

I(1):

Electron affinity increases with atomic numbers across the same period. Note that as noble gases cannot accept any more electrons, their electron affinities are 0. Therefore, F (3) has the largest electron affinity.

I(2):

Ionic radius increases with the number of electron shells across the same group. As Rb (4) has the greatest number of electron shells, it has the largest ionic radius.

I(3):

1) V-shaped

2) Tetrahedral

3) Linear

4) V-shaped

I(4):

The boiling points of substances increase with the strengths of their intermolecular forces. As HF (1) has hydrogen bonds between molecules while all other three have only van der Waals' forces, it has the highest boiling point.

I(5):

- 1) True, as both of them are metals.
 - 2) True, as both of them are metals.
 - 3) False, Au can only dissolve in aqua regia but no other acids.
 - 4) True, as the activity of Ag is higher than that of Au.
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I(6):

- 1) $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2(g)$ (redox)
- 2) $4HF + SiO_2 \rightarrow H_2O + H_2SiF_6$ (double displacement)*
- 3) $2HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2(g)$ (neutralisation)
- 4) $2NaOH + 2Al + 6H_2O \rightarrow 2NaAl(OH)_4 + 3H_2(g)$ (double displacement)

* SiF_4 gas formed, but it further reacted with water to form $H_2SiF_6 + SiO_2 + 2HF$ immediately.

I(7):

For ideal gas, we have the ideal gas equation $pV = nRT$. Therefore, (1) is wrong, pressure is directly proportional to the temperature at a constant volume.

II:

As the O atom has an oxidation number of -2 in SO_2 , the S atom has an oxidation number of $\boxed{+4}$ in SO_2 .

Similarly, the S atom has an oxidation number of $\boxed{+6}$ in SO_3 .

As SO_4^{2-} ion has an oxidation number of -2 , the S atom has an oxidation number of $\boxed{+6}$ in H_2SO_4 .

On the other hand, in the reaction between SO_2 and H_2S , as the S atom in H_2S is oxidised to S, the S atom in SO_2 should be reduced (and the product will be S). Therefore, we can deduce the equation $\boxed{2H_2S + SO_2 \rightarrow 3S + 2H_2O}$.

III:

The equation is given by $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$.

The number of moles of reactant $AgNO_3 = 0.30 \cdot \frac{10.0}{1000} = 3 \times 10^{-3} \text{ mol}$.

The number of moles of reactant $NaCl = 0.30 \cdot \frac{20.0}{1000} = 6 \times 10^{-3} \text{ mol}$.

Therefore, $AgNO_3$ is limited in the reaction, we have the number of moles of the AgCl precipitate $= 3 \times 10^{-3} \text{ mol}$.

On the other hand, after the reaction, there are $3 \times 10^{-3} \text{ mol}$ of Cl^- ions remaining from NaCl.

As the number of moles of Cl^- ions that can be dissociated from AgCl is negligible when comparing with that remained, we have $[Cl^-]$ approximately equals to $\frac{3 \times 10^{-3}}{\frac{10+20}{1000}} = \boxed{0.10} \text{ mol/L}$.

Now, considering the solubility product, we have $[Ag^+]$ approximately equals

to $\frac{1.8 \times 10^{-10}}{0.10} = \boxed{1.8 \times 10^{-9}} \text{ mol/L}.$

IV:

(1): The number of moles of KOH in 11.2 g KOH = $\frac{11.2}{39+16+1.0} = 0.2 \text{ mol}.$

Therefore, the heat of solution is $\frac{-11.6}{0.2} = \boxed{-58} \text{ kJ/mol}.$

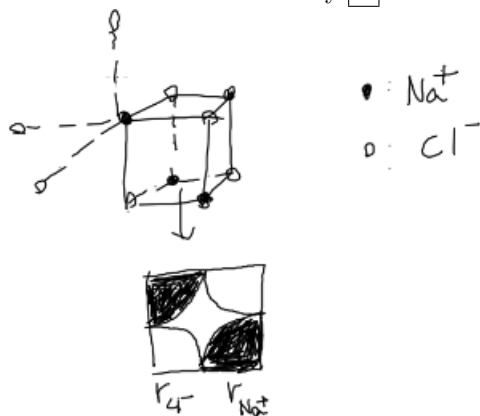
Moreover, after 2.0L water is added, $[OH^-]$ becomes $\frac{0.2}{2} = 0.1 \text{ mol/L}.$

When 5.0 mL of this solution is added, i.e. $0.1 \cdot \frac{5.0}{1000} = 5 \times 10^{-4} \text{ mol}$ of OH^- is added into 10.0 mL of 0.10 mol/L HCl, i.e. $0.10 \cdot \frac{10.0}{1000} = 10^{-3} \text{ mol}$ of H^+ , complete neutralisation occurs with $10^{-3} - 5 \times 10^{-4} = 5 \times 10^{-4} \text{ mol}$ of H^+ remains.

By that time, $[H^+] = \frac{5 \times 10^{-4}}{\frac{5.0+10.0}{1000}} = \frac{1}{30} \text{ mol/L}.$

Therefore, the pH value = $-\log \frac{1}{30} = \log 3 + 1 \approx \boxed{1.5}.$

(2): The unit cell of NaCl crystal has a simple cubic structure. Therefore, one Na^+ ion is surrounded by $\boxed{6}$ Cl^- ions, referring to the figure below:



Moreover, consider one face of the cube, the edge length of a cube of the unit

cell is $0.116+0.167=0.283$ nm. Therefore, the edge length of the unit cell is

$$2 \cdot 0.283 = \boxed{0.566} \text{ nm}.$$

Note: Unlike metallic crystals, the unit cells for ionic crystals have a symmetric

“A-B-A” structure by definition. Hence, a unit cell contains 8 cubes.

V:

(1):

The addition of H_2O to ethene with H_2SO_4 catalyst gives ethanol $\boxed{(3)}$. When

a sodium metal is put into ethanol, CH_3COONa $\boxed{(19)}$ will form and H_2 gas

$\boxed{(17)}$ will form.

The addition of HCl to ethene gives ClH_2CCH_2Cl $\boxed{(4)}$.

The addition of O_2 to ethene with $PdCl_2$ and $CuCl_2$ catalysts (Wacker reaction) gives CH_3CHO $\boxed{(6)}$.

After dimerisation, $CH_2 = CHCH_2CH_3$ is obtained. The addition of HCl

to it gives $CH_2ClCH_2CH_2CH_3$ or $CH_3CHClCH_2CH_3$. As the product of

it after dehydrochlorination can form CH_3CHO after ozonolysis, it should

be $CH_3CHClCH_2CH_3$ $\boxed{(15)}$. And the corresponding product after dehydrochlorination is $CH_3CH = CHCH_3$ $\boxed{(9)}$.

After ozonolysis, $CH_3CHO - O - OHCH_3$ forms, which can be broken into two CH_3CHO .

Moreover, the addition of H_2O to $CH_2 = CHCH_2CH_3$ with H_2SO_4 catalyst

gives $CH_3CHOHCH_2CH_3$ or $CH_2OHCH_2CH_2CH_3$. As it can undergo

the iodoform reaction (L), it contains a $-COH - CH_3$ branch, which implies it is $CH_3CHOHCH_2CH_3$ (20). Oxidation of it with $K_2Cr_2O_7$ gives $CH_3COCH_2CH_3$ (18) and after iodoform reaction, CH_3CH_2COONa (13) and CH_3I (11) form.

(2): As stated above, L is the iodoform reaction (1).

VI:

(1): By condition 3), the molecular formula of the compound is C_nH_{n+4} .

On the other hand, the general formula of alicyclic alkane is C_nH_{2n} . As one double bond reduces the number of H atoms by 2, the molecular formula of the compound is C_nH_{2n-4} .

Solving $n + 4 = 2n - 4$, we have $n = 8$, i.e. the compound is C_8H_{12} .

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

Moreover, phenol shows blue-violet when treated with $FeCl_3$ solution (6).

As phenol doesn't contain $-CHO$ groups, it doesn't undergo the silver mirror reaction.

(3): As aniline (4) is a weak alkali, it is neutralised by HCl and the resulting salt dissolves into the aqueous layer.

(4): HCO_3^- ion is a weak base. Phenol is too weak to undergo neutralisation with it. Among them, only salicylic acid (3) will be neutralised by $NaHCO_3$ and dissolve into the aqueous layer.

(5):

1) As there is a $-COOH$ group on the branch, it is acidic.

2) As there is a $-NH_2$ group on the branch, it is alkaline.

3) As there is a $-NH_2$ group on the branch, it is alkaline.

4) As there is an amine group on the branch, it is alkaline.

(5) It is neutral.

(6):

1) Carboxylic acids have two hydrogen bonds between molecules while alcohols have one only, therefore their boiling points are higher than that of alcohols'.

(2) Carboxylic acids have two hydrogen bonds between molecules while alcohols have one only, therefore their melting points are higher than that of alcohols'.

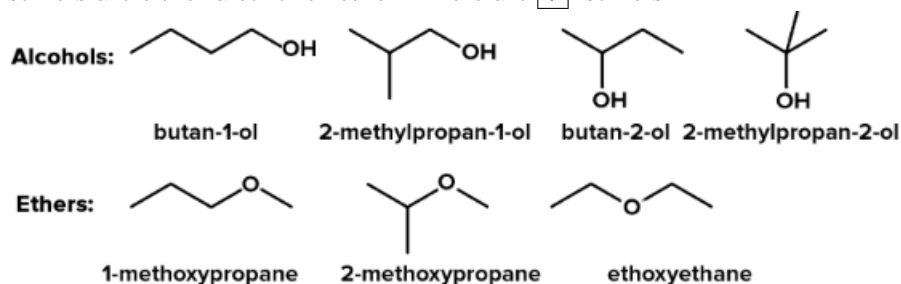
3) True

4) As the $-OH$ part of the $-COOH$ group can give hydrogen bond and the $=O$ part can receive a hydrogen bond, carboxylic acids can easily form the dimers.

5) Formic acid can be oxidised to H_2CO_3 due to the aldehyde group. Hence, it has the reducing property.

(6) Acetic anhydride indicates neutral.

(7) It can be seen that $C_4H_{10}O$ does not have any substitutions as the number of C atoms and H atoms match the general formula C_nH_{2n+2} . Therefore, its isomers are either alcohol or ether. There are 7 isomers:



VII:

(1): During the process of determining the percentage of nitrogen using the Kjeldahl method, N atoms are reduced to NH_4^+ ions, which combine with SO_4^{2-} ions to form $(NH_4)_2SO_4$ (1).

Note: In fact, part (2) of the question gives the answer to this part. The only two compounds that can produce NH_3 after alkalisng are $(NH_4)_2SO_4$ and NH_4Cl . However, there are no Cl atoms throughout the process. Therefore, the answer will be $(NH_4)_2SO_4$.

(2):

Let x be the weight percentage of nitrogen the protein contains, then the weight of nitrogen will be $0.056x$ g.

As the number of moles of N atoms determines the number of moles NH_3 pro-

duced, we have the number of moles of NH_3 is $\frac{0.056x}{14} = 0.004x \text{ mol}$.

Collected with 10.0 mL of 0.050 mol/L H_2SO_4 , i.e. $0.050 \cdot \frac{10.0}{1000} \cdot 2 = 1 \times 10^{-3} \text{ mol}$ of H^+ , $(1 \times 10^{-3} - 0.004x) \text{ mol}$ of H^+ remains.

As 3.6 mL of 0.10 mol/L NaOH, i.e. $0.10 \cdot \frac{3.6}{1000} = 3.6 \times 10^{-4} \text{ mol}$ of OH^- is used in the titration, we have $1 \times 10^{-3} - 0.004x = 3.6 \times 10^{-4}$, i.e. $x = \frac{6.4 \times 10^{-1}}{4} = \boxed{16\%}$.