







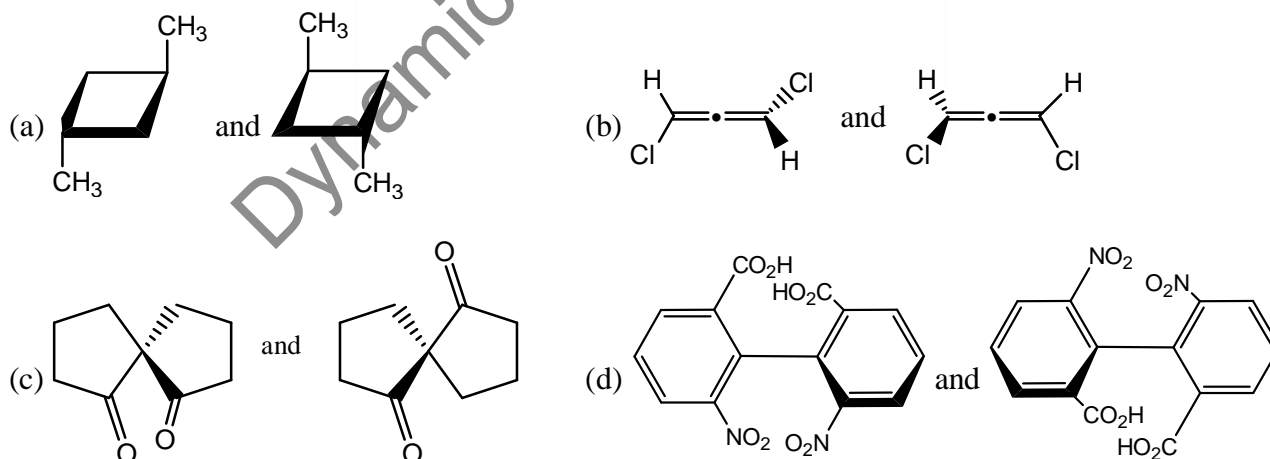


20. The energy of a hydrogen molecule in its ground state equilibrium configuration is  $-31.7$  eV. Its dissociation energy is \_\_\_\_\_ eV. (Upto one decimal places)
21. The molar heat capacity of a substance is represented in the temperature range 298K to 400K by the empirical relation  $C_{p,m} = 14 + bT$  JK<sup>-1</sup>mol<sup>-1</sup>, where  $b$  is a constant. The molar enthalpy change when the substance is heated from 300K to 350K is 2 kJ mol<sup>-1</sup>. The value of  $b$  is \_\_\_\_\_ J K<sup>-2</sup> mol<sup>-1</sup>. (Upto two decimal places)
22. In the electron ionization (EI) mass spectra, methyl hexanoate, methyl heptanoate and methyl octanoate give the same base peak. The  $m/z$  value of the base peak is \_\_\_\_\_
23. For the radioactive isotope <sup>131</sup>I, the time required for 50% disintegration is 8 days. The time required for the 99.9% disintegration of 5.5g of <sup>131</sup>I is \_\_\_\_\_ days. (Upto one decimal place)
24. The symmetry label of valence p orbitals of a metal ion in an octahedral ligand field is  
 (a)  $t_{1g}$  (b)  $t_{1u}$  (c)  $e_g + a_{1g}$  (d)  $t_{2g}$

25. Based on Wade's rule, the structure-type of  $[B_5H_8]^-$  is  
 (a) closo (b) nido (c) arachno (d) hypho

**Q.26 – Q.55 : Carry TWO marks each.**

26. Spectroscopic ground state term symbols of cobalt ions in  $[Co(H_2O)_6]^{2+}$  and  $[CoCl_4]^{2-}$  respectively are  
 (a)  $^2T_{1g}$  and  $^4A_2$  (b)  $^4T_{1g}$  and  $^4A_2$  (c)  $^2T_{2g}$  and  $^4T_1$  (d)  $^2T_1$  and  $^4A_1$
27. The reaction of equimolar quantities of  $Fe(CO)_5$  and  $OH^-$  gives a complex species X which on further reaction with  $MnO_2$  gives species Y. X and Y, respectively, are  
 (a)  $[Fe(CO)_5(OH)]^-$  and  $Fe_2(CO)_9$  (b)  $[Fe(CO)_4]^{2-}$  and  $Mn_2(CO)_{10}$   
 (c)  $[HFe(CO)_4]^-$  and  $Fe_2O_3$  (d)  $[HFe(CO)_4]^-$  and  $Fe_3(CO)_{12}$
28. The enantiomeric pair, among the following is

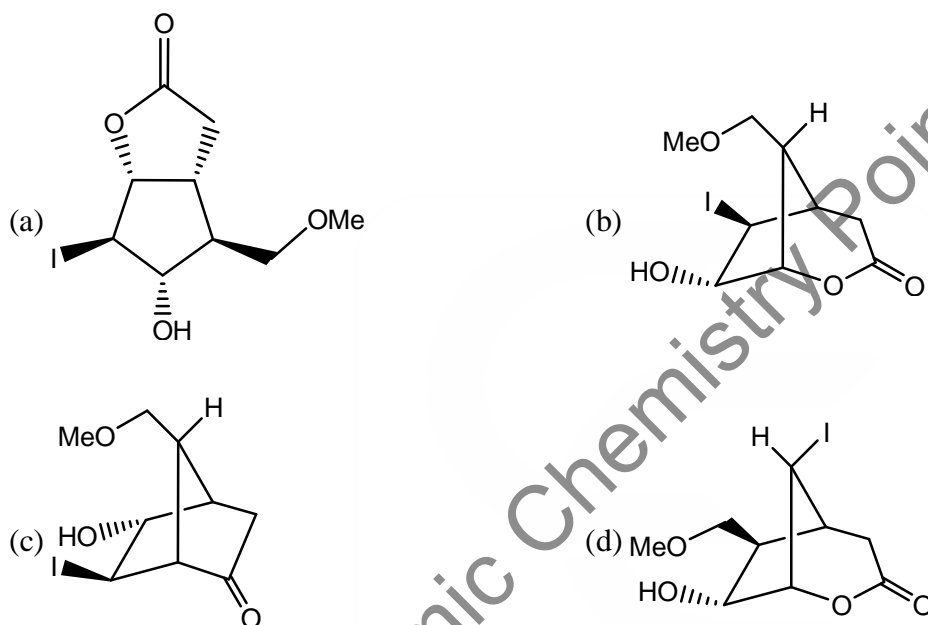
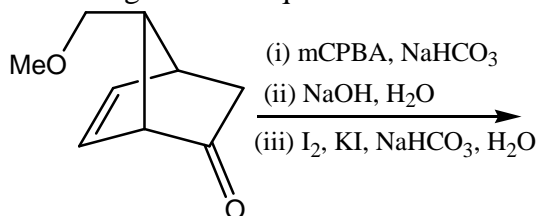


29. In a molecule XY, let  $\psi_X$  and  $\psi_Y$  denote normalized atomic orbitals of atoms X and Y, respectively. A normalized molecular orbital of XY is given by  $\psi_+ = 0.56(\psi_X + \psi_Y)$ . The value of the overlap integral of  $\psi_X$  and  $\psi_Y$  is \_\_\_\_\_ (Upto two decimal places)
30. The absorption maxima of two dyes X and Y are 520 and 460 nm, respectively. The absorbance data of these measured in a 1 cm path length cell are given in the table below.

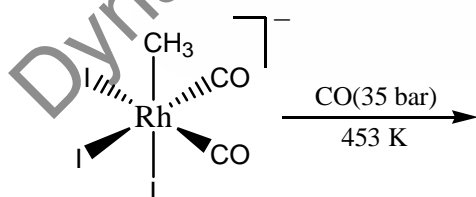
Dye solution	Absorbance at 460 nm	Absorbance at 520 nm
X (9 mM)	0.144	0.765
Y (12 mM)	0.912	0.168
Mixture of X and Y	0.700	0.680

The concentration of Y in the mixture is \_\_\_\_\_ mM. (Upto two decimal places)

31. The major product in the following reaction sequence is

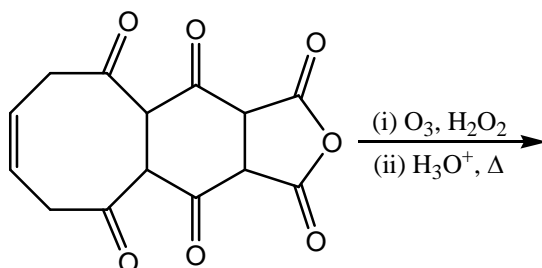


32. The elimination product of the following reaction is

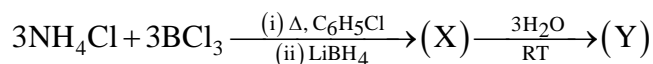


- (a) I<sub>2</sub>      (b) CH<sub>3</sub>I      (c) CH<sub>3</sub>COI      (d) I<sub>3</sub><sup>-</sup>

33. Number of carbonyl groups present in the final product of the following reaction sequence is



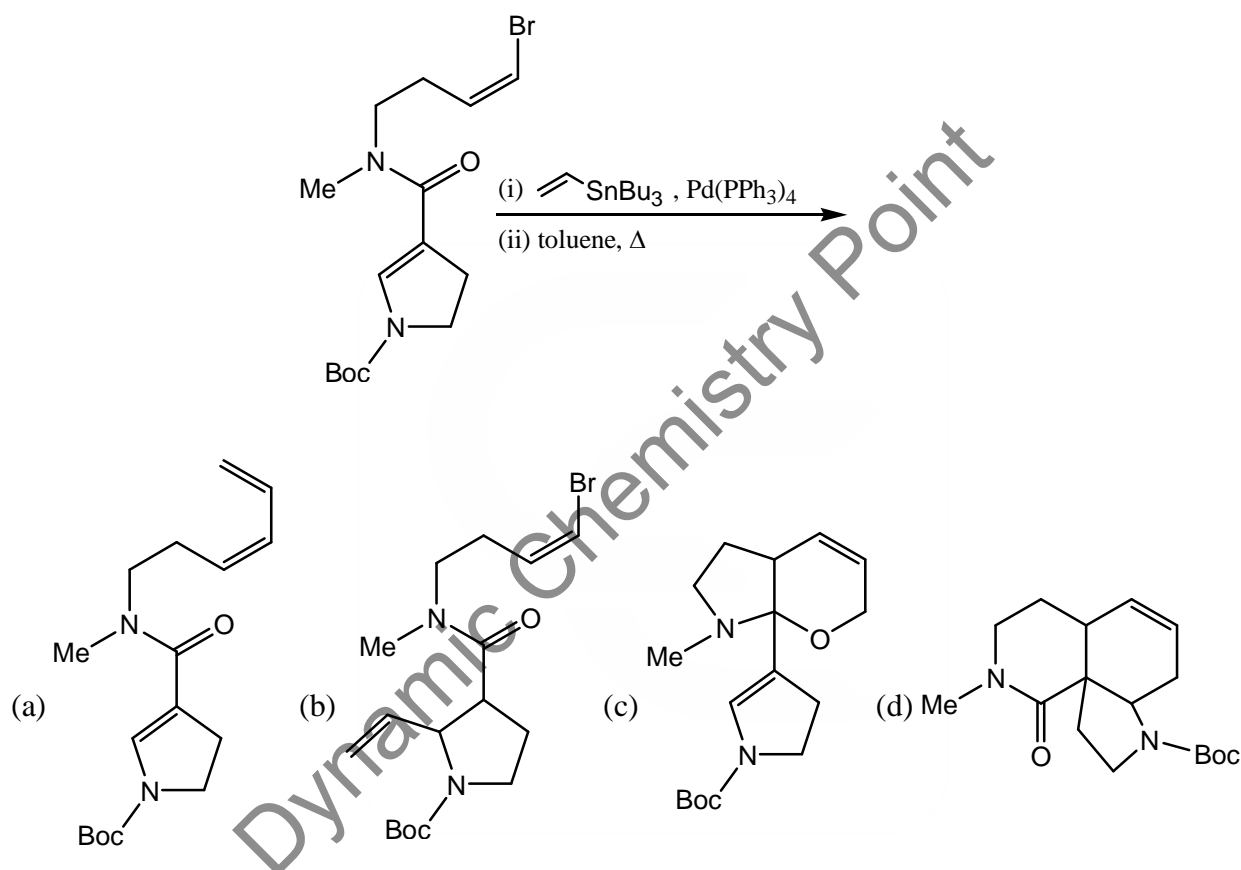
34. For the following reaction sequence,



X and Y, respectively, are

- (a)  $\{\text{HB}(\text{NH})\}_3$  and  $\{\text{H}(\text{OH})\text{B}(\text{NH}_2)\}_3$   
 (b)  $\{\text{HB}(\text{NH})\}_3$  and  $\{\text{HB}(\text{NH}_2\text{OH})\}_3$   
 (c)  $(\text{NH}_4)\{(\text{H})_2(\text{BH}_2)_3\}$  and  $\{\text{H}(\text{OH})(\text{NH}_2\text{OH})\}_3$   
 (d)  $(\text{NH}_4)\{(\text{H})_2(\text{BH}_2)_3\}$  and  $\{\text{HB}(\text{NH}_2\text{OH})\}_3$

35. The major product of the following reaction sequence is



36. For a diatomic vibrating rotor, in vibrational level  $v = 3$  and rotational level  $J$ , the sum of the rotational and vibrational energies is  $11493.6 \text{ cm}^{-1}$ . Its equilibrium oscillation frequency is  $2998.3 \text{ cm}^{-1}$ , anharmonicity constant is  $0.0124$  and rotational constant under rigid rotor approximation is  $9.716 \text{ cm}^{-1}$ . The value of  $J$  is \_\_\_\_\_ (Upto nearest integer)

37. At temperature  $T$ , the canonical partition function of a harmonic oscillator with fundamental frequency ( $\nu$ ) is given by

$$q_{\text{vib}}(T) = \frac{e^{-h\nu/2k_B T}}{1 - e^{-h\nu/k_B T}}$$

For  $\frac{h\nu}{k_B T} = 3$ , the probability of finding the harmonic oscillation in its ground vibrational state is \_\_\_\_\_ (Upto two decimal places)

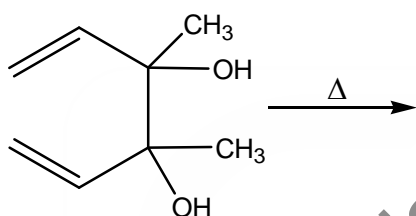
38. A one-dimensional anharmonic oscillator is treated by perturbation theory. The harmonic oscillator is used as the unperturbed system and the perturbation is  $\frac{1}{6}\gamma x^3$  ( $\gamma$  is a constant). Using only the first order correction, the total ground state energy of the anharmonic oscillator is

(Note: For a one-dimensional harmonic oscillator  $\psi_0(x) = \left(\frac{\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2}$ ;  $\alpha = \left(\frac{k\mu}{h^2}\right)^{1/2}$ )

(a)  $\frac{1}{2}\hbar\left(\frac{k}{\mu}\right)^{1/2}$       (b)  $\left(\frac{1}{2} + \frac{\gamma}{6}\right)\hbar\left(\frac{k}{\mu}\right)^{1/2}$       (c)  $\left(\frac{1}{2} + \frac{\gamma}{3}\right)\hbar\left(\frac{k}{\mu}\right)^{1/2}$       (d)  $\left(\frac{1}{2} + \frac{\gamma}{12}\right)\hbar\left(\frac{k}{\mu}\right)^{1/2}$

39. The rate constant of a first order reaction,  $X \rightarrow Y$ , is  $1.6 \times 10^{-1} \text{ s}^{-1}$  at 300K. Given that the activation energy of the reaction is  $28 \text{ kJ mol}^{-1}$  and assuming Arrhenium behaviour for the temperature dependence, the total time required to obtain 90% of Y at 350 K is \_\_\_\_\_ s. (Upto to one decimal place, use  $R = 8.31 \text{ JK}^{-1} \text{ mol}^{-1}$ ).

40. The strongest band observed in the IR spectrum of the final product of the following reaction appears, approximately at \_\_\_\_\_  $\times 100 \text{ cm}^{-1}$  (Upto one decimal place)



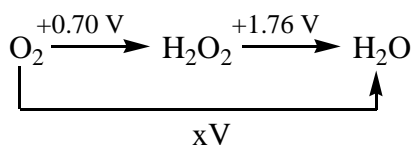
41. The reaction of  $\text{PCl}_3$  with  $\text{PhLi}$  in 1 : 3 molar ratio yields X as one of the products, which on further treatment with  $\text{CH}_3\text{I}$  gives Y. The reaction of Y with  $n\text{-BuLi}$  gives product Z. The product X, Y and Z respectively, are
- (a)  $[\text{PPh}_4]\text{Cl}$ ,  $[\text{Ph}_2\text{P} = \text{CH}_2]$  and  $\text{Ph}_2\text{P}(n\text{-Bu})$   
 (b)  $\text{PPh}_3$ ,  $[\text{Ph}_3\text{PI}](\text{CH}_3)$  and  $\text{Ph}_2\text{P}(n\text{-Bu})_3$   
 (c)  $\text{PPh}_3$ ,  $[\text{Ph}_3\text{P}(\text{CH}_3)]\text{I}$  and  $\text{Ph}_3\text{P} = \text{CH}_3$   
 (d)  $[\text{PPh}_4]\text{Cl}$ ,  $[\text{Ph}_3\text{P} = \text{CH}_2]$  and  $[\text{Ph}_3\text{P}(n\text{-Bu})]\text{Li}$

42. The  $\pi$  electrons in benzene can be modelled as particles in a ring that follow Pauli's exclusion principle. Given that the radius of benzene is  $1.4 \text{ \AA}$ , the longest wavelength of light that is absorbed during an electronic transition in benzene is \_\_\_\_\_ nm. (Upto one decimal place. Use  $m_e = 9.1 \times 10^{-31} \text{ kg}$ ,  $h = 6.6 \times 10^{-34} \text{ Js}$ ,  $c = 3.0 \times 10^8 \text{ ms}^{-1}$ )

43. Second-order rate constant for the reaction between  $[\text{Co}(\text{NH}_3)_5\text{X}]^{n+}$  ( $n = 3$  for  $\text{X} = \text{NH}_3$  and  $\text{H}_2\text{O}$ ;  $n = 2$  for  $\text{X} = \text{Cl}^-$ ) and  $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$  at room temperature varies with the X as

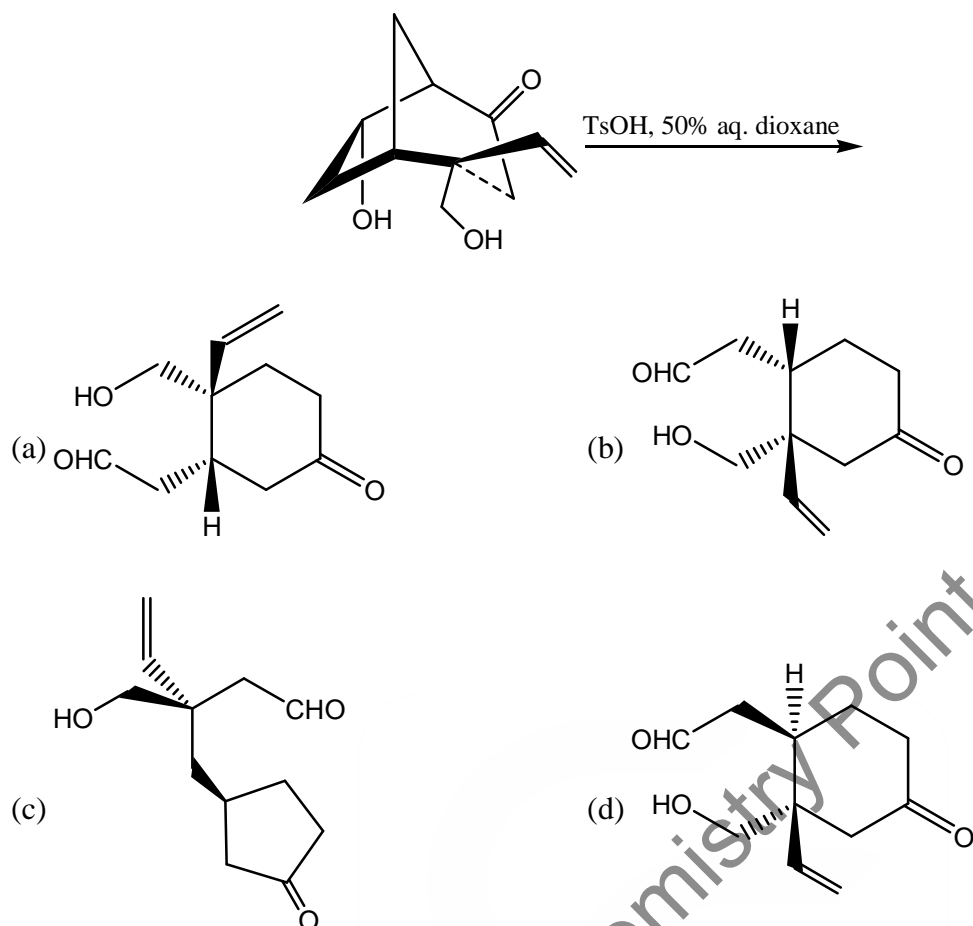
- (a)  $\text{NH}_3 > \text{H}_2\text{O} > \text{Cl}^-$       (b)  $\text{Cl}^- > \text{H}_2\text{O} > \text{NH}_3$   
 (c)  $\text{NH}_3 > \text{Cl}^- > \text{H}_2\text{O}$       (d)  $\text{H}_2\text{O} > \text{NH}_3 > \text{Cl}^-$

44. The Latimer diagram of oxygen is given below. The value of x is \_\_\_\_\_ V. (Upto two decimal places)



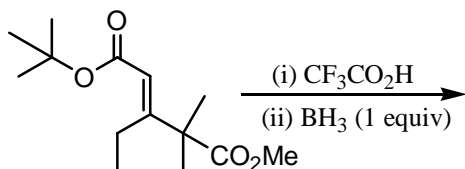


45. The major product formed in the following retro-aldol reaction is



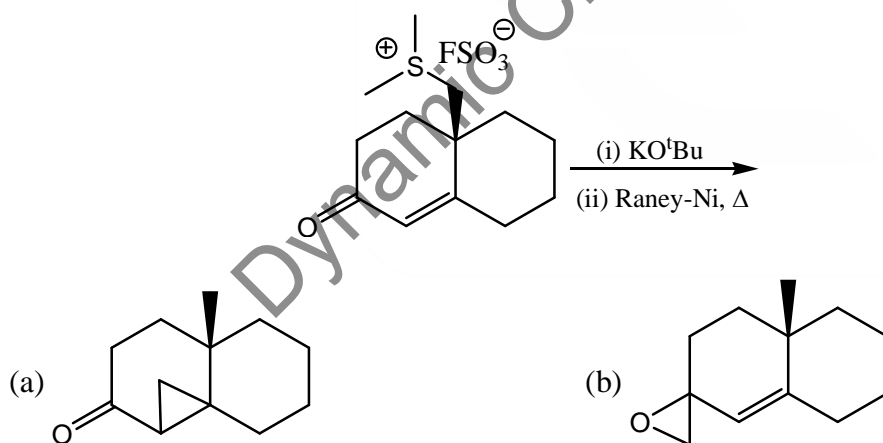
46. The enthalpy of vaporization of a liquid at its boiling point ( $T_b = 200 \text{ K}$ ) is  $15.3 \text{ kJ mol}^{-1}$ . If the molar volumes of the liquid and the vapour at  $200 \text{ K}$  are  $110$  and  $12000 \text{ cm}^3 \text{ mol}^{-1}$ , respectively, then the slope  $\frac{dP}{dT}$  of the liquid-boundary is \_\_\_\_\_  $\text{kPa K}^{-1}$  (Upto two decimal places. Note :  $1 \text{ Pa} = 1 \text{ J m}^{-3}$ )
47. The  $\text{O}_2$  coordinated to metal ion centres in oxy-myoglobin and oxy-hemocyanin exists, respectively, as  
 (a) superoxide and peroxide (b) superoxide and superoxide  
 (c) peroxide and peroxide (d) superoxide and oxygen
48. For an inverse spinel,  $\text{AB}_2\text{O}_4$ , the A and B, respectively, can be  
 (a) Ni(II) and Ga(III) (b) Zn(II) and Fe(III)  
 (c) Fe(II) and Cr(III) (d) Mn(II) and Mn(III)
49. The molar conductivity of a  $0.01 \text{ M}$  weak acid (HX) at  $298 \text{ K}$ , measured in a conductivity cell with cell constant of  $0.4 \text{ cm}^{-1}$ , is  $64.4 \text{ S cm}^2 \text{ mol}^{-1}$ . The limiting molar conductivities at infinite dilution of  $\text{H}^+$  and  $\text{X}^-$  at  $298 \text{ K}$  are  $350$  and  $410 \text{ S cm}^2 \text{ mol}^{-1}$ . Ignoring activity coefficients, the  $\text{pK}_a$  of HX at  $298 \text{ K}$  is \_\_\_\_\_ (Upto two decimal places)
50. The spacing between the two adjacent lines of the microwave spectrum of  $\text{H}^{35}\text{Cl}$ , is  $6.35 \times 10^{11} \text{ Hz}$ , given that bond length  $\text{D}^{35}\text{Cl}$  is  $5\%$  greater than that of  $\text{H}^{35}\text{Cl}$  the corresponding spacing for  $\text{D}^{35}\text{Cl}$  is \_\_\_\_\_  $\times 10^{11} \text{ Hz}$ . (Upto two decimal places)

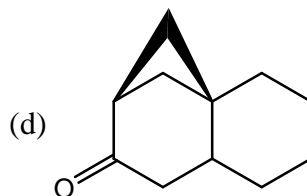
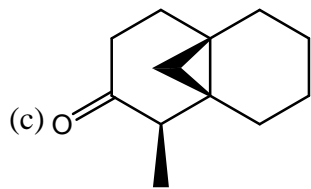
51. Generally, the coordination number and the nature of the electronic absorption band ( $f \rightarrow f$  transition) of lanthanide (III) ion in their complexes are, respectively
- (a) greater than 6 and sharp (b) 6 and broad  
 (c) less than 6 and sharp (d) greater than 6 and broad
52. A tetrapeptide, made up of natural amino acids, has alanine as the N-terminal residue which is coupled to a chiral amino acid. Upon complete hydrolysis, the tetrapeptide gives glycine, alanine, phenylalanine and leucine. The number of possible sequences of the tetrapeptide is \_\_\_\_\_
53. The major product formed in the following reaction sequence is



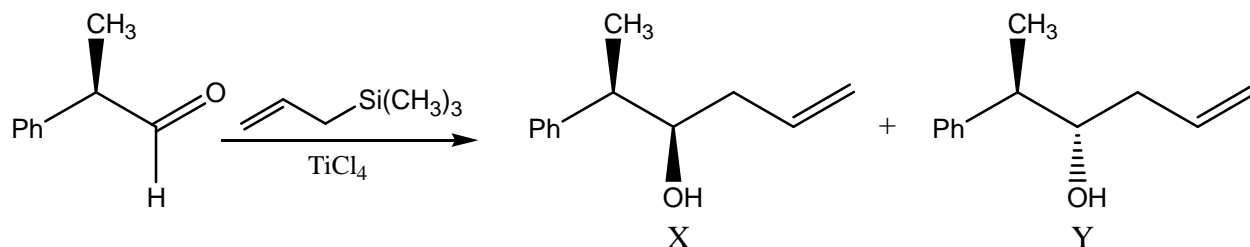
- (a)
- (b)
- (c)
- (d)

54. The major product formed in the following reaction sequence is





55. In the following reaction,



- (a) X is the major product and Y is the minor product  
 (b) X is the only product  
 (c) Y is the only product  
 (d) X is the minor product and Y is the major product

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