mg^{2+}$ are first combined with EBT to form a wine red colored complex and when we titrate with EDTA these ions are combined with EDTA due to its greater stability. At the end point free indicator is released which is of blue colour.

**$Ca^{2+}$ or $Mg^{2+}$ + EBT → [Ca-EBT] complex or [Mg-EBT]complex**

**Blue Wine red**

**Metal-EBT + EDTA → Metal-EDTA + EBT**

**Wine red Blue**

**2 What are the types of hardness? Explain its causes.**

Hardness of water is of two types.

(i) Temporary/ Alkaline or Carbonate hardness: It is due to presence of bicarbonates of calcium and magnesium. It can be removed by boiling.

(ii) Permanent/ Non-Alkaline or Non Carbonate hardness: It is due to presence of chlorides and sulphates of calcium and magnesium. It cannot be removed by boiling.

**3 Write the units of hardness. How are they related to each other?**

Following are the units of hardness:

1. Parts per million (ppm)
2. Milligrams per litre (mg./lit.)
3. Clarke's degree ( $^{\circ}$Cl)
4. Degree French ( $^{\circ}$Fr)
5. Millequivalent per litre( meq/lit.)

**Relationship between various units of hardness:**

1ppm = 1mg./lit. = 0.1$^{\circ}$ Fr =0.07 $^{\circ}$Cl =0.02 meq./lit.

**4 What is meant by hardness of water?**

The presence of $Ca^{2+}$ and $Mg^{2+}$ ions in water is a measure of hardness of water. Hard water does not form lather with soap.

**5 Why hardness and alkalinity of water is expressed in terms of calcium carbonate only?**

The hardness and alkalinity of water is expressed in terms of calcium carbonate only because its molecular weight is 100 which makes the calculations easier and it is the most easily precipitated out during water softening process.

6 **Hard water does not form lather with soap. Explain.**

With hard water, soap solutions form a white precipitate (soap scum) instead of producing lather. This effect arises because these ions forms a solid precipitate (the soap scum). A major component of such scum is calcium stearate, which arises from sodium stearate, the main component of soap:

$$2\ C_{17}H_{35}COO^- + Ca^{2+} \rightarrow (C_{17}H_{35}COO)_2Ca$$

Hardness can thus be defined as the soap-consuming capacity of a water sample, or the capacity of precipitation of soap as a characteristic property of water that prevents the lathering of soap.

**7 Differentiate between hard and soft water.**

Soft water: Water which produces lather with soap solution readily e.g. rain water.
Hard water: Water which does not produce lather with soap solution readily e.g. sea water, river water.

**8 Comment on the statement "Distilled water containing sodium bicarbonate exhibits only alkalinity whereas aqueous solution of calcium carbonate imparts both alkalinity and the hardness".**

Distilled water containing sodium bicarbonate exhibits only alkalinity because it ionizes to produce $Na^+$ and $HCO_3^-$. $Na^+$ ions does not cause hardness to the water and alkalinity was introduces by $HCO_3^-$. But aqueous solution of calcium carbonate imparts both alkalinity and the hardness because it ionizes into $Ca^{2+}$ and $CO_3^{2-}$. $Ca^{2+}$ ions are responsible for hardness and $CO_3^{2-}$ ions are responsible for alkalinity at the same time.

**9 What type of ligand is EDTA? Why the complex of $Ca^{2+}$ or $Mg^{2+}$ with EDTA is more stable than the complex of $Ca^{2+}$ or $Mg^{2+}$ with EBT?**

EDTA is ethylene diammine tetra Acetic acid and it is a hexavalent ligand means it can form 6 dative bonds. The 1:1 complex of EDTA with $Ca^{2+}$ or $Mg^{2+}$ have cyclic structure and hence more stable due to chelation.

**10 Calgon conditioning is better than phosphate conditioning-Justify?**

Calgon conditioning is better than phosphate conditioning because it forms a water soluble complex $Na_2[Ca_2(PO_3)_6]$ and does not form scale or scales in the boiler. On the other hand, in phosphate conditioning, sodium phosphate is added to the boiler water so that precipitates of calcium phosphate are formed. Although this ppt is non-adherent and soft, yet it has to be removed by frequent blow-down operation. Hence, calgon conditioning is definitely better than phosphate condition.

**11 Differentiate between scale and sludge?**

Sludge is a soft, loose and slimy deposit formed inside the boiler and can be removed by scrapping off with brush, while scale is hard, sticky and adherent deposit formed on the inner surface of the boiler and very difficult to remove even with the help of hammer and chisel.

# Water and Its Treatment Part II

**1.What do mean by demineralization?**

It is a process of removing all ions present in water by using ion exchange resin. Ion exchange resin consist of cross linked polymer and long chain polymer (Polystyrene and Divinylbenzene, Poly-methylmethacryic acid, Divinylbenzene or phenol formaldehyde resin). On the basis of functional group resin may be classified as:

1) Cation exchange resin: These are polymer Polystyrene Divinylbenzene containing acidic functional group like-COOH, $-SO_3H$ etc. and represented as RH. They exchange $H^+$ ion in water.
2) Anion exchange resin: These are polymer Polystyrene Divinylbenzene containing basic functional group like amine and represented as R'OH. They exchange $OH^-$ ion in water.

**2. What is Zeolite.**

Zeolite is known as permutit or boiling stone. Zeolite is naturally occurring hydrated Sodium Alumino silicate minerals ( $Na_2O\ Al_2O_3.xSiO_2.yH_2O$). Where x =2-10 , y = 2-6. These are capable of exchanging the ions causing hardness in $H_2O$ by sodium ion. Zeolite are of two types:

**Natural zeolite**: Are non porous , amorphous and durable and have low exchange capacity ( Natrolite- $Na_2O\ Al_2O_3.3SiO_2.2H_2O$), ( Laumontite $Na_2O\ Al_2O_3.xSiO_2.yH_2O$

**Synthetic zeolite**: are porous and have high exchange capacity and are prepared by $Na_2CO_3$, $Al_2O_3$ and $SiO_2$ eg. ( $Na_2O\ Al_2O_3.xSiO_2.yH_2O$).

Zeolite is represented as $Na_2Z$ where Z stands for insoluble radical frame work.

**3. What are ion-exchange resins?**

Ion exchange resin consist of cross linked polymer and long chain polymer (Polystyrene and Divinylbenzene, Poly-methylmethacryic acid, Divinylbenzene or phenol formaldehyde resin). On the basis of functional group resin may be classified as:

Cation exchange resin: These are polymer Polystyrene Divinylbenzene containing acidic functional group like-COOH, $-SO_3H$ etc. and represented as RH. They exchange $H^+$ ion in water. Anion exchange resin: These are polymer Polystyrene Divinylbenzene containing basic functional group like amine and represented as R'OH. They exchange $OH^-$ ion in water.

**4. What is meant by "desalination" of sea water?**

The process of removal of dissolved salts (NaCl etc.) from water is known as desalination. When water contains high concentration of dissolved solids then it is known as brackish water. It is unfit for drinking due to much salty taste. Because of scarcity of available fresh water this process has been adopted as much as possible in the world. It can be done by electrodialysis and reverse osmosis

**5. Give characteristics of drinking water.**

1. It should be colourless, odourless and tasteless.
2. It should not be hot.
3. It should be free from dissolved solids (compounds of As and Pb ) and harmful gases like $H_2S$, $SO_2$.
4. It should be free from disease producing microorganisms.
5. pH should be 7- 7.5 and Hardness should be less than 50 -60ppm.

# Corrosion & Its Control

1. **What is microbiological corrosion?**

   Corrosion which takes place microbiologically is called microbial corrosion. This corrosion is influenced by the presence and activities if micro-organisms. Bacteria, fungi and other micro-organisms can play a major part in soil corrosion. Examples:

   a) Sulphate reducing bacteria (sporovibrio desulphuricans) are responsible for anaerobic corrosion of iron and steel.

   b) Sulphur bacteria (Thiobacillus) are responsible for aerobic corrosion.

2. **What do you understand by galvanization?**

   **Galvanization** is the process of applying a protective zinc coating to steel or iron, in order to prevent rusting.

3. **What do you understand by anodic protection?**

   Sacrificial cathodic protection occurs when a metal is coupled to a more reactive (anodic) metal. This connection is referred to as a galvanic couple. In order to effectively transfer corrosion from the metal structure, the anode material must have a large enough natural voltage difference to produce an electrical current flow.

   An advantage of sacrificial anode systems is the flexibility in application. Anodes can be installed in a variety of applications and configurations. No outside power is required for cathodic protection to be effective. Another advantage is the minimal maintenance required for these systems to function.

   Disadvantages of sacrificial anode systems include the limited protection current available and limited life. Sacrificial anodes are subject to rapid corrosion (consumption) and require replacement on a regular basis. Typical design life of a pipeline system anode is five to ten years.

4. **What is the effect of pH on corrosion?**
   The lower the pH (or more acidic) greater is the corrosion.
5. **What is the effect of $CO_2$ on electrochemical corrosion?**
   The corrosion is speed up because $CO_2$ gets dissolved with water producing an acidic electrolyte.

6. **What is Pilling Bedworth rule? Explain it.**
   The oxide layer can be protective or non- protective, depending upon the ratio of volume of the metal oxide to the volume of the metal consumed. This is known as Pilling Bedworth rule.

   P.W. Ratio = Vol. of the metal oxide formed / Vol. of metal consumed

   If P.W. Ratio is less than unity= oxide layer is non- protective

   If P.W. Ratio is equal or greater than unity= oxide layer is protective

7. **Why corrosion starts at anode but oxide layer or film is formed at the cathode?**
   The rate of diffusion of $Fe^{2+}$ is faster than that of $OH^-$, so corrosion occurs at the anode but rust deposited at or near cathode.

8. How caustic embitterment is cause of corrosion?

**Caustic embrittlement** is the phenomenon in which the material of a boiler becomes brittle due to the accumulation of caustic substances.

As water evaporates in the boiler, the concentration of sodium carbonate increases in the boiler. Sodium carbonate is used in softening of water by lime soda process, due to this some sodium carbonate maybe left behind in the water. As the concentration of sodium carbonate increases, it undergoes hydrolysis to form sodium hydroxide.

$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$

The presence of sodium hydroxide makes the water alkaline. This alkaline water enters minute cracks present in the inner walls of the boiler by capillary action. Inside the cracks, the water evaporates and amount of hydroxide keeps on increasing progressively. This sodium hydroxide attacks the surrounding material and the dissolves the iron of the boiler as sodium ferrate. This causes embrittlement of boiler parts like rivets, bends and joints, which are under load owing to stress concentration.

**9. Why do the impurities accelerate the corrosion of metal?**

The rate and extent of corrosion increases with the increasing exposure and extent of the impurities. So, corrosion resistance of a metal may be increased by increasing its impurities.

**10. What is soil corrosion?**

Soil corrosion is the type of wet corrosion in which number of variables involved. Soil with the high proportion of sand have very limited storage capacity for water where as clays are excellent for retaining of water. The corrosion in soil depends upon its porosity, degree of aeration and electrical resistance. The rate of corrosion in soil also dependent on the diffusion of dissolved oxygen in soil water.

# LUBRICANTS

**1. State and explain cloud point and pour point.**

During the slow cooling of an oil, the temperature at which an oil becomes cloudy in appearance is called its cloud point, while the temperature at which the oil ceases to flow or pour is called pour point. Cloud point and pour point indicates the suitability of lubricants in cold conditions.

**2. Describe saponification value of a lubricant.**

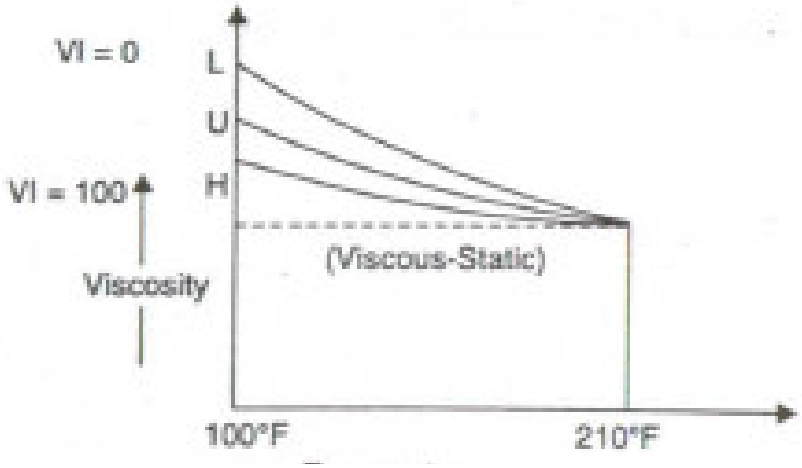
The number of milligrams of KOH required to saponify 1 gram of fat or oil is known as saponification value.

**3. Describe biodegradable lubricants.**

The lubricants which are easily decomposed or destroyed when spilled on to open land or into water, without leaving behind harmful substances. For example: sunflower oil, mustard oil etc…

**4. Define viscosity index.**

**Viscosity Index:-** The arbitrary scale which measures the variation of viscosity with temperature is called viscosity index . Generally the viscosity of an oil decreases with rise in temperatures. The viscosity of a good lubricant should not change very much with the rise of temperature. If the viscosity of oil is very much affected with this it is called "low viscosity index". Similarily if the viscosity of oil is slightly affected with the rise in temperature it is called "high viscosity index".A good lubricant should have high viscosity index. Some substances are- silicons, polyglycol ethers, diesters etc. **viscosity index (VI)= L – U / L-H X 100** where, **U**= viscosity of experimental oil at $100^{O}$F, **L=** viscosity of low viscosity index standard oil at $100^{o}$ F and also having the same viscisity experimental oil at $210^{o}$ F, **H=** viscosity of viscosity index standard oil at $100^{o}$ F and also having the same viscosity of experimental oil at $210^{o}$ F.



# Polymers

**1. What do you mean by degree of polymerization and glass transition temperature?**

The total no. of monomeric unit present in polymeric chain is called as degree of Polymerization. Glass transition temperature is the temp. below which polymer is glassy state and above which polymer is in viscoelastic state. It is represented as Tg. It is very important to determine the physical properties or thermal behavior of polymer.

**2. Differentiate between addition and condensation polymerization? Give example.**

Addition polymerization is a reaction in which same monomer adds on and the polymer is an exact multiple of the original monomeric molecule. Example PVC, PVA, Polyethylene

If the polymer is formed by the combination of two or more similar or different molecules of monomeric units usually with the loss of simple molecules like water, ammonia etc. is called condensation polymerization. Example Nylon-66, UF, PF.

**3. Differentiate between homopolymer and co-polymer.**

Homopolymers consists of identical monomers like ~A-A-A-A-A-A~

Example : Polyethene, Polyisoprene, Polystyrene

Copolymers consists of more than one type of monomers like ~A-B-A-B-A-B~

Example : Nylon-66, Bakelite

**4. Differentiate between thermosets and thermoplasts.**

Thermoplasts are the polymers which soften on heating and can be mould to any shape & retain the shape on cooling. This process can be done for several times. Polythene, PVC, Nylon, etc.

Thermosets are also known as permanent setting plastics means they change irreversibly into hard, infusible, rigid mass on heating and cannot be reshaped. Bakelite, vulcanized rubber, etc.

**5. What do you mean by tacticity of a polymer.**

Tacticity means orientation of monomers in a polymers.

a) Isotactic Polymer : If the side groups of the monomers lie on the same side of the chain.
b) Syndiotatic Polymer : If the side groups are arranged in an alternate fashion.
c) Atactic Polymer : If the side groups are arranged in irregular/random fashion around the main chain.

**6. What is functionality of a monomer.**

The number of reactive /bonding sites in a monomer is called its functionality. For a substance to act as monomer it should have two reactive sites.No. of functional group in a compound define its functionality. For Example

$HOOC\text{-}CH_2\text{-}COOH$ 2

$HO\text{-}CH_2\text{-}CH_2\text{-}OH$ 2

**7. What is bio-polymers? Give some examples also.**

In contrast to synthetic polymers, biopolymers tend to have a well-defined structure. Biopolymers provide an alternative to oil based plastics, as they are made from plants, usually polymers of starch or polylactic acid (PLA). They are currently used for bags, cutlery and plates, pens, clothing, credit cards, food packaging, agricultural films, teabags, coffee filters, diapers and napkins. Examples are: polymers based on Starch, Sugar- Cellulose ,Synthetic materials etc.

**8. Give important applications of following:**

PVC, PVA, Teflon, PF, UF, Buna-n, Buna -S

# Analytical Methods

**1. What do you mean by allowed and forbidden transition?**

The transitions with values of (Extinction Coefficient) €max, more than $10^4$ are usually called allowed transition. And they arise due to π- π* transition. In 1,3-butadiene the absorption at 217mμ and €max- 21000 is an example of allowed transition.

For forbidden transition €max is generally below $10^4$. And they arise due to n- π* transition. In Benzophenone the absorption at 325mμ and €max- 180, is an example of forbidden transition.

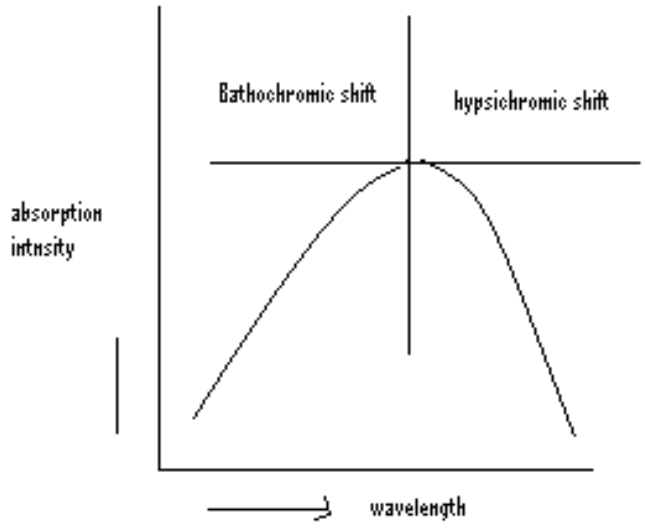
**2. What are Auxochromes and Chromphores.**

Chromophore may be defined as a functional group that absorbs EMR in UV-Visible region i.e. 200-400nm (UV) and 400-800nm (visible) whether it imparts colour to the compound or not. >C=O, COOH, -CN, >C=C<, etc.

Auxochromes are the groups which do not act as chromophore but when attached to chromophores the absorption band shifted towards longer wavelength region and also cause an increase in the intensity of absoption band. –OR, -OH, $-NH_2$, etc.

**3 . What is Bathochromic and Hypsochromic shift?**

Ans. Bathochromic shift: shift of an absorption band to a longer wavelength due to substitution or solvent effect is called as Bathochromic shift or Red Shift. Hypsochromic shift: the shift of an absorption band to a shorter wavelength due to substitution or solvent effect is called as Hypsochromic shift or Blue Shift.



**4. Write short note on finger print region?**

The region from 1500 to 900 $cm^{-1}$ is known as ***fingerprint region*** because in this region a molecule shows a unique absorption pattern as a person's finger prints are unique. This region is very important to characterize a compound.

**5. What type of molecules is IR active?**

Molecules having inheritant dipole moment or change in dipole moment when placed in IR radiation will be IR active. Like – OH,-$CH_2$, -COOH, -CO etc. And homo-diatomic molecules are IR inactive due to zero dipole moment or centre of symmetry.

**6. What is the principle of Flame photometer?**

It is an example of emission spectroscopy. When certain metallic salt solution is sprayed in to a flame the solvent gets evaporated and some of the salts undergo dissociation and forms constituent atoms in vapour state. Some atoms get excited by absorbing thermal energy and electrons get promoted from lower energy level to the higher energy level. When these electrons come back to the lower energy level they radiate energy of different wavelength. The radiated energy on passing through optical filter emitted the characteristic wavelength radiation which is amplify and recorded by a suitable digital read out system.