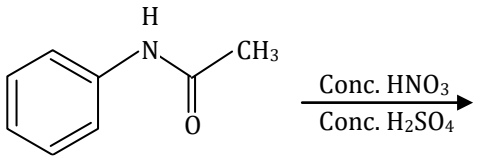
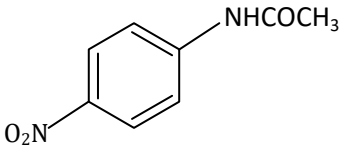
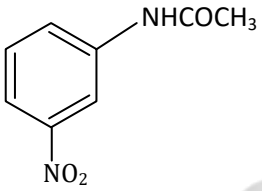
KVPY-SX 2017 (CHEMISTRY)

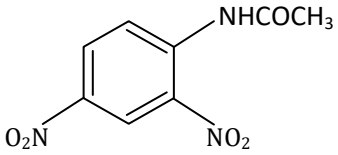
PART-I

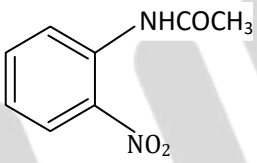
1. The major product formed in the following reaction is



(A) 

(B) 

(C) 

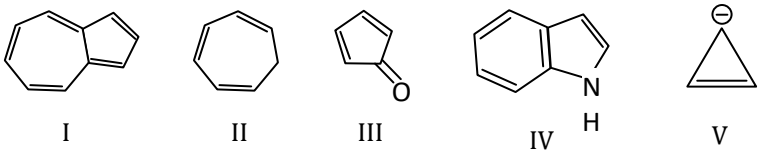
(D) 

2. Among the α-amino acids - threonine, tyrosine, methionine, arginine and tryptophan, those which contain an aromatic group in their side chain are
(A) threonine and arginine (B) tyrosine and tryptophan
(C) methionine and tyrosine (D) arginine and tryptophan

3. The number of stereoisomers possible for the following compound is
CH_3–CH=CH–CH(OH) –CH_3
(A) 1 (B) 2 (C) 3 (D) 4

4. In electrophilic aromatic substitution reactions of chlorobenzene, the ortho/para-directing ability of chlorine is due to its
(A) Positive inductive effects (+I) (B) negative inductive effect (–I)
(C) Positive resonance effect (+R) (D) negative resonance effect (–R)

5. Among the following,



I II III IV V

the anti-aromatic compounds are
(A) I and IV (B) III and V (C) II and V (D) I and III

6. Upon reaction with CH_3MgBr followed by protonation, the compound that produces ethanol is
(A) CH_3CHO (B) HCOOH (C) HCHO (D) $(CHO)_2$

7. Which of the following is **NOT** an oxidation-reduction reaction?
(A) $H_2 + Br_2 \rightarrow 2HBr$ (B) $NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$
(C) $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$ (D) $Cl_2 + H_2O \rightarrow HCl + HOCl$

8. The thermal stability of alkaline earth metal carbonates–$MgCO_3$, $CaCO_3$, $SrCO_3$and $BaCO_3$, follows the order
(A) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$ (B) $CaCO_3 > SrCO_3 > BaCO_3 > MgCO_3$
(C) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$ (D) $SrCO_3 > CaCO_3 > MgCO_3 > BaCO_3$

9. When a mixture of diborane and ammonia is heated, the final product is
(A) BH_3 (B) NH_4BH_4 (C) NH_2NH_2 (D) $B_3N_3H_6$

10. Among the following metals, the strongest reducing agent is
(A) Ni (B) Cu (C) Zn (D) Fe

11. The molecule which is **NOT** hydrolysed by water at 25°C is
(A) $AlCl_3$ (B) $SiCl_4$ (C) BF_3 (D) SF_6

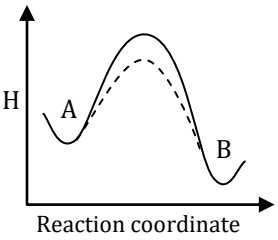
12. Among the following compounds, the one which does **NOT** produce nitrogen gas upon heating is
(A) $(NH_4)_2Cr_2O_7$ (B) NaN_3 (C) NH_4NO_2 (D) $(NH_4)_2(C_2O_4)$

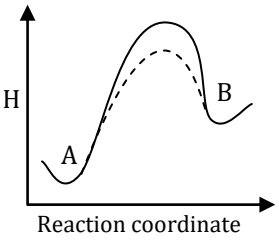
13. Chlorine has two naturally occurring isotopes, ^{35}Cl and ^{37}Cl. If the atomic mass of Cl is 35.45, the ratio of natural abundance of ^{35}Cl and ^{37}Cl is closest to
(A) 3.5 : 1 (B) 3 :1 (C) 2.5 : 1 (D) 4 : 1

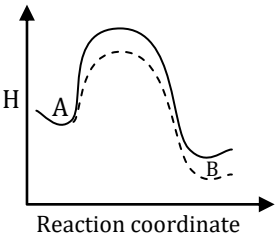
14. The reaction $C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$ is at equilibrium in a closed vessel at 1000 K. The enthalpy change (ΔH) for the reaction is 137.0 kJ mol^{-1}. Which one of the following actions would shift the equilibrium to the right?
(A) Decreasing the volume of the closed reaction vessel
(B) Decreasing the temperature at which the reaction is performed
(C) Adding an inert gas to the closed reaction vessel
(D) Increasing the volume of the closed reaction vessel

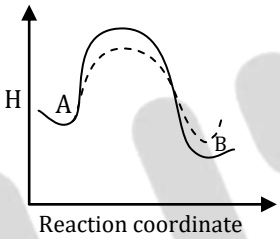
KVPY-SX 2017 (CHEMISTRY)

15. The enthalpy (H) of an elementary exothermic reaction A -> B is schematically plotted against the reaction coordinate. The plots in the presence and absence of a catalyst are shown in dashed and solid lines, respectively. Identify the correct plot for the reaction.

(A) 

(B) 

(C) 

(D) 

16. $Mg(OH)_2$is precipitated when NaOH is added to a solution of Mg^{2+}. If the final concentration of $Mg^{2+}$is 10^{-10}M, the concentration of OH^-(M) in the solution is [Solubility product for $Mg(OH)_2 = 5.6 \times 10^{-12}$]
(A) 0.056 (B) 0.12 (C) 0.24 (D) 0.025

17. A constant current (0.5 amp) is passed for 1 hour through (i) aqueous $AgNO_3$, (ii) aqueous $CuSO_4$and (iii) molten AlF_3, separately. The ratio of the mass of the metals deposited on the cathode is [M_{Ag}, M_{Cu}, M_{Al} are molar masses of the respective metals]
(A) M_{Ag}: 2 M_{Cu}: 3 M_{A1} (B) M_{Ag}: M_{Cu}: M_{A1}
(C) 6 M_{Ag}: 3 M_{Cu}: 2 M_{A1} (D) 3 M_{Ag}: 2M_{Cu}: M_{A1}

18. A reaction has an activation energy of 209 kJ mol^{-1}. The rate increases 10–fold when the temperature is increased from 27°C to X °C. The temperature X is closest to [Gas constant, R = 8.314 J $mol^{-1}K^{-1}$]
(A) 35 (B) 40 (C) 30 (D) 45

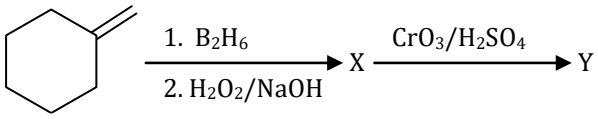
19. A mineral consists of a cubic close-packed structure formed by O^{2-}ions where half the octahedral voids are occupied by $Al^{3+}$and one eighth of the tetrahedral voids are occupied by Mn^{2+}. The chemical formula of the mineral is
(A) $Mn_3Al_2O_6$ (B) $MnAl_2O_4$ (C) $MnAl_4O_7$ (D) $Mn_2Al_2O_5$

20. For a 4p orbital, the numbers of radial and angular nodes, respectively, are
(A) 3,2 (B) 1,2 (C) 2, 4 (D) 2,1

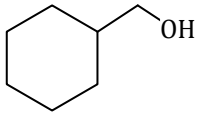
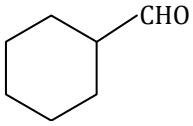
KVPY-SX 2017 (CHEMISTRY)

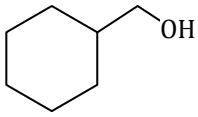
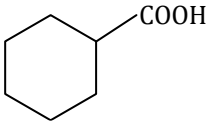
PART-II

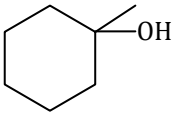
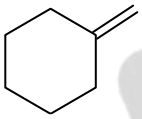
21. In the following reaction sequence

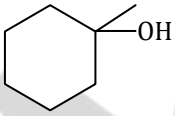
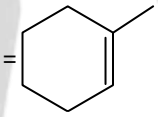


X and Y are

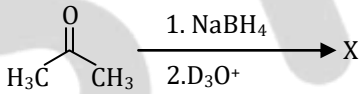
(A) X =  Y = 

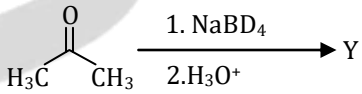
(B) X =  Y = 

(C) X =  Y = 

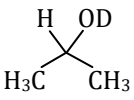
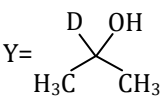
(D) X =  Y = 

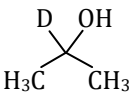
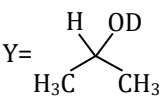
22. In the following reactions

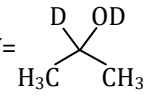


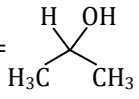


X and Y are

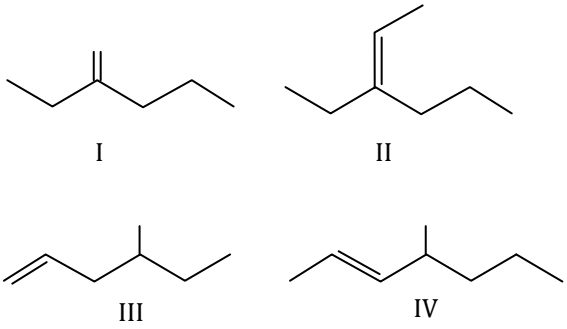
(A) X=  Y= 

(B) X=  Y= 

(C) X= Y= 

(D) X= Y= 

23. Which of the following alkenes can generate optically active compounds upon hydrogenation?



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

24. When heated in air, brown copper powder turns black. This black powder would turn brown again when heated with

(A) CO (B) O_2 (C) H_2 (D) NH_3

25. The geometry and magnetic property of $[NiCl4]^{2-}$, respectively, are

(A) Tetrahedral, paramagnetic (B) tetrahedral, diamagnetic

(C) Square planar, paramagnetic (D) square planar, diamagnetic

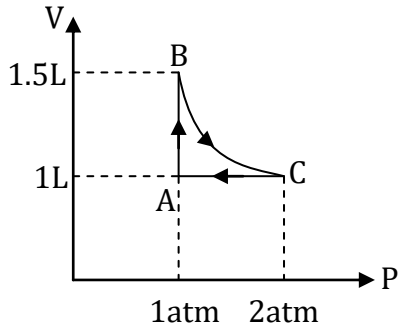
26. Among (i) $[Cr(en)_3]^{3+}$, (ii) trans-$[Cr(en)_2Cl_2]^+$, (iii) Cis-$[Cr(en)_2Cl_2]^+$(iv) $[Co(NH_3)_4Cl_2]^+$the optically active complexes are

(A) i and ii (B) i and iii (C) ii and iii (D) ii and iv

27. ^{227}Ac has a half-life of 22 years with respect to radioactive decay. The decay follows two parallel paths: $^{227}Ac \rightarrow {}^{227}Th$ and $^{227}Ac \rightarrow {}^{223}Fr$. If the percentage of the two daughter nuclides are 2.0 and 98.0, respectively, the decay constant (in $year^{-1}$) for $^{227}Ac \rightarrow {}^{227}Th$ path is closest to

(A) 6.3×10^{-2} (B) 6.3×10^{-3} (C) 6.3×10^{-1} (D) 6.3×10^{-4}

28. A system consisting of 1 mol of an ideal gas undergoes a reversible process, A →B→C → A (schematically indicated in the figure below). If the temperature at the starting point A is 300 K and the work done in the process B → C is 1 L atm, the heat exchanged in the entire process in L atm is

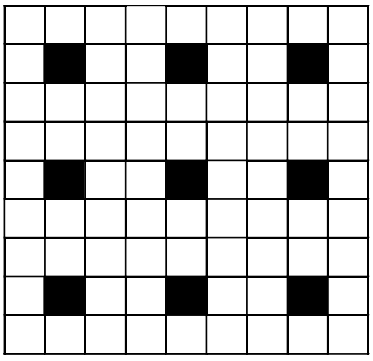


(A) 1.0 (B) 0.0 (C) 1.5 (D) 0.5

29. A mixture of toluene and benzene boils at 100°C. Assuming ideal behaviour, the mole fraction of toluene in the mixture is closest to [Vapour pressures of pure toluene and pure benzene at 100°C are 0.742 and 1.800 bar respectively. 1 atm = 1.013 bar]

(A) 0.824 (B) 0.744 (C) 0.544 (D) 0.624

30. A two-dimensional solid pattern formed by two different atoms X and Y is shown below. The black and white squares represent atoms X and Y, respectively. The simplest formula for the compound based on the unit cell from the pattern is



(A) XY_8 (B) X_4Y_9 (C) XY_2 (D) XY_4

KVPY-SX 2017 (CHEMISTRY)

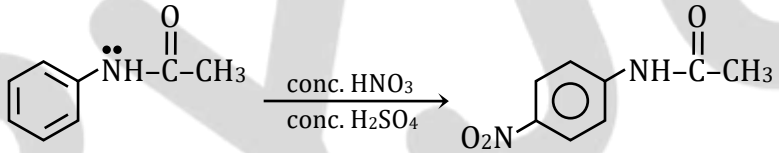
ANSWER KEY

1.	(A)	2.	(B)	3.	(D)	4.	(C)	5.	(B)
6.	(C)	7.	(B)	8.	(A)	9.	(D)	10.	(C)
11.	(D)	12.	(D)	13.	(B)	14.	(D)	15.	(A)
16.	(C)	17.	(C)	18.	(A)	19.	(B)	20.	(D)
21.	(B)	22.	(A)	23.	(C)	24.	(C)	25.	(A)
26.	(B)	27.	(D)	28.	(D)	29.	(B)	30.	(A)

SOLUTIONS

PART-I

1. (A)

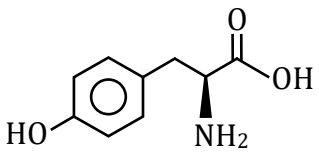


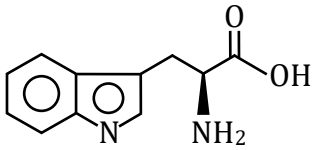
(Weak +M effect)

In the above molecule, lone pair of nitrogen is in conjugation with benzene as well as carbonyl group. Therefore, +M effect of 'NH' group on benzene will be weak.

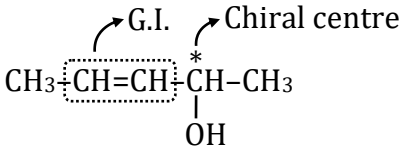
Only mono substitution will take place.

2. (B)

Tyrosine 

Tryptophan 

3. (D)



n = 2

∴ Number of possible stereoisomers = $2^n = 2^2 = 4$

G.I. → Can be cis/trans.

Chiral centre → can be R/S.

∴ possible combination

Cis – R

Cis – S

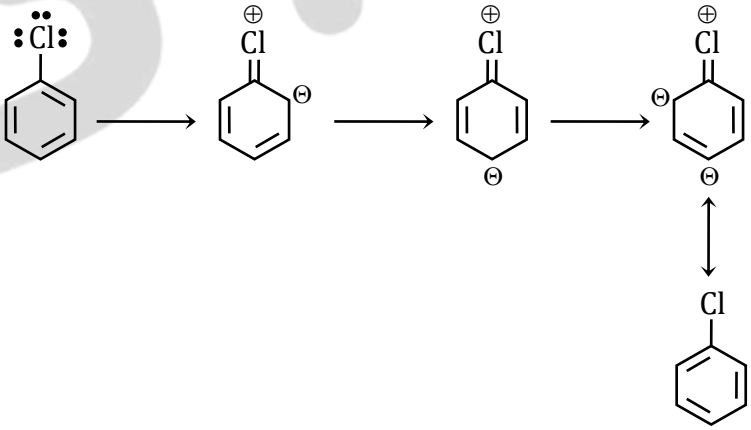
Trans – R

Trans – S

4. (C)

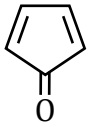
→ can show
–I effect and +R effect

But the dominating one is +R effect. That is why it act as o,p-directing group.



KVPY-SX 2017 (CHEMISTRY)

5. (B)

(III) 

→ All 'C' are sp^2 hybridised.

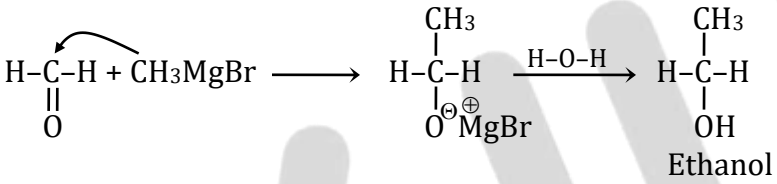
→ $4\pi e^-$ system → anti-aromatic

(IV) 

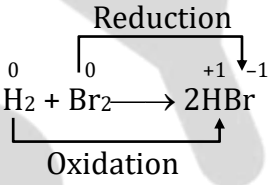
→ $4\pi e^-$, system

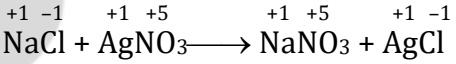
→ All 'C' are sp2 hybridised → Anti-aromatic.

6. (C)

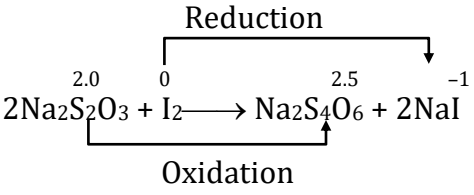


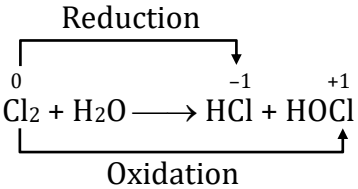
7. (B)

(A) 

(B) 

No change in oxidation number.

(C) 

(D) 

8. (A)

Mg^{2+}

Ca^{2+}

Sr^{2+}

Ba^{2+}

Down the group, size of cation increases and CO_3^{2-} is also large in size.

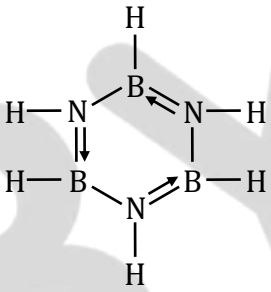
And large cation + large anion $\rightarrow$ more stability

Hence, more comparable the size of cation and anion, more will be the thermal stability of alkaline earth metal carbonates.

Hence, $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$

9. (D)

$$B_2H_6 + 2NH_3 \xrightarrow{\Delta} B_3N_3H_6$$



Borazole or Inorganic benzene

10. (C)

According to electrochemical series,

	SRP Value
Ni	–0.25V
Zn	–0.76V
Fe	–0.44V
Cu	+0.34V

Lesser the value of E^0_{RP}, higher will be the tendency to get oxidized itself and reduce others and hence stronger will be the reducing agent.

11. (D)

a. $AlCl_3 + 3H_2O \rightarrow Al(OH)_3\downarrow + 3HCl$

(Al has vacant p-orbital where H_2O can attack.)

b. $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$

(Si has vacant d-orbital where H_2O can attack.)

c. $BF_3 + 3H_2O \rightarrow B(OH)_3 + 3HF$

(B has vacant p-orbital where H_2O can attack.)

d. $SF_6 + H_2O \xrightarrow{25°C}$ No reaction

sulphur has vacant d-orbital but due to steric hindrance created by 6F , SF_6 cannot be hydrolysed at 25°C

12. (D)

$(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + H_2O$

$2NaN_3 \longrightarrow 2Na + 3N_2$

$NH_4NO_2 \longrightarrow N_2 + H_2O$

$(NH_4)_2C_2O_4 \longrightarrow 2NH_3 + H_2C_2O_4$

13. (B)

Atomic mass of Cl = 35.45 = Average atomic mass

Average atomic mass = $\frac{n_1M_1 + n_2M_2}{n_1 + n_2}$

$\Rightarrow$ 35.45 = $\frac{n_1 \times 35 + n_2 \times 37}{n_1 + n_2}$

$\Rightarrow$ $35.45n_1 + 35.45n_2 = 35n_1 + 37n_2$

$\Rightarrow$ $0.45n_1 = 1.55n_2$

$\Rightarrow$ $\frac{n_1}{n_2} = \frac{1.55}{0.45} \approx \frac{3}{1}$

$\Rightarrow$ 3 : 1

14. (D)

$C_2H_6\,(g) \rightarrow C_2H_4\,(g) + H_2\,(g); \Delta H = +ve$

(A) Volume$\downarrow \rightarrow$ Reaction will shift in the direction where number of moles $\downarrow$ according to Le-chatelier principle $\rightarrow$ backward direction.

(B) T$\downarrow \rightarrow$ Reaction will shift in a direction where temperature will increase (backward) as the reaction is endothermic.

(C) Addition of inert gas at constant volume (no effect on equilibrium).

(D) Volume$\uparrow \rightarrow$ Reaction will shift in a direction where number of moles will increase i.e. forward direction.

Correct option is (D).

15. (A)

For exothermic reaction

$\Delta H = E_P - E_R < 0$

$\Rightarrow E_B - E_A < 0$

$\Rightarrow E_B < E_A$

Catalyst does not change the initial and final position of the reaction. It will only decrease the activation energy, hence increase the rate of reaction.

16. (C)

$$Mg(OH)_{2\,(s)} \rightleftharpoons Mg^{2+} + 2OH^-$$

Equilibrium s 2s

$K_{sp} = [Mg^{2+}][OH^-]^2 = 5.6 \times 10^{-12}$

$10^{-10}\,[OH^-]^2 = 5.6 \times 10^{-12}$

$[OH^-] = \sqrt{5.6 \times 10^{-2}} = 0.24\ M$

17. (C)

	Ag^{+}	:	Cu^{+2}	:	Al^{+3}
No. of eq. deposit	x	:	x	:	x
no. of mole deposit	$\frac{x}{1}$	:	$\frac{x}{2}$	:	$\frac{x}{3}$
	6x	:	3x	:	2x
no. of mole deposit	6	:	3	:	2
mass deposit	$6M_{Ag}$	:	$3M_{Cu}$	:	$2M_{Al}$

18. (A)

$\varepsilon_a = 209\ kJmol^{-1}$

Given: $T_1 = 27°C = 300\ K$

$T_2 = x°C = (x + 273)K$

$\frac{K_2}{K_1} = 10$

Apply

$$\log\frac{K_2}{K_1} = \frac{\varepsilon_a}{2.303\,R}\left[\frac{1}{T_1}-\frac{1}{T_2}\right]$$

$$1 = \log 10 = \frac{209\times10^3}{2.303\times8.314}\left[\frac{1}{300}-\frac{1}{x+273}\right]$$

$\Rightarrow x + 273 = 308.4\ K$

$\Rightarrow x = 35.4°C \square\ 35°C$

19. (B)

No. of atoms in ccp = N

Then, No. of O.V. = N

No. of T.V. = 2 N

No. of O^{-2} per unit cell = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$

No. of Al^{+3} per unit cell = $4 \times \frac{1}{2} = 2$

No. of Mn^{+2} per unit cell = $8 \times \frac{1}{8} = 1$

$MnAl_2O_4$

20. (D)

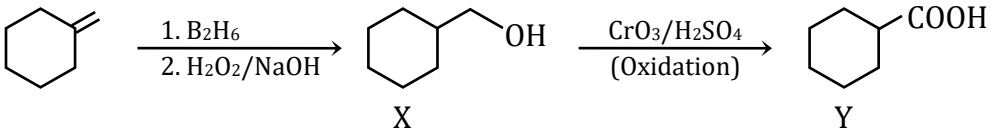
4p

n = 4, ℓ = 1

No. of Radial nodes = n – ℓ – 1 = 4 – 1 – 1 = 2

No. of Angular nodes = ℓ = 1

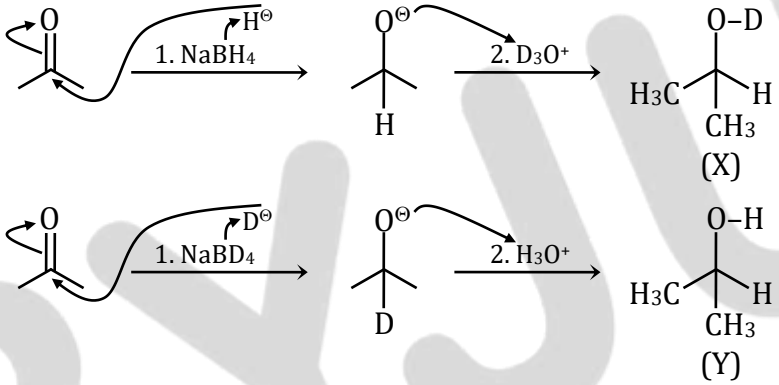
21. (B)



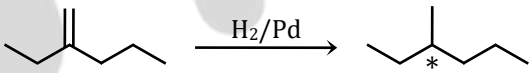
[Hydroboration-Oxidation Reaction]

Anti-markovnikov's rule

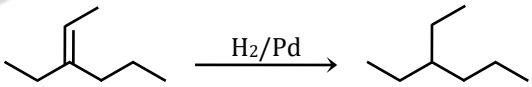
22. (A)



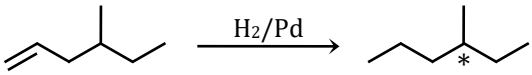
23. (C)

(I) 

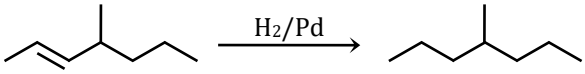
Chiral centre → Optically active

(II) 

Optically inactive

(III) 

Optically inactive

(IV) 

Optically inactive

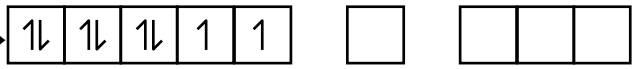
24. (C)

$2Cu + O_2 \longrightarrow \underset{\text{(black)}}{2CuO}$
(air)

$CuO + H_2 \longrightarrow Cu + H_2O$
(brown)

25. (A)

$[NiCl_4]^{2-}$

$Ni^{2+} \rightarrow d^8 \rightarrow$ 

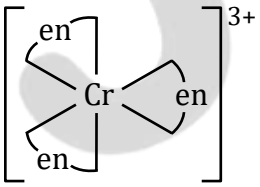
sp^3 hybridisation

Cl^- is weak ligand

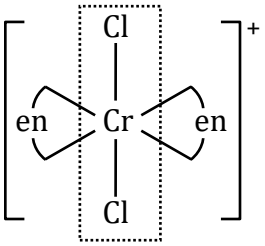
No pairing of electron will take place.

- sp^3 hybridisation, tetrahedral
- 2 unpaired electrons → paramagnetic

26. (B)

(i) $[Cr(en)_3]^{3+} \rightarrow$ 

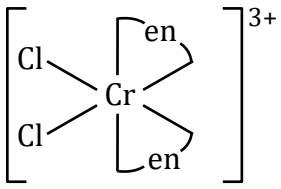
• Optically active [no POS, no COS]

(ii) trans-$[Cr(en)_2Cl_2]^+ \rightarrow$ 

POS present

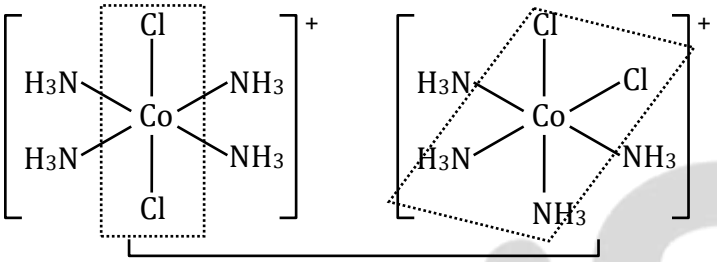
• Optically inactive

(iii) cis-$[Cr(en)_2Cl_2]^+$ →



• Optically active [no POS, no COS]

(iv) $[Co(NH_3)_4Cl_2]^+$ →



Both have POS

• Optically inactive

27. (D)

$^{227}Ac \xrightarrow{k_1}$ Th (2%)

$^{227}Ac \xrightarrow{k_2}$ Fr (98%)

$\frac{k_1}{k_2} = \frac{2}{98}$

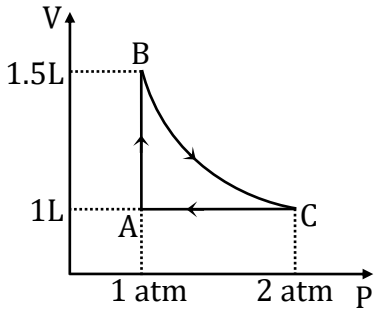
$t_{½}$ = 22 years

$k = \frac{0.693}{t_{½}} = \frac{0.693}{22}$ year $= k_1 + k_2$

$\frac{0.693}{22} = k_1 + \frac{98}{2}k_1$

$\Rightarrow \therefore \; k_1 = 6.3 \times 10^{-4}$

28. (D)



Given: n = 1 mole, T_A = 300 K, ω_{BC} = 1 L-atm

$\omega_{AB} = -P_{ext.}(V_2 - V_1) = -1(1.5 - 1) = -0.5$ L-atm

(Isobaric process)

$\omega_{CA} = 0$ (dV = 0)

(Isochoric process)

$\therefore \quad \omega_{total} = \omega_{AB} + \omega_{BC} + \omega_{CA}$

$= -0.5 + 1 + 0 = 0.5$ L-atm

ΔU calculation

For complete cyclic process ABC $\rightarrow \Delta U = 0$ ($\because$ U $\rightarrow$ is a state function)

According to first law,

$\Delta U = q + w = 0$

$q = -w = -0.5$ L-atm

Heat exchanged during the process = 0.5 L-atm

Correct option is (D).

29. (B)

$P°_{toluene}$ = 0.742 bar

$P°_{benzene}$ = 1.800 bar

Mixture boils at 100°C $\rightarrow$ at 1 atm = 1.013 bar

$P_T = 1.013 \text{ bar} = P_A X_A + P_B X_B$

$\Rightarrow P_T = P_t^o X_t + P_b^o X_b$

$1.013 = 0.742\, X_t + 1.8(1 - X_t)$

$\Rightarrow X_t = 0.744$

$X_b = 1 - 0.744 = 0.256$

X_t = mole fraction of toluene.

30. (A)

The unit cell of the above pattern will consist of 8 white square and 1 black square i.e. it will form centre unit cell.

$\therefore$ No. of white square Y = 8

No. of black square X = 1

$\therefore$ **Formula XY_8**