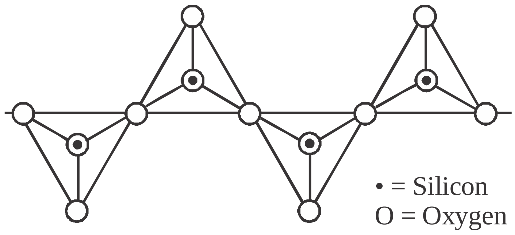
Section-A

Q.1 – Q.25 : Carry ONE mark each.

1. The Lewis acidity of BF_3 is less than BCl_3 even though fluorine is more electronegative than chlorine. It is due to
(a) stronger 2p(B)-2p(F) σ-bonding
(b) stronger 2p(B)-2p(F) π-bonding
(c) stronger 2p(B)-2p(Cl) σ-bonding
(d) stronger 2p(B)-2p(Cl) π-bonding

2. Pyrozenes are a class of silicate minerals, which exhibit a polymeric chain structure, as shown below



Its simplest repeat unit is
(a) $[SiO_4]^{4-}$ (b) $[SiO_3]^{2-}$ (c) $[Si_2O_7]^{6-}$ (d) $[Si_4O_{11}]^{6-}$

3. Among the following pentachlorides the one which does not exist due to the 'inertpair effect' is
(a) PCl_5 (b) $BiCl_5$ (c) $SbCl_5$ (d) $AsCl_5$

4. Band theory predicts that magnesium is an insulator. However, in practice it acts as a conductor due to
(a) presence of filled 3s orbital (b) overlap of filled 2p and filled 3s orbital
(c) overlap of filled 3s and emtpy 3p orbital (d) presence of unfilled 3p orbital

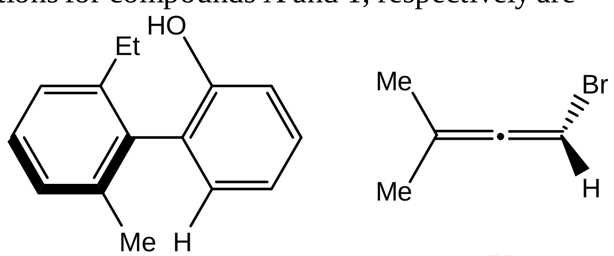
5. The number of 'framework electron pairs' present in the borane cluster $[B_{12}H_{12}]^{2-}$ is:
(a) 10 (b) 11 (c) 12 (d) 13

6. The reaction between $\{PdCl_4\}^{2-}$ and C_2H_4 produces a new compound. Compare to free C_2H_4, the C–C bond order of the product is:
(a) between 1 and 2 (b) less than 1
(c) unaltered (d) greater than 2

7. Among the following pair of metal ions present in Nature, the first one functions as an electrontransfer agent and the second one catalyzes the hydrolysis reactions. The correct pair is
(a) Fe and Zn (b) Mg and Fe (c) Co and Mo (d) Ca and Cu

8. Structurally nickellocene is similar to ferrocene. Nickellocene attains stability due to the formation of
(a) a monocation (b) a dication
(c) a monoanion (d) a dianion

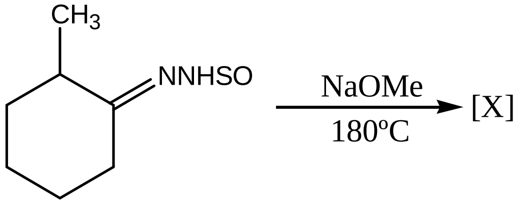
9. The absolute configurations for compounds X and Y, respectively are



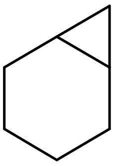
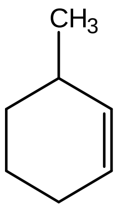
X Y

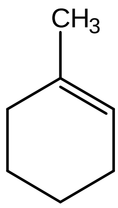
(a) R, S (b) S, R (c) R, R (d) S, S

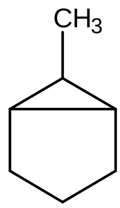
10. In the reaction,



the major product [X] is

(a) 
(b) 

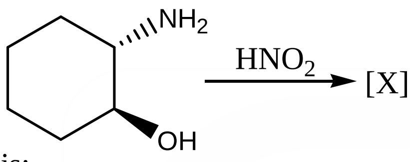
(c) 

(d) 

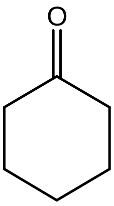
11. Among the following, a pair of resolvable configurational enantiomers is given by

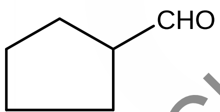
(a) cis-1, 2-dimethylcyclohexane
(b) cis-1, 3-dimethylcyclohexane
(c) cis-1, 4-dimethylcyclohexane
(d) trans-1, 3-dimethylcyclohexane

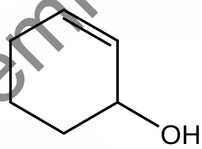
12. In the reaction,

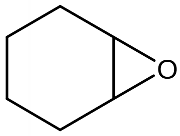


the major product [X] is:

(a) 

(b) 

(c) 

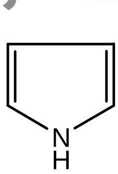
(d) 

13. The decreasing order of isoelectric point for the following α – amino acids is

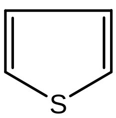
Lysine (I) Alanine (II) Glutamic acid (III)

(a) I > II > III (b) II > I > III (c) III > I > II (d) I > III > II

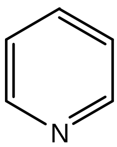
14. The decreasing order of the reactivity of the following compounds towards electrophiles is



I



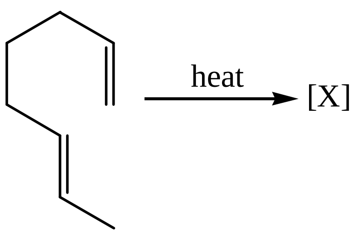
II



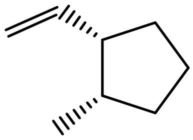
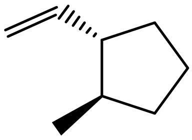
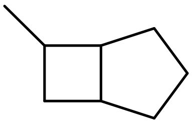
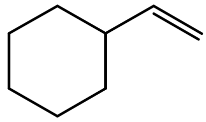
III

(a) II > I > III (b) II > III > I (c) III > I > II (d) I > II > III

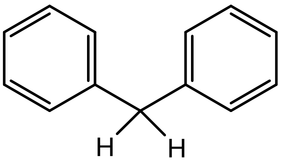
15. In the reaction,

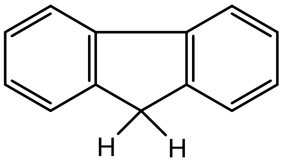


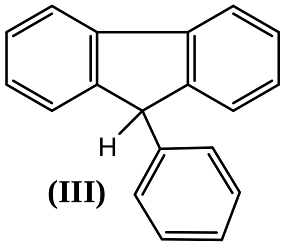
the major product [X] is

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

16. The decreasing order of acidity of marked **H** of the following molecules is


(I)


(II)


(III)

(a) I > II > III (b) III > I > II (c) III > II > I (d) II > I > III

17. The decreasing order of nucleophilicity for the following anions is

$CH_3CO_2^-$, CH_3O^-, $C_6H_5O^-$, NO_3^-

(a) $CH_3CO_2^- > CH_3O^- > C_6H_5O^- > NO_3^-$ (b) $CH_3O^- > NO_3^- > C_6H_5O^- > CH_3CO_2^-$

(c) $CH_3O^- > C_6H_5O^- > CH_3CO_2^- > NO_3^-$ (d) $C_6H_5O^- > CH_3O^- > NO_3^- > CH_3CO_2^-$

18. The molar entropy of crystallline CO at absolute zero is
(a) Zero (b) –Rln 2 (c) Rln 2 (d) 2Rln 2

19. For an ideal gas

(a) $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = 0$ (b) $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = -1$

(c) $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = +1$ (d) $\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial T}{\partial V}\right)_P \left(\frac{\partial V}{\partial P}\right)_T = +2$

20. Among W (work), Q (heat), U(internal energy) and S(entropy)
(a) W and U are path functions but Q and S are state functions.
(b) W and S are path functions but Q and U are state functions.
(c) S and U are path functions but Q and W are state functions.
(d) W and Q are path functions but U and S are state functions.

21. For eigen functions $\psi_1 = \sqrt{\frac{1}{b}}\sin\left(\frac{\pi x}{b}\right)$ and $\psi_2 = \sqrt{\frac{2}{b}}\sin\left(\frac{2\pi x}{b}\right)$ of particle in a 1-D box of length $b(0 \le x \le b)$

(a) ψ_1 is normalized but not orthogonal to ψ_2

(b) ψ_1 is normalized but not orthogonal to ψ_2

(c) ψ_2 is normalized and orthogonal to ψ_1

(d) ψ_2 is neither normalized nor orthogonal to ψ_1

22. The bond order of C_2 molecule is
(a) 0 (b) 1 (c) 2 (d) 3

23. Sulfur can exist in four phases. The possible number of triple points is

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

24. The standard reduction potentials at 298K for single electrodes are given below:

Electrode	**Electrode Potential (volt)**
Mg^{2+}/Mg	–2.34
Zn^{+2}/Zn	–0.76
Fe^{+2}/Fe	–0.44

From this we can infer that

(a) Zn can reduce both Mg^{2+} and Fe^{2+} (b) Fe can reduce both Mg^{2+} and Zn^{2+}

(c) Mg can reduce both Zn^{2+} and Fe^{2+} (d) Mg can reduce Zn^{2+} but not Fe^{2+}.

25. For the pair of reactions given below

(i) $N_2(g)+3H_2(g) \rightleftharpoons 2NH_3(g)$

(ii) $\frac{1}{2}N_2(g)+\frac{3}{2}H_2(g) \rightleftharpoons NH_3(g)$

If at a particular temperature, K_{p1} and K_{p2} are the equilibrium constants for reactions (i) and (ii) respectively, then

(a) $K_{P1}=2K_{P2}$ (b) $K_{P1}=2K_{P2}^2$ (c) $K_{P1}=K_{P2}^2$ (d) $K_{P1}^2=K_{P2}$

Q.26 – Q.55 : Carry TWO marks each.

26. According to VSEPR model, the shape of $[XeOF_5]^-$ is

(a) Octahedral (b) Trigonal bipyramidal

(c) square pyramidal (d) pentagonal monopyramidal

27. The number of unpaired electron(s) present in the species $[Fe(H_2O)_5(NO)]^{2+}$ which is formed during 'brown ring test' is:

(a) 2 (b) 3 (c) 4 (d) 5

28. Fe_3O_4 and Co_3O_4 are metal oxides having spinel structure. Considering their CFSEs, the correct statment regarding their structure is

(a) both have normal spinel structure

(b) both have inverse spinel structure

(c) Fe_3O_4 has normal and Co_3O_4 has inverse spinel structure

(d) Fe_3O_4 has inverse and Co_3O_4 has normal spinel structure.

29. The mechanism of the reaction between $[Fe(CN)_6]^{4-}$ and $[Fe(bpy)_3]^{3+}$ (bpy = 2, 2'–bipyridine) is

(a) outer-sphere electron-transfer (b) inner-sphere electron-transfer

(c) self-exchange reaction (d) ligand-exchange followed by electron transfer.

30. The d-d absorption band of $[Fe(H_2O)_6]^{2+}$ is split due to

(a) presence of octahedral geometry

(b) static Jahn-Teller distortion

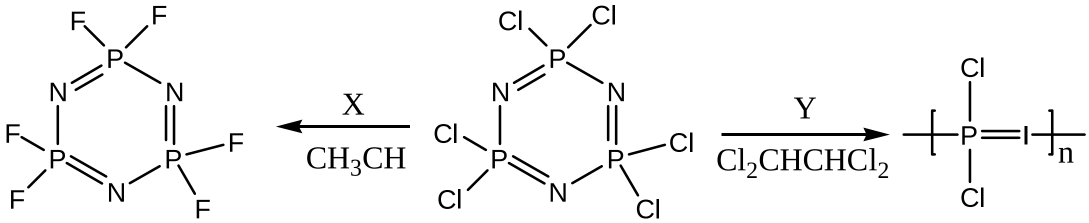
(c) dynamic Jahn-Teller distortion

(d) presence of trigonal bipyramidal geometry.

31. The crystal-field symbol for the ground-state of $[Mn(CN)_6]^{4-}$ is

(a) $^2T_{2g}$ (b) $^1A_{1g}$ (c) ^5E_g (d) $^6A_{1g}$

32. In the following reactions:



the reagent/conditions X and Y are

(a) X = BF_3; Y = heating at 1250ºC (b) X = NaF; Y = heating at 25ºC

(c) X = NH_4F; Y = HCl (d) X = CF_3SO_3H; Y = H_2SO_4

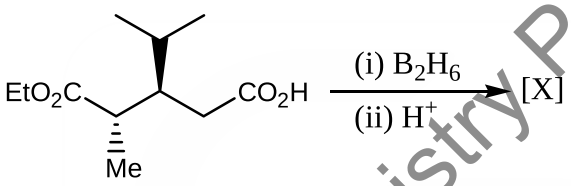
33. $[CoCl_4]^{2-}$ is a blue coloured complex. Controlled-treatment of this complex with water generates two isomeric light pink coloure complexes of composition $[Co(H_2O)_4Cl_2]$.

Identify the correct point groups for $[CoCl_4]^{2-}$ and two isomeric complexes $[Co(H_2O)_4Cl_2]$.

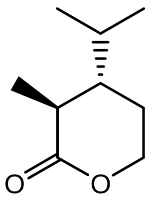
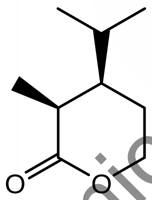
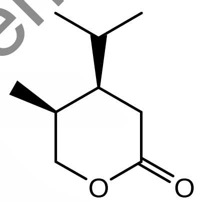
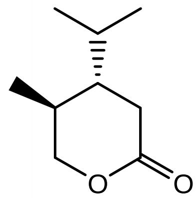
(d) D_{2h} and (C_{2v} and C_{2h}) (b) T_d and (C_{2v} and D_{4h})

(c) D_{4h} and (C_{2v} and D_{4h}) (d) T_d and (C_{2v} and C_{4v})

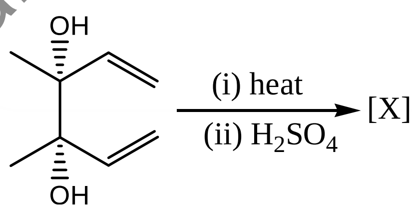
34. In the reaction



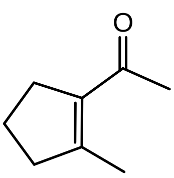
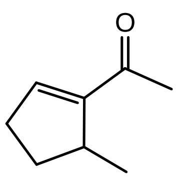
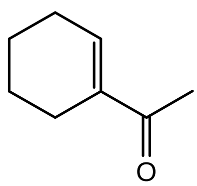
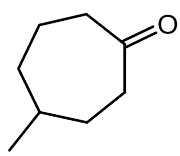
the major product [X] is:

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

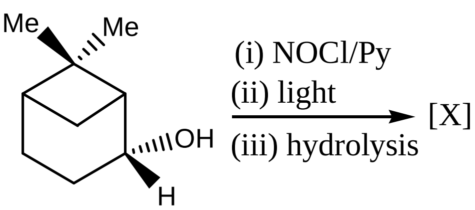
35. In the reaction,



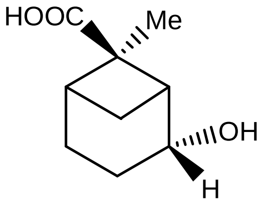
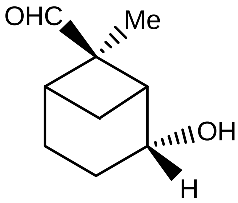
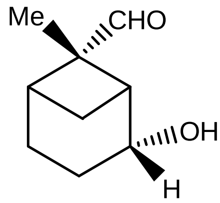
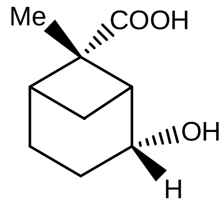
the major product [X] is:

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

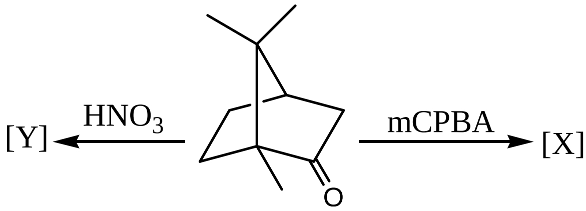
36. In the following reaction sequence



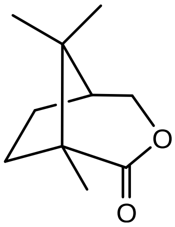
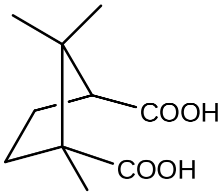
the major product [X] is

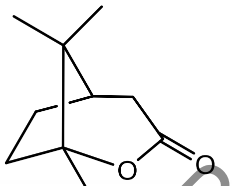
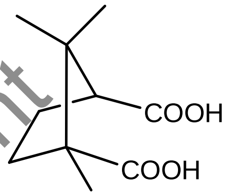
(a)  (b)  (c)  (d) 

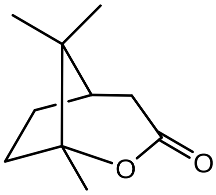
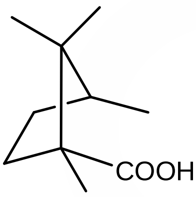
37. In the reaction,

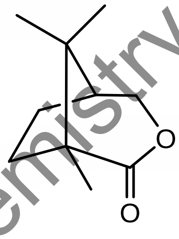
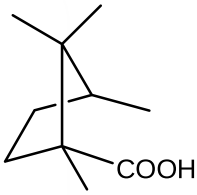


the major products, [X] and [Y], respectively, are

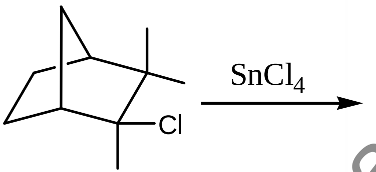
(a)  and 

(b)  and 

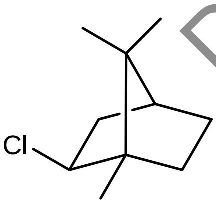
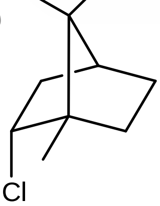
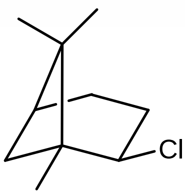
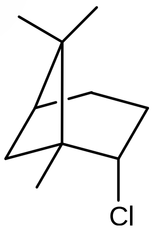
(c)  and 

(d)  and 

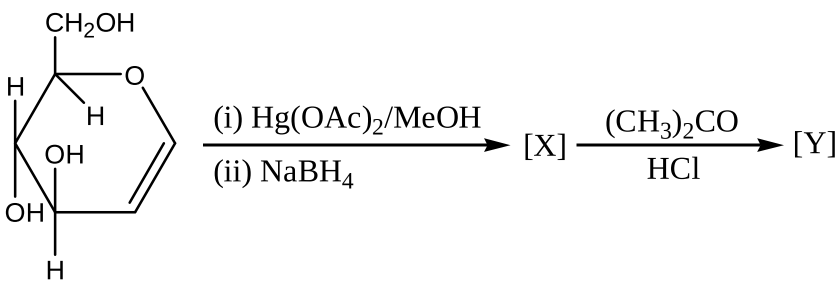
38. In the reaction,



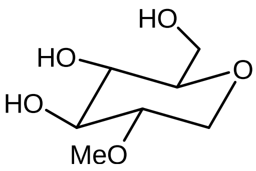
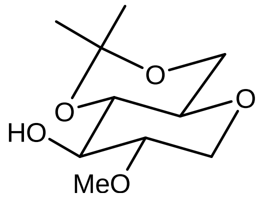
the major product [X] is

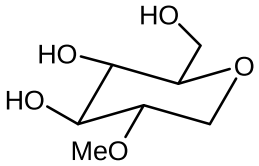
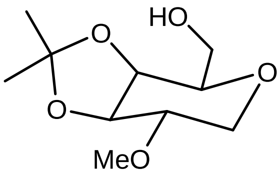
(a)  (b)  (c)  (d) 

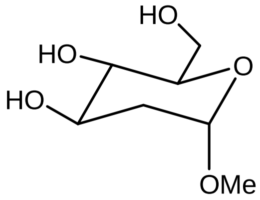
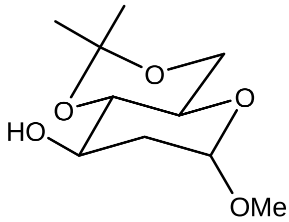
39. In the reaction sequence

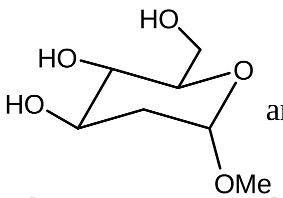
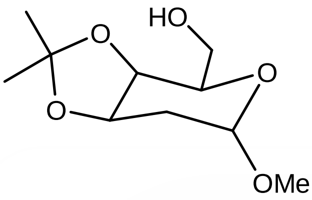


the major products, [X] and [Y] respectively, are

(a)  and 

(b)  and 

(c)  and 

(d)  and 

40. The change in entropy when two moles of Argon gas are heated at constant volume from 300K to 500K is:

(a) –12.74 J K^{-1} $mole^{-1}$ (b) –6.37 J K^{-1} $mole^{-1}$
(c) 6.37 J K^{-1} $mole^{-1}$ (d) 12.74 J K^{-1} $mole^{-1}$

41. At any temperature T, the fugacity coefficient (γ) is given by

$$\text{In } \gamma = \int_0^P \frac{Z-1}{P'} dP'$$

where Z is the compressiblity factor. The fugacity coefficient of a real gas governed by equations of state, P(V–b) = RT with 'b' a constant is given by

(a) $\frac{RT}{bP}$ (b) $e^{\frac{RT}{bP}}$ (c) $\frac{bP}{RT}$ (d) $e^{\frac{bP}{RT}}$

42. The specific rate constant of decomposition of a compound is represented by

$$\text{Ink} = 5.0 - \frac{12000}{T}$$

The activation energy of decomposition for this compound at 300K is

(a) 24 kcal/mole (b) 12 kcal/mole (c) 24 cal/mole (d) 12 cal/mole

43. The commutator $\left[x^3, p_x\right]$ is equal to

(a) $-\frac{3hx^2}{2\pi i}$ (b) $\frac{hx}{2\pi i}$ (c) $\frac{hx^2}{2\pi i}$ (d) $\frac{3hx^2}{2\pi i}$

44. An electron of mass 'm' is confined to a one dimensional box of length 'b'. If it makes a radiative transition from second excited state to the ground state, the frequency of the photon emitted is

(a) $\frac{9h}{8mb^2}$ (b) $\frac{3h}{8mb^2}$ (c) $\frac{h}{mb^2}$ (d) $\frac{2h}{mb^2}$

45. The point group of ClF_3 molecule and its corresponding number of irreducible representation are respectively.
(a) C_{3v} and 4 (b) C_{2v} and 4 (c) C_{3v} and 3 (d) C_{2v} and 3

46. The most populated rotational state for HCl(B = 8.5 cm^{-1}) at 300 K is:
(a) 2 (b) 3 (c) 5 (d) 7

47. The ratio of life times of two states that gives rise to line widths of 1.0 cm^{-1} and 0.2 cm^{-1} respectively is:
(a) 1 : 2 (b) 1 : 5 (c) 2 : 1 (d) 5 : 1

Commond Data Questions:

Commond data for Q.48 and Q.49:

A six-coordinate transition-metal complex is ESR and Mossbauer active. The effective magnetic moment of this complex is –5.9 B.M.

48. The metal-ion along with its oxidation state and the number of unpaired electron present are
(a) Fe(II) and 4 (b) Mn(II) and 5 (c) Fe(III) and 1 (d) Fe(III) and 5

49. The complex is
(a) $[Mn(H_2O)_6]^{2+}$ (b) $[Fe(CN)_6]^{3-}$ (c) $[Fe(H_2O)_6]^{2+}$ (d) $[Fe(H_2O)_6]^{3+}$

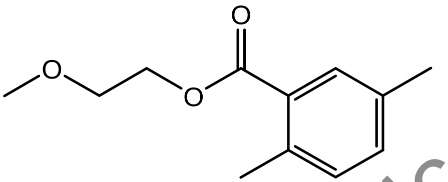
Common data for Q.50 and Q.51:

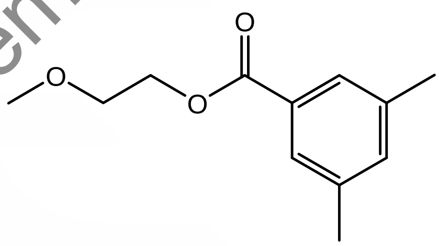
An organic compound [X] ($C_{12}H_{16}O_3$) exhibits the following spectral data IR: –1720 cm^{-1}

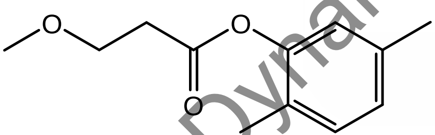
^{1}H NMR: 2.35 (s, 6H), 3.30 (s, 3H), 3.83 (t, 2H), 4.42 (t, 2H), 7.07 (s, 1H), 7.58 (s, 2H)

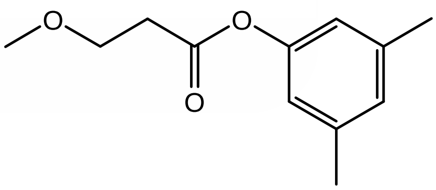
The compound [X] with an excess of MeMgBr gives a 1 : 1 mixture of compounds [Y] and [Z]. The compound [Z] exhibits the following ^{1}H NMR data: 2.0(bs, 1H), 3.30 (s, 3H), 3.56(t, 2H), 3.70 (t, 2H)

50. The compound [X] is:

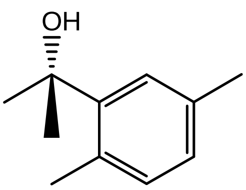
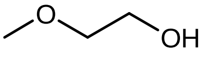
(a) 

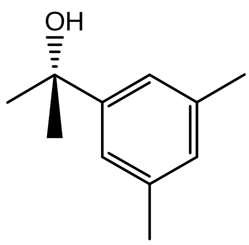
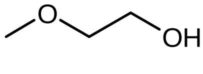
(b) 

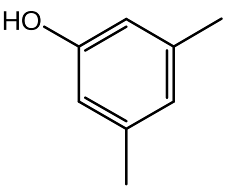
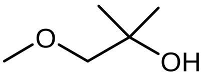
(c) 

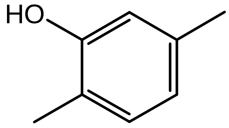
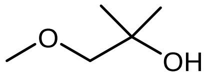
(d) 

51. The compound [Y[is:

(a)  and 

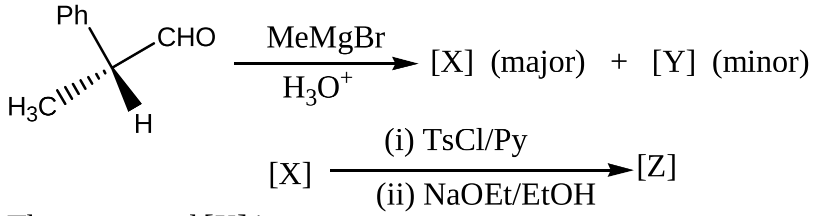
(b)  and 

(c)  and 

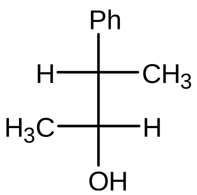
(d)  and 

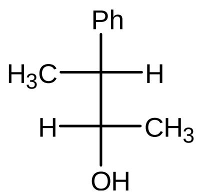
Linked Answer Q.52 and Q.53:

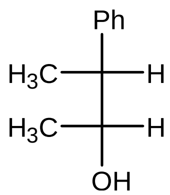
In the reaction sequence

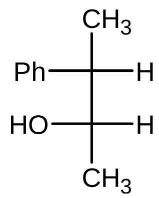


52. The compound [X] is:

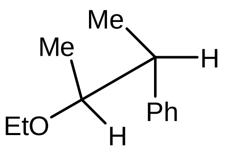
(a) 

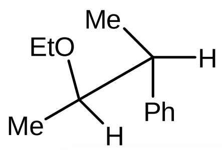
(b) 

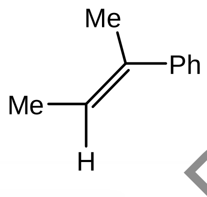
(c) 

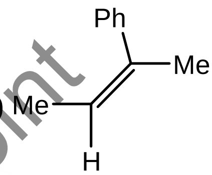
(d) 

53. The compound [Z] is:

(a) 

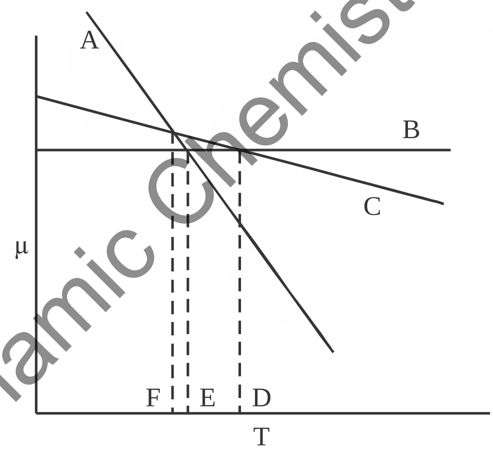
(b) 

(c) 

(d) 

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

In the m vs T diagram for different phases of the same substance at one atmospheric pressure, the lines A, B and C compound to



54. Based on the above diagram.
   (a) A represents the change in chemical potential as a function of temperature for the solid phase, B for the liquid and C for the gas.
   (b) A represents the change in chemical potential as a function of temperature for the gas phase, B for the gas and C for the solid
   (c) A represents the change in chemical potential as a function of temperaturefor the liquid phase, B for the gas and C for the solid
   (d) A represents the change in chemical potential as a function of temperaturefor the gas phase, B for the gas and C for the liquid.

55. From the same diagram
   (a) D represents boiling point, E sublimation point and F melting point.
   (b) E represents boiling point, D sublimation point and F melting point.
   (c) E represents melting point, F sublimation point and D boiling point.
   (d) D represents melting point, F boiling point and E sublimation point.