JEE Main 2020 Paper

Date: 8th January 2020

Time: 02:30 PM – 05:30 PM

Subject: Chemistry

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1. Arrange the following bonds according to their average bond energies in descending order:
C-Cl, C-Br, C-F, C-I

a. C-Cl > C-Br > C-I > C-F
b. C-Br>C-I>C-Cl>C-F
c. C-I>C-Br>C-Cl>C-F
d. C-F>C-Cl>C-Br>C-I

Answer: d

Solution: In C − F there is 2p-2p overlapping involved, in C − Cl the overlapping involved is 2p-3p whereas for C − Br and C − I the overlappings involved are 2p-4p and 2p-5p, respectively. The bond length for the various type of overlappings can be given as:

2p-2p < 2p-3p < 2p-4p < 2p-5p.

As we know that Bond energy $\alpha \frac{1}{\text{Bond length}}$

The order of bond energy comes out: C-F > C-Cl > C-Br > C-I

2. The radius of second Bohr orbit, in terms of the Bohr radius, a_0 , in Li^{2+} is:

a. $\frac{2a_0}{3}$
b. $\frac{4a_0}{9}$
c. $\frac{4a_0}{3}$
d. $\frac{2a_0}{9}$

Answer: c

Solution: The formula for Bohr's radius for any one electron species is: $r = \frac{a_0 n^2}{z}$

for Li^{2+} : $r = \frac{a_0 2^2}{3} = \frac{4a_0}{3}$

3. A metal (A) on heating in nitrogen gas gives compound B. B on treatment with H_2O gives a colourless gas which when passed through $CuSO_4$ solution gives a dark blue-violet coloured solution. A and B respectively, are :

a. Na and Na_3N
b. Mg and Mg_3N_2
c. Mg, $Mg(NO_3)_2$
d. Na, $NaNO_3$

Answer: b

Solution: As it is provided in the question that nitride is being formed so the option c and d can be eliminated. Amongst Mg and Na we already know that Mg can only form nitride so the correct choice is option a.

$3Mg + N_2 \rightarrow Mg_3N_2 \xrightarrow{H_2O} Mg(OH)_2 + NH_3$

4. The correct order of the calculated spin-only magnetic moments of complexes A to D is:

A. $Ni(CO)_4$
B. $[Ni(H_2O)_6]^{2+}$
C. $Na_2[Ni(CN)_4]$
D. $PdCl_2(PPh_3)_2$

a. (C) < (D) < (B) < (A)
b. (A) ≈ (C) ≈ (D) < (B)
c. (A) ≈ (C)<(B) ≈ (D)
d. (C) ≈ (D) < (B) < (A)

Answer: b

Solution: $[Pd(PPh_3)_2Cl_2]$: Here Pd is in +2 oxidation state and configuration of Pd^{2+} is $[Kr]4d^8$. As the CFSE value for Pd is very high so all the electrons will be paired and hence magnetic moment for this complex will be zero.

$[Ni(CO)_4]$: Here Ni is in 0 oxidation state and configuration of Ni is $[Ar]3d^84s^2$. As here the ligand is carbonyl which is a strong field ligand, all the electrons will be paired and hence magnetic moment for this complex will be zero.

$[Ni(CN)_4]^{2-}$: Here Ni is in +2 oxidation state and configuration of Ni^{2+} is $[Ar]3d^8$. As here the ligand is cyanide which is a strong field ligand, all the electrons will be paired and hence magnetic moment for this complex will be zero.

$[Ni(H_2O)_6]^{2+}$: Here Ni is in +2 oxidation state and configuration of Ni^{2+} is $[Ar]3d^8$. As here the ligand is water which is a weak field ligand, the electrons will not be paired and there are two unpaired electrons in this complex hence magnetic moment for this complex will be $\sqrt{8}$ BM.

So the order of magnetic moment is A=B=C<D.

5. Hydrogen has three isotopes (A), (B) and (C). If the number of neutron(s) in (A), (B) and (C) respectively, are (x), (y) and (z), the sum of (x), (y) and (z) is:

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

Answer: c

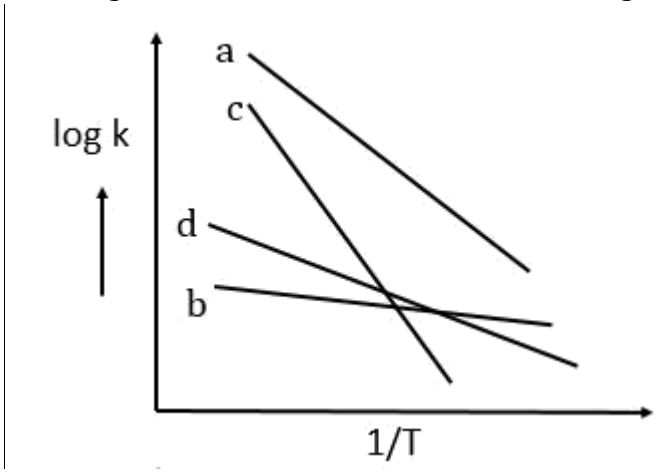
Solution: Number of neutrons in protium $= 0$

Number of neutrons in deuterium $= 1$

Number of neutrons in tritium $= 2$

So, total number of neutrons $= 3$

6. Consider the following plots of rate constant versus $\frac{1}{T}$ for four different reactions. Which of the following orders is correct for the activation energies of these reactions?



a. $E_a > E_c > E_d > E_b$
b. $E_c > E_a > E_d > E_b$
c. $E_b > E_d > E_c > E_a$
d. $E > E_a > E_d > E_c$

Answer: b

Solution:

To avoid confusion, in this question we'll be denoting activation energy by E_x

$K = Ae^{-E_x/RT}$

$\log K = \log A - \frac{E_x}{2.303RT}$ -----(1)

Here, the graph given in the question is of a straight line and we know that the equation of straight line is

$y = mx + c$ ----(2)

Comparing equation 1 with 2 we get,

$\text{Slope} = \frac{-E_x}{2.303R}$

So, from the graph we can conclude that the line with the most negative slope will have the maximum activation energy value.

$E_c > E_a > E_d > E_b$

7. Which of the following compounds is likely to show both Frenkel and Schottky defects in its crystalline form?

a. ZnS
b. CsCl
c. KBr
d. AgBr

Answer: d

Solution: The radius ratio for AgBr is intermediate. Thus, it shows both Frenkel and Schottky defects.

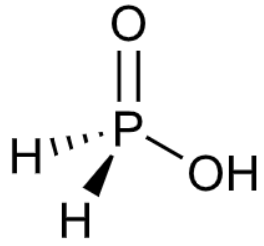
8. White phosphorus on reaction with concentrated NaOH solution in an inert atmosphere of CO_2 gives phosphine and compound (X). (X) on acidification with HCl gives compound (Y). The basicity of compound (Y) is:

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

Answer: d

Solution: $P_4 + NaOH + H_2O \rightarrow PH_3 + \boxed{NaH_2PO_2 \xrightarrow{HCl} H_3PO_2 + NaCl}$

Here the product B which is mentioned in the question is H_3PO_2. The structure of H_3PO_2 can be given as:



As only 1 Hydrogen atom is attached to the oxygen, its basicity is one.

9. Among the reactions (a) – (d), the reaction(s) that does/do not occur in the blast furnace during the extraction of iron is/are:

A. $CaO + SiO_2 \rightarrow CaSiO_3$
B. $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$
C. $FeO + SiO_2 \rightarrow FeSiO_3$
D. $FeO \rightarrow Fe + \frac{1}{2}O_2$

a. A
b. D
c. C and D
d. A and D

Answer: c

Solution: In metallurgy of iron, CaO is used as flux which is used to remove the impurities of SiO_2 , $CaO + SiO_2 \rightarrow CaSiO_3$.

Also here Fe_2O_3 is reduced by CO to Fe_3O_4 which is further reduced to FeO which is further reduced to Fe.

$3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$

$FeO + CO \rightarrow Fe + CO_2$

10. The increasing order of the atomic radii of the following elements is:
A. C B. O C. F D. Cl E. Br

a. B<C<D<A<E
b. C<B<A<D<E
c. A<B<C<D<E
d. D<C<B<A<E l

Answer: a

Solution:

Across the period size decreases, so the order that follows is: C > O >N> F

Down the group size increases and the order is: Br > Cl > F

Change in size down the group is much more significant as compared to across the period.

So, the overall order of radius of elements is: Br > Cl > C > O > F.

11. Among (a) – (d), the complexes that can display geometrical isomerism are:

A. $[Pt(NH_3)_3Cl]^+$
B. $[Pt(NH_3)Cl_5]^-$
C. $[Pt(NH_3)_2Cl(NO_2)]$
D. $[Pt(NH_3)_4ClBr]^{2+}$

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

Answer: a

Solution: The complexes of type Ma_4bc and Ma_2b_2 can show geometrical isomerism provided Ma_2b_2 is square planar. The compound given in B is Ma_4bc type and compound in D is Ma_2b_2 type also in D, Ni is surrounded with strong field ligands which will result in dsp^2 hybridisation and hence square planar geometry.

12. For the following Assertion and Reason, the correct option is:
Assertion: The pH of water increases with increase in temperature.

Reason: The dissociation of water into H^+ and OH^- an exothermic reaction.

a. Both assertion and reason are false.
b. Assertion is not true, but reason is true.
c. Both assertion and reason are true and the reason is the correct explanation for the assertion.
d. Both assertion and reason are true, but the reason is not the correct explanation for the assertion.

Answer: d

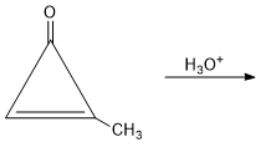
Solution: $H_2O \rightarrow H^+ + OH^-$ is an endothermic process. On increasing the temperature the value of K_w increases which will result in decrease in pK_w . So we can say that pH of water will decrease on increasing temperature because pH for water $=\frac{1}{2} pK_w$.

13. For the following Assertion and Reason, the correct option is:
Assertion: For hydrogenation reactions, the catalytic activity increases from group-5 to group-11 metals with maximum activity shown by group 7-9 elements
Reason: The reactants are most strongly adsorbed on group 7-9 elements
a. Both assertion and reason are false.
b. The assertion is true, but the reason is false.
c. Both assertion and reason are true, but the reason is not the correct explanation of assertion
d. Both assertion and reason are true and the reason is the correct explanation of assertion

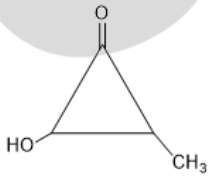
Answer: a

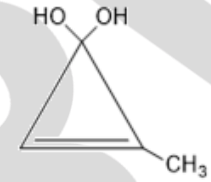
Solution: Group 7-9 elements of the periodic table show variable valencies so they have maximum activity because of the increase in adsorption rate.

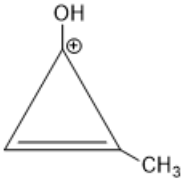
14. The major product of the following reactions is:

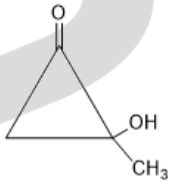


a.

b.


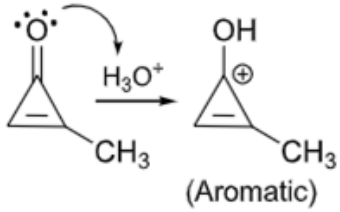
c.


d.


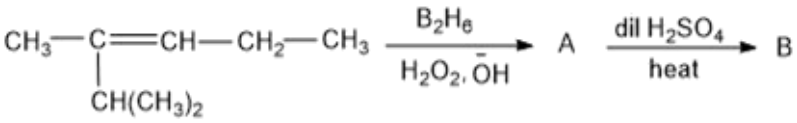


Answer: d

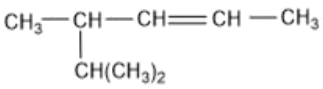
Solution:



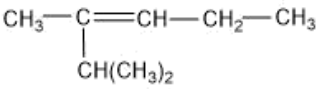
15. Find The major product [B] of the following sequence of reactions is:



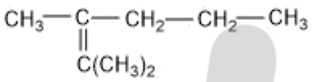
a.



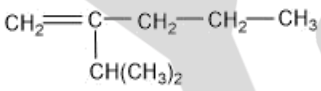
b.



c.

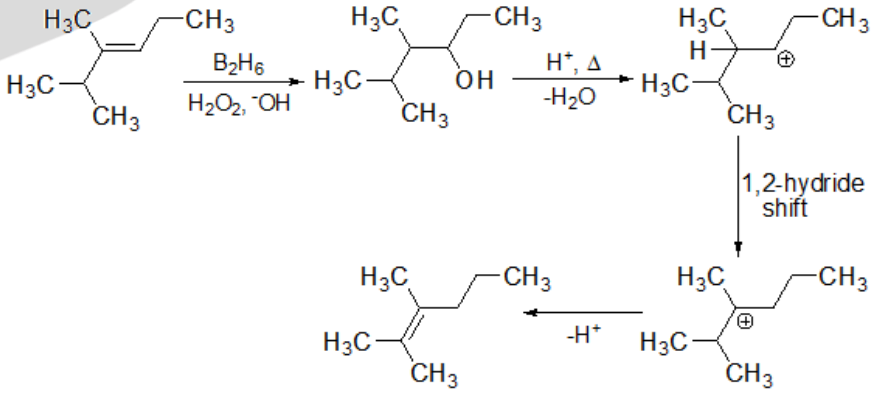


d.



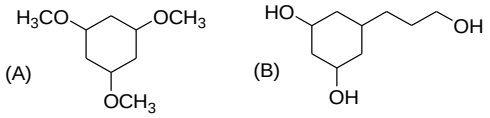
Answer: c

Solution:

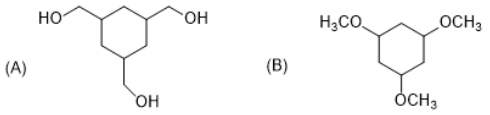


16. Among the following compounds A and B with molecular formula $C_9H_{18}O_3$, A is having higher boiling point than B. The possible structures of A and B are:

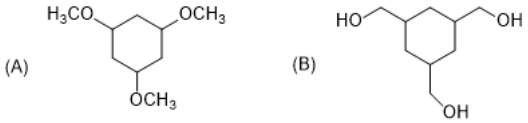
a.



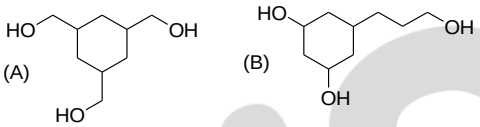
b.



c.



d.

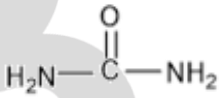


Answer: b

Solution: In option b compound A has extensive inter-molecular hydrogen bonding because of the 3 $-OH$ groups while in compound B there are $-OCH_3$ groups present and no inter-molecular hydrogen bonding is possible.

17. Kjeldahl's method cannot be used to estimate nitrogen for which of the following compounds?

a. $CH_3CH_2 - C \equiv N$
b. $C_6H_5NH_2$
c. $C_6H_5NO_2$
d.



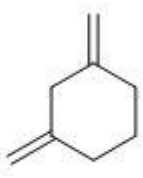
Answer: c

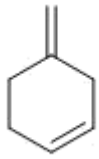
Solution: Kjeldahl method cannot be used for the estimation of nitrogen in the compounds in which nitrogen is involved in nitro, diazo groups or is present in the ring, as nitrogen atom can't be converted to ammonium sulphate under the reaction conditions.

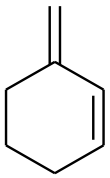
18. An unsaturated hydrocarbon absorbs two hydrogen molecules on catalytic hydrogenation, and also gives following reaction;

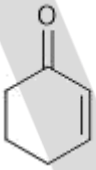
$X \xrightarrow{O_3, Zn/H_2O} A \xrightarrow{[Ag(NH_3)_2]^+} B$ (3-oxohexanedicarboxylic acid)

X will be:

a. 

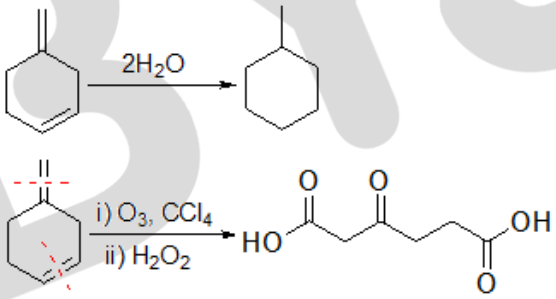
b. 

c. 

d. 

Answer: b

Solution:



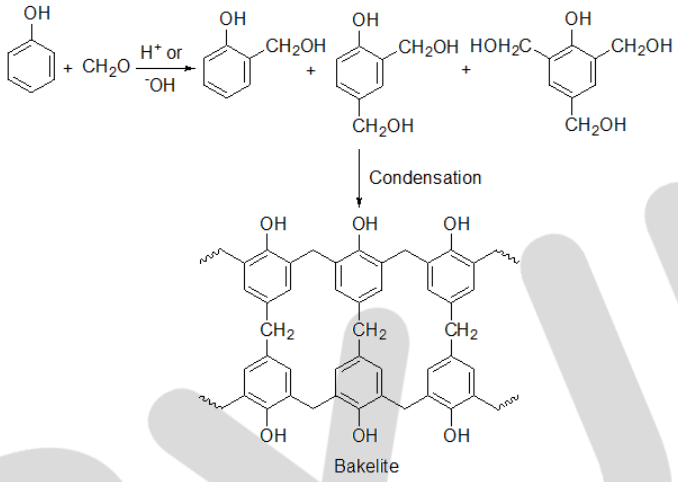
3-oxohexanedioic acid

19. Preparation of Bakelite proceeds via reactions :

a. Electrophilic substitution and dehydration.
b. Electrophilic addition and dehydration.
c. Condensation and elimination
d. Nucleophilic addition and dehydration

Answer: a

Solution: Bakelite is a condensation polymer of phenol and formaldehyde.

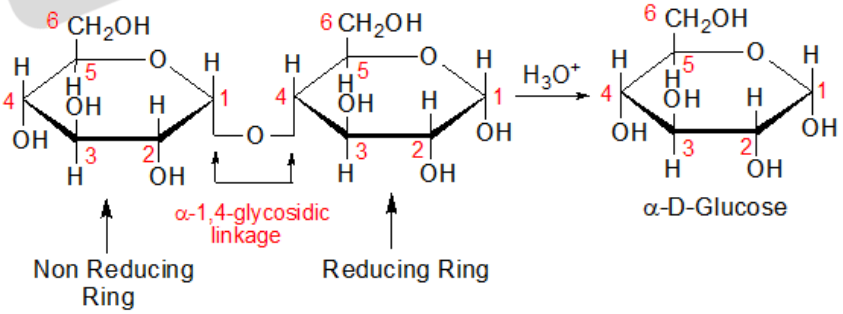


20. Two monomers of maltose are:

a. α-D-Glucose and α-D-Galactose
b. α-D-Glucose and α-D-Glucose
c. α-D-Glucose and α-D-Fructose
d. α-D-Glucose and β-D-Glucose

Answer: b

Solution:



Maltose is formed by the glycosidic linkage between C-1 of one α-D-Glucose unit to the C-4 of another α-D-Glucose.

21. At constant volume, 4 mol of an ideal gas when heated from 300 K to 500 K changes its internal energy by 5000 J. The molar heat capacity at constant volume is _____. .

Answer: 6.25

Solution:

$\Delta U = nC_v\Delta T$

$5000 = 4 \times Cv\ (500 - 300)$

$Cv = 6.25\ JK^{-1}\ mol^{-1}$

22. For an electrochemical cell

$$Sn(s)|Sn^{2+}(aq.,1\ M)||\ Pb^{2+}(aq.,1M)|Pb(s)$$

the ratio $\frac{[Sn^{2+}]}{[Pb^{2+}]}$ when this cell attains equilibrium is _____.

(Given : $E^{o}_{Sn^{2+}/Sn}$ = -0.14 V ; $E^{o}_{Pb^{2+}/Pb}$ =-0.13 V, $\frac{2.303RT}{F}$ =0.06 V).

Answer: 2.15

Solution:

Anodic half: $Sn \rightarrow Sn^{2+} + 2e^{-}$

Cathodic half: $Pb^{2+} + 2e^{-} \rightarrow Pb$

Net reaction: $Sn + Pb^{2+} \rightarrow Pb + Sn^{2+}$

$E^{0}_{cell} = E^{0}_{cathode} - E^{0}_{anode}$

$E^{0}_{cell} = 0.01\ V$

$E_{cell} = E^{0}_{cell} - \frac{0.06}{2}\log Q$

At equilibrium state $E_{cell} = 0$

So,

$0 = 0.01 - \frac{0.06}{2}\log\frac{[Sn^{2+}]}{[Pb^{2+}]}$

$0.01 = \frac{0.06}{2}\log\frac{[Sn^{2+}]}{[Pb^{2+}]}$

$\log\frac{[Sn^{2+}]}{[Pb^{2+}]} = \frac{1}{3}$

$\frac{[Sn^{2+}]}{[Pb^{2+}]} = 10^{\frac{1}{3}} = 2.154$

23. $NaClO_3$ is used, even in spacecrafts, to produce O_2. The daily consumption of pure O_2 by a person is 492 L at 1 atm, 300 K. How much amount of $NaClO_3$, in grams, is required to produce O_2 for the daily consumption of a person at 1 atm, 300 K ?
$NaClO_3(s) + Fe(s) \rightarrow O_2(g) + FeO(s) + NaCl(s)$
$R = 0.082$ L atm mol^{-1} K^{-1}

Answer: 2.13

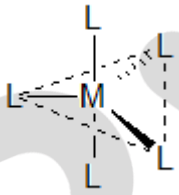
Solution:

Mol of $NaClO_3$ = mol of O_2
Mol of $O_2 = \frac{PV}{RT} = \frac{1\times492}{0.082\times300}$ = 20 mol
Molar mass of $NaClO_3$ is 106.5
So, mass = 20×106.5 = 2130 g = 2.13 kg

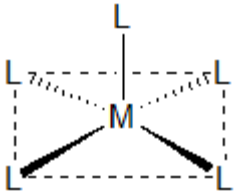
24. Complexes $[ML_5]$ of metals Ni and Fe have ideal square pyramidal and trigonal bipyramidal and geometries, respectively. The sum of the 90^0, 120^0 and 180^0 L-M-L angles in the two complexes is _____.

Answer: 20

Solution:



For trigonal bipyramidal geometry
Total number of 180^0 L-M-L bond angles = 1
Total number of 90^0 L-M-L bond angles = 6
Total number of 120^0 L-M-L bond angles = 3
Total = 10



For square pyramidal geometry
Total number of 180^0 L-M-L bond angles = 2
Total number of 90^0 L-M-L bond angles = 8
Total number of 120^0 L-M-L bond angles = 0
Total = 10
Total for both the structures = 20

25. In the following sequence of reactions, the maximum number of atoms present in molecule 'C' in one plane is _____.

$$A \xrightarrow{\text{Red hot/Cu tube}} B \xrightarrow{CH_3Cl(1\text{ eq.}),\ \text{anhy.}AlCl_3} C$$

(Where A is a lowest molecular weight alkyne).

Answer: 13

Solution: