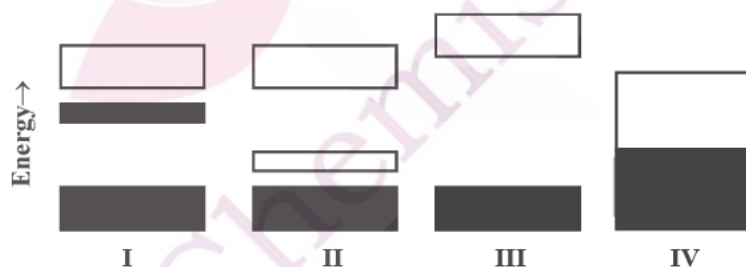


## CHEMISTRY-CY

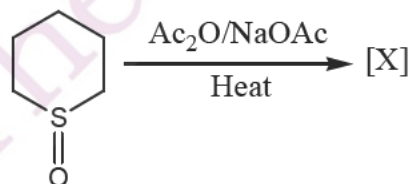
**Q.1 – Q.25 : Carry ONE mark each.**

- Jahn-Teller distortion of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  acts to
  - Raise symmetry
  - Remove an electronic degeneracy
  - Cause loss of  $\text{H}_2\text{O}$  ligand
  - Promote a d-electron to an antibonding molecular orbital.
- Among the following, the group of molecules that undergoes rapid hydrolysis is:
  - $\text{SF}_6$ ,  $\text{Al}_2\text{Cl}_6$ ,  $\text{SiMe}_4$
  - $\text{BCl}_3$ ,  $\text{SF}_6$ ,  $\text{SiCl}_4$
  - $\text{BCl}_3$ ,  $\text{SiCl}_4$ ,  $\text{PCl}_5$
  - $\text{SF}_6$ ,  $\text{Al}_2\text{Cl}_6$ ,  $\text{SiCl}_4$
- The reaction of solid  $\text{XeF}_2$  with  $\text{AsF}_5$  in 1:1 ratio affords
  - $\text{XeF}_4$  and  $\text{AsF}_3$
  - $\text{XeF}_6$  and  $\text{AsF}_3$
  - $[\text{XeF}]^+[\text{AsF}_6]^-$
  - $[\text{Xe}_2\text{F}_3]^+[\text{AsF}_6]^-$
- A well known naturally occurring organometallic compound is:
  - vitamin  $\text{B}_{12}$  coenzyme
  - chlorophyll
  - cytochrome P-450
  - myoglobin
- The complex that exists as a pair of enantiomers is
  - $\text{trans}-[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2\text{Cl}_2]^+$
  - $\text{cis}-[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$
  - $[\text{Pt}(\text{PPh}_3)(\text{Cl})(\text{Br})(\text{CH}_3)]^-$
  - $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{3+}$
- The region of electromagnetic spectrum employed in the electron spin resonance (ESR) spectroscopy is:
  - radiowave
  - microwave
  - infrared
  - visible
- The red color of oxyhaemoglobin is mainly due to the
  - d-d transition
  - metal to ligand charge transfer transition
  - ligand to metal charge transfer transition
  - intraligand  $\pi - \pi^*$  transition.
- The band structure in an n-type semiconductor is

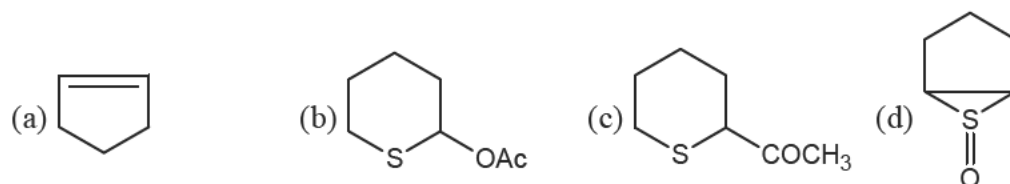


- (a) I                      (b) II                      (c) III                      (d) IV

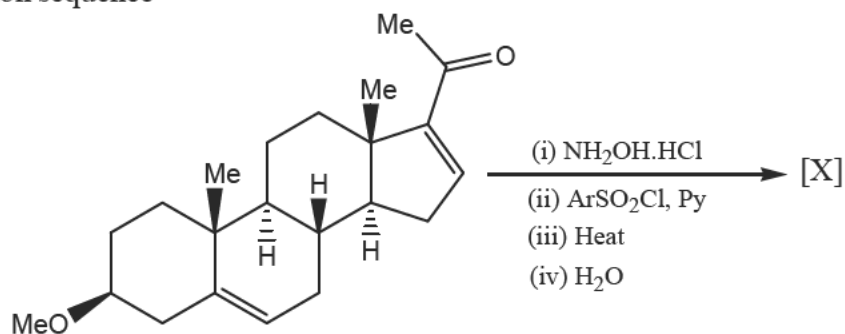
9. In the following reaction



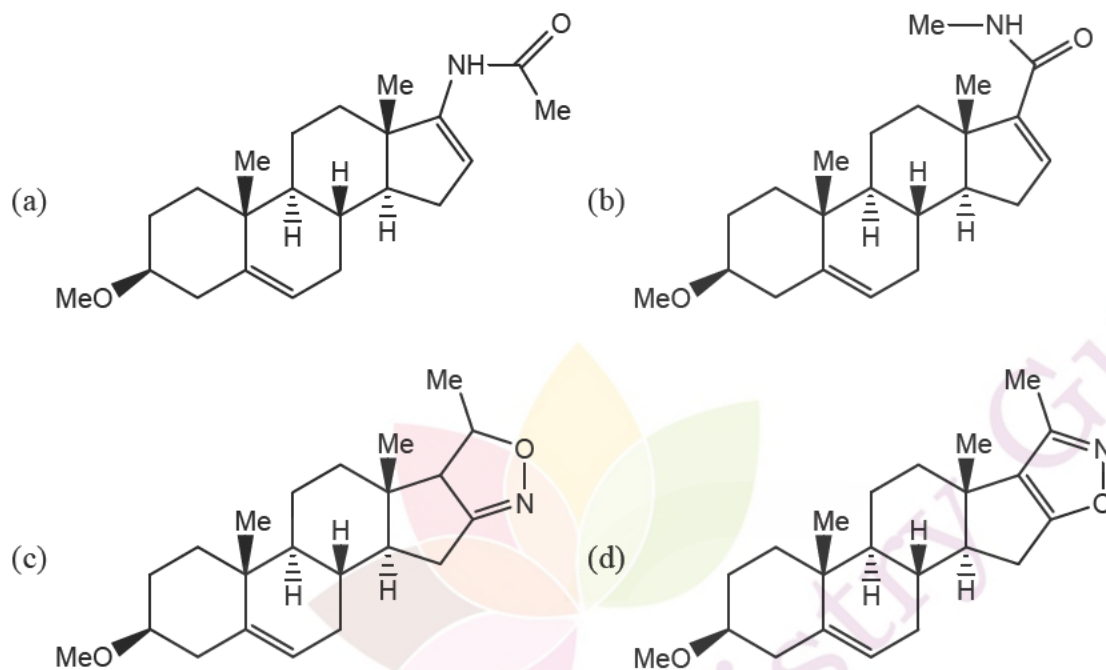
The major product [X] is:



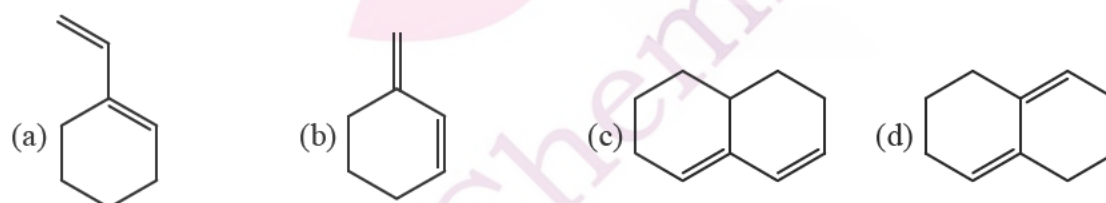
10. In the following reaction sequence



the major product [X] is:



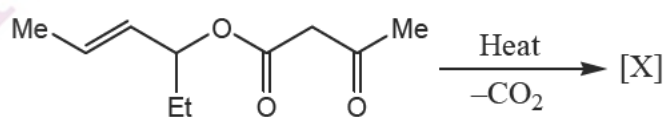
11. The diene which undergoes Diels-Alder reaction with maleic anhydride is:



12. The sequence of an mRNA molecule produced from a DNA template strand with the composition 5'-AGCTACACT-3' is

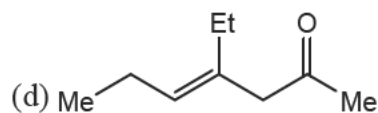
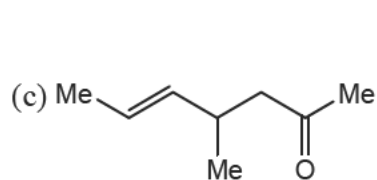
- (a) 5'-AGUGUAGCU-3' (b) 5'-UCGAUGUGA-3'  
(c) 5'-AGTGTAGCT-3' (d) 5'-TCGATGTGA-3'

13. In the following reaction,

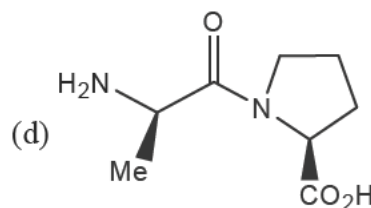
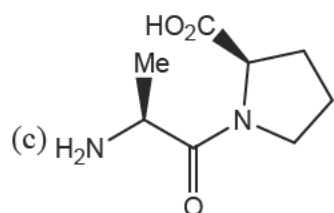
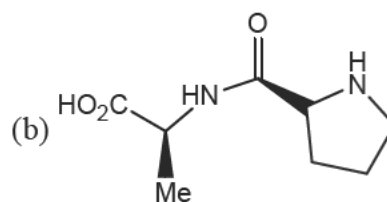
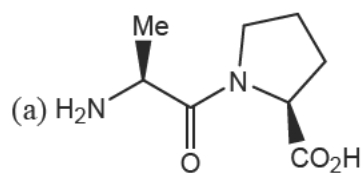


the major product [X] is:

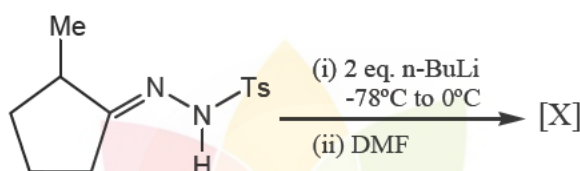




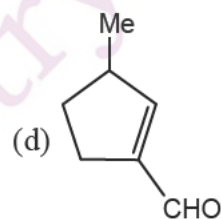
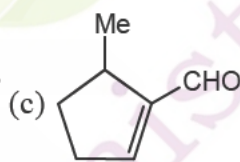
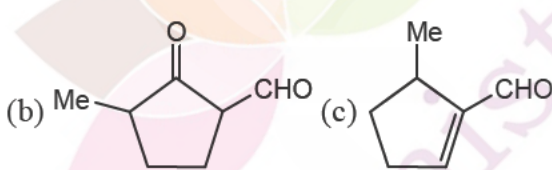
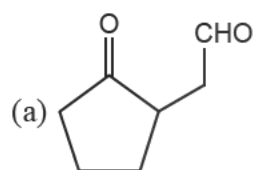
14. The structure of the dipeptide Ala-Pro derived from the natural amino acids is:



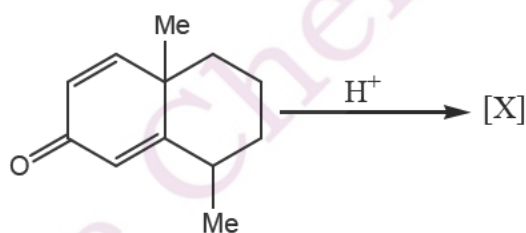
15. In the following reaction



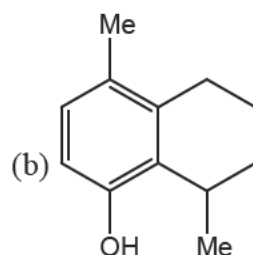
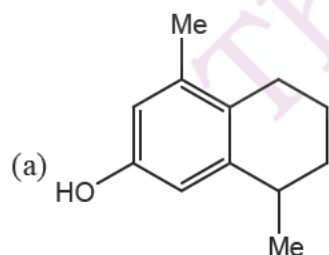
the major product [X] is:

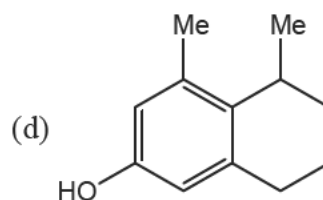
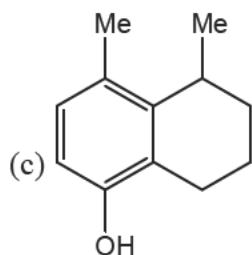


16. In the following reaction,

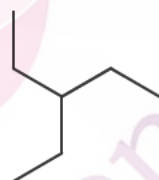


the major product [X] is:

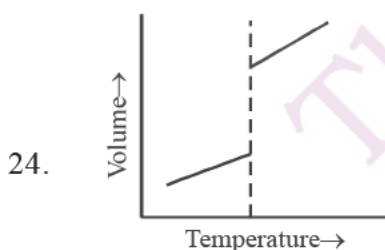




17. For a given first order reaction, the reactant reduces to  $1/4^{\text{th}}$  its initial value in 10 minutes. The rate constant of the reaction is:  
 (a)  $0.1386 \text{ min}^{-1}$  (b)  $0.0693 \text{ min}^{-1}$   
 (c)  $0.1386 \text{ mol L}^{-1} \text{ min}^{-1}$  (d)  $0.0693 \text{ mol L}^{-1} \text{ min}^{-1}$ .
18. The freezing point constant for water is  $1.86 \text{ K (mol kg}^{-1})^{-1}$ . The change in freezing point when 0.01 mol glucose is added to 1 kg water is:  
 (a) 1.86 K (b)  $-1.86 \text{ K}$  (c) 0.186 K (d)  $-0.0186 \text{ K}$
19. On the pressure-temperature diagram for a one-component system, the point where the solid-liquid and the liquid-gas curves intersect is:  
 (a) triple point (b) critical point (c) melting point (d) boiling point
20. The wave function for a harmonic oscillator described by  $Nx \exp(-\alpha x^2/2)$  has  
 (a) One maximum only (b) One maximum, one minimum only  
 (c) Two maxima, one minimum only (d) Two maxima, two minima only
21. If an arbitrary wave function is used to calculate the energy of a quantum mechanical system, the value calculated is never less than the true energy. The above statement relates to  
 (a) Perturbation theory (b) Variation principle  
 (c) Heisenberg's uncertainty principle (d) quantization of energy
22. The point group symmetry of the given planar shape is:



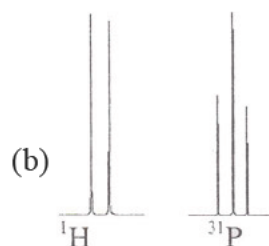
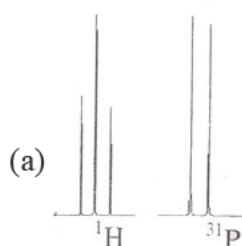
- (a)  $D_{3h}$  (b)  $C_3$  (c)  $C_{3h}$  (d)  $C_{3v}$
23.  $\left(\frac{\partial G}{\partial P}\right)_T =$   
 (a) V (b) S (c)  $-S$  (d)  $-V$

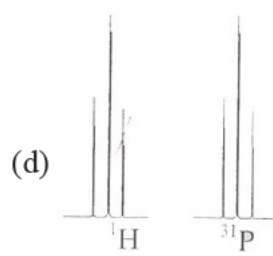
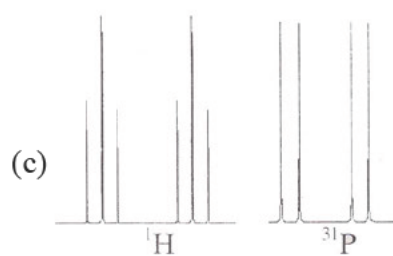


According to Ehrenfest classification of phase transitions, the above diagram refers to

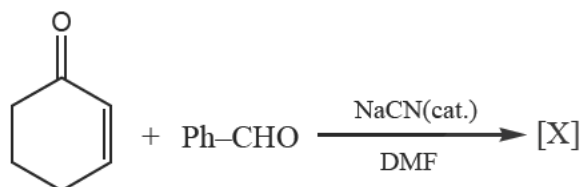
- (a) Zeroth order phase transition (b) First order phase transition  
 (c) Second order phase transition (d)  $\lambda$  transition.

25. According to conventional transition state theory, for elementary bimolecular reactions, the molar entropy of activation  $\Delta S^{\ddagger}$  is:
- (a) Positive (b) Zero (c) Negative  
(d) Positive for endothermic and negative for exothermic reactions.
- Q.26 – Q.55 : Carry TWO marks each.**
26. The crystal field stabilization energy (CFSE) value for  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  that has an absorption maximum at 492 nm is:  
(a) 20, 325  $\text{cm}^{-1}$  (b) 12, 195  $\text{cm}^{-1}$  (c) 10, 162  $\text{cm}^{-1}$  (d) 8, 130  $\text{cm}^{-1}$
27. For  $\text{Et}_2\text{AlX}$  ( $\text{X} = \text{PPh}_2^-, \text{Ph}^-, \text{Cl}^-$  and  $\text{H}^-$ ), the tendency towards dimeric structure follows the order  
(a)  $\text{PPh}_2^- > \text{Cl}^- > \text{H}^- > \text{Ph}^-$  (b)  $\text{Cl}^- > \text{PPh}_2^- > \text{H}^- > \text{Ph}^-$   
(c)  $\text{Ph}^- > \text{H}^- > \text{Cl}^- > \text{PPh}_2^-$  (d)  $\text{H}^- > \text{Ph}^- > \text{PPh}_2^- > \text{Cl}^-$
28. In the isoelectronic series,  $\text{VO}_4^{3-}$ ,  $\text{CrO}_4^{2-}$  and  $\text{MnO}_4^-$ , all members have intense charge transfer (CT) transitions. The **INCORRECT** statement is  
(a) CT transitions are attributed to excitations of electrons from ligand ( $\sigma$ ) to metal (e)  
(b)  $\text{MnO}_4^-$  exhibits charge transfer at shortest wavelength among the three  
(c) The wavelength of transitions increase in the order  $\text{VO}_4^{3-} < \text{CrO}_4^{2-} < \text{MnO}_4^-$   
(d) The charge on metal nucleus increases in the order  $\text{VO}_4^{3-} < \text{CrO}_4^{2-} < \text{MnO}_4^-$
29. The increasing order of wavelength of absorption for the complex ions  
(i)  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  (ii)  $[\text{CrCl}_6]^{3-}$  (iii)  $[\text{Cr}(\text{OH}_2)_6]^{3+}$  (iv)  $[\text{Cr}(\text{CN})_6]^{3-}$ , is  
(a)  $\text{iv} < \text{ii} < \text{i} < \text{iii}$  (b)  $\text{iv} < \text{iii} < \text{ii} < \text{i}$  (c)  $\text{iv} < \text{i} < \text{iii} < \text{ii}$  (d)  $\text{ii} < \text{iii} < \text{i} < \text{iv}$
30. The total number of metal-metal bonds in  $\text{Ru}_3(\text{CO})_{12}$  and  $\text{Co}_4(\text{CO})_{12}$ , respectively, is  
(a) 3 and 6 (b) 4 and 5 (c) zero and 4 (d) 3 and 4
31. According to VSEPR theory the shapes of  $[\text{SF}_2\text{Cl}]^+$  and  $[\text{S}_2\text{O}_4]^{2-}$  should be  
(a) trigonal planar for  $[\text{S}_2\text{O}_4]^{2-}$  and trigonal pyramidal for  $[\text{SF}_2\text{Cl}]^+$   
(b) both trigonal planar  
(c) trigonal pyramidal for  $[\text{S}_2\text{O}_4]^{2-}$  and trigonal planar for  $[\text{SF}_2\text{Cl}]^+$   
(d) both trigonal pyramidal
32. The product of the reaction between  $\text{CH}_3\text{Mn}(\text{CO})_5$  and  $^{13}\text{CO}$  is:  
(a)  $(\text{CH}_3^{13}\text{CO})\text{Mn}(\text{CO})_5$  (b)  $(\text{CH}_3\text{CO})\text{Mn}(\text{CO})_4(^{13}\text{CO})$   
(c)  $(^{13}\text{CH}_3\text{CO})\text{Mn}(\text{CO})_5$  (d)  $\text{CH}_3\text{Mn}(\text{CO})_4$
33. The correct pair of  $^1\text{H}$  and  $^{31}\text{P}$  NMR spectral patterns for  $\text{C}(\text{H})(\text{F})(\text{PCl}_2)_2$  is:

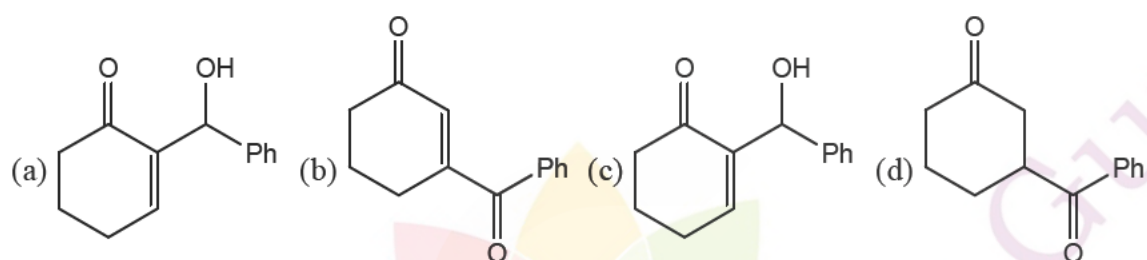




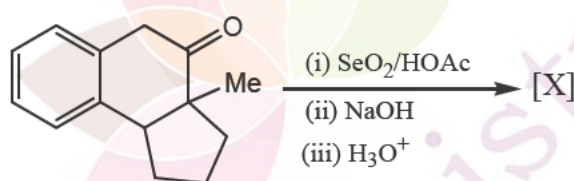
34. In the following reaction



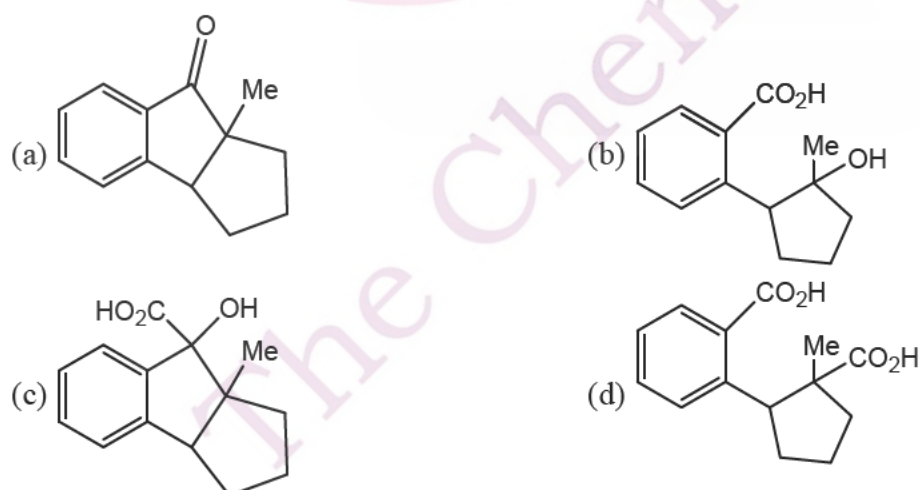
the major product [X] is:



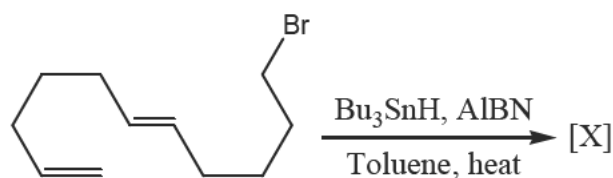
35. In the following reaction,



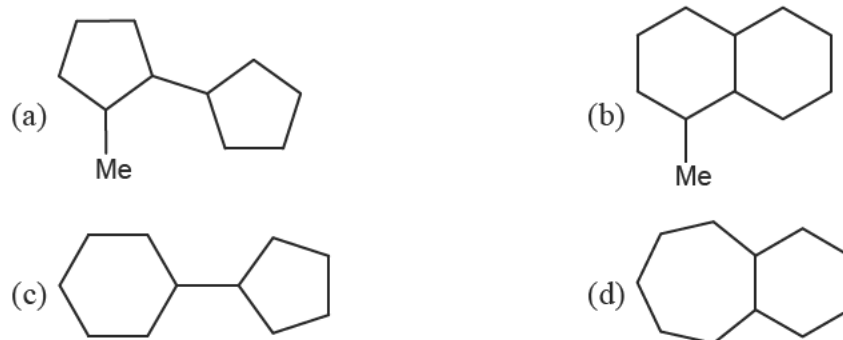
the major product [X] is:



36. In the following reaction,



the major product [X] is:



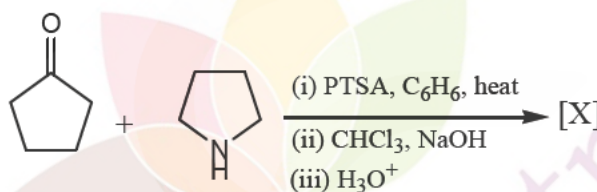
37. The most appropriate sequence of reactions for carrying out the following conversion



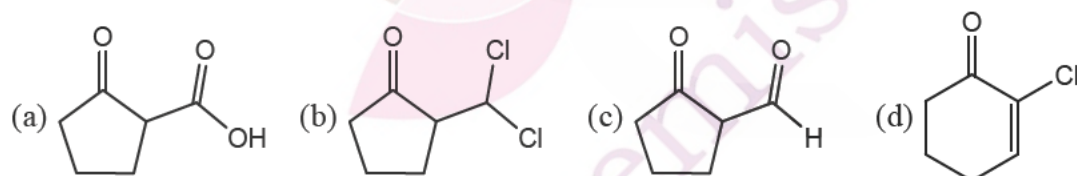
is

- (a) (i) Peracid; (ii)  $H^+$ ; (iii) Zn/dil. HCl  
 (b) (i) Alkaline  $KMnO_4$ ; (ii)  $NaIO_4$ ; (iii)  $N_2H_4/KOH$   
 (c) (i) Alkaline  $KMnO_4$ ; (ii)  $H^+$ ; (iii) Zn/dil. HCl  
 (d) (i)  $O_3/Me_2S$ ; (ii)  $NaOEt$ ; (iii)  $N_2H_4/KOH$

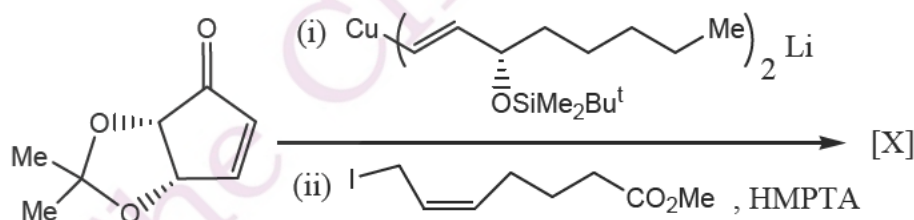
38. In the following reaction sequence



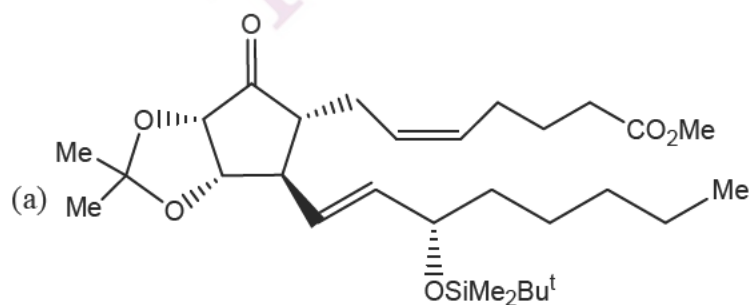
the major product [X] is:

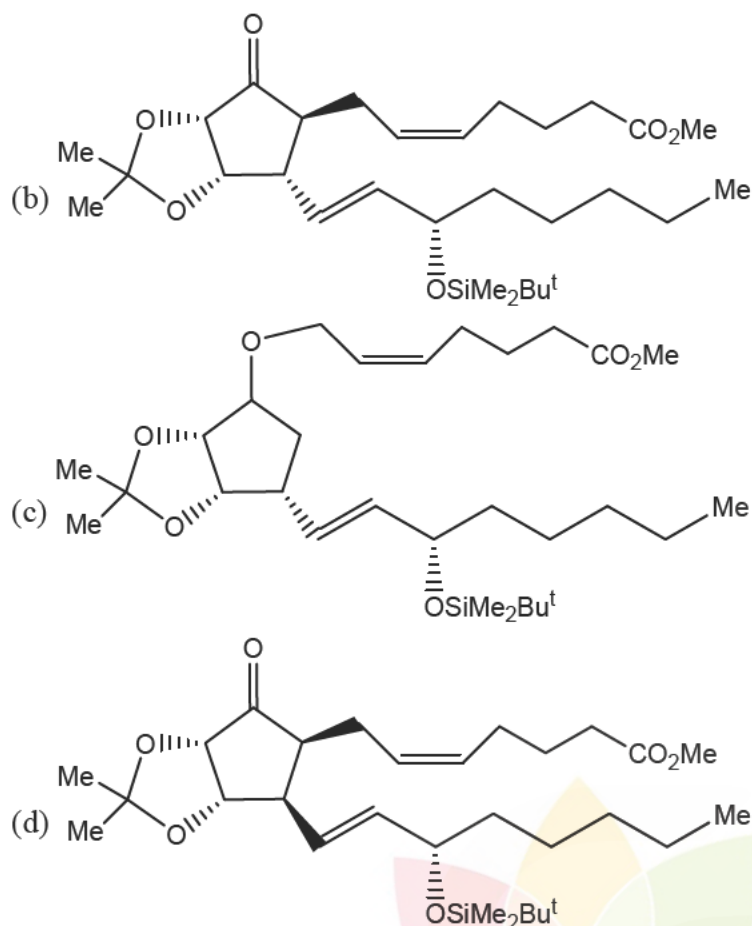


39. In the following conversion

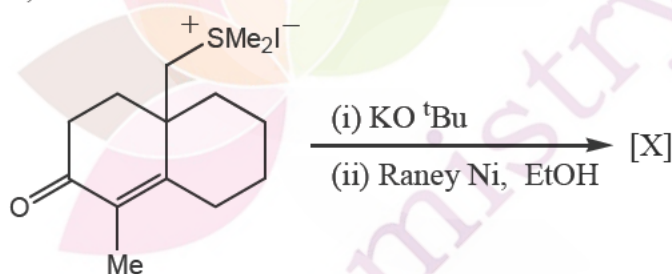


the major product [X] is:

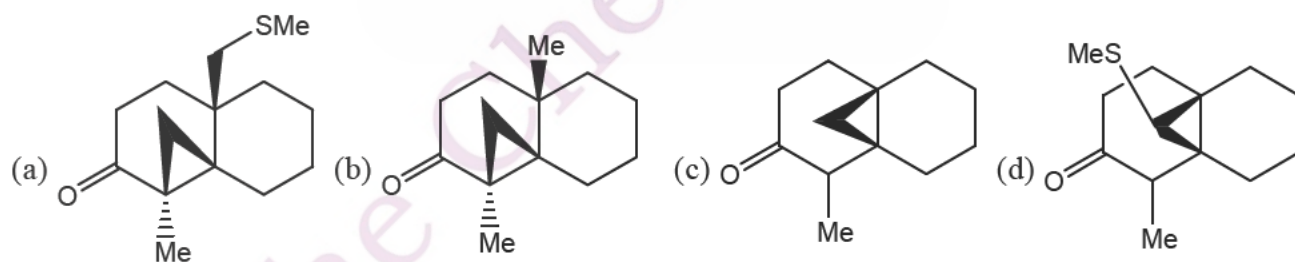




40. In the following reaction,



the major product [X] is:



41. In the reaction,



the major product [X] is:

- (a) racemic trans-1, 2-cyclohexanediol diacetate  
 (b) optically active trans-1, 2-cyclohexanediol diacetate  
 (c) racemic cis-1, 2-cyclohexanediol diacetate  
 (d) optically active cis-1, 2-cyclohexanediol diacetate.

42. The activity of water at 11 bar and 298K is:

- (a) 1.101      (b) 1.007      (c) 0.998      (d) 0.898



43. For the process



assuming ideal gas behavior, the change in molar entropy is:

- (a)  $-27.57 \text{ J K}^{-1} \text{ mol}^{-1}$  (b)  $+27.57 \text{ J K}^{-1} \text{ mol}^{-1}$   
 (c)  $-24.20 \text{ J K}^{-1} \text{ mol}^{-1}$  (d)  $+24.20 \text{ J K}^{-1} \text{ mol}^{-1}$

44. The wave function for a quantum mechanical particle in a 1-dimensional box of length 'a' is given by

$$\psi = A \sin \frac{\pi x}{a}$$

The value of 'A' for a box of length 200 nm is

- (a)  $4 \times 10^4 \text{ (nm)}^2$  (b)  $10\sqrt{2} \text{ (nm)}^{\frac{1}{2}}$  (c)  $\sqrt{2}/10 \text{ (nm)}^{-\frac{1}{2}}$  (d)  $0.1 \text{ (nm)}^{-1/2}$

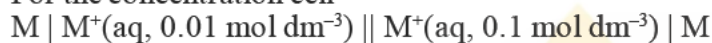
45. For 1 mole of a monoatomic ideal gas, the relation between pressure (p), volume (V) and average molecular kinetic energy ( $\bar{\epsilon}$ ) is

- (a)  $p = \frac{N_A \bar{\epsilon}}{V}$  (b)  $p = \frac{N_A \bar{\epsilon}}{3V}$  (c)  $p = \frac{2N_A \bar{\epsilon}}{3V}$  (d)  $p = \frac{2N_A \bar{\epsilon}}{3V\bar{\epsilon}}$

46. For a 1 molal aqueous NaCl solution, the mean ionic activity coefficient ( $\gamma_{\pm}$ ) and the Deby-Huckel Limiting Law constant (A) are related as

- (a)  $\log \gamma_{\pm} = \sqrt{2} A$  (b)  $\log \gamma_{\pm} = -\sqrt{2} A$  (c)  $\gamma_{\pm} = 10^A$  (d)  $\gamma_{\pm} = 10^{-A}$

47. For the concentration cell



the EMF (E) of the cell at a temperature (T) equals

- (a)  $2.303 \frac{RT}{F}$  (b)  $-2.303 \frac{RT}{F}$   
 (c)  $E_{M^+/M}^0 + 2.303 \frac{RT}{F}$  (d)  $E_{M^+/M}^0 - 2.303 \frac{RT}{F}$

#### Common Data Questions:

##### Common data for Q.48 and Q.49:

A hypothetical molecule XY has the following properties

Reduced mass:  $2 \times 10^{-26} \text{ kg}$

X–Y bond length: 100 pm

Force constant of the bond:  $8 \times 10^2 \text{ N.m}^{-1}$

48. The frequency of radiation (in  $\text{cm}^{-1}$  units) required to vibrationally excite the molecule from  $v = 0$  to  $v = 1$  state is

- (a) 3184.8 (b) 2123.2 (c) 061.6 (d) 840.0

49. The frequency of radiation (in  $\text{cm}^{-1}$  units) required to rotationally excite the molecule from  $J = 0$  to  $J = 1$  state is

- (a) 1.4 (b) 2.8 (c) 3.2 (d) 3.6

##### Common data for Q.50 and Q.51:

$\text{Na}_2\text{HPO}_4$  and  $\text{NaH}_2\text{PO}_4$  on heating at high temperature produce a chain sodium pentaphosphate quantitatively.

50. The ideal molar ratio of  $\text{Na}_2\text{HPO}_4$  to  $\text{NaH}_2\text{PO}_4$  is:

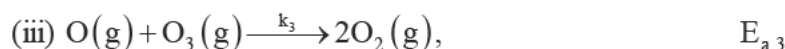
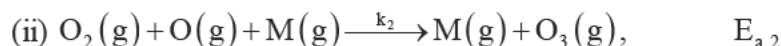
- (a) 4 : 1 (b) 1 : 4 (c) 3 : 2 (d) 2 : 3

51. The total charge on pentaphosphate anion is:

- (a) -5 (b) -3 (c) -7 (d) -9

**Linked Answer Q.52 and Q.53:**

The decomposition of ozone to oxygen  $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$  occurs by mechanism



where, M is the catalyst molecule.

$k_i$  ' are rate constants and  $E_{a,i}$  's the activation energies for the elementary steps,

52. Under the steady state approximation for the intermediates, the rate of decomposition of ozone,  $-\frac{d[\text{O}_3]}{dt}$ , is

$$\text{(a) } \frac{2k_1k_3[\text{O}_3]^2[\text{M}]}{k_2[\text{O}_2][\text{M}] + k_3[\text{O}_3]}$$

$$\text{(b) } \frac{2k_1k_3[\text{O}_3]^2[\text{M}]}{k_2[\text{O}_2][\text{M}] - k_3[\text{O}_3]}$$

$$\text{(c) } \frac{2k_2k_3[\text{O}_3][\text{M}]}{k_2[\text{O}_2][\text{M}] + k_3[\text{O}_3]}$$

$$\text{(d) } \frac{2k_1k_2[\text{O}_3]^2[\text{M}]}{k_2[\text{O}_2][\text{M}] - k_3[\text{O}_3]}$$

53. Assuming  $k_3[\text{O}_3] \gg k_2[\text{O}_2][\text{M}]$ , the activation of the overall reaction is

$$\text{(a) } \frac{E_{a,1}E_{a,3}}{E_{a,2}}$$

$$\text{(b) } E_{a,3} + E_{a,1} - E_{a,2}$$

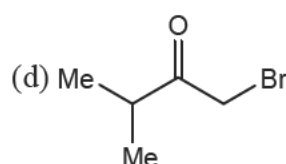
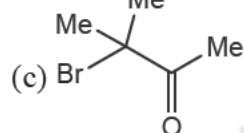
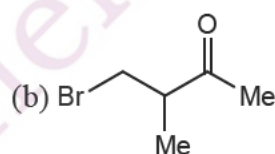
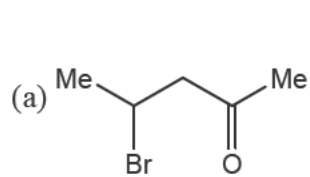
$$\text{(c) } E_{a,2}$$

$$\text{(d) } E_{a,1}$$

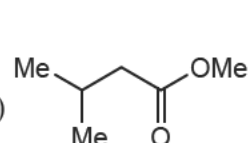
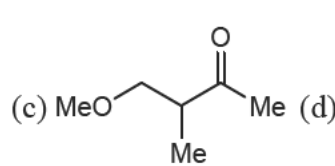
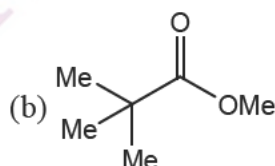
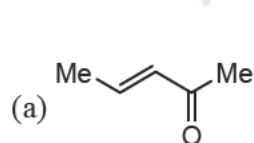
**Statement for Linked Answer Q.54 and Q.55:**

A ketone on treatment with bromine in methanol gives the corresponding monobromo compound [X] having molecular formula  $\text{C}_5\text{H}_9\text{BrO}$ . The compound [X] when treated with NaOMe in MeOH produces [Y] as the major product. The spectral data for compound [X] are:  $^1\text{H}$  NMR:  $\delta$  1.17(d, 6H), 3.02 (m, 1H), 4.10(s, 2H);  $^{13}\text{C}$  NMR:  $\delta$  17, 37, 39, 210.

54. The compound [X] is:



55. The major product [Y] is:



\*\*\*\*\* END OF THE QUESTION PAPER \*\*\*\*\*