Q. No. 2 (i) **Boiling temporary hard water:-** By boiling, temporary hardness of water can be removed. The soluble magnesium and calcium hydrogen carbonates precipitate out. The Ca^{+2} and Mg^{+2} ions are removed as their insoluble carbonates. On large scale, this method is uneconomical. The predicted products are:-

insoluble carbonate (Mg or Ca), Water, Carbondioxide (CO_2)

Chemical equation (General):-

$$M(HCO_3)_2(aq) \xrightarrow{\Delta} MCO_3(s) + CO_2(g) + H_2O(l)$$

Where $M = Ca^{+2}, Mg^{+2}$

Example:-

- $Mg(HCO_3)_2(aq) \xrightarrow{\Delta} MgCO_3(s) + CO_2(g) + H_2O(l)$
- $Ca(HCO_3)_2(aq) \xrightarrow{\Delta} CaCO_3(s) + CO_2(g) + H_2O(l)$

⇒Thus, by boiling temporary hardness of water is removed.

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Q. No. 2 (ii) **Arrhenius concept of Acids and Bases:- Arrhenius acid:-** "An Arrhenius acid is a substance that ionizes in water to produce H^+ ions".

Examples:

- $HCl(g) \xrightleftharpoons{H_2O} H^+(aq) + Cl^-(aq)$
- $H_2SO_4(l) \xrightleftharpoons{H_2O} 2H^+(aq) + SO_4^{-2}(aq)$
- $HNO_3(l) \xrightleftharpoons{H_2O} H^+(aq) + NO_3^{-1}(aq)$

} Arrhenius acid (give H^+ in water)

General ionization:- $HA(aq) \xrightleftharpoons{H_2O} H^+(aq) + A^-(aq)$

Arrhenius Base: "An Arrhenius base is a substance that ionizes in water to produce OH^- ions."

Examples:

$NaOH(s) \xrightleftharpoons{H_2O} Na^+(aq) + OH^-(aq)$

$KOH(s) \xrightleftharpoons{H_2O} K^+(aq) + OH^-(aq)$

$NH_4OH(aq) \xrightleftharpoons{H_2O} NH_4^+(aq) + OH^-(aq)$

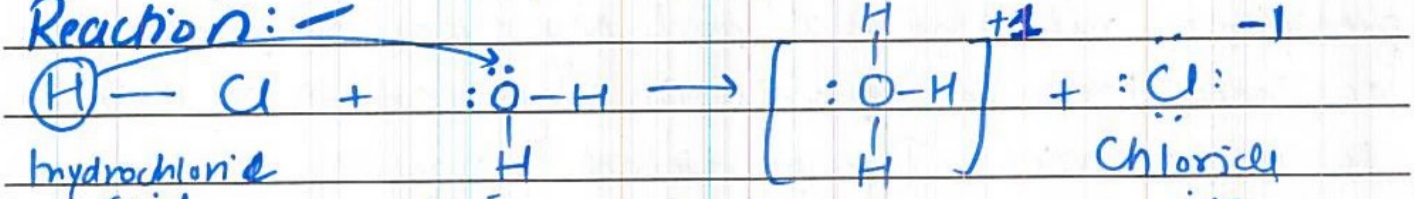
} Arrhenius bases (give OH^- in water)

General ionization: $BOH(aq) \xrightleftharpoons{H_2O} B^+(aq) + OH^-(aq)$

⇒This concept was proposed by Svante Arrhenius in 1887.

Q. No. 2 (iii) **Bronsted Acid**:- A Bronsted Acid is a proton (H^+) donor. **Bronsted Base**:- A Bronsted base is a proton acceptor (H^+)

Reaction:-



Acid: HCl donates a proton forming conjugate base Cl^-. Thus, it is an acid.

Base: H_2O accepts a proton forming conjugate acid H_3O^+ thus it it a Bronsted base.

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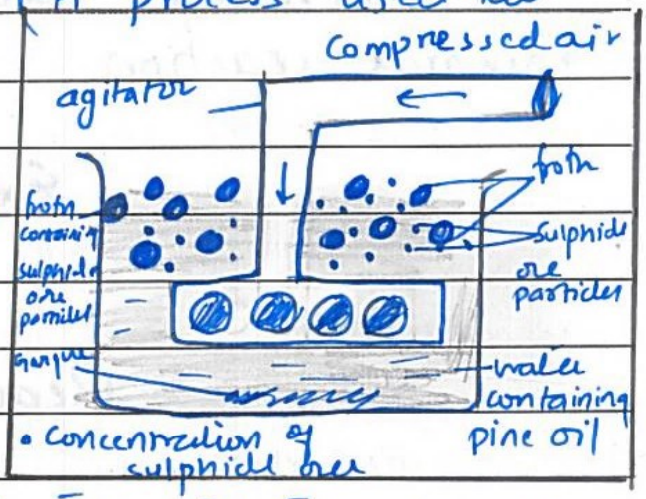
Q. No. 2 (iv)

Q. No. 2 (v) **Froth Floatation:-** (A process used to concentrate the ore):



Process: • Pulverized ore is fed into the tank containing water and oil-detergent mixture. The mixture is agitated with air.

• The detergent wets the mineral particles but not the silicate gangue.

• Silicate gangue settles down at bottom of tank. The mineral particles rise to the top of tank as froth from where they are skimmed off

• This process is usually used to concentrate the copper sulphide ores.

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Q. No. 2 (vi) (a) $CH_3-CH\equiv CH_2$

Double bond is present so it is an **alkene**. Its name is Propene.

(b) $CH_3-\underset{\underset{O}{\|}}{C}-OH$ → carboxyl group

It is **carboxylic acid**, due to presence of carboxyl group ($-COOH$). It has general formula $R-COOH$. Its name is Ethanoic acid (acetic acid).

(c) $H-\underset{\underset{O}{\|}}{C}-CH_2-CH_2-CH_3$ (formyl group)

It is an **aldehyde**, due to the presence of formyl group. It has general formula ($RCOH$). Its name is Butanal.

Q. No. 2 (vii) **Macroscopic characteristics :-**

Forwards reaction	Reverse reaction
Reactants produce products.	Products produce reactants.
Expression	
It is written from left the right.	It is written from right to Left.
Reaction Rate	
The reaction rate is fastest in beginning and gradually slows down.	Initially, the reaction rate is negligible and gradually speeds up.

Example

$$N_2(g) + 3H_2(g) \underset{\text{200 atm, 400°C}}{\overset{Fe}{\rightleftharpoons}} 2NH_3(g)$$

Forward reaction :- $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

Reversed reaction :- $2NH_3(g) \longrightarrow N_2(g) + 3H_2(g)$

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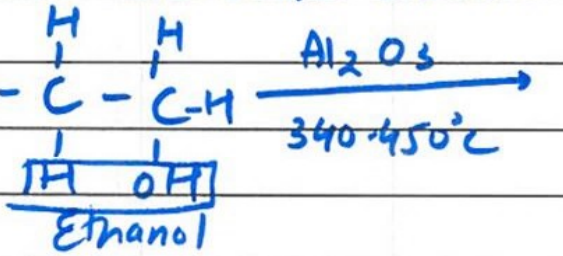
Q. No. 2 (viii) **PROPERTIES OF WATER :-**

Existence in all 3 states: Water is the only substance on Earth that exists in three different states.

Pure water: Pure water is colourless, tasteless, transparent and odourless. It freezes at 0°C and boils at 100°C.

Density of water: Usually, liquids expand on heating and contract on cooling. However, water shows a strange behaviour in this regard. On cooling upto 4°C, it contracts, but after that water begins to expand. This phenomenon is called anamolous expansion of water. So water expands

Q. No. 2 (ix) **(a) Dehydration of alcohols:** Alcohols dehydrate when their vapours are passed over heated Alumina. OH group is removed from one carbon atom which H is removed from adjacent carbon atom. Two such carbon atoms form double bond.



(b) Dehydrohalogenation of alkyl halides:-
Alkyl halides on treatment with alcoholic KOH undergo dehydrohalogenation producing an alkene.

$$CH_3CH_2Cl + KOH \xrightarrow{\text{alcohol}} CH_2 = CH_2 + KCl + H_2O.$$

Chloroethane Potassium hydroxide Ethene

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Q. No. 2 (x)

Q. No. 2 (xi)

Q. No. 2 (xii) **Depletion of Ozone layer**:- "The region in which the ozone layer has been reduced is called ozone hole".

CFCs:- Chlorofluorocarbon (CFCs) are low boiling liquids or gases. They are inert and donot react with any chemicals in troposphere. They slowly diffuse into the stratosphere where they are broken down by UV radiations:-

$CCl_3F_{(g)} \xrightarrow{UV} CCl_2F_{(g)} + Cl_{(g)}$

- Chlorine radical is very reactive it reacts with ozone to form ClO which again reacts with atomic Oxygen

$Cl_{(g)} + O_{3(g)} \rightarrow ClO_{(g)} + O_{2(g)}$

$ClO^{\cdot}_{(g)} + O^{\cdot}_{(g)} \rightarrow Cl^{\cdot}_{(g)} + O_{2(g)}$

Net reaction :- $O_{3(g)} + O_{(g)} \rightarrow 2O_{2(g)}$

Cl generated in step 1 is re-generated in step 2. Therefore, one Cl radical

Q. No. 2 (xiii) **Clark's Method (Adding Slaked lime):**
It is carried out on large scale and is used to remove the temporary hardness of water. It can be removed by adding an estimated amount of slaked lime ($Ca(OH)_2$). $Ca(OH)_2$ reacts with soluble hydrogen carbonates (Mg and Ca) to form their insoluble carbonates which then precipitate out.

Reactions:-

$$Ca(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow 2CaCO_{3(s)} + 2H_2O_{(l)}$$

$$Mg(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow MgCO_{3(s)} + CaCO_{3(s)} + 2H_2O_{(l)}$$

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Q. No. 2 (xiv) **Urea:** Urea is used as synthetic fertilizer. It is a carbamide. Its formula is NH_2CONH_2. It is an important industrial product.

Raw materials:

(i) Ammonia (NH_3)

(ii) CO_2

Preparation:

(i) Reaction of CO_2 and NH_3 to produce ammonium carbamate.

$$NH_{3(l)} + CO_{2(l)} \longrightarrow NH_2COONH_4$$

(ii) Distillation of ammonium carbamate:-

$$NH_2COONH_4 \xrightarrow{\Delta} \underset{\text{liquid Urea}}{NH_2-\overset{O}{\overset{\|}{C}}-NH_2} + H_2O$$

(iii) Evaporation and granulation of liquid urea:-

Liquid urea is concentrated in vacuum evaporators, from where it is sent to the prilling tower. Urea prills are then packed and marketed.

Q. No. 2 (xv) FRACTIONS OF PETROLEUM

Fractions	No of C atoms	B.P	Uses
LPG (Petroleum gas)	1 – 4	Below 20°	Cylinder gas for cooking
Petrol	5-10	35 - 70°	fuel for automobiles
Naphtha	8 -12	70° - 120°	Chemical feedstock for making many drugs etc.
Diesel	10 - 16	170° - 250°	fuel for buses, boats
Kerosene	14 - 20	270° - 340°	fuel for jet engines
Lubricating oil	20 - 50	350° - 500°	making lubricants, waxes & polishes
Fuel oil	50 - 70	500° - 600°	Power stations
Residual oil (Bitumen)	More than 70	More than 500°	Paving roads, roofing materials

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Q. No. 3 (Page 1/4)

(a) LAW OF MASS ACTION

Statement:

"The rate at which a substance reats is directly proportional to its active mass. The rate at which a reaction proceeds is directly proportional to the product of active masses of reactants."

Pioneers:

Chemists generally express the composition of equilibrium mixture in terms of numerical values. The numerical values relate the amount of products to amount of reatants. In 1864, two chemists C.M Guldberg and P. Waage purposed the law of mass action.

Active mass:

Active mass represents the (molar) concentration of reactants and products in $mol dm^{-3}$ for a dillute solution. It is expressed in terms of square brackets [ ].

General derivation/Formula:-

Consider a hypothetical reaction in which 'a' moles of reactant 'A' react with 'b' moles of reactant 'B' to form 'c' moles of reactant 'C' and 'd' moles of reactant 'D'. Then, equilibrium constant expression is given as:-

$$aA(g) + bB(g) \rightleftharpoons cC(g) + dD(g)$$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

Q. No. 3 (Page 2/4)

Where $K_c = \frac{K_f}{K_r}$ is the equilibrium constant and the above expression is called the equilibrium constant expression.

* The square brackets represent concentration of reactants and products in $mol dm^{-3}$
* In K_c, "c" represents molar concentration and is dependent on temperature but independent of initial concentration of reactants and products.
* Concentration of products is written in numerator while the concentration of reactants is taken in denominator.
* Equilibrium constant: Equilibrium constant is defined as the ratio of product of concentration of ~~reactants~~ products to the product of concentration of reactants each raised to the power equal to the co-efficients in a balanced chemical equation.

Derivation of K_c for given expression:-

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5$$

=) Let the rate of forward reaction be represented by 'R_f' and rate of reverse reaction be represented by 'R_r'.

According to Law of Mass Action:-

$$R_f \propto [PCl_3][Cl_2]$$

$$R_f = K_f [PCl_3][Cl_2]$$

Q. No. 3 (Page 3/4)

$R_r \propto [PCl_5]$

$R_r = k_r [PCl_5]$

⇒ At equilibrium state:-

Rate of forward reaction = Rate of reverse reaction

$R_f = R_r$

$k_f [PCl_3][Cl_2] = k_r [PCl_5]$

$\frac{k_f}{k_r} = \frac{[PCl_5]}{[PCl_3][Cl_2]}$

As, $K_c = \frac{k_f}{k_r}$,

$$\boxed{K_c = \frac{[PCl_5]}{[PCl_3][Cl_2]}}$$

'k_f' and 'k_r' are the rate constants for forward and reverse reactions respectively.

⇒ The above expression is called the equilibrium constant expression.

Units:- As number of reactants and products are unequal, K_c will have units:

$$K_c = \frac{[mol dm^{-3}]}{[mol dm^{-3}][mol dm^{-3}]}$$

$$K_c = \frac{1}{mol dm^{-3}}$$

$$K_c = [mol dm^{-3}]^{-1}$$

$$\boxed{K_c = mol^{-1} dm^3}$$

Q. No. 3 (Page 4/4) (b) Functional groups

(i) CH_3OCH_3

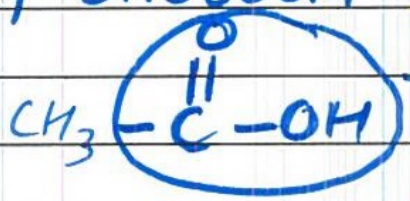
CH_3-O-CH_3

functional group:- Ether. In ether, oxygen is attached on both sides with carbon atoms. There is C-O-C linkage in its molecule.

Name :- Methoxy methane (Dimethyl ether)

General formula of ethers is $R-O-R'$

(ii) CH_3COOH

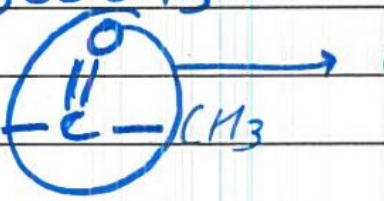


Functional group: Carboxyl (-COOH) group. The compound itself is a carboxylic acid.

General formula:- $R-COOH$

Name:- Ethanoic acid (Acetic acid)

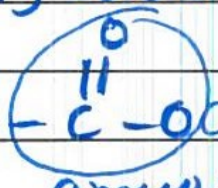
(iii) CH_3COCH_3



Functional group:- Carbonyl group. Since alkyl groups are attached on both sides, it is a **Ketone**. General formula is $R-\overset{O}{\overset{\|}{C}}-R'$.

Name:- Propanone (Acetone)

(iv) CH_3COOCH_3



Functional group:- $-R-COOR'$, Esters.

Q. No. 4 (Page 1/4)

Q. No. 4 (Page 2/4)

Q. No. 4 (Page 3/4)

Q. No. 4 (Page 4/4)

Q. No. 5 (Page 1/4) (a)

Types of Hardness of Water

There are two types of hardness of water:-

1-**Temporary hardness**: Temporary hardness is called so because it can be removed by boiling. It is due to dissolved hydrogen carbonates of calcium and magnesium.

2- **Permanent hardness**:- Permanent hardness is called so because it cannot be removed by boiling. Some other techniques are applied to remove it. It is due to the dissolved sulphates and chlorides of calcium and magnesium.

METHODS FOR REMOVAL OF PERMANENT HARDNESS

- Permanent hardness can be removed by:-

(i) **By adding washing soda**:-

Permanent hardness of water can be removed by adding washing soda ($Na_2CO_3 \cdot 10H_2O$). The Ca^{+2} and Mg^{+2} ions are removed as their insoluble carbonates.

$$M^{+2}(aq) + CO_3^{-2}(aq) \longrightarrow MCO_3(s)$$

where $M = Ca^{+2}, Mg^{+2}$.

Examples:-

$$CaSO_4(aq) + Na_2CO_3(aq) \longrightarrow Na_2SO_4(aq) + CaCO_3(s)$$

$$MgCl_2(aq) + Na_2CO_3(aq) \longrightarrow 2NaCl(aq) + MgCO_3(s)$$

Q. No. 5 (Page 2/4)

$MgSO_4(aq) + Na_2CO_3(aq) \rightarrow MgCO_3(s) + Na_2SO_4(aq)$

$CaCl_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

(ii) Ion-exchange Method:

- The hard water is passed through a container containing some suitable resin.
- Sodium Zeolite is a natural ion exchanger (Na_2Z)
- Chemically, it is sodium Aluminium silicate
- The Ca^{+2} and Mg^{+2} ions are exchanged with Na^+ ions in the resins.

General reaction:-

$$M^{+2}(aq) + Na_2Z(s) \rightarrow MZ(s) + 2Na^+(aq)$$

Where $M = Mg^{+2}, Ca^{+2}$

Example:-

$$CaCl_2(aq) + Na_2Z(s) \rightarrow CaZ(s) + 2NaCl(aq)$$

$$MgSO_4(aq) + Na_2Z(s) \rightarrow MgZ(s) + Na_2SO_4(aq)$$

Regeneration:-

Sodium zeolite can be regenerated by heating up the used up zeolite with concentrated solution of NaCl.

$$CaZ(s) + 2NaCl(aq) \rightarrow CaCl_2(aq) + Na_2Z(s)$$

(b)

(SOLVAY PROCESS)

Sodium carbonate:- Solvay process is used to manufacture sodium carbonate

Q. No. 5 (Page 3/4) drugs, dyes, glass etc.

Raw Materials:

(i) Ammonia NH_3
(ii) Brine, conc solution of NaCl
(iii) Limestone which is the source of CO_2 and $Ca(OH)_2$

Basic Reactions:

(i) Preparation of ammonical brine:-

In the first step, ammonia gas is reacted with brine to produce ammonical brine. Ammonical brine is fed into the carbonating tower.

(ii) Carbonation:-

In carbonation towel, CO_2 gas is passed through the ammonical brine. The following reaction occurs:—

$$NH_3(g) + H_2O(l) + CO_2(g) \longrightarrow NH_4HCO_3(aq)$$

$$NH_4HCO_3(aq) + NaCl(aq) \xrightarrow{15^\circ C} NaHCO_3(s) + NH_4Cl(aq)$$

In the lower compartments of the carbonating tower, temperature is lowered to 15°C due to which $NaHCO_3$ precipitates out. NH_4Cl is fed into ammonia recovery tower.

(iii) Filtration:

The precipitates of $NaHCO_3$ are removed from the milky solution by filtration. $NaHCO_3$ is used as baking soda.

Q. No. 5 (Page 4/4)

(iv) Calcinations:

$NaHCO_3$ is heated to get sodium carbonate.

$$2NaHCO_3(s) \xrightarrow{\Delta} Na_2CO_3(aq) + H_2O(l) + CO_2(g)$$

CO_2 produced as a result of this reaction is recycled.

(v) Preparation of CO_2 & slaked lime:-

$CaCO_3$ is heated in limekiln to produce CO_2.

$$CaCO_3(l) \xrightarrow{\Delta} CaO(s) + CO_2(g)$$

CO_2 is pumped into carbonating tower. Equal amounts of CaO and H_2O are reacted together to produce slaked lime.

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s)$$

$Ca(OH)_2$ is pumped to ammonia recovery tower.

(vi) Recovery of Ammonia:-

In ammonia recovery tower, $Ca(OH)_2$ is heated with aqueous solution of NH_4Cl produced in carbonation tower. Almost all ammonia is recovered and re-used.

$$2NH_4Cl(aq) + Ca(OH)_2(aq) \xrightarrow{\Delta} 2NH_3(g) + CaCl_2(g) + 2H_2O(l)$$