Total Time : 120 minutes (A–1 and A–2)

A – 1
ONLY ONE OUT OF FOUR OPTIONS IS CORRECT

1. Myoglobin, (Mb), an oxygen storage protein, contains 0.34% Fe by mass and in each molecule of myoglobin one ion of Fe is present. Molar mass of Mb (g mol^{-1}) is (Molar mass of Fe = 5.845 g mol^{-1})

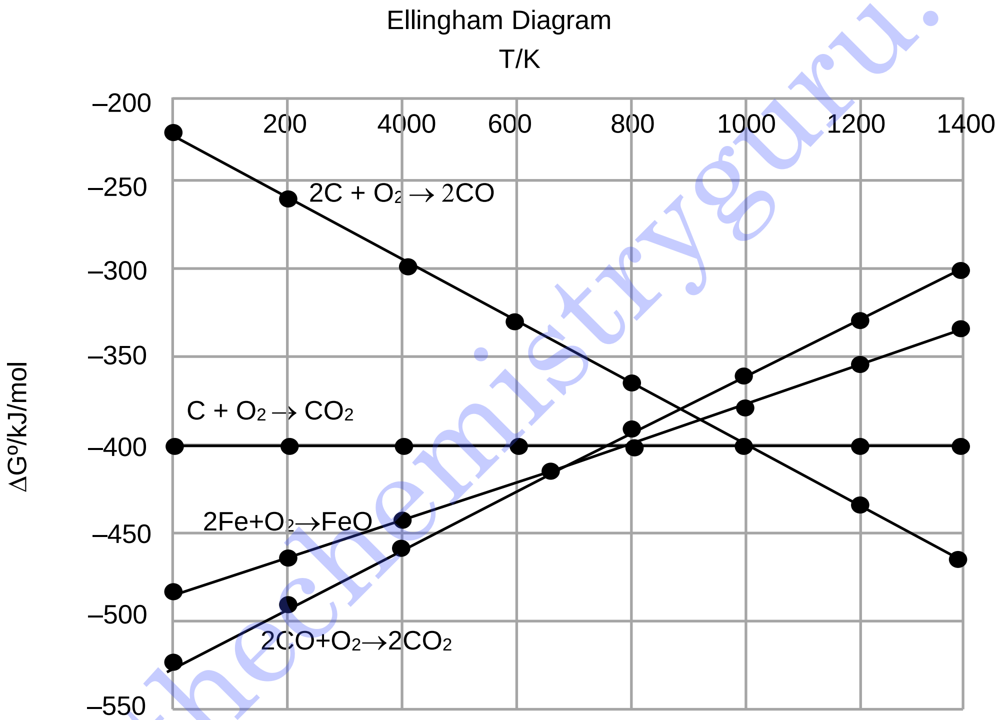
(A) 16407 (B) 164206 (C) 16425 (D) 164250

Ans. (C)

Sol. Molar mass of Myoglobin (Mb)

$$= \frac{55.845}{0.34} \times 100 = 16425$$

2. The following Ellingham diagram depicts the oxidation of 'C', 'CO' and Fe'. Which of the following is correct?



I. FeO can be reduced by C below 600 K
II. FeO can be reduced by CO below 600 K
III. FeO can be reduced by C above 1000 K
IV. FeO can be reduced by CO above 1000 K

(A) II and III (B) I and IV (C) I and III (D) II and IV

Ans. (A)

Sol. Below 600 K, reaction-

$FeO + CO \longrightarrow Fe + CO_2$ is feasible

Above 1000 K, reaction-

$FeO + C \longrightarrow Fe + CO$ is feasible

3. A balance having a precision of 0.0001 g was used to measure a mass of a sample of about 15 g. The number of significant figures to be reported in this measurement is

(A) 2 (B) 3 (C) 5 (D) 1

Ans. (C)

4. N^{3-}, F^-, Na^+ and Mg^{2+}, have the same number of electrons. Which of them will have the smallest and the largest ionic radii respectively?

(A) Mg^{2+} and N^{3-} (B) Mg^{2+} and Na^+ (C) N^{3-} and Na^+ (D) F^- and N^{3-}

Ans. (A)

Sol. For isoelectronic species, as no. of proton$\uparrow \Rightarrow$ size$\downarrow$

so correct order of size is $Mg^{2+} < Na^+ < F^- < N^{3-}$

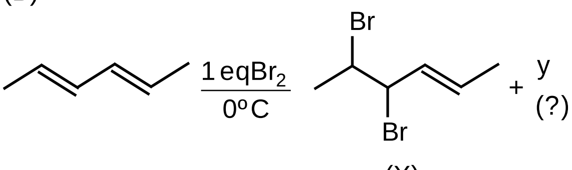
5. The reaction of 2,4-hexadiene with one equivalent of bromine at 0ºC gives a mixture of two compounds 'X' and 'Y'. If 'X' is 4,5-dibromohex-2-ene, 'Y' is

(A) 2,5-dibromohex-2-ene (B) 2,5-dibromohex-3-ene

(C) 2,3-dibromohex-3-ene (D) 3,4-dibromohex-3-ene

Ans. (B)

Sol.

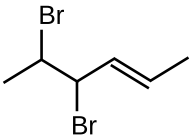


(X)

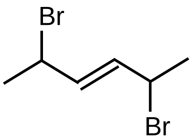
Conjugated diene give two types of electrophilic addition reaction.

(A) 1,2-addition

(B) 1,4-addition

X is 

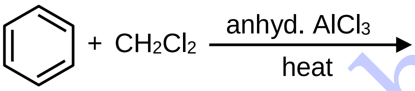
1,2 addition

Y will be 

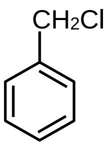
1,4,-addition

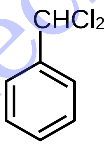
So answer is 2,5-Dibromohex-3-ene

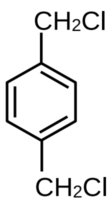
6. The major product of the following reaction is

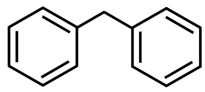


Excess

(A) 

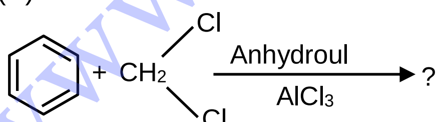
(B) 

(C) 

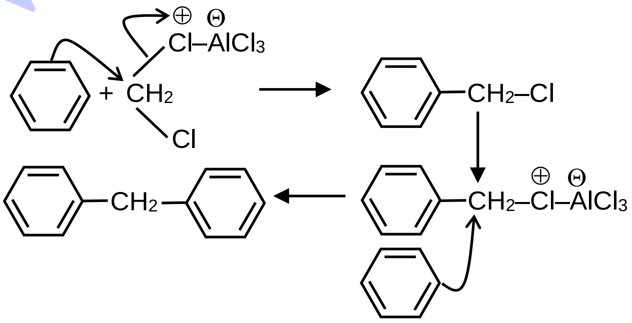
(D) 

Ans. (D)

Sol.



Excess



7. An electrochemical cell was constructed with Fe^{2+}/Fe and Cd^{2+}/Cd at 25ºC with initial concentrations of 'Fe^{2+}] = 0.800 M and [Cd^{2+}] = 0.250 M. The EMF of the cell when [Cd^{2+}] becomes 0.100 M is

Half cell	Eº(V)
$Fe^{2+}(aq)/Fe(s)$	– 0.44
$Cd^{2+}(aq)/Cd(s)$	– 0.40

(A) 0.013 V (B) 0.011 V (C) 0. 051 V (D) 0.022 V

Ans. (B)

Sol. Reaction

$Cd^{2+} + Fe(s) \longrightarrow Fe^{2+} + Cd(s)$

t = 0 0.25 M 0.8 M

t = t 0.25 – x 0.8 + x

= 0.1

$\therefore$ x = 0.15.

At this instance [Cd^{2+}] = 0.1 M

[Fe^{2+}] = 0.8 + x = 0.95

$$E_{cell} = E^0_{cell} - \frac{0.059}{2}\log\frac{[Fe^{2+}]}{[Cd^{2+}]}$$

$$E_{cell} = (-0.4 + 0.44) - \frac{0.059}{2}\log\left(\frac{0.95}{0.1}\right)$$

= 0.011V

8. The kinetic energy of the photoelectrons ejected by a metal surface increased from 0.6 eV to 0.9 eV when the energy of the incident photons was increased by 20%. The work function of the metal is

(A) 0.66 eV (B) 0.72 eV (C) 0.90 eV (D) 0.30 eV

Ans. (C)

Sol. $KE_{max} = E - E_0$

$0.6 = E - E_0 \Rightarrow E = 0.6 + E_0$

$0.9 = 1.2E - E_0 \Rightarrow 1.2E = 0.9 + E_0$

On dividing $\frac{1}{1.2} = \frac{0.6 + E_0}{0.9 + E_0}$

$0.9 + E_0 = 0.72 + 1.2\,E_0$

$\therefore E_0 = 0.9$ eV

9. The alkene ligand (π –C_2R_4) is both a 'σ' donoar and a 'π' acceptor, similar to the CO ligand in metal carbonyls, and exhibits synergic bonding with metals. Correct order of C–C bond length in $K[PtCl_3(\pi\text{–}C_2R_4)]$ complexes in which R = H, F or CN is

(A) H > F > CN (B) H > CN > F (C) CN > F > H (D) F > H > CN

Ans. (C)

Sol. $K[PtCl_3(\pi\text{–}C_2R_4]$

In C_2R_4 as electron withdrawing nature of R$\uparrow$ $\Rightarrow$ back bonding from pt to alkene$\uparrow$

$\Rightarrow$ C–C bond order$\downarrow$

so order of electron withdrawing nature-

H < F < CN

order of C–C bond length

$K[PtCl_3(\pi\text{–}C_2R_4)] < K[PtCl_3(\pi\text{–}C_2F_4)] < K[PtCl_3(\pi\text{–}C_2(CN)_4)]$

10. The correct order of CFSE among $[Zn(NH_3)_4]^{2+}$ and $[Co(NH_3)_6]^{2+}$ and $[Co(NH_3)_6]^{3+}$ is

(A) $[Co(NH_3)_6]^{3+} > [Co(NH_3)_6]^{2+} > [Zn(NH_3)_4]^{2+}$ (B) $[Zn(NH_3)_4]^{2+} > [Co(NH_3)_6]^{2+} > [Co(NH_3)_6]^{3+}$

(C) $[Co(NH_3)_6]^{3+} > [Zn(NH_3)_4]^{2+} > [Co(NH_3)_6]^{2+}$ (D) $[Co(NH_3)_6]^{2+} > [Co(NH_3)_6]^{3+} > [Zn(NH_3)_4]^{2+}$

Ans. (A)

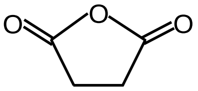
Sol. CFSE in $[Zn(NH_3)_4]^{2+}$ is zero.

so correct order of CFSE

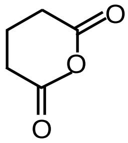
$Co(NH_3)_6^{3+} > Co(NH_3)_6^{2+} > [Zn(NH_3)_4]^{2+}$

11. When acid 'X' is heated to 230 ºC, along with CO_2 and H_2O, a compound 'Y' is formed. If 'X' is $HOOC(CH_2)_2CH(COOH)_2$, the structure of 'Y' is

(A) $HOOC(CH_2)_3COOH$

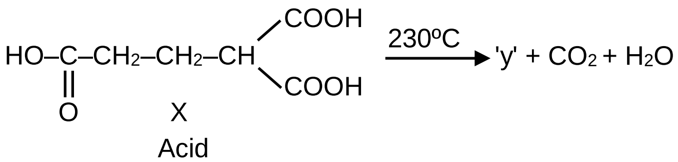
(B) 

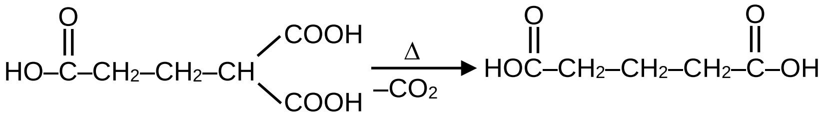
(C) $CH_3CH_2CH(COOH)_2$

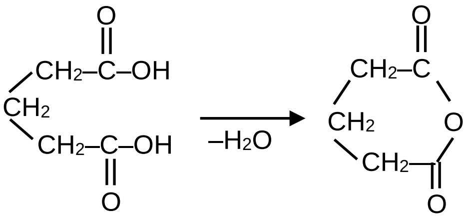
(D) 

Ans. (D)

Sol.







12. Which of the following is correct about the isoelectronic species, Li^+ and H^-?

I. H^- is larger in size than Li^+

II. Li^+ is better reducing agent than H^-

III. It requires more energy to remove and electron from H^- and from Li^+

IV. The chemical properties of the two ions are the same

(A) I only (B) II and III (C) I, II and IV (D) I and II

Ans. (A)

Sol. $Li^+ < H^-$ size.

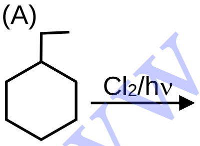
$Li^+ < H^-$ reducing nature.

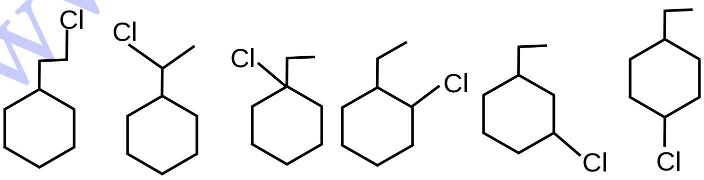
$Li^+ > H^-$ ionization enthalpy.

13. Number of products formed (ignoring stereoisomerism) in the monochlorination of ethylcyclohexane is

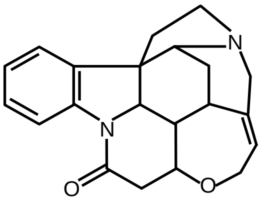
(A) 6 (B) 8 (C) 5 (D) 4

Ans. (A)

Sol.  Monochloro products (ignoring stereoisomers)



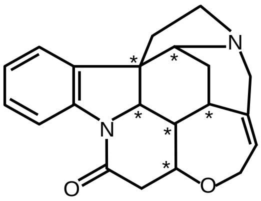
14. The number of asymmetric carbon atoms in strychnine, whose structure given below is



(A) 5 (B) 4 (C) 6 (D) 7

Ans. (C)

Sol.



Number of asymmetric carbon = 6

15. Molten NaCl is electrolysed for 35 minutes with a currect of 3.50 A at 40ºC and 1 bar pressure. Volume of chlorine gas evolved in this electrolysis is

(A) 0.016 L (B) 0.98 L (C) 9.8 L (D) 1.96 L

Ans. (B)

Sol. $2NaCl \longrightarrow 2Na^+ + 2Cl^- \longrightarrow Cl_2$

Mole of electron transfer = $\frac{i \times t}{F}$

$= \frac{3.5 \times 35 \times 60}{96500} = 0.076$

Moles of Cl_2 evolved = $\frac{0.076}{2} = 0.038$

Volume of Cl_2 = $\frac{nRT}{P} = \frac{0.038 \times 0.083 \times 313}{1}$

= 0.98 Lt.

16. Which of the following pairs of compounds can be stable while retaining the identity of each compound in the pair over a period of time?

I. $FeCl_3$, $SnCl_2$ II. $HgCl_2$, $SnCl_2$ III. $FeCl_2$, $SnCl_2$ IV. $FeCl_3$, KI

(A) I only (B) I and III (C) III only (D) II and IV

Ans. (C)

Sol. $HgCl_2 + SnCl_2 \longrightarrow SnCl_4 + Hg$

$FeCl_3 + SnCl_2 \longrightarrow FeCl_2 + SnCl_4$

$FeCl_3 + KI \longrightarrow FeCl_2 + I_2 + KCl$

17. The reaction $xX(g) \rightleftharpoons yY(g) + zZ(g)$ was carried out at a certain temperature with an initial pressure of X = 30 bar. Initially 'Y' and 'Z' were not present. If the equilibrium partial pressure of 'X', 'Y' and 'Z' are 20, 5 and 10 bar respectively x : y : z is

(A) 4 : 1 : 2 (B) 2 : 1 : 2 (C) 1 : 2 : 1 (D) 1 : 1 :2

Ans. (B)

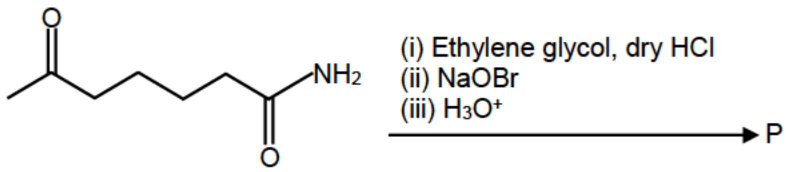
Sol.

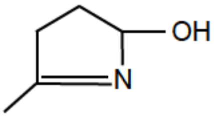
	$xX(g) \rightleftharpoons$	$yY(g)$ +	$zZ(g)$
t = 0	30		
$t = t_{eq}$	30–xn = 20	yn = 5	zn = 10

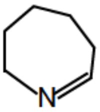
∴ xn : yn : zn = 10 : 5 : 10

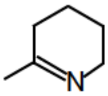
x : y : x = 2 : 1 : 2

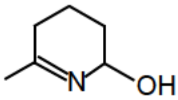
18. The major product 'P' formed in the following sequence of reactions is



(A) 

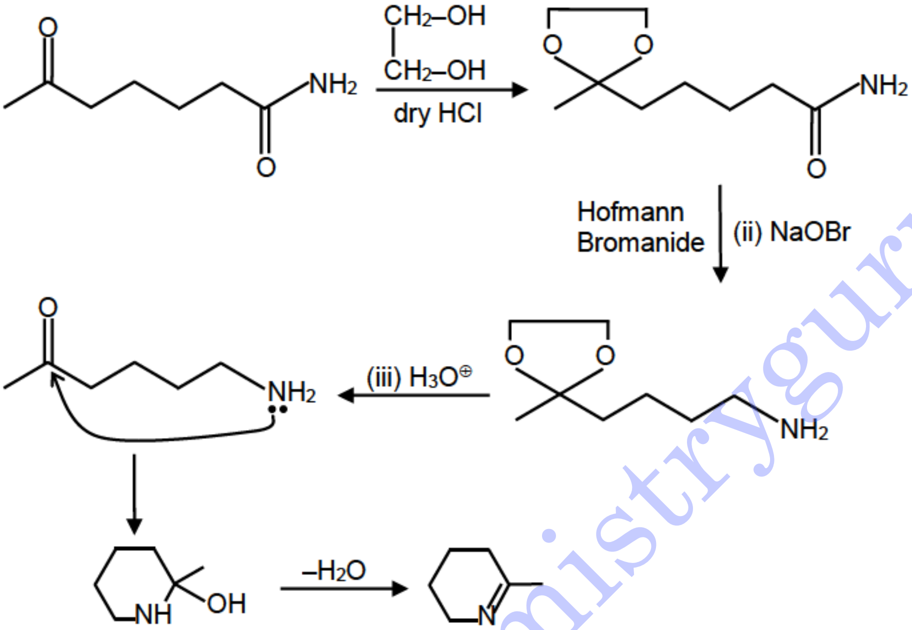
(B) 

N
(C) 

(D) 

Ans. (C)

Sol.



19. Sodium lauryl sulphate (SLS) is a surface active agent, which is adsorbed on water surface. The number of molecules of SLS that can be adsorbed on the surface of a spherical water droplet of diameter 3.5 mm is

(effective area of one molecule of SLS = 4.18 nm^2)

(A) 9.20×10^{12} (B) 9.20×10^{18} (C) 1.15×10^{12} (D) 3.68×10^{13}

Ans. (A)

Sol. Total surface area of water droplet

$= 4\pi r^2$

$= 4 \times \frac{22}{7} \times \frac{(3.5 \times 10^{+6})^2}{4}$

$= 3.85 \times 10^{13}\ nm^2$

No. of molecules adsorbed $= \frac{3.85 \times 10^{13}}{4.18}$

$= 9.21 \times 10^{12}$

20. The unit of Planck's constant, 'h', is the same as that of

(A) angular momentum (B) energy (C) wavelength (D) frequency

Ans. (A)

Sol. Unit of Planck's constant 'h' = Unit of angular momentum

$mvr = \frac{nh}{2\pi}$

21. The set in which all the species are diamagnetic is

(A) B_2, O_2, NO

(B) O_2, O_2^+, CO

(C) N_2, O_2^-, CN^-

(D) C_2, O_2^{2-}, NO^+

Ans. (D)

Sol. B_2, O_2, NO, O_2^+, O_2^- $\rightarrow$ Paramagnetic

O_2^{2-}, C_2, N_2, NO^+, CO $\rightarrow$ Diamagnetic

22. A solid comprises of three types of elements, 'P', 'Q' and 'R'. 'P' forms an FCC lattice in which 'Q' and 'R' occupy all the tetrahedral voids and half the octahedral voids respectively. The molecular formula of the solid is

(A) P_2Q_2R

(B) PQ_2R_4

(C) P_4Q_2R

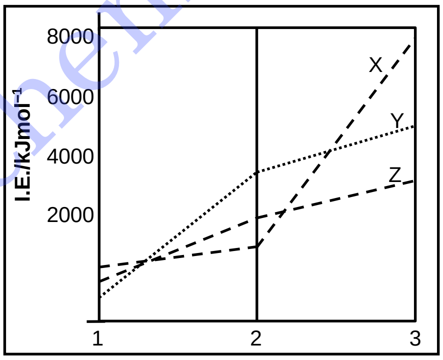
(D) P_4QR

Ans. (A)

Sol. Formula of solid

$= P_4Q_8R_{4/2} = P_4Q_8R_2 = P_2Q_4R$

23. The following qualitative plots depict the first, second and third ionization energies (I.E.) of Mg, Al and K. Among the following, the correct match of I.E. and the metal is



(A) X-Al; Y-Mg ; Z-K

(B) X-Mg; Y-Al ; Z-K

(C) X-Mg; Y-K ; Z-Al

(D) X-Al; Y-K ; Z-Mg

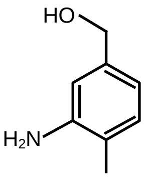
Ans. (C)

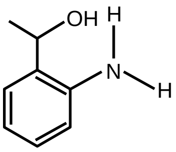
Sol.

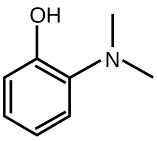
		K	Mg	Al
		$4s^1$	$3s^2$	$3s^23p^1$
Order	IE_1	K < Al < Mg		
Order	IE_2	Mg < Al < K		
Order	IE_3	Al < K < Mg		

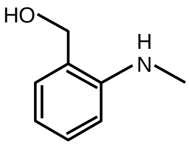
24. The structure of compound 'X' ($C_8H_{11}NO$) based on the following tests and observations is

Reagent/s	Observation
Neutral $FeCl_3$	No coloration
Lucas reagent	Turbidity
$NaNO_2$/HCl at 273 K	Yellow oil

(A) 

(B) 

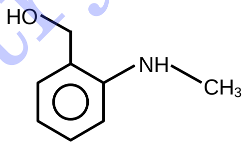
(C) 

(D) 

Ans. (D)

Sol. X($C_8H_{11}NO$) —

- Neutral $FeCl_3$ ⟶ No coloration (No phenol)
- Lucas reagent ⟶ Turbidity (alcohol)
- $NaNO_2$/HCl 273 ⟶ Yellow oil (sec. Aromatic ammine)



25. The number of stereoisomers is maximum for

(A) $[Co(en)_3]^{3+}$ (B) $[Co(en)_2ClBr]^+$

(C) $[Co(NH_3)_4Cl_2]^+$ (D) $[Co(NH_3)_4ClBr]^+$

Ans. (B)

Sol. $[Co(en)_3]^{3+} \longrightarrow$ Total no. of stereoisomers = 2

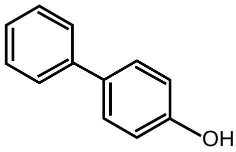
$[Co(en)_2ClBr]^+ \longrightarrow$ Total no. of stereoisomers = 2 + 1 = 3

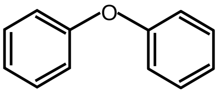
$[Co(NH_3)_4Cl_2]^+ \longrightarrow$ Total no. of stereoisomers = 2

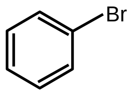
$[Co(NH_3)_4ClBr]^+ \longrightarrow$ Total no. of stereoisomers = 2

26. Reaction of C_6H_5MgBr with phenol gives

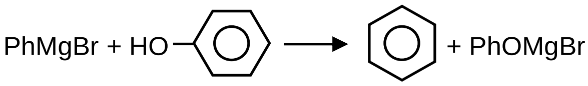
(A) 

(B) 

(C) 

(D) 

Ans. (A)

Sol. 

27. The power and wavelength emitted by a laser pointer commonly used in Power Point presentations are 1.0 mW and 670 nm respectively. Number of photons emitted by this pointer during a presentation of 5 minutes is

(A) 1.01×10^9

(B) 1.01×10^{21}

(C) 1.6×10^{16}

(D) 1.01×10^{18}

Ans. (D)

Sol. Total energy emitted in 5 min = $10^{-3} \times 5 \times 60$ J = 0.3 J

$$E = \frac{Nhc}{\lambda}$$

$$N = \frac{E \times \lambda}{hc} = \frac{0.3 \times 670 \times 10^{-9}}{6.626 \times 10^{-34} \times 3 \times 10^{8}} = 1.01 \times 10^{18}$$

28. The work done (kJ) in the irreversible isothermal compression of 2.0 moles of an ideal gas from 1 bar to 100 bar at 25ºC at constant external pressure of 500 bar is

(A) 2452

(B) 490

(C) 2486

(D) – 490

Ans. (A)

Sol. $W = -P_{ext}(\Delta V)$

$$= -500\left(\frac{nRT}{100} - \frac{nRT}{1}\right)$$

$$= -nRT(5 - 500)$$

$$= +2 \times 8.314 \times 298 \times 495 \times 10^{-3} \text{ kJ} = +2452 \text{ kJ}$$

29. Atropine ($C_{17}H_{23}O_3N$) is a naturally occurring compound used to treat certain types of poisoning. The degree of unsaturation in atropine is

(A) 7

(B) 6

(C) 5

(D) 4

Ans. (A)

Sol. ($C_{17}H_{23}O_3N$)

$$DU = \frac{2N+2+Z-M-X}{2}$$

Where = N = no. of carbon

M = no. of H

Z = no. of N

X = no. of Halogen

Hence = DU = 7

30. $MnCl_2.4H_2O$ (molar mass = 198 g mol^{-1}) when dissolved in water forms a complex of Mn^{2+}. An aqueous solution containing 0.400 g of $MnCl_2.4H_2O$ was passed through a column of a cation exchange resin and the acid solution coming out was neutralized with 10 mL of 0.20 M NaOH. The formula of the complex formed is

(A) $[Mn(H_2O)_4Cl_2]$

(B) $[Mn(H_2O)_6]Cl_2$

(C) $[Mn(H_2O)_5Cl]Cl$

(D) $Na[Mn(H_2O)_3Cl_3]$

Ans. (C)

Sol. $MCl_2.4H_2O \longrightarrow xH^+ \xrightarrow{NaOH}$

moles of compound taken = $\frac{0.4}{198}$

moles of H^+ formed = $\frac{x \times 0.4}{198}$

moles of OH^- required = 0.2 × 0.01 = 0.002

$\therefore \frac{x \times 0.4}{198} = 0.002$

$\Rightarrow x \approx 1$

Compound is $[Mn(H_2O)_5Cl]Cl$

31. Which of the following is NOT correct about hydrides ?
I. Saline hydrides are stoichiometric and metallic hydrides are non-stoichiometric

II. BeH_2 is monomeric whereas MgH_2 is polymeric

III. Hydrides of the elements of Group 13 are electron deficient and those of Group 15 are electron rich

IV. NaH reacts with water and liberates H_2 whereas B_2H_6 does not react with water

(A) IV only

(B) I and III

(C) III only

(D) II and IV

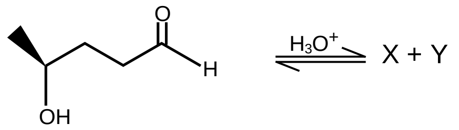
Ans. (D)

Sol. BeH_2 is polymetric while MgH_2 is monomeric

$2NaH + H_2O \longrightarrow 2NaOH + H_2$

$B_2H_6 + H_2O \longrightarrow B(OH)_3 + H_2$

32. The compounds 'X' and 'Y' formed in the following reaction are



(A) hemiacetals with identical physical and chemical properties

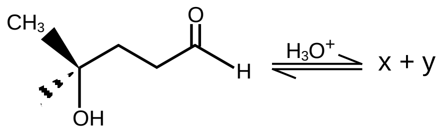
(B) acetals with identical physical and chemical properties

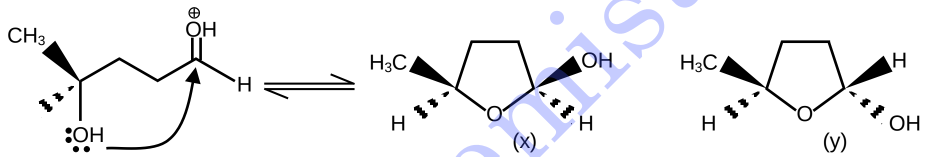
(C) hemiacetals with different physical and chemical properties

(D) acetals with different physical and chemical properties

Ans. (C)

Sol.





x and y are hemiacetal and are diastereisomers of each other, so they will have different physical and chemical properties.

33. Aqueous solution of slaked lime, $Ca(OH)_2$, is extensively used in municipal waste water treatment. Maximum pH possible in an aqueous solution of slaked lime is (K_{sp} of $Ca(OH)_2 = 5.5 \times 10^{-6}$)

(A) 1.66 (B) 8.14

(C) 12.04 (D) 12.34

Ans. (D)

Sol. $Ca(OH)_2(s) \rightleftharpoons Ca^{2+} + 2OH^-$

S 2S

$K_{sp} = 4S^3$; S = 0.011

$\therefore [OH^-] = 2S = 0.022$

$P_{OH} = 1.65$; = $P_H = 12.34$

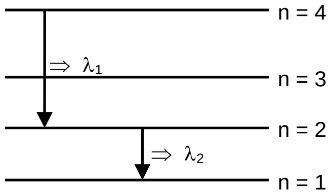
34. An electron present in the third exited state of a H atom returns of the first exited state and then to the ground state. If λ_1 and λ_2 are the wavelengths of light emitted in these two transitions respectively, $\lambda_1 : \lambda_2$ is

(A) 4 : 1 (B) 5 : 9

(C) 3 : 1 (D) 2 : 1

Ans. (A)

Sol.



$$\frac{1}{\lambda_1} = R_H\left(\frac{1}{4} - \frac{1}{16}\right) \Rightarrow \lambda_1 = \frac{16}{3R_H}$$

$$\frac{1}{\lambda_2} = R_H\left(\frac{1}{1} - \frac{1}{4}\right) \Rightarrow \lambda_2 = \frac{4}{3R_H}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{16}{4} = \frac{4}{1}$$

35. The percentage dissociation of 0.08 M aqueous acetic acid solution at 25ºC is (K_a of acetic acid at 25ºC = 1.8×10^{-5})

(A) 2.92 (B) 1.5

(C) 1.2 (D) 4.8

Ans. (B)

Sol. $CH_3COOH \rightleftharpoons CH_3COO^- + H^{\oplus}$

C

$C(1-\alpha)$ $C\alpha$ $C\alpha$

$$\alpha = \sqrt{\frac{K_a}{C}} = \sqrt{\frac{1.8 \times 10^{-5}}{0.08}} = 0.015$$

% dissociation = 1.5

36. In which of the following, is a new C-C bond formed in the product ?

I. $CH_3CHO \xrightarrow{\text{dil. NaOH}}$

II. $CH_3MgCl + C_2H_5OH \xrightarrow{\text{heat}}$

III. $CO_2 + CH_3MgBr \xrightarrow{H_3O^+}$

IV. $C_2H_2 + NaNH_2 \xrightarrow{CH_3Br}$

(A) I, III and IV (B) II and III (C) III only (D) III and IV

Ans. (A)

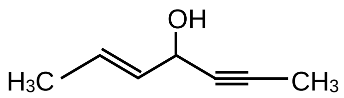
Sol. (I) $CH_3CH = O \xrightarrow[\text{Aldol}]{\text{dil / NaOH}} CH_3\text{–}CH(OH)\text{–}CH_2\text{–}C(=O)\text{–}H$ (C–C bond formed)

(II) $CH_3MgBr + EtOH \xrightarrow[\text{acid, base}]{\text{heat}}$ (CH_4 + EtOMgBr (No C–C bond)

(III) $CO_2 + CH_3MgBr \xrightarrow{H_3O^{\oplus}} CH_3COOH$ (C–C bond)

(IV) $CH \equiv CH + NaNH_2 \longrightarrow CH_3\equiv\ddot{C}^{-}$ $\xrightarrow{CH_3\text{–}Br}$ $HC\equiv C\text{–}CH_3$ (C–C bond)

37. IUPAC name of the following molecule is



(A) 4-hydroxyhept-2-en-5-yne

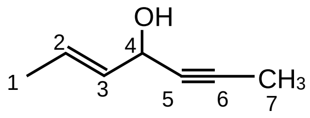
(B) hept-2-en-5-yn-4-ol

(C) hept-5-en-2-yn-4-ol

(D) 4-hydroxyhept-5-en-2-yne

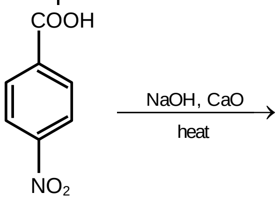
Ans. (B)

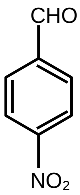
Sol.



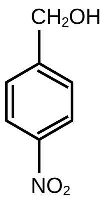
Hept-2-en-5-yn-4-ol

38. The product/s of the following reaction is/are

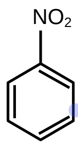




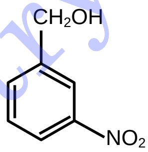
(I)



(II)



(III)



(IV)

(A) I and II

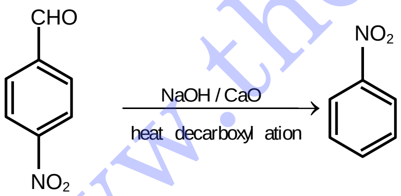
(B) II

(C) III

(D) IV

Ans. (C)

Sol.



39. For which of the following processes, carried out in free space, energy will be absorbed ?

I. Separating an electron from an electron

II. Removing an electron from a neutral atom

III. Separating a proton from a proton

IV. Separating an electron from a proton

(A) I only

(B) II and IV

(C) I and III

(D) II only

Ans. (B)

40. Decay of radioisotopes follows first order kinetics, Radioisotope U^{238} undergoes decay to a stable isotope, Th^{234}. The ratio of the number of atoms of U^{238} to that of Th^{234} after *three* half lives is

(A) 1/3 (B) 3/4

(C) 1/4 (D) 1/7

Ans. (D)

Sol. $U^{238} \longrightarrow Th^{234}$

t = 0 N_0

$t = 3t_{1/2}$ $N_0 - \frac{7N_0}{8}$ $\frac{7N_0}{8}$

$= \frac{N_0}{2^3}$

$\therefore \frac{\text{No. of } U^{238} \text{ atoms}}{\text{No. of } Th^{234} \text{ atoms}} = \frac{N_0/8}{7N_0/8} = \frac{1}{7}$

41. The anhydride of HNO_3 is

(A) NO (B) NO_2 (C) N_2O (D) N_2O_5

Ans. (D)

Sol. Anhydride of HNO_3 is N_2O_5

42. Which of the following is correct?

I. Sodium (Na) is present as metal in nature

II. Na_2O_2 is paramagnetic

III. NaO_2 is paramagnetic

IV. Na reacts with N_2 to form Na_3N

(A) III only (B) II and IV (C) I, III and IV (D) II, III and IV

Ans. (A)

Sol. Na_2O_2 is diamagnetic

NaO_2 is paramagnetic.

43. An excess of aqueous ammonia is added to three different flasks (F_1, F_2, F_3) containing aqueous solutions of $CuSO_4$, $Fe_2(SO_4)_3$ and $NiSO_4$ respectively. Which of the following is correct about this addition ?

I. A precipitate will be formed in all three flasks

II. Ammonia acts as a base as well as a ligand exchange reagent in F_1 and F_3

III. A soluble complex of NH_3 and the metal ion is formed in F_1 and F_3

IV. A precipitate will be formed only in F_2

(A) I only (B) IV only (C) II and IV (D) II, III and IV

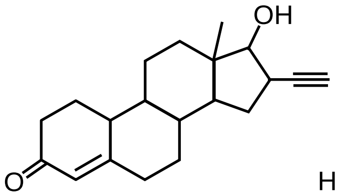
Ans. (D)

Sol. $CuSO_4(aq) \xrightarrow{\text{excess of aq. } NH_3} \underset{\text{deep blue solu ion}}{[Cu(NH_3)_4]^{2+}}$

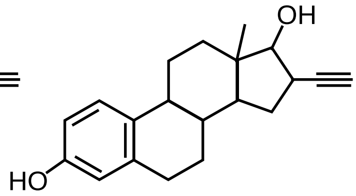
$Fe_2(SO_4)_3 \xrightarrow{\text{excess of aq. } NH_3} \underset{\text{reddish brown}}{Fe(OH)_3 \downarrow}$

$NiSO_4 \xrightarrow{\text{excess of aq. } NH_3} \underset{\text{deep blue solution}}{[Ni(NH_3)_6]^{2+}}$

44. The reagent/s that can be used to separate norethindrone and novestrol from their mixture is/are



Norethindrone



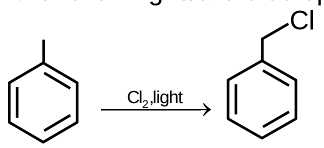
Novestrol

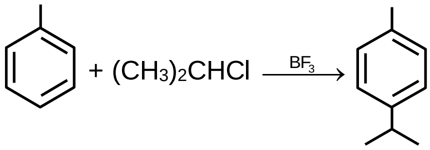
I. HCl **II.** NaOH **III.** $NaHCO_3$ **IV.** $NaNH_2$

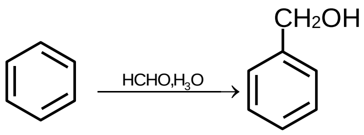
(A) III (B) I and IV (C) I, II and IV (D) II

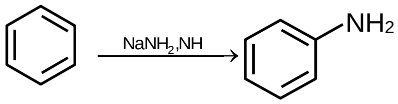
Ans. (D)

45. Which of the following is/are electrophilic aromatic substitution reaction/s ?

I. 

II. 

III. 

IV. 

(A) II, III and IV (B) II and III (C) I, II and III (D) II only

Ans. (B)

46. Among the halides NCl_3 (I), PCl_3(II) and $AsCl_3$(III), more than one type of acid in aqueous solution is formed with

(A) I, II and III (B) II only (C) I and II (D) II and III

Ans. (D)

Sol. $NCl_3 + 3H_2O \longrightarrow NH_3 + 3HOCl$

$PCl_3 + 3H_2O \longrightarrow H_3PO_3 + 3HCl$

$AsCl_3 + 3H_2O \longrightarrow H_3AsO_3 + 3\ HCl$

47. The normal boiling point and ΔH_{vap} of a liquid 'X' are 400 K and 40 kJ mol^{-1} respectively. Assuming ΔH_{vap} to be constant, which of the following is correct?

I. $\Delta S_{vap} > 100$ J K^{-1} mol^{-1} at 400 K and 0.5 atm

II. $\Delta S_{vap} < 100$ J K^{-1} mol^{-1} at 400 K and 1 atm

III. $\Delta S_{vap} < 100$ J K^{-1} mol^{-1} at 400 K and 2 atm

IV. $\Delta S_{vap} = 100$ J K^{-1} mol^{-1} at 400 K and 1 atm

(A) II and IV (B) II only (C) I and III (D) I, III and IV

Ans. (C)

Sol. At normal boiling point ($P_{ext.}$ = atm)

$$\Delta S_{vap} = \frac{\Delta H_{vap}}{T_b^{\,o}} = \frac{40000}{400} = 100 \text{ J/mol K}$$

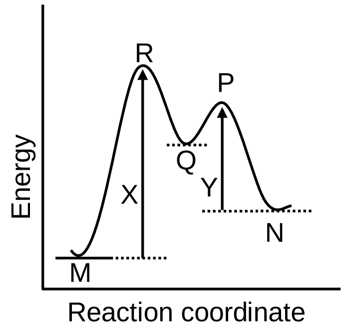
At $P_{ext} = 0.5$ atm $\Rightarrow$ Tb < 400 K

$\therefore\ \Delta S_{vap} > 100$ J/mol-K

At $P_{ext} = 2$ atm $\Rightarrow$ Tb > 400 K

$\Delta S_{vap} < 100$ J/mol-K

48. About the energy level diagram given below, which of the following statement/s is/are correct ?

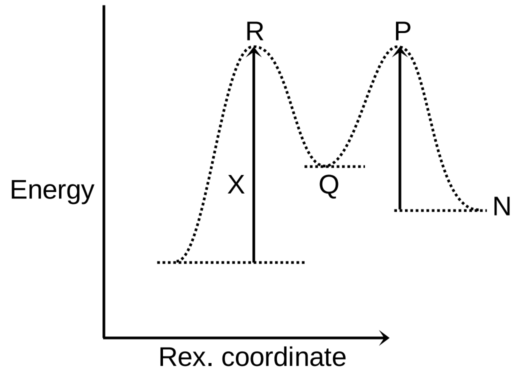


I. The reaction is of two steps and 'R' is an intermediate
II. The reaction is exothermic and step-2 is rate determining
III. 'Q' is an intermediate and 'R' is the transition state for the reaction M $\rightarrow$ Q
IV. 'P' is the transition state for the reaction Q $\rightarrow$ N

(A) III and IV (B) I, III and IV (C) I, II and IV (D) III only

Ans. (A)

Sol.



49. The F – X – F bond angle is the smallest in (X is the central atom)

(A) CF_4 (B) NH_3 (C) OF_2 (D) XeF_5^-

Ans. (D)

Sol.

CF_4	F–X–F bond angle = 109º29
NF_3	F–X–F bond angle = 102º
OF_2	F–X – F bond angle = 103º
XeF_5^-	F–X – F bond angle = 72º

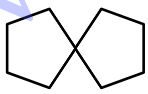
50. The correct IUPAC name of the compound, $[Pt(py)_4][Pt(Br)_4]$ is

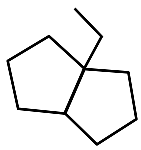
(A) tetrapyridineplatinum(II) tetrabromidoplatinate(II)
(B) tetrabromidoplatinum(IV) tetrapyridineplatinate(II)
(C) tetrabromidoplatinate(II) tetrapyridineplatinum(II)
(D) tetrapyridineplatinum(IV) tetrabromidoplatinate(IV)

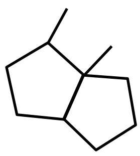
Ans. (A)

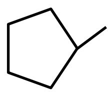
Sol. $[Pt(Py)_4][PtBr_4]$ IUPAC name is tetrapyridineplatinum(II) tetrabromidoplatinate(II)

51. All four types of carbon (1°, 2°, 3° and 4°) are present in


I


II


III


IV

(A) I, II and III (B) II, III and IV (C) I, II and IV (D) II and IV

Ans. (D)

52. The mass (g) of NaCl that has to the dissolved to reduce the vapour pressure of 100 g of water by 10% (Molar mass of NaCl = 58.5 g mol^{-1}) is:

(A) 36.11 g (B) 17.54 g (C) 81.25 g (D) 3.61 g

Ans. (B)

Sol. Raoult's law

$P_s = P^\circ \times$ mole fraction of solvent

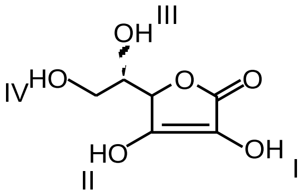
$$90 = 100 \times \left(\frac{100/18}{\frac{100}{18} + \frac{w \times 2}{58.5}} \right)$$

$$0.9\left(\frac{100}{18} + \frac{w \times 2}{58.5} \right) = \frac{100}{18}$$

$\Rightarrow$ w = 18.11 gm

Answer is not given in options, correct answer is (B).

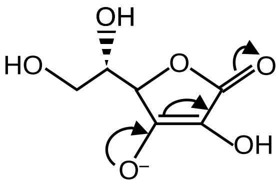
53. The most acidic hydrogen in the following molecule is



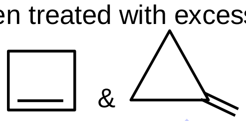
(A) I (B) II (C) III (D) IV

Ans. (B)

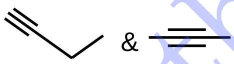
Sol. The conjugate base of II OH is resonance stabilized.

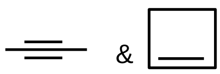


54. Two isomeric hydrocarbons 'X' and 'Y' (C_4H_6), give the same product (C_4H_8O) on catalytic hydration with dillute acid. However, they form different products but with same molecular formula ($C_4H_6Br_4$) when treated with excess bromine. 'X' and 'Y' are

(A) 

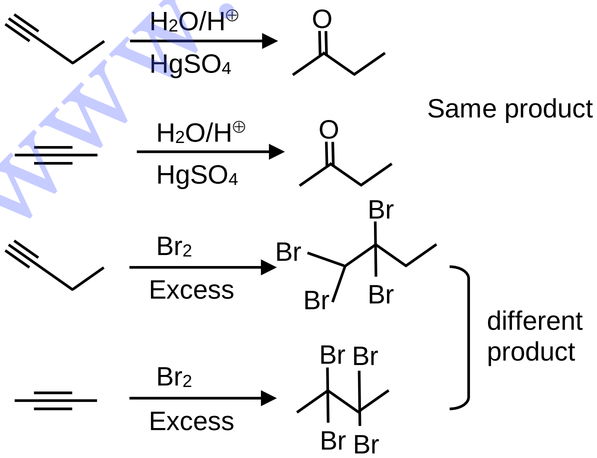
(B) 

(C) 

(D) 

Ans. (C)

Sol.



55. Mercury is highly hazardous and hence its concentration is expressed in the units of ppb (micrograms of Hg present in 1 L of water). Permissible level of Hg in drinking water is 0.0335 ppb. Which of the following is an alternate representation of this concentration?

(A) 3.35×10^{-2} mg dm^{-3} (B) 3.35×10^{-5} mg dm^{-3}
(C) 3.35×10^{-5} mg m^{-3} (D) 3.35×10^{-4} g L^{-1}

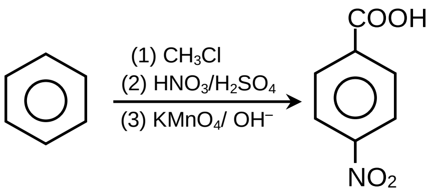
Ans. (B)

Sol. Concentration of Hg = 0.0335 ppb of Hg(μg/L)
$= 0.0335 \times 10^{-3}$ mg/lt
$= 3.35 \times 10^{-5}$ mg/dm^3

56. The correct sequence of reaction which will yield 4-nitrobenzoic acid from benzene is

(A) CH_3Cl; HNO_3/H_2SO_4; $KMnO_4/OH^-$ (B) HNO_3/H_2SO_4; $CH_3Cl/AlCl_3$; $KMnO_4/OH^-$
(C) $CH_3Cl/AlCl_3$; $KMnO_4/OH^-$; HNO_3/H_2SO_4 (D) $CH_3Cl/AlCl_3$; HNO_3/H_2SO_4; $KMnO_4/OH^-$

Ans. (D)

Sol.


57. The volume of one drop of aqueous solution from an eyedropper is approximately 0.05 mL. One such drop of 0.2 M HCl is added to 100 mL of distilled water. The pH of the resulting solution will be

(A) 4.0 (B) 7.0 (C) 3.0 (D) 5.5

Ans. (A)

Sol. Conc. of HCl = $\dfrac{0.2 \times 0.05}{100} = 10^{-4}$ M

So pH = 4

58. In which of the following species the octet rule is NOT obeyed?

I. I_3^- **II.** N_2O **III.** OF_2 **IV.** NO^+

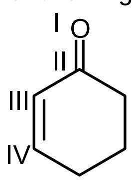
(A) I and IV (B) II and III (C) I only (D) IV only

Ans. (C)

Sol. I_3^- $[I-\ddot{\underset{..}{I}}-I]^-$ Octet rule not obeyed

N_2O follows octet rule
OF_2 follows octet rule
NO^+ follows octet rule

59. Which atom/s will have a δ^+ charge in the following molecule ?



(A) I and III (B) II only (C) II and III (D) II and IV

Ans. (D)

60. 2.0 moles of an ideal gas expands isothermally (27°C) and reversibly from a pressure of 1 bar to 10 bar. The heaviest mass that can be lifted through a height of 10 m by the work of this expansion is

(A) 50.8 kg (B) 50.8 g (C) 117.1 kg (D) 117.1 g

Ans. (C)

Sol. |work done| = change in potential energy

$$nRT\ln\frac{V_2}{V_1} = mgh$$

$$2\times8.314\times300\times2.303\ \log\frac{10}{1} = m\times9.81\times10$$

$$m = 117.1\ kg$$

A – 2

In Q. Nos. 61 to 70 any number of options (A or B or C or all D) may be correct. You are to identify all of them correctly to get 6 marks. Even if one answer identified is incorrect or one correct answer is missed, you get zero marks.

---

61. A commercial sample of oleum ($H_2S_2O_7$) labeled as '106.5% oleum' contains 6.5 g of water. The percentage of free SO_3 in this oleum sample is

(A) 2.88 (B) 28.8 (C) 0.029 (D) 0.28

Ans. (B)

Sol. 106.5% Oleum sample

$\therefore$ % of free $SO_3 = \frac{40}{9} \times (106.5 - 100) = 28.8$ %

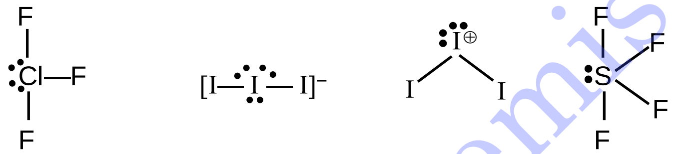
Note: Question is controvercial since formula of oleum is given ($H_2S_2O_7$), however it is actually a mixture. Also oleum does not contains water, however in question, it is said to be present.

62. Which of the following species has one lone pair of electrons on the central atom?

(A) ClF_3 (B) I_3^- (C) I_3^+ (D) SF_4

Ans. (D)

Sol.



63. Among the following, the complex ion/s that will have a magnetic moment of 2.82 B.M. is/are

I. $[Ni(CO)_4]$ II. $[NiCl_4]^{2-}$ III. $[Ni(H_2O)_6]^{2+}$ IV. $[Ni(CN)_4]^{2-}$

(A) I and IV (B) II only (C) II and III (D) II, III and IV

Ans. (C)

Sol. $Ni(CO)_4$ number of unpaired electron = 0

$[NiCl_4]^{2-}$ number of unpaired electron = 2

$[Ni(H_2O)_6]^{2+}$ number of unpaired electron = 2

$[Ni(CN)_4]^{2-}$ number of unpaired electron = 0

$\mu = \sqrt{n(n+2)} \Rightarrow 2.82 = \sqrt{n(n+2)}$ n = number of unpaired electrons = 2

64. Morphine, a pain killer is basic with molecular formula $C_{17}H_{19}NO_3$. The conjugate acid of morphine is

(A) $C_{17}H_{19}NO_3^+$ (B) $C_{17}H_{18}NO_3$ (C) $C_{17}H_{19}NO_3^-$ (D) $C_{17}H_{20}NO_3^+$

Ans. (D)

65. A suboxide of carbon, C_3O_2, has a linear structure. Which of the following is correct about C_3O_2 ?

I. Oxidation state of all three C atoms is +2

II. Oxidation state of the central C atom is zero

III. The molecule contains 4 σ and 4 π bonds

IV. Hybridization of the central carbon atom is sp^2

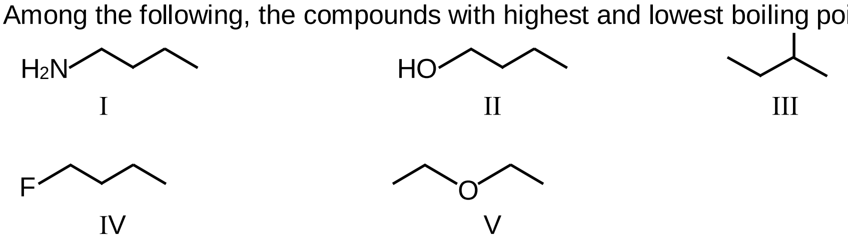
(A) I and IV (B) II and III (C) II and IV (D) III only

Ans. (B)

Sol. $\overset{+2}{C}$, $\overset{0}{C}$, $\overset{+2}{C}$ in O=C=C=C=O

Hyb. sp sp sp

66. Among the following, the compounds with highest and lowest boiling points respectively are



(A) I and III (B) II and III (C) I and IV (D) II and V

Sol. (B)

67. At 25ºC K_a of HPO_4^{2-} and HSO_3^- are 4.8×10^{-13} and 6.3×10^{-8} respectively. Which of the following is correct?

(A) HPO_4^{2-} is a stronger acid than HSO_3^- and PO_4^{3-} is a weaker base than SO_3^{2-}

(B) HPO_4^{2-} is a weaker acid than HSO_3^- and PO_4^{3-} is a weaker base than SO_3^{2-}

(C) HPO_4^{2-} is a weaker acid than HSO_3^- and PO_4^{3-} is a stronger base than SO_3^{2-}

(D) HPO_4^{2-} is a stronger acid than HSO_3^- and PO_4^{3-} is a stronger base than SO_3^{2-}

Sol. (C)

K_a of $HPO_4^{2-} = 4.8 \times 10^{-13}$

K_a of $HSO_3^- = 6.3 \times 10^{-8}$

$\therefore$ HSO_3^- is stronger acid than HPO_4^{2-}

& SO_3^{2-} is weaker base than PO_4^{3-}

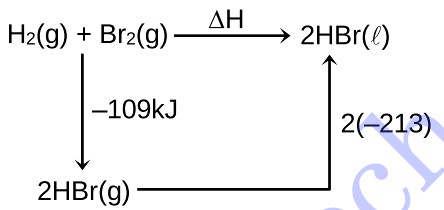
68. The change in internal energy (ΔU) for the reaction $H_2(g) + Br_2(g) \rightarrow 2HBr(\ell)$ when 2.0 moles each of $Br_2(g)$ and $H_2(g)$ react is

($H_2(g) + Br_2(g) \rightarrow 2HBr(g)$; $\Delta H_{reaction} = -109$ kJ; ΔH_{vap} of HBr = 213 kJ mol^{-1})

(A) –644 kJ (B) 644 kJ (C) –322 kJ (D) –1070 kJ

Ans. (D)

Sol.

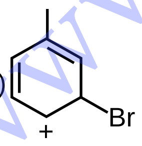


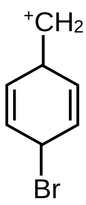
$\Delta H_{rex.} = -109 - 426 = -535$ kJ/mol

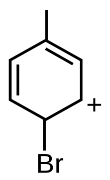
$\Delta U_{rex.} = \Delta H_{rex} - \Delta n_{gas} RT = -535$ kJ/mol

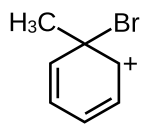
$\therefore$ ΔU for 2 moles each of Br_2 & H_2 = $2 \times (-535) = -1070$ kJ

69. The structure that represents the major intermediate formed in bromination of toluene is

(A) 

(B) 

(C) 

(D) 

Ans. (C)

70. About sea water, which of the following statement/s is/are correct?

I. Frozen sea water melts at a lower temperature than pure ice

II. Boiling point of sea water increases as it evaporates

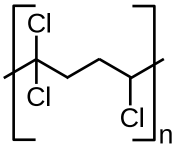
III. Sea water boils at a lower temperature than fresh water

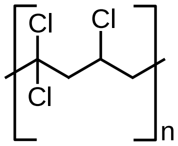
IV. Density of sea water at STP is same as that of fresh water

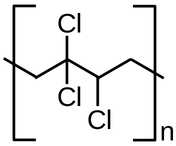
(A) I only (B) I and II (C) I, II and III (D) III only

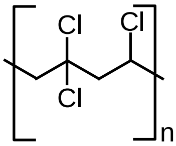
Ans. (B)

71. Saran wrap, a polymer used in food packaging is a copolymer of 1, 1-dichloroethene and vinyl chloride. In the chain initiation step, 1, 1-dichloroethene generates a free radical which reacts with vinyl chloride. Structure of Saran wrap is

(A) 

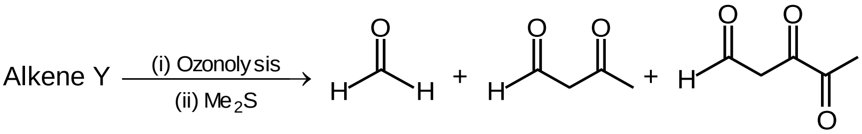
(B) 

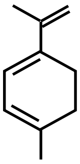
(C) 

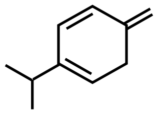
(D) 

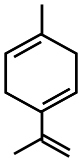
Ans. (D)

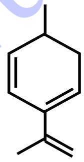
72. The alkene 'Y' in the following reaction is



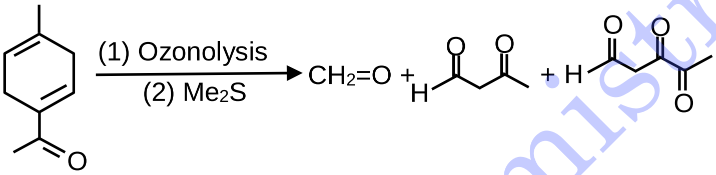
(A) 

(B) 

(C) 

(D) 

Sol. (C)



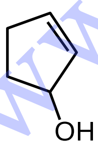
73. In solid state, PCl_5 exists as $[PCl_4]^+ [PCl_6]^-$. The hybridization of P atoms in this solid is/are

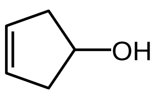
(A) sp^3d ($d = d_{x^2-y^2}$)
(B) sp^3d ($d = d_{z^2}$)
(C) sp^3 and sp^3d^2 ($d = d_{x^2-y^2}, d_{z^2}$)
(D) sp^3d and dsp^3 ($d = d_{z^2}$)

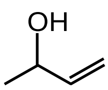
Ans. (C)

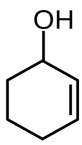
Sol. $\underset{\text{Solid}}{PCl_5} \Rightarrow \underset{sp^3}{\left[PCl_4^+\right]}\underset{sp^3d^2}{\left[PCl_6^-\right]}$

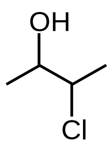
74. Which of the following compounds have chiral carbon atom/s ?


I


II


III

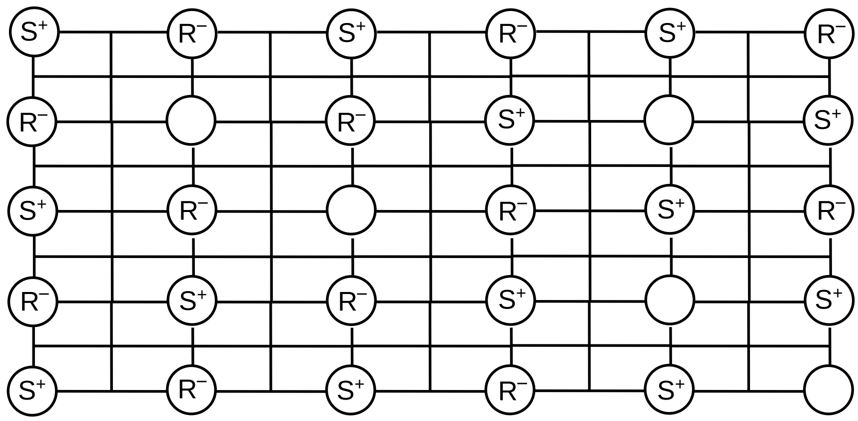

IV


V

(A) I and II
(B) I, III, IV and V
(C) II, IV and V
(D) II, III and IV

Ans. (B)

75. The crystal defect indicated in the diagram below is



(A) Frenkel defect
(B) Schottky defect
(C) Frenkel and Schottky defects
(D) Interstitial defect

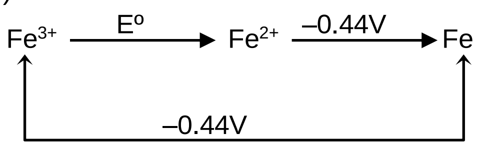
Ans. (B)

76. If the standard electrode potentials of Fe^{3+}/Fe and Fe^{2+}/Fe are –0.04 V and –0.44 V respectively then that of Fe^{3+}/Fe^{2+} is

(A) 0.76 V
(B) –0.76 V
(C) 0.40 V
(D) –0.40 V

Ans. (A)

Sol.



$E^o + 2(-0.44) = 3(-0.04)$

$E^o = -0.12 + 0.88 = 0.76V$

77. Given below is the data for the reaction $2NO\,(g) \rightleftharpoons N_2(g) + O_2(g)$

Where 'k_f' and 'k_b' are rate constants of the forward and reverse reactions respectively

Temperature (K)	k_f ($mol^{-1}\,dm^3\,s^{-1}$)	K_b ($mol^{-1}\,dm^3\,s^{-1}$)
1400	0.20	1.1×10^{-6}
1500	1.3	1.4×10^{-5}

The reaction is

(A) exothermic and K_{eq} at 1400 K = 3.79×10^{-6}
(B) endothermic and K_{eq} at 1400 K = 2.63×10^{-5}
(C) exothermic and K_{eq} at 1400 K = 1.8×10^{5}
(D) endothermic and K_{eq} at 1500 K = 9.28×10^{-4}

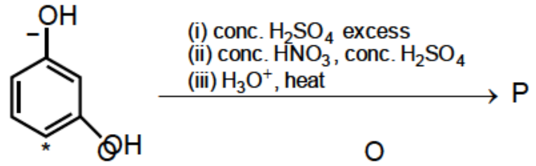
Ans. (C)

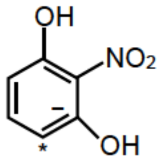
Sol. At 1400 K $\quad K_{eq} = \dfrac{K_f}{R_b} = \dfrac{0.2}{1.1\times10^{-6}} = 1.8\times10^{5}$

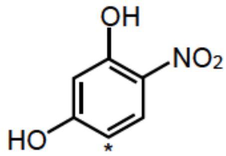
At 1500 K $\quad K_{eq} = \dfrac{1.3}{1.4\times10^{-5}} = 9.3 \times 10^{4}$

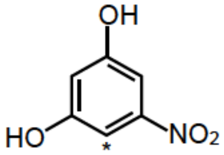
$\therefore$ reaction is exothermic

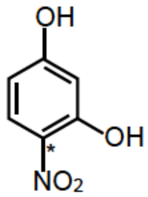
78. The major product 'P' formed in the following is (*denotes radioactive carbon)



(A) 

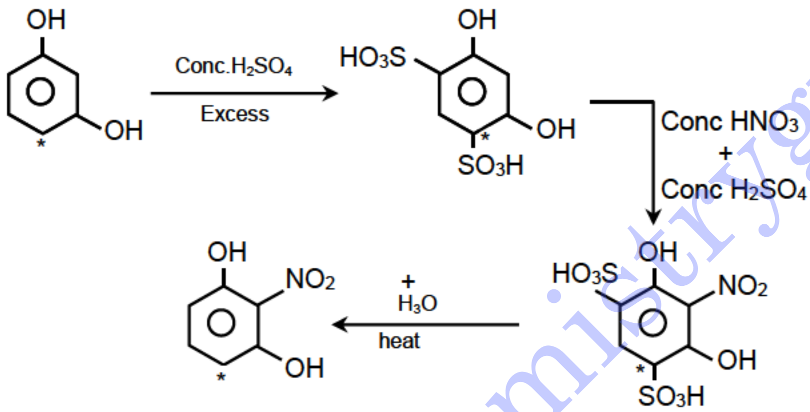
(B) 

(C) 

(D) 

Ans. (A)

Sol.



79. A helium cylinder in which the volume of gas = 2.24 L at STP (1 atm, 273 K) developed a leak and when the leak was plugged the pressure in the cylinder was seen to have dropped to 550 mm of Hg. The number of moles of He gas that had escaped due to this lead is

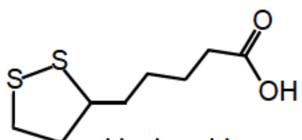
(A) 0.028 (B) 0.072 (C) 0.972 (D) 0.099

Ans. (A)

Sol. Moles of He escaped

$$= \frac{(\Delta P)\times V}{RT} = \frac{\left(1-\frac{550}{760}\right)\times 2.24}{0.0821\times 273} = \left(1-\frac{55}{76}\right)\frac{1}{10} = 0.028$$

80. Lipoic acid with the following structure is a growth factor required by many organisms. Percentages of 'S' and 'O' in lipoic acid respectively are (atomic masses of 'S' and 'O' are 32.065 g mol^{-1} and 15.999 g mol^{-1} respectively)



Lipoic acid

(A) 33.03, 16.48 (B) 31.11, 18.24 (C) 31.11, 15.52 (D) 31.42, 15.68

Ans. (C)

Sol. Molecular mass = 206.13u

$$\% \text{ of S} = \frac{64.13}{206.13}\times 100 = 31.11\%$$

$$\% \text{ of O } \frac{31.998}{206.13}\times 100 = 15.22\%$$