KVPY 2018 (CHEMISTRY) – Stream - (SA)

PART-I

1. The number of water molecules in 250 mL of water is closest to
[Given: Density of water is 1.0 g mL^{-1} ; Avogadro's number = 6.023×10^{23}]
   a. 83.6×10^{23}
   b. 13.9×10^{23}
   c. 1.5×10^{23}
   d. 33.6×10^{23}

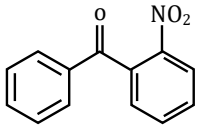
2. Among the following, the correct statement is
   a. pH decreases when solid ammonium chloride is added to a dilute aqueous solution of NH_3
   b. pH decreases when solid sodium acetate is added to dilute aqueous solution of acetic acid
   c. pH decreases when solid NaCl added to a dilute aqueous solution of NaOH
   d. pH decreases when solid sodium oxalate is added to a dilute aqueous solution of oxalic acid

3. The solubility of $BaSO_4$ in pure water (in g L^{-1}) is closest to
[Given :K_{sp} for $BaSO_4$ is 1.0×10^{-10} at 25°C. Molecular weight of $BaSO_4$ is 233 g mol^{-1}]
   a. 1.0×10^{-5}
   b. 1.0×10^{-3}
   c. 2.3×10^{-5}
   d. 2.3×10^{-3}

4. Among the following, the **INCORRECT** statement is
   a. No two electrons in an atom can have the same set of four quantum numbers
   b. The maximum number of electrons in the shell with principal quantum number, n, is equal to n2+2
   c. Electrons in an orbital must have opposite spin
   d. In the ground state, atomic orbitals are filled in the order of their increasing energies

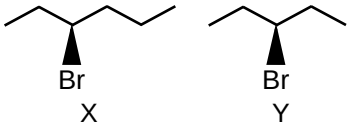
5. A container of volume 2.24 L can withstand a maximum pressure of 2 atm at 298 K before exploding. The maximum amount of nitrogen (in g) that can be safely put in this container at this temperature is closest to
   a. 2.8
   b. 5.6
   c. 1.4
   d. 4.2

6. The compound shown below



Can be readily prepared by Friedel-Crafts reaction between
   a. benzene and 2-nitrobenzoyl chloride
   b. benzyl chloride and nitrobenzene
   c. nitrobenzene and benzoyl chloride
   d. benzene and 2-nitrobenzyl chloride

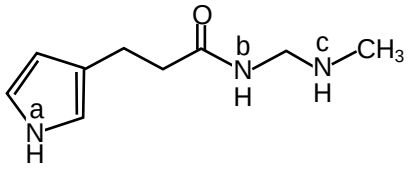
7. The correct statement about the following compounds is



X Y

a. both are chiral
b. both are achiral
c. X is chiral and Y is achiral
d. X is achiral and Y is chiral

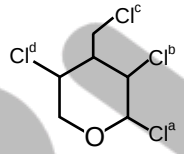
8. The most acidic proton and the strongest nucleophilic nitrogen in the following compound



Respectively, are

a. N^a–H; N^b
b. N^b–H; N^c
c. N^a-H; N^c
d. N^c-H; N^a

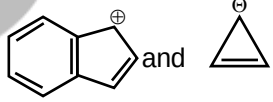
9. The chlorine atom of the following compound

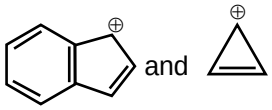


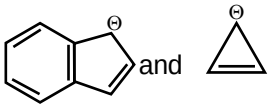
That reacts most readily with $AgNO_3$ to give a precipitate is

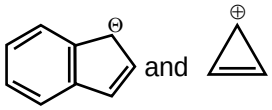
a. Cl^a
b. Cl^b
c. Cl^c
d. Cl^d

10. Among the following sets, the most stable ionic species are

a. 

b. 

c. 

d. 

11. The correct order of energy of 2s orbitals in H, Li, Na and K, is

a. K < Na < Li < H
b. Na < Li < K < H
c. Na < K < H < Li
d. H < Na < Li < K

12. The hybridization of xenon atom in XeF_4 is

a. sp^3
b. dsp^3
c. sp^3d^2
d. d^2sp^3

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13. The formal oxidation numbers of Cr and Cl in the ions $Cr_2O_7^{2-}$ and ClO_3^- respectively, are

a. +6 and + 7
b. +7 and +5
c. +6 and + 5
d. +8 and + 7

14. A filter paper soaked in salt X turns brown when exposed to HNO_3 vapor. The salt X is –

a. KCl
b. KBr
c. KI
d. K_2SO_4

15. The role of haemoglobin is to

a. store oxygen in muscles
b. transport oxygen to different parts of the body
c. convert CO to CO_2
d. convert CO_2 into carbonic acid

PART-II

16. Among the following, the species with identical bond order are

a. CO and O_2^{2-}
b. O_2^{2-} and CO
c. O_2^{2-} and B_2
d. CO and N_2^+

17. The quantity of heat (in J) required to raise the temperature of 1.0 kg of ethanol from 293.45 K to the boiling point and then change the liquid to vapour at that temperature is closest to

[Given : Boiling point of ethanol 351.45 K
Specific heat capacity of liquid ethanol 2.44 J g^{-1} K^{-1}
Latent heat of vaporization of ethanol 855 J g^{-1}]

a. 1.42×10^2
b. 9.97×10^2
c. 1.42×10^5
d. 9.97×10^5

18. A solution of 20.2 of 1,2-dibromopropane in MeOH upon heating with excess Zn produce 3.58 g of an unsaturated compound X. The yield (%) of X is closest to

[Atomic weight of Br is 80]

a. 18
b. 85
c. 89
d. 30

19. The lower stability of ethyl anion compared to methyl anion and the higher stability of ethyl radical compared to methyl radical, respectively, are due to
    a. +I effect of the methyl group in ethyl anion and σ→ p-orbital conjugation in ethyl radical
    b. –I effect of the methyl group in ethyl anion and σ → σ∗ conjugation in ethyl radical
    c. +I effect of the methyl group in both cases
    d. +I effect of the methyl group in ethyl anion and σ → σ∗ conjugation in ethyl radical

20. The F – Br-F bond angles in BrF_5 and the Cl – P – Cl bond angles in PCl_5 , respectively, are
    a. identical in BrF_5 but non-identical in PCl_5
    b. identical in BrF_5 and identical in PCl_5
    c. non-identical in BrF_5 but identical in PCl_5
    d. non-identical in BrF_5 and non-identical in PCl_5

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ANSWER KEYS

1. (a)	2. (a)	3. (d)	4. (b)	5. (b)	6. (a)	7. (c)	8. (b)	9. (a)	10. (d)
11. (a)	12. (c)	13.(c)	14.(c)	15. (b)	16. (c)	17. (d)	18.(b)	19. (a)	20. (d)

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Solution

PART-I

1. (a)

Given

Density of water = 1 g / ml

Volume of water = 250 ml

$\because$ We know tha $d = \frac{m}{v} \Rightarrow m = d \times v$

$\therefore$ Mass of $H_2O = 250 \times 1 = 250$ g

Mw of $H_2O = 18$ g mol^{-1}

Moles of $H_2O = \frac{wt}{Mw} = \frac{250}{18} = 13.89$ moles

$\because$ We know that in 1 mole, the number of H_2O Molecules $= N_A = 6.023 \times 10^{23}$ molecules

$\therefore$ In 13.89 moles, the no of H_2O Molecules

$= 6.023 \times 10^{23} \times 13.89$

$= 83.6 \times 10^{23}$ Molecules

Therefore, the correct option is (a).

2. (a)

dil. aq. Sol^n of $NH_3 \rightarrow NH_3 + H_2O \Rightarrow NH_4OH$ (Weak Base)

$NH_4Cl \xrightarrow{H_2O} NH_4OH + HCl$

(Weak Base) Strong acid (100% Ionisation)

$\Rightarrow$ If we add NH_4Cl, It is an acidic salt because it is prepared by strong acid (HCl) weak base (NH_4OH)

$\Rightarrow$ So overall pH $\downarrow$ because concentrationof H^+ ion $\uparrow$

$pH \propto \frac{1}{[H^+]}$ or $[H^+] \uparrow$ pH $\downarrow$

Therefore, the correct option is (a).

3. (d)

Given,

K_{sp} of $BaSO_4 = 1.0 \times 10^{-10}$

Molecular weight of $BaSO_4 = 233$ g mol^{-1} $\quad \{\text{Moles(n)} = \frac{\text{weight(g)}}{\text{molecular weight}}\}$

$BaSO_4 \rightleftharpoons Ba^{+2} + SO_4^{2-}$

$K_{sp}\ (BaSO_4) = S^2$

$\Rightarrow$ $S = \sqrt{K_{sp}} = \sqrt{1\times10^{-10}} = 10^{-5}$ mol L^{-1}

$\Rightarrow$ $S = 10^{-5} \times Mw = 10^{-5} \times 233$ g L^{-1}

Moles (n) = $\frac{wt(g)}{mw}$

Wt (g) = n × Mw

$S = 2.33 \times 10^{-3}$ gL^{-1}

Therefore, the correct option is (d).

4. (b)

(A) According to Pauli's Exclusion Principle, no two e^-s in the same atom can have identical values for all four of their quantum numbers.

Ex for He $\rightarrow 1s^2$ $\boxed{\uparrow\downarrow}$

$1^{st}e^- \rightarrow n = 1, \ \ell = 0, \ m = 0 \qquad s = +\frac{1}{2}$

$II^{nd}e^- \rightarrow n = 1, \ \ell = 0, \ m = 0 \qquad s = -\frac{1}{2}$

(B) The Maximum number of electrons in the shell with principle quantum number'n' is equal to $2n^2$

(C) Electron in an orbital must have opposite Spin Example $\boxed{\downarrow\uparrow}$

(D) In ground state, atomic orbitals are filled in the order of their ↑ energy [see $(n+\ell)$ Rule)

1s > 2s > 2p > 3s.....

Therefore, the correct option is (b).

5. (b)

Given v = 2.24 L T = 298 K

p = 2 atm R = 0.0821 atm mol^{-1} k^{-1}

from ideal gas equation Pv =nRT

$\Rightarrow$ Moles of $N_2 = \frac{Pv}{RT} = \frac{2\times2.24}{0.0821\times298} = 0.1831$ moles.

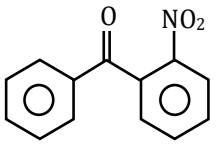
$\Rightarrow$ Molecular weight of N_2 = 28 g mol^{-1}

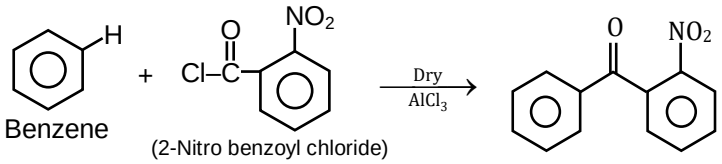
$\therefore$ Moles = $\frac{\text{Weight}}{\text{Molecular weight}} \Rightarrow$ Weight (g) = moles × Molecular Weight (g mol^{-1})

Wt of $N_2 = 0.1831 \times 28 \approx 5.6$ g

Therefore, the correct option is (B).

6. (a)

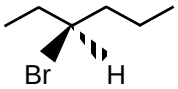
The preparation of  via friedel craft Reaction follow as



Therefore, the correct option is (a).

7. (c)

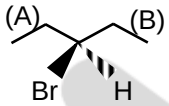
Asymmetric centre → sp^3 carbon with 4 different group attached.



(X)

Here all 4 group are different

Hence It is a chiral carbon



(Y)

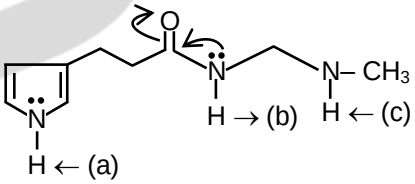
Here two groups are same

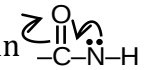
→ Hence it is not chiral compound.

So,here X is chiral & Y is achiral compound.

Therefore, the correct option is (c).

8. (b)

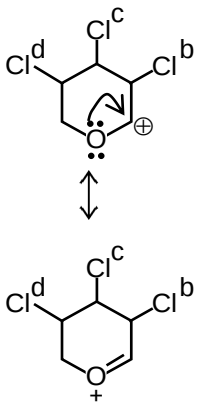


⇒ Due to Resonance of N & O in  . It is most acidic.

⇒ In case of (C) the lone pair of N is not involved in delocalization, hence it is strongest Nucleophilic.

Therefore, the correct option is (b).

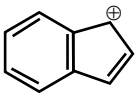
9. (a)



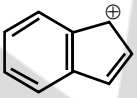
→ It is most stable carbocation due to Resonance

Hence,it reacts most readily with $AgNO_3$ to give a precipitate
Therefore, the correct option is (a).

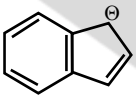
10. (d)

(A) 
$(8\pi)e^-$ Anti Aromatic

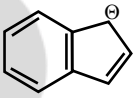

$(4\pi)e^-$ Anti Aromatic

(B) 
Anti Aromatic


Aromatic

(C) 
Aromatic


Anti Aromatic

(D) 
Aromatic


Aromatic

Order of stability
Aromatic > Non Aromatic > Anti Aromatic
Hence option (D) correct because in case of (D) both are aromatic

11. (a)

As we go down the group IA, there is ↑ in shell, so size of atom ↑& energy of 2s orbital ↓

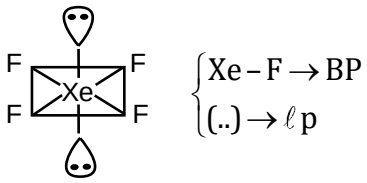
Hence the correct order is ⇒ K < Na < Li < H
Therefore, the correct option is (a).

12. (c)

In XeF_4 : $\rightarrow$ Xe has $8e^-$ its outer most shell (initial)

$\rightarrow$ After formation of XeF_4

It has 4 bond pair and 2 lone pair as shown in figure



Hence steric number = $\ell p + BP = 6$

Thus the hybridization is SP^3d^2
Therefore, the correct option is (c).

13. (c)
Filter paper soaked with KI turns brown when exposed to HNO_3 vapour to libration of I_2, the reaction follow as
$6KI + 8HNO_3 \longrightarrow 6KNO_3 + 4H_2O + 2NO + 3I_2$
Therefore, the correct option is (c).

14. (c)
Let the oxidation number of Cr = x
$Cr_2O_7^{2-}$ $\Rightarrow 2x + (-2) \times 7 = -2$
$\Rightarrow 2x = 12$
$x = +6$
Let the oxidation number of Cl = x
$ClO_3^- \rightarrow x\ (-2) \times 3 = -1$
$\Rightarrow x = +5$
Therefore, the correct option is (c).

15. (b)
The role of haemoglobin is to transport of oxygen to different parts of the body.
Therefore, the correct option is (b).

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PART-II

16. (c)

According to MOT, bond order of all species are

(A) $CO \rightarrow O \equiv C$, $O_2^{2-} \rightarrow \overset{\Theta}{O} - \overset{\Theta}{O}$

B.O = 3 B.O = 1

(B) $O_2^{-2} \rightarrow$ B.O = 1 , $CO \rightarrow$ B.O = 3

(C) $CO \rightarrow$ B.O = 3 , $B_2 \rightarrow$ B – B

B.O = 1

(D) $CO \rightarrow$ B.O = 3 , $N_2^{+} \rightarrow$ B.O = 2.5

Hence here identical bond order observed in case of (C)

$\Rightarrow$Bond order, $O_2^{2-} = B_2 = 1$

Therefore, the correct option is (c).

17. (d)

$C_2H_5OH(\ell) \xrightarrow{\Delta} C_2H_5OH(\ell) \longrightarrow C_2H_5OH(g)$

T = 293.45K T = T_b = 351.45K T = T_b = 351.45K

(T_b = boiling point)

Heat required (Q) = MsΔT + Heat of vaporization

$= 10^3 \times 2.44\,[351.45 - 293.45] + 10^3(855)$

$= 10^3\,[(2.44 \times 58) + 855] = 10^3[996.52]$

$Q = 9.97 \times 10^5$ J

Therefore, the correct option is (d).

18. (b)

Reaction of Zn with 1, 2 dibromo propane in MeOH follow as

$$CH_3\underset{Br}{\underset{|}{-}}CH\underset{Br}{\underset{|}{-}}CH_3 \xrightarrow[MeOH]{Zn} CH_3{=}CH{-}CH_3 + ZnBr_2$$

$\rightarrow$ Here 1 mol. Reactant give one mole product

$\rightarrow$ M. wt of Reactant (1, 2 dibromo propane) = 202 g mol^{-1}

$\rightarrow$ wt of Reactant = 20.2 g

$\rightarrow$ Mw of product = 42 g mol^{-1}

wt of product = 3.58 g

$\because$ We know moles = $\dfrac{\text{wt of substance}}{\text{Mw of substance}}$

Obtain moles of product = $\dfrac{3.58}{42} = 0.085\text{moles}$

$\because$ Moles of Reactant = $\dfrac{20.2}{202} = 0.1\,\text{moles}$

$\rightarrow$ Now according to equation theoretically,

Mole of Product = moles of Reactant = 0.1 moles

% yield = $\dfrac{\text{obtain Moles}}{\text{theoriticle moles}} \times 100$

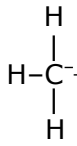
$= \dfrac{0.085}{0.1} \times 100 = 85\%$

Therefore, the correct option is (b).

19. (a)

(1) $\boxed{CH_3} - \overset{\ominus}{C}H_2 \rightarrow sp^3$hybridization$\rightarrow$Pyramidal shape $\rightarrow$No hyper conjugation

+IEffect



$\rightarrow$ No, +I effect group attached

In ethyl anion, methyl group have + I effect which ↑ the e^- density on carbanion and decrease the stability

(2) $CH_3 - \dot{C}H_2$, $\dot{C}H_3$

↓

Due to σ – p orbital conjugation (Hyperconjugation), it is more stable compared to $\dot{C}H_3$ redical.

$\Rightarrow$ Number of α H ↑ stability of Radical ↑. Because number of hyperconjugation structure ↑ and energy of molecule ↓.

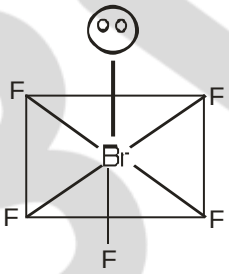
Therefore, the correct option is (a).

20. (d)

(1) $BrF_5 \longrightarrow \frac{7+5}{2} = 6 \rightarrow sp^3d^2$Hybridisation

$n \rightarrow \ell p + Bp \quad \Rightarrow \quad 6 = 5 + \ell p$

$\ell p = 1$



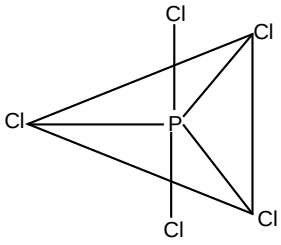
(BrF_5)

Hence the shape of BrF_5 is square pyramidal

Hence here [F– Br – F] bond angle is non identicals

(2) $PCl_5 \rightarrow \frac{5+5}{2} = 5 \rightarrow Sp^3d$

[$\ell p = n - BP = 5 - 5 = 0$]



$\rightarrow$ Hence the shape is Trigonal bipyramidal

$\rightarrow$ (Cl – P – Cl) bond angle 120° & 90°

$\Rightarrow$ So, here (Cl–P–Cl) bond angle is not identical

Therefore, the correct option is (d).