JEE Main 2020 Paper

Date: 9th January 2020

Time: 09:30 AM – 12:30 PM

Subject: Chemistry

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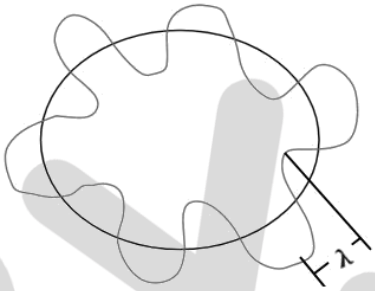
1. The de Broglie wavelength of an electron in the 4th Bohr orbit is:
   a. $4\pi a_0$
   b. $2\pi a_0$
   c. $8\pi a_0$
   d. $6\pi a_0$

Answer: c

Solution: n=4
Z=1
Λ=?



Circumference ($2\pi r$)= $n\lambda$

$\frac{2\pi a_o n^2}{z}=n\lambda$

On solving, we get $8\pi a_o$

2. If the magnetic moment of a dioxygen species is 1.73 B.M, it may be:
   a. O_2, O_2^- *or* O_2^+
   b. O_2^- *or* O_2^+
   c. O_2 *or* O_2^-
   d. O_2 *or* O_2^+

Answer: b

Solution:

$O_2: \sigma_{1s^2}\ \sigma^*_{1s^2}\ \sigma_{2s^2}\ \sigma^*_{2s^2}\ \sigma_{2p_z^2}\ \pi_{2p_x^2} = \pi_{2py^2}\ \ \pi^*_{2p_x^1}\ = \pi^*_{2p_y^1}$

$O_2^-: \sigma_{1s^2}\ \sigma^*_{1s^2}\ \sigma_{2s^2}\ \sigma^*_{2s^2}\ \sigma_{2p_z^2}\ \pi_{2p_x^2} = \pi_{2py^2}\ \ \pi^*_{2p_x^2}\ = \pi^*_{2p_y^1}$

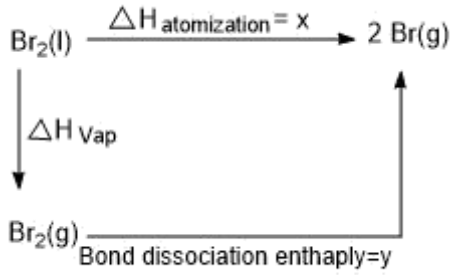
$O_2^+: \sigma_{1s^2}\ \sigma^*_{1s^2}\ \sigma_{2s^2}\ \sigma^*_{2s^2}\ \sigma_{2p_z^2}\ \pi_{2p_x^2} = \pi_{2py^2}\ \ \pi^*_{2p_x^1}$

3. If enthalpy of atomisation for $Br_2(l)$ is x kJ/mol and bond enthalpy for Br_2 is y kJ/mol, the relation between them:

a. is $x > y$
b. is $x < y$
c. is $x = y$
d. does not exist

Answer: a

Solution:



$\Delta H_{atomisation} = \Delta H_{vap} + y$

$x - y = \Delta H_{vap}$

4. Which of the following oxides are acidic, basic and amphoteric, respectively?

a. MgO, Cl_2O, Al_2O_3
b. N_2O_3, Li_2O, Al_2O_3
c. SO_3, Al_2O_3, Na_2O
d. P_4O_{10}, Cl_2O, CaO

Answer: b

Solution:

Non-metallic oxides are acidic in nature, metallic oxides are basic in nature and Al_2O_3 is amphoteric in nature

5. Complex X of composition$Cr(H_2O)_6Cl_n$, has a spin only magnetic moment of 3.83 BM. It reacts with $AgNO_3$ and shows geometrical isomerism. The IUPAC nomenclature of X is :

a. Hexaaqua chromium(III) chloride
b. Tetraaquadichlorido chromium(III) chloride dihydrate
c. Hexaaquachromium(IV) chloride
d. Tetraaquadichlorido chromium(IV) chloride dihydrate

Answer: b

Solution:

Spin only magnetic moment = 3.8 B. M. This implies, $\mu = \sqrt{(n(n+2))}$ B.M.

($\sqrt{16} = 4$ implies that $\sqrt{15}$ should be less than four.
This means, n=3 as $\sqrt{15} = \sqrt{(3(3+2))}$
Cr (24) = $[Ar]4s^1\ 3d^5$ (g.s)

For 3 unpaired electrons, the oxidation state of Cr should be +3
Cr^{3+} can be attained if the complex has a structure that looks like: $[Cr(H_2O)_4Cl_2]Cl.\ 2H_2O$
$[Cr(H_2O)_4Cl_2]Cl.\ 2H_2O$ has the IUPAC name : Tetraaquadichloridochromium(III) chloride dihydrate

6. The electronic configuration of bivalent europium and trivalent cerium, are:
(Atomic Number : Xe = 54, Ce = 58, Eu = 63)

a. $[Xe]4f^7, [Xe]4f^1$
b. $[Xe]4f^7 6s^2, [Xe]4f^2 6s^2$
c. $[Xe]4f^2, [Xe]4f^7$
d. $[Xe]4f^4, [Xe]4f^9$

Answer: a

Solution:

Ce (58): $[Xe]\ 6s^2 4f^2$ (g.s)

Ce^{3+}: $[Xe]4f^1$
Eu(63) : $[Xe]6s^2 4f^7$ (g.s)
Eu^{2+} : $[Xe]4f^7$

7. The K_{sp} for the following dissociation is $= 1.6 \times 10^{-5}$.

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$$

Which of the following choices is correct for a mixture of 300 mL 0.134 M $Pb(NO_3)_2$ and 100mL 0.4 M NaCl ?

a. $Q > K_{sp}$
b. $Q < K_{sp}$
c. $Q = K_{sp}$
d. Not enough data provided

Answer: a

Solution: Given K_{sp} of $PbCl_2 = 1.6 \times 10^{-5}$

$Pb(NO_3)_2$: mmoles= 300 mL × 0.134 M = 40.2

NaCl: mmoles = 100 mL × 0.4 M = 40

This implies, $[Pb]^{2+} = \frac{40.2}{400} \approx 0.1$ M

$$[Cl]^- = \frac{40}{400} = 0.1 \text{ M}$$

$Q_{sp} = [Pb^{2+}][2Cl^-]^2 = 4 \times 10^{-3} > K_{sp}$

8. The compound that cannot act both as oxidising and reducing agent is :

a. H_2SO_3 b. HNO_2

c. H_3PO_4 d. H_2O_2

Answer: c

Solution:

When the oxidation state is maximum it acts like a strong oxidising agent

When the oxidation state is minimum it acts like a strong reducing agent

When the oxidation state is between its maximum and minimum, it acts like both an oxidizing and as a reducing agent

In H_3PO_4, P has a +5 oxidation state and hence can act like a strong oxidising agent. In the rest, the oxidation state is between their maximum and minimum.

9. B has a smaller first ionization enthalpy than Be. Consider the following statements:

(i) It is easier to remove 2p electron than 2s electron

(ii) 2p electron of B is more shielded from the nucleus by the inner core of electrons than the 2s electron of Be

(iii) 2s electron has more penetration power than 2p electron

(iv) Atomic radius of B is more than Be

(Atomic number B=5, Be=4)

The correct statements are:

a. (i), (ii), and (iii) b. (i), (iii) and (iv)

c. (ii), (iii) and (iv) d. (i), (ii), (iv)

Answer: a

Solution:

Be (4): $1s^2 2s^2$

B (5): $1s^2 2s^2 2p^1$

The electron in $2p^1$ can easily be extracted.

The penetrating power is of the order: s > p > d > f

The shielding power order: s > p > d > f

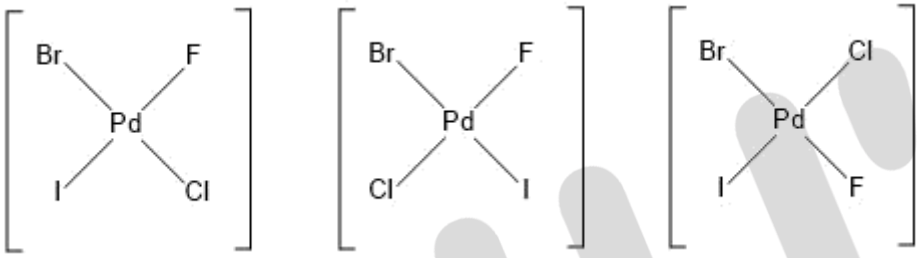
As we move along the period, the size decreases, as Z_{eff} increases. Hence the radius of B is smaller than the radius of Be.

10. $[Pd(F)(Cl)(Br)(I)]^{2-}$,has n number of geometrical Isomers. Then, the spin-only magnetic moment and crystal field stabilisation energy [CFSE] of $[Fe(CN)_6]^{n-6}$, respectively, [Note: Ignore pairing energy].

a. 1.73 BM and $-2\,\Delta_0$
b. 2.84 BM and $-1.6\,\Delta_0$
c. 0 BM and $-2.4\,\Delta_0$
d. 5.92 BM and 0

Answer: a

Solution:



Number of geometrical isomers (n) = 3

$[Fe(CN)_6]^{n-6} = [Fe(CN)_6]^{3-6} = [Fe(CN)_6]^{-3}$

This implies, that Iron is in its +3 oxidation state.

$Fe^{3+}(26)$: $[Ar]3d^5$

CN^- is a strong ligand in $[Fe(CN)_6]^{-3}$ and causes pairing. Hence, according to CFT, the configuration will be $t_{2g}^5\, e_g^0$.

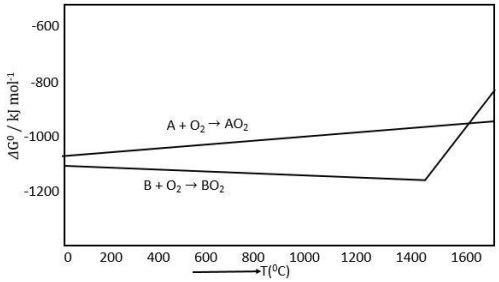
Hence, there is only 1 unpaired electron, i.e, n=1 in $\sqrt{n(n+2)} = \sqrt{3}$ = 1.73 B.M

$CFSE = (-0.4 \times n_{t2g} + 0.6 \times n_{eg})\Delta_0$

$= (-0.4 \times 5 + 0.6 \times 0)\Delta_0$

$= -2\Delta_0$

11. According to the following diagram, A reduces BO_2 when the temperature is:



a. $>$ 1400 °C
b. $<$ 1400 °C
c. $>$ 1200 °C but <1400 °C
d. $<$ 1200 °C

Answer: a

Solution: In Ellingham's diagram, the line of the element that lies below can reduce the oxide of the element which lies above it. Therefore, for A to reduce BO_2 , the temperature when the line for element A is below that of BO_2, according to the graph when T $>$ 1400 °C.

For T > 1400 °C , $\Delta G_r < 0$ for $A + BO_2 \rightarrow B + AO_2$

12. For following reactions

$A \xrightarrow{700K}$ Product;

$A \xrightarrow{\text{Catalyst,500K}}$ Product;

It was found that the E_a is decreased by 30 kJ/mol in the presence of catalyst. If the rate remains unchanged , the activation energy for catalysed reaction is (Assume pre exponenetial factor is same)

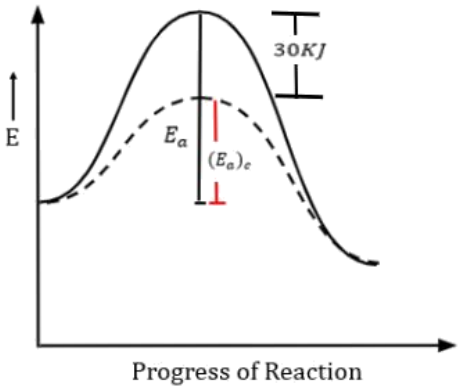
a. 75 kJ/mol
b. 135 kJ/mol
c. 105 kJ/mol
d. 198 kJ/mol

Answer: c

Solution:

$K = Ae^{\left(-\frac{E_a}{RT}\right)}$

$K_{catalyst} = K_{without\ catalyst}$



$Ae^{\left(-\frac{(E_a)c}{RT_{500k}}\right)} = Ae^{\left(-\frac{(E_a)}{RT_{700k}}\right)}$

$e^{\left(-\frac{(E_a)c}{RT_{500k}}\right)} = e^{\left(-\frac{(E_a)}{RT_{700k}}\right)}$

$-\frac{(E_a)\,c}{RT_{500k}} = -\frac{(E_a)}{RT_{700k}}$

$(E_a)c = E_a - 30$

$-\frac{(E_a-30)}{T_{500k}} = -\frac{(E_a)}{T_{700k}}$

On Solving, $E_a = 105\ kJmol^{-1}$

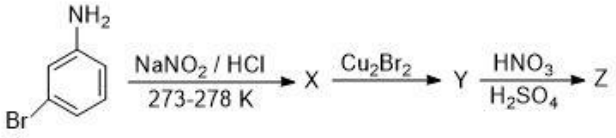
13. 'X' melts at low temperature and is a bad conductor of electricity in both liquid and solid state. X is :

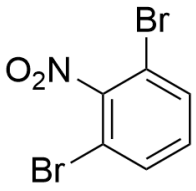
a. mercury
b. silicon carbide
c. zinc sulphide
d. carbon tetrachloride

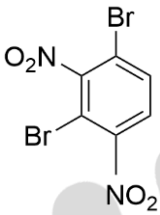
Answer: d

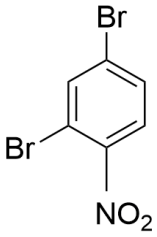
Solution: CCl_4 is non polar and does not conduct in either solid or liquid state.

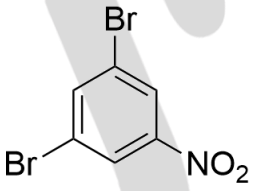
14. The major product Z obtained in the following reaction scheme is:



a. 

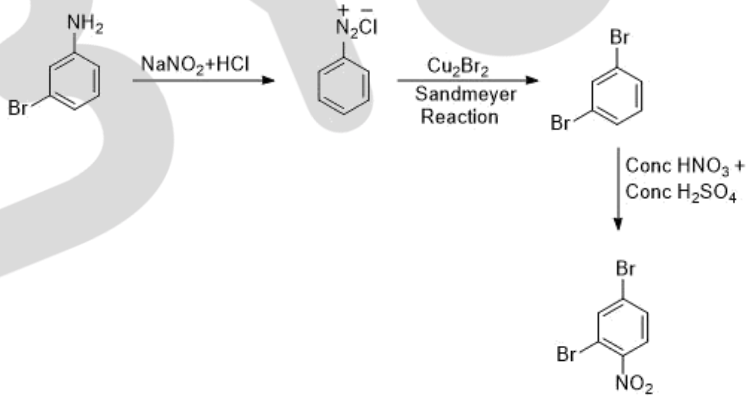
b. 

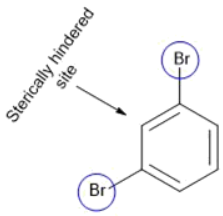
c. 

d. 

Answer: c

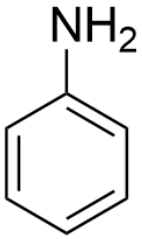
Solution:

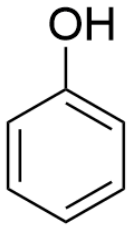


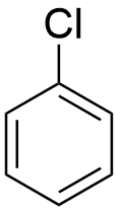


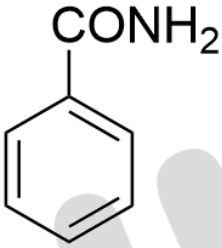
Hence, major product formed is that of option c.

15. Which of these will produce the highest yield in Friedel-Craft's reaction?

a. 

b. 

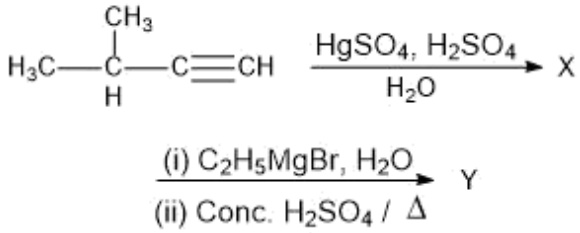
c. 

d. 

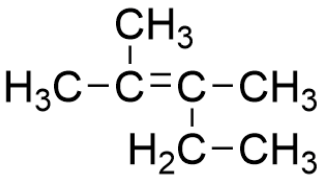
Answer: b

Solution: Out of the four options given, only aniline and phenol show strong +R effects, but as we know, aniline is a Lewis base and can react with a Lewis acid that is added during the reaction. Hence, Phenol gives the highest yield in Friedel-Craft's reaction.

16. The major product (Y) in the following reactions is :



a.



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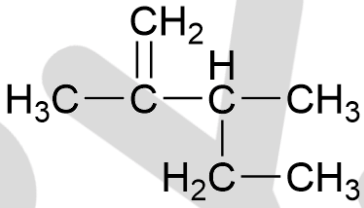
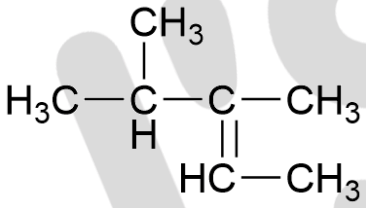
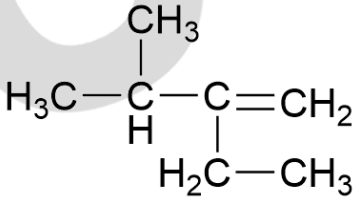


c.

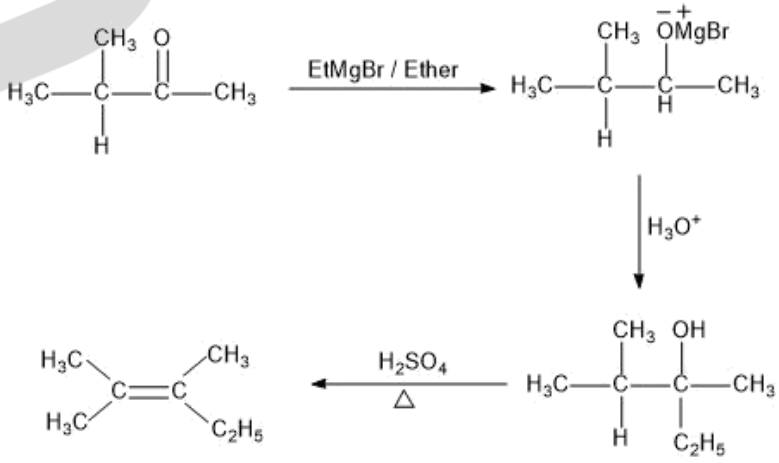


d.

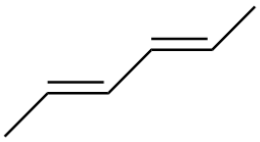
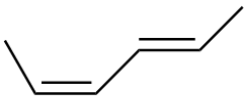
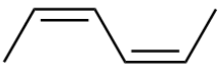


Answer: a

Solution:



17. The correct order of heat of combustion for following alkadienes is:

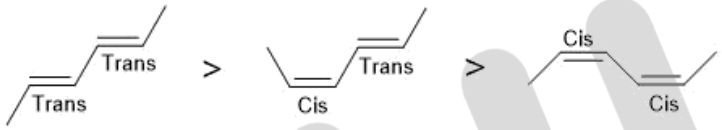
(A)  (B)  (C) 

a. C > B > A
b. B > A > C
c. A > B > C
d. C > A > B

Answer: c

Solution: Heat of combustion $\alpha \frac{1}{\text{stability}}$

The trans-isomer is more stable than the cis-isomer. More the number of trans forms in a structure, higher the stability.



(A) (B) (C)

18. The increasing order of basicity for the following intermediates is (from weak to strong)

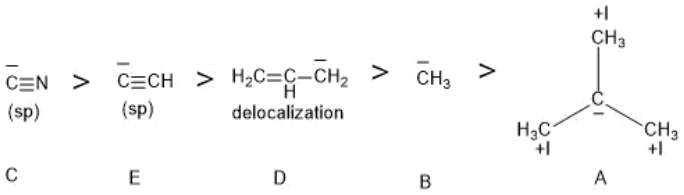
(A) (B) (C) (D) (E)

a. A > B > D > E > C
b. B > A > D > C > E
c. A > B > E > D > C
c. C > E > D > B > A

Answer: a

Solution: As we know weaker the conjugate base, stronger the acid.

The order of stability of conjugate base:



C E D B A

Hence, the order of basicity or acidic strength is:

A > B > D> E> C

19. A chemist has 4 samples of artificial sweetener A, B, C and D. To identify these samples, he performed certain experiments and noted the following observations:

(i) A and D both form blue-violet colour with ninhydrin.

(ii) Lassaigne extract of C gives positive $AgNO_3$ test and negative $Fe_4[Fe(CN)_6]_3$ test.

(iii) Lassaigne extract of B and D gives positive sodium nitroprusside test.

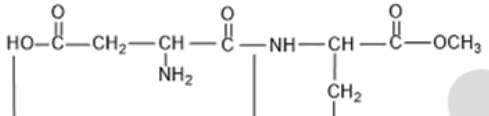
Based on these observations which option is correct?

a. A – Alitame, B – Saccharin, C – Aspartame, D – Sucralose
b. A –Saccharin, B – Alimate, C – Sucralose, D – Aspartame
c. A – Aspartame, B – Alitame, C – Saccharin , D – Sucralose
d. A – Aspartame, B – Saccharin, C – Sucralose, D – Alitame

Answer: d

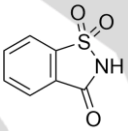
Solution:

A - Aspartame



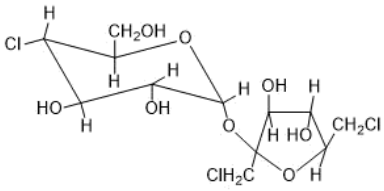
It has a free amine group and hence reacts with ninhydrin to give a purple colour known as Ruhemann's purple.

B- Saccharine



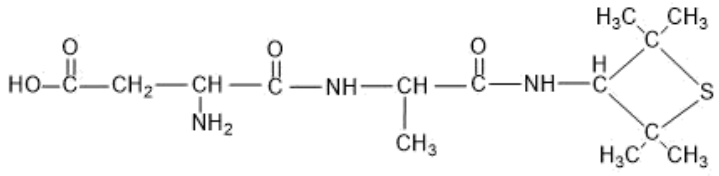
It has Sulphur, therefore, it will give a positive test with sodium nitroprusside.

C - Sucralose



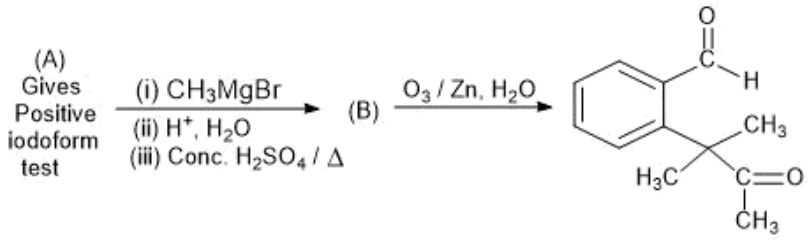
It has chlorine and hence it forms a precipitate with $AgNO_3$ in the Lassaigne's extract of the sugar.

D - Alitame

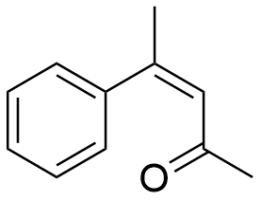


It has a free amine group and hence reacts with ninhydrin to give purple colour known as Ruhemann's purple. Also, it has Sulphur, therefore, it will give positive test with sodium nitroprusside.

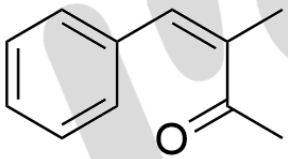
20. Identify (A) in the following reaction sequence:



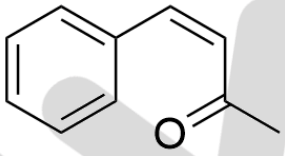
a.



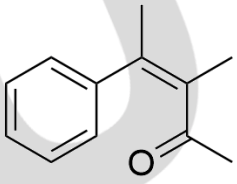
b.



c.

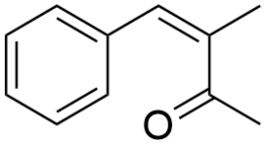


d.

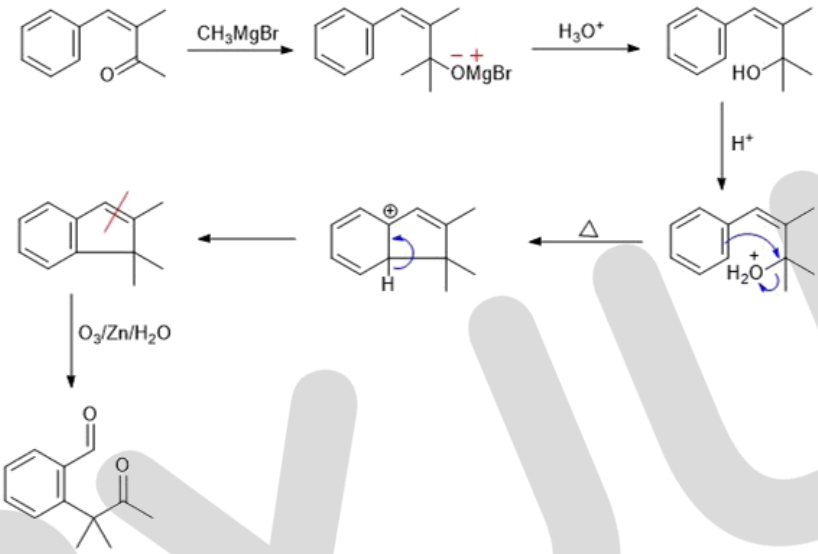


Answer: b

Solution:



is a methyl ketone, which gives positive Iodoform test.



21. The molarity of HNO_3 in a sample which has density 1.4 g/mL and mass percentage of 63% is ---------- (Molecular weight of HNO_3= 63).

Answer: 14.00

Solution: $\%\frac{w}{w}$= 63%

ρ= 1.4 g/mL

$$M = \frac{\left(\%\frac{w}{w} \times \rho \times 10\right)}{MM}$$

$$M = \frac{(63 \times 1.4 \times 10)}{63}$$

M= 14 mol/L

22. The hardness of a water sample containing 10^{-3} M $MgSO_4$ expressed as $CaCO_3$ equivalents (in ppm)is ---------- (molar mass of $MgSO_4$ is 120.37 g/mol)

Answer: 100.00

Solution:

Hardness of water is measured in ppm in terms $CaCO_3$.

$n_{CaCO_3} = n_{MgSO_4}$

ppm is the parts (in grams) present per million i.e, 10^6

1000 mL has 10^{-3} moles of $MgSO_4$.

Grams of $CaCO_3$ in 1000 mL = $10^{-3} \times 100$ grams

Grams of $CaCO_3$ in 1 mL = $\frac{10^{-3} \times 100}{1000\ mL}$ grams

Hardness = $\frac{10^{-3} \times 100}{1000\ mL} \times 10^6 = 100$

23. How much amount of NaCl should be added to 600 g of water (ρ=1.00 g/mL) to decrease the freezing point of water to -0.2°C?
(The freezing point depression constant for water = 2 K Kg mol^{-1})

Answer: 1.76

Solution: NaCl is strong electrolyte and gives 2 ions in the solution. This implies, i=2.

Molarity= $\frac{w \times 1000}{58.5 \times 600}$

$\Delta T_f = 0.2°C$

$\Delta T_f = i \times k_f \times m$

On solving we get,

w= 1.76 grams

24. 108 g silver (molar mass 108 g mol^{-1}) is deposited at cathode from $AgNO_3$(aq) solution by a certain quantity of electricity. The volume (in L) of oxygen gas produced at 273K and 1 bar pressure from water by the same quantity of electricity is ----------

Answer: 5.68

Solution: On applying Faraday's 1st law,

Moles of Ag deposited= 108/108= 1 mol.

$Ag^+ + e^- \rightarrow Ag$

1Faraday is required to deposit 1 mole of Ag.

$H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$

$\frac{1}{2}$ moles of O_2 are deposited by 2 F of charge.
This implies, 1 F will deposit $\frac{1}{4}$ moles of O_2
Using PV=nRT
P= 1 bar
T= 273 K
R= 0.0823 Lbar $mol^{-1}K^{-1}$
On solving we get,
V = 5.68 L

25. The mass percentage of nitrogen in histamine is ----------
Answer: 37.84

Solution:

Molecular mass of Histamine= 111

In Histamine, 3 nitrogen atoms are present (42g)

The percentage of nitrogen by mass in Histamine = $\frac{42}{111} \times 100 = 37.84\%$