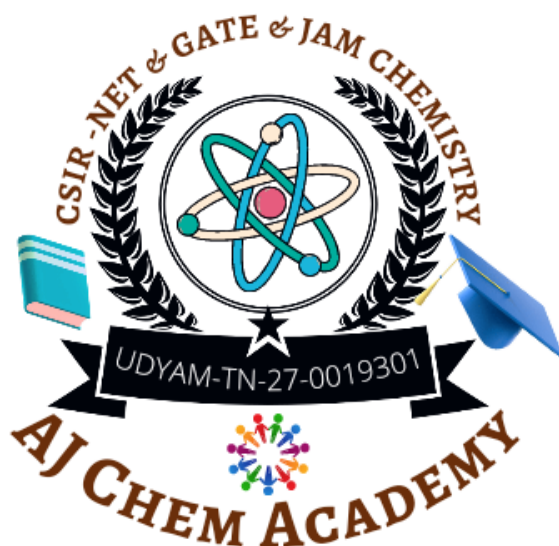


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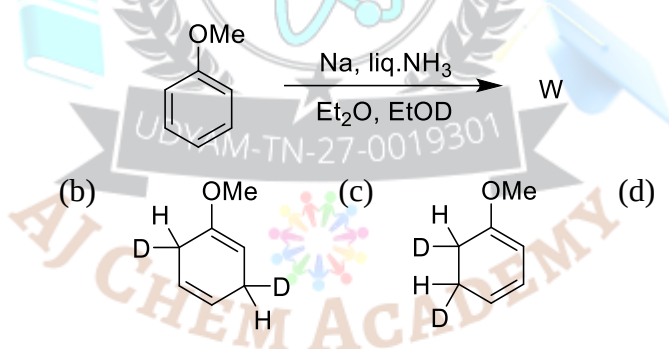
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(Q1-10) MCQ carry ONE mark each (for each wrong answer: – 1/3).

- The molecule that gets **inter-converted** into its **enantiomer**, upon **ring flipping** in its **chair conformation**, is _____.
 (a) cis-1,2-dimethylcyclohexane (b) cis-1,3-dimethylcyclohexane
 (c) cis-1,4-dimethylcyclohexane (d) trans-1,2-dimethylcyclohexane
- In **DNA**, the **number of hydrogen bonds** that hold each **adenine-thymine base pair** and each **guanine-cytosine base pair**, respectively, are _____.
 (a) 3 and 3 (b) 2 and 2 (c) 2 and 3 (d) 3 and 2
- The **correct relationship** between the molecules **X** and **Y** is that, they are _____.


- The **major product W** formed in the following reaction is


- Ellingham diagram** is a plot of _____.
 (a) $\Delta_f H^\circ$ versus temperature (b) $\Delta_f G^\circ$ versus time
 (c) $\Delta_f G^\circ$ versus temperature (d) $\Delta_f H^\circ$ versus time
- The major product formed from the reaction between **B₂H₆** and two equivalents of **NH₃** at **300 °C** is
 (a) BH₃.NH₃ (b) [NH₄]⁺ [BH₄]⁻ (c) [(H₃N)₂BH]²⁺ 2[BH₄]⁻ (d) (HBNH)₃
- The metal that is used as a **catalyst** in the synthesis of **(CH₃)₂SiCl₂** in **Rochow Müller process** is
 (a) Cu (b) Zn (c) Sn (d) Fe
- The molecule that has **ONLY one lone pair of electrons on xenon** is
 (a) XeF₂ (b) XeF₄ (c) XeO₂F₂ (d) XeO₃F₂

9. For first-order diffraction, the smallest value of d_{hkl} that can be detected with X-ray having a wavelength of $1.54 \text{ \AA}$ is ____ $\text{\AA}$.

(a) 0.38 (b) 0.77 (c) 1.02 (d) 2.05

10. For an ideal gas, the isothermal compressibility $[K_T = -\frac{1}{V}(\frac{\partial V}{\partial P})_T]$ is

(a) $1/P$ (b) $1/T$ (c) nR/P (d) nRT

(Q.11-30) MCQ carry TWO marks each (for each wrong answer: - 2/3).

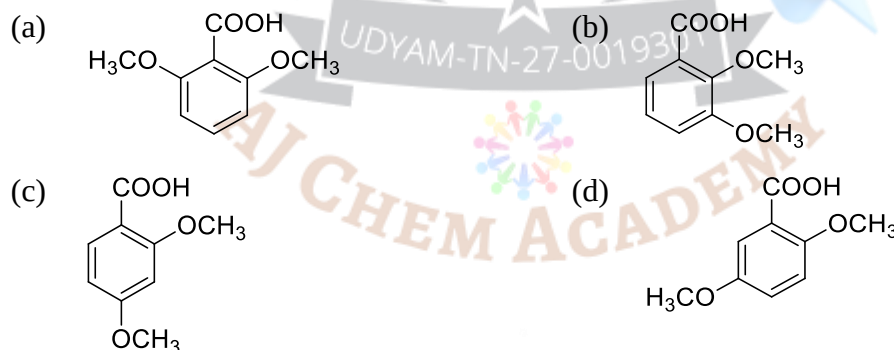
11. The Lennard-Jones (LJ) potential of interaction between two molecules as a function of distance (r), is given by $V_{LJ}(r) = 4\epsilon \left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^6 \right]$, where ϵ and σ are constants. The expression of r at which $V_{LJ}(r)$ reaches minimum is

(a) $\left(\frac{11}{6}\right)^{1/4} \sigma^{3/2}$ (b) $2^{1/6} \sigma$ (c) σ (d) $4^{1/5} \epsilon^{1/6}$

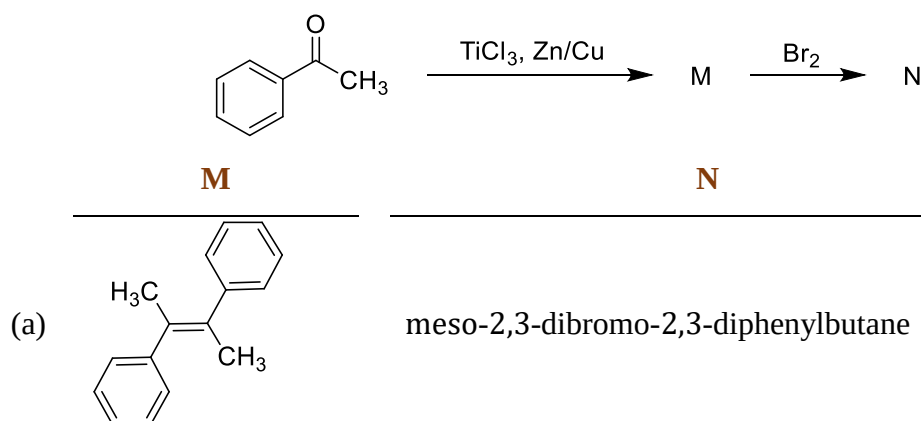
12. The $^1\text{H-NMR}$ spectral data of a compound X is as follows:

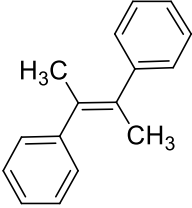
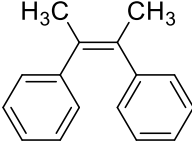
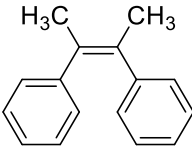
δ (ppm) : 11.6 (s, 1H, D_2O exchangeable),
7.60 (d, 1H, $J = 7.2 \text{ Hz}$), 7.20 (t, 1H, $J = 7.2 \text{ Hz}$),
6.90 (d, 1H, $J = 7.2 \text{ Hz}$), 3.70 (s, 3H), 3.58 (s, 3H)

Based on the spectral data, choose the appropriate structure for compound X.

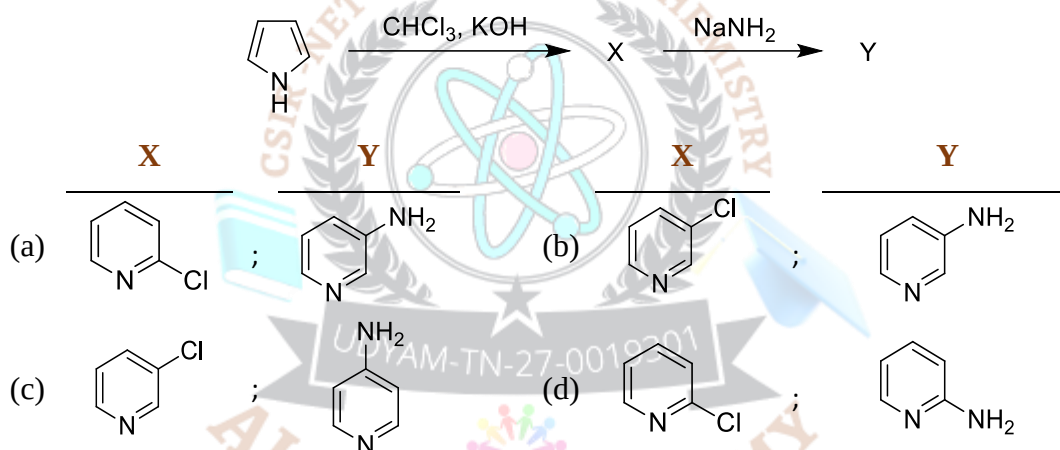


13. The major products M and N formed in the following reaction sequence are

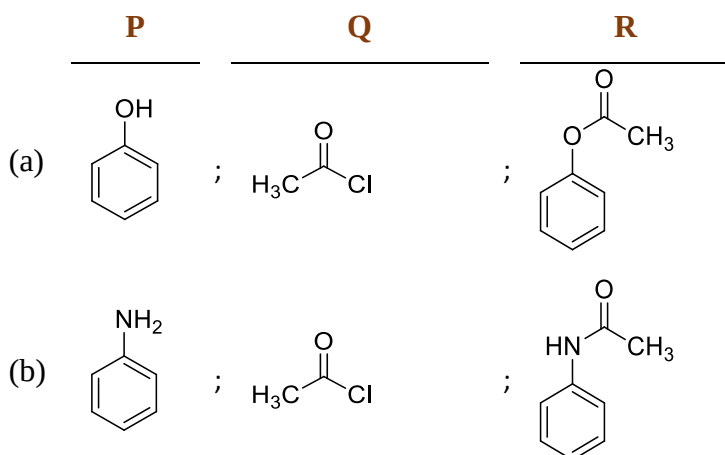


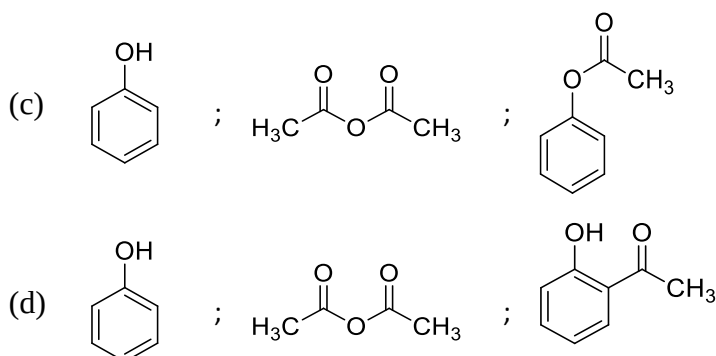
- (b)  racemic-2,3-dibromo-2,3-diphenylbutane
- (c)  racemic-2,3-dibromo-2,3-diphenylbutane
- (d)  meso-2,3-dibromo-2,3-diphenylbutane

14. The major products **X** and **Y** formed in following reaction sequence are

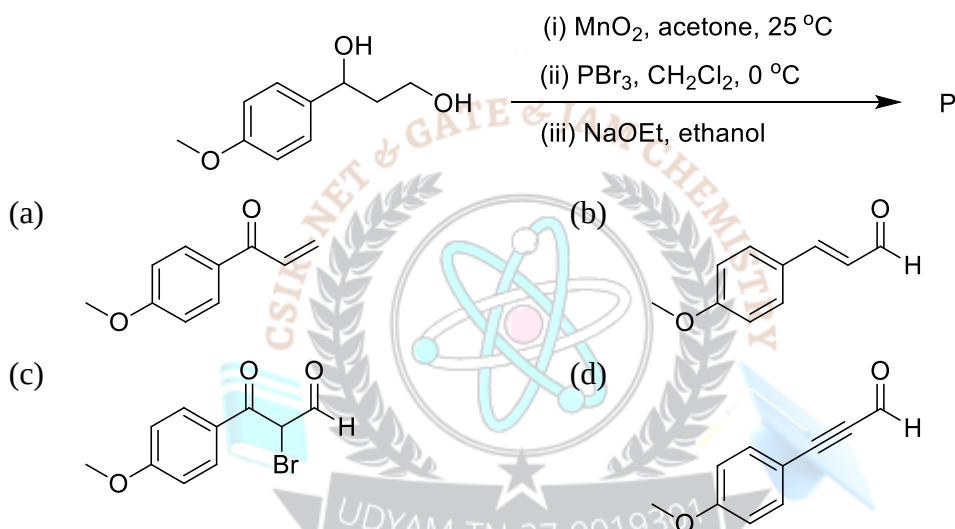


15. A mono-substituted aromatic compound **P** decolourizes bromine water, gives a purple red colour with aqueous FeCl_3 and is also soluble in aqueous NaOH . Compound **P** undergoes acetylation with reagent **Q** in the presence of a base to give **R** as the major product. Reagent **Q** displays two characteristic bands at 1830 cm^{-1} and 1750 cm^{-1} in its IR spectrum. **P**, **Q** and **R** are

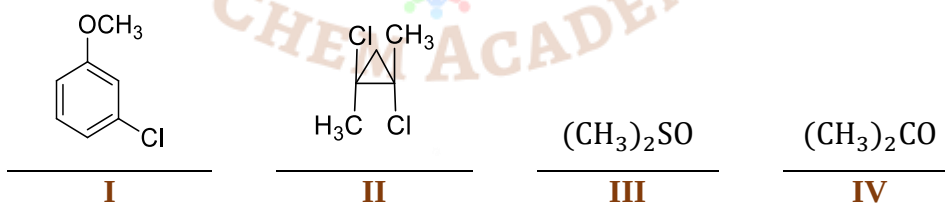




16. The **major product P** formed in the following transformation is

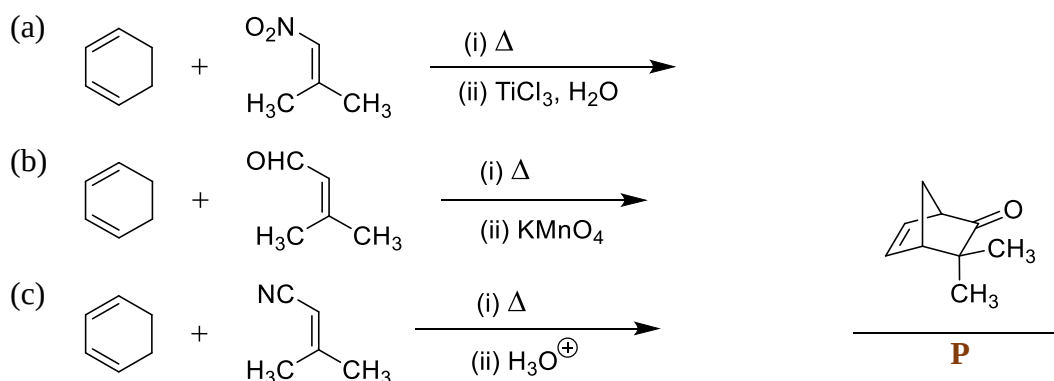


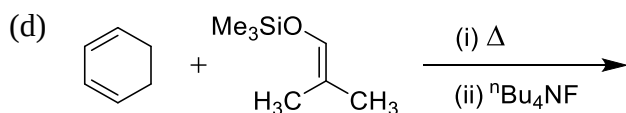
17. The molecules that possess σ (plane of symmetry) as the **ONLY** element of symmetry are



- (a) II and IV (b) I and IV (c) III and IV (d) I and III

18. Reaction that **yields P** as the **major product** is





19. **D-Glucose** and its stereoisomers undergo oxidation with **conc. HNO_3** to give the corresponding dicarboxylic acids. The **number of stereoisomers of glucose** that would give **meso-dicarboxylic acid** is
- (a) 2 (b) 4 (c) 6 (d) 8
20. Among the following, the one that has the **lowest melting point** is
- (a) LiBr (b) AlBr₃ (c) NaBr (d) MgBr₂
21. The correct order of **F–M–F bond angle** of compounds given in the options is
(where M represents the central element)
- (a) $\text{XeF}_2 > \text{BF}_3 > \text{OF}_2 > [\text{NF}_4]^+$ (b) $\text{XeF}_2 > \text{BF}_3 > [\text{NF}_4]^+ > \text{OF}_2$
(c) $\text{BF}_3 > \text{XeF}_2 > [\text{NF}_4]^+ > \text{OF}_2$ (d) $\text{XeF}_2 > \text{OF}_2 > \text{BF}_3 > [\text{NF}_4]^+$
22. The correct order of **bond length** between **carbon** and **oxygen atoms** in the metal carbonyls given in the options is
- (a) $\text{Na}_2[\text{Fe}(\text{CO})_4] > \text{Na}[\text{Co}(\text{CO})_4] > [\text{Ni}(\text{CO})_4]$
(b) $[\text{Ni}(\text{CO})_4] > \text{Na}[\text{Co}(\text{CO})_4] > \text{Na}_2[\text{Fe}(\text{CO})_4]$
(c) $\text{Na}_2[\text{Fe}(\text{CO})_4] > [\text{Ni}(\text{CO})_4] > \text{Na}[\text{Co}(\text{CO})_4]$
(d) $[\text{Ni}(\text{CO})_4] > \text{Na}_2[\text{Fe}(\text{CO})_4] > \text{Na}[\text{Co}(\text{CO})_4]$
23. The solid having the **least packing efficiency** is ____.
- (a) caesium chloride (b) cadmium iodide
(c) zinc sulfide (wurtzite form) (d) zinc sulfide (zinc blende form)
24. The **ligand to metal charge transfer (LMCT) transition energy** of the given ions follows the order
- (a) $[\text{WO}_4]^{2-} > [\text{MoO}_4]^{2-} > [\text{CrO}_4]^{2-}$
(b) $[\text{CrO}_4]^{2-} > [\text{MoO}_4]^{2-} > [\text{WO}_4]^{2-}$
(c) $[\text{MoO}_4]^{2-} > [\text{CrO}_4]^{2-} > [\text{WO}_4]^{2-}$
(d) $[\text{MoO}_4]^{2-} > [\text{WO}_4]^{2-} > [\text{CrO}_4]^{2-}$
25. The species that has **‘T’ shape** is
- (a) PCl_3 (b) SOCl_2 (c) BrF_3 (d) $[\text{IO}_3]^-$
26. The correct pair in which both the complex ions show the **ground state electronic degeneracy** is
- (a) $[\text{TiF}_6]^{2-}$ and $[\text{Ti}(\text{H}_2\text{O})_6]^{2+}$ (b) $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{Mn}(\text{CN})_6]^{3-}$
(c) $[\text{Ti}(\text{H}_2\text{O})_6]^{2+}$ and $[\text{Mn}(\text{CN})_6]^{3-}$ (d) $[\text{Fe}(\text{CN})_6]^{4-}$ and $[\text{TiF}_6]^{2-}$

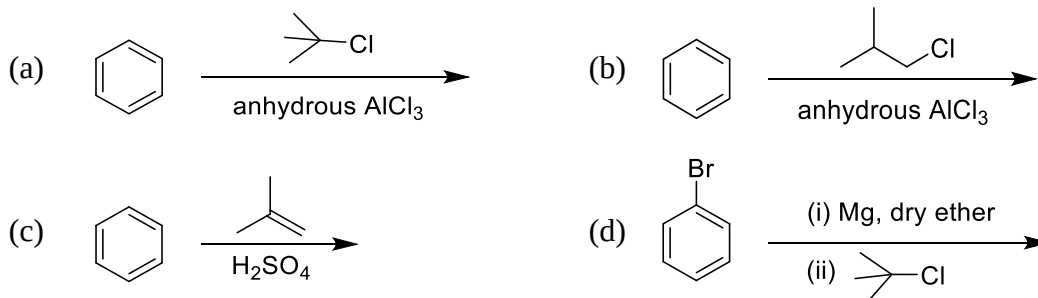
27. The complex having the **lowest molar extinction coefficient** is
 (a) $\text{Na}_2[\text{Ni}(\text{Br})_4]$ (b) $[\text{Cr}(\text{NH}_3)_6]\text{SO}_4$ (c) $\text{Na}_2[\text{Co}(\text{Cl})_4]$ (d) $[\text{Mn}(\text{H}_2\text{O})_6]\text{SO}_4$
28. For the reaction $\text{NO}_2\text{Cl} \rightarrow \text{NO}_2 + \frac{1}{2}\text{Cl}_2$, the proposed mechanism involves the following two elementary steps: $\text{NO}_2\text{Cl} \xrightarrow{k_1} \text{NO}_2 + \text{Cl}$ & $\text{NO}_2\text{Cl} + \text{Cl} \xrightarrow{k_2} \text{NO}_2 + \text{Cl}_2$. Assuming **steady state approximation** for Cl, the correct expression for the rate of formation of NO_2 is
 (a) $\frac{d[\text{NO}_2]}{dt} = 2k_1[\text{NO}_2\text{Cl}]$ (b) $\frac{d[\text{NO}_2]}{dt} = \left(\frac{k_1}{k_2}\right)[\text{NO}_2\text{Cl}]$
 (c) $\frac{d[\text{NO}_2]}{dt} = (k_1 + k_2)[\text{NO}_2\text{Cl}]$ (d) $\frac{d[\text{NO}_2]}{dt} = (k_1 k_2)[\text{NO}_2\text{Cl}]$
29. In the **van der Waals equation of state**, the volume correction factor (b) arises from the repulsive interactions between the gas molecules. Considering the molecules to behave as hard spheres of radius r, $b = Y \times V_{\text{molecule}} \times N_A$. The value of Y is _____.
 [Given: N_A is the Avogadro's Number, V_{molecule} is the volume of a gas molecule]
 (a) 8 (b) 2 (c) 16 (d) 4
30. For the transformation of 1 mole of an **ideal gas** from an initial temperature of 27°C and an initial pressure of 1 atm to a final temperature of 327°C and a final pressure of 17 atm, the **change in enthalpy**, ΔH is ____ kJ.
 [$C_p(\text{J K}^{-1} \text{mol}^{-1}) = a + bT$, where $a = 20.9 \text{ J K}^{-1} \text{mol}^{-1}$, $b = 0.042 \text{ J K}^{-2} \text{mol}^{-1}$].
 (a) 6.30 (b) 8.50 (c) 11.94 (d) 17.61

(Q31-40) MCQ carry TWO marks each (for each wrong answer: - 2/3).

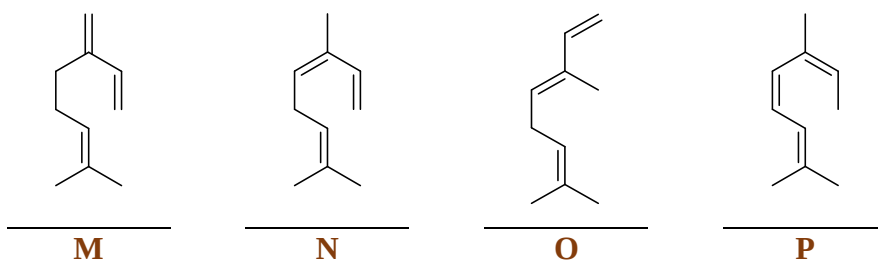
31. The **possible value(s) of energy (E)** obtained from setting the following determinant equal to zero is/are

$$\begin{vmatrix} \alpha - E & \beta & 0 \\ \beta & \alpha - E & \beta \\ 0 & \beta & \alpha - E \end{vmatrix}$$

- (a) $\alpha + \sqrt{2}\beta$ (b) $\alpha + \beta$ (c) $\alpha - \sqrt{2}\beta$ (d) α
32. The reaction(s) that give(s) **tert-butylbenzene** as the **major product** is/are

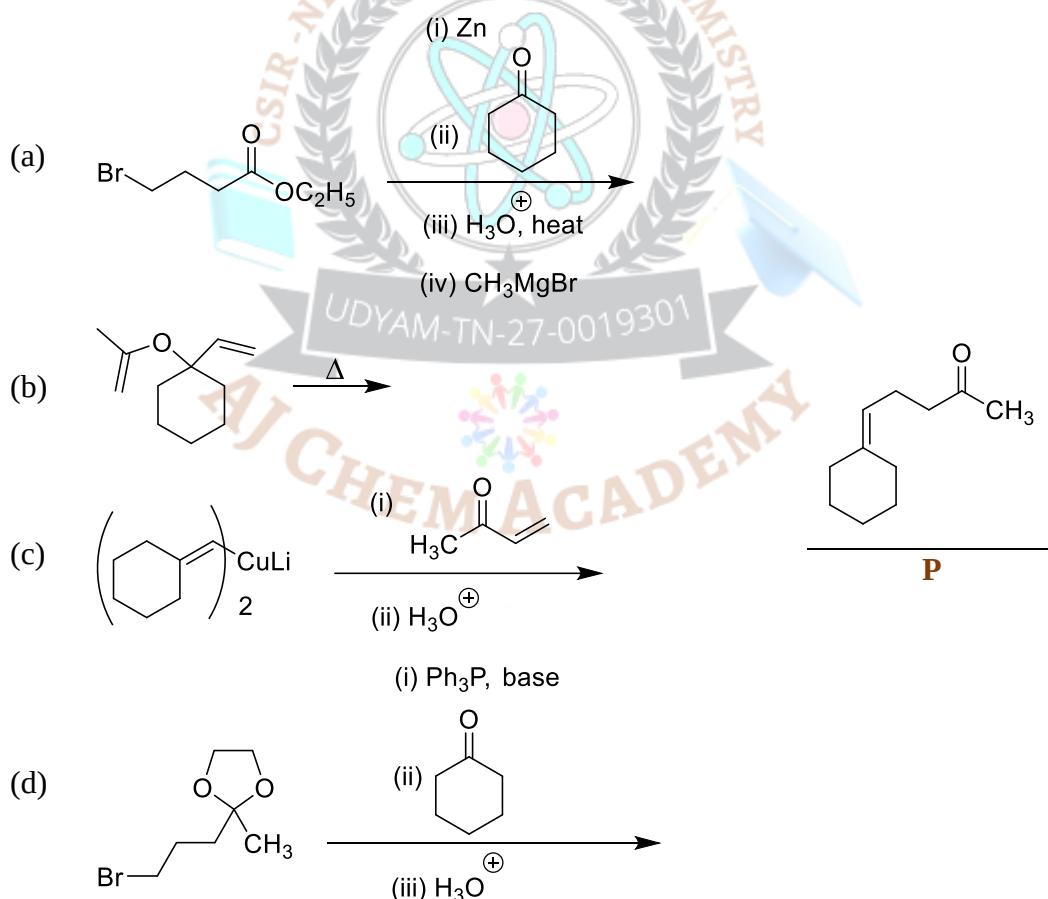


33. Choose the **correct statement(s)** with regard to **the terpenes** given below.



- (a) Upon ozonolysis, all the terpenes would produce at least one identical carbonyl compound
- (b) Terpenes N and O are geometrical isomers
- (c) Terpene O cannot undergo Diels-Alder reaction with maleic anhydride
- (d) Amongst all, $\lambda_{\max}$ for $\pi-\pi^*$ absorption is the lowest for terpene P

34. The reaction(s) that **yield(s) P** as the **major product** is/are



35. Set(s) of reagents that convert(s) **benzoyl chloride** to **aniline** is/are

- (a) (i) NH_3 ; (ii) Br_2, NaOH ; (iii) H_2O
- (b) (i) CH_2N_2 ; (ii) H_2O
- (c) (i) NaN_3 ; (ii) H_2O

- (d) (i) NH_2OH ; (ii) TsCl , Pyridine; (iii) NaOH , Δ ; (iv) H_2O
36. The reactions of **Li**, **Na** and **K** with an excess of oxygen results in the formation of **X**, **Y** and **Z** respectively, as major products. The correct option(s) is/are
- X is an oxide, Y is a peroxide and Z is a superoxide
 - X and Y are diamagnetic but Z is paramagnetic
 - X is an oxide, Y is a superoxide and Z is a peroxide
 - aqueous solutions of X, Y and Z are basic in nature
37. Choose the correct option(s) with regard to **haemoglobin (Hb)**
- Hb binds oxygen in a co-operative process
 - The metal ion in oxy-Hb has a larger size than that in deoxy-Hb
 - Hb takes up more oxygen at pH 7.4 than at pH 6.8
 - The metal ion is paramagnetic in deoxy-Hb
38. Choose the correct statement(s) with regard to the **complexometric titration** of **$[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$** ion with a complexing agent **$\text{Na}_2\text{H}_2\text{EDTA}$** , using a suitable indicator under basic conditions,
- The correct choice of indicator is phenolphthalein
 - The stoichiometry of nickel and EDTA ions in the metal complex formed between metal and complexing agent is 1 : 1
 - The binding constant for the complex formed between metal ion and complexing agent is higher than that for the complex formed between metal ion and indicator
 - The stoichiometry of nickel and EDTA ions in the metal complex formed between metal and complexing agent is 1 : 3
39. The correct **statement(s)** for **graphite** is/are
- It shows lubricating property
 - Each carbon atom of graphite is sp -hybridized
 - It conducts electricity
 - The thermal conductivity of graphite is higher than that of diamond
40. The **Langmuir isotherm** for the adsorption of a gas on a solid surface can be expressed as $\theta = \frac{KP}{1+KP}$. The correct statement(s) about this isotherm is/are
- [Given: θ is the fractional coverage; P is the pressure of the gas; K is a constant]**
- At very low pressures, plot of θ against P is a straight line passing through the origin with slope equal to K

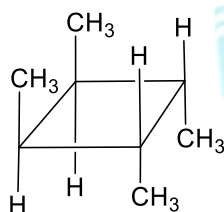


- (b) At very high pressures, plot of θ against P is a straight line parallel to the x-axis with the value of the y-intercept equal to 1
- (c) The Langmuir isotherm can also be expressed as $\frac{1}{\theta} = 1 + \frac{1}{KP}$
- (d) The Langmuir isotherm is applicable for multilayer adsorption

(Q 41-50) NAT carry ONE mark each (no negative marks).

41. For the equation $y = 3x^5 + 4x^4 - 3x^3 + x^2 - 2x + 1$, the value of $\frac{d^5y}{dx^5}$ is _____.
(answer in integer)
42. The number of stereogenic centre(s) present in the given alkaloid is _____.
(answer in integer)

43.



The type(s) of chemically non-equivalent protons present in the following molecule is _____. (answer in integer)

44. The number of unpaired electron(s) of chromium in $[(\eta^6\text{-C}_6\text{H}_6)\text{Cr}(\text{CO})_3]$ is _____.
(answer in integer)
45. Consider the following radioactive decay process, ${}^{238}_{92}\text{U} \rightarrow {}^{210}_{82}\text{Pb} + 7\alpha + m\beta$. The value of m is _____.
(answer in integer)
46. The Debye temperatures (θ_D) of diamond and copper are 2230 K and 343 K, respectively. The maximum value of the frequency of the atomic oscillations of diamond is Y times the maximum value of the frequency of the atomic oscillations of copper. The value of Y is _____. (rounded off to two decimal places)
47. A system consists of 110 (one hundred and ten) particles. Each particle can have only two non-degenerate energy states ϵ_1 and ϵ_2 (with $\epsilon_2 > \epsilon_1$). The energy difference between these two states is 0.10 eV. The temperature at which only 10 particles of the system will be present in the energy state ϵ_2 is ____ K.
(rounded off to two decimal places)

[Boltzmann's constant = $1.38 \times 10^{-23} \text{ J K}^{-1}$; $1\text{eV} = 1.6 \times 10^{-19} \text{ J}$]

48. When **3.00 g** of a substance of molar mass **250 g mol^{-1}** is dissolved in **100 g** of **CCl_4** , the **boiling point of the solvent (CCl_4)** will be elevated by _____ K.

[rounded off to two decimal places, K_b for $\text{CCl}_4 = 5.00 \text{ K kg mol}^{-1}$]

49. The **number of normal modes of vibration in benzene** is _____.
(answer in integer)

50. At **30°C** , the **half-life** for the decomposition of a compound is **100 seconds** and the value of the half-life is independent of the initial concentration of the reactant. The **time required for 30%** of the reactant to be consumed is _____ seconds.

(rounded off to one decimal place)

(Q 51-60) NAT carry ONE mark each (no negative marks).

51. The specific rotation $[\alpha]_D^{25}$ of (S)-2-pentanol is **$+13.0$ degrees**. A one molar solution of (S)-2-pentanol is mixed with an equal volume of one molar solution of **racemic 2-pentanol**. The observed rotation, α , of the resulting solution, when measured in a polarimeter tube of path length **10 cm** is _____ degrees. (rounded off to three decimal places).
(Given: Molar mass of 2-pentanol is 88 g mol^{-1})

52. The **number of iron atom(s)** in **Fe_3O_4** with an oxidation state of **III** along with a **coordination number of six** is _____. (answer in integer)

53. The **total number of P–O–P bridge(s)** in the solid state structure of **P_4O_8** is _____.
(answer in integer)

54. At **pH 7**, the reaction for the oxidation of **NADH** at **298 K** and a pressure of **1 atm** is given below: $\text{NADH} + \text{H}^+ + \frac{1}{2}\text{O}_2 \rightarrow \text{NAD}^+ + \text{H}_2\text{O}$.

At **298 K**, $E^0_{(\text{NAD}^+/\text{NADH})} = -0.320 \text{ V}$ and $E^0_{\text{O}_2/\text{H}_2\text{O}} = 0.816 \text{ V}$.

The **standard Gibbs free energy change (ΔG^0)** for this reaction is _____ kJ.
(rounded off to two decimal places) [Given: Faraday's constant = 96500 C mol^{-1}]

55. The **mobility of Na^+ ions** in water at **298 K** is **$5.19 \times 10^{-8} \text{ m}^2 \text{ s}^{-1} \text{ V}^{-1}$** . If the effective radius of a **Na^+ ions** is **$Y \times 10^{-2} \text{ m}$** , the value of **Y** is _____.

(rounded off to two decimal places)

[Elementary charge = $1.6 \times 10^{-19} \text{ C}$, Viscosity of water at 298 K is 1 mPa s]

56. For the dissociation reaction, $\text{N}_2\text{O}_{3(g)} \rightleftharpoons \text{NO}_{2(g)} + \text{NO}_{(g)}$, when **1 mole of $\text{N}_2\text{O}_{3(g)}$** is allowed to reach equilibrium at **27°C** and at a total pressure of **1 bar**, its **degree of dissociation** is found to be **0.20**. The value of equilibrium constant, **K_p** , is _____. (rounded off to three decimal places)



57. A free particle of mass M confined within the walls of a **one-dimensional box** of length a (with the potential outside the box being infinity), is in the eigenstate having quantum number $n = 4$. The **magnitude of uncertainty** in the measurement of momentum of the particle is $Y \times \frac{h}{a}$. The value of Y is _____. (answer in integer)

[The potential V inside the box is equal to zero and h is the Planck's constant]

58. The **rotational spectrum** of HF has equally spaced lines that are 40.9 cm^{-1} apart. The **moment of inertia** of HF is $Y \times 10^{-47} \text{ kg m}^2$. The value of Y is _____. (rounded off to three decimal places)

[Speed of light, $c = 3 \times 10^8 \text{ m s}^{-1}$, Planck's constant, $h = 6.63 \times 10^{-34} \text{ J s}$]

59. At a constant pressure, **entropy of mixing** of 1 mole of oxygen with 3 moles of nitrogen at 25°C is _____ J K^{-1} . (rounded off to two decimal places)

[Given: $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$, Assume that the gases behave ideally]

60. If the radial wavefunction of the **3p orbital** of a hydrogen-like atom is

$$R_{31}(r) = \frac{1}{\sqrt{486}} \left(\frac{Z}{a_0} \right)^{\frac{3}{2}} (4 - \rho) e^{-\rho/2}$$

then, the **radial node of the orbital** is located at $Y \times \frac{a_0}{Z}$, where Y is equal to ____.

(answer in integer)

[Given: Z is the atomic number of the hydrogen-like atom a_0 is the Bohr radius

$\rho = \left(\frac{2Z}{na_0} \right) r$, n is the principal quantum number]



Answer Key

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
1.	a	16.	a	31.	a,c,d	46.	6.40 to 6.60
2.	c	17.	d	32.	a,b,c,	47.	500.00 to 505.00
3.	d	18.	a	33.	a,b	48.	0.60 to 0.60
4.	b	19.	b	34.	b,c,d	49.	30 to 30
5.	c	20.	b	35.	a,c,d or a,d	50.	50.5 to 52.5
6.	d	21.	b	36.	a,b,d	51.	0.560 to 0.580
7.	a	22.	a	37.	a,c,d	52.	1 to 1
8.	c	23.	a	38.	b,c	53.	6 to 6
9.	b	24.	a	39.	a,c	54.	-220.00 to -219.00
10.	a	25.	c	40.	a,b,c,	55.	162.50 to 164.50
11.	b	26.	c	41.	360 to 360	56.	0.040 to 0.044
12.	b	27.	d	42.	5 to 5	57.	2 to 2
13.	a	28.	a	43.	2 to 2	58.	1.300 to 1.500
14.	c	29.	d	44.	0 to 0	59.	18.55 to 18.80
15.	c	30.	c	45.	4 to 4	60.	6 to 6

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