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**2011**

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Question: 1 – 30

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**Question: 1**

[1]

Define 'order of a reaction'

**Answer:**

The sum of powers of the concentration terms of the reactants in the rate law expression is called the order of that chemical reaction.

**Question: 2**

[1]

What is meant by 'shape selective catalysis'?

**Answer:**

The catalytic reaction in which the pore structure of the catalyst and the size of the reactant and product molecules are comparable.

**Question: 3**

[1]

Differentiate between a mineral and an ore.

**Answer:**

The naturally occurring chemical substances which occur in the earth's crust and are obtainable by mining are called minerals, while the minerals from which the element is extracted economically is called an ore.

**Question: 4**

[1]

What is meant by 'lanthanide contraction'?

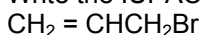
**Answer:**

The regular decrease in the atomic and ionic radii of Lanthanides with increasing atomic number is known as Lanthanide contraction.

**Question: 5**

[1]

Write the IUPAC name of the following compound:



**Answer:**

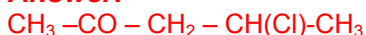
3-Bromoprop-1-ene / 3-Bromopropene

**Question: 6**

[1]

Draw the structure of 4-chloropentan-2-one.

**Answer:**



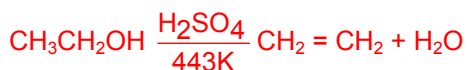
**Question: 7**

[1]

How would you convert ethanol to ethane?



**Answer:**



**Question: 8**

[1]

Rearrange the following in an increasing order of their basic strengths:  
 $\text{C}_6\text{H}_5\text{NH}_2$ ,  $\text{C}_6\text{H}_5\text{N}(\text{CH}_3)_2$ ,  $(\text{C}_6\text{H}_5)_2\text{NH}$  and  $\text{CH}_3\text{NH}_2$ .

**Answer:**



**Question: 9**

[2]

Explain how you can determine the atomic mass of an unknown metal if you know its mass density and dimensions of unit cell of its crystal.

**Answer:**

We can determine the atomic mass of an unknown by using the formula

$$M = \frac{d \times a^3 \times N_A}{Z}$$

By knowing  $d$ ,  $a$ ,  $N_A$  and  $Z$ , we can calculate the  $M$  where,

$d$ : density,

$N_A$ : Avogadro number

$a$ : cell edge or edge length

$Z$ : no. of atoms present in one unit cell

**Question: 10**

[2]

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

**Answer:**

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

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

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

**Question: 11**

[2]

State the following:

- i. Raoult's law in its general form in reference to solutions.

**Answer:**

Raoult's law states that for a solution of volatile liquids, the partial vapor pressure of each component in the solution is directly proportional to its mole fraction.



- ii. Henry's law about partial pressure of a gas in a mixture.

**Answer:**

Henry's law states that at a constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution.

**Question: 12**

[2]

What do you understand by the rate law and rate constant of a reaction? Identify the order of a reaction if the units of its rate constant are:

- i.  $\text{L}^{-1} \text{mol s}^{-1}$

**Answer:**

See topics on 'Rate law'

Zero order

- ii.  $\text{L mol}^{-1} \text{s}^{-1}$

**Answer:**

Second order

**Question: 13**

[2]

The thermal decomposition of  $\text{HCO}_2\text{H}$  is a first order reaction with a rate constant of  $2.4 \times 10^{-3} \text{ s}^{-1}$  at a certain temperature. Calculate how long will it take for three-fourths of initial quantity of  $\text{HCO}_2\text{H}$  to decompose. ( $\log 0.25 = -0.6021$ )

**Answer:**

$$t = \frac{2.303}{k} \times \log \frac{[A]_0}{[A]}$$

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

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

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

$$t = 578 \text{ s}$$

**Question: 14**

[2]

Describe the principle controlling each of the following processes:

- i. Vapor phase refining of titanium metal

**Answer:**

In this method the titanium metal is heated with  $\text{I}_2$  to form a volatile compound  $\text{TiI}_4$  which on further heating at higher temperature decomposes to give pure titanium metal.

- ii. Froth floatation method of concentration of a sulphide ore.



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**Answer:**

This method is based upon the fact that the surface of the sulphide ores is preferentially wetted by oil while that of gangue is wetted by water.

**Question: 15**

[2]

How would you account for the following:

- i.  $\text{Cr}^{2+}$  is reducing in nature while with the same d-orbital configuration ( $d^4$ )  $\text{Mn}^{3+}$  is an oxidizing agent.

**Answer:**

$\text{Cr}^{2+}$  is reducing as its configuration changes from  $d^4$  to  $d^3$ , the latter having half-filled  $t_{2g}$  level whereas  $\text{Mn}^{3+}$  to  $\text{Mn}^{2+}$  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]

Complete the following chemical equations:

- i.  $\text{MnO}_4^-(\text{aq}) + \text{S}_2\text{O}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow$

**Answer:**

- ii.  $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{Fe}^{2+}(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow$

**Answer:**

OR

State reasons for the following:

- i.  $\text{Cu}(\text{I})$  ion is not stable in an aqueous solution.

**Answer:**

Because copper (I) ion is unstable in aqueous solution and undergoes disproportion.

- ii. Unlike  $\text{Cr}^{3+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Fe}^{3+}$  and the subsequent other  $\text{M}^{2+}$  ions of the 3d series of elements, the 4d and the 5d series metals generally do not form stable cationic species.

**Answer:**

Due to lanthanide contraction the expected increase in size does not occur.



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**Question: 17**

[2]

Explain what is meant by the following:

- i. Peptide linkage

**Answer:**

See topics on 'Peptides'

- ii. Pyranose structure of glucose

**Answer:**

The term pyranose is term used for carbohydrates with name being derived from pyran. Its chemical structure includes that of a six membered ring with 5 carbon atom and one oxygen atom. Pyranose does not have double bonds.

**Question: 18**

[2]

Write the main structural difference between DNA and RNA. Of the four bases, name those which are common to both DNA and RNA.

**Answer:**

In DNA, sugar is Deoxyribose while in RNA, it is ribose. DNA is a double stranded while RNA is single stranded. The common bases present in both are adenine, cytosine and guanine.

**Question: 19**

[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°C. assuming that the gene fragment is a non-electrolyte, calculate its molar mass

**Answer:**

$$\pi = CRT$$

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

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

$$M_2 = 14193.3 \text{ g mol}^{-1} \text{ or } 1.42 \times 10^4 \text{ g mol}^{-1}$$

**Question: 20**

[3]

Classify colloids where the dispersion medium is water. State their characteristics and write an example of each of these classes.

**Answer:**

See topics on 'Colloids'

OR

Explain what is observed when

- i. An electric current is passed through a sol



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**Answer:**

Electrophoresis takes place when sol particles move towards opposite electrodes due to attraction.

- ii. A beam of light is passed through a sol

**Answer:**

Tyndall effect will be observed due to scattering of light by colloidal particles.

- iii. An electrolyte (say NaCl) is added to ferric hydroxide sol

**Answer:**

Coagulation takes place due to neutralization of charges.

**Question: 21**

[3]

How would you account for the following:

- i.  $\text{H}_2\text{S}$  is more acidic than  $\text{H}_2\text{O}$ .

**Answer:**

Because bond dissociation enthalpy of H-S bond is lower than that of H-O bond

- ii. The N-O bond in  $\text{NO}_2^-$  is shorter than the N-O bond in  $\text{NO}_3^-$

**Answer:**

In the resonance structure of these two species in  $\text{NO}_2^-$ , 2 bonds are sharing a double bond while in  $\text{NO}_3^-$ , 3 bonds are sharing a double bond which means that bond in  $\text{NO}_2^-$  will be shorter than in  $\text{NO}_3^-$

- iii. Both  $\text{O}_2$  and  $\text{F}_2$  stabilize high oxidation states but the ability of oxygen to stabilize the higher oxidation state exceeds that of fluorine.

**Answer:**

In  $\text{NO}_2^-$  bond order is 1.5 while in  $\text{NO}_3^-$ , bond order is 1.33. Because of the tendency of oxygen to form multiple bonds with metal.

**Question: 22**

[3]

Explain the following terms giving a suitable example in each case:

- i. Ambident ligand

**Answer:**

It is a colloidal dispersion of a liquid in a gas. Example: fog.

- ii. Denticity of a ligand

**Answer:**

It is a colloidal solution of a solid in water as the dispersion medium. Example starch solution.

- iii. Crystal field splitting in an octahedral field



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**Answer:**

The splitting of d-orbitals under the influence of approaching ligand is known as crystal field splitting for example for  $d^4$ , configuration is  $t_{2g}^3 e_g^1$

**Question: 23**

[3]

Rearrange the compounds of each of the following sets in order of reactivity towards  $S_N2$  displacement:

- i. 2-Bromo-2-methylbutane, 1-Bromopentane, 2-Bromopentane

**Answer:**

1-Bromopentane > 2-Bromopentane > 2-Bromo-2-methylbutane

- ii. 1-Bromo-3-methylbutane, 2-Bromo-2-methylbutane, 3-Bromo-2-methylbutane

**Answer:**

1-Bromo-3-methylbutane > 3-Bromo-2-methylbutane > 2-Bromo-2-methylbutane

- iii. 1-Bromobutane, 1-Bromo-2,2-dimethylpropane, 1-Bromo-2-methylbutane

**Answer:**

1-Bromobutane > 1-Bromo-2-methylbutane > 1-Bromo-2,2-dimethylpropane

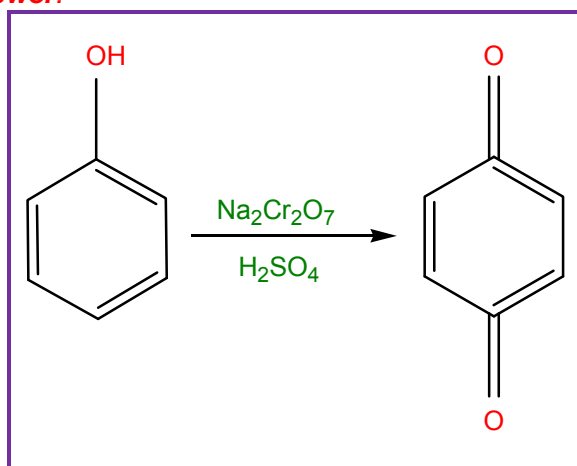
**Question: 24**

[3]

How would you obtain the following:

- i. Benzoquinone from phenol

**Answer:**

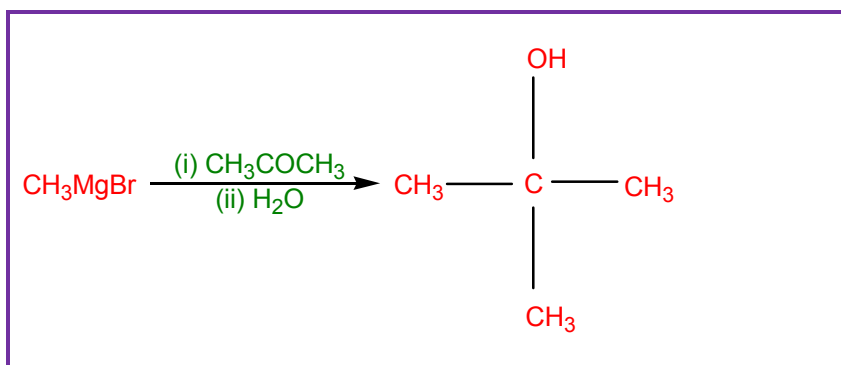


- ii. 2-Methylpropan-2-ol from methylmagnesium bromide



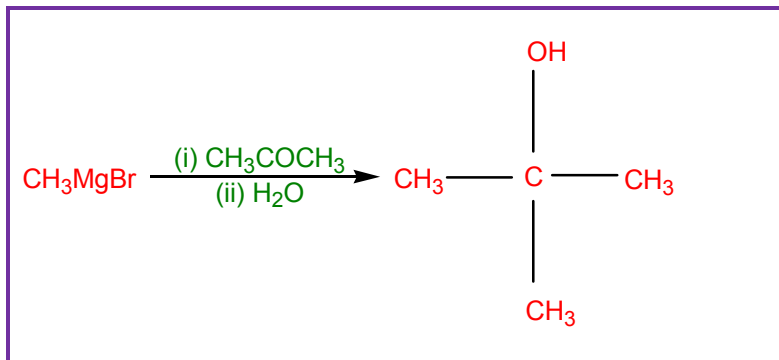


**Answer:**



iii. Propan-2-ol from propene

**Answer:**



**Question: 25**

[3]

State reasons for the following:

i.  $\text{pK}_b$  value for aniline is more than that for methylamine.

**Answer:**

Due to resonance in aniline, N acquires positive charge, which increases its  $\text{pK}_b$  whereas due to electron donating methyl group electron density increases on N which decreases its  $\text{pK}_b$ .

ii. Ethylamine is soluble in water whereas aniline is not soluble in water.

**Answer:**

Due to formation of hydrogen bond with water ethyl amine is soluble in water whereas due to bulky phenyl group aniline does not form H-bond and thus is insoluble.

iii. Primary amines have higher boiling points than tertiary amines.

**Answer:**

Due to hydrogen bonding in primary amines, they have higher boiling points whereas there is no hydrogen bonding in tertiary amines.



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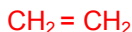
**Question: 26**

[3]

Draw the structures of the monomers of the following polymers:

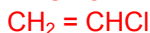
i. Polythene

**Answer:**



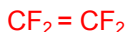
ii. PVC

**Answer:**



iii. Teflon

**Answer:**

**Question: 27**

[3]

What are the following substances? Give one example of each.

i. Food preservatives

**Answer:**

They are the compounds which prevent spoilage of food due to microbial growth e.g. sodium benzoate, vinegar

ii. Synthetic detergents

**Answer:**

They are sodium salts of long chain alkyl sulphonates or benzene sulphonates e.g. Sodium lauryl sulphate.

iii. Antacids

**Answer:**

They are the drugs used to prevent the overproduction of acid in the stomach e.g. Sodium hydrogencarbonate.

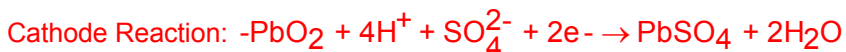
**Question: 28**

[3]

a. What type of a battery is lead storage battery? Write the anode and cathode reactions and the overall cell reaction occurring in the operation of a lead storage battery.

**Answer:**

It is secondary cell



- b. Calculate the potential for half-cell containing 0.10 M  $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ , 0.20 M  $\text{Cr}^{3+}(\text{aq})$  and  $1.0 \times 10^{-4}$  M  $\text{H}^+(\text{aq})$ . the half-cell reaction is  $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$  and the standard electrode potential is given as  $E^\circ = 1.33 \text{ V}$

**Answer:**

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0591}{n} \log \frac{[\text{Cr}^{3+}]^2}{[\text{Cr}_2\text{O}_7^{2-}][\text{H}^+]^{14}}$$

$$E_{\text{cell}} = 1.33 \text{ V} - \frac{0.0591}{6} \log \frac{(0.20)^2}{(0.10)(10^{-4})^{14}}$$

$$= 1.33 \text{ V} - 0.55 \text{ V}$$

$$= 0.78 \text{ V}$$

OR

- a. How many moles of mercury will be produced by electrolyzing 1.0 M  $\text{Hg}(\text{NO}_3)_2$  solution with a current of 2.00 A for 3 hours? [ $\text{Hg}(\text{NO}_3)_2 = 200.6 \text{ g mol}^{-1}$ ]

**Answer:**

$$m = ZIt$$

$$m = \frac{M \times I \times t}{nF}$$

$$m = \frac{M}{2 \times 96500 \text{ C mol}^{-1}} \times 2\text{A} \times 3 \times 60 \times 60\text{s}$$

$$m = 0.112 \text{ mol} \times M$$

$$\text{No. of moles of mercury} = \frac{0.112 \text{ mol} \times M}{M}$$

- b. A voltaic cell is set up at  $25^\circ\text{C}$  with the following half cells:  $\text{Al}^{3+}$  (0.001 M) and  $\text{Ni}^{2+}$  (0.50 M)  
Write an equation for the reaction that occurs when the cell generates an electric current and determine the cell potential.

(Given :  $E^\circ_{\text{Ni}^{2+}/\text{Ni}} = -0.25\text{V}$ ,  $E^\circ_{\text{Al}^{3+}/\text{Al}} = -1.66\text{V}$ )

**Answer:**



$$E_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

$$= [0.25 \text{ V} - (-1.66 \text{ V})] = 1.41 \text{ V}$$

$$E^\circ_{\text{Cell}} = 1.41 \text{ V}$$

Nernst equation:



$n = 6$  electrons

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.059}{n} \log \frac{[\text{Al}^{3+}]^2}{[\text{Ni}^{2+}]^3}$$



$$E_{\text{cell}} = 1.41 \text{ V} - \frac{0.059}{6} \log \frac{(0.001\text{M})^2}{(0.50\text{M})^3}$$

$$= 1.41 \text{ V} + 0.050 \text{ V} = 1.46 \text{ V}$$

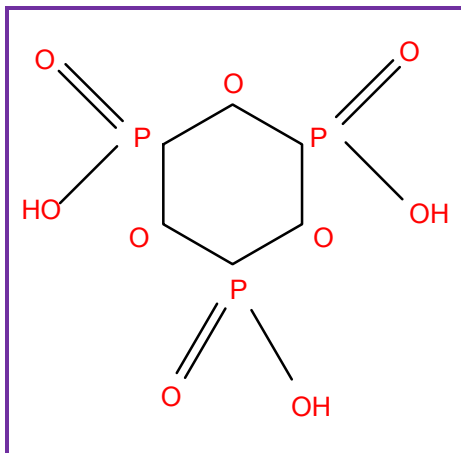
**Question: 29**

[3]

a. Draw the structures of the following molecules:

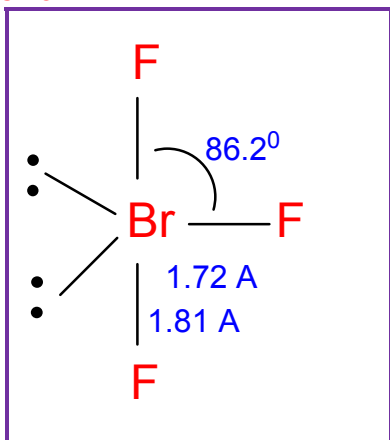
i.  $(\text{HPO}_3)_3$

**Answer:**



ii.  $\text{BrF}_3$

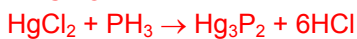
**Answer:**



b. Complete the following chemical equations:

i.  $\text{HgCl}_2 + \text{PH}_3 \rightarrow$

**Answer:**

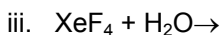


ii.  $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow$



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**Answer:**



**Answer:**



OR

a. What happens when

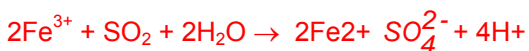
i. Chlorine gas is passed through a hot concentrated solution of NaOH?

**Answer:**



ii. Sulphur dioxide gas is passed through an aqueous solution of a Fe (III) salt?

**Answer:**



b. Answer the following:

i. What is the basicity of  $\text{H}_3\text{PO}_3$  and why?

**Answer:**

Two, due to presence of two P-OH bonds.

ii. Why does fluorine not play the role of a central atom in interhalogen compounds?

**Answer:**

Due to high electronegativity of fluorine.

iii. Why do noble gases have very low boiling points?

**Answer:**

There are no interatomic forces except weak dispersion forces.

**Question: 30**

[5]

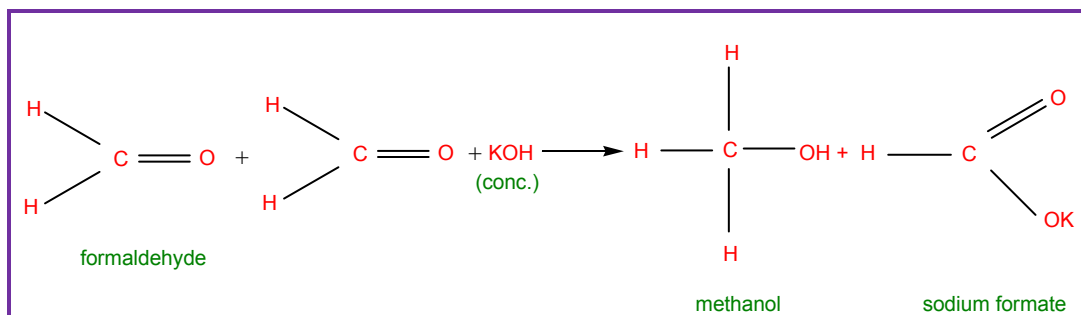
a. Illustrate the following name reactions by giving example:

i. Cannizzaro's reaction

**Answer:**

Aldehydes which do not have an  $\alpha$ -hydrogen atom, undergo self oxidation and reduction reaction on treatment with concentrated alkali.

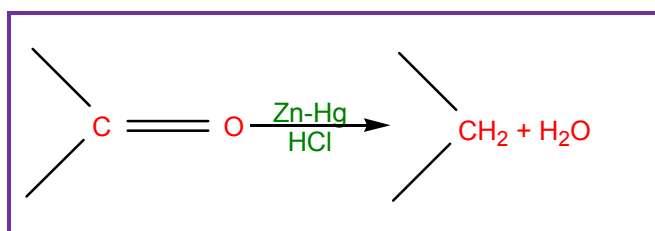




ii. Clemmensen reduction

**Answer:**

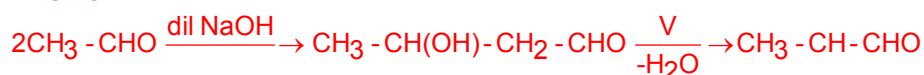
The carbonyl group of aldehydes and ketones is reduced to CH<sub>2</sub> group on treatment with zinc and amalgam and concentrated HCl.



b. How would you obtain the following:

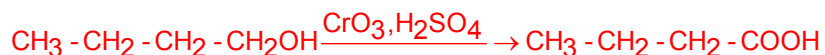
i. But-2-enal from ethanol

**Answer:**



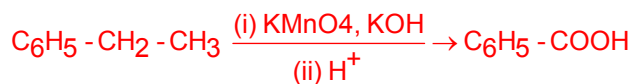
ii. Butanoic acid from butanol

**Answer:**



iii. Benzoic acid from ethyl benzene

**Answer:**



OR

a. Give chemical tests to distinguish between the following:

i. Benzoic acid from ethyl benzene



**Answer:**

Sodium bicarbonate test. Warm each compound with  $\text{NaHCO}_3$ , Benzoic acid gives brisk effervescence of  $\text{CO}_2$  gas whereas ethyl benzoate does not respond to this test.

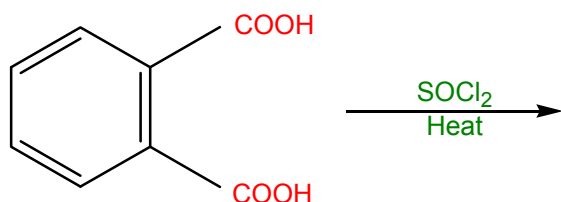
ii. Benzaldehyde from acetophenone.

**Answer:**

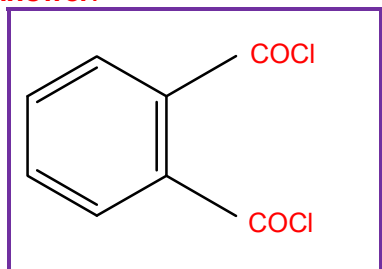
Iodoform test: Warm each organic compound with  $\text{I}_2$  and  $\text{NaOH}$  solution with Acetophenone ( $\text{C}_6\text{H}_5\text{COCH}_3$ ) yellow precipitates of iodoform is formed while Benzaldehyde does not respond to this test.

b. Complete each synthesis by giving the missing material, reagent or products:

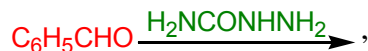
i.



**Answer:**



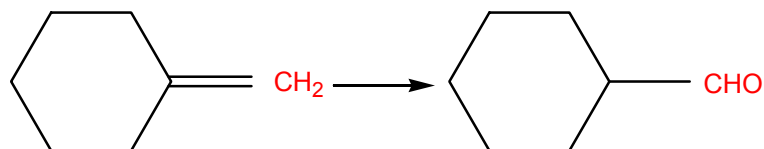
ii.



**Answer:**



iii.



**Answer:**

