2014

Question: 1
What is the coordination number of each type of ions in a rock-salt type crystal structure? [1]

Answer:
Rock salt type crystal structure has 6:6 coordination number of each type of ion. In NaCl, coordination of no. of Na^+ = 6 and coordination no. of Cl^- = 6.

Question: 2
Arrange the following compounds in an increasing order of their acid strengths: [1]

$(CH_3)_2CHCOOH$, $CH_3CH_2CH(Br)COOH$, $CH_3CH(Br)CH_2COOH$

Answer:
We know that +I –effect while –I-effect increases the acid strength of carboxylic acids. the overall acid strength increases in the order.

$(CH_3)_2CHCOOH < CH_3CH(Br)CH_2COOH < CH_3CH_2CH(Br)COOH$

Question: 3
State the type of hybrid orbitals associated with (i) P in PCl_5 and (ii) S in SF_6. [1]

Answer:
i. sp^3d of P in PCl_5
ii. $sp^3\ d^2$ of S in SF_6.

Question: 4
Write the IUPAC name for any of the isomers with the molecular formula $[Pt(\ NH_3\ )_2\ Cl_2]\ Cl_2$. [1]

Answer:
Diamine dichloro platinum(IV) chloride.

Question: 5
In the transition series, with an increase in atomic number the atomic radius does not change very much. Why is it so? [1]

Answer:
As one proceeds along a transition series, the nuclear charge increases which tend to decrease the size but the addition of electrons in the d-subshell increases the screening effect which counter balances the effect of increased nuclear charge.

Question: 6
Why do the transition elements have higher enthalpies of atomization? In 3d series (Sc to Zn), which element has the lowest enthalpy of atomization and why? [1]

Answer:
Solutions with sameosmotic pressure

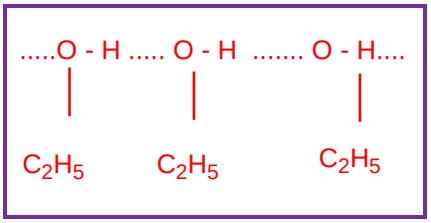
Question: 7
Mention a use of formalin in industry. [1]

Answer:
Formalin is used as disinfectant and germicide.

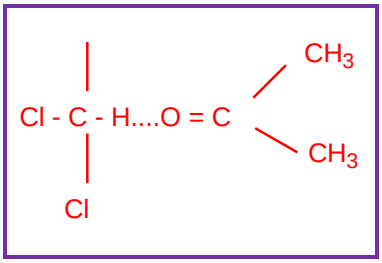
Question: 8
Give one example each of miscible liquid pairs showing positive and negative deviations from Raoult's law. Give one reason each for such deviations. [2]

Answer:

Solution of n-hexane and ethanol shows positive deviations from Raoult's law because n-hexane molecules weaken the H-bonds between ethanol molecules which increase its vapor pressure.



Solution of acetone and chloroform shows negative deviations from Raoult's law because of the formation of H-bonds between acetone and chloroform molecules.



Question: 9

Explain as to why haloarenes are much less reactive than haloalkanes towards nucleophilic substitution reactions. [2]

Answer:

Haloarenes are much less reactive than haloalkanes towards nucleophilic substitution reactions due to the following reasons:

i. Resonance effect
ii. Difference is hybridization of carbon atom in C-X bond
iii. Instability of phenyl cation

Question: 10

Which compound in each of the following pairs will react faster in SN_2 reaction with –OH? Why? [2]

i. CH_3Br or CH_3I
ii. $(CH_3)_3CCl$

Answer:

Since I- ion is a better leaving group than Br^- ion, therefore CH_3Br reacts than CH_3 Br in S_N2 reaction with OH^- ion.

Question: 11

State Henry's law correlating the pressure of a gas and its solubility in a solvent and mention two applications for the law. [2]

Answer:

It states that at constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

Applications:
a. in the production of carbonated beverages
b. in the deep sea diving
c. in the function of lungs

Question: 12

List the reactions of glucose which cannot be explained by its open chain structure. [2]

Answer:

Limitation of the open chain structure: Although the open chain structure of D – (+) glucose explains most of its reactions yet it fails to explain the following facts.

i. D(+) – glucose does not undergo certain reactions of aldehydes. For example, glucose does not form $NaHSO_3$ addition product, aldehyde – ammonia 2 and 4-DNP derivative and does not respond to Schniff;s reagent test.

ii. Glucose reacts with NH_2OH to form an oxide but glucose penta-acetate does not.

Question: 13

Calculate the packing efficiency of a metal crystal for a simple cubic lattice.

Answer:

$$\text{Packing efficiency} = \frac{Z \times \text{volume of an atom}}{\text{Volume of cubic unit cell}} = \frac{1 \times 4/3\ \pi r^3}{a^3}$$

For simple cubic lattice, $a = 2r$.

$$\text{Therefore packing efficiency} = \frac{1 \times 4/3\ \pi r^3}{8r^3} \quad 0.524 \text{ or } 52.4\%$$

Question: 14 [2]

The thermal decomposition of HCO_2H is a first order reaction with a rate constant of $2.4 \times 10^{-3}\ s^{-1}$ at a certain temperature. Calculate how long will it take for three-fourths of initial quantity of HCO_2H to decompose. (log 0.25 = -0.6021)

Answer:

$$t = \frac{2.303}{k} \times \log \frac{[A]}{[A]}0$$

$$t = \frac{2.303}{2.4 \times 10^{-3}\ s^{-1}} \times \log \frac{[A]}{[A]_0 / 4}0$$

$$t = \frac{2.303}{2.4 \times 10^{-3}\ s^{-1}} \times \log\ 4$$

$$t = \frac{2.303}{2.4 \times 10^{-3}\ s^{-1}} \times\ 0.60212$$

$t = 578s$

Question: 15 [2]

How would your account for the following:

i. Cr^{2+} is reducing in nature while with the same d-orbital configuration (d4) Mn3+ is an oxidizing agent.

Answer:

Cr^{2+} is reducing as its configuration changes from d^4 to d^3, the latter having half-filled t_{2g} level whereas Mn^{3+} to Mn^{2+} results in half filled orbitals (d^5)

ii. In a transition series of metals, the metal which exhibits the greatest number of oxidation states occurs in the middle of the series.

***Answer**:*
In a transition metal series the oxidation state first increases and then decreases; At the middle it will be maximum due to greater number of unpaired electron in (n-1) d and ns orbitals.

Question: 16 [2]
A solution prepared by dissolving 8.95 mg of a gene fragment in 35.0 mL of water has an osmotic pressure of 0.335 torr at 25^0C. assuming that the gene fragment is a non-electrolyte, calculate its molar mass

Answer:
$\pi = CRT$

$$M_2 = \frac{w_2 RT}{\pi V}$$

$$M_2 = \frac{8.95 \times 10^{-3}\ g \times 0.0821 L\ atm\ mol^{-1}\ K^{-1} \times 298 \times 760 \times 1000}{0.335\ atm \times 35L}$$

$M_2 = 14193.3\ g\ mol^{-1}$ or $1.42 \times 104\ g\ mol^{-1}$

Question: 17 [2]
18g of glucose, $C_6H_{12}O_6$ (Molar Mass= 180g mol^{-1}) is dissolved in 1Kg of water in a sauce pan. At what temperature will this solution boil? [2]

Answer:
w_1 = weight of solvent (H_2O) = 1 kg and w_2 = weight of solute ($C_6H_{12}O_6$) = 18 gm
M_2 = Molar mass of solute (C6H12O6) = 180 g mol^{-1}
K_b = 0.52 K Kg mol^{-1}
T_b^0 = 373.15K

$$\Delta DT_b = \frac{K_b \times 1000}{M_2 \times w_1} = \frac{0.52 \times 1000 \times 18}{180 \times 1000} = 0.052K$$

$\Delta T_b = T_b - T_b^0 \Rightarrow 0.052 = T_b - 373.15 \Rightarrow T_b = 373.202K$

Question: 18 [2]
What are lyophilic and lyophobic colloids? Which of these sols can be easily coagulated on the addition of small amounts of electrolytes?

Answer:
Lyophillic colloids: It is made up of two words; 'Lyo' meaning liquid and 'Phillic' meaning loving, so those colloids which are attracted by the liquid (solvent), are called as lyophillic colloids. These are also called reversible sols. These are quite stable and cannot be easily coagulated.

Lyophobic colloids: It is made up of two words; 'Lyo' meaning liquid and 'Phobic' meaning repelling, so those colloids which are repelled by the liquid (solvent), are called as lyophobic colloids. These are also called irreversible sols and these are unstable and can be easily coagulated due to lack of protecting layer around charged colloidal particles, they easily form cluster. Hence, they got easily coagulated on addition of small amount of electrolyte.

Question: 19
Write the differences between physisorption and chemisorption with respect to the following: [2]

i. Specificity
ii. Temperature dependence
iii. Reversibility and
iv. Enthalpy change

Answer:

S.No.	Point of difference	Physiosorption	Chemisorption

(i)	Specificity	This is not specific in nature.	This is highly specific in nature.
(ii)	Temperature dependence	Low temperature is favourable for physiosorption. It decreases with increase in temperature.	High temperature is favourable for chemisorption. It increases with the increase in temperature.
(iii)	Reversibility	This is reversible in nature.	This is irreversible in nature.
(iv)	Enthalpy change	Enthalpy of adsorption is low.	Enthalpy of adsorption is high.

OR

Determine the osmotic pressure of a solution prepared by dissolving 2.5 x 10^{-2} g of K_2SO_4 in 2L of water at 25° C , assuming that it is completely dissociated. (R=0.0821 L atm $K^{-1}mol^{-1}$, Molar mass of K_2SO_4=174g mol^{-1}).

Answer:

W_2 = 2.5 x 10-2 (Mass of K2SO4) and M2 = 174 g mol-1(Molar mass K2SO4)
V = 2L, R = 0.0821 L atm K-1 mol-1 and T = 250C = 298 K

Osmotic pressure, $\pi = \frac{w_2RT}{M_2V}$

$$\pi = \frac{2.5 \times 10^{-2} \times 0.0821 \times 298}{174 \times 2} = \frac{61.1645 \times 10^{-2}}{348} = 1.76 \times 10^{-3} \text{ atm.}$$

Question: 20 [3]

How would you account for the following?

i. Transition metals exhibit variable oxidation states.

Answer:

The variable oxidation states of transition elements are due to the participation of *ns* and (*n*−1)*d*-electrons in bonding. Lower oxidation state is exhibited when *ns*- electrons take part in bonding. Higher oxidation states are exhibited when (*n* − 1) *d*-electrons take part in bonding.

ii. Zr (Z=40) and Hf (Z=72) have almost identical radii.

Answer:

This is because the atomic radii of 4d and 5d transition elements are nearly same. This similarity in size is consequence of lanthanide contraction. Because of this lanthanide contraction the radii of Hf becomes nearly equal to that of Zr.

iii. Transition metals and their compounds act as catalyst.

Answer:

Transition elements act as good catalyst in chemical reaction because they can lend electrons or withdraw electrons from the reagent, depending on the nature of the reaction. The ability of transition metals to be in a variety of oxidation states, the ability to interchange between the oxidation states and the ability to form complexes with the reagents and be a good source for electrons make transition metals good catalysts.

Question: 21 [3]

Complete the following chemical equations:

i. $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow$

Answer:

$Cr_2 + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

ii. $2CrO_4^{2-} + 2H^+ \rightarrow$

Answer:

$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

iii. $2MnO_4^- + 5C2O_4^{2-} + 16H^+ \rightarrow$

Answer:

$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

Question: 22

Give reasons for the following observations:

i. Physisorption decreases with increase in temperature.

Answer:

ii. Addition of alum purifies the water.

Answer:

iii. Brownian movement provides stability to the colloidal solution.

Answer:

Question: 23 [3]

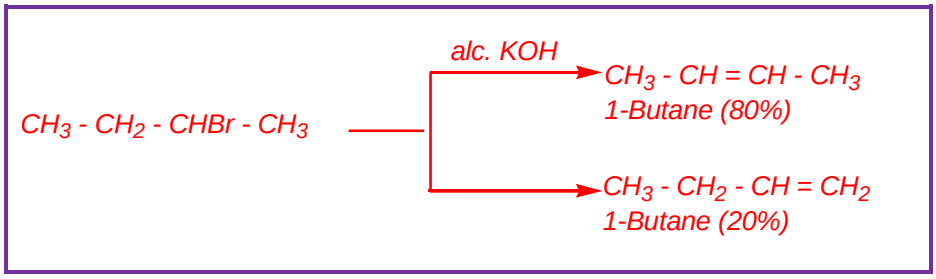
What is Saytzeff rule? Illustrate with suitable example.

Answer:

Sometimes a haloalkane can undergo elimination in two different ways forming a mixture of two products. The products in the reaction are that the alkene having the lesser number of hydrogen's on the double bonded carbon atom.

This generalization is known as Saytzeff's rule.

For example,



Question: 24

An antifreeze solution is prepared from 222.6 g of ethylene glycol ($C_2H_4(OH_2)$) and 200 g of water. Calculate the molality of the solution. If the density of these solutions be 1.072 g mL^{-1}, what will be the molarity of the solution? [3]

Answer:

Molar ethylene glycol

$C_2H_4(OH)_2 = 12 \times 2 + 1 \times 4 + (16 + 1) \times 2.$
$M_2 = 24 + 4 + 34 = 62$ g mol-1

Mass of ethylene glycol , $w_2 = 22.6$ g
Mass of water, w1 = 200 g

$$\text{Molality} = \frac{w_2 \times 1000}{M_2 \times w_1}$$

$$= \frac{222.6 \times 1000}{62 \times 200}$$

$$= 17.95 m$$

Calculation of Molarity

Total mass of antifreeze solution = 222.6 + 200 = 422.6 g

$$\text{Volume of this solution } V = \frac{\text{Mass}}{\text{Density}} = \frac{422.6}{1.072}$$

$$\text{Molarity} = \frac{w_2 \times 1000}{M_2 \times V}$$

$$= \frac{222.6 \times 1000}{62 \times 394.22}$$

$$= 9.11 M$$

Question: 25

a. Complete the following chemical equations :

i. $NaOH_{(aq)} + Cl_{2(g)} \rightarrow$
(Hot and conc.)

Answer:

$6\ NaOH + 3Cl_2 \rightarrow 5\ NaCl + NaClO_3 + 3H_2O$

ii. $XeF_6(s) + H_2O\ (l) \rightarrow$

Answer:

$XeF_6(s) + 3H_2O\ (l) \rightarrow XeO_3 + 6HF$

b. How would you account for the following?

i. The value of electron gain enthalpy with negative sign for sculpture is higher Than that for oxygen.

Answer:

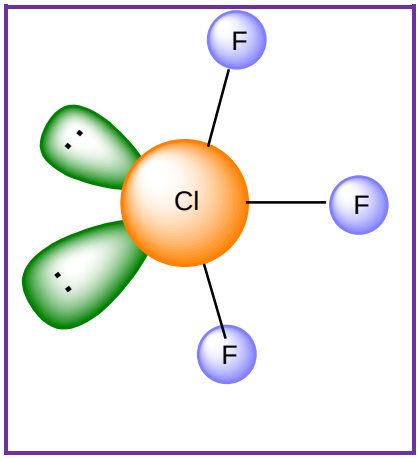
This is because oxygen has a smaller size than sulphur. Hence, electron repulsions will be more in the case of oxygen than sulphur.

ii. NF_3 is an exothermic compound but NCl_3 is endothermic compound.

Answer:
This is because NF_3 is a stable compound whereas NCl_3 is an unstable compound. NF_3 is stable because of small difference between the size of N and F which results in stable N-F bond. NCl_3 is unstable because of large difference between the size of N and Cl which results is weak N-Cl bond.

iii. ClF_3 molecule has a T – shaped structure and not a trigonal planar one.

Answer:
This is because in ClF_3, Cl is sp^3d hybridized and two lone pairs are present on equatorial positions.



Question: 26

a. Complete the following chemical reaction equations:

i. $P_4 + SO_2Cl_2 \rightarrow 4PCl_5 + 10SO_2$

Answer:
$P_4 + SO_2Cl_2 \rightarrow 4PCl_5 + 10SO_2$

ii. $XeF_4 + H_2O \rightarrow$

Answer:
$6XeF_4 + 12H_2O \rightarrow 4Xe + 2XeO_3 + 24\ HF + 3O_2$

b. Explain the following observations giving appropriate reasons :

i. The stability of +5 oxidation state decreases down the group in group 15 of the periodic table.

Answer:
This is because of inert pair effect. As we move down the group, due to poor shielding of inner d-electrons, ns electrons are pulled strongly towards the nucleus. Thus, ns electrons are difficult to release and do not participate in bond formation.

ii. Solid phosphorus pentachloride behaves as an ionic compound.

Answer:
This is because in solid state it exists as $[PCl4]^+$ $[PCl6]^-$

iii. Halogens are strong oxidizing agents.

***Answer**:*
This is because of their high electron affinities that they have a great tendency to take up electrons.

Question: 27

a. Account for the following: Propanol and propanone [2]

Answer:

i. CH_3CHO is more reactive than CH_3COCH_3 towards reaction with HCN.

Answer:
Because the positve charge on carbonyl carbon of CH_3 CHO decreases to a lesser extent due to one electron releasing(+I effect) CH_3 group as compared to CH_3 $COCH_3$(two electron releasing CH_3 group) and hence more reactive.

ii. Carboxylic acid is a stronger acid than phenol.

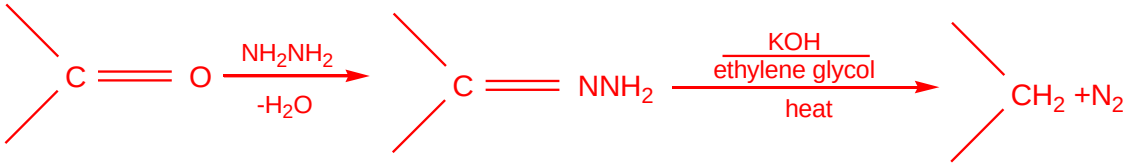
Answer:
Because carboxylate ion (conjugate base) is more resonance stablized than phenoxide ion.

b. Write the chemical equations to illustrate the following name reactions : [3]

Answer:

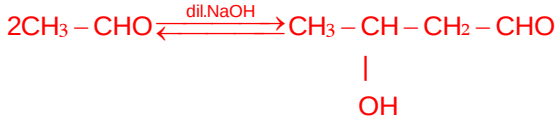
i. Wolff-Kishner reduction

Answer:



ii. Aldol condensation

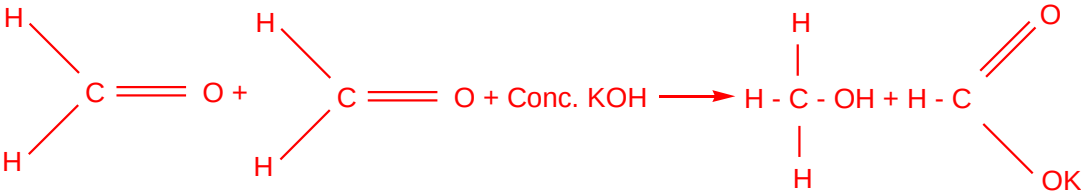
Answer:



(or any other example)

iii. Cannizzaro reaction

Answer:



(or any other example)

Question: 28

a. Define the following terms: [2]

i. Limiting molar conductivity

Answer:

Limiting molar conductivity when concentration approches zero the conductivity is known as limiting molar conductivity.

ii. Fuel cell

Answer:

Fuel cells are the cells which convert the energy of combustion of fuels to electrical energy.

b. Resistance of a conductivity cell filled with 0.1 mol L^{-1} KC/ solution is 100Ω. If the resistance of the same cell when filled with 0.02 mol^{-1} KCl, solution is 520 Ω, calculate the conductivity and molar conductivity of 0.02 mol L^{-1} KCl solution. The conductivity of 0.1 mol L^{-1} KC/ solution is 1.29 x 10^{-2} x 10-2 Ω^{-1} cm^{-1}.

Answer:

Cell constant (G* is Conductivity X Resistance): 1.29 $\frac{S}{m} \times 100\ \Omega = 129\ m^{-1} = 129\ cm^{-1}$

Conductivity of 0.02 mol L^{-1} KCL solution = $\frac{\text{cell constant}}{\text{resistance}}$

$x = \left(\frac{G^*}{R}\right) = \left(\frac{129\ m^{-1}}{520\Omega}\right) = 0.248\ S\ m^{-1} = 0.248 \times 10^{-2}\ Scm^{-1}$

Concentration = 0.02 mol L^{-1} = 1000 x 0.02 mol m^{-3}= 20 mol m^{-3}

Molar conductivity $\left(\Delta_m\right): \left(\frac{K}{c}\right) = \frac{248 \times 10^{-3} Sm^{-1}}{20 mol m^{-3}}$ =124 x 10^{-4} S m^2 mol^{-1}= 124 S cm^2 mol^{-1}

OR

a. Explain the State Faraday's frst law of electrolysis. How much charge in terms of Faraday isrequired for the reduction of 1 mol of Cu^{2+} to Cu.

Answer:

The amount of substance deposited at any electrode during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte. (aq. Solution or melt) Charge = Q = 2F.

b. Calculate emf of the following cell at 298K $Mg(s)\left|Mg^{2+}(0.1M)\right\|Cu^{2+}(0.01)\left|Cu(s)\right.$

[Given E^o_{cell} = +2.71V, I F = 96500 C mol^{-1}]

Answer:

E cell = E^0 cell $- \frac{0.059}{n} \log \frac{\left[Mg^{2+}\right]}{\left[Cu^{2+}\right]}$

E cell = $2.71 - \frac{0.059}{2} \log \frac{0.10}{0.01}$

E cell = $2.71 - \frac{0.059}{2} \log 10$= 2.71 – 0.0295 = 2.68 V

Question: 29

a. In the button cell, widely used watches and other devices, the following reaction takes place: $Zn(s) + Ag_2O(s) + H_2O(l) \rightarrow Zn^{2+}(aq) + 2Ag(s) + 2OH^-(aq)$. Determine E^0 and $\Delta_r G^0$ for the reaction. Given $E^0_{Ag^+/Ag} = +0.80\,V$, $E^0_{Zn^{2+}/Zn} = 0.76\,V$

Answer:

In this cell, zinc is oxidized and silver is reduced.

$E^0_{cell} = E^0_{cathode} - E^0_{anode} = E^0\ Ag + /Ag - E^0 Zn^{2+} / Zn$

= 0.34 – (-0.76) + 1.10 V

The reactions occurring in the cell are

At anode: $Zn(s) \rightarrow Zn^2(aq) + 2e^-$

At cathode: $Ag_2\ O\ (s) + H2O\ (l) + 2e^- \rightarrow 2Ag\ (s) + 2OH^-\ (aq)$

$\Delta_r G^0 = nF\ E^0_{cell}$

= -2 x 96500 x 1.10

= -212300 J mol^{-1}

b. Explain with examples the terms weak and strong electrolytes. How can these be distinguished?

Answer:

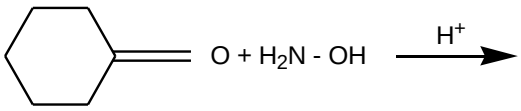
The electrolytes which are ionized almost completely in aqueous solution are called strong electrolytes. For example H_2SO_4, NaCl etc.

The electrolytes which ionize to a small extent are called weak electrolytes. For e.g. CH_3COOH, NH_4OH etc.

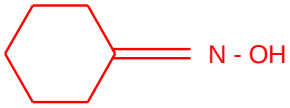
These electrolytes can be distinguished by their conducting power which is expressed in terms of degree of ionization (α). For strong electrolytes, α is almost equal to 1 but for weak electrolytes α has a value smaller than 1.

Question: 30 [3]

a. Write the products of the following reactions:

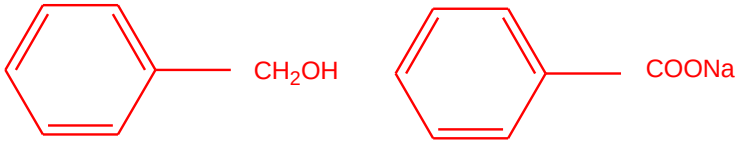
i. 

Answer:



ii. 2 C_6H_5CHO + conc. NaOH

Answer:



iii. $CH_3COOH \xrightarrow{Cl_2/P}$

Answer:

Cl - CH_2 - COOH

b. Give simple chemical tests to distinguish between the following pairs of compounds: [2]

i. Benzaldehyde and Benzoic acid

Answer:

Add $NaHCO_3$, benzoic acid will give brisk effervescence whereas benzaldehyde will not give this test. (or any other test).

ii. Propanal and hopanone

Answer:

Add tollen's reagent , propanal will give silver mirror whereas propanone will not give this test. (or any other test)