GATE – 2011 – Chemistry

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GATE – 2011 – CY

Q.1 – Q.25 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. **Jahn-Teller distortion of $CuSO_4.5H_2O$ acts to**

(a) Raise symmetry

(b) Remove an electronic degeneracy

(c) Cause loss of H_2O ligand

(d) Promote a d-electron to an antibonding molecular orbital

2. **Among the following, the group of molecules that undergoes rapid hydrolysis is:**

(a) SF_6, Al_2Cl_6, $SiMe_4$ (b) BCl_3, SF_6, $SiCl_4$ (c) BCl_3, $SiCl_4$, PCl_5 (d) SF_6, Al_2Cl_6, $SiCl_4$

3. **The reaction of solid XeF_2 with AsF_5 in 1:1 ratio affords**

(a) XeF_4 and AsF_3 (b) XeF_6 and AsF_3 (c) $[XeF]^+[AsF_6]^-$ (d) $[Xe_2F_3]^+[AsF_6]^-$

4. **A well known naturally occurring organometallic compound is:**

(a) vitamin B_{12} coenzyme (b) chlorophyll (c) cytochrome P-450 (d) myoglobin

5. **The complex that exists as a pair of enantiomers is**

(a) trans-$[Co(H_2NCH_2CH_2NH_2)_2Cl_2]^+$ (b) cis-$[Co(NH_3)_4Cl_2]^+$

(c) $[Pt(PPh_3)(Cl)(Br)(CH_3)]^-$ (d) $[Co(H_2NCH_2CH_2NH_2)_3]^{3+}$

6. **The region of electromagnetic spectrum employed in the electron spin resonance (ESR) spectroscopy is:**

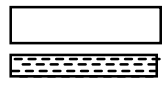
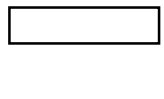
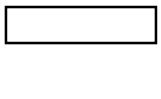
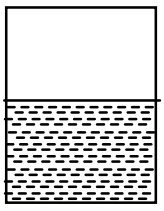
(a) radiowave (b) microwave (c) infrared (d) visible

7. **The red color of oxyhaemoglobin is mainly due to the**

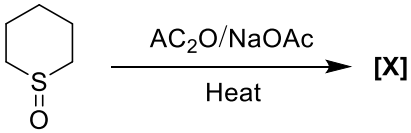
(a) d-d transition (b) metal to ligand charge transfer transition

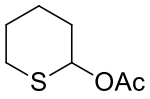
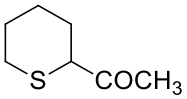
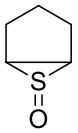
(c) ligand to metal charge transfer transition (d) intraligand $\pi - \pi^*$ transition.

8. **The band structure in an n-type semiconductor is**

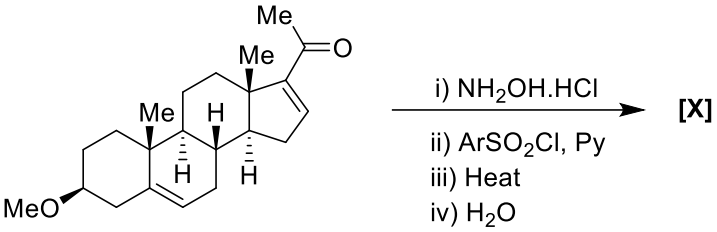
(a)  (b)  (c)  (d) 

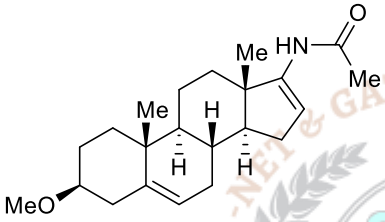
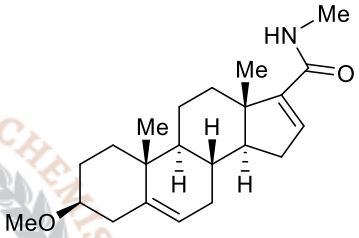
9. **In the following reaction, the major product [X] is:**

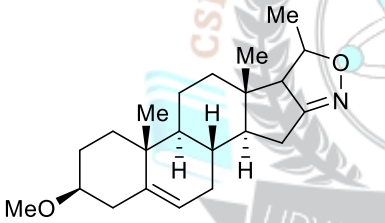
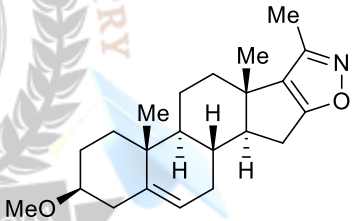


(a)  (b)  (c)  (d) 

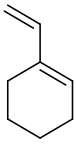
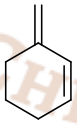
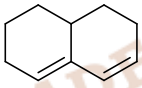
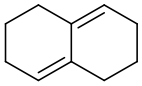
10. In the following reaction sequence, the major product [X] is:



(a)  (b) 

(c)  (d) 

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

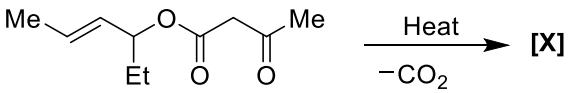
(a)  (b)  (c)  (d) 

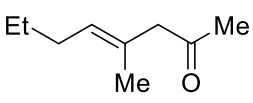
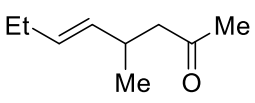
12. The sequence of an mRNA molecule produced from a DNA template strand with the composition; 5′-AGCTACACT-3′ is

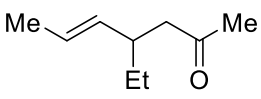
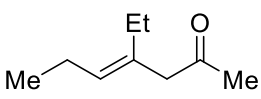
(a) 5′-AGUGUAGCU-3′ (b) 5′-UCGAUGUGA-3′

(c) 5′-AGTGTAGCT-3′ (d) 5′-TCGATGTGA-3′

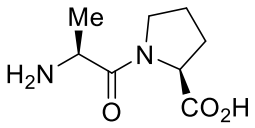
13. In the following reaction, the major product [X] is:

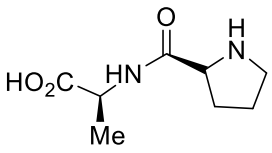


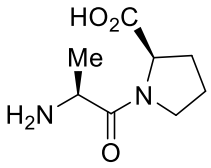
(a)  (b) 

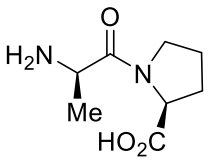
(c)  (d) 

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

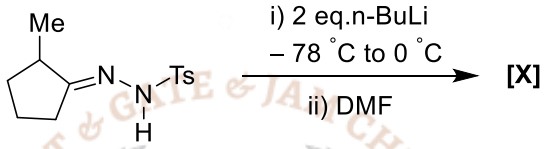
(a) 

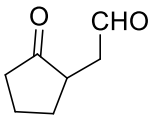
(b) 

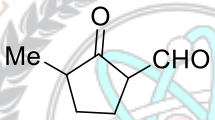
(c) 

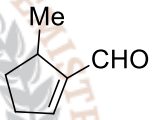
(d) 

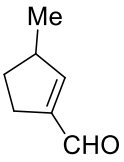
15. **In the following reaction, the major product [X] is:**



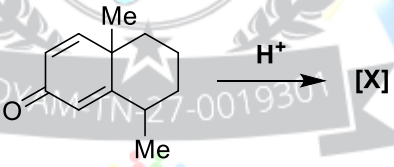
(a) 

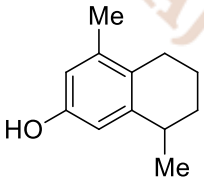
(b) 

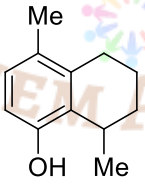
(c) 

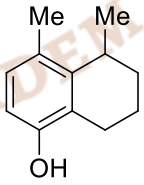
(d) 

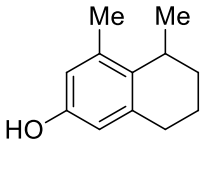
16. **In the following reaction, the major product [X] is:**



(a) 

(b) 

(c) 

(d) 

17. **For a given first order reaction, the reactant reduces to $1/4^{th}$ its initial value in 10 minutes. The rate constant of the reaction is:**

(a) 0.1386 min^{-1} (b) 0.0693 min^{-1}

(c) 0.1386 mol $L^{-1}min^{-1}$ (d) 0.0693 mol $L^{-1}min^{-1}$

18. **The freezing point constant for water is 1.86 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 K (c) 0.186 K (d) −0.0186 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

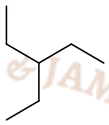
(c) Two maxima, one minimum only (d) Two maxima, two minima only

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:**

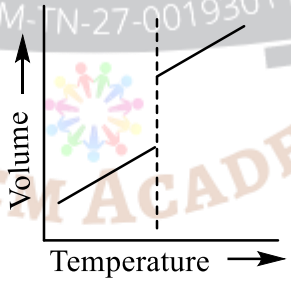


(a) D_{3h} (b) C_3 (c) C_{3h} (d) C_{3v}

23. $\left(\frac{\partial G}{\partial p}\right)_T =$

(a) V (b) S (c) $-S$ (d) $-V$

24. **According to Ehrenfest classification of phase transitions, the given diagram refers to**



(a) Zeroth order phase transition (b) First order phase transition

(c) Second order phase transition (d) λ transition

25. **According to conventional transition state theory, for elementary bimolecular reactions, the molar entropy of activation $\Delta S^{0\ddagger}$ is :**

(a) Positive

(b) Zero

(c) Negative

(d) Positive for endothermic and negative for exothermic reactions

Q.26 – Q.55 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

26. **The crystal field stabilization energy (CFSE) value for $[Ti(H_2O)_6]^{3+}$ that has an absorption maximum at 492 nm is:**

(a) 20325 cm^{-1} (b) 12195 cm^{-1} (c) 10162 cm^{-1} (d) 8130 cm^{-1}

27. **For Et_2AlX ($X = PPh_2^-, Ph^-, Cl^-$ and H^-), the tendency towards dimeric structure follows the order**

(a) PPh_2^- > Cl^- > H^- > Ph^-

(b) Cl^- > PPh_2^- > H^- > Ph^-

(c) Ph^- > H^- > Cl^- > PPh_2^-

(d) H^- > Ph^- > PPh_2^- > Cl^-

28. **In the isoelectronic series, $[VO_4]^{3-}, [CrO_4]^{2-}$ and $[MnO_4]^-$, all members have intense charge transfer (CT) transitions. The INCORRECT statement is**

(a) CT transitions are attributed to excitations of electrons from ligand (σ) to metal (e)

(b) $[MnO_4]^-$ exhibits charge transfer at shortest wavelength among the three

(c) The wavelength of transitions increase in the order $[VO_4]^{3-} < [CrO_4]^{2-} < [MnO_4]^-$

(d) The charge on metal nucleus increases in the order $[VO_4]^{3-} < [CrO_4]^{2-} < [MnO_4]^-$

29. **The increasing order of wavelength of absorption for the complex ions is:**

$[Cr(NH_3)_6]^{3+}$	$[CrCl_6]^{3-}$	$[Cr(H_2O)_6]^{3+}$	$[Cr(CN)_6]^{3-}$
i	ii	iii	iv

(a) iv < ii < i < iii (b) iv < iii < ii < i

(c) iv < i < iii < ii (d) ii < iii < i < iv

30. **The total number of metal-metal bonds in $Ru_3(CO)_{12}$ and $Co_4(CO)_{12}$, respectively,**

(a) 3 and 6 (b) 4 and 5 (c) zero and 4 (d) 3 and 4

31. **According to VSEPR theory the shapes of $[SF_2Cl]^+$ and $[S_2O_4]^{2-}$ should be**

(a) trigonal planar for $[S_2O_4]^{2-}$ and trigonal pyramidal for $[SF_2Cl]^+$

(b) both trigonal planar

(c) trigonal pyramidal for $[S_2O_4]^{2-}$ and trigonal planar for $[SF_2Cl]^+$

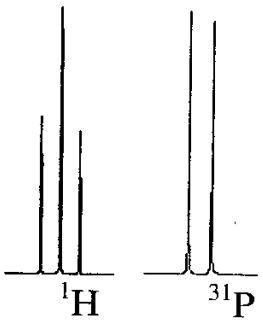
(d) both trigonal pyramidal

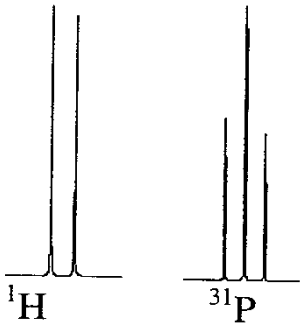
32. **The product of the reaction between $CH_3Mn(CO)_5$ and ^{13}CO is:**

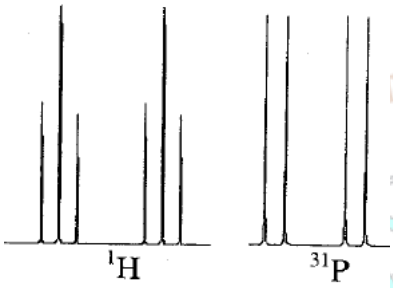
(a) $(CH_3{}^{13}CO)Mn(CO)_5$ (b) $(CH_3CO)Mn(CO)_4(^{13}CO)$

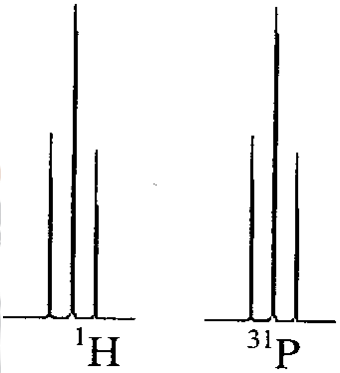
(c) $(^{13}CH_3CO)Mn(CO)_5$ (d) $CH_3Mn(CO)_4$

33. **The correct pair of ^1H and ^{31}P-NMR spectral patterns for $C(H)(F)(PCl_2)_2$ is:**

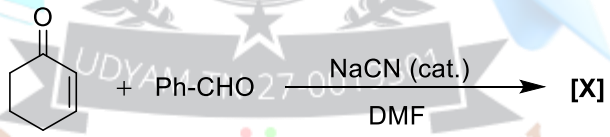
(a) 

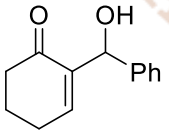
(b) 

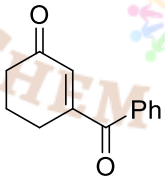
(c) 

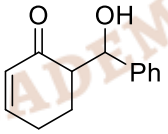
(d) 

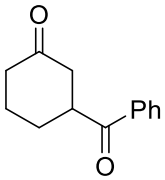
34. In the following reaction, the major product [X] is:



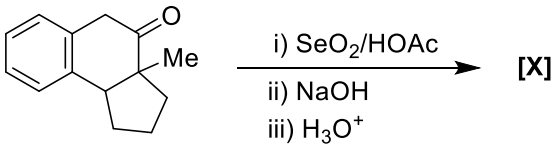
(a) 

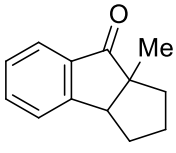
(b) 

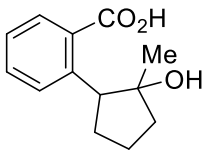
(c) 

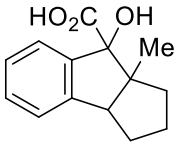
(d) 

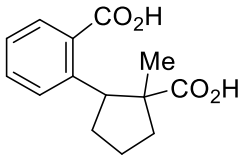
35. In the following reaction, the major product [X] is:



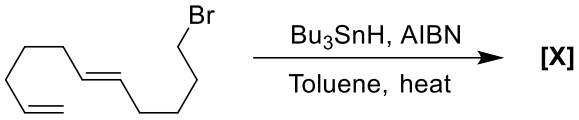
(a) 

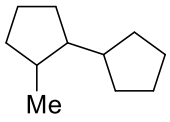
(b) 

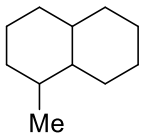
(c) 

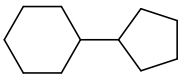
(d) 

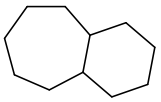
36. In the following reaction, the major product [X] is:



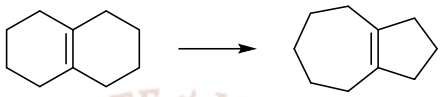
(a) 

(b) 

(c) 

(d) 

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



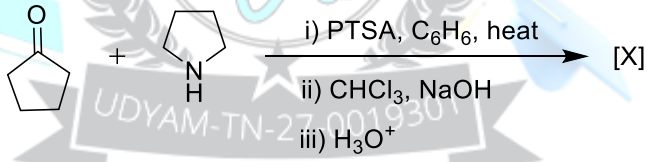
(a) **(i)** Peracid ; **(ii)** H^+ ; **(iii)** Zn/dil. HCl

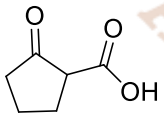
(b) **(i)** Alkaline $KMnO_4$; **(ii)** $NaIO_4$; **(iii)** N_2H_4/KOH

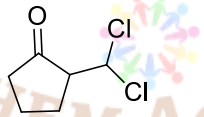
(c) **(i)** Alkaline $KMnO_4$; **(ii)** H^+ ; **(iii)** Zn/dil. HCl

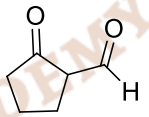
(d) **(i)** O_3/Me_2S ; **(ii)** NaOEt ; **(iii)** N_2H_4/KOH

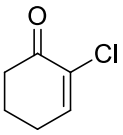
38. In the following reaction sequence, the major product [X] is:



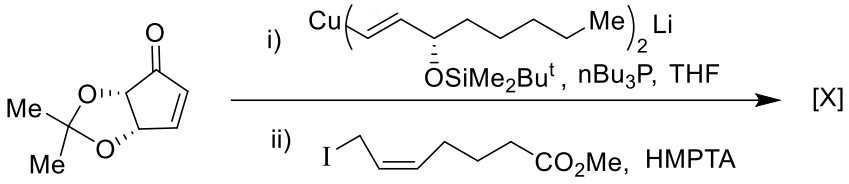
(a) 

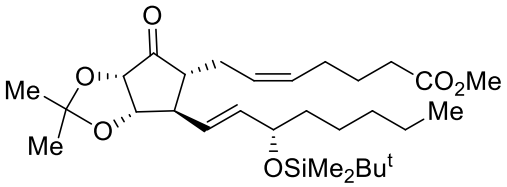
(b) 

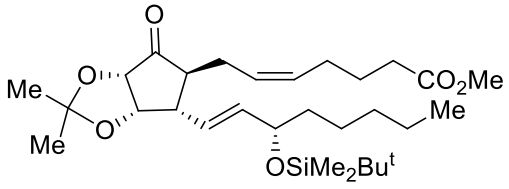
(c) 

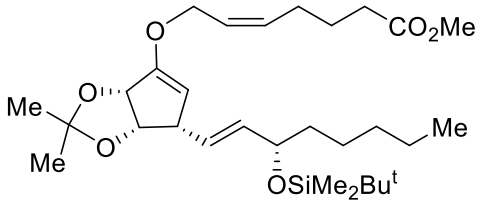
(d) 

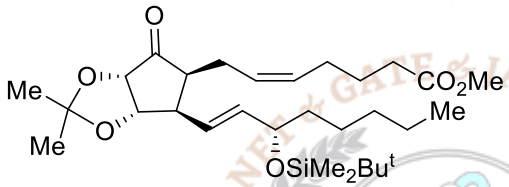
39. In the following reaction sequence, the major product [X] is:



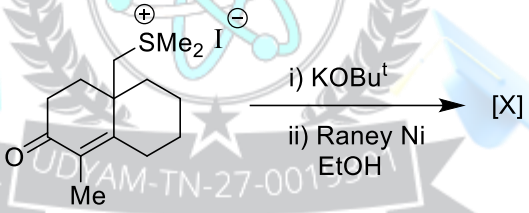
(a) 

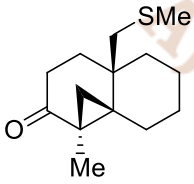
(b) 

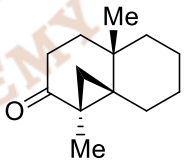
(c) 

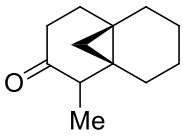
(d) 

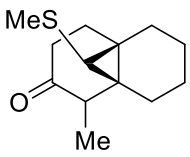
40. In the following reaction, the major product [X] is:



(a) 

(b) 

(c) 

(d) 

41. In the given reaction, the major product [X] is:

Optically pure(+)-trans-2-acetoxycyclohexyl tosylate $\xrightarrow[\Delta]{\text{HOAc, KOAc}}$ **[X]**

(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, 1Ar (300K, 1 bar) ⟶ 1Ar (200K, 10 bar); assuming ideal gas behavior, the change in molar entropy is:**

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

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

44. **The wave function for a quantum mechanical particle in a 1-dimensional box of length 'a' is given by $\varphi = A \sin\frac{\pi x}{a}$; The value of 'A' for a box of length 200 nm is**

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

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

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

46. **For a 1 molal aqueous NaCl solution, the mean ionic activity coefficient ($\gamma_\pm$) and the Debye-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, $M \mid M^+(aq, 0.01\ mol\ dm^{-3}) \parallel M^+(aq, 0.1\ mol\ dm^{-3}) \mid M$ the EMF (E) of the cell at a temperature (T) equals to**

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

Common data for Q.48 and Q.49:

A hypothetical molecule XY has the following properties

Reduced mass	**:**	$\mathbf{2 \times 10^{-26}\ kg}$
X–Y bond length	**:**	**100 pm**
Force constant of the bond	**:**	$\mathbf{8 \times 10^2\ N.m^{-1}}$

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

(a) 3184.8 (b) 2123.2 (c) 1061.6 (d) 840.0

49. **The frequency of radiation (in 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:

Na_2HPO_4 and NaH_2PO_4 on heating at high temperature produce a chain sodium pentaphosphate quantitatively.

50. **The ideal molar ratio of Na_2HPO_4 to NaH_2PO_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 $2O_{3(g)} \longrightarrow 3O_{2(g)}$ occurs by mechanism

(i) $M_{(g)} + O_{3(g)} \xrightarrow{k_1} O_{2(g)} + O_{(g)} + M_{(g)}, E_{a,1}$

(ii) $O_{2(g)} + O_{(g)} + M_{(g)} \xrightarrow{k_2} M_{(g)} + O_{3(g)}, E_{a,2}$

(iii) $O_{(g)} + O_{(g)} \xrightarrow{k_3} 2O_{2(g)}, E_{a,3}$

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, $-\frac{d[O_3]}{dt}$, is

(a) $\frac{2k_1k_3[O_3]^2[M]}{k_2[O_2][M]+k_3[O_3]}$ (b) $\frac{2k_1k_3[O_3]^2[M]}{k_2[O_2][M]-k_3[O_3]}$ (c) $\frac{2k_2k_3[O_3][M]}{k_2[O_2][M]+k_3[O_3]}$ (d) $\frac{2k_1k_2[O_3]^2[M]}{k_2[O_2][M]-k_3[O_3]}$

53. Assuming $k_3[O_3] \gg k_2[O_2][M]$, the activation energy of the overall reaction is

(a) $\frac{E_{a,1}E_{a,3}}{E_{a,2}}$ (b) $E_{a,3} + E_{a,1} - E_{a,2}$ (c) $E_{a,2}$ (d) $E_{a,1}$

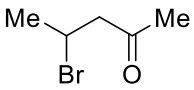
Statement for Linked Answer Q.54 and Q.55:

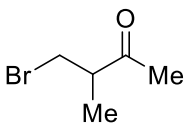
A ketone on treatment with bromine in methanol gives the corresponding monobromo compound-[X] having molecular formula C_5H_9BrO. The compound [X] when treated with NaOMe in MeOH produces [Y] as the major product. The spectral data for compound [X] are:

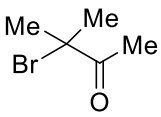
^{1}H-NMR : 1.17 (d, 6H), 3.02 (m, 1H), 4.10 (s, 2H)

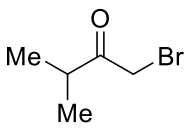
^{13}C-NMR : 17, 37, 39, 210

54. The compound [X] is:

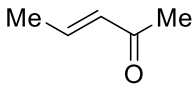
(a) 

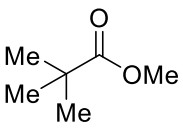
(b) 

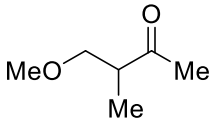
(c) 

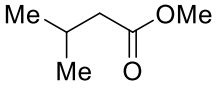
(d) 

55. The Major Product [Y] is:

(a) 

(b) 

(c) 

(d) 

Answer Key

Q.No	Ans		Q.No	Ans		Q.No	Ans		Q.No	Ans
1.	b		16.	a		31.	a		46.	d
2.	c		17.	a		32.	b		47.	a
3.	c		18.	d		33.	c		48.	c
4.	a		19.	a		34.	d		49.	b
5.	d		20.	b		35.	c		50.	d
6.	b		21.	b		36.	a		51.	c
7.	d		22.	c		37.	d		52.	a
8.	a		23.	a		38.	d		53.	d
9.	b		24.	b		39.	a		54.	d
10.	a		25.	c		40.	b		55.	b
11.	a		26.	d		41.	a			
12.	c		27.	d		42.	b			
13.	b		28.	b		43.	a			
14.	a		29.	c		44.	d			
15.	c		30.	a		45.	c			