

CHEMISTRY SOLUTION**(Rev-2019'C' Scheme DEC- 2019 SEM-1)**

Q1] A) What are the characteristics of aromatic compounds? (3)

Solution:-

Aromatic compounds are organic compounds in which:-

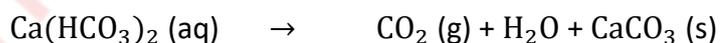
1. Molecule is planar.
2. They all have rings as a conjugated system.
3. All carbon atoms are in sp^2 hybrid state.
4. Follow Huckel Rule (It states that any aromatic compound must have $(4n+2)$ electrons forming π bonds).
5. They are one the most stable organic compounds in nature.
6. Generally (not always), they have benzene ring.
7. Their characteristic reactions are electrophilic aromatic substitution which include hlogenation, sulphonation, nitration, Friedal Craft alkylation, Friedal Craft acylation.
8. They have a sweet smell. That's why they are aromatic (derived from Greek word aroma , meaning fragrance).

Q1] B) What happens when temporary hard water is boiled? Give examples (3)

Solution :-

Temporary hardness of water is due to presence of calcium Hydrogen carbonate, $Ca(HCO_3)_2$ (aq) and magnesium Hydrogen carbonate $Ma(HCO_3)_2$ (aq).

Both Calcium Hydrogen carbonate and Magnesium Hydrogen carbonate decompose when heated. When water is boiled the original insoluble carbonate is reformed:



Boiling water causes precipitation of calcium carbonate(s) or magnesium carbonate(s). Therefore hardness due to Hydrogen carbonate is said to be temporary.

Q1] C) Difference between Thermoplastic and Thermosetting Plastic resins? (3)

Solution :-

Thermoplastic Plastic resins	Thermosetting Plastic resins
Thermoplastic can be synthesized by the process called addition polymerization.	Thermosetting plastics are synthesized by condensation polymerization.
Thermoplastic is processed by injection moulding, extrusion process, blow moulding, thermoforming process, and rotational moulding.	Thermosetting Plastic is processed by compression moulding, reaction injection moulding.
Thermoplastics have secondary bonds between molecular chains.	Thermosetting plastics have primary bonds between molecular chains and held together by strong cross-links.
Thermoplastics have low melting points and low tensile strength.	Thermosetting plastics have high melting points and tensile strength.
Thermoplastic is lower in molecular weight, compared to thermosetting plastic.	Thermosetting Plastic is high in molecular weight.

Q1] D) Difference between Bonding and Anti Bonding orbitals? (3)

Solution:-

Bonding molecular orbital	Anti Bonding molecular orbital
i) It is formed by the addition overlap of atomic orbitals.	i) It is formed by subtraction overlap of atomic orbital.
ii) It may or may not have a node.	ii) It always has a node in between the nuclei of bonded atoms.
iii) In this orbital electron density is more in	iii) In this orbital electron density is less in

between the nuclei. Electrons in this orbital lead to attraction between atoms.	between the nuclei. Electrons in this orbital lead to repulsion between atoms.
iv) Its energy is less than the energy of the atomic orbitals.	iv) Its energy is more than the energy of the atomic orbitals.

Q1] E) What is the temporary and permanent hardness of water sample having the following impurities in ppm: $\text{Ca}(\text{HCO}_3)_2 = 32.4$, $\text{CaSO}_4 = 13.5$, $\text{Mg}(\text{HCO}_3)_2 = 29.2$ (3)

Solution :-

$$\text{Ca}(\text{HCO}_3)_2 = 32.4 \text{ mg/lit}$$

$$\text{Mg}(\text{HCO}_3)_2 = 29.2 \text{ mg/lit}$$

$$\text{CaSO}_4 = 13.5 \text{ mg/lit}$$

Calculation of CaCO_3 equivalents

Impurities	Quantity	Multiplying factor	CaCO_3 equivalents in ppm
$\text{Ca}(\text{HCO}_3)_2$	32.4 mg/lit	$32.4 \times \frac{100}{162}$	20
$\text{Mg}(\text{HCO}_3)_2$	29.2 mg/lit	$29.2 \times \frac{100}{146}$	20
CaSO_4	13.5 mg/lit	$13.5 \times \frac{100}{136}$	10

$$\text{Thus, temporary hardness} = \text{Mg}(\text{HCO}_3)_2 + \text{Ca}(\text{HCO}_3)_2$$

$$= 20 + 20$$

$$= 40 \text{ ppm}$$

$$\text{Permanent hardness} = \text{CaSO}_4$$

$$= 10 \text{ ppm}$$

$$\text{Total hardness} = \text{temporary} + \text{permanent}$$

$$= 40 + 10$$

$$= 50 \text{ ppm}$$

Q1] F) Discuss the reduced phase rule.

(3)

Solution:-

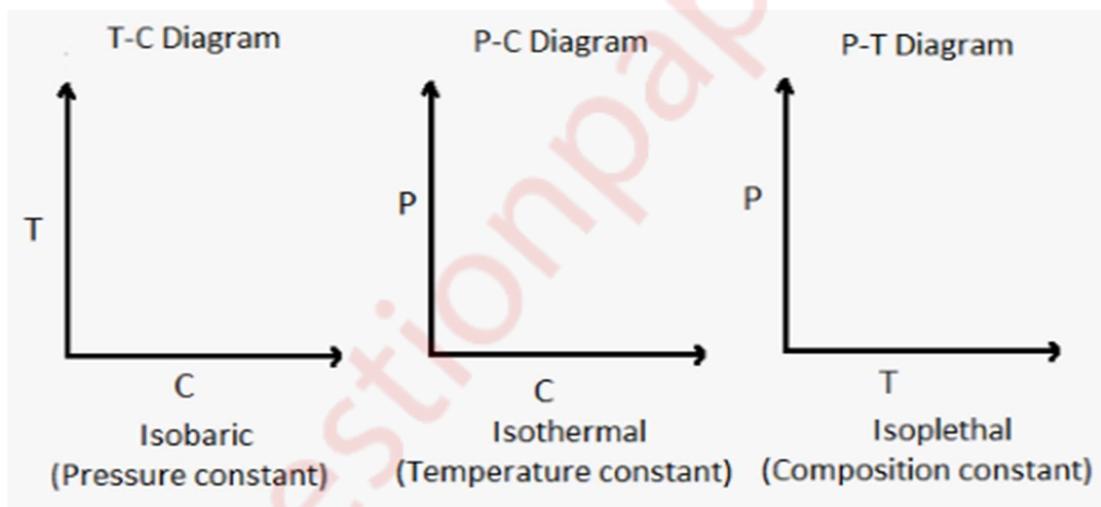
1. The maximum number of phases in a two component system will be four. Maximum number of phases exists when degree of freedom is zero

$$P=C-F+2=2-0+2=4$$

2. Maximum degree of freedom in a 2 component system will be 3 when system exists as one phase

$$F=C-P+2=2-1+2=3$$

3. System will have three variables namely temperature, pressure and concentration. For constructing a phase diagram of 2-component system, a three dimensional space model is required using these 3 variables as its coordinates.
4. It is possible to split such a 3D diagram into 2D by keeping the third variable in each case as constant.



1. It is convenient to prepare temperature – composition (T-C) diagrams keeping pressure constant, such diagrams are called Isobaric.

Similarly, P-C diagrams at constant temperature are called isothermal.

P-T diagrams at constant composition are called isoplethal.

2. Any such restriction in phase rule equation regarding constancy of one of the variables reduces the phase rule equation to following form –

$$F = C - P + 1$$

OR

$$F + P = C + 1$$

This is known as reduced phase rule equation

Q1] G) What is a real gas? (3)

Solution:-

A real gas is a gas that does not behave as an ideal gas due to interactions between gas molecules. A real gas is also known as a non ideal gas because the behavior of a real gas is only approximated by the ideal gas law.

While cool air at ordinary pressure behaves like an ideal gas, increasing its pressure or temperature increases the interactions between molecules, resulting in real gas behavior that cannot be predicted reliably using the ideal gas law.

When Real Gases Differ From Ideal Gases

Usually, it's fine to use the ideal gas law to make calculations for gases. However, the approximation gives considerable error at very high pressure, near the critical point, or near the condensation point of a gas. Unlike ideal gases, a real gas is subject to:

- Van der Waals forces;
 - Compressibility effects;
 - Non-equilibrium thermodynamic effects;
 - Variable specific heat capacity; and
 - Variable composition, including molecular dissociation and other chemical reactions.
-
-

Q2] A) Explain the application of phase rule to one component system with an appropriate graph, area and the triple point. (6)

Solution :-

Phase rule helps to study different equilibria and classify them accordingly. It indicates behaviour of the system under a particular set of conditions. Different systems with the same degree of freedom behave in a similar manner. Helps to find out under a set of conditions whether all substances involved in an equilibrium can exist or a particular phases ceases to exist or whether any transformation has taken place.

One component system with the phase diagram

Three curves OA, OB, and OC represents the equilibrium conditions between two phases solid with vapour , vapour with liquid and liquid with solid phase of water.

In water there is only one component i.e., water and its three phases : ice, water, steam which are solid, liquid, and gaseous respectively. Figure below represents phase diagram or pressure v/s temperature diagram for the water system.

Curve OB represents the equilibrium between liquid and vapour. It is known as vaporization curve. Here also it is necessary to state either temperature or pressure. E.g., at atmospheric pressure , water and vapour can exist in equilibrium only at 1 temperature i.e., the boiling point of water. Water -vapour system has one degree of freedom $F=C-P+2=1$.

Curve OC represents the equilibrium between solid and liquid phase of the water. This curve is known as fusion pressure or melting point curve. Along this curve there are two phases in equilibrium that is ice and water. At atmospheric pressure, ice and water can be in equilibrium only at one temperature i.e., the freezing point of water.

We have $C=1$, $P=2$ thus,

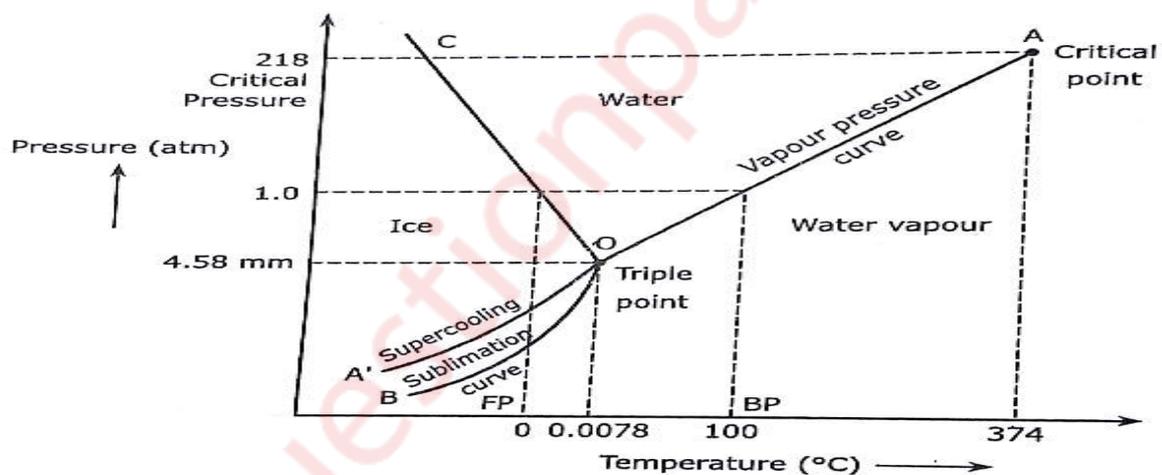


Fig. 4.1 : Phase diagram of water system

$$F=C-P+2=1.$$

TRIPLE POINT:- The three curves OA, OB, and OC meet at O at which solid, liquid and vapour co-exist in equilibrium. This point at 273.16K (0.0075°C) and 4.58 mm of Hg pressure is called Triple point. The system is invariant.

$$F=C-P+2 \quad \therefore F=3-3+2=2 \quad \therefore F=0$$

This means the degree of freedom is zero therefore neither pressure nor temperature can be changed without causing the disappearance of one of the phases. If either temperature

or pressure is changed even slightly , one of the three phases disappears and the system changes from non-variant to univariant.

Q2] B) What is compounding of plastic? Discuss the below mentioned constituents with appropriate examples (5)

Solution :-

Compounding consists of preparing plastic formulations by mixing and/or blending polymers and additives in a molten state, these blends are automatically dosed with fixed set points usually through feeders/hoppers. It is mostly a blend of copolymers such as ABS, SAN, SMA etc. with additives such as anti-oxidants, UV-stabilizers and other value adding agents and sometimes a strengthening component is added such as glass fibre.

There are different critical criteria to achieve a homogenous blend of the different raw material. Dispersive and distributive mixing as well as heat are important factors.

Compounding is usually done by extrusion. The hopper feeds the begin of the screw which will gradually transport the resins towards the die. The screw itself is confined in a barrel that has different zones that can be heated according to the resins properties.

1.FILLERS (or EXTENDERS).

Fillers are added to a base polymer to lower the manufacturing cost of a product made from it. Functions of fillers are as follows:

- Reducing the cost of plastic.
- Increases the tensile strength and hardness.
- Reduces the flexibility.
- Decreases the shrinkage during moulding.
- Gives opacity to the product.
- Examples:-mica, talc, asbestos , saw dust ,chalk etc.

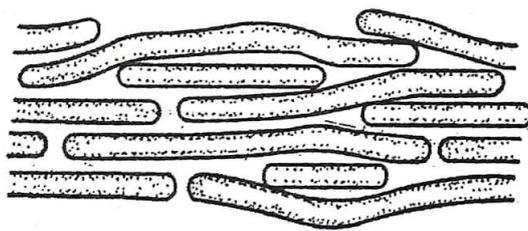
II) PLASTICIZERS

Plasticizers are added to increase the plasticity and flexibility of the polymers.

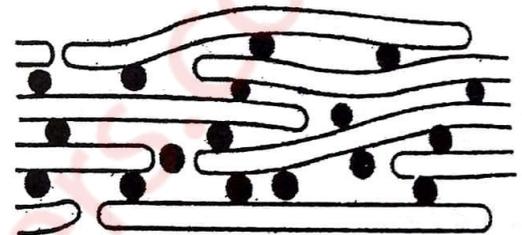
The Plasticizer molecule occupies between the polymeric chains and neutralizes the intermolecular forces of attraction and thus allows freedom of movement. The functions of plasticizers are as follows:-

- Increases the plasticity of the plastics.
- Lowers the softening temperature and hence moulding and remoulding can be done at low temperature.
- Imparts flames proofness.
- Reduces resistance towards chemical , solvents etc.
- Examples:- esters of fatty acids, vegetables oils etc.

The presence of small molecules of plasticizers reduces the attraction of the large polymer molecules for one another and thus permit more flexibility and easier slip.



(a) No plasticizer



(b) Plasticizer present

Q2] C) Write notes on :

(4)

- BOD

Solution :-

1. It means the oxygen demand of bio-degradable pollutants only.
2. Less stable measurement method as it uses micro-organism which are susceptible to pH , temperature and other variable in the water.
3. Slow process. It takes 5 days.
4. BOD values are generally less than COD values.
5. $BOD = (DO_b - DO_i) \times \frac{\text{Volume of undiluted sample}}{\text{Volume of diluted sample}}$.

- COD

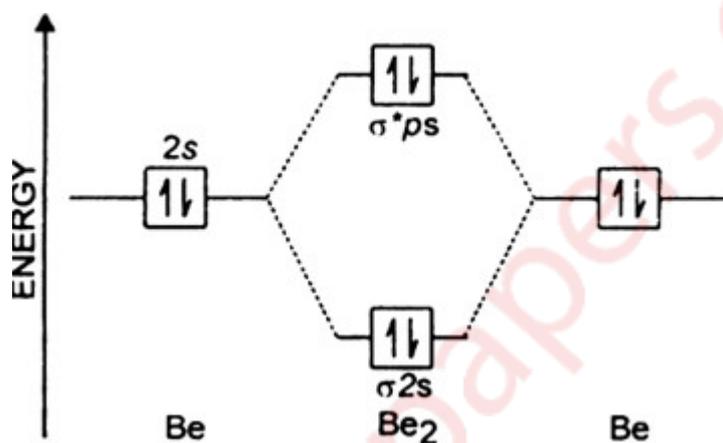
Solution :-

1. It measures the oxygen demand for bio-degradable pollutants along with non-biodegradable pollutants.
2. More stable measurement method as it uses potassium dichromate which oxidises regardless of water condition.

3. Fast process. It takes 2-3 hours.
4. COD values are generally greater than BOD values.
5.
$$\text{COD} = \frac{(V_1 - V_2) \times N \times 8000}{Y}$$

Q3] A) Draw the Molecular Orbital diagram of Be_2 . Give its electronic configuration. Explain why it does not exist (6)

Solution:-

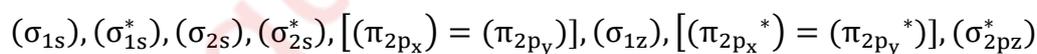


The electronic configuration of Beryllium is $1s^2 2s^2$.

From the electronic configuration it is clear that there is no singly filled atomic orbital present in beryllium.

Without the half filled orbital, the overlapping is not possible, therefore Be_2 molecule does not exist.

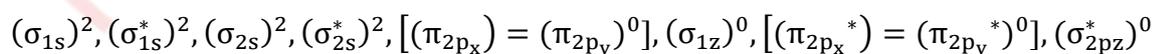
According to the molecular orbital theory, the general molecular orbital configuration of beryllium will be,



As there are 4 electrons present in beryllium.

The number of electrons present in Be_2 molecule = $2(4) = 8$

The molecular orbital configuration of Be_2 molecule will be,



The number of unpaired electron in Be_2 molecule is, 0. So, this is diamagnetic.

The formula of bonding order = $\frac{1}{2} \times (\text{number of bonding electrons} - \text{number of anti-bonding electrons})$

The bond order of $\text{Be}_2 = \frac{1}{2} \times (4 - 4) = 0$

The bond order of Be_2 is, zero. So, Be_2 will not exist.

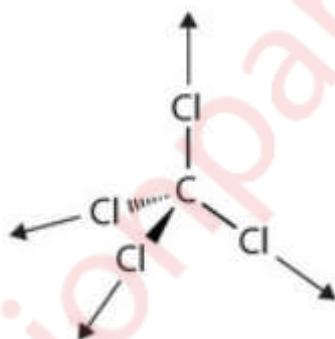
Q3] B) 1) Identify the most important intermolecular interaction in each of the following: (2)

1. CCl_4

CCl_4 is a tetrahedral molecule with a Cl-C-Cl bond angle of 109.5° .

The two C-Cl bond dipoles in the plane of the paper have a resultant pointing to the right at an angle of 54.75° from the vertical.

The two C-Cl bond dipoles behind and in front of the paper have an equal and opposite resultant to the first.



Since the bond dipoles are equal and in opposite directions, they cancel.

CCl_4 is a nonpolar molecule. Its strongest intermolecular forces are London dispersion forces.

2. HF

The bonding of hydrogen and fluorine results in the formation of a polar covalent bond and, by extension, an electric dipole. This is also a textbook example of hydrogen bonding. The polar covalent bond is formed due to the difference in electronegativity between fluorine and hydrogen. The ionic resonance structures of HF contribute unequally to the resonance hybrid. (The compound in bold makes the greater contribution)

$[\text{H}^+][\text{F}^-] \leftrightarrow [\text{H}^-][\text{F}^+] \leftrightarrow \text{H}-\text{F}$ (3 lone pairs)

Due to the hydrogen's comparatively low electronegativity, the shared electrons are drawn towards the fluorine ion. Such a bond is admirably strong, and can be observed to bear an exceedingly high boiling point when compared to other such molecules.

2) Explain the correction for volume term in the ideal gas equation (3)

Solution:-

We can use a number of different equations to model the behavior of real gases, but one of the simplest is the van der Waals (VdW) equation. The VdW equation basically incorporates the effect of gas molecule volume and intermolecular forces into the ideal gas equation.

$$\left[P + \frac{an^2}{V^2} \right] [V - nb] = nRT$$

where:

P = equals measured pressure

V = equals volume of container

n = equals moles of gas

R = equals gas constant

T = equals temperature (in Kelvin)

Compared to the ideal gas law, the VdW equation includes a “correction” to the pressure term, $\frac{an^2}{V^2}$ which accounts for the measured pressure being lower due to attraction between gas molecules. The “correction” to the volume, nb subtracts out the volume of the gas molecules from the total volume of the container to get a more accurate measure of the empty space available for the gas molecules. a and b are measured constants for a specific gas (and they might have some slight temperature and pressure dependence).

At low temperatures and low pressure, the correction for volume is not as important as the one for pressure, so Z is less than 1. At high pressures, the correction for the volume of the molecules becomes more important so Z is greater than 1. At some range of intermediate pressure, the two corrections cancel out and the gas appears to follow the relationship given by the ideal gas equation.

Q3] C) A polymer consists of 9 polymer chains as given below: (4)

No of polymer(N₁): 1 3 2 1 2

Mol. Wt of each polymer: 200 100 300 500 400

Calculate the number- average molecular weight of the polymer

Solution:-

The number-average molecular weight (M_n) of the polymer is given by,

$$\overline{M}_n = \frac{\sum N_i M_i}{\sum N_i} = \frac{1 \times 200 + 3 \times 100 + 2 \times 300 + 1 \times 500 + 2 \times 400}{9} = \frac{800}{9}$$

$$\overline{M}_n = 266.67$$

The number average molecular weight of the polymer is 266.67

Q4] A) Discuss the following with examples: (6)

1. Phase 2. Components 3. Degree of freedom

Solution :-

1. PHASE: A phase is defined as any homogenous , physically distinct and mechanically separable portion of a system , which is separated from other parts of the system by definite surface. Example:-

- In a freezing water system ice, water and water vapour are the three phases which are physically distinct and homogenous.
- A gaseous mixture which is thoroughly miscible in all proportion consists of a single phase.
- If two liquids are miscible they will form one liquid phase only.
- Thermal decomposition of CaCO_3 consists of three phases namely, two solids and one gaseous.
- A mixture of CaO and CaCO_3 consists of two phases.
- Two immiscible liquids like water and oil will form two separate phases.

2. COMPONENT : It is defined as the smallest number of independently variable constituents taking part in the state of equilibrium by means of which the

composition of each phase can be expressed directly or in the form of chemical equation. Examples :-

- $\text{CaCO}_3 - \text{CaO} - \text{CO}_2$ system

This is an example of a system with several phases, which at ordinary temperatures are two solids and a gas. There are three chemical species (CaCO_3 , CaO and CO_2) and one reaction:



The number of components is then $3 - 1 = 2$.

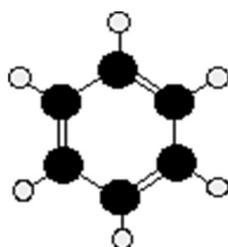
- Water - Hydrogen - Oxygen

The reactions included in the calculation are only those that actually occur under the given conditions, and not those that might occur under different conditions such as higher temperature or the presence of a catalyst. For example, the dissociation of water into its elements does not occur at ordinary temperature, so a system of water, hydrogen and oxygen at 25°C has 3 independent components.

3. DEGREE OF FREEDOM :- It is defined as the minimum number of the independently variable factors such as the temperature, pressure and composition of the phases which must be arbitrarily specified in order to represent perfectly the condition of a system.

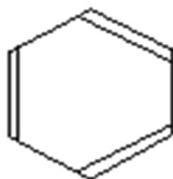
Q4] B) Give the Kekule structure for benzene. Discuss the problem with the structure. (any two) (5)

Solution :-



Kekule was the first to suggest a sensible structure for benzene. The carbons are arranged in a hexagon, and he suggested alternating double and single bonds between them. Each

carbon atom has a hydrogen attached to it. This diagram is often simplified by leaving out all the carbon and hydrogen atoms!



In diagrams of this sort, there is a carbon atom at each corner. You have to count the bonds leaving each carbon to work out how many hydrogens there are attached to it. In this case, each carbon has three bonds leaving it.

Problems with the shape

Benzene is a planar molecule (all the atoms lie in one plane). and that would also be true of the Kekule structure. The problem is that C-C single and double bonds are different lengths.

C-C 0.154 nm

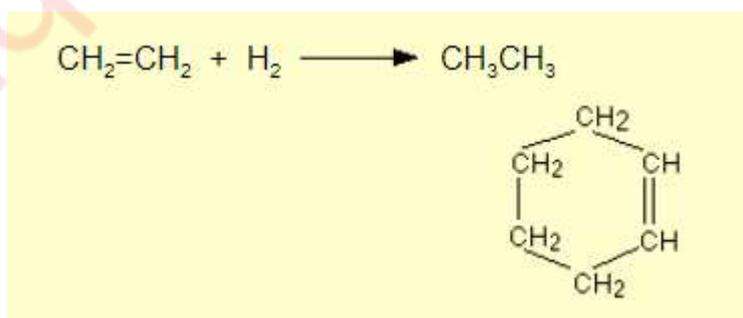
C=C 0.134 nm

That would mean that the hexagon would be irregular if it had the Kekule structure, with alternating shorter and longer sides. In real benzene all the bonds are exactly the same - intermediate in length between C-C and C=C at 0.139 nm. Real benzene is a perfectly regular hexagon.

Problems with the stability of benzene

Real benzene is a lot more stable than the Kekule structure would give it credit for. Every time you do a thermochemistry calculation based on the Kekule structure. you get an answer which is wrong by about 150 kJ mol⁻¹. This is most easily shown using enthalpy changes of hydrogenation.

Hydrogenation is the addition of hydrogen to something. If, for example, you hydrogenate ethene you get ethane:



In order to do a fair comparison with benzene (a ring structure) we're going to compare it with cyclohexene. Cyclohexene, C_6H_{10} is a ring of six carbon atoms containing just one $C=C$.

Q4] C) Write notes on: supercritical fluids and critical temperature. (4)

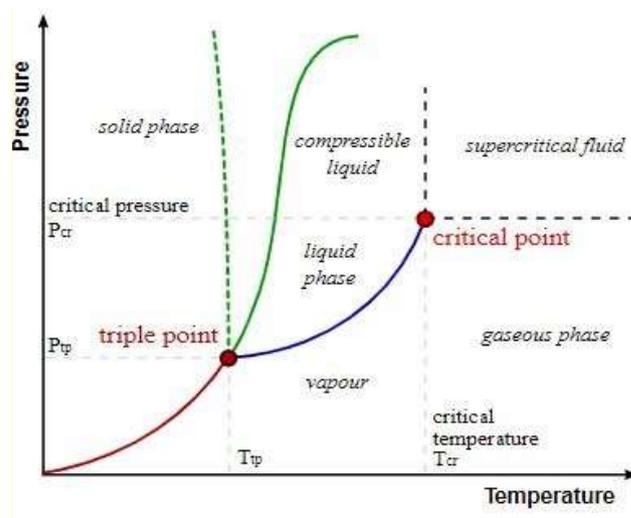
Solution :-

SUPERCRITICAL FLUIDS

Matter can be pushed to temperatures and pressures beyond those of its critical point. This stage is characterized by the inability to distinguish whether the matter is a liquid or a gas, as a result. Supercritical fluids (SCF) do not have a definite phase. In 1822 Baron Charles Cagniard de la Tour discovered supercritical fluids while conducting experiments involving the discontinuities of the sound of a flint ball in a sealed cannon barrel filled with various fluids at various temperatures ("Charles Cagniard de la Tour"). Supercritical fluids have the low viscosity of a gas and the high density of a liquid. making it impossible to liquefy the matter using any amount of pressure. However, it is possible to go from a gas to a liquid without crossing the boundary between the vapor and liquid phase using a supercritical fluid just by lowering the temperature of the liquid

CRITICAL TEMPERATURE

The critical temperature of a substance can be defined as the highest temperature at which the substance can exist as a liquid. At temperatures above the critical temperature, the substance in question (in its vapour/gaseous state) can no longer be liquified, regardless of the amount pressure applied to it. A graph describing the triple point (the point at which a substance can exist in all three states of matter) and the critical point of a substance is provided below. It can be noted that the graph is plotted with pressure on the Y-axis and temperature on the X-axis. Therefore, the critical temperature can be obtained from the X-axis value of the critical point. The corresponding Y-axis value of the critical point, which is the pressure required to liquefy a substance at its critical temperature, is known as the critical pressure of the substance.



Q5] A) Give the preparation, properties and uses of:

(6)

1. Kevlar

2. PMMA

Solution :-

KEVLAR

1. PREPARATION.

It is prepared by polycondensation between aromatic dichloride like terephthalic acid dichloride (terephthaloyl chloride) and aromatic diamines like 1,4-phenylene diamine (1,4-diamine benzene).

2. PROPERTIES.

- It is exceptionally strong, 5 times stronger than steel and 10 times stronger than aluminium.
- It has high heat stability and flexibility.
- It has resistance against almost all the solvents except some powerful acids.
- It does not lose its strength at -196°C .

3. USES.

- It is used in aerospace and aircraft industries.
- It is used for the preparation of car parts such as tyres, brakes, clutch, lining etc.
- Used for the preparation of ropes, cables, helmets etc.

1. For making lenses, optical parts of instruments, air craft, light fixtures, artificial eyes, wind screen, bone splints, decorative articles etc.
2. It is found in paint. Acrylic "latex" paints often contain PMMA suspended in water.
3. Used in making window glasses.

Q5] B) What are atomic orbitals? Explain the s-orbitals and p-orbitals (5)

Solution :-

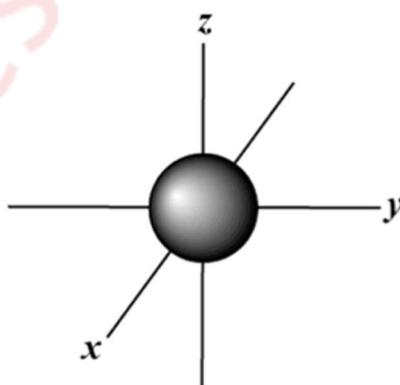
Atomic orbitals are mathematical functions that describe the wave nature of electrons (or electron pairs) in an atom. They offer a way to calculate the probability of finding an electron in a specified region around the nucleus of the atom.

According to the quantum atomic model, an atom can have many possible numbers of orbitals. These orbitals can be categorized on the basis of their size, shape or orientation. A

smaller sized orbital means there is a greater chance of getting an electron near the nucleus. The orbital wave function or ψ is a mathematical function used for representing the coordinates of an electron. The square of the orbital wave function or ψ^2 represents the probability of finding an electron.

This wave function also helps us in drawing boundary surface diagrams. Boundary surface diagrams of the constant probability density for different orbitals help us understand the shape of orbitals

The Shape of s Orbitals

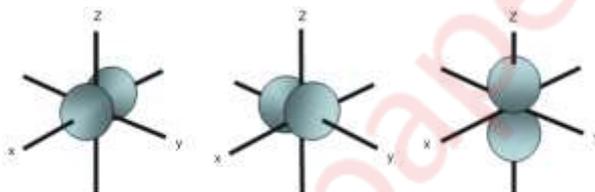


- The boundary surface diagram for the s orbital looks like a sphere having the nucleus as its center which in two dimensions can be seen as a circle.
- Hence, we can say that s-orbitals are spherically symmetric having the probability of finding the electron at a given distance equal in all the directions.

- The size of the s orbital is also found to increase with the increase in the value of the principal quantum number (n), thus, $4s > 3s > 2s > 1s$.

The Shape of p Orbitals

- Each p orbital consists of two sections better known as lobes which lie on either side of the plane passing through the nucleus.
- The three p orbitals differ in the way the lobes are oriented whereas they are identical in terms of size shape and energy.
- As the lobes lie along one of the x, y or z-axis, these three orbitals are given the designations $2p_x$, $2p_y$, and $2p_z$. Thus, we can say that there are three p orbitals whose axes are mutually perpendicular.
- Similar to s orbitals, size, and energy of p orbitals increase with an increase in the principal quantum number ($4p > 3p > 2p$).



The Shape of p Orbitals

Q5] C) 1gm of CaCO_3 was dissolved in 1 litre of distilled water. 50ml of solution required 45ml EDTA for titration. 50ml of hard water required 25ml of EDTA for titration. The water sample after boiling and filtering consumed 15ml of EDTA for titration. Calculate the total and permanent hardness of the sample. (4)

Solution:-

$$\begin{aligned}
 1 \text{ ml SHW} &\equiv 1 \text{ mg of } \text{CaCO}_3 \text{ eq.} \\
 \therefore 50 \text{ ml SHW} &\equiv 50 \text{ mg of } \text{CaCO}_3 \text{ eq.} \\
 50 \text{ ml of SHW} &\equiv 45 \text{ ml of EDTA solution.} \\
 25 \text{ ml of EDTA} &\equiv 50 \text{ mg of } \text{CaCO}_3 \text{ eq}
 \end{aligned}$$

$$\begin{aligned}
\therefore 1 \text{ ml of EDTA} &\equiv \frac{50}{25} \text{ mg of CaCO}_3 \text{ eq.} \\
&= 2 \text{ mg of CaCO}_3 \text{ eq.} \\
50 \text{ ml of water sample} &\equiv 15 \text{ ml of EDTA solution.} \\
\therefore 1000 \text{ ml of water sample} &\equiv \frac{1000 \times 15}{50} \\
&= 300 \text{ ml of EDTA solution} \\
1 \text{ ml of EDTA} &\equiv 2 \text{ mg of CaCO}_3 \text{ eq.} \\
\therefore 300 \text{ ml of EDTA} &\equiv 2 \times 300 \\
&= 600 \text{ mg of CaCO}_3 \text{ eq} \\
\therefore \text{ Total hardness of water sample} &= 600 \text{ mg/L} = 600 \text{ ppm}
\end{aligned}$$

Q6] A) Explain the ion-exchange method for softening of water giving the following details: (6)

Diagram, process and Reactions

Solution:-

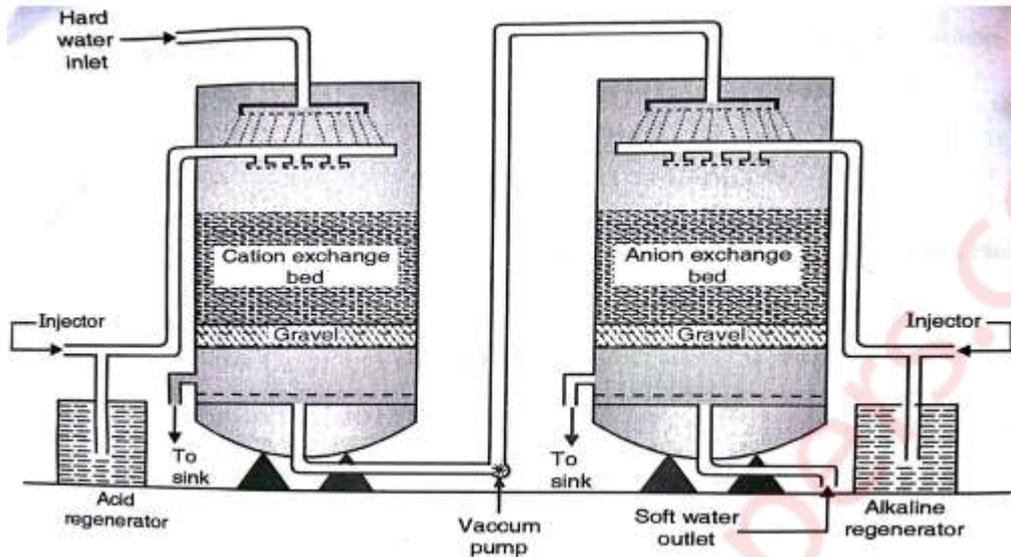
Ion exchange is an exchange of ions between two electrolytes or between an electrolyte solution and a complex. In most cases the term is used to denote the processes of purification, separation, and decontamination of aqueous and other ion-containing solutions with solid polymeric or mineralic 'ion exchangers'.

Typical ion exchangers are ion exchange resins (functionalized porous or gel polymer), zeolites, montmorillonite, clay, and soil humus. Ion exchangers are either cation exchangers that exchange positively charged ions (cations) or anion exchangers that exchange negatively charged ions (anions).

Natural water contains calcium and magnesium ions (see water analysis) which form salts that are not very soluble. These cations, together with the less common and even less soluble strontium and barium cations, are called together hardness ions. When the water evaporates even a little, these cations precipitate. This is what you see when you let water evaporate in a boiling kettle on the kitchen stove.

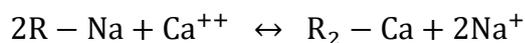
Hard water also forms scale in water pipes and in boilers, both domestic and industrial. It

may create cloudiness in beer and soft drinks. Calcium salts deposit on the glasses in your dishwasher if the city water is hard and you have forgotten to add salt. Strongly acidic cation exchange resins (SAC, see resin types) used in the sodium form remove these hardness cations from water. Softening units, when loaded with these cations, are then regenerated with sodium chloride (NaCl, table salt).



Reactions

Here the example of calcium:

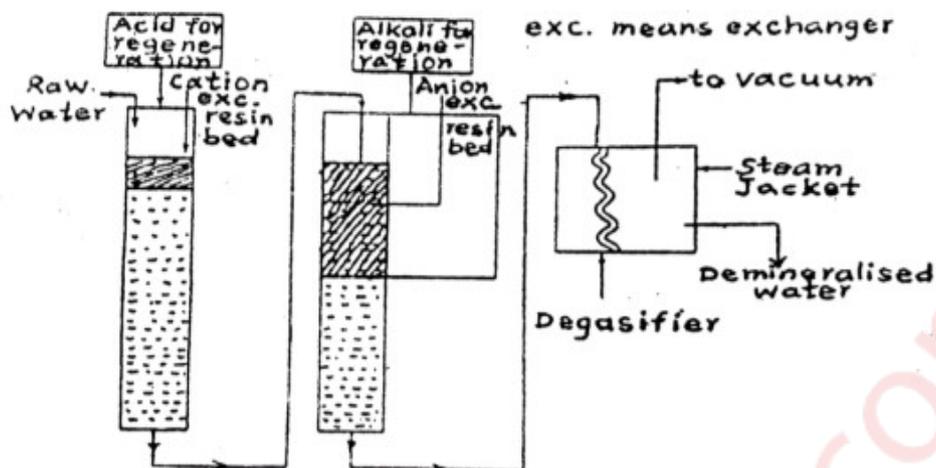


R represents the resin, which is initially in the sodium form. The reaction for magnesium is identical.

The above reaction is an equilibrium. It can be reversed by increasing the sodium concentration on the right side. This is done with NaCl, and the regeneration reaction is:



The water salinity is unchanged, only the hardness has been replaced by sodium. A small residual hardness is still there, its value depending on regeneration conditions.



Q6] B) Calculate the number of phase in the following examples:

1. Rhombic Sulphur → Monoclinic Sulphur (1)
2. An alloy of tin and lead contains 73% tin. Find the mass of eutectic contains 64% of tin. (4)

Solution :-

1. Mixture of rhombic sulphur and monoclinic sulphur.

Number of phases = two (mixture of two phases of sulphur rhombic and monoclinic sulphur)

2. An alloy of tin and lead contains 73% tin. Find the mass of eutectic contains 64% of tin

73% tin present in alloy means 730g of tin and 270g of lead are present in 1kg alloy. Eutectic contains 64% tin means 640g of tin and 360g of lead is present in 1kg of eutectic.

Therefore mass of tin present in eutectic = $\frac{640 \times 270}{360} = 480\text{g}$

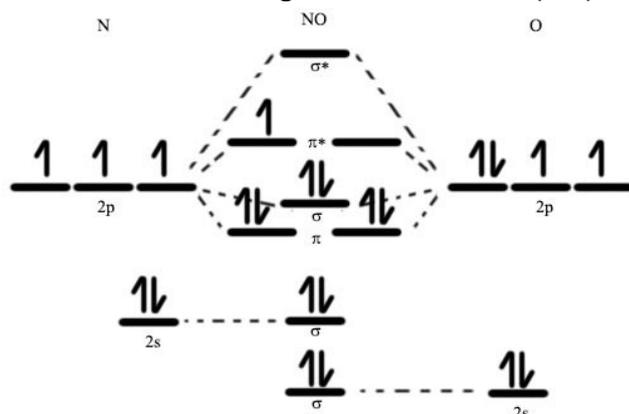
Total mass of eutectic in an alloy = 480g + 270g = 750g

Q6] C) 1. Give the Molecular Orbital diagram of nitric oxide(NO) molecule. (2)

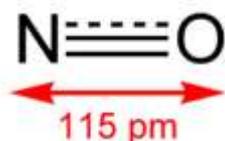
2. Discuss: Glass transition temperature (2)

Solution :-

1. Molecular Orbital diagram of nitric oxide(NO) molecule



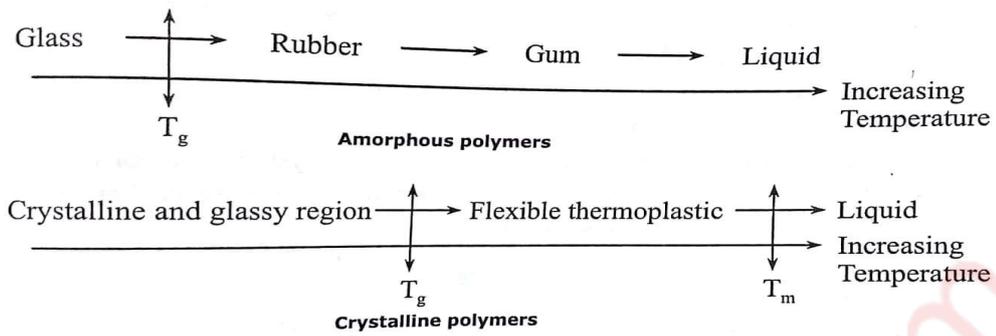
As the modern theory of molecular orbitals considers, there is some inter-atomic space between two atoms, where the bonding electron allocation is the most likely situated in by the moment. There is exactly where our "third" electron is situated towards that molecule. It doesn't ever belong to oxygen atom, but, technically, we can consider that structure as a resonant. It would be more correct, if to represent its structure like that:



As that molecule has one anti bonding electron π^*2p_x it is a molecular diradical and it has an unstable structure. That also follows because of its real physical-chemical properties (semi-stable only under low temperatures, and is very chemically active molecule).

2. GLASS TRANSITION TEMPERATURE

The temperature at which polymer experience the transition from rubbery to rigid state is termed as the 'Glass transition temperature' (T_g). The behaviour of a polymer is temperature sensitive. Glass transition temperature is also defined as the lowest temperature below which the polymer becomes hard and brittle and above which it becomes soft and flexible. The polymer becomes too soft, that it behaves like a fluid called as the visco fluid state. The temperature at which the soft, flexible polymer goes to the visco fluid state is called the melting temperature T_m .



Factors Influencing T_g .

1. Cross linking increases the T_g value.
2. Presence of bulky groups increases the T_g value.
3. Addition of plasticizer decreases the T_g value.
4. Polymers having strong intermolecular forces of attraction increases T_g value.
5. Polar side atoms or groups of atoms increases the T_g value.