

I(1):

1) Forms an ionic crystal.

2) Forms a molecular crystal.

3) Forms a covalent crystal.

4) Forms a metallic crystal.

5) Forms a covalent crystal.

I(2):

The reaction is a redox, where MnO_2 is reduced to Mn^{2+} and Cl^- is oxidised to Cl_2 gas.

Note: The overall equation is $MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2(g)$.

I(3):

1) NO_3^- ion does not precipitate with any cations.

2) CO_3^{2-} ion precipitates with both Cu^{2+} and Pb^{2+} .

3) SO_4^{2-} ion precipitates with Pb^{2+} but not Cu^{2+} .

4) S^{2-} ion precipitates with both Cu^{2+} and Pb^{2+} .

I(4):

At $0^\circ C$ and 1 atm, 1 mol of gas is equivalent to 22.4 l. Therefore, the mixture

contains totally $\frac{4.0}{22.4} = \frac{1}{5.6}$ mol of gas molecules.

Let the number of moles of A molecules be x mol, then that of B molecules will be $(\frac{1}{5.6} - x)$ mol.

Consider the mass of the mixture, $4.0x + 20(\frac{1}{5.6} - x) = 3.0$, we have $x = \frac{1}{28}$.

Therefore, the molar ratio = $\frac{1}{28} : (\frac{1}{5.6} - \frac{1}{28}) = \boxed{1 : 4}$.

I(5):

During the electrolysis, H^+ ions are reduced to H_2 and OH^- ions are oxidised to O_2 .

The half equation at anode is $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$.

As 0.50 F of charges, i.e. 0.5 mol of electrons was passed through the solution,

$\frac{0.5}{4} = 0.125$ mol of O_2 was evolved at the anode.

The mass of it = $0.125 \cdot 32 = \boxed{4.0}$ g.

I(6):

1) CO_3^{2-} ions absorb H^+ to reach the equilibrium $CO_3^{2-} \rightleftharpoons HCO_3^- \rightleftharpoons H_2CO_3$. By Brønsted–Lowry acid–base theory, it is basic.

2) Is neutral.

3) Is neutral.

$\boxed{4)}$ NH_4^+ ions absorb OH^- to reach the equilibrium $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$. By Brønsted–Lowry acid–base theory, it is acid.

5) Same as 1), it is basic.

I(7):

By (a), the reactivity of $A > B$.

By (b), the reactivity of $C > A, B$.

Therefore, we have the order of reactivity $C > A > B$. As a metal with higher reactivity is easier to be ionised, we have the order of ionisation tendency

$C > A > B$.

I(8):

(a): $Fe(OH)_3$ forms, which is dark reddish-brown.

(b): Fe_2S_3 forms, which is black.

(c): $Fe_4(Fe(CN_6))_3$ forms, which is dark blue.

II:

$[H^+]$ for pH of 1.0 = $10^{-1.0} = 0.1 \text{ mol/l}$.

Therefore, number of moles of H^+ in the 10 ml of $HCl(aq) = 0.1 \cdot \frac{10}{1000} = 0.001 \text{ mol}$.

(a): Number of moles of H^+ in the solution = $0.15 \cdot \frac{40}{1000} = 0.006 \text{ mol}$.

Mixing the two solutions together, number of moles of H^+ becomes

$$0.001 + 0.006 = 0.007 \text{ mol and } [H^+] = \frac{0.007}{\frac{10+40}{1000}} = 0.14 \text{ mol/l}.$$

Therefore,

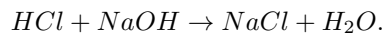
$$\text{pH} = -\log 0.14 = -\log 14 + \log 100 = 2 - \log 2 - \log 7 \approx 2 - 0.30 - 0.85 = \boxed{0.85}.$$

(b): There is no reaction between $AgNO_3$ and HCl . Moreover, $AgNO_3$ itself does not contain any H^+ except those from water, which are negligible.

Therefore, $[H^+] = \frac{0.001}{\frac{10+40}{1000}} = 0.02 \text{ mol/l}$ and

$$\text{pH} = -\log 0.02 = -\log 2 + \log 100 \approx 2 - 0.30 = \boxed{1.7}.$$

(c): Neutralisation occurs when HCl is mixed with $NaOH$:



Number of moles of OH^- in the solution = $0.15 \cdot \frac{40}{1000} = 0.006 \text{ mol}$.

Therefore, OH^- is in excess and $0.006 - 0.001 = 0.005 \text{ mol}$ of OH^- remains after the reaction.

We have $[OH^-] = \frac{0.005}{\frac{10+40}{1000}} = 0.1 \text{ mol/l}$ and hence $\text{pOH} = -\log 0.1 = 1$.

By $\text{pH} + \text{pOH} = 14$, we have $\text{pH} = 14 - 1 = \boxed{13}$.

III:

(1): Saturated $Na_2SO_3(aq)$ contains 27 g of Na_2SO_3 and 100 g of water when the total mass of it is $100 + 27 = 127 \text{ g}$.

Hence, the percentage weight of $Na_2SO_3 = \frac{27}{127} \times 100\% \approx \boxed{21}\%$

(2): Let the solubility $Na_2SO_3 \cdot 7H_2O$ be x g in 50 g water at $20^\circ C$.

The mass fraction of Na_2SO_3 in the compound $= \frac{2 \cdot 23 + 32 + 3 \cdot 16}{2 \cdot 23 + 32 + 3 \cdot 16 + 7 \cdot 18} = 0.5$ and

hence that of H_2O in the compound is also 0.5.

Then, when x g of the compound is dissolved in water, the weight of water will be increased by $0.5x$ g and $0.5x$ g of Na_2SO_3 will be dissolved in water.

Consider the solubility of Na_2SO_3 in water, we have $\frac{0.5x}{50+0.5x} = \frac{27}{100}$. By solving, we have $x \approx \boxed{37}$.

IV:

(1): Adding conc. H_2SO_4 into benzene gives benzene sulfonic acid $\boxed{(11)}$. Neutralising it with $NaOH$ will give sodium benzene sulfate $\boxed{(16)}$. Moreover, it can also undergo alkali fusion with solid $NaOH$ to form sodium phenolate $\boxed{(8)}$ and Na_2SO_3 .

Now, adding CO_2 , following by H^+ into it gives salicylic acid $\boxed{(15)}$, where the $-COOH$ group will undergo esterification with CH_2OH under reflux with conc. H_2SO_4 . The corresponding ester product is $\boxed{(19)}$.

Moreover, treat it with H^+ will give phenol $\boxed{(3)}$ by shifting the equilibrium position of the dissociation of weak acid (phenol). Adding excess Br_2 into phenol will give tribromophenol $\boxed{(12)}$ and adding HNO_3 into phenol with H_2SO_4 catalyst will give trinitrophenol $\boxed{(17)}$.

On the other hand, with Fe catalyst, $-Cl$ can substitute $-H$ in benzene and give chlorobenzene (1). Treat it with $NaOH$ at high pressure and temperature will also give sodium phenolate.

V:

(1): Phenol dissolves in water to give acidic solution (3).

Moreover, phenol turns $FeCl_3(aq)$ into blue or purple (6).

However, phenol shows negative result with the silver mirror test as it does not contain aldehyde groups.

(2): Ethanol is soluble in water because of its hydrogen bond and the solution is neutral (1).

Moreover, ethanol does not show positive result with either silver mirror test or $FeCl_3$ test.

(3): $NaOH(aq)$ neutralised phenol and form sodium phenolate salt which is soluble in water to give a colourless solution (1).

VI:

Having a $C = C$ double bond is a necessary condition for having geometrical isomers.

We are looking at options (1), (4), (5) and (6):

1) It has no geometrical isomers as the carbon at the left contains two same branches (-H).

4) Same as (1), it has no geometrical isomers.

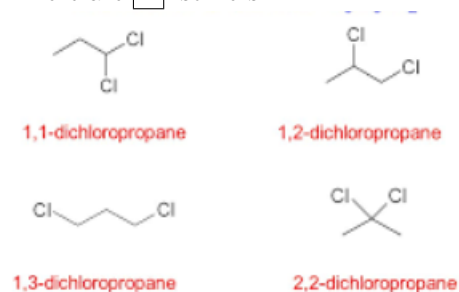
5) It has geometrical isomers: fumaric acid (trans-butenedioic acid) and maleic acid (cis-butenedioic acid).

5) It has no geometrical isomers as the carbon at the right contains two same branches (-H).

VII:

We draw the parent chain first. Then, we are going to attach the -Cl branches.

There are 4 isomers:



VIII:

The equation is $C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$.

As the molar ratio $C_3H_6 : Br_2 = 1 : 1$, 1 mol of Br_2 can react with 1 mol of propene.

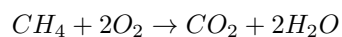
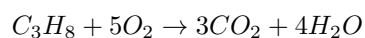
IX:

The molar ratio $C : H : Br = \frac{1.14}{12} : \frac{0.19}{1} : \frac{7.63}{79.9} \approx 1 : 2 : 1$.

Therefore, the empirical formula is $\boxed{CH_2Br}$.

X:

The equations of combustion of propane and methane are:



As for 1 g of propane and methane, the number of moles are $\frac{1}{3 \cdot 12 + 8} = \frac{1}{44}$ mol and $\frac{1}{12 + 4} = \frac{1}{16}$ mol respectively, the number of moles of O_2 required are $\frac{5}{44}$ mol and $\frac{1}{8}$ mol respectively.

Note that the ratio of weight of O_2 required is equal to the ratio of number of moles of O_2 required. Therefore, the ratio = $\frac{5}{44} : \frac{1}{8} = \boxed{10 : 11}$.

XI:

There are $\frac{50}{6 \cdot 12 + 6} = \frac{25}{39}$ mol of benzene used.

Theoretically, there should be $\frac{25}{39}$ mol, i.e. $\frac{25}{39}(6 \cdot 12 + 5 + 14 + 2 \cdot 16) = \frac{1025}{13}$ g of nitrobenzene produced.

Therefore, the yield = $\frac{55}{\frac{1025}{13}} \times 100\% \approx \boxed{70\%}$.