2009

Question 1
What is the number of atoms in a body-centred cubic unit cell of a crystal? [1]

Answer:

8 (Corner atoms) $\times \frac{1}{8}$ +1 (body center atom) $\times$ 1 = 1 + 1 = 2

Question 2
What is an emulsion? [1]

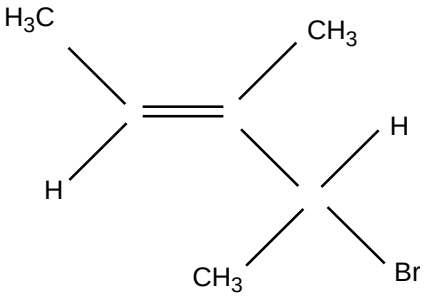
Answer:
Emulsion is a colloidal solution in which both the dispersed phase and dispersion medium are liquids e.g. milk, cod liver oil, etc.

Question 3
Which one has higher electron gain enthalpy with negative sign, sulphur or oxygen? [1]

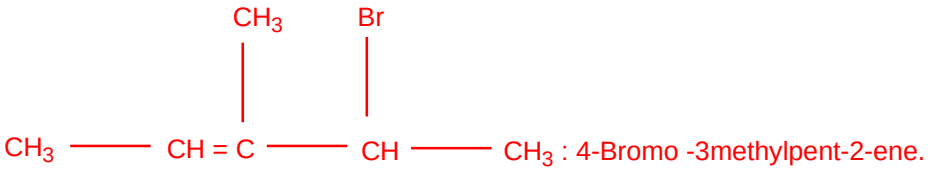
Answer:

Sulphur.

Question 4
Give the IUPAC name of the following compound. [1]

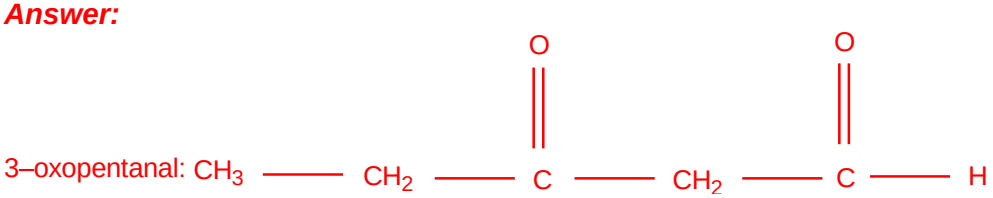


Answer:



Question 5
Write the structural formula of 3-oxopentanal. [1]

Answer:



Question 6
Name two metals which. occur in nature as oxides. [1]

Answer:
Aluminum occurs as $Al_2O_3.2H_2O$
Iron occurs as Fe_2O_3

Question 7
Arrange the following compounds in an increasing order of their basic strength in aqueous solutions [1]

NH_3, RNH_2, R_2NH, R_3N

Answer:
$NH_3 < R\text{-}NH_2 < R_3N < R_2NH$

Question 8
Write the name of an antacid which is often used as a medicine. [2]

Answer:
Ranitidine (zantac).

Question 9
Differentiate between molality and molarity of a solution. What is the effect of rise in temperature on molality and molarity of the solution? [2]

Answer:
Molality is the number of moles of solute per thousand grams of solvent whereas molarity is the number of moles of solute dissolved in one litre of solution.

Molality is independent of temperature whereas molarity changes with change in temperature as volume changes with temperature.

Question 10
Describe the role of the following: [2]
i. NaCN in the extraction of silver

Answer:
Dilute NaCN forms a soluble complex with Ag or Ag2S while the impurities remain unaffected which are filtered off.

$$4Ag + 8NaCN + o_2 + 2H_2o \rightarrow 4Na[Ag(CN_2)] + 4NaOH$$

Or $Ag_2S + 4NaCN \rightarrow 2Na[Ag(CN)_2]\ Na_2S$

Sodium dicyanoargentate(I)
(Soluble complex)

ii. CO in the purification of nickel

Answer:
Carbon monoxide forms a volatile complex, nickel tetracarbonyl with nickel which on decomposition gives pure nickel.

$$Ni + 4CO \xrightarrow{330\text{-}350K} Ni(CO)_4$$

Impure nickel tetracarbony1

$$Ni + (CO)_4 \xrightarrow[\text{pure}]{450\text{-}470K} Ni + 4CO$$

Question 11

Corrosion is essentially an electrochemical phenomenon. With the help of a diagram explain the reactions occurring during the corrosion of iron kept in open atmosphere. [2]

Answer:

At anode: Oxidation of Fe atoms takes place

$$Fe \rightarrow Fe^{2+} + 2e^- \qquad E^o Fe^{2+}/Fe = -0.44V$$

At cathode: Reduction of oxygen in the presence of H^+ ions. The H^+ ions are produced by either H_2O or H_2CO_3 (formed by dissolution of CO_2 in moisture)

$$2H^+(aq) + 2e^- \rightarrow 2H$$

$$2H + \frac{1}{2}O_2(g) \rightarrow H_20$$

Net reaction at cathodic area

$$2H^+(aq) + \frac{1}{2}O_2 + 2e^- \rightarrow H_2O \qquad E^o H^+/o_2/H_2O = 1.23V$$

The overall reaction

$$Fe(s) + 2H^+(aq) + \frac{1}{2}O_2(g) \rightarrow Fe^{2+}(aq) + H2O(l) \qquad E^o cell = 1.67V$$

The ferrous ions are further oxidised by atmospheric oxygen to ferric ions which come out as rust in the form of hydrated ferric oxide (Fe_2O_3 . xH_2O).

OR

Define the term molar conductivity and indicate how molar conductivity of a substance changes with change in concentration of a weak electrolyte and a strong electrolyte in its solution.

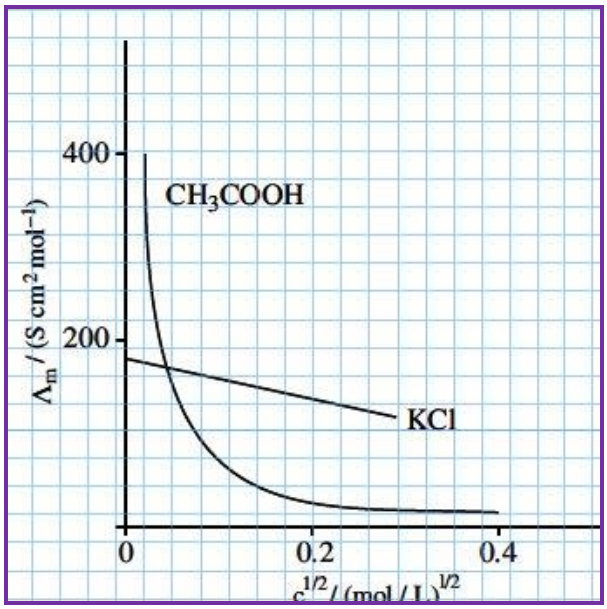
Answer:

Molar Conductivity (Lm): It may be defined as the conductance of a solution containing 1 mole of electrolyte such that the entire solution is placed is between two electrodes one centimeter apart.

$$Lm = k \times v$$

or

$$Lm = \frac{k \times 1000}{M}$$



Molar conductivity increases with decrease in concentration or increase in dilution as number of ions as well as mobility of ions increased with dilution.
For strong electrolytes the number of ions do not increase appreciably on dilution and only mobility or ions increases due to decrease in inter-ionic attractions. Therefore □*m* increases a little as shown in graph by a straight line. For weak electrolyte the number of ions as well as mobility of ions increases on dilution as shown by curve in the figure.

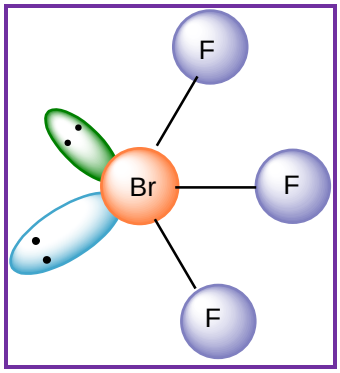
Question 12

Draw the structures of the following molecules [2]

i. BrF_3

Answer:

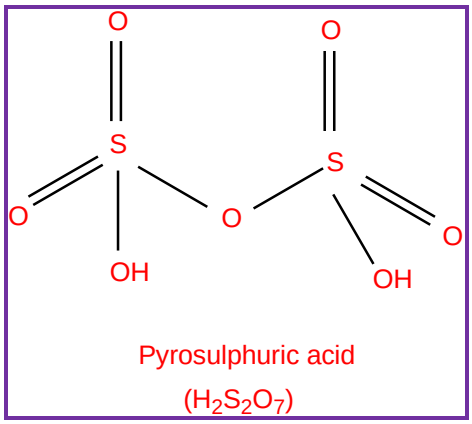
No. of electron pairs around central atom (Br) = 5
- b.p.=3
- l.p.=2



The shape would be slightly bent T.

ii. $H_2S_2O_7$

Answer:



Pyrosulphuric acid

($H_2S_2O_7$)

Question 13

State reasons for the following observations: [2]

i. The enthalpies of atomization of transition elements are quite high.

Answer:

This is because, transition elements have strong metallic bonds due to presence of large number of unpaired electrons.

ii. There is a greater horizontal similarity in the properties of the transition elements than of the main group elements.

Answer:

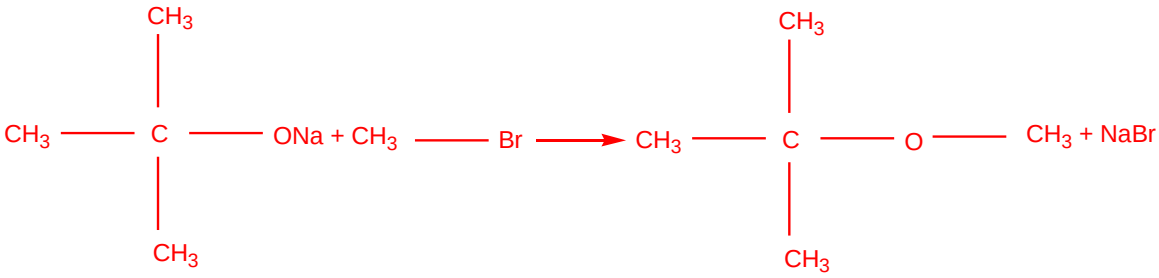
This is because in transition elements incoming electron goes into d-orbitals of inner shell whereas in main group elements, the incoming electron goes to outermost shell.

Question 14

Give a chemical equation for each of the following reactions. [2]

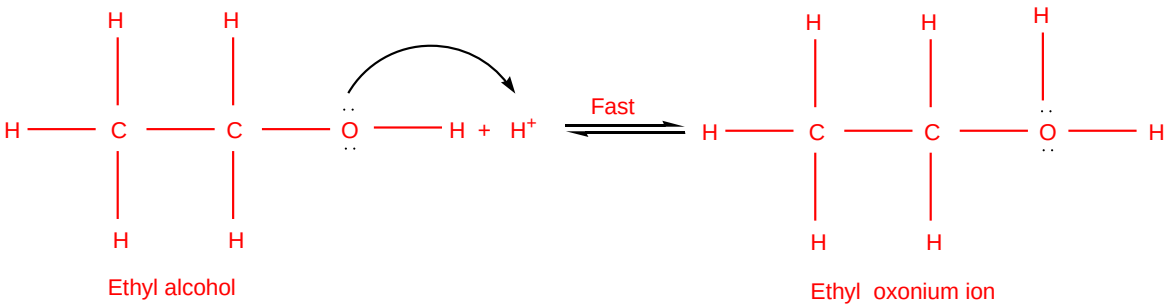
i. Williamson synthesis

Answer:



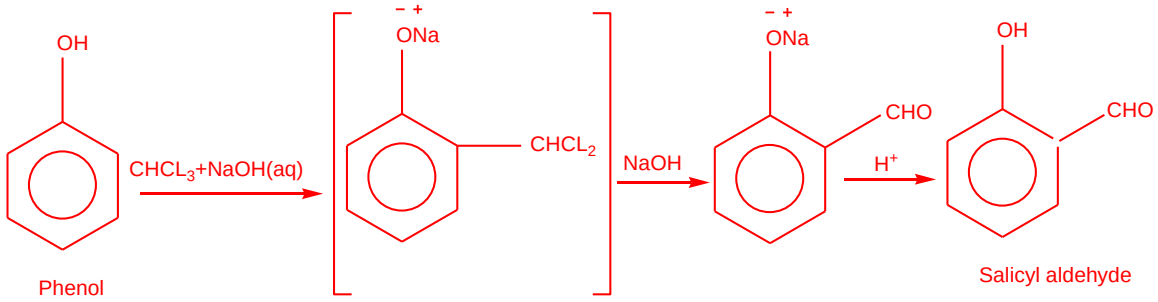
Sodium tert-butoxide

Methyl tert-butyl (ether)



ii. Reimer - Tiemann reaction

Answer:



Question 15

Explain the mechanism of each of the following processes. [2]

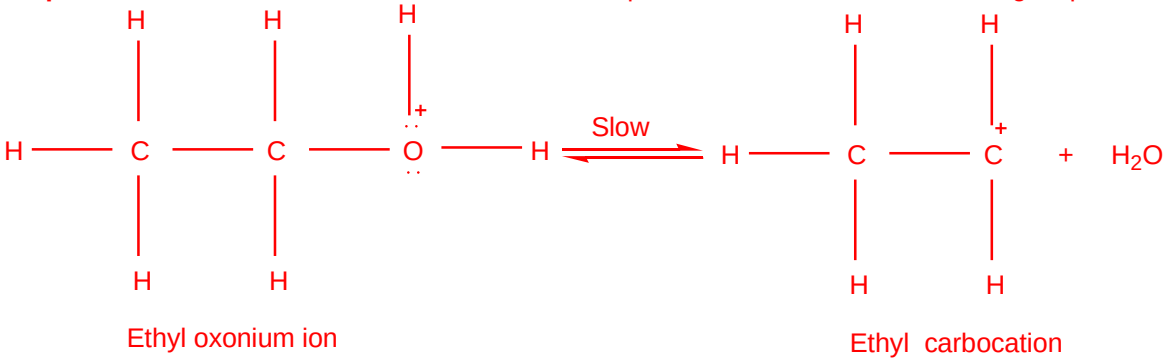
i. Acid catalysed dehydration of an alcohol

Answer:

$$CH_3 - CH_2 - OH \xrightarrow{H^+} CH_2 = CH2 + H_2O$$

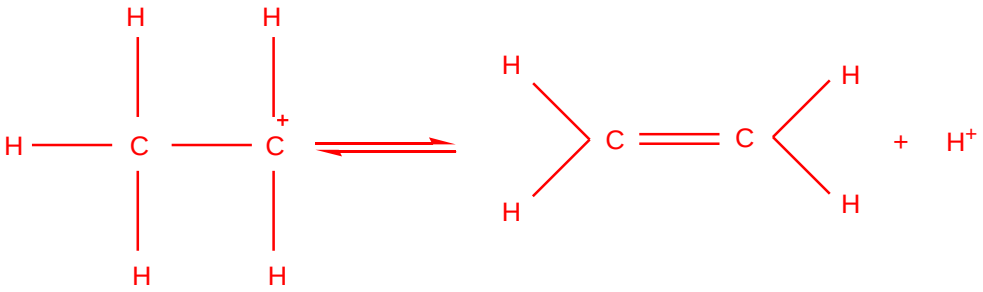
Mechanism

Step I: Formation of carbocation: It is the slowest step and hence, the rate determining step.



Step II: Formation of protonated alcohols

Step III: Formation of ethylene by elimination of a proton

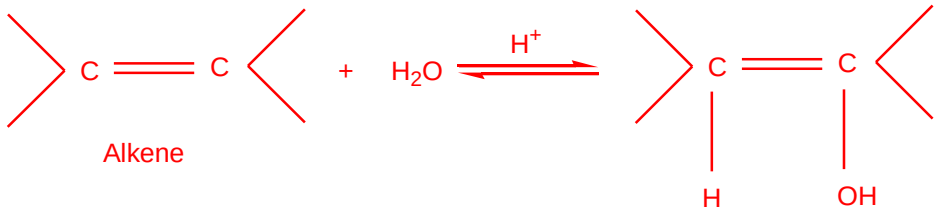


Ethyl carbocation Ethylene

To drive the equilibrium to the right, ethylene is removed as it is formed.

ii. Hydration of ethane to yield ethanol

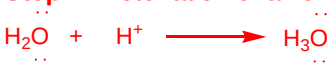
Answer:

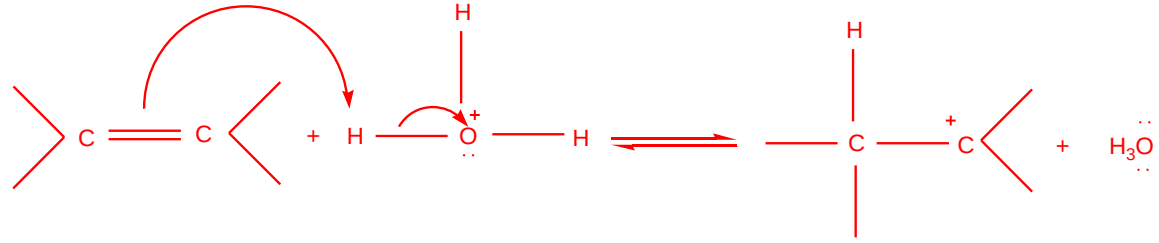


Alkene

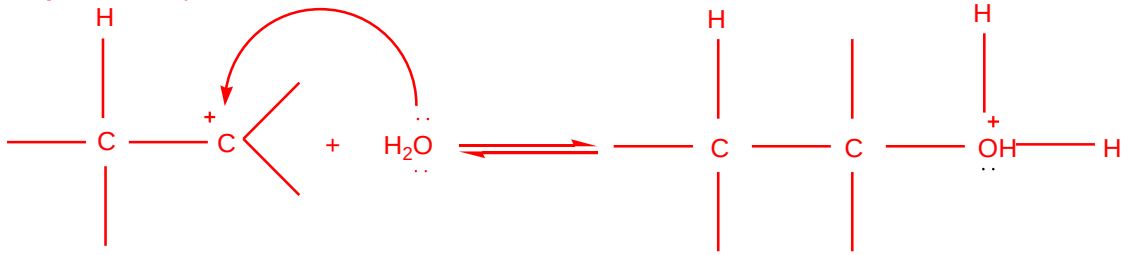
Mechanism

Step I: Protonation of alkene to form carbocation by electrophilic attack of H_3O^{+}.

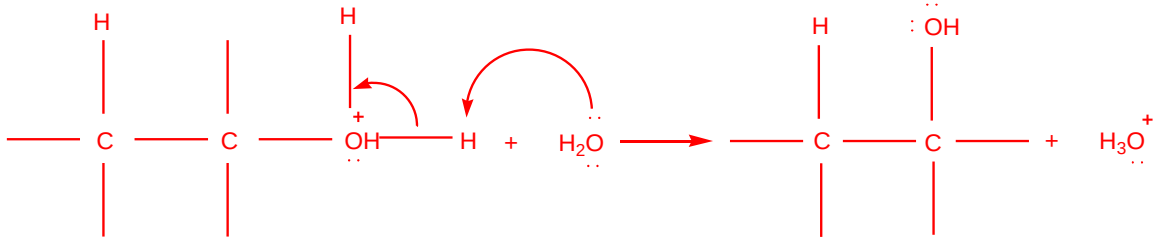




Step II: Nucleophilic attack of water on carbocation.



Step III: Deprotonation to form an alchohol



Question 16

Name two water soluble vitamins, state their sources and the diseases caused due to their deficiency in diet. [2]

Answer:

B group vitamin and vitamin C are soluble in water.

	Name of Vitamins	Sources	Deficiency diseases
(*i*)	Vitamin B_{12}	Meat, fish, egg and curd	Pernicious anaemia
(*ii*)	Vitamin C	Citrus fruits and amla	Scurvy

Question 17

What are the following substances? [2]

i. Invert sugar.

Answer:

Invert Sugar: Sucrose is dextrorotatory, on hydrolysis in the presence of HCl or enzyme invertase, it produces a mixture of D–C(+)–glucose and D–(–)–fructose which is laevorotatory called invert sugar.

ii. Polypeptides.

Answer:

Polypeptide: If more than ten a-amino acids are joined together by peptide bond (–CONH–) the polyamide thus formed is called polypeptide.

Question 18

State reasons for t h e following occurrences.

i. Soaps do not do the cleansing in hard water.

Answer:

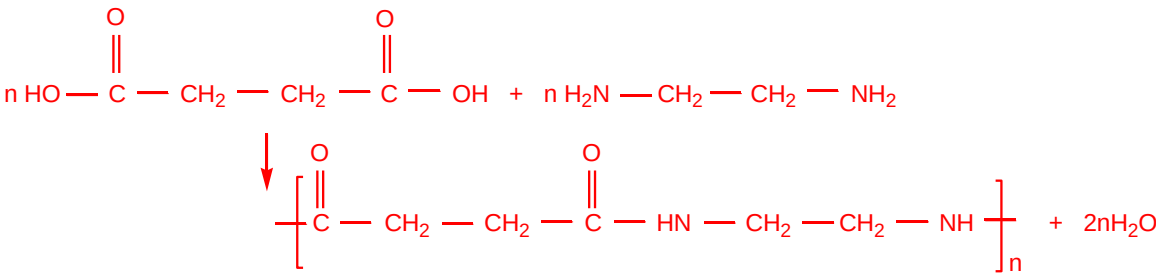
This is because the Ca^{2+} and Mg^{2+} ions present in hard water get precipitated as calcium and magnesium soap which being insoluble stick to the clothes as gummy mass.

ii. Synthetic deter gents are preferred to soaps in washing machines [2]

Answer:

This is because detergents can be used in hard water as well as in acidic solutions, as sulphuric acid and their calcium and magnesium salts are soluble in water but the fatty acids and their calcium and magnesium salts are insoluble.

OR



Question 19

Silver crystallises in face-centred cubic unit cells. Each side of the unit cell has a length of 409 pm. What is the radius of silver atom?
(Assume that each face atom is touching the four corner atoms in the unit cell.) [3]

Answer:

For fcc unit cell

$$r = \frac{a}{2\sqrt{2}}$$

Given a = 409 pm

$$\therefore\ r = \frac{409}{2\sqrt{2}} = \frac{409\sqrt{2}}{4}$$

r = 144.58 pm

Question 20

Calculate the equilibrium constant for the reaction equilibrium. [3]

$$Fe(s)Cd^{2+}(aq) \rightleftharpoons Fe^{2+}(aq) + Cd(s)$$

Given: $E^{o}_{\frac{Cd^{2+}}{Cd}} = -0.40\,V$; $E^{o}_{\frac{Fe^{2+}}{Fe}} = -0.44\,V$

Answer:

$$Fe(s) + Cd^{2+}(aq) \rightleftharpoons Fe^{2+}(aq) + Cd(s)$$

$$\log k_c = n\frac{E^{o}cell}{0.059}$$

Here, *n* = 2

$$E^{o}cell = E^{o}_{cathode} - E^{o}anode$$

$$= E^{o}_{cd^{2+}/cd} - E^{o}_{Fe^{2+}/Fe} = -0.40 - (-0.44)$$

$$E^{o}cell = 0.04V$$

$$\log k_c = \frac{2\times 0.04}{0.059} = \frac{0.08}{0.059}$$

$$\log k_c = 1.3536$$

$$k_c = \text{Antilog } 1.3536$$

$$k_c = 22.57$$

Question 21

Calculate the freezing point depression for 0·0711 m aqueous solution of sodium sulphate, if it is completely ionised in solution. If this solution actually freezes at -0·320 ^{o}C, what is the value of Van't Hoff factor for it at the freezing. Point? (K_f for water is 1·86 ^{o}C mol^{-1}) [3]

Answer:

$$\triangle T_f = [273.15 - (-0.320 + 273.15)]K = 0.320K$$

$$\triangle T_f = K_f.m$$

$= 1.86\ K\ kg\ mol^{-1} \times 0.0711\ mol\ kg^{-1}$
$= 0.132\ K$

$$i = \frac{\text{Observed value of } VT_f}{\text{Calculated value of } VT_f} = \frac{0.320K}{0.132K}$$

$i = 2 \times 42$

Question 22

Describe what is observed when [3]

i. An electric current is passed through a colloidal solution.

Answer:

Electrophoresis takes place in which colloidal particles move towards the oppositely charged electrode where they lose their charge and get coagulated.

ii. A beam of light is passed through a colloidal solution.

Answer:

The path of light becomes visible due to scattering of light by colloidal particles (Tyndall effect).

iii. An electrolyte such as NaCl, is added to hydrated ferric oxide sol

Answer:

The positively charged colloidal particles of Fe(OH)3 get coagulated by the negatively charged ions provided by electrolyte.

Question 23

Explain the following observations: [3]

i. With the same d-orbital configuration (d^4) Cr^{2+} ion is a reducing agent while Mn^{3+} ion is an oxidizing agent.

Answer:

Cr^{2+} is reducing as its configuration changes from d^4 to d^3, the latter having a half filled t_{2g} configuration. On the other hand, the change from Mn^{3+} to Mn^{2+} results in the half-filled d^5 configuration which has extra stability therefore Mn^{3+} is oxidising.

ii. Cu^+ ion is not stable in aqueous solutions.

Answer:

Because the high hydration enthalpy of Cu^{2+} easily compensates the second ionization enthalpy of Cu.

iii. Among the 3d series of transition elements, the largest number of oxidation states are exhibited by manganese.

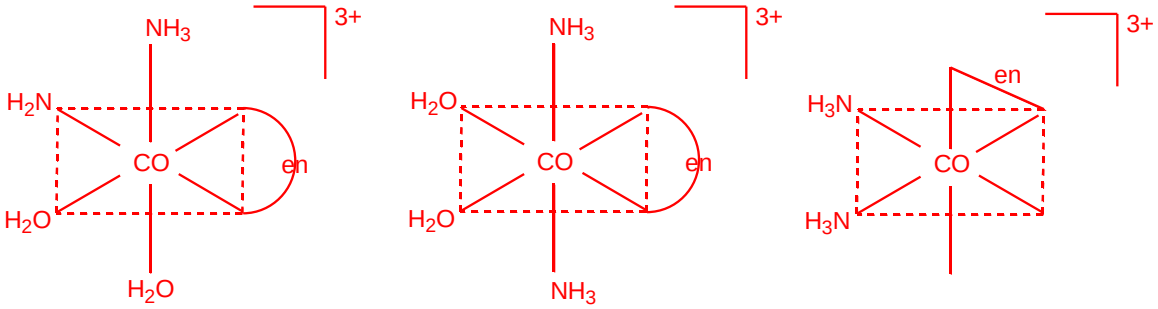
Answer:

This is because manganese has electronic configuration [Ar]3*d*54*s*2, with five unpaired electrons in 3*d* orbitals.

Question 24

Three geometrical isomers are possible for $[Co\ (en)\ (H_20)_2(NH_3)_2]^{3+}$.
Draw molecular structures of these three isomers and indicate which one of them is chiral. [3]

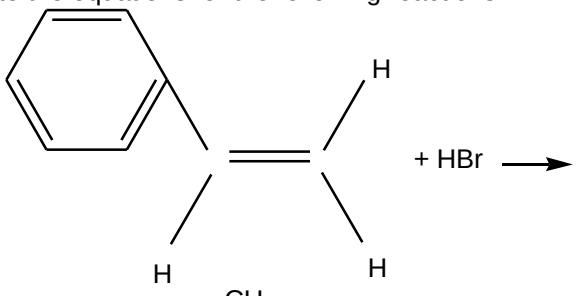
Answer:



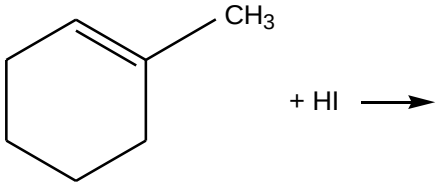
Question 25

Complete the equations for the following reactions. [3]

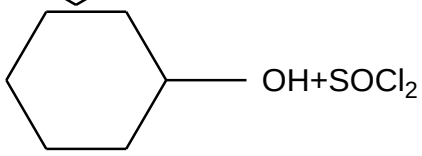
i.



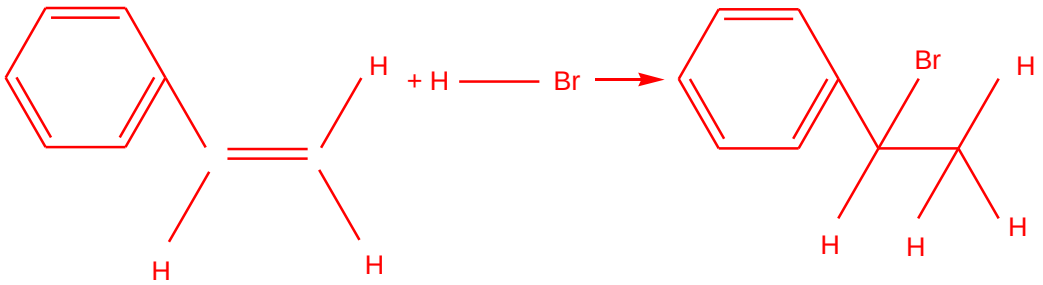
ii.



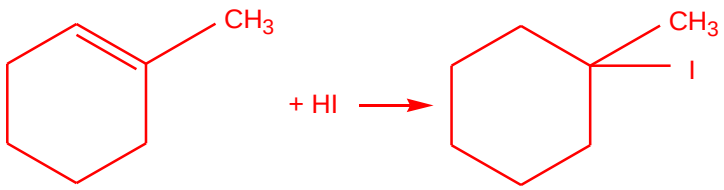
iii.



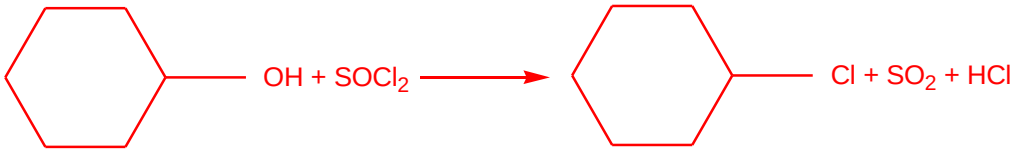
Answer:



i. 1 - Bromo - 1 - phenyl - ethane



ii. 1 - Iodo - 1 - methyl cyclohexane



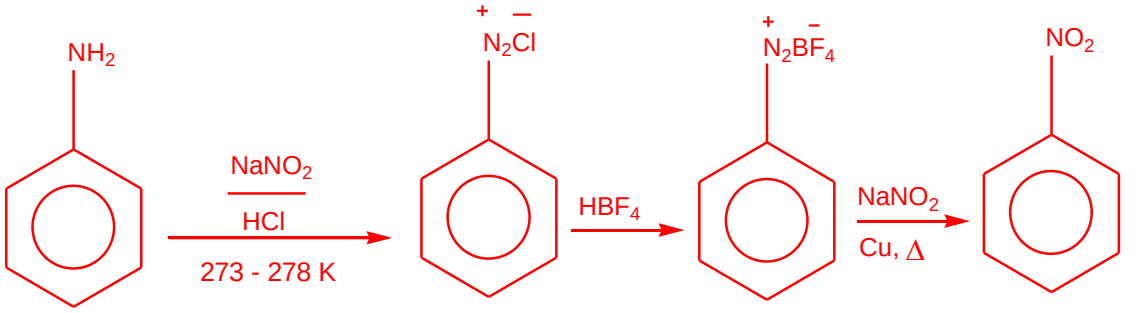
iii. Chlorocylohexane

Question 26

How are the following conversions carried out? [3]

i. Aniline to ·nitrobenzene

Answer:

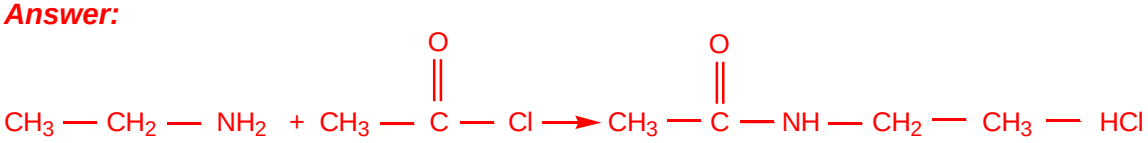


Aniline

Nitrobenzene

ii. Ethanamine to N-ethylethanamide

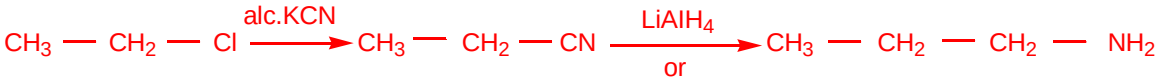
Answer:



Ethanamine Ethanoyl chloride N-Ethyl ethanamine

iii. Chloroethane to propan-1-amine

Answer:



Chloroethane Propan - 1 - amine

OR

Give one chemical test each to distinguish between the compounds in the following pairs: [3]

i. Methylamine and dimethylamine

Answer:

(*i*) Methylamine on treatment with alcoholic KOH and $CHCl_3$ gives offensive smell of methyl isocyanide but dimethyl amine does not.

$$CH_3 - NH_2 + CHCl_3 + 3KOH \xrightarrow{(alc)} CH_3 - CH_2 - NC + 3KCl + 3H_2O$$

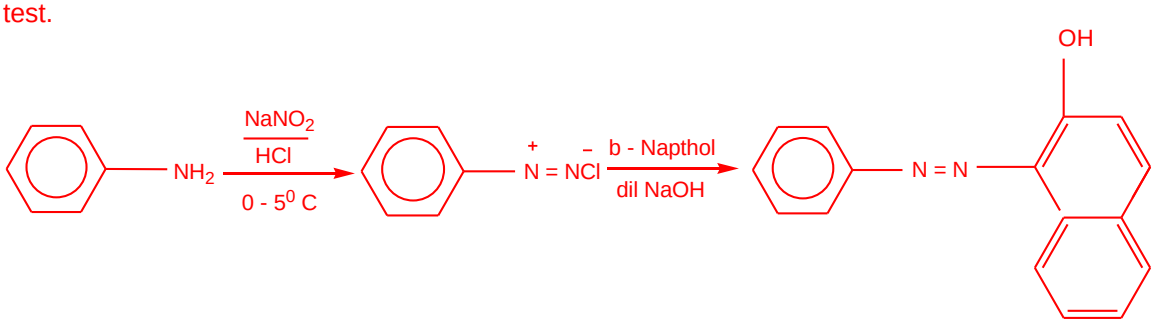
Methu 1 amine (1^oamine) — Ethyl isocyanide (offensive smell)

$$(CH_3)_2NH \xrightarrow[\Delta]{CHCl_3/KOH} \text{No reaction.}$$

ii. Aniline and benzylamine

Answer:

Aniline on treatment with $NaNO_2/HCl$ (HNO_2) at 0–5°C followed by treatment with an alkaline solution of b-naphthol gives an orange coloured azodye while benzylamine does not give this test.

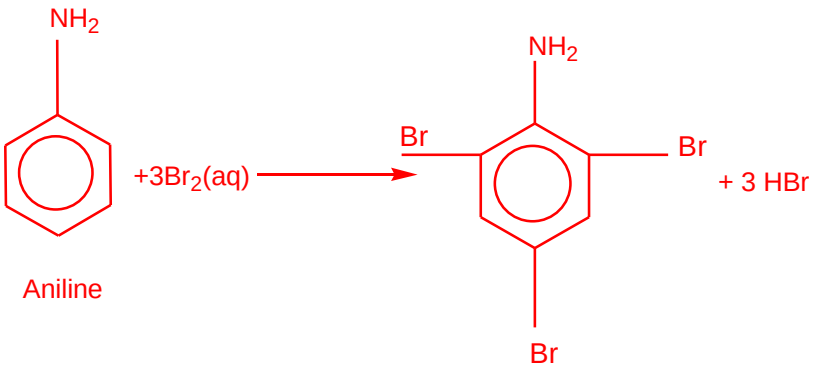


Orange dye

iii. Ethylamine and aniline

Answer:

Add $Br_2(aq)$, aniline forms white ppt while ethyl amine does not form such ppt.



Aniline

2, 4, 6 - Tribromo aniline
(white ppt)

Question 27

Differentiate between the modes of formation of an addition polymer and a condensation polymer. Give one example of each of these formations. [3]

Answer:

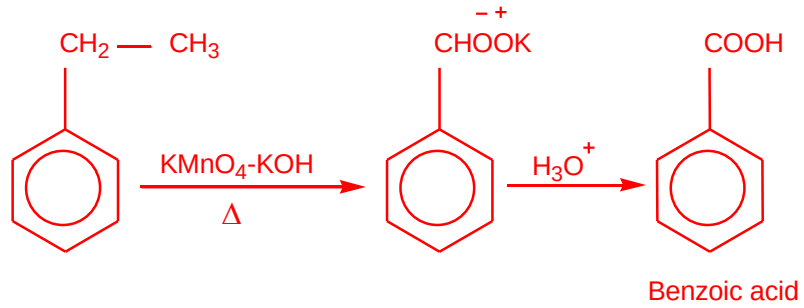
Addition Polymerisation	Condensation Polymerisation
(*i*) Monomers are unsaturated molecules	(*i*) Monomers have di or polyfunctional groups.
(*ii*) Involves chain reaction	(*ii*) Does not involve chain reaction.
(*iii*) Formed by adding monomers to a growing chain without loss of any molecules. Examples: Polyethene, Polystyrene, Teflon etc.	(*iii*) Monomers combine together with the loss of molecules like H2O, NH3, etc. Examples: Terylene, Bakelite, Nylon-66, etc.

Question 28

a. How are the followmg obtained:

i. Benzoic acid from ethylbenzene

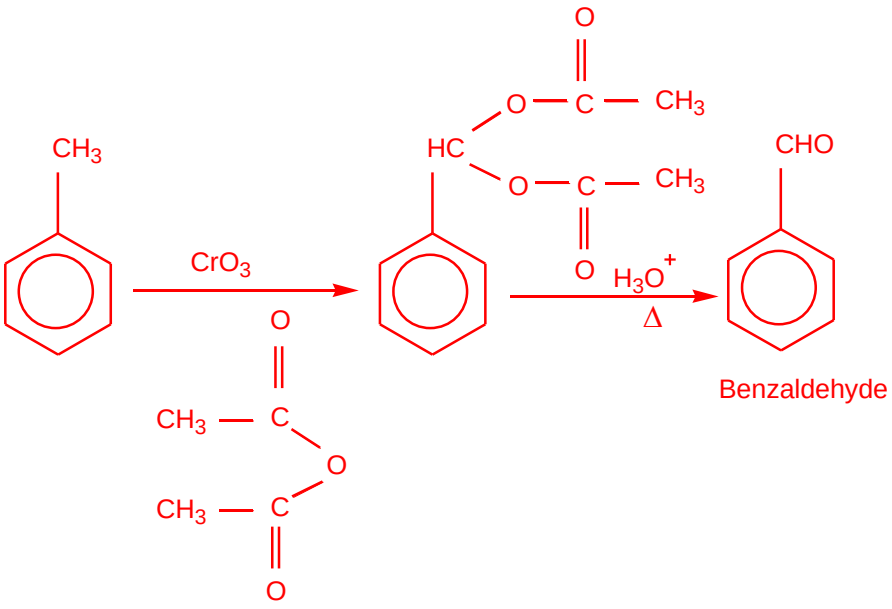
Answer:



Benzoic acid

ii. Benzaldehyde from toluene

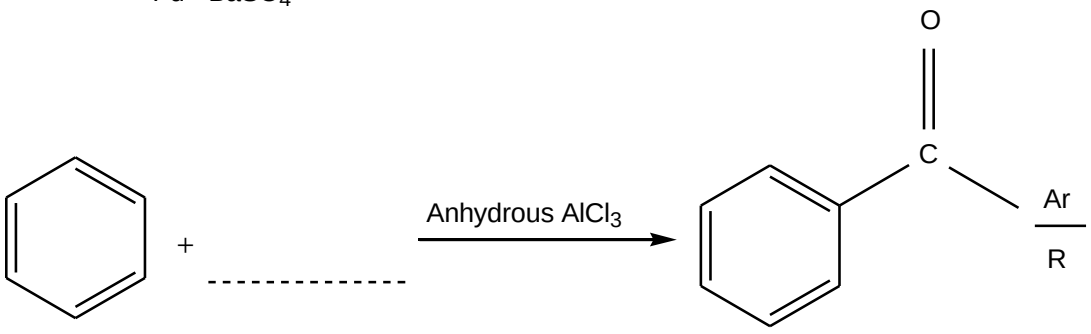
Answer:

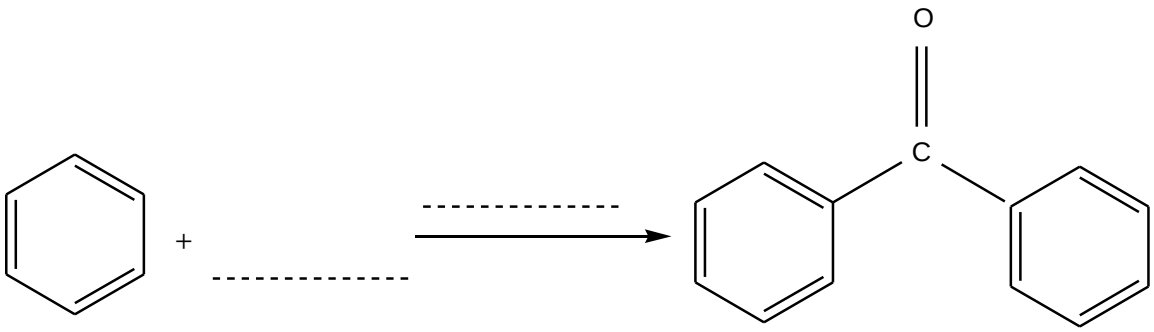


Benzaldehyde

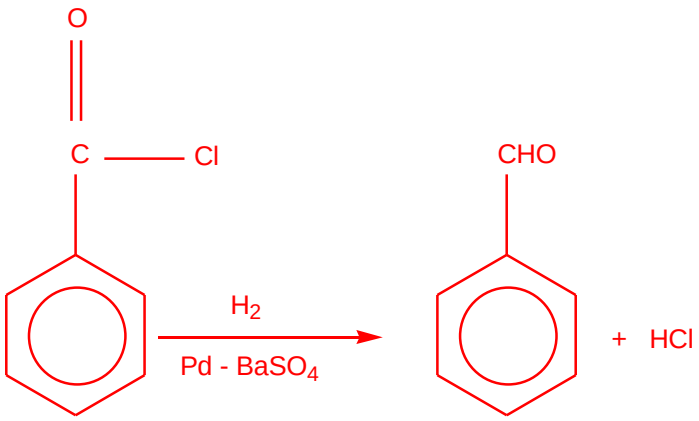
b. Complete each of the following reactions by reactant, reagent or product: [5]

i. $C_6H_5COCl \xrightarrow[Pd - BaSO_4]{H_2}$ ----------

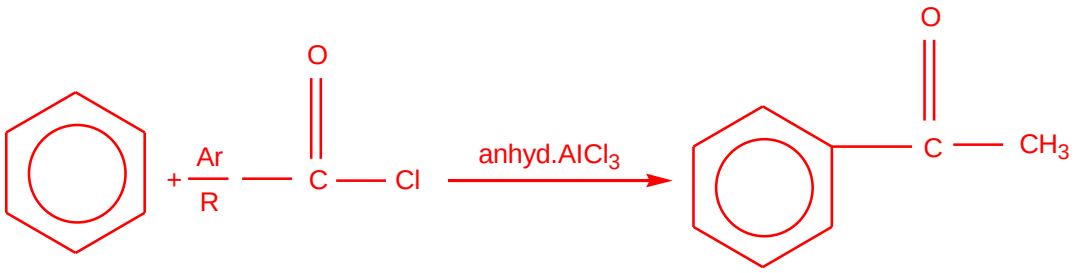
ii. 

iii. 

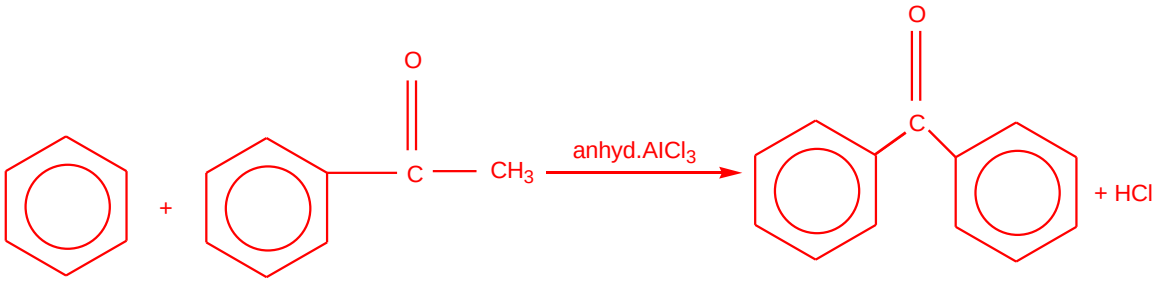
Answer:

i. 

Benzol chloride Benzaldehyde



ii. Benzene Acetyl chloride Acetophenone



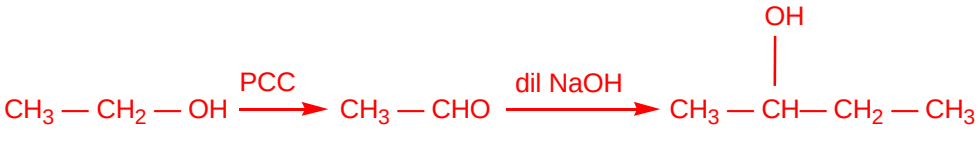
iii. Benzene Acetophenone

OR

a. How will you bring about the following conversions?

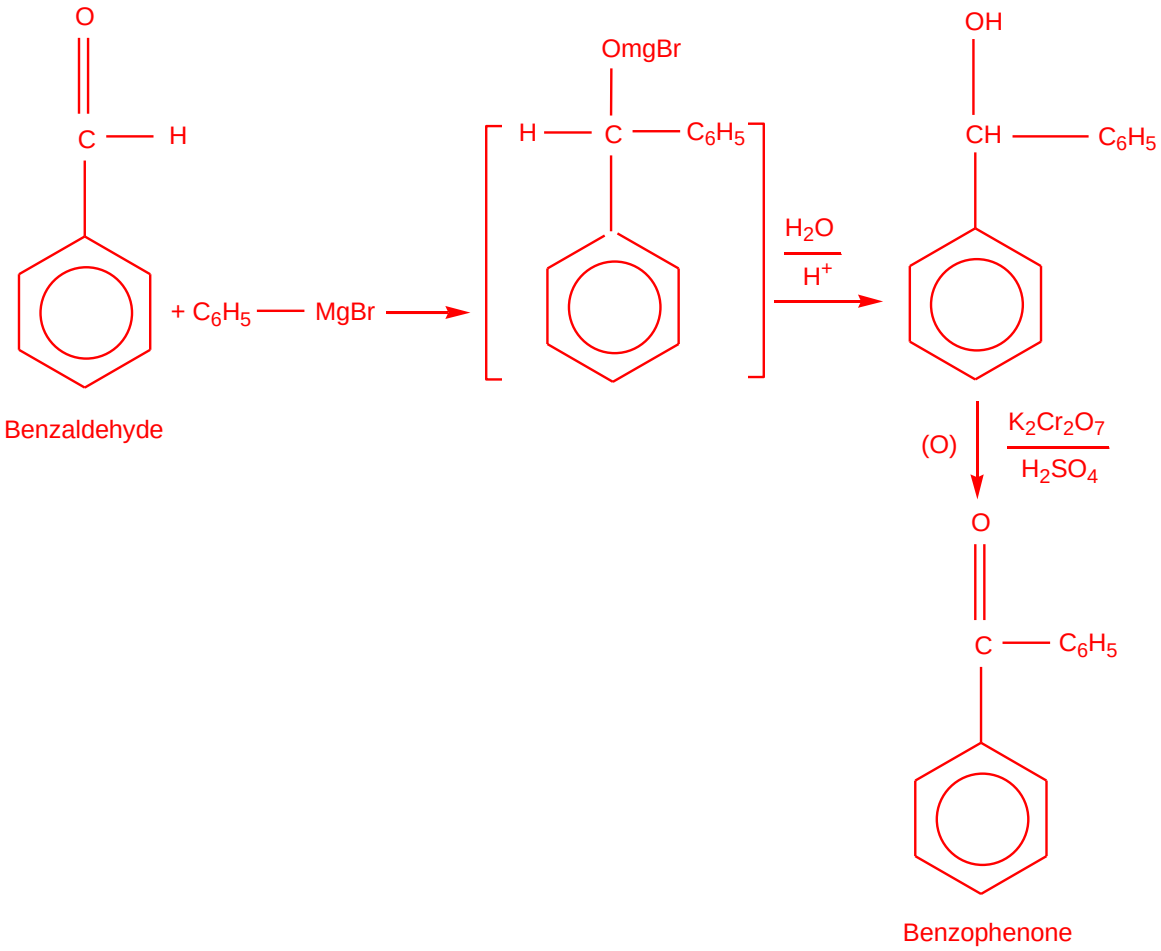
i. Ethanol to 3-hydroxybutanal

Answer:



ii. Benzaldehyde to berizophenone

Answer:



b. An organic compound A contains 69·77% carbon, 11·63% hydrogen and the rest oxygen. The molecular mass of the compound is 86. It does not react with Tollen's reagent but forms an addition compound with sodium hydrogen sulphite and gives a positive iodoform test. On vigorous -oxidation it gives a mixture of ethanoic and proppanoic acids. Derive the structure of compound A. [5]

Answer:

Element	Percentage	Atomic mass	No. of moles	Simplest molar ratio
C	69.77	12	$\frac{69.77}{12} = 5.81$	$\frac{5.81}{1.16} = 5$
H	11.63	1	$\frac{11.63}{1} = 11.63$	$\frac{11.63}{1.16} = 10$
O	(100 – 81.4) = 18.60	16	$\frac{18.60}{16} = 1.16$	$\frac{1.16}{1.16} = 1$

Empirical formula of the compound A = C5H10O
Molecular formula of the compound A = n (Empirical formula)

$$n = \frac{\text{Molecular mass of compound}}{\text{Empirical formula mass}}$$

Molecular mass of compound A = 86

Empirical formula mass of compound A = 5´12 +1´10 +1´16

= 60 + 10 + 16

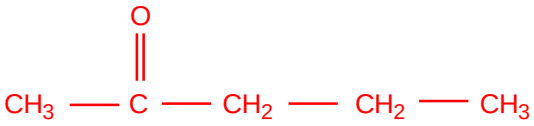
= 86

$$n = \frac{86}{86} = 1$$

Molecular formula of the compound *A* = 1($C_5H_{10}O$)

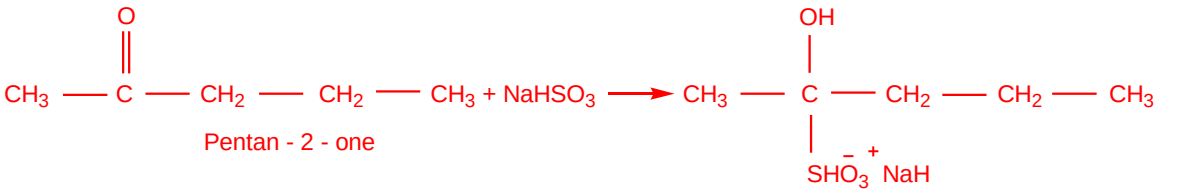
= $C_5H_{10}O$

As the compound *A* forms addition compound with $NaHSO_3$ therefore it must be either an aldehyde or ketone. As it does not reduce Tollens reagent and give positive iodoform test therefore it must be a methyl ketone. As on oxidation the compound A gives a mixture of ethanoic acid and propanoic acid, therefore compound A is



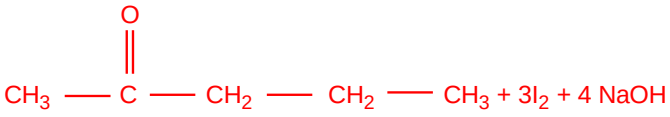
Pentan - 2 - one

The chemical reactions are:

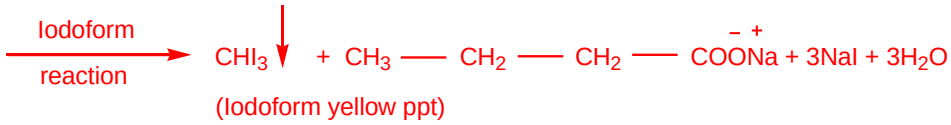


Pentan - 2 - one

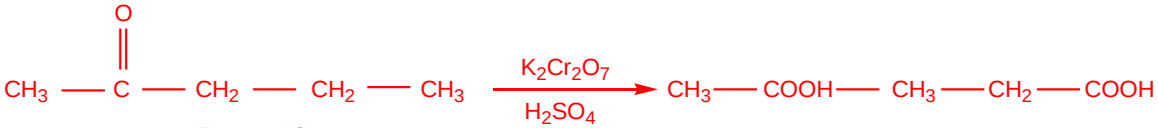
Sodium hydrogen sulphite addition product



Pentan - 2 - one



(Iodoform yellow ppt)



Pentan - 2 - one

Ethanoic acid

Propanoic acid

Question 29

a. Complete the following reaction equations:

i. $XeF_2 + PF_5 \rightarrow$

Answer:

$XeF_2 + PF_5 \rightarrow [XeF]^+ [PF_6]^-$

ii. $Cl_2(g)$ + NaOH (aq)$\rightarrow$(hot and conc.)

Answer:

$3Cl_2(g) + 6NaOH(aq) \rightarrow 5NaCl + NaClO_3 + 3H_2O$

(Hot and conc.)

b. Explain the following observations:

i. + 3 oxidation state becomes more and more stable from As to Bi in the group.

Answer:

This is due to inert pair effect.

ii. Sulphur in vapour state exhibits paramagnetism.

Answer:

In vapour state sulphur partly exists as S_2 molecule having two unpaired electrons in the anti bonding p* orbitals like O_2 and, hence exhibits paramagnetism.

iii. Fluorine does not exhibit any positive oxidation state

Answer:

This is because fluorine is the most electronegative element and does not have *d* orbitals in its valence shell.

OR

a. Complete the following reaction equations:

i. $PCl_5 + H_2O$ (excess) $\rightarrow$

Answer:

$PCl_5 + 4H_2O$ (excess) $\rightarrow H_3PO_4 + 5HCl$

ii. $F_2 + H_2O \rightarrow$

Answer:

$2F_2(g) + 2H_2O(l) \rightarrow 4H^+(aq) + 4F^-(aq) + O_2(g)$

b. Explain the following observations:

i. No distinct chemical compound of helium is known.

Answer:

This is due to small size, high ionisation enthalpy and stable electronic configuration of helium.

ii. Phosphorus has a greater tendency for catenation than nitrogen.

Answer:

This is because P–P single bond is stronger than N–N single bond.

iii. In solutions of H_2SO_4 in water, the second dissociation constant K_{a_2}, is lessthan the first dissociation constant K_{a_1}. [5]

Answer:

$Ka_2 << Ka_1$, because HSO^-_4 ion has much less tendency to donate a proton to H_2O as compared to H_2SO_4.

Question 30

a. A reaction is of second order with respect to a reactant. How is the rate of reaction affected if the concentration of this reactant is

i. Double,

Answer:

Let the rate law be, $r_1 = k\,[A]^2$

If $[A]$ is doubled than rate $r_2 = k(2A)^2 = 4k\,[A]^2 = 4r_1$, *i.e.*, rate becomes 4 times.

ii. Reduced to half

Answer:

If $[A]$ is reduced to half then rate, $r_3 = k = [\frac{A}{2}]^2 = \frac{1}{4}k\,[A]^2 = \frac{1}{4}r_1$, i.e., rate becomes $\frac{1}{4}$ times

b. A first order reaction has a rate constant of 0·0051. min^{-1}. If we begin with 0·10 M concentration of the reactant, what will be the concentration of the reactant left after 3 hours?

Answer:

For a first order reaction

$$t = \frac{2.303}{k}\log\frac{[R]_o}{[R]}$$

Here, t = 3 h = 3 × 60 min = 180 min

$k = 0.0051 min^{-1}$, $[R]_o = 0.10$ M, [R] = ?

$$180\text{ min} = \frac{2.303}{0.0051 min^{-1}}\log\frac{0.10}{[R]}$$

$$\text{Log}\frac{0.1}{[R]} = \frac{180\text{ min}\times 0.0051\text{ min}^{-1}}{2.303} = \frac{918}{2303}$$

$$\text{Log}\frac{0.1}{[R]} = 0.3986$$

$$\frac{0.1}{[R]} = \text{Anti log } (0.3986) = 2.503$$

$$[R] = \frac{0.1}{2.503} = 0.03995M$$

[R] = 0.04M

OR

a. Define the following:
   i. Rate of a reaction

Answer:
Elementary step: Each step of a complex reaction is called an elementary step.

   ii. Elementary step in a reaction

Answer:
Rate of reaction: It is the change in the concentration of any of the reactants or productsper unit time.

b. For a decomposition reaction, the values of rate constant k at two different temperatures are given below:
   i. $k_1 = 2.15x10^{-8}\ L\ mol^{-1}\ s^{-1}$ at 650K
   ii. $k_2 = 2.39x10^{-7}\ L\ mol^{-1}\ s^{-1}$ at 700K

   Calculate the value of activation energy (E_a) for this reaction. (R = 8.314 J $K^{-1}\ mol^{-1}$)

Answer:

$$\log\frac{k_2}{k_1} = \frac{E_a}{2303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$$

$$E_a = \frac{2.303 \times R \times T_1 \times T_2}{T_2 - T_1}\log\frac{k_2}{k_1}$$

$$E_a = \frac{2.303 \times 8.314 J\ mol^{-1}k^{-1} \times 650k \times 700k}{T_2 - T_1}\log\frac{2.39 \times 10^{-7}}{2.15 \times 10^{-8}}$$

$$E_a = \frac{19.147 \times 650 \times 700}{50}\log(23.9 - \log 2.15)\ J\,mol^{-1}$$

E_a = 174237.7(1.3783 – 0.3324) J mol-1

$E_a = 174237.7 \acute{}\ 1.0459\ J\ mol^{-1} = 182235.2\ J\ mol^{-1}$

$E_a = 182.24\ kJ\ mol^{-1}$.