

I(1):

1) $AgCl$ in excess ammonia dissolves as $Ag(NH_3)_2^+$ ions.

2) $Al(OH)_3$ is insoluble in $NH_3(aq)$.

3) $Cu(OH)_2$ in excess ammonia dissolves as $Cu(NH_3)_4^{2+}$ ions.

4) $Zn(OH)_2$ in excess ammonia dissolves as $Zn(NH_3)_4^{2+}$ ions.

I(2):

By the state equation $pV = nRT$, we have $p = \frac{\rho RT}{m}$, i.e. $\rho = \frac{pm}{RT}$.

For 1 atm and 273 K, $\frac{p}{RT} = \frac{1}{0.082 \cdot 273} \approx 0.045 \text{ mol/l}$.

1) $\rho = 2 \cdot 16 \cdot 0.045 \approx 1.44 \text{ g/l}$

2) $\rho = 2 \cdot 14 \cdot 0.045 \approx 1.26 \text{ g/l}$

3) $\rho = (1 + 35.5) \cdot 0.045 \approx 1.60 \text{ g/l}$

4) $\rho = (3 \cdot 12 + 8 \cdot 1) \cdot 0.045 \approx 1.98 \text{ g/l}$

5) $\rho = (4 \cdot 12 + 10 \cdot 1) \cdot 0.045 \approx 2.61 \text{ g/l}$

Note: The error is due to the approximation made beforehand, which can be avoided if one leaves all the calculations at last.

Alternative 1 mol of gas at $0^\circ C$ and 1 atm is equivalent to 22.4l.

1) $\rho = \frac{2 \cdot 16}{22.4} \approx 1.43 \text{ g/l}$

2) $\rho = \frac{2 \cdot 14}{22.4} \approx 1.25 \text{ g/l}$

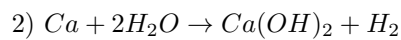
3) $\rho = \frac{1+35.5}{22.4} \approx 1.63 \text{ g/l}$

$$\boxed{4)} \quad \rho = \frac{3 \cdot 12 + 8 \cdot 1}{22.4} \approx 1.96 \text{ g/l}$$

$$5) \quad \rho = \frac{4 \cdot 12 + 10 \cdot 1}{22.4} \approx 2.59 \text{ g/l}$$

I(3):

1) No reaction with water



3) No reaction with water

4) No direct reaction with water (rusting occurs when exposed to water and air for sufficient long time)

5) No reaction with water

6) No reaction with water at room temperature (but does react with steam)

I(4):

The reaction is given by $2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2\boxed{HCl}(g)$.

Note: HCl is volatile, which evaporates easily when heated.

I(5):

The larger the distance between the outermost electron shell and the nucleus, i.e. the larger number of electron shells, the smaller the first ionisation potential.

Therefore, Xe (5) has the smallest first ionisation potential.

I(6):

- 1) Al does not form precipitate with S^{2-} .
- 2) Ba does not form precipitate with S^{2-} .
- 3) CdS is yellow.
- (4) PbS is black.
- 5) ZnS is white.

Note: Generally, metal sulfides are black in colour, with some exceptions (ZnS : white; CdS : yellow; SnS : brown and MnS : pale red) only.

I(7):

Let m be the molecular mass of the gas.

Then, the number of moles of the compound = $\frac{0.42}{m}$.

By $pV = nRT$, we have $(0.90)(0.410) = (\frac{0.42}{m})(0.082)(300)$.

By solving, we have $m = 28$.

- 1) Molecular mass = $12 + 4 \cdot 1 = 16$
- 2) Molecular mass = $2 \cdot 12 + 6 \cdot 1 = 30$
- (3) Molecular mass = $2 \cdot 12 + 4 \cdot 1 = 28$
- 4) Molecular mass = $2 \cdot 12 + 2 \cdot 1 = 26$

5) Molecular mass = $3 \cdot 12 + 8 \cdot 1 = 44$

6) Molecular mass = $3 \cdot 12 + 6 \cdot 1 = 42$

I(8):

1) pH value of acid in standard condition cannot exceed 7.

2) Number of moles of OH^- ions = $10^{-3} \cdot \frac{10}{1000} = 10^{-5} \text{ mol}$. Therefore,

$[OH^-] = \frac{10^{-5}}{1} = 10^{-5} \text{ mol/l}$ and $pOH = -\log 10^{-5} = 5$. By

$pH + pOH = 14$, we have $pH = 14 - 5 = 9$.

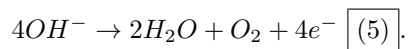
3) Although the calculated value of pH is 4, as CH_3COOH is a weak acid, where H^+ ions are not completely dissociated, the actual value of pH is higher than 4.

4) 1 mol of H_2SO_4 can dissociate 2 mol of H^+ ions. Therefore, number of moles of H^+ ions = $2 \cdot 10^{-3} \cdot \frac{10}{1000} = 2 \times 10^{-5} \text{ mol}$ and $[H^+] = \frac{2 \times 10^{-5}}{2} = 10^{-5} \text{ mol/l}$ and $pH = -\log(10^{-5}) = 5$.

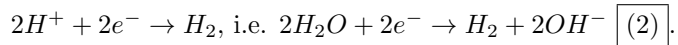
I(9):

The ions present in the solution are H^+ , OH^- and Na^+ . Among them, H^+ has the highest oxidising power and OH^- has the highest reducing power.

Therefore, OH^- is oxidised to O_2 at the anode, the half equation is



On the other hand, H^+ is reduced to H_2 at the cathode, the half equation is



Note: During a redox, the only side products allowed to form are H_2O (in an aqueous solution) and H^+ or OH^- (depending on whether the environment is acidic or alkaline). Therefore, option (4) is primarily wrong.

II:

Let the volume of SO_2 be V l, then the weight of it is $2.85V$ g and the number of moles of it is $\frac{2.85V}{64}$ mol.

As the molar ratio $SO_2 : H_2SO_4$ when SO_2 is converted to H_2SO_4 is 1:1, the number of moles of converted $H_2SO_4 = \frac{2.85V}{64}$ mol. Therefore, there are $2 \cdot \frac{2.85V}{64} = \frac{5.7V}{64}$ mol of H^+ ions in the solution.

When $0.0100 \cdot \frac{25.0}{1000} = 2.5 \times 10^{-4}$ mol of OH^- ions is added, neutralisation happens and the number of moles of OH^- ions remains $= (2.5 \times 10^{-4} - \frac{5.7V}{64})$ mol.

In the back-titration, $0.0100 \cdot \frac{13.6}{1000} = 1.36 \times 10^{-4}$ mol of H^+ ions are used to completely neutralise the solution. Therefore, we have

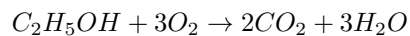
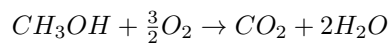
$$2.5 \times 10^{-4} - \frac{5.7V}{64} = 1.36 \times 10^{-4}. \text{ By solving, } V = 1.28 \times 10^{-3}.$$

Therefore, there are 1.28 ml of SO_2 per 40l $= 0.04 \times 10^6$ ml of sample.

The parts per million sample of $SO_2 = \frac{1.28}{0.04} = \boxed{32}$ ppm.

III:

(1): The two equations are:



Let the mass of $CH_3OH = m$ g, then the mass of $C_2H_5OH = (2.16 - m)$ g.

The number of moles of CH_3OH and C_2H_5OH are $\frac{m}{32}$ mol and $\frac{2.16-m}{46}$ mol respectively.

Therefore, the number of moles of O_2 used $= \frac{m}{32} \cdot \frac{3}{2} + \frac{2.16-m}{46} \cdot 6 = \frac{3(69.12-9m)}{1472}$ mol.

As the number of moles of O_2 used $= \frac{4.32}{32} = 0.135$ mol, by solving

$\frac{3(69.12-9m)}{1472} = 0.135$, we have $m = 0.32$.

Therefore, the number of moles of ethanol $= \frac{2.16-0.32}{46} = \boxed{0.04}$ mol.

(2): The percentage by weight $= \frac{0.32}{2.16} \cdot 100\% = \boxed{15}\%$.

IV:

(1):

A	B	C
①	k	f
②	g	a
③	f	g
④	c	c
⑤	l	j
⑥	b	h
⑦	d	e
⑧	a	k

Note: No explanation can be given for this question as the names of functional groups and compounds are merely some memorising tasks.

(2): Heating alcohol and carboxylic acid with H_2SO_4 will form an ester. The ester formed in this case is methyl ethanoate, which has the common name methyl acetate (b).

(3): $Ag(NH_3)_2^+$ is the active component of the Tollen's reagent used in the silver mirror test. During the test, the reagent is reduced to Ag and the sample (aldehyde) is oxidised to a carboxylic acid. The corresponding carboxylic acid that can be obtained when CH_3CHO is oxidised is ethanoic acid, which has the common name acetic acid (h).

V:

(1): The esterification of fatty acids and glycerol $\boxed{(c)}$ gives oils and fats.

(2): The specific gravity (relative density) of oil and fats are smaller $\boxed{(c)}$ than water.

Note: We usually describe densities using the adjectives “high” and “low”.

Note: If one is not sure of the answer, by common sense, oils are floating on the surface of water, which suggests they have a smaller density than water.

(3): $\boxed{(e)}$

(4): $\boxed{(a)}$

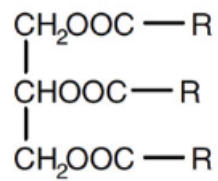
Note: For these two questions, of course we won't call oil and fats ether or soap. Moreover, margarine is a food flavour rather than a chemical. Therefore, the answer must be either (a) or (e). Sensibly, we prefer to call liquids as “oil” but not solid. Hence, one can easily guess the answer.

(5): The reaction is given by Oil and fats + $3KOH \rightarrow$ Glycerol + 3Fatty acids.

As $0.2 \cdot \frac{15}{1000} = 3 \times 10^{-3}$ mol of KOH are used, the number of moles of oil and fats = $\frac{3 \times 10^{-3}}{3} = 10^{-3}$ mol.

Therefore, we have $\frac{0.884}{m} = 10^{-3}$, i.e. $m = \boxed{884}$.

(6): Here is the structure of oil and fats:



Referring to the structure, we have

3(The formula weight of R)= $884 - (6 \cdot 12 + 5 \cdot 1 + 6 \cdot 16) = 711$. Therefore, the formula weight of R= $\frac{711}{3} = 237$.

As the fatty acid is $R - \text{COOH}$, the molecular weight of it

$$= 237 + 12 + 2 \cdot 16 + 1 = \boxed{282}.$$