JEE Main 2020 Paper

Date: 8th January 2020

Time: 09:30 AM – 12:30 PM

Subject: Chemistry

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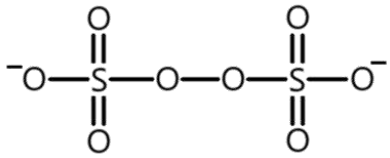
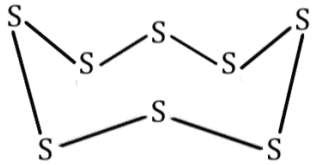
1. The number of S–O bonds in $S_2O_8^{2-}$ and number of S–S bonds in Rhombic sulphur, respectively, are:
   a. 8, 8
   b. 6, 8
   c. 2, 4
   d. 4, 2

Answer: a

Solution: Here, we have to count $S-O$ single bonds as well as $S=O$ in $S_2O_8^{2-}$, as each double bond also has one sigma bond. The structure of $S_2O_8^{2-}$ and S_8 is shown below:





2. Which of the following van der Waals forces are present in ethyl acetate liquid?
   a. H- bond, London forces
   b. Dipole-dipole interaction, H-bond
   c. Dipole-dipole interaction, London forces
   d. H-bond, dipole-dipole interaction, London forces

Answer: c

Solution: London dispersion forces (also called as induced dipole - induced dipole interactions), exist because of the generation of temporary polarity due to collision of particles and for this very reason, they are present in all molecules and inert gases as well.

Because of the presence of a permanent dipole, there will be dipole-dipole interactions present here.

There is no H that is directly attached to an oxygen atom, so H-bonding cannot be present.

3. Given, for H-atom

$$\bar{\nu} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

Select the correct options regarding this formula for Balmer series:

A) $n_1 = 2$.
B) Ionization energy of H atom can be calculated from above formula.
C) $\lambda_{maximum}$ is for $n_2 = 3$.
D) If λ decreases then spectrum lines will converge.

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

Answer: c

Solution:

(A) is correct since the series studied in H-spectrum, including Balmer series, are de-excitation series or emission series. So, electrons get de-excited to n= 2 which means that $n_{lower} = 2$.

(B) It is possible to obtain I.E. from the formula above, but since the question has stated the formula for the Balmer series, n_{lower} has been fixed as 2. So, it is not possible to calculate I.E. from it. To calculate I.E., we'll have to put $n_{lower} = 1$, which isn't possible here.

(C) $\Delta E = hc/\lambda$

With n_{lower} fixed as 2, ΔE increases as n_{higher} is increased. So, the last line of the Balmer series, i.e. from infinity to n= 2, will have the maximum energy in the series and thus, the lowest wavelength. Similarly, the first line in the series, i.e. from n= 3 to n= 2 will have the lowest energy in the series and thus, the highest wavelength. Which makes this statement correct.

(D)As orbits with higher orbit number or those that are further away from the nucleus are considered, the energy gap in-between subsequent orbits decreases. Now, consider the following for example and with n_{lower} fixed as 2.

Energy of a photon released on transition from n= 100 to n= 2 will have similar energy to that of the photon that gets released on transition from n= 101 to n= 2, because energy of the 100^{th} and the 101^{th} orbit will be very close in value. That means they will also have very close values of wavelengths, which further implies that these two lines will be situated quite close to each other on the photographic plate.

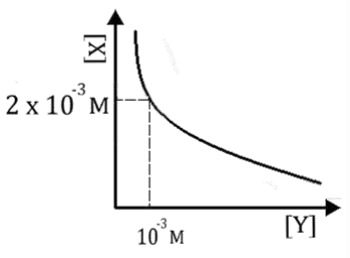
In a similar fashion, we can see that as the n_{higher} increases, the lines start to converge together. And since, increasing the n_{higher} will indeed lead to an increase in the energy of the photon released, it will end up releasing photons of shorter wavelengths. Combining these two statements we can easily see that as the wavelength decreases, the spectral lines start to converge.

4. The correct order of the first ionization energies of the following metals; Na, Mg, Al, Si in $kJmol^{-1}$, respectively is:
   a. 497, 737, 577, 786
   b. 497, 577, 737, 786
   c. 786, 739, 577, 497
   d. 739, 577, 786, 487

Answer: a

Solution:
The expected order is Na < Mg < Al < Si.
But the actual/experimental order turns out to be Na < Al < Mg < Si, because of the fully filled s-subshell of magnesium and the s^2p^1 configuration of Al which makes it relatively easy for Al to lose its outermost electron.

5. Select the correct stoichiometry and its K_{sp} value according to the given graph:



   a. XY, $K_{sp} = 2 \times 10^{-6}$
   b. XY_2, $K_{sp} = 4 \times 10^{-9}$
   c. X_2Y, $K_{sp} = 9 \times 10^{-9}$
   d. XY_2, $K_{sp} = 1 \times 10^{-9}$

Answer: a

Solution:

(a) $XY_{(s)} \rightleftharpoons X^+ + Y^-$

$K_{sp} = [X^+][Y^-] = 2 \times 10^{-3} \times 10^{-3} = 2 \times 10^{-6}$

(b) $XY_{2(s)} \rightleftharpoons X^{2+} + 2Y^-$

$K_{sp} = [X^{2+}][Y^-]^2 = 2 \times 10^{-3} \times 10^{-6} = 2 \times 10^{-9}$

(c) $X_2Y_{(s)} \rightleftharpoons 2X^+ + Y^{2-}$

$K_{sp} = [X^+]^2[Y^{2-}] = 4 \times 10^{-6} \times 10^{-3} = 4 \times 10^{-9}$

(d) $XY_{2(s)} \rightleftharpoons X^{2+} + 2Y^-$

$K_{sp} = [X^{2+}][Y^-]^2 = 2 \times 10^{-3} \times 10^{-6} = 2 \times 10^{-9}$

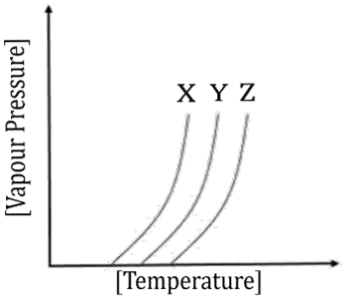
6. Which of the following complex exhibit facial-meridional geometrical isomerism?

a. $[Pt(NH_3)Cl_3]^-$
b. $[PtCl_2(NH_3)_2]$
c. $[Ni(CO)_4]$
d. $[Co(NO_2)_3(NH_3)_3]$

Answer: d

Solution: Facial and meridional geometrical isomerism is observed only in $[MA_3B_3]$ type complexes which is given in option d.

7.



A) Intermolecular force of attraction of X > Y
B) Intermolecular force of attraction of X < Y.
C) Intermolecular force of attraction of Z < X.

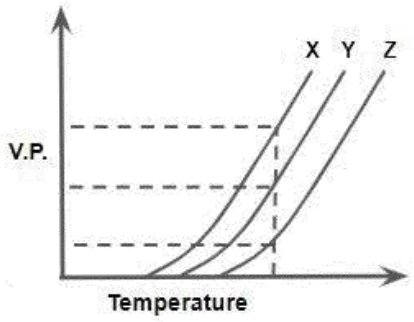
Select the correct option(s):

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

Answer: c

Solution:

As shown in the plot below, for the same T, the vapour pressure of X is the highest and of Z is the lowest. Now, that means with the same average K.E. of X, Y and Z molecules, the X molecules are able to compensate their respective intermolecular forces better. So, X molecules have the highest vapour pressure. Which implies that the intermolecular forces in X are the weakest among the three. The opposite could be said for Z as well.



8. Rate of a reaction increases by 10^6 times when a reaction is carried out in presence of enzyme catalyst at the same temperature. Determine the change in activation energy.
   a. $-6 \times 2.303\ RT$
   b. $+6 \times 2.303\ RT$
   c. $+6RT$
   d. $-6RT$

Answer: a

Solution:

$K_1 = Ae^{-E_{a1}/RT}$----(1)

$K_2 = Ae^{-E_{a2}/RT}$----(2)

Dividing equation 1 with equation 2, we get

$\frac{K_1}{K_2} = e^{(E_{a2}-E_{a1})/RT}$

$10^{-6} = e^{(E_{a2}-E_{a1})/RT}$

Taking $\log_e$ on both sides, we get

$\Delta E = E_{a2} - E_{a1} = -6 \times 2.303\ RT$

9. Gypsum on heating at 393K produces:

   a. Dead burnt plaster
   b. Anhydrous $CaSO_4$
   c. $CaSO_4.\frac{1}{2}\ H_2O$
   d. $CaSO_4 \cdot 5H_2O$

Answer: c

Solution: $CaSO_4.2H_2O \xrightarrow{393K} CaSO_4.\frac{1}{2}H_2O$

10. Among the following, the least 3^{rd} ionization energy is for:
    a. Mn
    b. Co
    c. Fe
    d. Ni

Answer: c

Solution:
Consider an element E
$E^{2+} \rightarrow E^{3+}$ would be the 3rd I.E. of the element E.

Electronic configuration of Mn is $[Ar]4s^2 3d^5$

Electronic configuration of Co is $[Ar]4s^2 3d^7$

Electronic configuration of Fe is $[Ar]4s^2 3d^6$

Electronic configuration of Ni is $[Ar]4s^2 3d^8$

Electronic configuration of Mn^{2+} is $[Ar]3d^5$

Electronic configuration of Co^{2+} is $[Ar]3d^7$

Electronic configuration of Fe^{2+} is $[Ar]3d^6$

Electronic configuration of Ni^{2+} is $[Ar]3d^8$

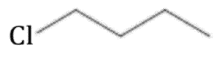
As it is evident from the above configurations of the E^{2+} for the given elements, Fe^{2+} would require the least amount of energy for removal of electron as it has the configuration $3d^6\ 4s^0$. That means that its E^{3+} form is the most stable among the four elements provided in their respective E^{3+} states, i.e., when compared, the next electron removal will require least amount of energy.

11. Accurate measurement of concentration of NaOH can be performed by which of the following titration?
    a. NaOH in burette and oxalic acid in conical flask
    b. NaOH in burette and concentrated H_2SO_4 in conical flask
    c. NaOH in volumetric flask and concentrated H_2SO_4 in conical flask
    d. Oxalic acid in burette and NaOH in conical flask

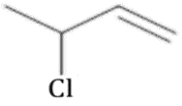
Answer: d

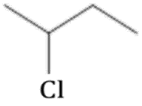
Solution: The standard solution is always kept in burette. The oxalic acid is a primary standard solution while H_2SO_4 is a secondary standard solution.

12. Arrange the following compounds in order of dehydrohalogenation (E_1) reaction:

A. 

B. 

C. 

D. 

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

Answer: b

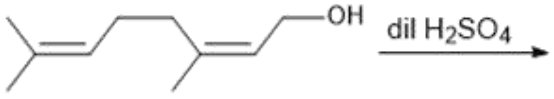
Solution: In E_1 mechanism, the rate determining step is formation of carbocation. So, stability of carbocation formed decides the rate.

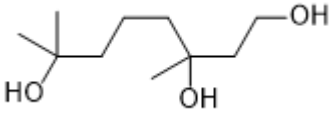
In option c, the cation formed is resonance stabilised.

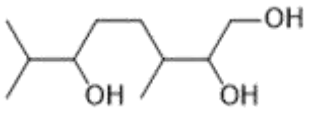
In option d, the cation formed is a 2^o carbocation.

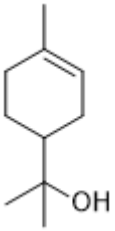
In option a and b, the carbocations formed are 1^o but there is a chance of rearrangement in option b and after the rearrangement, the carbocation formed in option b will be allylic. So, the order of reaction is as follows:
C > D > B > A.

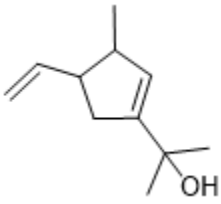
13. Major product in the following reaction is:



a. 

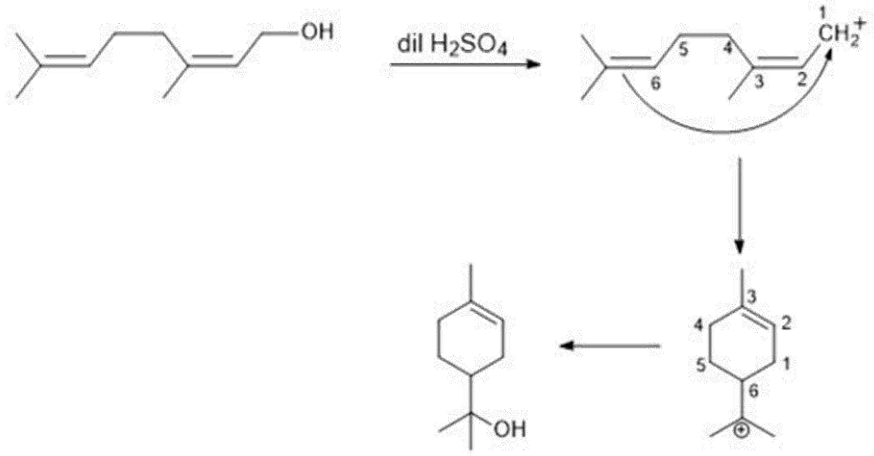
b. 

c. 

d. 

Answer: c

Solution:



14. Arrange the order of C—OH bond length in the following compounds:

Methanol	Phenol	p-Ethoxyphenol
(A)	(B)	(C)

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

Answer: b

Solution: In methanol, there is no resonance. In phenol, there is resonance. In p-Ethoxyphenol, there is resonance involved but the involvement of lone pair of oxygen in OH group is poor as compared with phenol due to the presence of lone pair oxygen in OCH_3 group which are also involved in resonance.

So, partial double bond character develops in C—OH bond of phenol and p-Ethoxyphenol but in case of p-Ethoxyphenol, resonance is poor as compared to phenol. So, bond length follows the order: A > C > B

15. Which of the following are "greenhouse gases"?

i. CO_2
ii. O_2
iii. O_3
iv. CFC
v. H_2O vapours

a. i, ii and iv
b. i, ii, iii and iv
c. i, iii and iv
d. i, iii, iv and v

Answer: d

Solution: CO_2, O_3, H_2O vapours and CFC's are green house gases.

16. Two liquids, isohexane and 3-methylpentane have boiling points 60 °C and 63 °C, respectively. They can be separated by:
    a. Simple distillation and isohexane comes out first
    b. Fractional distillation and isohexane comes out first.
    c. Simple distillation and 3-Methylpentane comes out first.
    d. Fractional distillation and 3-Methylpentane comes out first

Answer: b

Solution: When the difference between the B.P. of the two liquids is less than around 40 ^oC, fractional distillation is more efficient. The difference between the boiling points of isohexane and 3-methylpentane is only 3 degrees. So, fractional distillation is the best suitable method. Since, isohexane has a lower boiling point, it comes out first.

17. Which of the given statement is incorrect about glucose?
    a. Glucose exists in two crystalline forms α and β.
    b. Glucose gives Schiff's test.
    c. Penta acetate of glucose does not form oxime.
    d. Glucose forms oxime with hydroxylamine.

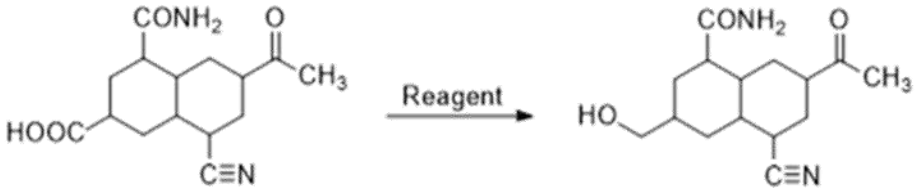
Answer: b

Solution: Glucose exists in two crystalline forms α and β which are anomers of each other.

Glucose does not react with Schiff's reagent because after the internal cyclisation, it forms either α-anomer or β-anomer. In these forms, free aldehydic group is not present.

Glucose forms open chain structure in aqueous solution which contains aldehyde at chain end. This aldehydic group reacts with NH_4OH to form oxime. On the other hand, glucose penta acetate being a cyclic structure even in aqueous form does not have terminal carbonyl group. Therefore it will not react with NH_4OH.

18. The reagent used for the given conversion is:



    a. H_2, Pd
    b. B_2H_6
    c. $NaBH_4$
    d. $LiAlH_4$

Answer: b

Solution: B_2H_6 does not reduce amide, carbonyl group and cyanide. It selectively reduces carboxylic acid to alcohol. So, for this conversion, it is the best suitable reagent.

19. 0.3 g $[ML_6]Cl_3$ of molar mass 267.46 g/mol is reacted with 0.125 M $AgNO_{3(aq)}$ solution, calculate volume of $AgNO_3$ required in mL.

Answer: 26.92

Solution: To react completely with one mole of $[ML_6]Cl_3$, 3 moles of $AgNO_3$ is required.

0.3 g $[ML_6]Cl_3$ means $\frac{0.3}{267.46}$moles of $[ML_6]Cl_3$.

So, moles of $AgNO_3$ required will be $\frac{0.3\times3}{267.46}$moles

To find the volume,

$\frac{0.3\times3}{267.46} = 0.125\times V(L)$

$V(L) = 0.02692$

$V(mL) = 26.92$

20. Given : $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$; $E^\circ = -1.23$ V

Calculate the electrode potential at pH= 5.

Answer: -0.93

Solution:

$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$; $E^\circ = -1.23$ V

$E = -1.23 - \frac{0.0591}{4}\log[H^+]^4$

$= -1.23 + (0.0591 \times pH) = -1.23 + 0.0591 \times 5$

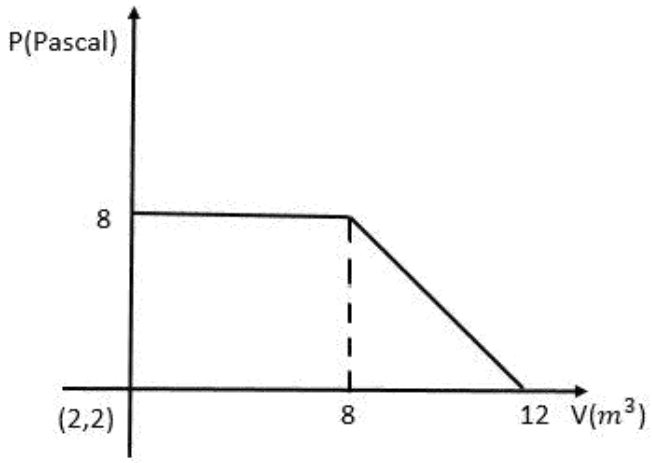
$= -1.23 + 0.2955 = -0.9345$ V $= -0.93$ V

21. Calculate the mass of $FeSO_4.7H_2O$, which must be added in 100 kg of wheat to get 10 ppm of Fe.

Answer: 4.96

Solution: 10 ppm of Fe means 10 g of Fe in 10^6 g of wheat. So, for 100 kg i.e., 10^5 g of wheat. Fe needed is 1 g. So, for 1 g of Fe, the mass of $FeSO_4.7H_2O$ required is $\frac{278}{56} = 4.96$ g.

22. A gas undergoes expansion according to the following graph. Calculate work done by the gas (in Joules).



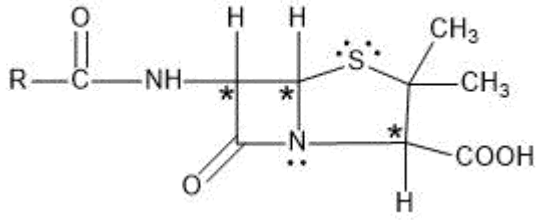
Answer: 48

Solution:
Work done by the gas
= The area under the curve
= (Area of the square) + (Area of the triangle)
= 48 J

23. The number of chiral centres in Penicillin is ____.

Answer: 3

Solution: The structure of penicillin is shown below:



So, the number of chiral centres= 3