Solutions

CMR INSTITUTE OF TECHNOLOGY

Sub:	**Engineering Chemistry**						Code:	18CHE12
Date:	04/12/2018	Duration:	90 mins	Max Marks:	50	Sem: I	Branch:	All

Internal Assessment Test III

1. (a) Define calorific value of fuel. Explain the experimental determination of calorific value of solid fuel using Bomb Calorimeter. (05 Marks) (CO3, L3)

Solution: It is defined as the amount of heat released when unit quantity (unit mass or volume) of fuel is burnt completely in excess of air or oxygen.

Calorific values of solid or liquid fuels are determined by using **Bomb calorimeter**.

Principle: A known weight of the sample (solid or liq fuel) is burnt completely in excess of oxygen. The liberated heat is absorbed by the surrounding water and the calorimeter. Thus the heat generated during the combustion of fuel is equal to the heat absorbed by water and copper calorimeter. The GCV of fuel is calculated from the data.

Construction

The calorimeter consists of a stainless steel bomb. It has an airtight screw lid valve for introducing oxygen inside the bomb. It also has an electrical ignition coil for the initiation of combustion of fuel. The bomb is placed in a large well insulated Cu calorimeter. The calorimeter is equipped with a mechanical stirrer for dissipation of heat and a thermometer to read accurately the temperature rise.

Working

A known wt. of fuel (solid or liq) is placed in a small stainless steel crucible. The crucible is placed inside the bomb. The bomb is sealed airtight by the lid. The sealed bomb is placed in a large well insulated copper Calorimeter. The known mass of water is taken inside calorimeter. The water is continuously stirred by the mechanical stirrer. The initial temp of the water is carefully measured. The bomb is filled with oxygen and the combustion of fuel is initiated by passing electric current. As the sample burnt in the bomb, heat is liberated and it is absorbed by surrounding water and calorimeter. The temperature of water gradually rises and attains the maximum value. The maximum temp is carefully noted.

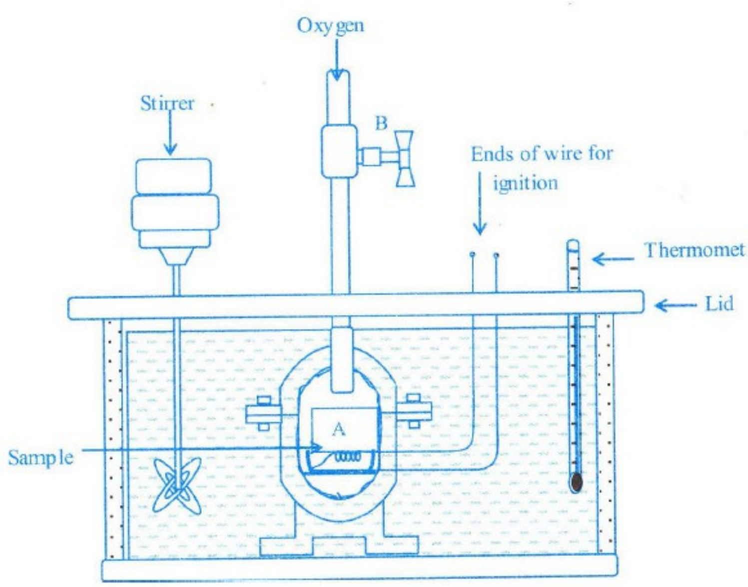


Fig. Bomb Calorimeter

Observation and calculation

Mass (wt) of the fuel = m (kg)

Mass of the water taken in calorimeter = W_1 (kg)

Water equivalent of calorimeter = W_2 (kg)

Initial temp. of water = T_1 °C

Final temp. of water = T_2 °C

Specific heat of water = s (4.18 KJ Kg^{-1} °K)

Heat generated by burning 'm' kg of fuel = Heat gained by (surrounding water + calorimeter

$$m \times GCV = (W_1 + W_2)(T_2 - T_1)(s)$$

Where, 'GCV' is gross calorific value of the fuel.

$$GCV = \frac{(W_1 + W_2)(T_2 - T_1)\, 4.187}{m} \text{ KJ kg}^{-1} \qquad \text{............(1)}$$

And, net calorific value,

$$NCV = GCV - 0.09 \times H \times L_v \text{ KJ kg}^{-1} \qquad \text{..............(2)}$$

Where, H is the percentage amount of hydrogen in the fuel and L_v = **587 x 4.187 kJ kg^{-1}** (**2454 kJ/kg**) is the latent heat of condensation of steam.

(b) What are PV cells? Explain construction and working of PV cell. (05 Marks) (CO3, L3)

Solution:

Photovoltaic cells or solar cells are semi conductor device that converts sunlight into direct current (DC) electricity. As long as light is shining on the solar cell, it generates electrical power. When light stops, electricity stops.

Construction & Working of PhotoVoltaic Cells-

PhotoVoltaic Cells consist of a semiconductor diode (p-n junction) made of a silicon. It has two electrical contact, on one of its sides, a mettalic grid is used and on the other side a layer of noble metal (such as Ag) is used. The metal grids permits the light to fall on the diode between the grid lines. Electromagnetic radiation consists of particle called photon (hv). They carry a certain amount of energy given by the Plank quantum equation. **E = hc/λ w**here, h = Planck's constant, c = velocity of light, λ = wavelength of the radiation. The electromagnetic radiation (sunlight) falls normal to the plane of the solar

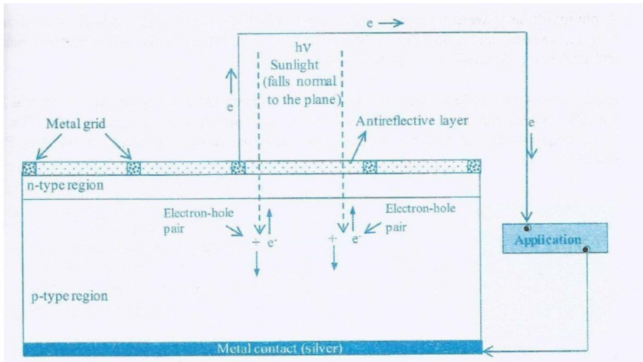


Fig. Photovoltaic cells

cell, the photons which possess energy sufficient to overcome the barrier potential are absorbed, electrons are ejected and electron-hole pairs are formed. The electrons move towards the n-region (as it is positively charged). The electrons are driven into the external circuit and used for various applications or appliances.

2. (a) A coal sample containing, carbon 90%, H2 5.8% and ash 4.2% is subjected to combustion in a bomb calorimeter. Calculate the Gross and Net calorific values. Given that mass of coal sample is 0.78g, mass of water is 2500g, water equivalent of calorimeter is 0.83kg, rise in temperature is 3.2°C, latent heat of steam is 587kcal/kg. . (06 Marks) (CO3, L3)

Solution: Given, m =0.78g = 0.78×10^{-3} kg

W_1= 2500g = 2.5 kg

W_2= 0.83kg

$(T_2 - T_1)$ = 3.2°C

%H = 5.8%

s = 4.187 kJ kg^{-1} °C^{-1}

L_q =587kcal/kg = 2454 kJ/kg

$$GCV = \frac{(W_1 + W_2)(T_2 - T_1)\, s}{m}$$

$$= \frac{(2.5 + 0.83)\,(3.2)\, 4.187}{0.78 \times 10^{-3}}$$

= 57,200.86 kJ kg^{-1}

NCV = GCV - 0.09 x %H x L_v

= 57,200.86 - 0.09 x 5.8 x 2454

= 57200.86 -1,280.988

= 55919.872 kJ/kg

(b) Define fuel cell. Differentiate between fuel cell and battery. (04 Marks) (CO3, L3)

Solution:

A fuel cell is a device that converts the chemical energy of a fuel (hydrogen, natural gas, methanol, gasoline, etc.) and an oxidant (air or oxygen) into electricity.

	Battery		**Fuel Cells**
1.	Anodic and cathodic compartments are preloaded and reaction products are retained in the battery.	1.	Permit continuous movement of fuel, oxidant and reaction products in and out of battery.
2.	They have definite amount of stored energy.	2.	They are only energy conversion devices, do not store any energy.
3.	As long as active components exist, battery continues delivering energy.	3.	As long as fuel and oxidant are supplied at respective electrodes, energy is available.
4.	Generally function at ambient temperatures without an active catalyst	4.	Generally work at higher temperature or in presence of an

	being employed.		electrocatalyst.

3. (a) Describe construction and working of CH_3OH-O_2 fuel cell. Mention its applications. (05 Marks) (CO3, L3)

Solution: ***Construction:*** Methanol – oxygen fuel cell consist of

1. Anode – It is a porous platinium (Pt) electrode.
2. Cathode **-** It is a porous platinium (Pt) electrode.
3. Electrolyte – Aqueous sulphuric acid (H_2SO_4)
4. Active components: (a) Fuel – Methanol mixed with sulphuric acid supplied at anode.
   (b) Oxidant – Pure oxygen is supplied at cathode.
5. Adjacent to cathode towards electrolyte side, a semi permeable membrane is inserted to allow the diffusion of H^+ ions, but disallow the diffusion of methanol and its direct oxidation at cathode.

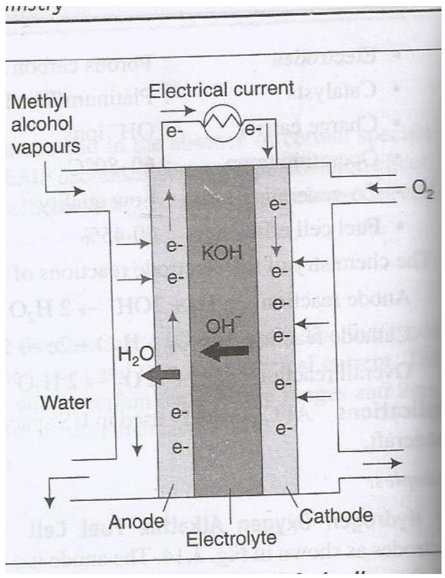


Fig: ***Methanol – oxygen fuel cell***

Working:

Anode Reaction: $CH_3OH (l) + H_2O(l) \longrightarrow CO_2 (g) + 6H^+ (aq) + 6e-$

Cathode Reaction**:** $3/2\ O_2 (g) + 6\ H^+ (aq) + 6e- \longrightarrow 3\ H_2O (l)$

Overall Cell Reaction: $CH_3OH (l) + 3/2\ O_2 (g) \longrightarrow CO_2 (g) + 2\ H_2O (l)$

Applications:

1. used in automobiles, military applications.

2. Power backup and portable instruments.

3. in large scale power production.

(b) Explain the production of solar grade silicon by Union Carbide process. (05 Marks) (CO3, L3)

Solution: Preparation of Solar Grade Silicon by union carbide process:

- Metallurgical grade silicon is heated to 300-350 ºC and dry hydrogen chloride is passed. Trichlorosilane and a small amount of tetrachlorosilane are formed as given below

$$Si + 3HCl \longrightarrow HSiCl_3 + H_2$$

Trichlorosilane

$$Si + 4HCl \longrightarrow SiCl_4 + 2H_2$$

Tetrachlorosilane

- Tetrachlorosilane is converted to trichlorosilane by treating with hydrogen at 1000ºC.

$$SiCl_4 + H_2 \longrightarrow HSiCl_3 + HCl$$

- Trichlorosilane is passed through ion exchange resin containing quaternary ammonium salts to give dichlorosilane and tetrachlorosilane. Dichlorosilane subsequently forms trichlorosilane and silane (silicon tetra hydride).

$$2HSiCl_3 \longrightarrow H_2SiCl_2 + SiCl_4$$
$$3H_2SiCl_2 \longrightarrow SiH_4 + 2HSiCl_3$$

- Tetrachlorosilane is hydrogenated again to trichlorosilane and trichlorosilane is again passed through ion exchange resin. The process is continued to get silane (silicon tetra hydride). Silicon hydride or silane obtained above is further purified by distillation. Silane is passed into a reactor containing heated silicon seed rods. Silane gets pyrolysed to form polysilicon (semiconductor grade silicon).

$$SiH_4 \longrightarrow Si + 2H_2$$

4. (a) Write a note on (i) Power Alcohol (ii) Unleaded Petrol. (06 Marks) (CO3, L2)

Solution: (i) **Power Alcohol**: A blend containing **10 to 85% of ethanol and 15-90% of gasoline**, used as fuel is known as power alcohol. The addition of alcohol to petrol increases its octane number. Power alcohol is used as a fuel by blending with petrol in IC engine. It is also blended with diesel to form E-diesel. Power alcohol has calorific value of about 7000 cal/g and its octane no. is 90.

Advantages:

- Addition of alcohol to petrol increases octane number (octane number of ethanol is 112) and reduces knocking.
- Because of increased O.N., it can be used in engine with high CR, thus better power output is achieved.
- Because, alcohol contains oxygen, it is referred as oxygenate which assist better combustion efficiency. Also, VOC (volatile organic content) emissions are reduced or pollution is lessened.
- Alcohol can be synthesized from plants. Thus, especially, with higher proportion of alcohol, one has a sustainable fuel [an alternative to fast depleting fossil fuels].
- When synthesised, helps in improved economy of a country because imports are avoided.

Disadvantages:

- Lowers the calorific value of the fuel (two third that of gasoline).
- Atomization is difficult because of high surface tension of alcohol.
- Alcohol gets oxidised to acids and may corrode concerned engine equipment.
- Modification of CR of the engine is required otherwise, power out put is reduced.

(Gasoline engines generally have a CR of around 8 which need be increased to around 12).

- Alcohol as such has good affinity for water and as a result separation of alcohol and petrol layers takes place especially at low temperature. To avoid this blending agent such as benzene or toluene are used.

(ii) **Unleaded Petrol**: An alternative to increase the octane rating of gasoline and employ higher CR or power output is to blend gasoline with compounds of higher octane rating. Gasoline or petrol with better anti-knock properties, however, without the presence of leaded compounds but with the presence of higheroctane blending reagents is called unleaded petrol.

Following are some blending reagents:

- Methyl tertiary butyl ether (MTBE)
- Ethyl tertiary butyl ether (ETBE)
- Methyl tertiary amyl ether
- Ethyl tertiary amyl ether
- Methanol
- Ethanol
- Isopropanol, etc.

All the above blending reagents have higher octane rating of nearly 100 or more. When blended with gasoline in proportions of more than 10% (unlike 0.1% of ethyl fluid) overall octane rating of the blend is increased and so is the anti-knock property of the blend.

Advantages:

1. Higher octane number, higher CR and higher power output with better anti-knock characteristics.
2. Better combustion efficiencies because blending agents are also oxygenates and lower the emissions of volatile organic contents.
3. Emission of leaded compounds is avoided safeguarding the health of living beings.
4. Catalytic converters are employable with vehicle exhaust lines and relatively safer combustion products are ensured.

(b) What is knocking? Explain mechanism of knocking in petrol engine. (04 Marks) (CO3, L3)

Solution: Knocking: It is defined as the characteristic rattling, metallic sound produced due to thermal shock waves hitting the cylinder walls and piston during explosive combustion of fuel in an internal combustion (IC) engine.

Following are the reasons for knocking to happen:

- Higher compression ratio (CR) beyond the optimum level
- Lower octane gasoline.
- Formation of highly reactive intermediates (peroxides), which lead to explosive reactions.

Petrol Knocking: Petrol engine is spark ignited engine. Gasoline is burnt to produce energy.

During knocking,

- Petrol is vaporised and vapour is mixed with air.
- The petrol air mixture is drawn into combustion chamber (Suction stroke).
- The petrol air mixture is compressed (Compression stroke).
- The mixture is ignited by a spark from spark plug and burnt.
- The gases produced by the combustion reaction expand.
- Expansion causes the piston to move i.e. kinetic energy is produced.
- When the flame front (after ignition) moves at optimum speed, fuel is burnt smoothly and completely.
- When the flame front moves slowly, products of initially burnt fuel, exert pressure on un-burnt fuel-air mixture. Due to build up of pressure, temperature will also increase.
- All the un-burnt fuel is ignited ahead of the flame front. This produces thermal shock waves (explosive combustion) which hit the cylinder walls and piston; resulting in a characteristic metallic sound called "knocking" or "pinking".

The probable reactions during normal combustion and knocking are presented below taking ethane as the fuel component.

Normal combustion: $C_2H_6 + 3\frac{1}{2}\ O_2 \longrightarrow 2CO_2 + 3H_2O$

Explosive combustion: $C_2H_6 + O_2 \longrightarrow CH_3 - O - O - CH_3$ (ethane peroxide)

$CH_3 - O - O - CH_3 \longrightarrow CH_3CHO + H_2O$ (acetaldehyde)

5. (a) Write a note on fullerenes. Mention its properties and applications. (04 Marks) (CO5, L2)

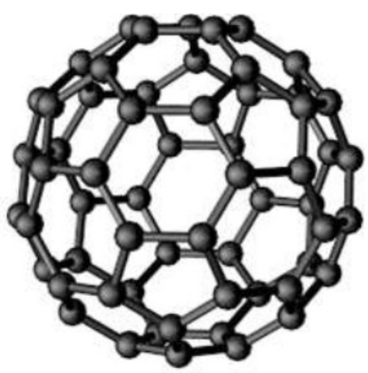
Solution: Fullerenes are clusters made of carbon and are zero dimensional solids. They are allotropes of carbon with the formula C-60 and have 60 C atoms arranged spherically. They are also called Bucky balls and have truncated icosahedrons structure with 20 hexagonal and 12 pentagonal rings forming the symmetry.

Fullerenes have particle size of 2 nm, density of 1.65g/cm3 and sublimes at 800K. The carbon atoms are sp2 hybridised**, e**ach carbon being bonded to three others in this material. Accordingly, there are two C-C bond lengths in fullerenes, the hexagonal bonds are shorter than pentagonal bonds.

They behave as soft electrophile and readily accept electrons during reactions. C60 structure can be easily hydrogenated, methylated and fluorinated. They form exohedral complexes in which an atom or group is attached to the outside of the cage, as well as endohedral complexes in which an atom is trapped inside the cage structure.

Synthesis: Fullerenes are prepared by creating an electric arc between two carbon or graphite electrodes in an inert gas atmosphere, when a black powder in the form of soot is produced. 10% of the soot is made up of C-60. They can be extracted from the soot by solvation in small amounts of toluene. After extraction, solvent is removed using a rotary evaporator, leaving behind a solid mixture of mostly C-60 with small amounts of larger fullerenes.
Bucky balls having more number of C atoms such as, 70, 76, 78, 84 etc arranged spherically have been isolated.

More properties:
 Superconductivity is discovered in alkali doped fullerites at moderately high temperatures.
 Superconducting critical temperature (Tc) of doped fullerites increases with curvature of fullerenes cages, ie. as cluster size is reduced from C60 to C36, C28 and C20, their Tc increases.
 The index of refraction for fullerenes is 2.2 at 600 nm and they have a resistivity of 1014 Ω/m.
 They function as catalysts in organic reactions.



Buckminister Fullerene - C60

(b) Explain the theory, instrumentation and applications of flame photometry. (06 Marks) (CO5, L3)

Solution: The principle of flame photometry is atomic spectra arising due to the emission of different wavelength when atoms are excited in a flame. Emission of characteristic radiation by an element and the correlation of the emission intensity with concentration of the element form the basis of flame photometry. This instrument is used to measure the concentration of only alkali metals and alkaline earth metals. When a solution containing sample element or ion is aspirated into the flame, following changes takes place,

a) Firstly, solvent gets evaporated leaving behind salt (solid residue) in the flame.
b) Then, salt gets evaporated into salt vapours, which further undergo dissociation into its constituent atoms.
c) Some of the metal atoms formed may absorb heat energy from flame and get electronically excited to their higher energy level. Being unstable in the excited state, atoms fall back to their ground state, by emitting the energy in form of light radiation.
d) Intensity of emitted light is proportional to number of atoms in the excited state, which in turn is proportional to the concentration of solution fed into the flame.
e) Different metals emit their characteristic radiations at different wavelengths, they do not nterfere with each other, even when they are present together.
Series of changes taking place at the flame are summarized as follows:

	Flame	Evaporation	Vaporization	Dissociation
M^+X^- →	M^+X^- →	MX →	MX →	M (gas) + X (gas)
Solution	Mist	Solid	gas	↓ absorption of heat
				M* (g)
				↓Flame emission, hν
				M (g)

Intensity of emitted radiation, measured as detector response is related to the concentration by an expressi

$E = k\, \alpha\, c$

E = detector response

k = constant

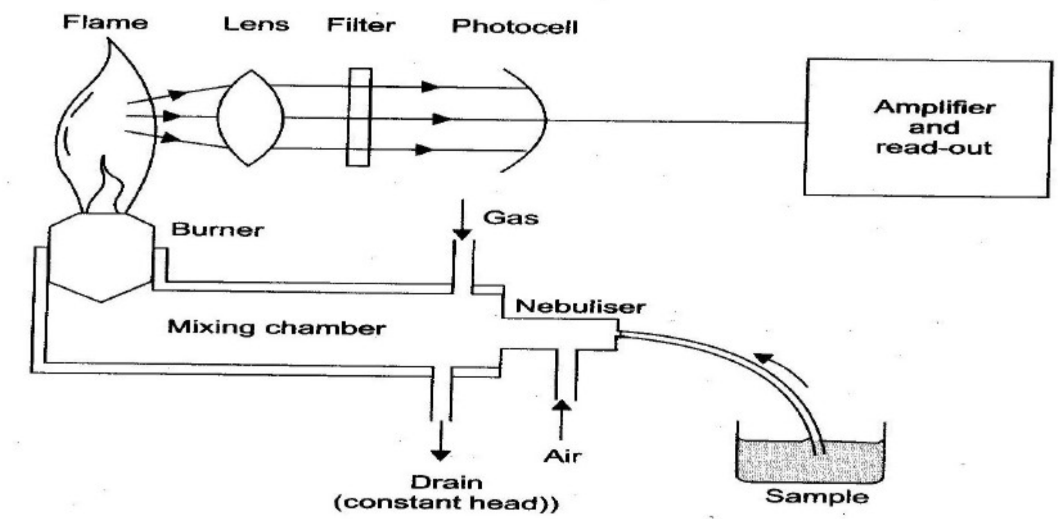
α = efficiency of atomic exc

c = concentration

Flame photometer consists of an **atomizer**, **mixing chamber**, **burner**, **filter**, **detector** and a **display device**. Pressurized air is passed into atomizer and due to suction sample solution is drawn into the atomizer. Inside atomizer it mixes with air stream as a fine mist and passes into the mixing chamber. In mixing chamber it mixes with gas and then passes into burner where mixture is burnt. The emitted radiation from flame passes through lens and then through a filter which allows only radiation characteristic of element under

INSTRUMENT:

ut on a display device.

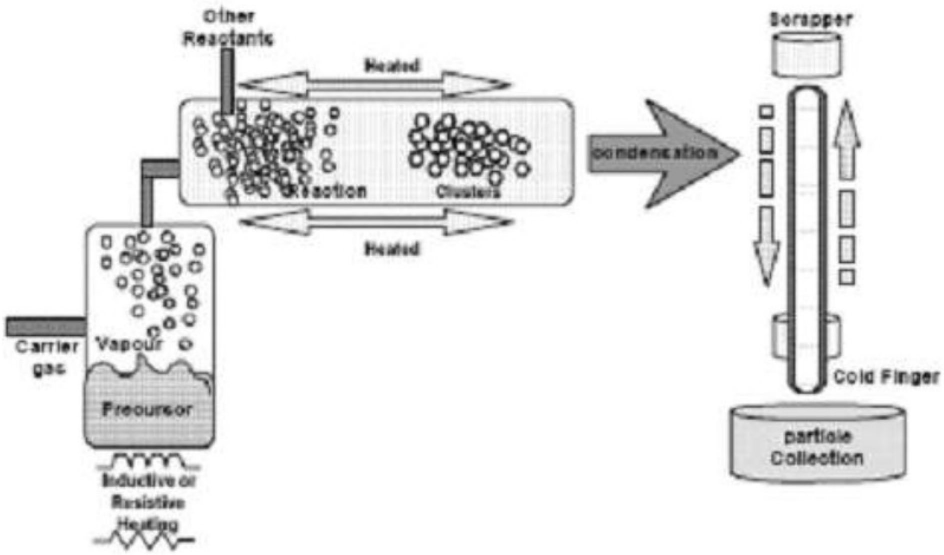


n curve method. For this, to flame and emission of on curve is obtained by itions. Sample solution is From calibration curve,

Schematic Layout of Flame Photometer

6. (a) Explain the synthesis of nano-materials by chemical vapor condensation method. (04 marks) (CO5, L3)

Solution: In this method, the precursor material is vaporized, and the vapours are brought into contact with a hot surface of a reactor under supercritical conditions favouring nucleation of particles. The precursor material can be solid, liquid or gas at room temperature, but are delivered to the reactor as a vapour. In case of solids, they are sublimed by heating from an external source, and for liquids and volatile solids dissolved in solvents, precursors are bubbled out using inert gas. Vapours decompose in the hot zone and form particles that agglomerate. They are further swept by inert gas onto the surface of a cold finger, where they get condensed. The particles are scrapped into a collector at regulated intervals. Due to high supersaturation that results in this method, it is typically used to synthesis NPs of metals in large scale.



(b) Describe the theory, instrumentation and applications of potentiometry. (06 marks) (CO5,L3)

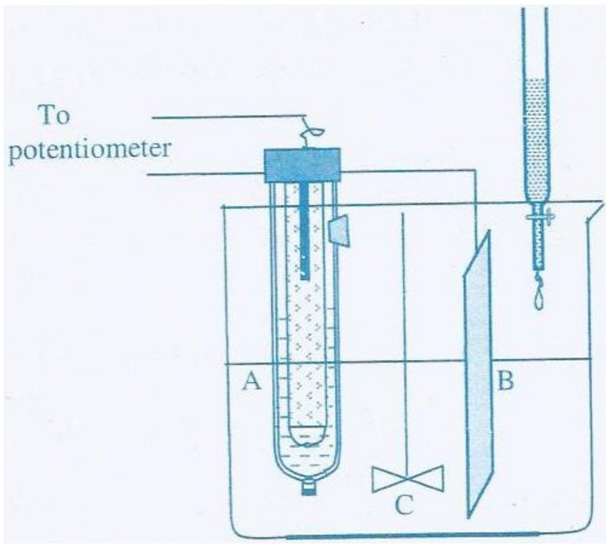
Solution: Potentiometry is the determination of concentration of a solution by measuring the e.m.f.

Theory:

When a metal M is immersed in a solution containing its own ions M^{n+}, the electrode potential is given by Nernst equation.

$$E = E^0 + \frac{0.0591}{n}\log\left[M^{n+}\right]$$

Thus, the potential of an electrode E depends upon the concentration of the ion M^{n+} to which it is reversible. In potentiometric titration the potential is measured. The potential developed is a function of the concentration of the ions of the analyte. Assume the concentration of the analyte to be x mol dm-3. Let y mol dm-3 is the volume of titrant added at given instant and z mol of the product is formed under above conditions. The value of z will change throughout the course of titration because y is being changed continuously. If an indicator electrode is placed in the solution the potential will vary throughout the titration. Initially the change in potential will be



small. At the equivalence point, there will be a steep rise in the potential. Beyond the equivalence point, there will be no significant change in the potential. The equivalent point can be determined by plotting change in potential against volume of titrant added.

Instrumentation: A potentiometer consists of a reference electrode, an indicator electrode and a device for measuring the potential. The emf of indicator electode depends upon the concentration of ions of analyte.

A is a ref. electrode (Satuated calomel electrode), B is the indicator electrode and C is a mechanical stirrer. A known volume of the analyte is taken ia a beaker and its potential is determined by connecting the assembly to a potentiometer. The titrant is added in increments of 1 mL and the potential is measured each time. Close to the equivalence point the potential tends to increase rapidly. A few readings are taken beyond the equivalence point. The equivalence point is determined by plotting change in potential against the volume of the titrant.

Application of Potentiometric Titrations:

(i)Acid – Base titrations (ii) Redox Titrations (Oxidation reduction titration) (iii) Precipitation Titration

7. (a) Explain the synthesis of nanomaterials by Sol-gel method. (05 Marks) (CO5, L3).

Solution:

(i) Sol-Gel:

This is a colloidal process in which dispersions have two phases, a dispersed phase with particles having colloidal dimensions (< μm) and a dispersion medium. The process can be used to obtain metal and metal oxide nanocrystals with controlled particle sizes.

Sols are solid particles formed by hydrolysis of metal precursors and are dispersed in the solution medium. The commonly used metal precursors are their (i) alkoxides $[M(OR)_n]$and (ii) salts (MX), and should have the tendency to form gels. Examples of $M(OR)_n$, where –OR is an alkoxide group, may be methoxides, ethoxides, propoxides of Al, Fe, Ti, Zn, and salts like $FeCl_3$, $MnCl_2$, $AlCl_3$, $Zn(NO)_3$ etc.

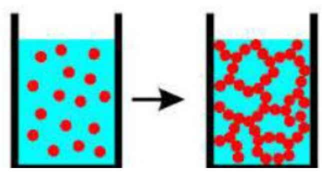
For nanomaterial synthesis, the process involves:

(i) Hydrolysis of precursors

(ii) Condensation and polycondensation to form particles

(iii) Allowing gelation to occur (ageing)

(iv) Drying of gel to obtain solid material, followed by its sintering to form na



The important reactions in the process:

(i) Hydrolysis of metal salt through de-protonation

$$M(H_2O)_n^{Z+} \rightarrow [M(H_2O)_{n-2}(OH)_2]^{(Z-2)+} + 2H^+$$

(ii) Condensation-polymerisation of the hydroxide intermediate

$$M(H_2O)_n^{Z+} + [M(H_2O)_{n-2}(OH)_2]^{(Z-2)+} \rightarrow \underbrace{[M(H_2O)_{n-1}M(OH)_2]^{(2Z-2)+}}_{\text{poly-condensed sol}} + (H_2O)_{n-1}$$

$$[M(OH)_2M(H_2O)_{b-1}]^{(2Z-2)+} \xrightarrow{gelation} \underset{\text{(M-OH-M bonds)}}{\text{sol-gel}} \xrightarrow[(ii)sintering]{(i)drying} \underset{\text{(M-O-M bonds)}}{\text{metal oxide particles}}$$

When an alkoxide is used, the important reactions are:

$$Si(OR)_4 + 4\,H_2O \rightarrow Si(OH)_4 + 4ROH \quad \text{(alcoholysis)}$$

$$Si(OH)_n + Si(OH)_n \rightarrow (Si\text{-}O\text{-}Si)_n + nH_2O$$

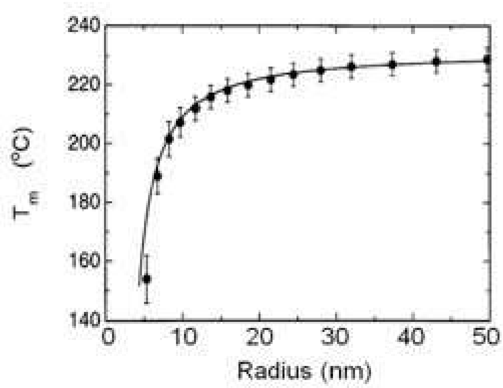
The material can be used to prepare nanocrystals, films and fibres.

(b) What are nano-materials? Explain any size dependent properties of nanomaterials. (05 marks) (CO5, L2)

Solution: Nanomaterials are nano-sized materials having atleast one physical dimension in the size range of 1-100 nm.

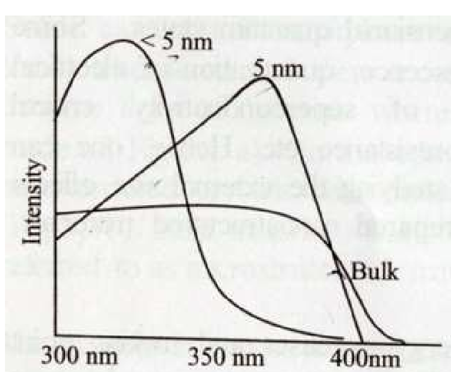
Any two size dependent properties of nanomaterials:

Thermal properties: As size decreases, the surface energy of the crystals increases and their melting point decreases. This occurs because, the surface atoms in nano-sized crystals are in contact with fewer atoms of the substance and so require less energy to diffuse. For example, 3 mm CdSe nanocrystals (NCs) melts at 700 K compared to bulk CdSe, whose melting point is 1678 K.



Variation in melting points with particle size for Sn particles

Optical properties: Optical properties are connected with the electronic structure. A change in crystal size brings about changes in electronic structure and bandgap (electrons are more restricted in movement in nano-sized particles) leading to changes in absorption or luminescence behavior of the material. Example: Bulk gold appears yellow in colour, whereas nanosized Au appears red. In ZnO, the luminescence spectra shows blue-shift as particle size reduces. ie. The wavelength of the emitted light shifts towards lower wavelengths.



Luminiscence spectra of ZnO with change in particle size. Wavelength of PL shifts towards lower wavelengths (blue shift) with size.

8. (a) Explain the theory, instrumentation and applications of colorimtery. (06 Marks) (CO5, L4)

Solution: It is an analytical technique used for determination of conc. of compound in a solution. It is used for those solution which are coloured or which gives a colour when mixed with a suitable reagents. A measure of the variation of the color of a solution with change in concentration of the solute forms the basis of colorimetry.

Theory: When a monochromatic radiation of intensity I is passed through a solution of a sample under investigation taken in a cell, a portion of the radiation is absorbed (Ia), a portion is reflected (Ir) and the remainder is transmitted (It), then,

I = Ia + Ir + It

For a glass cell, Ir is negligible and therefore the above equation reduces to

I = Ia + It

Colorimetric estimation is based on the Beer-Lambert law.

Beer Lambert's Law: According to this the amount of light absorbed is directly proportional to the conc. and path length of solution.

Combining equations for Beer's law and Lambert's law, equation for Beer-Lambert's law can be written obtained;

$$I_t = I_o e^{-kct}$$

Or $$I_t = I_o 10^{-\in ct}$$

where $\in$ called *molar absorptivity* or *molar absorption coefficient*, is a constant for a given substance at a given wavelength. If c is expressed in mol. dm^{-3} and t in centimeters, $\in$ has the unit $dm^3 mol^{-1} cm^{-1}$.

The above equation can be written as

Colorimetric Estimation of Copper:

- A series of solutions of copper sulphate of different concentrations is prepared.
- Each of these solutions is treated with ammonia solution. the
- Deep blue colored cupraammonium complex is formed.

$$Cu^{2+} + 4\ NH_3 \longrightarrow \underset{\text{Deep Blue}}{Cu\ [NH_3]_4^{2+}}$$

- This complex shows maximum absorbance at **620** nm.
- Hence, the absorbance of each of the above solutions is measured against blank a is 620 nm.
- A graph of absorbance against concentration is plotted to get a calibration curve. he
- The calibration curve is a straight line passing through the origin. at
- The absorbance of the test solution against blank at 620nm is measured.
- From the calibration curve, the concentration of the analyte is determined.
- Since same cuvette is used for all the solutions, t is constant.

(b) Write a note on graphene. Mention its properties and applications. (04 Marks) (CO4, L2)

Solution:

Graphene is a one-atom-thick layer of carbon atoms arranged in a hexagonal lattice. It is the building-block of Graphite (which is used, among others things, in pencil tips), but graphene is a remarkable substance on its own - with a multitude of astonishing properties which repeatedly earn it the title "wonder material".

Graphene is the thinnest material known to man at one atom thick, and also incredibly strong - about 200 times stronger than steel. On top of that, graphene is an excellent conductor of heat and electricity and has interesting light absorption abilities. It is truly a material that could change the world, with unlimited potential for integration in almost any industry.

Graphene is indeed very exciting, but producing it is not easy, especially if you are aiming towards high-quality sheets. Several companies are producing Graphene today in small volumes (most companies are using CVD based processes), and there's a lot of research going into developing new ways to mass produce the material in an affordable manner.

Applications:

- touchscreens (for LCD or OLED displays)
- transistors
- computer chips
- batteries
- energy generation
- supercapacitors
- DNA sequencing
- water filters
- antennas
- solar cells
- Spintronics-related products