JEE Main 2020 Paper

Date: 9th January 2020

Time: 02:30 PM – 05:30 PM

Subject: Chemistry

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1. 5 g of Zinc is treated separately with an excess of

I. dilute hydrochloric acid and

II. aqueous sodium hydroxide.

The ratio of the volumes of H_2 evolved in these two reactions is:

a. 2:1 b. 1:2

c. 1:1 d. 1:4

Answer: c

Solution:

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

So, the ratio of volume of H_2 released in both the cases is 1:1.

2. The solubility product of $Cr(OH)_3$ at 298 K is 6×10^{-31}. The concentration of hydroxide ions in a saturated solution $Cr(OH)_3$ will be :

a. $(18 \times 10^{-31})^{1/4}$ b. $(18 \times 10^{-31})^{1/2}$

c. $(2.22 \times 10^{-31})^{1/4}$ d. $(4.86 \times 10^{-29})^{1/4}$

Answer: a

Solution:

$Cr(OH)_{3(s)} \rightarrow Cr^{3+}_{(aq.)} + 3OH^-_{(aq.)}$

1-S S 3S

$K_{sp} = 27S^4$

$6\times10^{-31} = 27S^4$

$S = \left[\frac{6}{27}\times10^{-31}\right]^{1/4}$

$[OH^-] = 3S = 3\times\left[\frac{6}{27}\times10^{-31}\right]^{1/4} = (18\times10^{-31})^{1/4}M$

3. Among the statements (a)-(d), the correct ones are :
   a) Lithium has the highest hydration enthalpy among the alkali metals.
   b) Lithium chloride is insoluble in pyridine.
   c) Lithium cannot form ethynide upon its reaction with ethyne.
   d) Both lithium and magnesium react slowly with H_2O.

a. (a), (b) and (d) only
b. (b) and (c) only
c. (a), (c) and (d) only
d. (a) and (d) only

Answer: a

Solution:
Only LiCl amongst the first group chlorides dissolve in pyridine because the solvation energy of lithium is higher than the other salts of the same group.
Lithium does not react with ethyne to form ethynilide due to its small size and high polarizability.
Lithium and Magnesium both have very small sizes and very high ionization potentials so, they react slowly with water.
Amongst all the alkali metals, Li has the smallest size hence, the hydration energy for Li is maximum.

4. The first and second ionization enthalpies of a metal are 496 and 4560 kJ mol^{-1} respectively. How many moles of HCl and H_2SO_4 , respectively, will be needed to react completely with 1 mole of metal hydroxide?

a. 1 and 2
b. 1 and 0.5
c. 1 and 1
d. 2 and 0.5

Answer: b

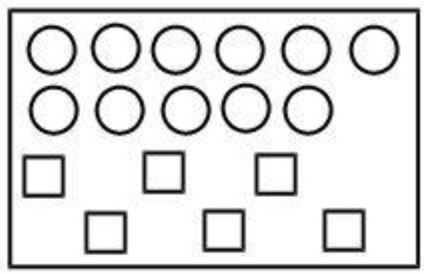
Solution:
The given data for ionization energies clearly shows that $IE_2 \gg IE_1$. So, the element belongs to the first group. Therefore, we can say that this element will be monovalent and hence forms a monoacidic base of the type MOH.

$$MOH + HCl \rightarrow MCl + H_2O$$

$$2MOH + H_2SO_4 \rightarrow M_2SO_4 + 2H_2O$$

So, from the above equation we can say that,
1 mole of metal hydroxide requires 1 mole of HCl and 0.5 mole of H_2SO_4.

5. In the figure shown below reactant A (represented by the square) is in equilibrium with product B (represented by circle). The equilibrium constant is:



a. 1
b. 2
c. 8
d. 4

Answer: b

Solution:
Let us assume the equation to be A ⇌ B,
Number of particles of A = 6
Number of particles of B = 11
K= $\frac{11}{6} \approx 2$

6. The correct order spin-only magnetic moments of the following complexes is :
I. $[Cr(H_2O)_6]Br_2$
II. $Na_4[FeCN_6]$
III. $Na_3[Fe(C_2O_4)_3]$ (Δ_0 > P)
IV. $(Et_4N)_2[CoCl_4]$

a. (III)>(I)>(II)>(IV)
b. (III)>(I)>(IV)>(II)
c. (I)>(IV)>(III)>(II)
d. (II)≊(I)>(IV)>(III)

Answer: c

Solution:

Complex (I) has the central metal ion as Fe^{2+} with strong field ligands.
Configuration of Fe^{2+}= [Ar] $3d^6$
Strong field ligands will pair up all the electrons and hence the magnetic moment will be zero.

Complex (II) has the central metal ion as $Cr^{2+}$with weak field ligands.
Configuration of Cr^{2+}= [Ar] $3d^4$
As weak field ligands are present, pairing does not take place. There will be 4 unpaired electrons and hence the magnetic moment = $\sqrt{24}$ B.M.

Complex (III) has the central metal ion as Co^{2+} with weak field ligands.
Configuration of Co^{2+}= [Ar] $3d^7$
As weak field ligands are present no pairing can occur. There will be 3 unpaired electrons and hence the magnetic moment = $\sqrt{15}$ B.M.

Complex (IV) has the central metal ion as Fe^{3+} with strong field ligands.
Configuration of Fe^{3+} =[Ar] $3d^5$
Strong field ligands will pair up the electrons but as we have a [Ar] $3d^5$ configuration, one electron will remain unpaired and hence the magnetic moment will be $\sqrt{3}$ B.M.

7. The true statement amongst the following
   a. S is a function of temperature but ΔS is not a function of temperature.
   b. Both ΔS and S are functions of temperature.
   c. Both S and ΔS are not functions of temperature.
   d. S is not a function of temperature but ΔS is a function of temperature.

Answer: b

Solution:
Entropy is a function of temperature, at any temperature, the entropy can be given as:
$$S_T = \int_0^T \frac{nCdT}{T}$$

Change in entropy is also a function of temperature, at any temperature, the entropy change can be given as:
$$\Delta S = \int \frac{dq}{T}$$

8. The reaction of $H_3N_3B_3Cl_3$ (A) with $LiBH_4$ in tetrahydrofuran gives inorganic benzene (B). Furthur, the reaction of (A) with (C) leads to $H_3N_3B_3(Me)_3$. Compounds (B) and (C) respectively, are:
   a. Boron nitride, MeBr
   b. Diborane, MeMgBr
   c. Borazine, MeBr
   d. Borazine, MeMgBr

Answer: d

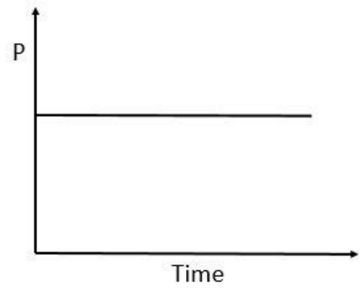
Solution:
$$B_3N_3H_3Cl_3 + LiBH_4 \rightarrow B_3N_3H_6 + LiCl + BCl_3$$

$$B_3N_3H_3Cl_3 + 3CH_3MgBr \rightarrow B_3N_3H_3(CH_3)_3 + 3MgBrCl$$

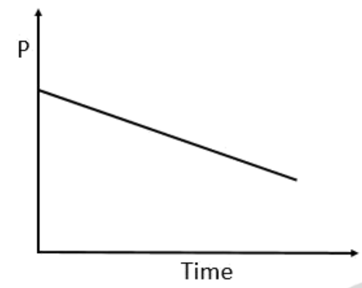
So, we can say that,
B is $B_3N_3H_6$
C is CH_3MgBr

9. A mixture of gases O_2 , H_2 and CO are taken in a closed vessel containing charcoal. The graph that represents the correct behaviour of pressure with time is :

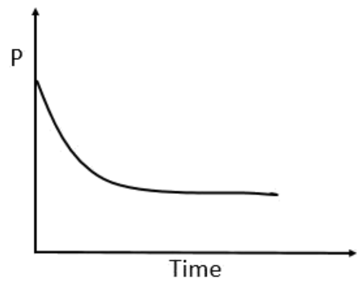
a.



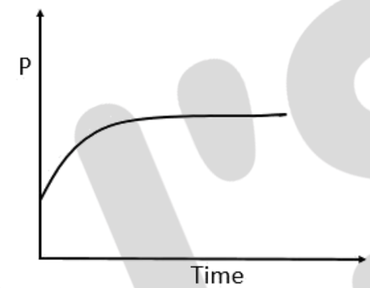
b.



c.



d.



Answer: c

Solution:
As H_2, O_2 and CO gets adsorbed on the surface of charcoal, the pressure decreases. So, option (a) and (d) can be eliminated. After some time, as almost all the surface sites are occupied, the pressure becomes constant.

10. The isomer(s) of $[Co(NH_3)_4Cl_2]$ that has/have a Cl–Co–Cl angle of 90^o, is/are :

a. cis only
b. trans only
c. meridional and trans
d. cis and trans

Answer: a

Solution:
In cis-isomer, similar ligands are at an angle of 90^o.

11. Amongst the following, the form of water with lowest ionic conductance at 298 K is :

a. distilled water
b. sea water
c. saline water used for intra venous injection
d. water from a well

Answer: a

Solution:
In distilled water there are no ions present except H^+ and OH^- ions, both of which are immensely minute in concentration, that renders their collective conductivity negligible.

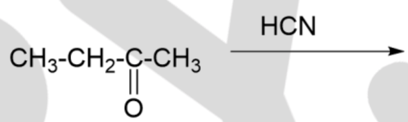
12. The number of sp^2 hybrid orbitals in molecule of benzene is:

a. 18
b. 24
c. 6
d. 12

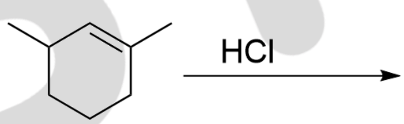
Answer: a

Solution:
Benzene (C_6H_6) has 6 sp^2 hybridized carbons. Each carbon has 3 σ-bonds and 1 π-bond. 3 σ-bonds means that there are 3 sp^2 hybrid orbitals for each carbon. Hence, the total number of sp^2 hybrid orbitals is 18.

13. Which of the following reactions will not produce a racemic product?

a.


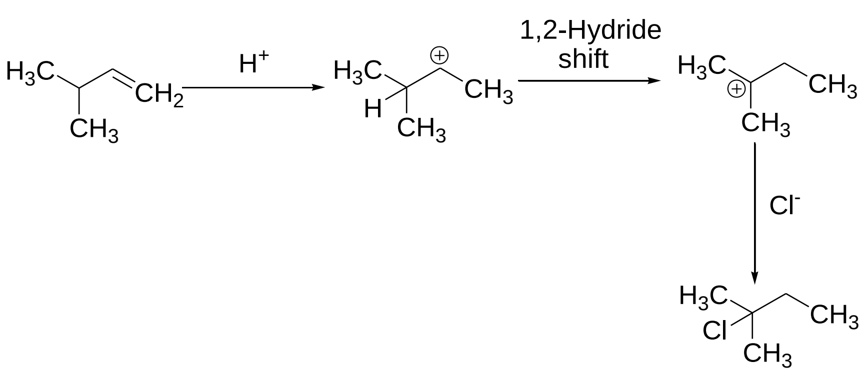
b. $(CH_3)_2\text{-}CH\text{-}CH{=}CH_2 \xrightarrow{HCl}$

c.


d. $CH_3CH_2\text{-}CH{=}CH_2 \xrightarrow{HBr}$

Answer: b

Solution:

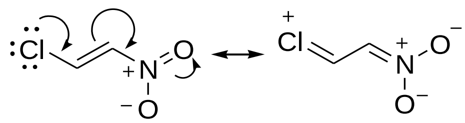


14. Which of the following has the shortest C–Cl bond?

a. $Cl-CH=CH_2$
b. $Cl-CH=CH-CH_3$
c. $Cl-CH=CH-OCH_3$
d. $Cl-CH=CH-NO_2$

Answer: d

Solution:
There is extended conjugation present in option (d), which will reduce the length of C-Cl bond to the greatest extent which can be represented as follows:



15. Biochemical oxygen demand (BOD) is the amount of oxygen required (in ppm) :

a. for the photochemical breakdown of waste present in 1m^3 volume of a water body
b. by anaerobic bacteria to break-down inorganic waste present in a water body.
c. by bacteria to break-down organic waste in a certain volume of water sample.
d. for sustaining life in a water body

Answer:c

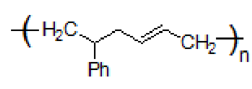
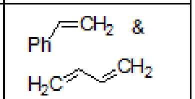
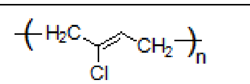
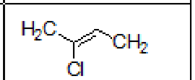
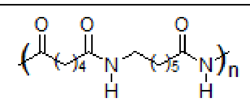
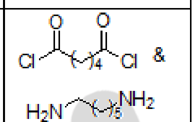
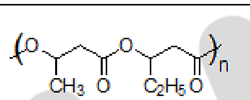
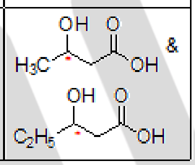
Solution:
Biochemical oxygen demand (BOD) is the amount of dissolved oxygen used by microorganisms in the biological process of metabolizing organic matter in water.

16. Which polymer has chiral, monomer(s)?

a. Buna-N
b. Neoprene
c. Nylon 6,6
d. PHBV

Answer: d

Solution:

	Polymers	Monomers
Buna-S		
Neoprene		
Nylon-6,6		
PHBV		

17. A, B and C are three biomolecules. The results of the tests performed on them are given below :

	Molisch's Test	Barfoed Test	Biuret Test
A	Positive	Negative	Negative
B	Positive	Positive	Negative
C	Negative	Negative	Positive

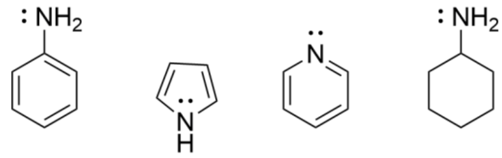
A, B and C are respectively

a. A=Lactose B=Glucose C=Albumin
b. A=Lactose B=Glucose C=Alanine
c. A=Lactose B=Fructose C=Alanine
d. A=Glucose B=Sucrose C=Albumin

Answer: a

Solution:
Lactose, glucose and fructose gives positive Molisch's test.
Glucose gives positive Barfoed's test whereas sucrose gives a negative for Barfoed's test.
Albumin gives positive for Biuret test whereas alanine gives a negative Biuret test.

18. The decreasing order of basicityof the following amines is:



a. I > II > III > IV

b. IV > III > I > II

c. II > I > III > IV

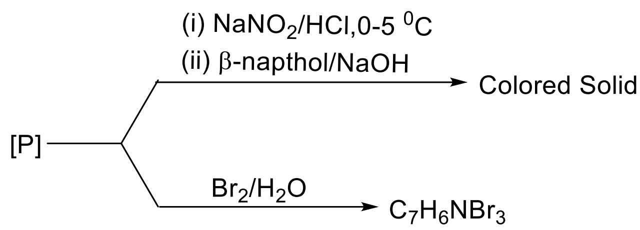
d. IV > I > II > III

Answer: b

Solution:

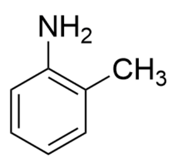
The basicity of the compound depends on the availability of the lone pairs.
In compound IV, Nitrogen is sp^3 hybridized.
In compound III, Nitrogen is sp^2 hybridized and the lone pairs are not involved in resonance.
In compound I, Nitrogen is sp^2 hybridized and the lone pairs are involved in resonance.
In compound II, Nitrogen is sp^2 hybridized and the lone pairs are involved in resonance such that, they are contributing to the aromaticity of the ring.
From the above points we can conclude that the basicity order should be IV > III > I > II.

19.

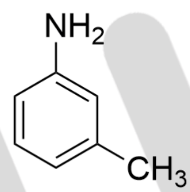


The compound [P] is :

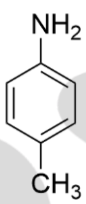
a.



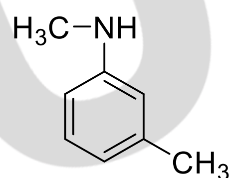
b.



c.

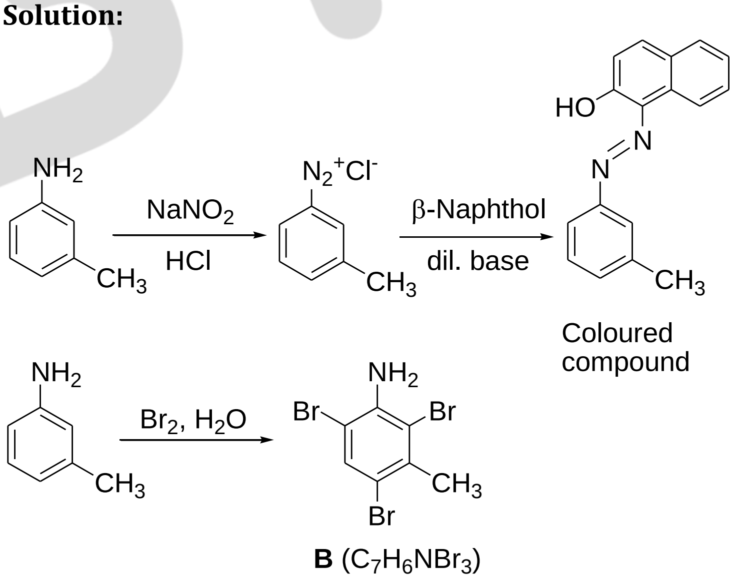


d.

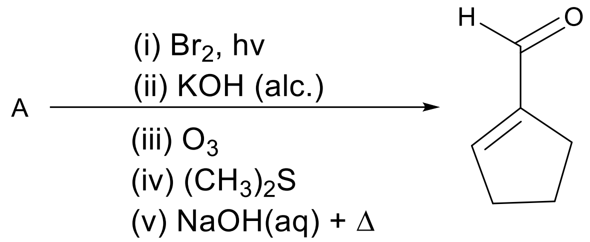


Answer: b

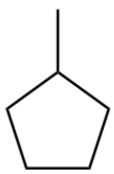
Solution:



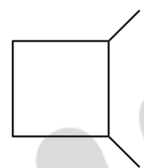
20. In the following reaction A is :



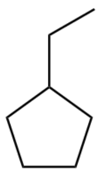
a.



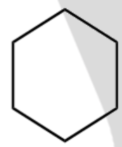
b.



c.

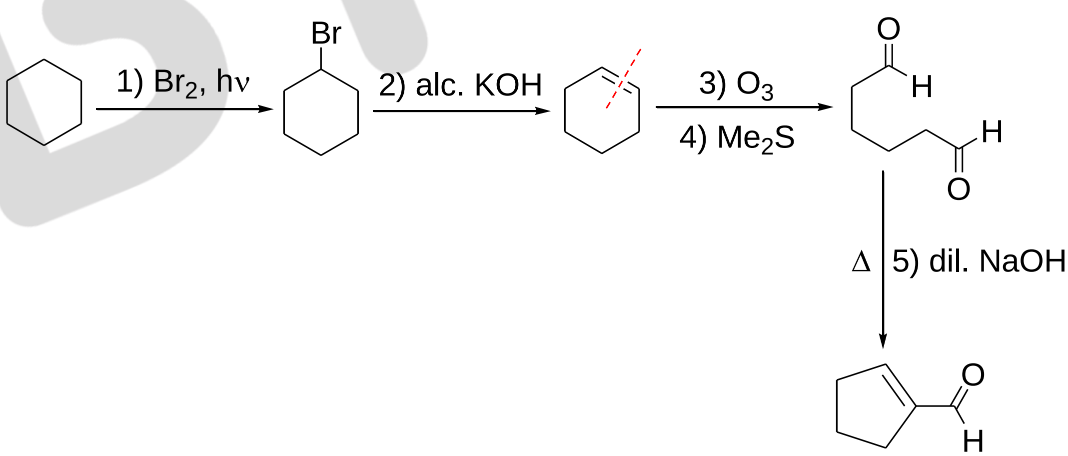


d.



Answer: d

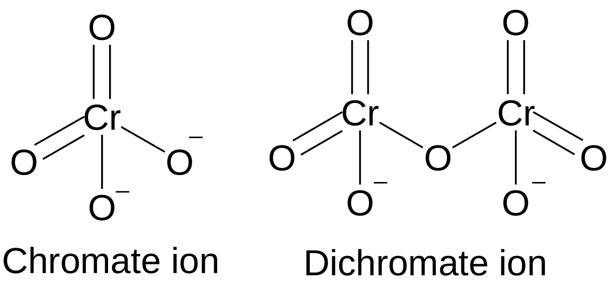
Solution:



21. The sum of total number of bonds between chromium and oxygen atoms in chromate and dichromate ions is ____

Answer: 12

Solution:



22. A sample of milk splits after 60 min. at 300K and after 40 min at 400K when the population of lactobacillus acidophilus in it doubles . The activation energy (in kJ/mol) for this process is closest to ----- .
(Given, $R = 8.3\ \text{J mol}^{-1}\text{K}^{-1}$), $\ln\left(\frac{2}{3}\right) = 0.4$, $e^{-3} = 4.0$)

Answer: 3.98

Solution:

The generation time can be utilized to get an indication of the rate ratio. Let the amount generated be (x).

$$\text{Rate} = \frac{\text{Amount generated}}{\text{Time taken}}$$

$$\text{Rate}_{300\text{ K}} = \frac{(x)}{60} \qquad \text{Rate}_{400\text{ K}} = \frac{(x)}{40}$$

$$\frac{\text{Rate}_{300\text{K}}}{\text{Rate}_{400\text{K}}} = \frac{40}{60}$$

For the same concentration (which is applicable here), the rate ratio can also be equaled to the ratio of rate constants.

$$\ln\left[\frac{K_{\text{at }400\text{K}}}{K_{\text{at }300\text{K}}}\right] = \frac{E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\ln\frac{60}{40} = \frac{E_a}{8.3}\left[\frac{1}{300} - \frac{1}{400}\right]$$

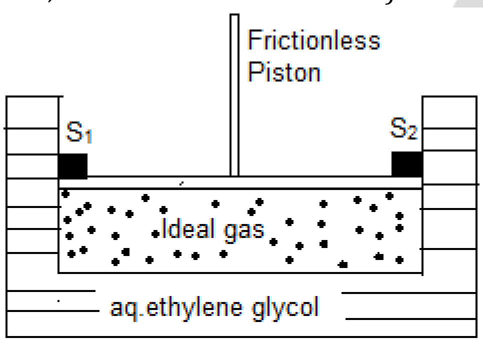
$E_a = 0.4 \times 8.3 \times 1200 = 3984$ J/mol = 3.98 kJ/mol

23. One litre of sea water ($d = 1.03 \frac{g}{cm^3}$) contains 10.3 mg of O_2 gas. Determine the concentration of O_2 in ppm:

Answer: 10.00

Solution:
$Ppm = \frac{w_{Solute}}{w_{Solution}} x\ 100$
Using the density of the solution and its volume ($1L = 1000\ mL = 1000\ cm^3$), the weight of the solution can be calculated.
$W_{solution} = 1.03 \times 1000 = 1030$ g
Thus, $ppm = \frac{10.3 \times 10^{-3} g}{1030\ g} x\ 100$

24. A cylinder containing an ideal gas (0.1 mol of 1.0 dm^3)
is in thermal equilibrium with a large volume of 0.5 molal aqueous solution of ethylene glycol at it freezing point. If the stoppers S_1 and S_2 (as shown in the figure) suddenly withdrawn, the volume of the gas in liters after equilibrium is achieved will be ----(Given, K_f (water)=2.0 K kg mol^{-1} ,R = 0.08 dm^3 atm K^{-1} mol^{-1})



Answer: 2.18

Solution:

$K_f = 2$

Molality, 'm' = 0.5

$\Delta T_f = K_f \,.\, m$

$= (0.5 \times 2) = 1$

So, the initial temperature now becomes 272 K. Further using the given value of moles and initial volume of the gas and the calculated initial temperature value, we can find out the initial pressure of the ideal gas contained inside the piston.

$P_{gas} = \frac{nRT}{V_1}$

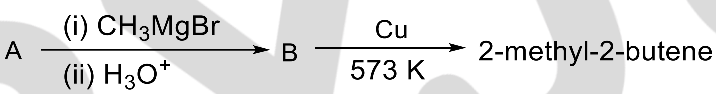
$= (0.1)(0.08)(272) = 2.176$ atm

Now, on releasing the piston against an external pressure of 1 atm, the gas will expand until the final pressure of the gas, i.e. P_2 becomes equal to 1 atm. During this expansion, since no reaction is happening and the temperature of the gas is not changing as well, the boyle's law relation can be applied.

$P_1V_1 = P_2V_2$

$2.176 \times 1 = 1 \times V_2$

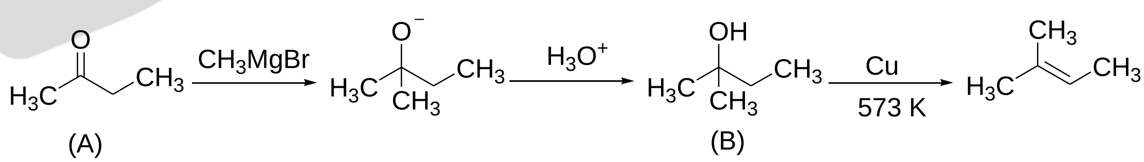
25. Consider the following reactions



The mass percentage of carbon in A is:

Answer: 66.67

Solution:



Compound A is $CH_3(CO)CH_2CH_3$ (C_4H_8O)

The percentage of carbon in compound A by weight is $\frac{w_{Carbon}}{w_{Compound}} = \frac{12 \times 4}{72} = 66.67$