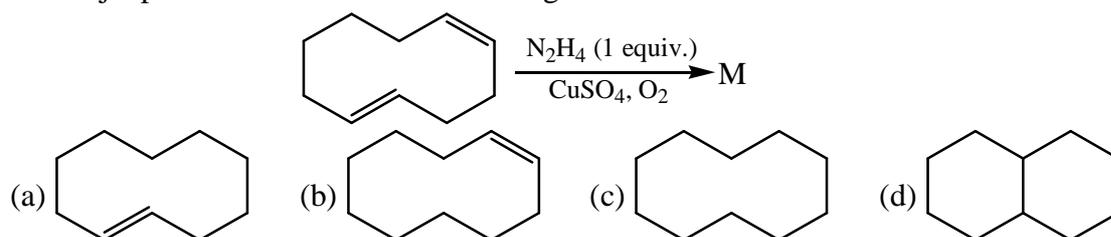


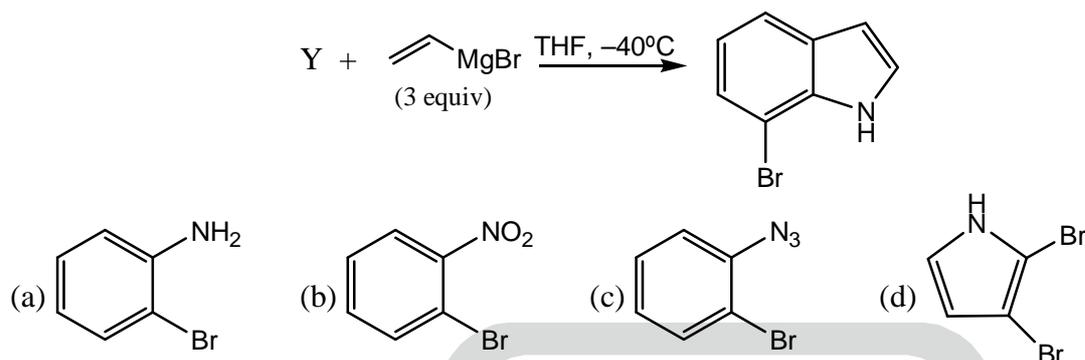
## CHEMISTRY

**Q.1 – Q.25 : Carry ONE mark each.**

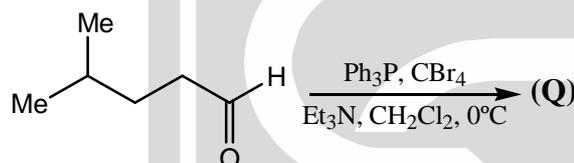
1. The major product **M** formed in the following reaction is



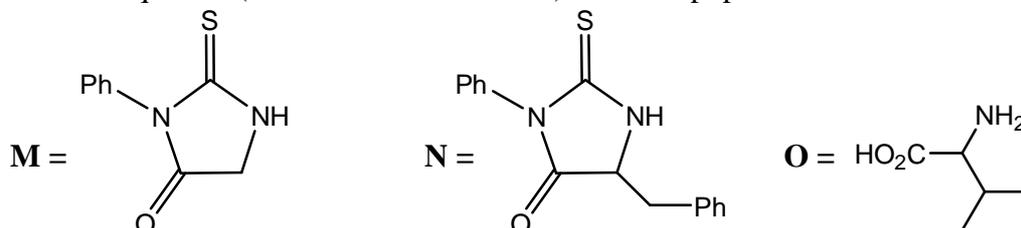
2. The starting material **Y** in the following reaction is



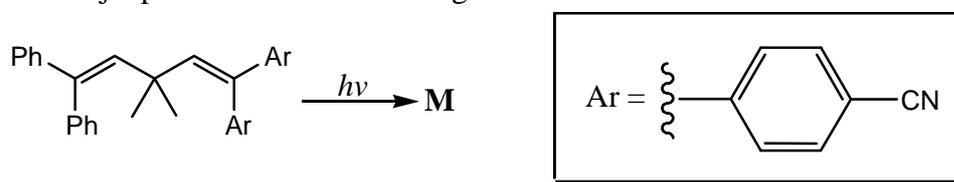
3. The major product in the given reaction is **Q**. The mass spectrum of **Q** shows  $\{[M] = \text{molecular ion peak}\}$

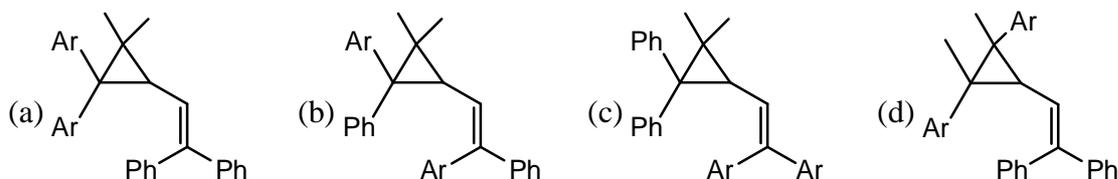


- (a)  $[M]$ ,  $[M+2]$  and  $[M+4]$  with relative intensity of 1:2:1  
 (b)  $[M]$  and  $[M+2]$  with relative intensity of 1:1  
 (c)  $[M]$ ,  $[M+2]$  and  $[M+4]$  with relative intensity of 1:3:1  
 (d)  $[M]$  and  $[M+2]$  with relative intensity of 2:1
4. A tripeptide on treatment with PhNCS (pH = 8.0) followed by heating with dilute HCl afforded a cyclic compound **M** and a dipeptide. The dipeptide on treatment with PhNCS (pH = 8.0) followed by heating with dilute HCl afforded a cyclic compound **N** and an acyclic compound **O**. The CORRECT sequence (from N- to C-terminus) of the tripeptide is

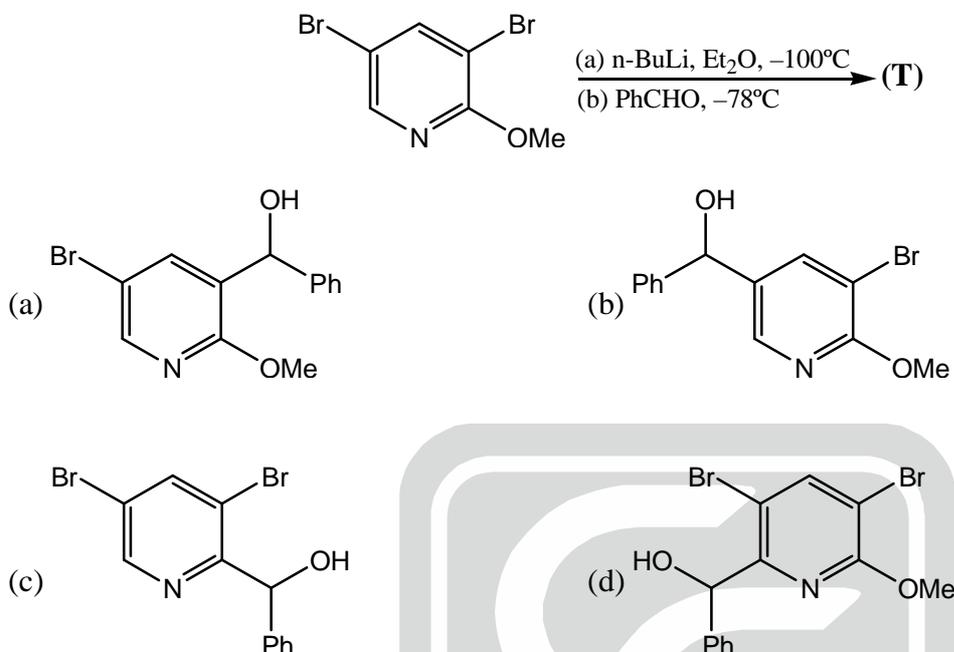


- (a) glycine-phenylalanine-valine  
 (b) valine-phenylalanine-glycine  
 (c) glycine-tyrosine-valine  
 (d) glycine-phenylalanine-alanine
5. The major product **M** in the following reaction is





6. The major product T formed in the following reaction is



7. In differential thermal analysis (DTA)

- (a) the temperature differences between the sample and reference are measured as a function of temperature  
 (b) the differences in heat flow into the reference and sample are measured as a function of temperature  
 (c) the change in the mass of the sample is measured as a function of temperature  
 (d) the glass transition is observed as a sharp peak

8. The  $\nu_{O-O}$  resonance Raman stretching frequency ( $\text{cm}^{-1}$ ) of the coordinated dioxygen in oxy-hemoglobin and oxy-hemocyanin appears, respectively, nearly at

- (a) 1136 and 744      (b) 1550 and 744      (c) 744 and 1136      (d) 744 and 1550

9. The number of metal-metal bond(s), with  $\sigma$ ,  $\pi$  and  $\delta$  character, present in  $[\text{Mo}_2(\text{CH}_3\text{CO}_2)_4]$  complex is(are), respectively,

- (a) 1, 2, 1      (b) 1, 2, 0      (c) 1, 1, 0      (d) 1, 1, 1

10.  $1s_A$  and  $1s_B$  are the normalized eigenfunctions of two hydrogen atoms  $H_A$  and  $H_B$ , respectively. If

$S = \langle 1s_A | 1s_B \rangle$ , the option that is ALWAYS CORRECT is

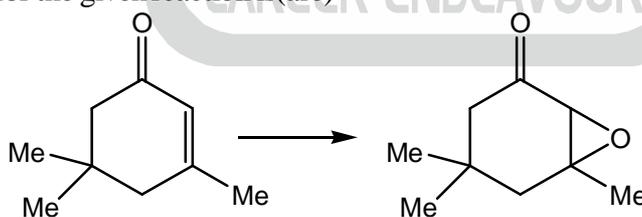
- (a)  $S = 1$       (b)  $S = 0$   
 (c)  $S = \text{imaginary constant}$       (d)  $0 \leq S \leq 1$

11. The pure vibrational spectrum of a hypothetical diatomic molecule shows three peaks with the following intensity at three different temperatures.

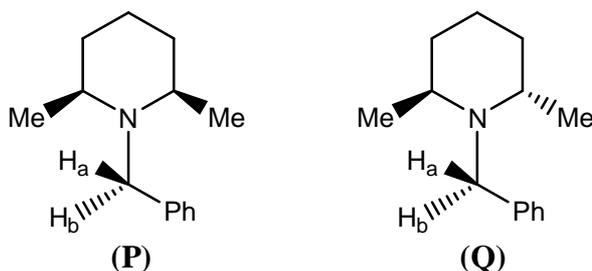
Peak	Intensity (arbitrary unit)		
	300 K	600 K	900 K
I	1.0	1.0	1.0
II	0.1	0.1	0.1
III	0.02	0.04	0.06

The **correct** statement is

- (a) Peak I appears at the lowest energy      (b) Peak II appears at the lowest energy  
 (c) Peak III appears at the lowest energy      (d) Peak I appears at the highest energy
12. The point group of  $SF_6$  is  
 (a)  $D_{6h}$       (b)  $O_h$       (c)  $D_{6d}$       (d)  $C_{6v}$
13. A point originally at (1, 3, 5) was subjected to a symmetry operation ( $\hat{O}_1$ ) that shifted the point to (-1, -3, 5). Subsequently, the point at (-1, -3, 5) was subjected to another symmetry operation ( $\hat{O}_2$ ) that shifted this point to (-1, -3, -5). The symmetry operators  $\hat{O}_1$  and  $\hat{O}_2$  are, respectively,  
 (a)  $\hat{C}_2(x)$  and  $\hat{\sigma}(xy)$       (b)  $\hat{C}_2(z)$  and  $\hat{\sigma}(xy)$   
 (c)  $\hat{\sigma}(xy)$  and  $\hat{C}_2(z)$       (d)  $\hat{S}_1$  and  $\hat{S}_2$
14. Adsorption of a gas with pressure P on a solid obeys the Langmuir adsorption isotherm. For a fixed fractional coverage, the correct relation between K and P at a fixed temperature is  
 [  $K = k_a / k_b$ ,  $k_a$  and  $k_b$  are the rate constants for adsorption and desorption, respectively. Assume non-dissociative adsorption.]  
 (a)  $K \propto P^{-1/2}$       (b)  $K \propto P$       (c)  $K \propto P^{-1}$       (d)  $K \propto P^{1/2}$
15. The temperature dependence of the rate constant for a second-order chemical reaction obeys the Arrhenius equation. The SI unit of the 'pre-exponential factor' is  
 (a)  $s^{-1}$       (b)  $m^3 mol^{-1} s^{-1}$       (c)  $mol m^{-3} s^{-1}$       (d)  $(m^3 mol^{-1})^2 s^{-1}$
16. The correct reagent(s) for the given reaction is(are)



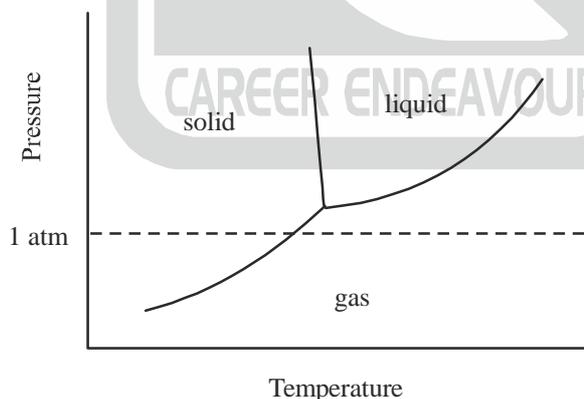
- (a)  $H_2O_2$ , NaOH      (b)      (c) DIBAL-H, then mCPBA      (d)  $SO_3$  pyridine,  $Me_2SO$
17. The CORRECT statement(s) about the  $^1H$  NMR spectra of compounds P and Q is(are)



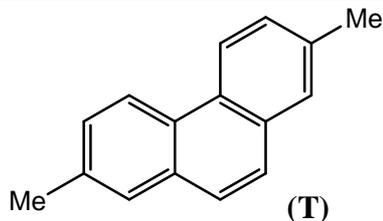
- (a) **P** shows a sharp singlet at  $\delta = 3.70$  ppm (for  $H_a$  and  $H_b$ )  
 (b) **Q** shows a sharp singlet at  $\delta = 3.70$  ppm (for  $H_a$  and  $H_b$ )  
 (c) **P** shows a AB-quartet centered at  $\delta = 3.63$  ppm (for  $H_a$  and  $H_b$ )  
 (d) **Q** shows a AB-quartet centered at  $\delta = 3.63$  ppm (for  $H_a$  and  $H_b$ )
18. The CORRECT statement(s) about thallium halides is(are)  
 (a) TlF is highly soluble in water whereas other Tl-halides are sparingly soluble  
 (b) TlF adopts a distorted NaCl structure  
 (c)  $TlI_3$  is isomorphous with  $CsI_3$  and the oxidation state of Tl is +3  
 (d) Both TlBr and TlCl have CsCl structure
19. The CORRECT statement(s) about the spectral line broadening in atomic spectra is(are)  
 (a) The collision between atoms causes broadening of the spectral line  
 (b) Shorter the lifetime of the excited state, the broader is the line width  
 (c) Doppler broadening is more pronounced as the flame temperature increases  
 (d) In flame and plasma, the natural line broadening exceeds the collisional line broadening
20. Match the CORRECT option(s) from column A with column B according to the metal centre present in the active site of metalloenzyme.

A		B	
P	Cu	I	$B_{12}$ -coenzyme
Q	Mo	II	Carboxypeptidase
R	Co	III	Nitrate reductase
S	Zn	IV	Cytochrome P-450
		V	Tyrosinase

- (a) P-V, Q-III, R-I, S-II  
 (b) P-IV, Q-II, R-I, S-III  
 (c) P-II, Q-IV, R-V, S-III  
 (d) P-V, Q-III, R-II, S-IV
21. The CORRECT statement(s) about the following phase diagram for a hypothetical pure substance X is(are)



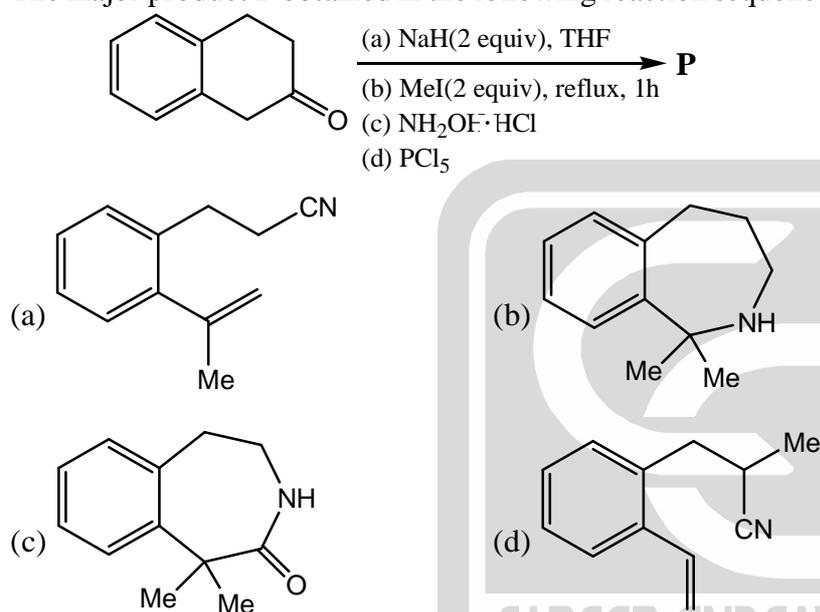
- (a) The molar volume of solid X is less than the molar volume of liquid X  
 (b) X does not have a normal boiling point  
 (c) The melting point of X decreases with increase in pressure  
 (d) On increasing the pressure of the gas isothermally, it is impossible to reach solid phase before reaching liquid phase.
22. The parameter(s) fixed for each system in a canonical ensemble is(are)  
 (a) temperature      (b) pressure      (c) volume      (d) composition
23. The number of peaks exhibited by T in its broadband proton decoupled  $^{13}C$  NMR spectrum recorded at  $25^\circ C$  in  $CDCl_3$  is



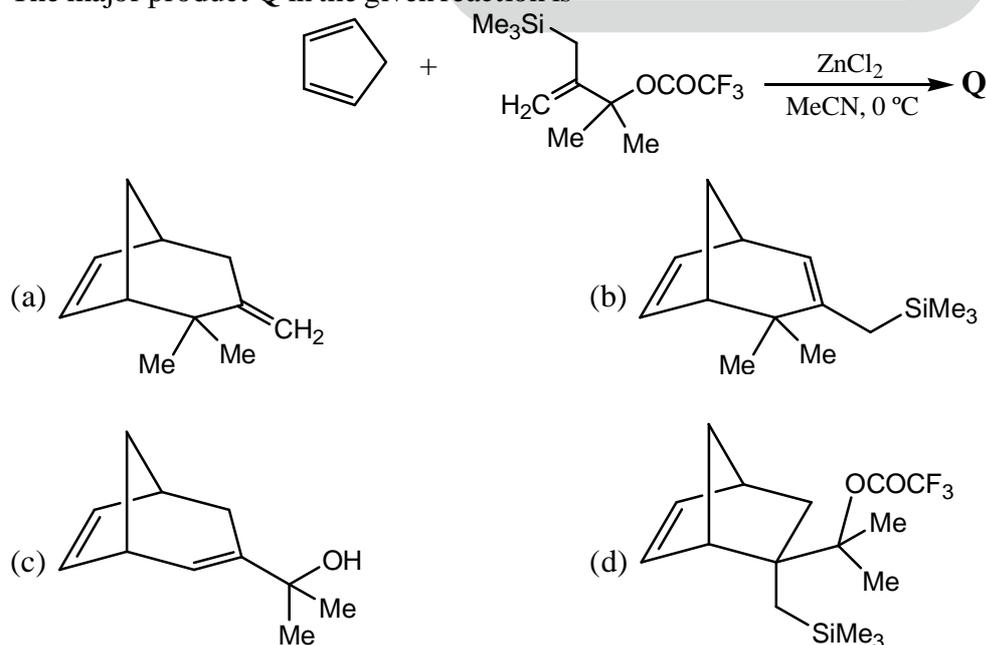
24. The diffraction angle (in degree, rounded off to one decimal place) of (321) sets of plane of a metal with atomic radius 0.125 nm, and adopting BCC structure is  
(Given: the order of reflection is 1 and the wavelength of X-ray is 0.0771 nm)
25. For the angular momentum operator  $\hat{L}$  and the spherical harmonics  $Y_{lm}(\theta, \phi)$ ,  $(\hat{L}_x^2 + \hat{L}_y^2)Y_{21}(\theta, \phi) = n\hbar^2 Y_{21}(\theta, \phi)$ . The value of  $n$  is

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

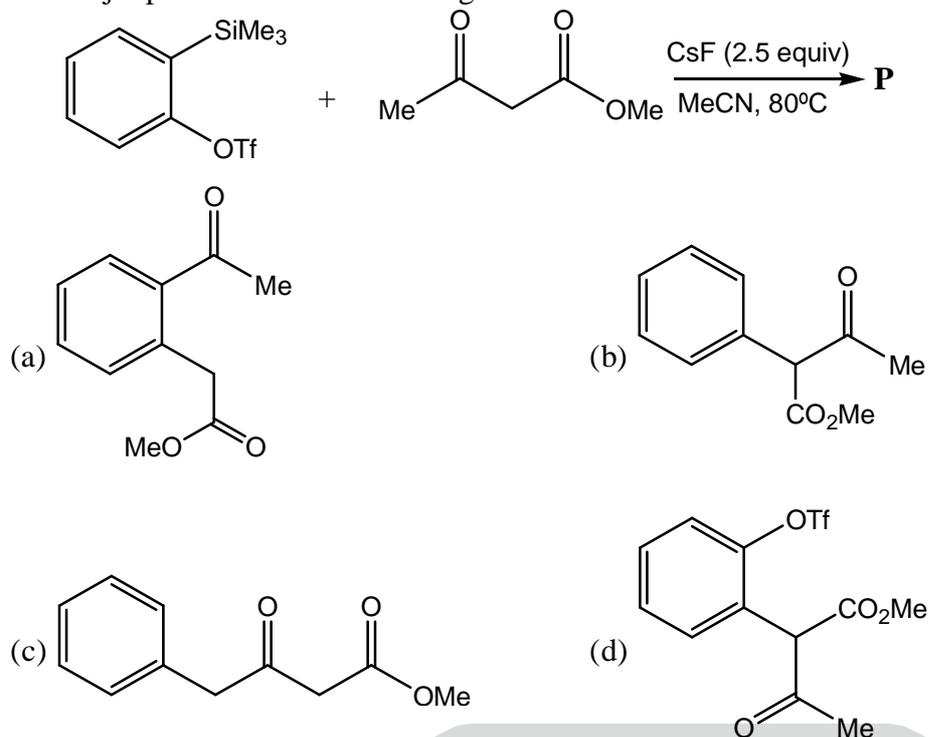
26. The major product **P** obtained in the following reaction sequence is



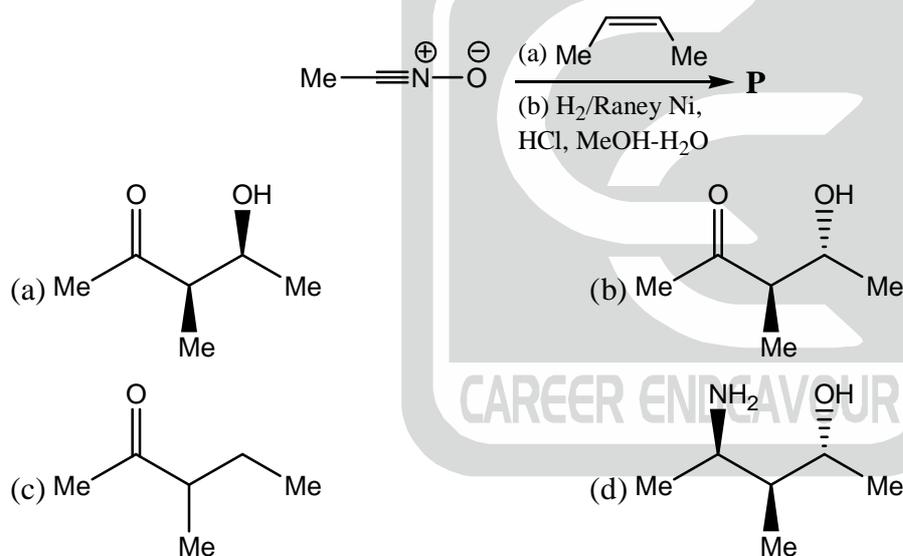
27. The major product **Q** in the given reaction is



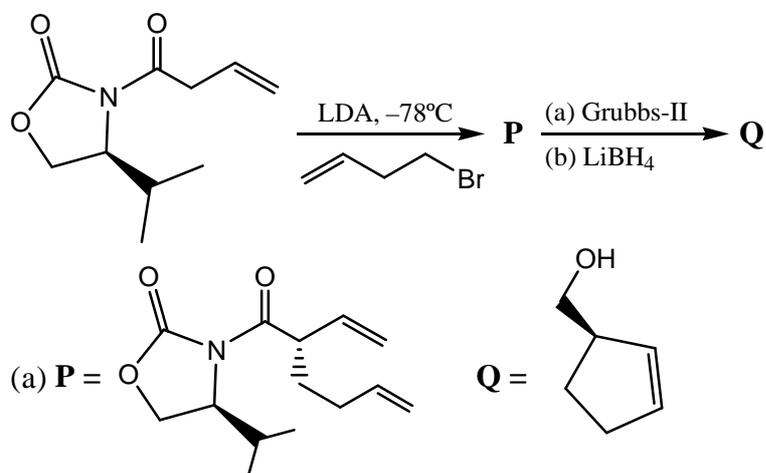
28. The major product P in the following reaction is

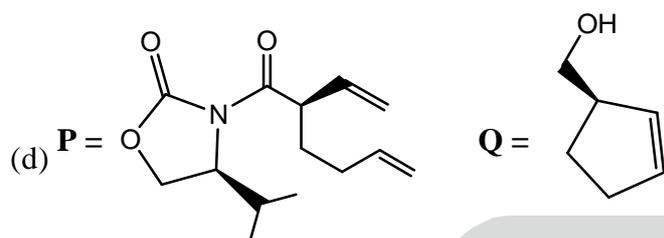
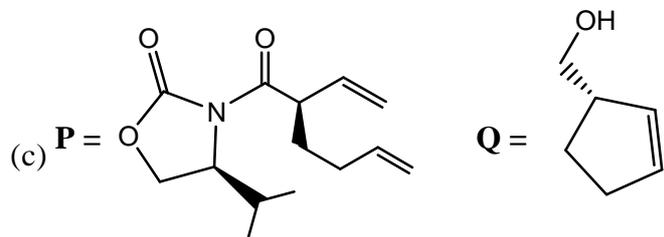
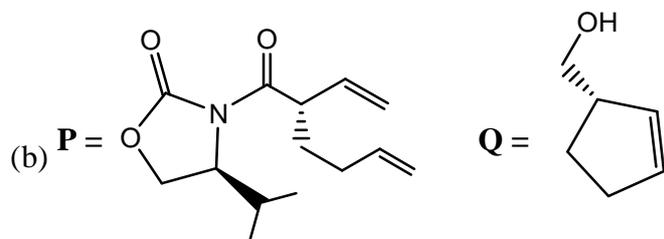


29. The major product P in the reaction sequence is

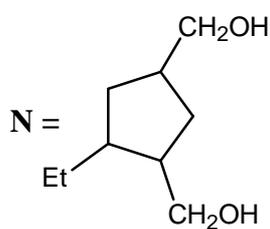
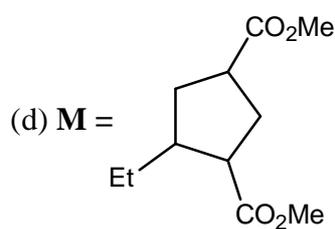
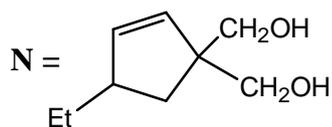
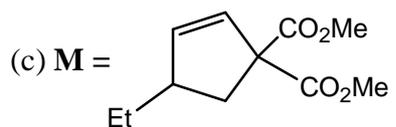
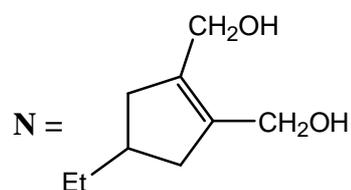
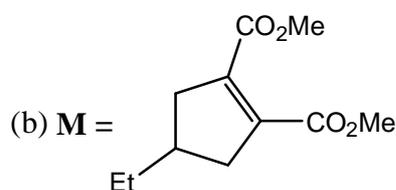
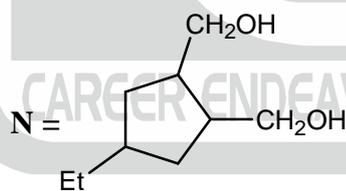
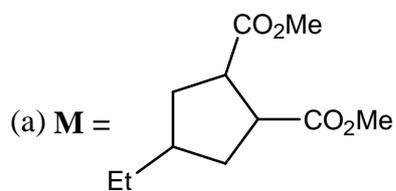
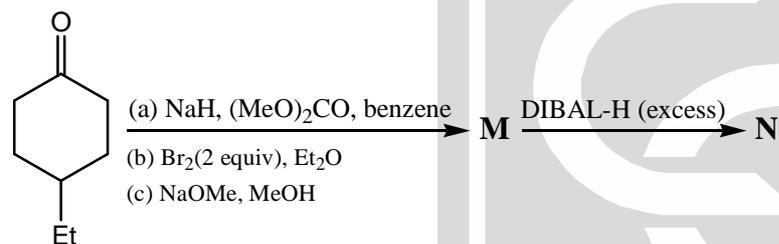


30. The major product P and Q in the following reaction sequence are

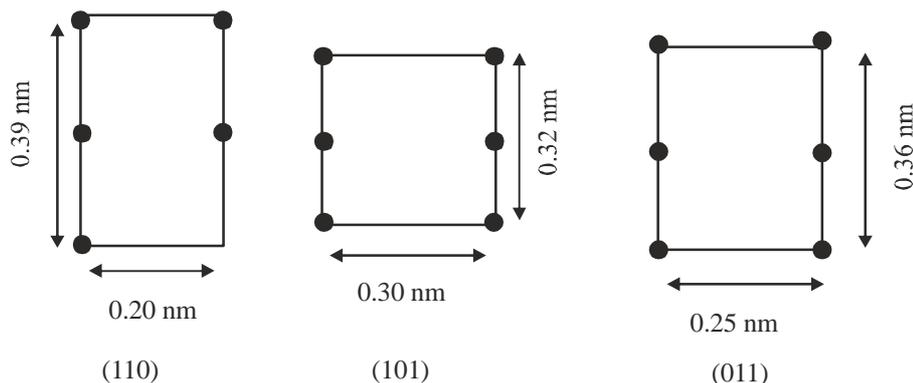




31. The major products **M** and **N** in the given reaction sequence are



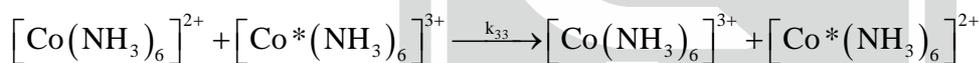
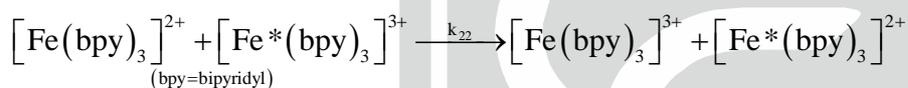
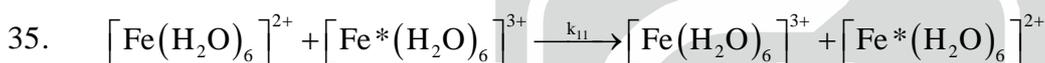
32. Three different crystallographic planes of a unit cell of a metal are given below (solid circles represent atom). The crystal system of the unit cell is



- (a) triclinic                      (b) monoclinic                      (c) tetragonal                      (d) orthorhombic
33. The number of equivalents of  $H_2S$  gas released from the active site of rubredoxin, 2-iron ferredoxin, and 4-iron ferredoxin when treated with mineral acid, respectively, are
- (a) 4, 6, 8                      (b) 0, 2, 4                      (c) 1, 2, 4                      (d) 0, 2, 3

34. The number of  $\nu_{S=O}$  stretching vibration band(s) observed in the IR spectrum of the high-spin  $[Mn(dmsO)_6]^{3+}$  complex (dmsO: dimethylsulfoxide) is

- (a) only one                      (b) two with intensity ratio 1 : 2  
(c) two with intensity ratio 1 : 1                      (d) six with intensity ratio 1 : 1:1:1:2:1

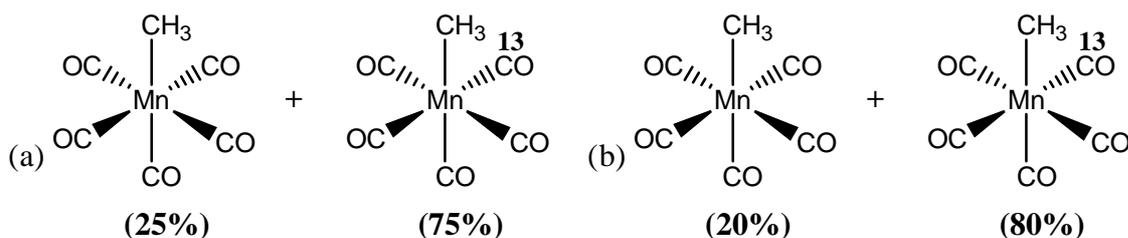
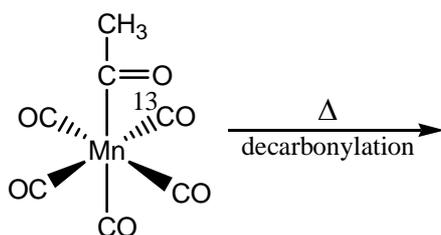


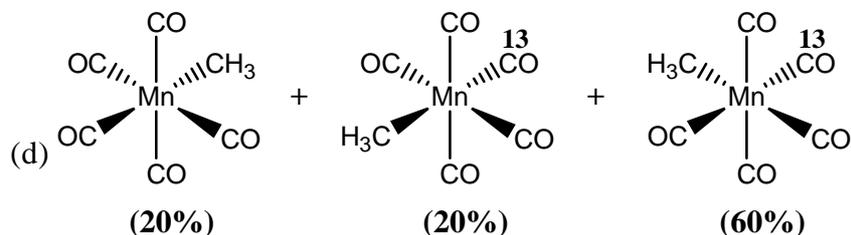
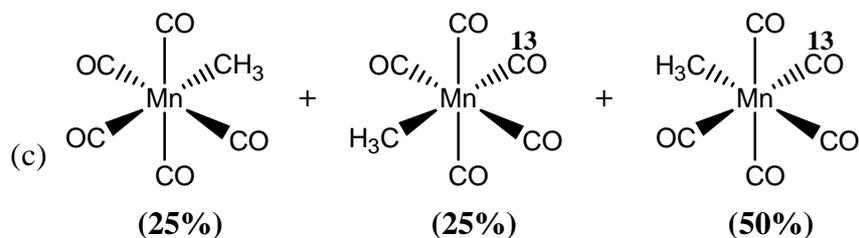
\*indicates a radioactive isotope

The rate constants in the given self-exchange electron transfer reactions at a certain temperature follow

- (a)  $k_{11} > k_{22} > k_{33}$                       (b)  $k_{22} > k_{11} > k_{33}$                       (c)  $k_{33} > k_{22} > k_{11}$                       (d)  $k_{22} > k_{33} > k_{11}$

36. The CORRECT distribution of the products in the following reaction is





37. The addition of  $K_4[Fe(CN)_6]$  to a neutral aqueous solution of the cationic species of a metal produces a brown precipitate that is insoluble in dilute acid. The cationic species is  
 (a)  $Fe^{3+}$                       (b)  $UO_2^{2+}$                       (c)  $Th^{4+}$                       (d)  $Cu^{2+}$
38. The electronic spectrum of a Ni(II) octahedral complex shows four  $d-d$  bands, labelled as P, Q, R, and S. Match the bands corresponding to the transitions.

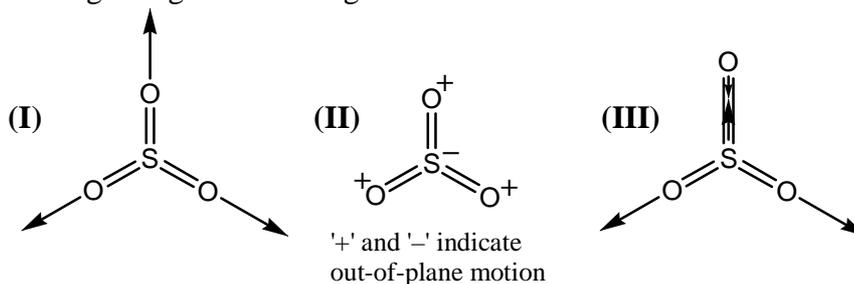
	$\lambda_{max}, nm (\epsilon, M^{-1}cm^{-1})$		Transitions
P	1000(50)	I	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(P)$
Q	770(8)	II	${}^3A_{2g}(F) \rightarrow {}^3T_{1g}(F)$
R	630(55)	III	${}^3A_{2g}(F) \rightarrow {}^3T_{2g}(F)$
S	375(110)	IV	${}^3A_{2g}(F) \rightarrow {}^1E_g(D)$

- (a) P-IV, Q-III, R-II, S-I                      (b) P-III, Q-IV, R-II, S-I  
 (c) P-II, Q-IV, R-I, S-III                      (d) P-I, Q-IV, R-II, S-III
39. In the following table, the left column represents the rigid-rotor type and the right column shows a set of molecules.

P. Symmetric rotor (oblate)	1. $SiH_4$
Q. Symmetric rotor (prolate)	2. $CH_3Cl$
R. Spherical rotor	3. $C_6H_6$
S. Asymmetric rotor	4. $CH_3OH$
	5. $CO_2$

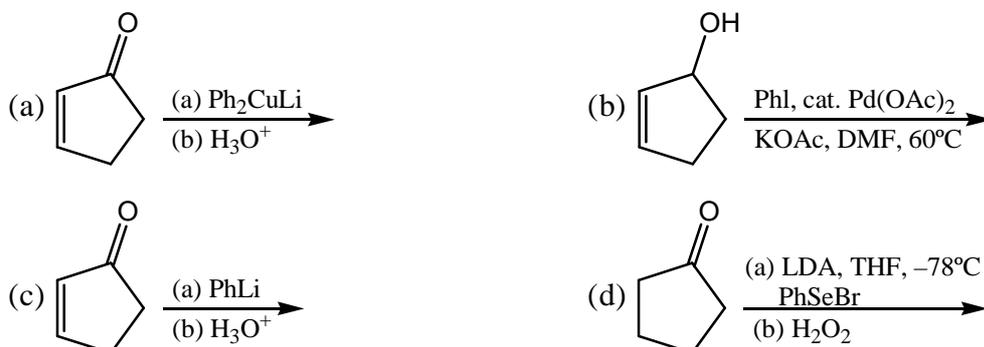
The CORRECT match is

- (a) P-1, Q-2, R-3, S-4                      (b) P-3, Q-2, R-1, S-4  
 (c) P-3, Q-5, R-1, S-2                      (d) P-5, Q-4, R-3, S-2
40. The CORRECT statement regarding the following three normal modes of vibration of  $SO_3$  is

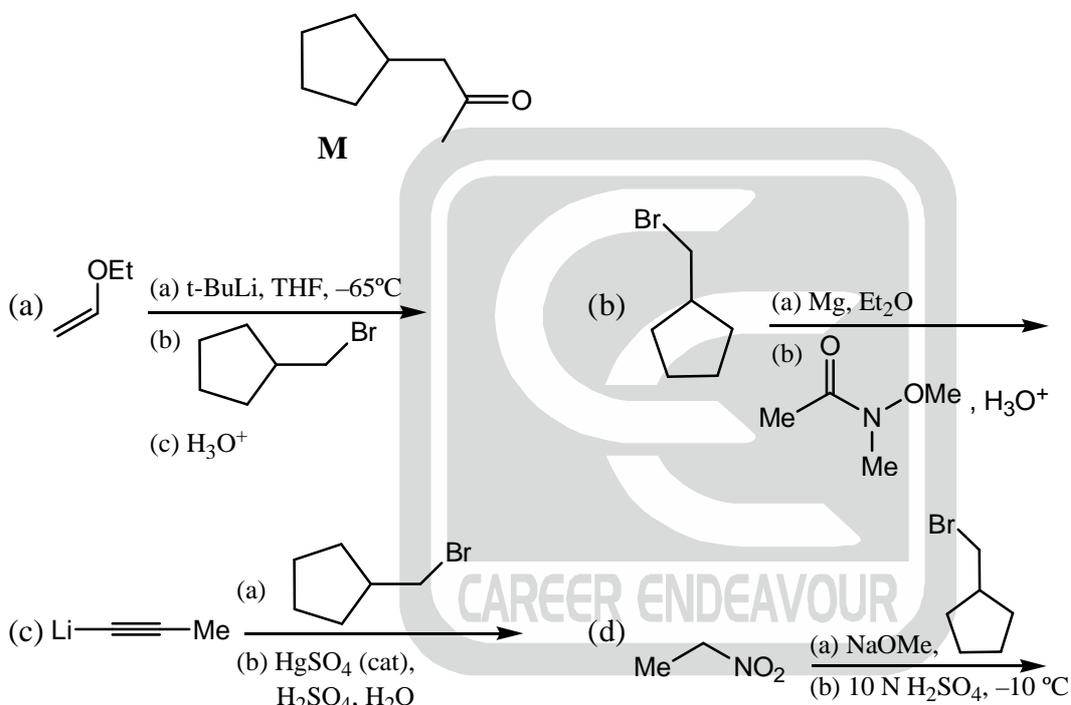


- (a) (I) and (II) are infrared active while (III) is infrared inactive  
 (b) (I) is infrared inactive while (II) and (III) are infrared active  
 (c) (I) and (III) are infrared inactive while (II) is infrared active  
 (d) None of the modes are infrared active since  $\text{SO}_3$  has zero dipole moment

41. The reaction(s) that yield(s) 3-phenylcyclopentanone as the major product is(are)



42. The reaction(s) that yield(s) M as the major product is(are)



43. The CORRECT statement(s) regarding  $\text{B}_{10}\text{H}_{14}$  is(are)

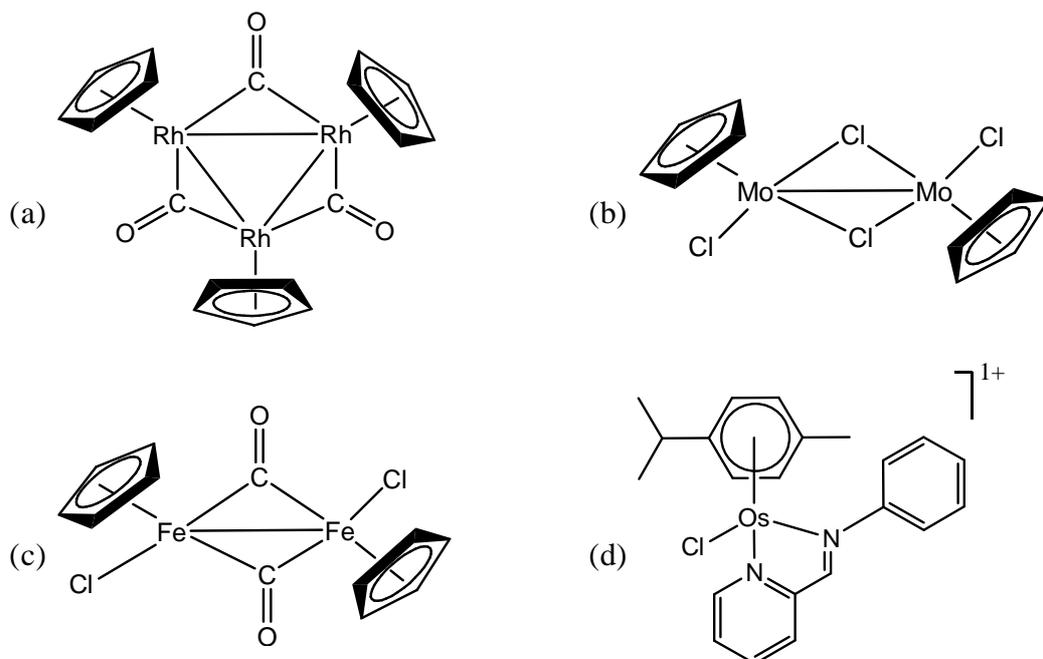
- (a) Brønsted acidity of  $\text{B}_{10}\text{H}_{14}$  is higher than that of  $\text{B}_5\text{H}_9$   
 (b) Structurally  $\text{B}_{10}\text{H}_{14}$  is a closo-borane  
 (c) The metal-promoted fusion of  $\text{B}_5\text{H}_8^-$  produces  $\text{B}_{10}\text{H}_{14}$   
 (d) Both  $\text{B}_{10}\text{H}_{14}$  and  $\text{B}_{10}\text{H}_{12}(\text{SEt}_2)_2$  have the same number of valence electrons

44. The CORRECT statement(s) about the Group-I metals is(are)

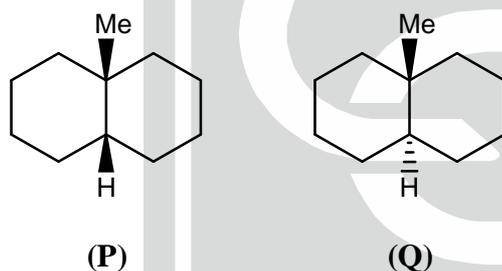
- (a) Reactivity of Group-I metals with water decreases down the group  
 (b) Among the Group-I metals, Li spontaneously reacts with  $\text{N}_2$  to give a red-brown layer-structured material  
 (c) Thermal stability of Group-I metal peroxides increases down the group  
 (d) All the Group-I metal halide are high-melting colorless crystalline solids

45. The compound(s) that satisfies/satisfy the 18-electron rule is(are)

- (Atomic number of Os = 76, Rh = 45, Mo = 42, and Fe = 26)



46. For three operators  $\hat{A}$ ,  $\hat{B}$ , and  $\hat{C}$ ,  $[\hat{A}, [\hat{B}, \hat{C}]] + [\hat{B}, [\hat{C}, \hat{A}]] =$
- (a)  $[\hat{C}, [\hat{A}, \hat{B}]]$       (b)  $[\hat{C}, [\hat{B}, \hat{A}]]$       (c)  $[[\hat{B}, \hat{A}], \hat{C}]$       (d)  $[[\hat{A}, \hat{B}], \hat{C}]$
47. The difference between the number of Gauche-butane interactions present in **P** and **Q** is



48. The calculated magnetic moment (in BM, rounded off to two decimal places) of a  $\text{Ce}^{3+}$  complex is
49. The state of the electron in a  $\text{He}^+$  ion is described by the following normalized wavefunction.

$$\psi(r, \theta, \phi) = \sqrt{\frac{3}{8}} R_{21}(r) Y_{10}(\theta, \phi) - i \sqrt{\frac{7}{16}} R_{10}(r) Y_{00}(\theta, \phi) + x R_{32}(r) Y_{20}(\theta, \phi)$$

Here,  $R_{nl}$  and  $Y_{lm}$  represent the radial and angular components of the eigenfunctions of  $\text{He}^+$  ion, respectively, and  $x$  is an unknown constant. If the energy of the ion is measured in the above state, the probability (rounded off to two decimal places) of obtaining the energy of  $-\frac{2}{9}$  atomic unit is

50. A certain wavefunction for the hydrogen-like atom is given by

$$\psi(r, \theta, \phi) = \frac{2^{\frac{1}{2}}}{81 \pi^{\frac{1}{2}}} \left( \frac{Z}{a_0} \right)^{5/2} \left( 6 - \frac{Zr}{a_0} \right) r e^{-Zr/3a_0} \cos \theta$$

The number of node(s) in this wavefunction is

51. EMF of the following cell  
 $\text{Cu} | \text{CuSO}_4(\text{aq}, 1.0 \text{ mol/kg}) | \text{Hg}_2\text{SO}_4(\text{s}) | \text{Hg}(\text{l}) | \text{Pt}$   
at  $25^\circ\text{C}$  and 1 bar is 0.36 V. The value of the mean activity coefficient (rounded off to three decimal places) of  $\text{CuSO}_4$  at  $25^\circ\text{C}$  and 1 bar is  
[Given: Standard electrode potential values at  $25^\circ\text{C}$  for  
 $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$  and  $\text{Hg}_2\text{SO}_4 + 2\text{e}^- \rightarrow 2\text{Hg} + \text{SO}_4^{2-}$  are 0.34 V and 0.62 V, respectively.  
Consider:  $RT/F$  at  $25^\circ\text{C} = 0.0256 \text{ V}$ ]
52. The radius of gyration (in nm, rounded off to one decimal place), for three dimensional random coil linear polyethylene of molecular weight 8,40,000 is  
[Given: C–C bond length = 0.154 nm]
53. The activation energy of the elementary gas-phase reaction  $\text{O}_3 + \text{NO} \rightarrow \text{NO}_2 + \text{O}_2$  is  $10.5 \text{ kJ mol}^{-1}$ . The value of the standard enthalpy of activation (rounded off to two decimal places in  $\text{kJ mol}^{-1}$ ) at  $25^\circ\text{C}$  is  
[Given:  $R$  is  $8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ ]
54. In a collection of molecules, each molecule has two non-degenerate energy levels that are separated by  $5000 \text{ cm}^{-1}$ . On measuring the population at a particular temperature, it was found that the ground state population is 10 times that of the upper state. The temperature (in K, rounded off to the nearest integer) of measurement is  
[Given: Value of the Boltzmann constant =  $0.695 \text{ cm}^{-1} \text{ K}^{-1}$ ]
55. The change in entropy of the surroundings (in  $\text{J K}^{-1}$ , rounded off to two decimal places) to convert 1 mol of supercooled water at 263 K to ice at 263 K at 1 bar is  
[Consider:  $\Delta_{\text{fus}}H^0$  at 273 K =  $6.0 \text{ kJ mol}^{-1}$ , and the molar heat capacity of water is higher than that of ice by  $37.0 \text{ J K}^{-1} \text{ mol}^{-1}$  in the temperature range of 263 K to 273 K]

