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 Zn reacts with
   I. Excess of NaOH
   II. Dilute HCl , then the volume ratio of H_2 gas evolved in I and II is:

a. 2:1
b. 1:2
c. 1:1
d. 3:1

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. Given, K_{sp} for $Cr(OH)_3$ is 6×10^{-31} then determine $[OH^-]$:

a. $(18 \times 10^{-31})^{1/4}$ M
b. $(18 \times 10^{-31})^{1/2}$ M
c. $(6 \times 10^{-31})^{1/4}$ M
d. $\left(\frac{6}{27} \times 10^{-31}\right)^{1/4}$ M

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. Select the correct statements among the following:

A. LiCl does not dissolve in pyridine
B. Li does not react ethyne to form ethynide
C. Li and Mg react slowly with water
D. Among the alkali metals, Li has highest tendency for hydration

a. B, C, D
b. A, B, C, D
c. A, B, C
d. C, D

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. Given an element having the following ionization enthalpies, $IE_1 = 496$ kJ mol^{-1} and $IE_2 = 4562$ kJ mol^{-1}. One mole of hydroxide of this element is treated separately with HCl and H_2SO_4 respectively. Moles of HCl and H_2SO_4 reacted respectively are:

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

Answer: a

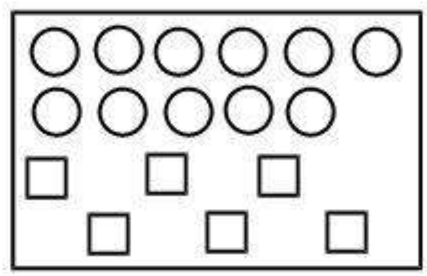
Solution:
The given data for ionization energies clearly shows that $IE_2 \gg IE_1$. So, the element belongs to the first group. Therefore, we can say that this element will be monovalent and hence forms a monoacidic base of the type MOH.

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

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

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. Reactant A is represented by the squares which is in equilibrium with product B represented by circles. Then the value of equilibrium constant is:



a. 1
b. 2
c. 3
d. 4

Answer: b

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

6. Given following complexes:
   I. $Na_4[Fe(CN)_6]$
   II. $[Cr(H_2O)_6]Cl_2$
   III. $(NEt_4)_2[CoCl_4]$
   IV. $Na_3[Fe(C_2O_4)_3]$ $(\Delta_0 > P)$
   The correct order of spin only magnetic moment for the above complexes

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

Answer: a

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. Select the correct option:
   a. Entropy is a function of temperature and also entropy change is a function of temperature.
   b. Entropy is a function of temperature & entropy change is not a function of temperature.
   c. Entropy is not a function of temperature & entropy change is a function of temperature.
   d. Both entropy & entropy change are not a function of temperature.

Answer: a

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. A compound (A: $B_3N_3H_3Cl_3$) reacts with $LiBH_4$ to form inorganic benzene (B). (A) reacts with (C) to form $B_3N_3H_3(CH_3)_3$. (B) and (C) respectively are:
   a. Boron nitride, MeMgBr
   b. Boron nitride, MeBr
   c. Borazine, MeBr
   d. Borazine, MeMgBr

Answer: d

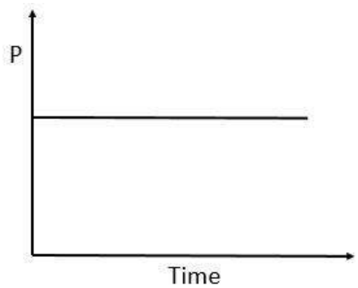
Solution:
$$B_3N_3H_3Cl_3 + LiBH_4 \rightarrow B_3N_3H_6 + LiCl + BCl_3$$

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

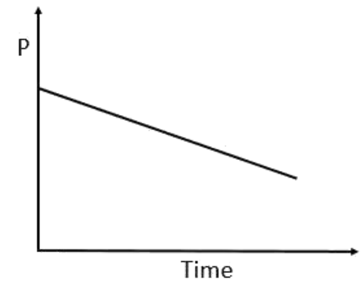
So, we can say that,
B is $B_3N_3H_6$
C is CH_3MgBr

9. In a box, a mixture containing H_2, O_2 and CO along with charcoal is present. Then, the variation of pressure with time will be:

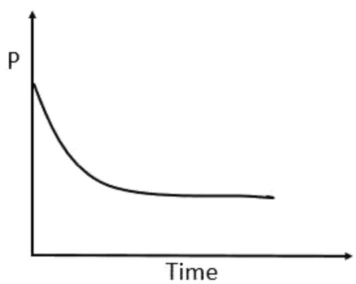
a.



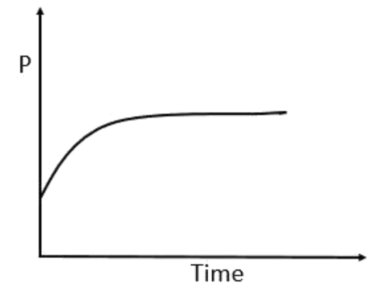
b.



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. Given the complex: $[Co(NH_3)_4Cl_2]$. If in this complex, the Cl–Co–Cl bond angle is 90^o, then it is a:

a. Cis-isomer
b. Trans-isomers
c. Meridional and Trans
d. Cis and trans both

Answer: a

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

11. Amongst the following, which has the least conductivity?

a. Distilled water
b. Sea water
c. Saline water used for intra venous injection
d. Well water

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. Number of sp^2 hybrid orbitals in Benzene is:

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

Answer: a

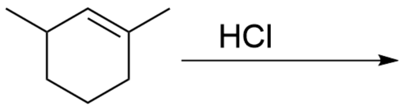
Solution:
Benzene (C_6H_6) has 6 sp^2 hybridized carbons. Each carbon has 3 σ-bonds and 1 π-bond. 3 σ-bonds means that there are 3 sp^2 hybrid orbitals for each carbon. Hence, the total number of sp^2 hybrid orbitals is 18.

13. Which of the following reaction will not give a racemic mixture as the product?

a. $CH_3-CH_2-\underset{\underset{O}{\|}}{C}-CH_3 \xrightarrow{HCN}$

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

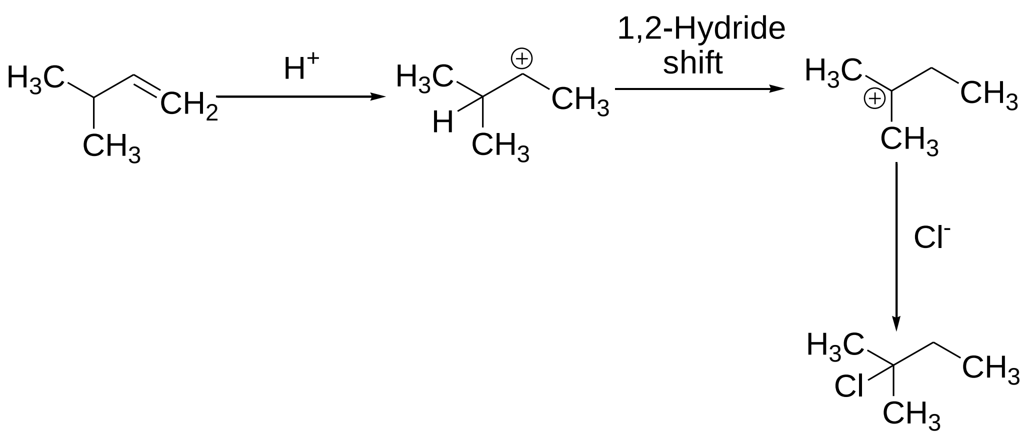
c.



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

Answer: b

Solution:

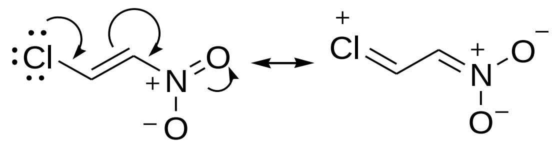


14. In which compound is the C–Cl bond length the shortest?

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 defined as .... in ppm of O_2.

a. Required to sustain life.
b. The amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water.
c. The amount of oxygen required by anaerobic bacteria to break down the inorganic matter present in a certain volume of a sample of water.
d. Required photochemical reaction to degrade waste.

Answer: b

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

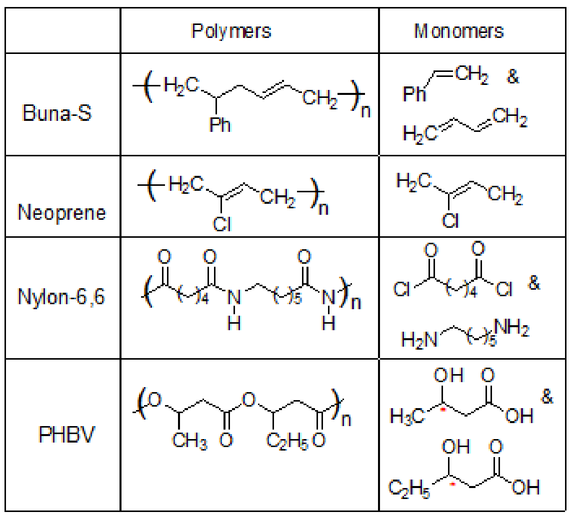
16. Monomer(s) of which of the given polymer is chiral?

a. Buna-S b. Neoprene

c. Nylon-6,6 d. PHBV

Answer: d

Solution:



17.

Lab tests			
Compound	**Molisch's test**	**Barfoed's test**	**Biuret test**
A	✓	x	x
B	✓	✓	x
C	x	x	✓

Which of the following options is correct?

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

Answer: a

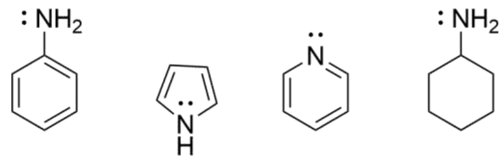
Solution:

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 order of basic character is:



(I) (II) (III) (IV)

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.

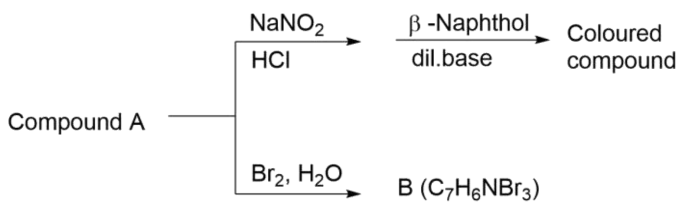
In compound III, Nitrogen is sp^2 hybridized and the lone pairs are not involved in resonance.

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.

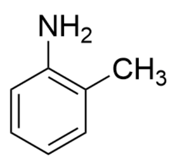
From the above points we can conclude that the basicity order should be IV > III > I > II.

19.

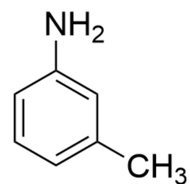


Compound A will be:

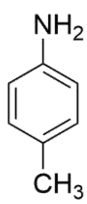
a.



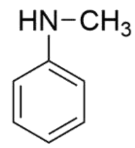
b.



c.

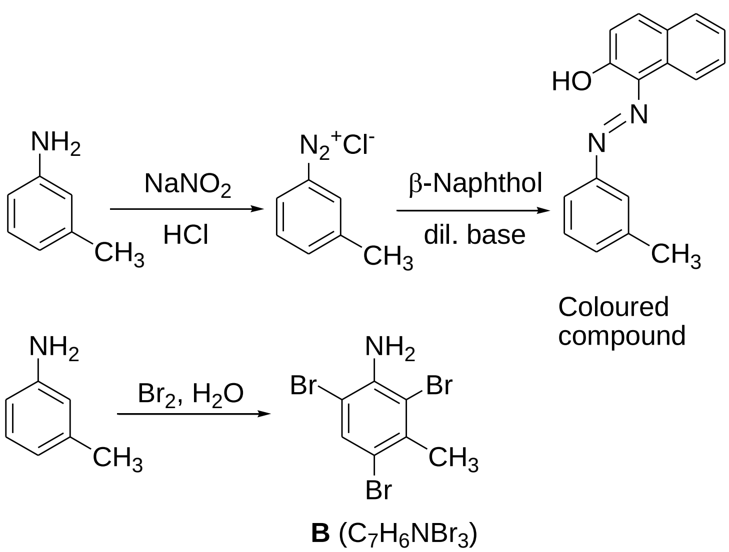


d.

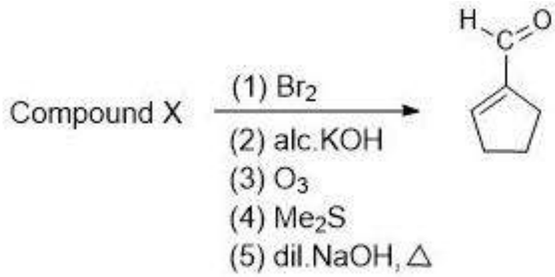


Answer: b

Solution:

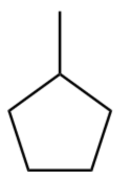


20.

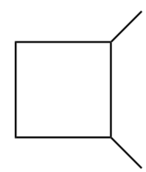


Compound X will be:

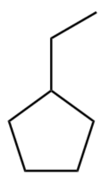
a.



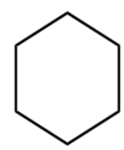
b.



c.

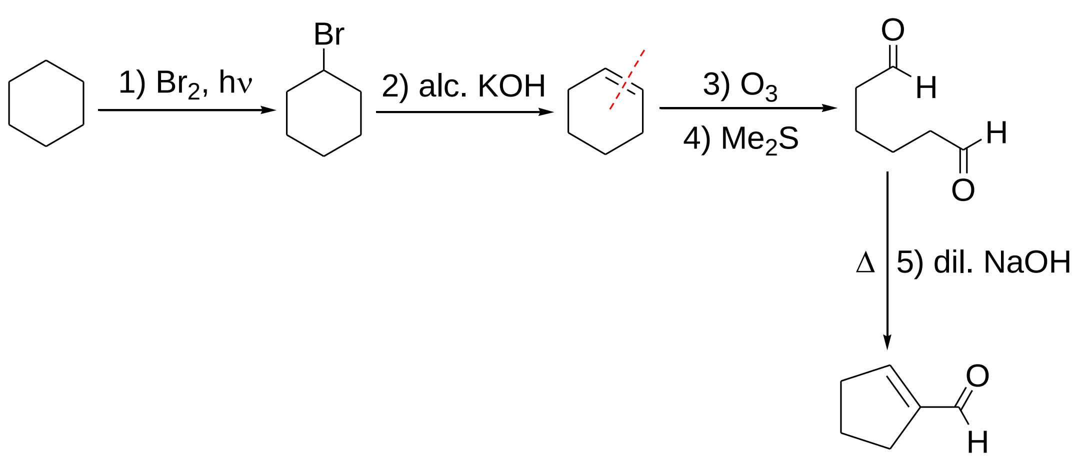


d.



Answer: d

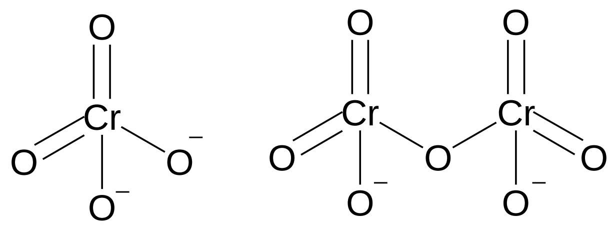
Solution:



21. Total number of Cr–O bonds in Chromate ion and Dichromate ion is:

Answer: 12

Solution:



Chromate ion   Dichromate ion

22. Lacto bacillus has a generation time of 60 minutes at 300K and 40 minutes at 400K. Determine the activation energy in $\frac{\text{kJ}}{\text{mol}}$. (R = 8.3 J $K^{-1}mol^{-1}$)[ln$\left(\frac{2}{3}\right)$ = -0.4]

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 x 8.3 x 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. 0.1 mole of an ideal gas has volume 1 dm^3 in a locked box with a frictionless piston. The gas is in thermal equilibrium with an excess of 0.5 m aqueous ethylene glycol at its freezing point. If the piston is released all of a sudden at 1 atm, then determine the final volume of gas in dm^3
($R = 0.08$ atm L $mol^{-1} K^{-1}$; $K_f = 2.0$ K $molal^{-1}$)

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.

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

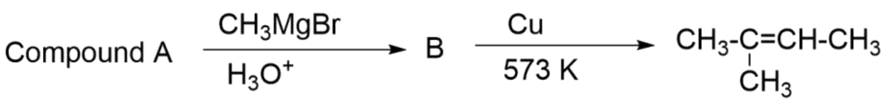
$= (0.1)(0.08)(272) = 2.176$ atm

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.

$P_1V_1 = P_2V_2$

$2.176 \times 1 = 1 \times V_2$

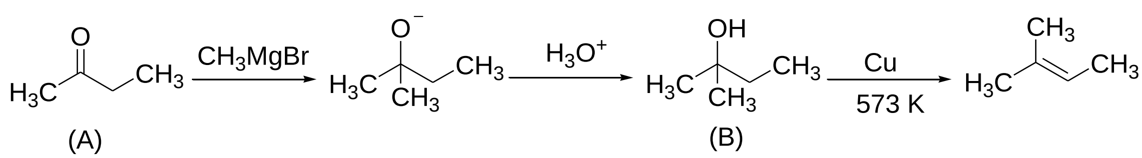
25.



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