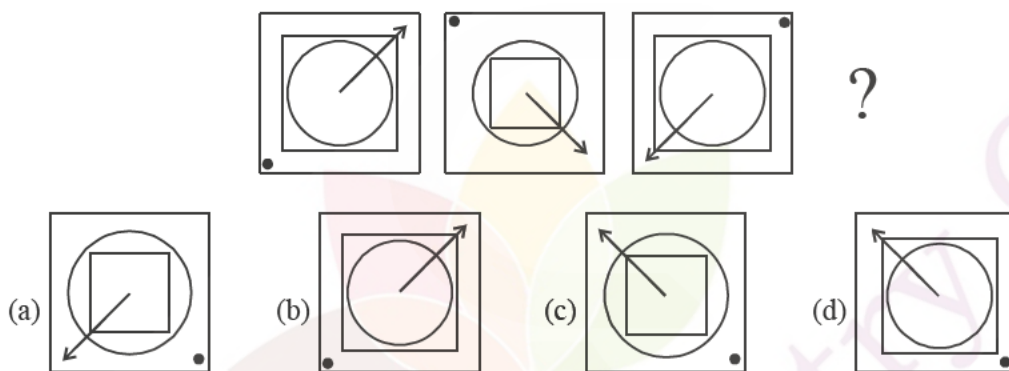
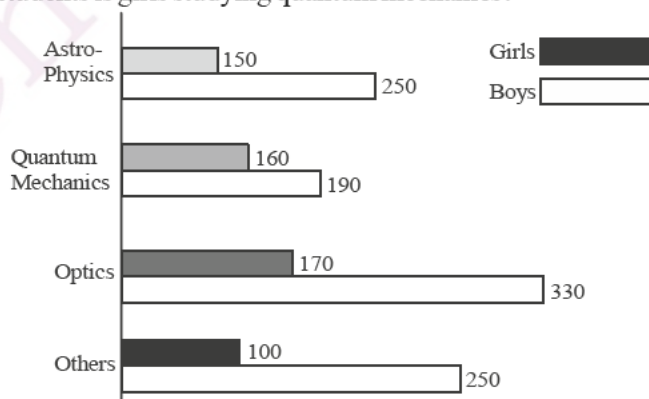
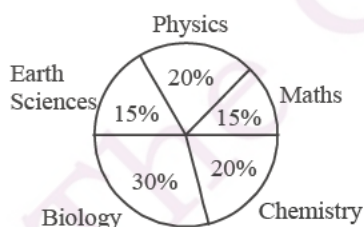


- A mineral contains a cubic and spherical cavity. The length of the side of the cube is the same as the diameter of the sphere. If the cubic cavity is half filled with a liquid and the spherical cavity is completely filled with liquid, what is the approximate ratio of the volume of the liquid in the cubic cavity to that in the spherical cavity?  
 (a) 2 : 1                      (b) 1 : 1                      (c) 1 : 2                      (d) 1 : 4
- Out of 6 unbiased coins, 5 are tossed independently and they all result in heads. If the 6<sup>th</sup> is now independently tossed, the probability of getting head is  
 (a) 1.                      (b) 0.                      (c) 1/2.                      (d) 1/6.
- What could the fourth figure in the sequence be?

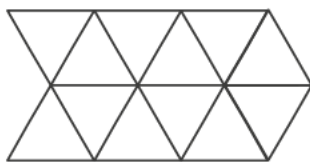


- The average age of A, B and C, whose ages are integers  $x$ ,  $y$  and  $z$  respectively. ( $x \leq y \leq z$ ) is 30. If the age of B is exactly 5 more than that of A, what is the minimum possible value of  $z$ ?  
 (a) 31                      (b) 33                      (c) 35                      (d) 37
- Percentage-wise distribution of all science students in a university is given in the pie-diagram. The bar chart shows the distribution of physics students in different sub-areas, where a student takes one and only one sub-area. What percentage of the total science students is girls studying quantum mechanics?



- (a) 10                      (b) 1                      (c) 0.2                      (d) 2

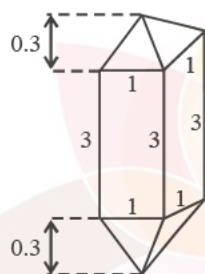
6. What is the total number of parallelograms in the given diagram?



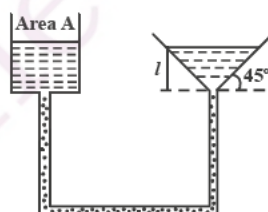
- (a) 27 (b) 24 (c) 22 (d) 14
7. Election results of a city, which contains 3 segments (A, B and C) are given in the Table. Percentage votes obtained by parties X, Y and Z are also shown. Which party won the election?

Segment	Total Voters	% of voting	X	Y	Z
A	2,00,000	60	30	30	40
B	2,50,000	70	40	30	30
C	3,00,000	80	30	40	30

- (a) Y (b) X (c) Z (d) It was a tie between X and Y
8. The diagram shows the dimensions (in cm) of a zircon crystal having a square prism and two identical square pyramids. What is the volume of this crystal (in  $\text{cm}^3$ )?



- (a) 3.2 (b) 3.6 (c) 6.4 (d) 7.2
9. A boy throws a ball with a speed  $v$  at a vehicle that is approaching him with a speed  $V$ . After bouncing from the vehicle, the ball hits the boy with a speed
- (a)  $v$  (b)  $v + V$  (c)  $v + 2V$  (d)  $v + 4V$
10. Four friends were sharing a pizza. They decided that the oldest friend will get an extra piece of pizza. Bahu is two months older than Kattappa, who in turn is three months younger than Bhalla. Devsena is one month older than Kattappa. Who should get the extra piece of pizza?
- (a) Bahu (b) Devsena (c) Bhalla (d) Kattappa
11. A funnel is connected to a cylindrical vessel of cross-sectional area  $A$  as shown, to make an interconnected system of vessels. Water is poured in the cylinder such that the height of water in the funnel is  $l$  as shown. If the level of water in the cylindrical vessel is pushed down by a distance  $x \ll l$ , the level of water in the funnel:



- (a) remains unchanged (b) rises by  $\frac{Ax}{\pi l^2}$

(c) rises by  $\frac{\pi l^2}{Ax}$  (d) rises by  $\frac{A^2 x}{\pi^2 l^4}$

12. Marks (out of 30) of seven students in an examination are 4, 15, 6, 7, 5,  $a$  and  $b$ , where  $a (> 0)$  is a multiple of 4 and  $b$  is a prime. What is the maximum possible value of the difference between the maximum and minimum marks?  
 (a) 25 (b) 26 (c) 27 (d) 29
13. Two persons A and B start walking in opposite directions from a point. A travels twice as fast as B. The speed at which B travels is 1 km/h. If A travels 2 km and turns back and starts walking towards B, at what distance from the starting point will A cross B?  
 (a) 2 km (b) 4 km (c) 6 km (d) 8 km
14. A person wanted to travel from Charbag to Alambag with an average speed of 60 km/h by car. The distance between Charbag and Alambag is 2 km. Due to heavy traffic, he could travel at 30 km/h for the first kilometre of his journey. What should his speed be for the remaining journey to achieve his average speed target of 60 km/h?  
 (a) Cannot achieve his target with any finite speed  
 (b) 60 km/h  
 (c) 90 km/h  
 (d) 120 km/h
15. The average rainfall over a given place during the three-year period of 2003-2005 was 65 cm. During the three-year period 2002-2004 the average rainfall was 63 cm. The actual rainfall during 2005 was 60 cm. What was the rainfall in 2002?  
 (a) 55 cm (b) 60 cm (c) 54 cm (d) 53 cm
16. In a four consecutive day schedule, four pilots flew flights each on a different day. Mr. A was scheduled to work on Monday, but he traded with Ms. B who was originally scheduled to work on Wednesday. Ms. C traded with Mr. D, who was originally scheduled to work on Thursday. After all the switching was done, who worked on Tuesday?  
 (a) Mr. A (b) Mr. D (c) Ms. B (d) Ms. C
17. After 6g of carbon is completely burnt in an atmosphere of 40g of oxygen, the percentage oxygen left is:  
 (a) 80 (b) 60 (c) 40 (d) 20
18. What fraction of the equilateral triangle shown below with three identical sectors of a circle is shaded?



(a)  $1 - \frac{\pi}{2\sqrt{3}}$  (b)  $\frac{\pi}{2\sqrt{3}}$  (c)  $1 - \frac{2\pi}{\sqrt{3}}$  (d)  $1 - \frac{\sqrt{3}\pi}{2}$

19. How many different vegetables can be made from cauliflower, tomatoes, onions, potatoes and carrots?  
 (a) 16 (b) 28 (c) 31 (d) 32
20. A bottle of perfume is opened and a person at a distance of 10 m gets the smell after 10 seconds. The time taken for a person 20 m away to get the smell is about

- (a) 20s                      (b) 40s                      (c) 14s                      (d) 80s

**PART - B**

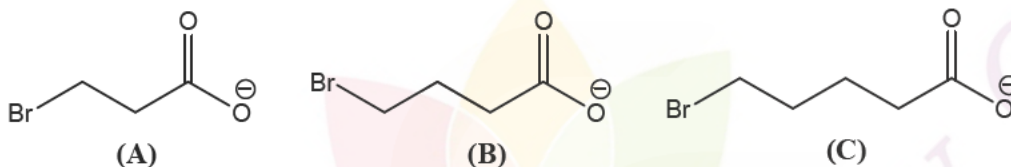
21. The correct order of acceptor ability of the phosphorus ligands is  
 (a)  $\text{PMe}_3 > \text{PPh}_3 > \text{P(OPh)}_3 > \text{PF}_3$                       (b)  $\text{PF}_3 > \text{P(OPh)}_3 > \text{PPh}_3 > \text{PMe}_3$   
 (c)  $\text{PF}_3 > \text{PMe}_3 > \text{PPh}_3 > \text{P(OPh)}_3$                       (d)  $\text{P(OPh)}_3 > \text{PF}_3 > \text{PMe}_3 > \text{PPh}_3$
22. In the  $^{31}\text{P}\{^1\text{H}\}$  NMR spectrum of a diamagnetic complex  $\text{mer-}[\text{M}(\text{PR}_3)_3\text{Cl}_3]$  ( $\text{M} = \text{transition metal}, I = 0$ ) expected number of resonance(s) is  
 (a) Three                      (b) One                      (c) Two                      (d) Six
23. Consider the species  $\text{NO}, \text{I}_2, \text{I}_2^-, \text{Cu}^{2+}$  and  $\text{VO}^{2+}$ . The number of paramagnetic species among them and the EPR inactive species, respectively, are  
 (a) 4 and  $\text{I}_2^-$                       (b) 4 and  $\text{I}_2$                       (c) 3 and  $\text{VO}^{2+}, \text{Cu}^{2+}$                       (d) 3 and  $\text{NO}, \text{Cu}^{2+}$
24. Identify the correct statement(s) for  $\text{H}_3\text{B}\cdot\text{CO}$ .  
 (A)  $\text{sp}^2$  hybridized orbital of B accepts the lone pair of CO.  
 (B) Its  $\nu_{\text{CO}}$  value is more than that for free CO  
 (C) Formal oxidation state of C is +4 in the compound  
 Answer is  
 (a) A and B                      (b) B only                      (c) A only                      (d) A and C
25. Match the items of **Column-I** with those of **Column-II**.  

<b>Column-I</b> (A) Laser source (B) Thermometric titration (C) Gelatin (D) Gas-liquid chromatography	<b>Column-II</b> (I) Electron Capture Detector (II) Polarography (III) Heat of reaction (IV) Spectrofluorimetry
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 Correct answer is  
 (a) A-IV, B-III, C-II, D-I                      (b) A-I, B-III, C-II, D-IV  
 (c) A-IV, B-II, C-III, D-I                      (d) A-III, B-II, C-IV, D-I
26. Consider compounds  $\text{PF}_5, \text{SbF}_5, \text{PH}_3$  and  $\text{SbH}_3$ . The strongest acid and the strongest base among these are, respectively.  
 (a)  $\text{PF}_5$  and  $\text{PH}_3$                       (b)  $\text{SbF}_5$  and  $\text{PH}_3$                       (c)  $\text{SbF}_5$  and  $\text{SbH}_3$                       (d)  $\text{PF}_5$  and  $\text{SbH}_3$
27. Among  $\text{SiCl}_4, \text{P(O)Cl}_3, \text{NF}_3, \text{trans-}[\text{SnCl}_4(\text{py})_2]$  ( $\text{py} = \text{pyridine}$ ), those with zero dipole moment are  
 (a)  $\text{SiCl}_4$  and  $\text{NF}_3$                       (b)  $\text{SiCl}_4, \text{P(O)Cl}_3$  and  $\text{trans-SnCl}_4(\text{py})_2$   
 (c)  $\text{SiCl}_4$  and  $\text{trans-SnCl}_4(\text{py})_2$                       (d)  $\text{NF}_3$  and  $\text{trans-SnCl}_4(\text{py})_2$
28. The standard reduction potentials in acid medium for  $\text{F}_2, \text{Cl}_2, \text{Na}$  and  $\text{Zn}$  are in the order  
 (a)  $\text{F}_2 > \text{Cl}_2 > \text{Na} > \text{Zn}$                       (b)  $\text{F}_2 > \text{Cl}_2 > \text{Zn} > \text{Na}$   
 (c)  $\text{Na} > \text{Zn} > \text{Cl}_2 > \text{F}_2$                       (d)  $\text{Cl}_2 > \text{F}_2 > \text{Zn} > \text{Na}$
29. The characters of LUMO and  $\text{CN}^-$  and  $\text{O}_2$  respectively, are  
 (a)  $\sigma_g$  and  $\pi_u$                       (b)  $\pi_u$  and  $\sigma_u$                       (c)  $\pi_g$  and  $\sigma_u$                       (d)  $\sigma_u$  and  $\pi_g$
30. The intermediate  $[\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+}$  is detected in the reaction of  $[\text{Co}(\text{NCS})(\text{NH}_3)_5]^{2+}$  with  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$  in aqueous medium to produce  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  and  $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$

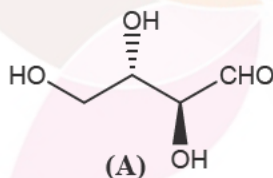
The mechanism of the reaction is

- (a) Interchange dissociative (b) Interchange associative  
 (c) Inner sphere electron transfer (d) Outer sphere electron transfer
31. The chelate rings made by macrocyclic ligand in vitamin B<sub>12</sub> are  
 (a) One five-membered and three six-membered  
 (b) Two five-membered and two six-membered  
 (c) Three five-membered and one six-membered  
 (d) Four six-membered
32. For magnesium complex of EDTA<sup>2-</sup>, the number of N-donor and O-donor centers, are respectively,  
 (a) two and four (b) two and two (c) two and six (d) two and eight
33. The correct set of electronic configurations for metal ions in octahedral coordination geometry for strong Jahn-Teller distortion is  
 (a)  $t_{2g}^6 e_g^1, t_{2g}^3 e_g^1, t_{2g}^6 e_g^3$  (b)  $t_{2g}^1, t_{2g}^3 e_g^2, t_{2g}^6 e_g^1$   
 (c)  $t_{2g}^3, t_{2g}^3 e_g^1, t_{2g}^3 e_g^2$  (d)  $t_{2g}^3 e_g^2, t_{2g}^6 e_g^2, t_{2g}^6 e_g^3$
34. The order of relative rate of cyclization of following bromocarboxylates to generate corresponding lactones is

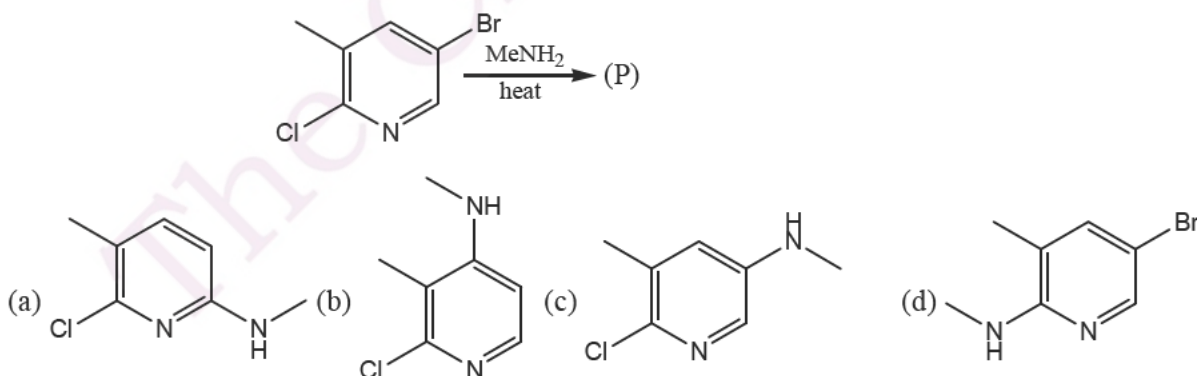


- (a) B > A > C (b) A > C > B (c) B > C > A (d) C > B > A

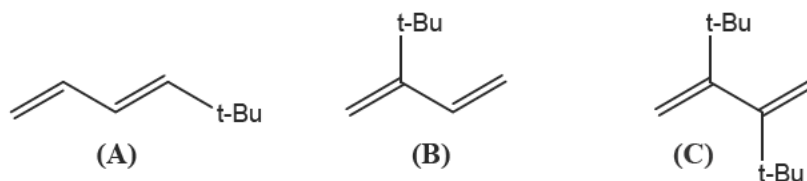
35. Oxidation of A with HNO<sub>3</sub>/H<sub>2</sub>O provides the product(s), which is (are)



- (a) Optically inactive as it is racemic mixture  
 (b) Optically inactive as it is *meso*  
 (c) Optically active as it is a single diastereomer  
 (d) Optically active as it is a single enantiomer
36. The major product formed in the following reaction is



37. The order of reactivity of the following dienes towards Diels-Alder reaction is

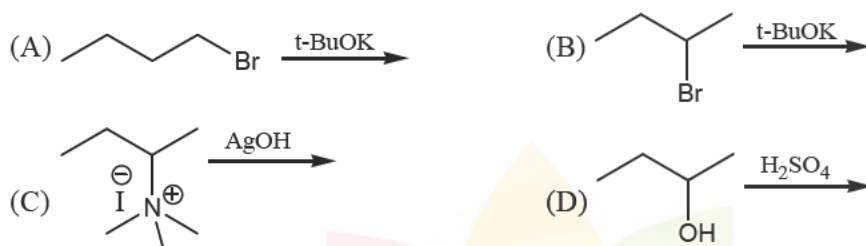


- (a)  $B > A > C$  (b)  $A > C > B$  (c)  $B > C > A$  (d)  $C > B > A$

38. Among the following, the optically active compound is

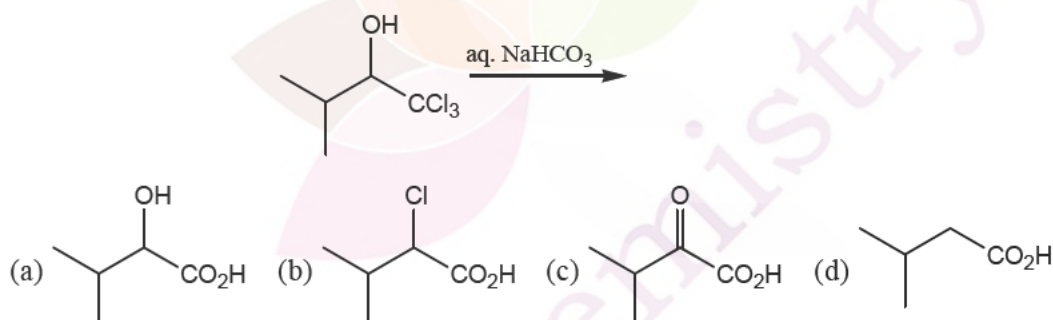


39. Among the following, reaction(s) which provide(s) 1-butene as the major product is (are)

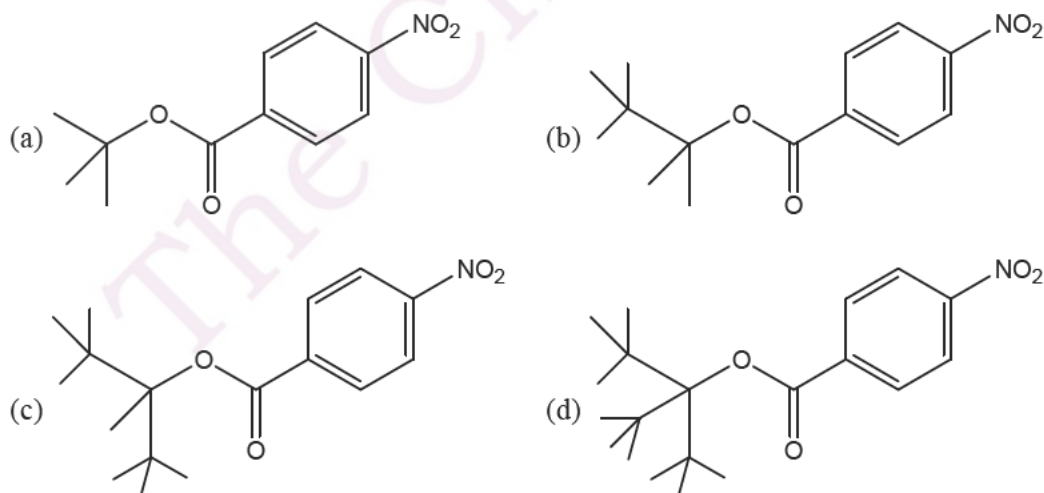


- (a) A alone (b) A and B (c) A and C (d) C and D

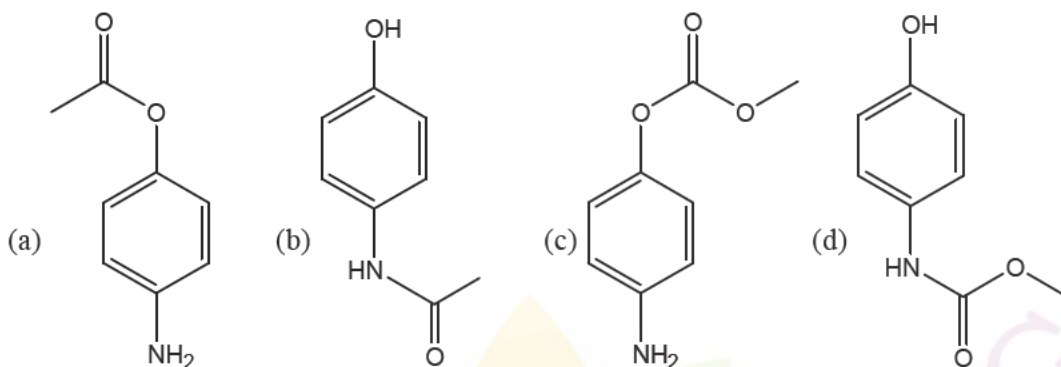
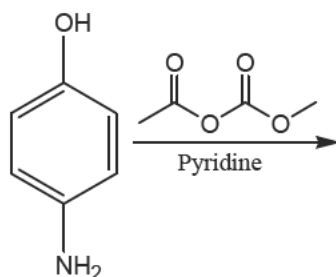
40. The major product formed in the following reaction is



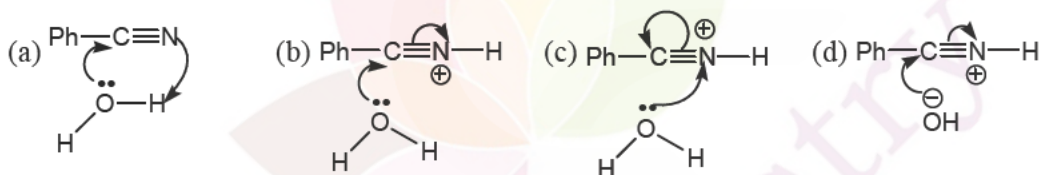
41. Among the following, the compound that will have highest rate for nucleophilic substitution through  $S_N1$  mechanism is



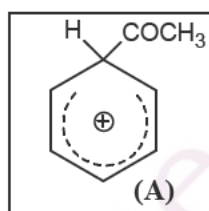
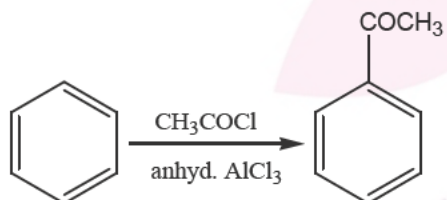
42. The major product formed in the following reaction is

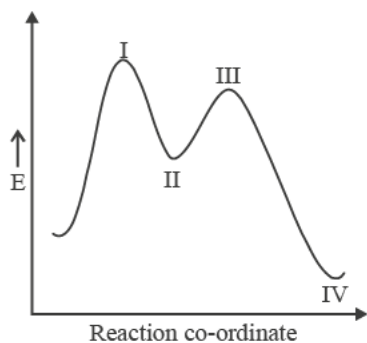


43. The mechanism of acid catalyzed hydrolysis of benzonitrile involves

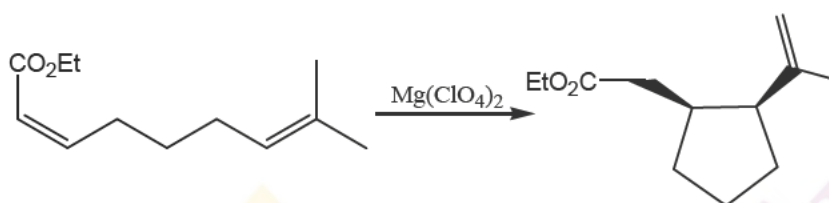


44. In the energy profile diagram of the reaction given below, the species A would correspond to the position

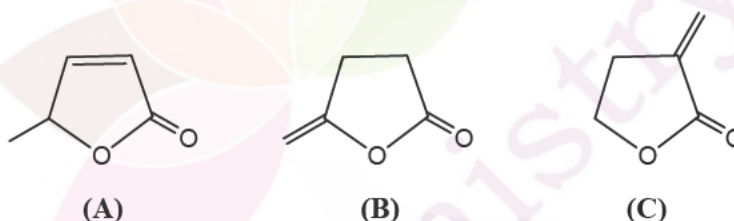




45. (a) I (b) II (c) III (d) IV  
Following reaction is an example of



- (a) Alder-Ene reaction (b) Michael addition  
(c) Sigmatropic Rearrangement (d) Wagner-Meerwein Rearrangement
46. In IR spectra, the stretching frequency (in  $\text{cm}^{-1}$ ) of the carbonyl group of the following compounds is in the order



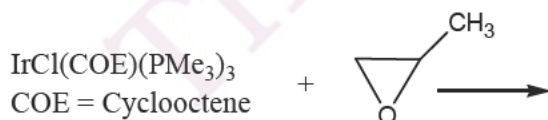
- (a)  $B > A > C$  (b)  $A > C > B$  (c)  $B > C > A$  (d)  $C > B > A$
47. The uncertainty in the position of a moving electron is 100 pm. The uncertainty in its speed is closest to ( $m_e = 9.11 \times 10^{-31} \text{ kg}$ ;  $h = 6.63 \times 10^{-34} \text{ J.s}$ )  
(a)  $6.0 \times 10^2 \text{ m.s}^{-1}$  (b)  $6.0 \times 10^5 \text{ m.s}^{-1}$  (c)  $6.0 \times 10^8 \text{ m.s}^{-1}$  (d)  $6.0 \times 10^{11} \text{ m.s}^{-1}$
48. The spectrum of sodium atom has a closely separated doublet at 16956.2 and 16973.4  $\text{cm}^{-1}$ . The higher energy transition is due to  
(a)  $^2P_{3/2} \rightarrow ^2S_{1/2}$  (b)  $^2P_{1/2} \rightarrow ^2S_{1/2}$  (c)  $^2P_{3/2} \rightarrow ^2P_{1/2}$  (d)  $^2S_{1/2} \rightarrow ^2P_{3/2}$
49.  $\text{N}_2\text{O}$  molecule belongs to the point group  
(a)  $D_{\infty h}$  (b)  $C_{\infty v}$  (c)  $C_{2v}$  (d)  $S_2$
50. For a closed system in the absence of non-PV work, the correct statement is  
(a)  $dU = TdS - PdV$  (b)  $dG = VdP + SdT$   
(c)  $dU = TdS + PdV$  (d)  $dU = VdP - SdT$
51. The volume change in a certain phase transition is  $2.0 \text{ mL mol}^{-1}$  at the transition point. From this, we may conclude that the transition is most likely to

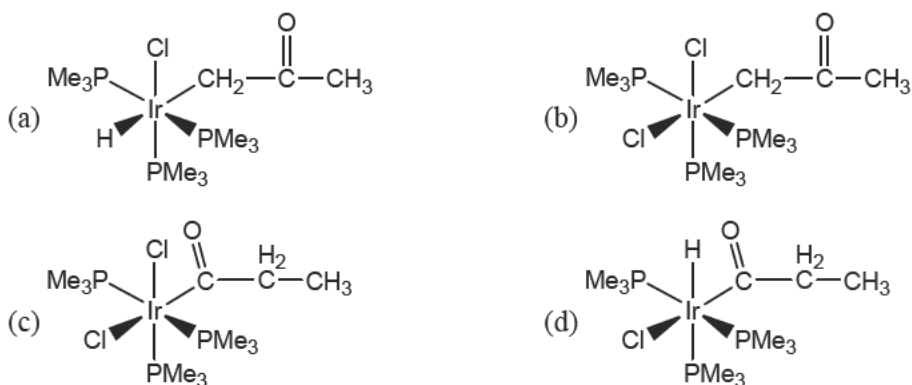


- (a) first order phase transition (b) second order phase transition  
 (c) third order phase transition (d)  $\lambda$  phase transition
52. Root mean square speed of the molecules of a perfect gas is proportional to  
 (a)  $1/T^{1/2}$  (b)  $T$  (c)  $T^{1/2}$  (d)  $1/T$
53. For a second-order reaction, the straight line among the following plots is  
 (a)  $[X]$  versus time (b)  $1/[X]$  versus time  
 (c)  $\log[X]$  versus  $1/\text{time}$  (d)  $\log[X]$  versus time
54. The activation energy of a reaction reduces by  $12 \text{ kcal mol}^{-1}$  in the presence of an enzyme at  $300 \text{ K}$ . Assuming pseudo-first order kinetics, calculate the factor by which the reaction rate is increased. [Given:  $R = 2 \text{ cal K}^{-1}\text{mol}^{-1}$ ]  
 (a)  $2 \times 10^{-9}$  (b)  $1.02$  (c)  $8.7 \times 10^6$  (d)  $5 \times 10^8$
55. The correct statement among the following is  
 (a) Salt bridge is required for the mixing of the solutions in the two half cells.  
 (b) Salt bridge allows current to flow between the half cells without mixing the solutions  
 (c) Salt bridge enhances the rate of the reaction  
 (d) Salt bridge consists of a non-electrolyte in a gel.
56. The standard free energy of the reaction  
 $\text{AgBr(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq})$   
 is closest to  
 $(E^0(\text{AgBr}/\text{Ag}, \text{Br}^-) = 0.07 \text{ V}, E^0(\text{Ag}/\text{Ag}^+) = 0.80 \text{ V}; F = 96500 \text{ C mol}^{-1})$   
 (a)  $7 \text{ kJ mol}^{-1}$  (b)  $70 \text{ J mol}^{-1}$  (c)  $70 \text{ kJ mol}^{-1}$  (d)  $7 \text{ J mol}^{-1}$
57. The internal pressure of a liquid drop (radius =  $10^{-6} \text{ m}$ ) is greater than the external pressure by  $1.5 \times 10^5 \text{ Nm}^{-2}$ . The surface tension ( $\text{mN m}^{-1}$ ) of the liquid is closest to  
 (a) 150 (b) 125 (c) 100 (d) 75
58. In a cubic crystal, the (1 1 1) and (222) reflections are observed, but not the (001) reflection. The Bravais lattice is  
 (a) body centred cubic (b) face centred cubic  
 (c) simple cubic (d) side centred cubic
59. The dispersity of a polymeric sample is  
 (a)  $\frac{\langle M^2 \rangle}{\langle M \rangle^2}$  (b)  $\frac{\langle M \rangle^2}{\langle M^2 \rangle}$  (c)  $\frac{\langle M^2 \rangle}{\langle M \rangle}$  (d)  $\frac{\langle M \rangle}{\langle M^2 \rangle}$
60. The keto-hexose among the following is  
 (a) Xylose (b) Galactose (c) Fructose (d) Mannose

## PART - C

61. The product for the reaction given below is





62. The  $^{31}\text{P}\{^1\text{H}\}$  NMR spectrum of  $\text{cis-}[\text{Pt}(\text{PEt}_3)_2\text{Cl}_2]$  ( $^{195}\text{Pt}$  (33.8% abundance)  $I = \frac{1}{2}$ ; its other isotopes are NMR inactive;  $^{31}\text{P}$  :  $I = \frac{1}{2}$ ) is comprised with satellite peaks of a  
 (a) triplet (b) singlet (c) doublet (d) quartlet
63. The correct order of intensity of the d-d transitions in the complexes of a 3d-transition metal ion  $\text{M}^{2+}$  is  
 (a)  $\text{cis-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2] > \text{trans-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2] > [\text{M}(\text{H}_2\text{O})_6]^{2+}$   
 (b)  $[\text{M}(\text{H}_2\text{O})_6]^{2+} > \text{cis-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2] > \text{trans-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2]$   
 (c)  $\text{trans-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2] > \text{cis-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2] > [\text{M}(\text{H}_2\text{O})_6]^{2+}$   
 (d)  $[\text{M}(\text{H}_2\text{O})_6]^{2+} > \text{cis-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2] \approx \text{trans-}[\text{M}(\text{H}_2\text{O})_4\text{Cl}_2]$
64. The reaction of decaborane  $\text{B}_{10}\text{H}_{14}$  with acetylene in the presence of  $\text{Et}_2\text{S}$  gives  
 (a)  $\text{C}_2\text{B}_{10}\text{H}_{12}$  (b)  $\text{C}_2\text{B}_8\text{H}_{10}$  (c)  $\text{C}_2\text{B}_{10}\text{H}_{14}$  (d)  $\text{C}_2\text{B}_9\text{H}_{11}$
65. In compound  $\text{N}_3\text{P}_3\text{F}_6$ , the geometry around nitrogen and phosphorus, respectively, are  
 (a) pyramidal and tetrahedral (b) planar and tetrahedral  
 (c) pyramidal and planar (d) planar and trigonal bipyramidal
66. The number of 2c-2e bonds ('x') of a molecule is related to 'N' (valence electrons) and 'n' (skeletal atoms) by  $x = (8n - N)/2$ . For  $\text{P}_4\text{S}_3$ , the values of x, N and n, respectively, are  
 (a) 7, 38, 9 (b) 7, 24, 9 (c) 9, 38, 7 (d) 9, 24, 7
67. Match the following complexes with their  $\nu_{\text{CO}}$  stretching frequency

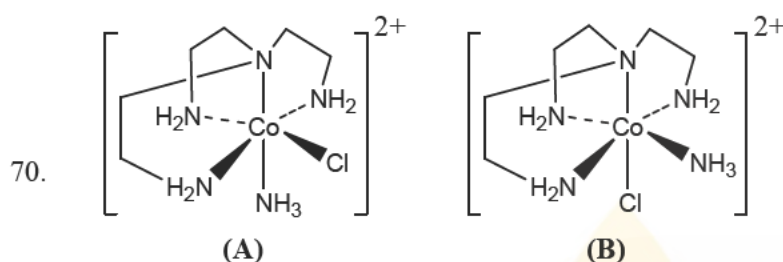
Complex	$\nu_{\text{CO}}$ ( $\text{cm}^{-1}$ ) values
(A) $\text{Mo}(\text{PF}_3)_3(\text{CO})_3$	(I) 1835, 1934
(B) $\text{Mo}\{\text{P}(\text{OMe})_3\}_3(\text{CO})_3$	(II) 1888, 1977
(C) $\text{Mo}(\text{PPh}_3)_3(\text{CO})_3$	(III) 2055, 2090
(D) $\text{Mo}(\text{pyridine})_3(\text{CO})_3$	(IV) 1746, 1888

The correct match is

- (a) A-I, B-IV, C-II, D-III (b) A-III, B-II, C-I, D-IV  
 (c) A-IV, B-III, C-I, D-II (d) A-I, B-II, C-III, D-IV

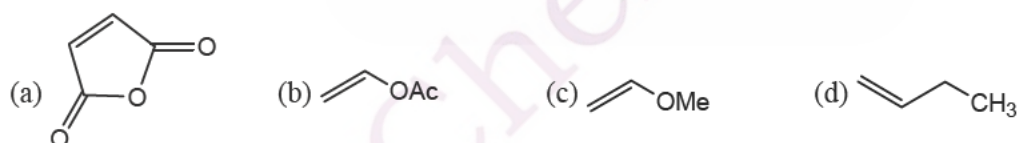
68. The  $\nu_{\text{CN}}$  in  $[\text{Fe}(\text{CN})_6]^{3-}$  (A) and  $[\text{Fe}(\text{CN})_6]^{4-}$  (B) and  $\nu_{\text{CO}}$  in  $[\text{Cr}(\text{CO})_3(\text{NH}_3)_3]$  (C) and  $[\text{Cr}(\text{CO})_6]$  (D) are compared below. The pair with correct order is  
 (a)  $A > B ; C > D$  (b)  $A > B ; C < D$  (c)  $A < B ; C > D$  (d)  $A < B ; C < D$

69. Consider the following statements for  $[\text{FeO}_4]^{2-}$   
 (A) It is stable in the pH range 0-14  
 (B) It is stable in strongly basic medium only  
 (C) It is a very strong oxidizing agent  
 (D) The isomer shift in its Mossbauer spectrum is more negative compared to that of  $\text{FeCl}_3$ .  
 The correct statements are  
 (a) A, C and D (b) B, C and D (c) B and C (d) C and D



The isomers A and B undergo base hydrolysis by forming a trigonal bipyramidal intermediate. The correct statement is

- (a) A reacts faster than B and both results in a mixture of products  
 (b) B reacts faster than A and both results in a mixture of products  
 (c) A reacts faster than B and B results in a mixture of products  
 (d) B reacts faster than A and A results in a mixture of products.
71.  $\text{B}_2\text{H}_6$  reacts with  
 (A) water to give boric acid and  $\text{H}_2$  (B) oxygen to give  $\text{B}_2\text{O}_3$  and  $\text{H}_2$   
 (C) water to give boric acid and  $\text{H}_2\text{O}$  (D) oxygen to give  $\text{B}_2\text{O}_3$  and  $\text{H}_2\text{O}$   
 Correct statements from the above are  
 (a) A and B (b) A and D (c) B and C (d) B and D
72. The ligand that binds strongly to the nickel center in (2, 2'-bipyridine) Ni(0) complex is



73. Match the items given in **Column-I** with those given in **Column-II**

**Column-I**

- (A) Magic number  
 (B) Liquid drop model of nucleus  
 (C) Actinides  
 (D) Threshold energy

The correct match is

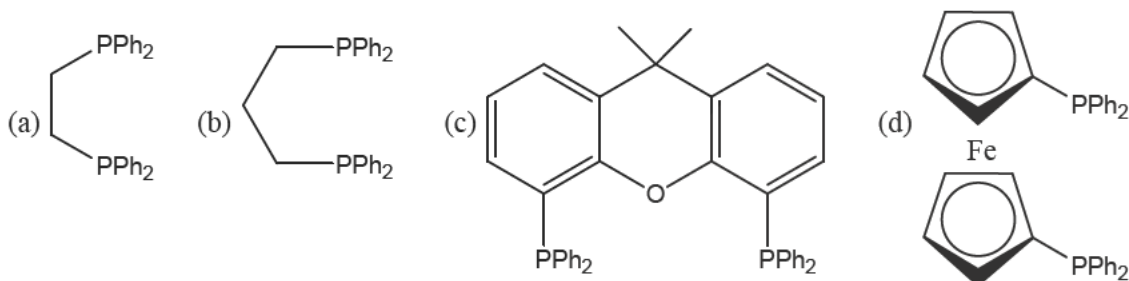
- (a) A-IV, B-I, C-III, D-II  
 (c) A-III, B-IV, C-I, D-II

**Column-II**

- (I) Nuclear fission  
 (II) Q-value  
 (III) Radioactivity  
 (IV) Shell model of nucleus

- (b) A-II, B-I, C-III, D-IV  
 (d) A-IV, B-III, C-I, D-II

74. The cluster type and geometry of the species  $[\text{Rh}_9\text{P}(\text{CO})_{21}]^{2-}$  are  
 (a) closo, tricapped trigonal prism (b) arachno, trigonal prism  
 (c) nido, capped square antiprism (d) nido, bicapped trigonal prism
75. Hydroformylation of 1-propene with  $[\text{HRh}(\text{CO})\text{L}_2]$  leads to linear and branched formylated products. The linear hydroformylated product is formed with highest selectivity when 'L' in the rhodium complex is



76. The hydrocarbon having an analogous structure to that of  $\text{P}_4\text{O}_6$  is  
 (a)  $[(\text{CH})_4(\mu-\text{CH}_2)_6]$  (b)  $[(\text{CH})_6(\mu-\text{CH}_2)_4]$   
 (c)  $[(\text{CH}_2)_4(\mu-\text{CH})_6]$  (d)  $[(\text{CH}_2)_4(\mu-\text{CH})_4]$
77. Match the items given below in the three columns:

Metalloprotein		Species coordinated to metal centre(s)		Resonance Raman O–O stretching frequency ( $\text{cm}^{-1}$ )	
(A)	Oxymyoglobin	(I)	$\eta^2:\eta^2-\text{O}_2^{2-}$	(X)	844
(B)	Oxyhemocyanin	(II)	$\text{HO}_2^-$	(Y)	803
(C)	Oxyhemerythrin	(III)	$\text{O}_2^-$	(Z)	1105

Correct matches:

- (a) A-III-Z, B-I-Y, C-II-X (b) A-II-Y, B-I-X, C-III-Z  
 (c) A-III-Y, B-I-Z, C-II-X (d) A-I-X, B-II-Y, C-III-Z
78. A solid sample of  $\text{Na}[\text{Fe}(\text{EDTA})(\text{H}_2\text{O})_5]$  (X) showed 5.6% weight loss at  $120^\circ\text{C}$  in a thermogravimetric experiment. Identify the complex left after this weight loss.  
 (a)  $\text{Na}[\text{Fe}(\text{EDTA})(\text{H}_2\text{O})]$  (b)  $\text{Na}[\text{Fe}(\text{EDTA})]$   
 (c)  $\text{Na}[\text{Fe}(\text{EDTA})(\text{H}_2\text{O})_2]$  (d)  $\text{Na}[\text{Fe}(\text{EDTA})(\text{H}_2\text{O})_3]$
79. Consider the two sets of molecules.

Set A:  $[\text{AlF}_6]^{3-}$ ,  $[\text{PF}_6]^-$ ,  $[\text{SF}_6]$  and  $[\text{SiF}_6]^{2-}$

Set B:  $[\text{Ba}(\text{H}_2\text{O})_6]^{2+}$ ,  $[\text{Ca}(\text{H}_2\text{O})_6]^{2+}$ ,  $[\text{Mg}(\text{H}_2\text{O})_6]^{2+}$ ,  $[\text{Sr}(\text{H}_2\text{O})_6]^{2+}$

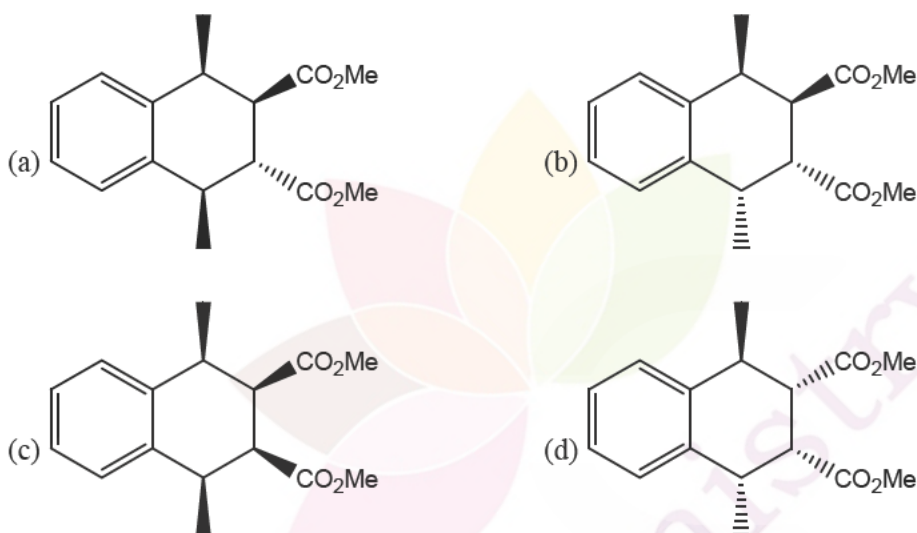
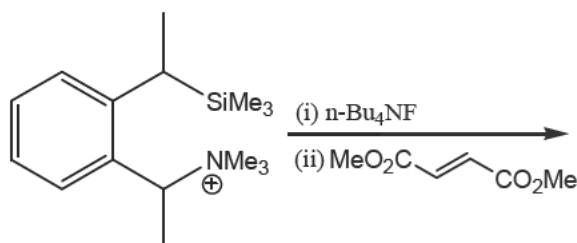
The slowest ligand exchange rate in Set A and Set B are, respectively

- (a)  $[\text{AlF}_6]^{3-}$  and  $[\text{Sr}(\text{H}_2\text{O})_6]^{2+}$  (b)  $[\text{SF}_6]$  and  $[\text{Mg}(\text{H}_2\text{O})_6]^{2+}$   
 (c)  $[\text{SiF}_6]^{2-}$  and  $[\text{Ca}(\text{H}_2\text{O})_6]^{2+}$  (d)  $[\text{PF}_6]^-$  and  $[\text{Ca}(\text{H}_2\text{O})_6]^{2+}$

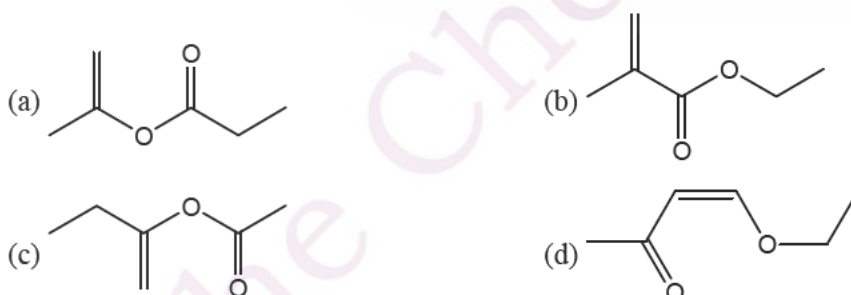
80. Consider following statements for  $\text{Eu}^{3+}$   
 (A) The positions of sharp bands in UV-vis spectra of its complexes depend heavily on the ligand environment  
 (B) Its ground state term symbol is  ${}^7F_0$ .  
 (C) The observed magnetic moment is due to populated higher J level  
 (D) At 2 K its magnetic moment approaches to zero

The set of correct statements is

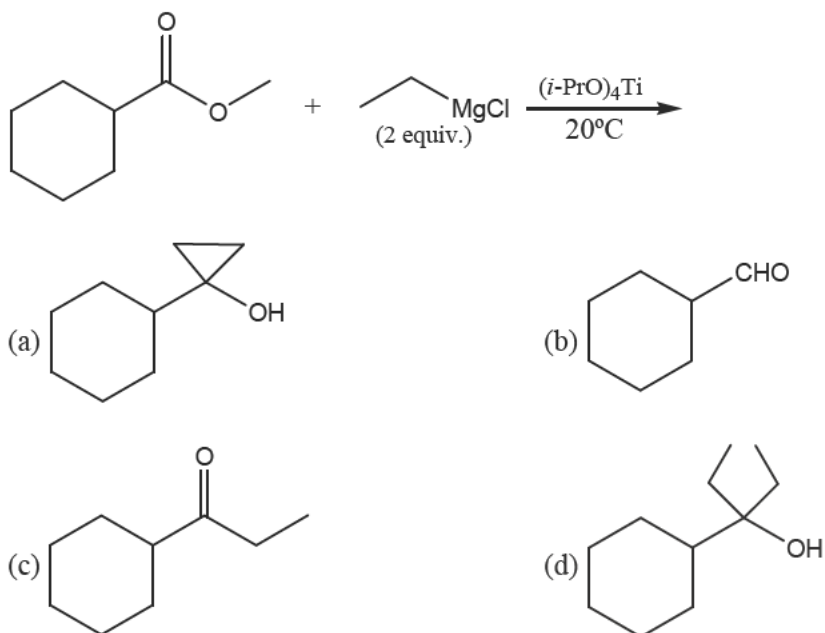
- (a) A, C and D      (b) B, C and D      (c) A, B and D      (d) A, B and C
81. The major product formed in the following reaction is



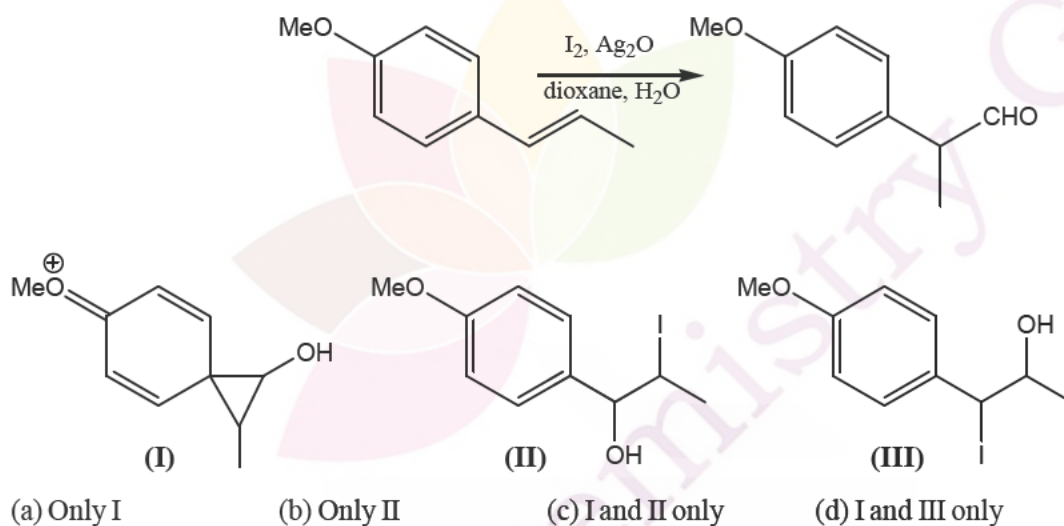
82. Structure of the compound displaying following characteristics spectral data  
 IR :  $1720\text{ cm}^{-1}$   
 ${}^1\text{H NMR}$  : 6.2 (br s, 1H), 5.5 (br, s, 1H), 4.2 (q, 2H), 2.0 (s, 3H), 1.1 (t, 3H) is



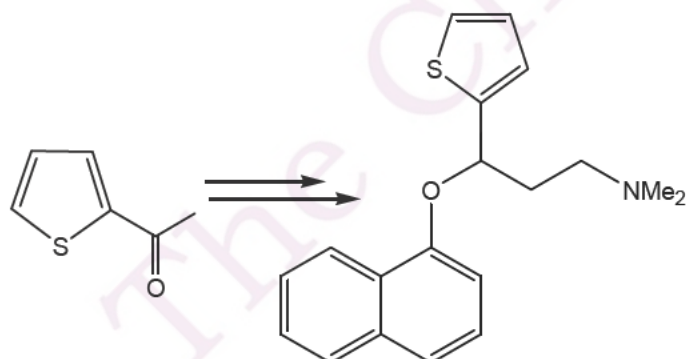
83. The major product formed in the following reaction is



84. The intermediate(s) involved in the following reaction is(are)



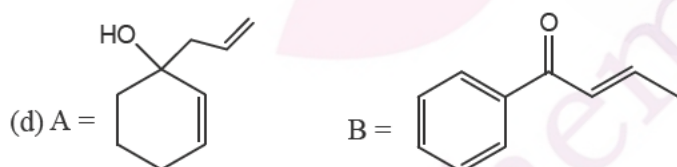
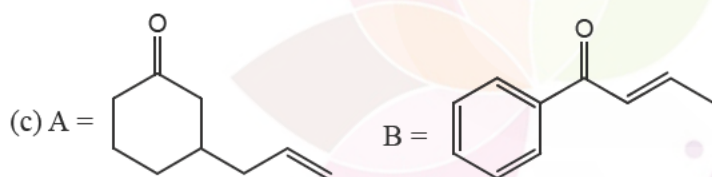
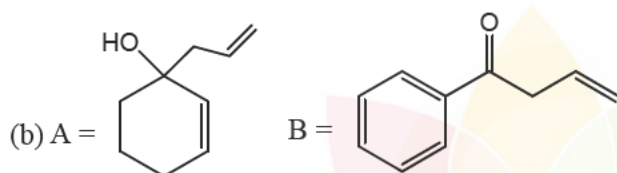
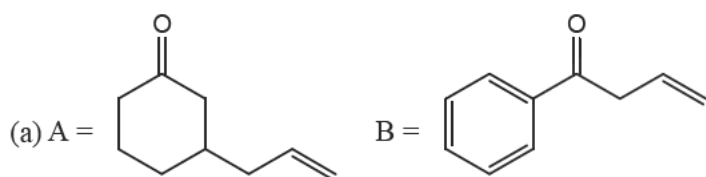
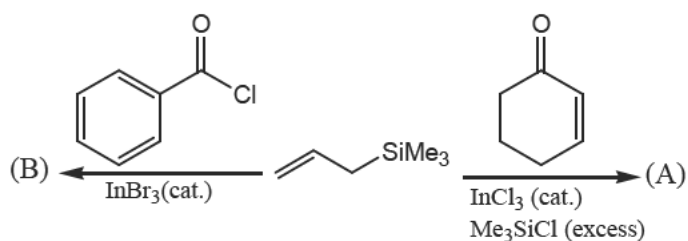
85. Correct sequence of reagents to be used for the following conversion is



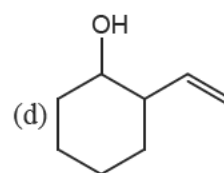
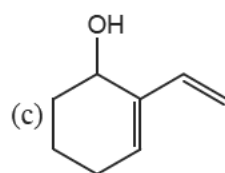
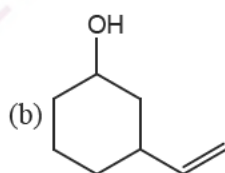
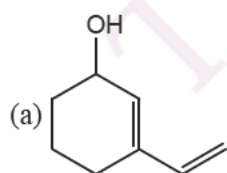
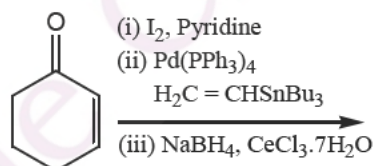
- (a) (I) NaH, 1-fluoronaphthalene; (II) NaBH<sub>4</sub>; (III) (i) (CH<sub>2</sub>O)<sub>n</sub>, Me<sub>2</sub>NH.HCl; (ii) 5 N NaOH  
 (b) (I) NaBH<sub>4</sub>; (II) NaH, 1-fluoronaphthalene; (III) (i) (CH<sub>2</sub>O)<sub>n</sub>, Me<sub>2</sub>NH.HCl (ii) 5 N NaOH

- (c) (I) (i)  $(\text{CH}_2\text{O})_n$ ,  $\text{Me}_2\text{NH}\cdot\text{HCl}$ ; (ii) 5N NaOH; (II)  $\text{NaBH}_4$ ; (III) NaH, 1-fluoronaphthalene  
 (d) (I) (i)  $(\text{CH}_2\text{O})_n$ ,  $\text{Me}_2\text{NH}\cdot\text{HCl}$ ; (ii) 5 N NaOH; (II) NaH, 1-fluoronaphthalene; (III)  $\text{NaBH}_4$ .

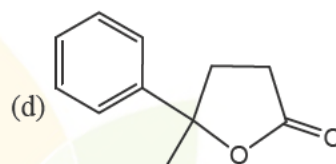
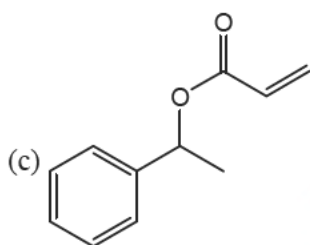
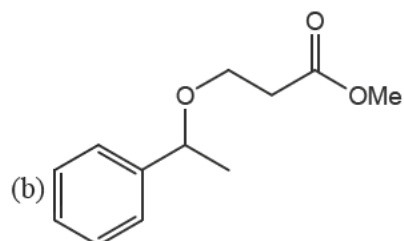
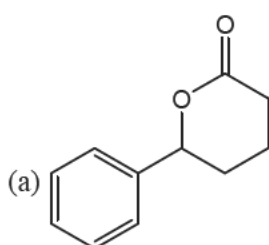
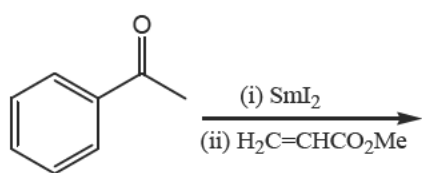
86. The major products (A) and (B) formed in the following reactions are



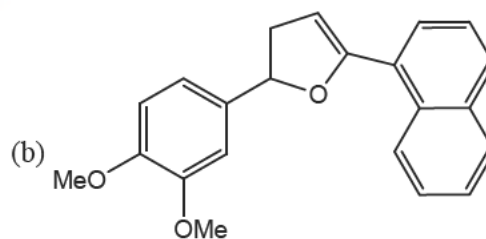
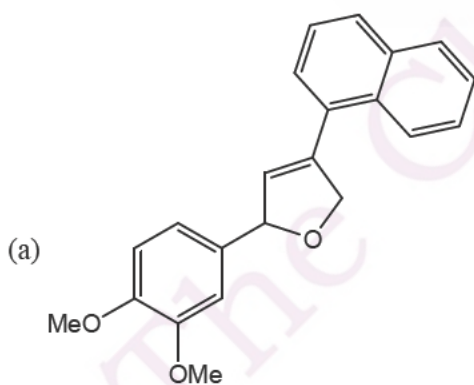
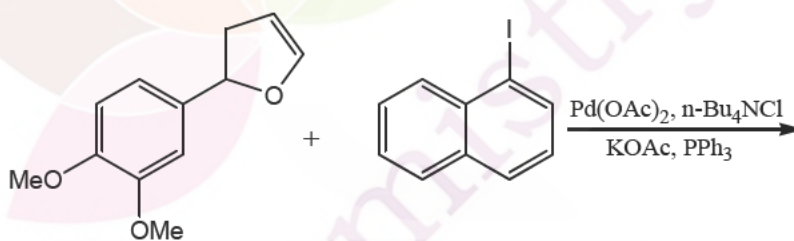
87. The major product formed in the following reaction is



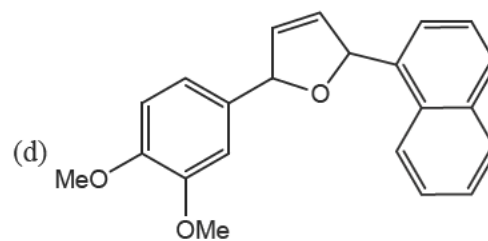
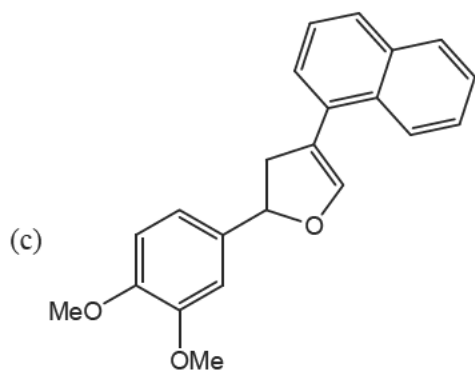
88. The major product formed in the following reaction is



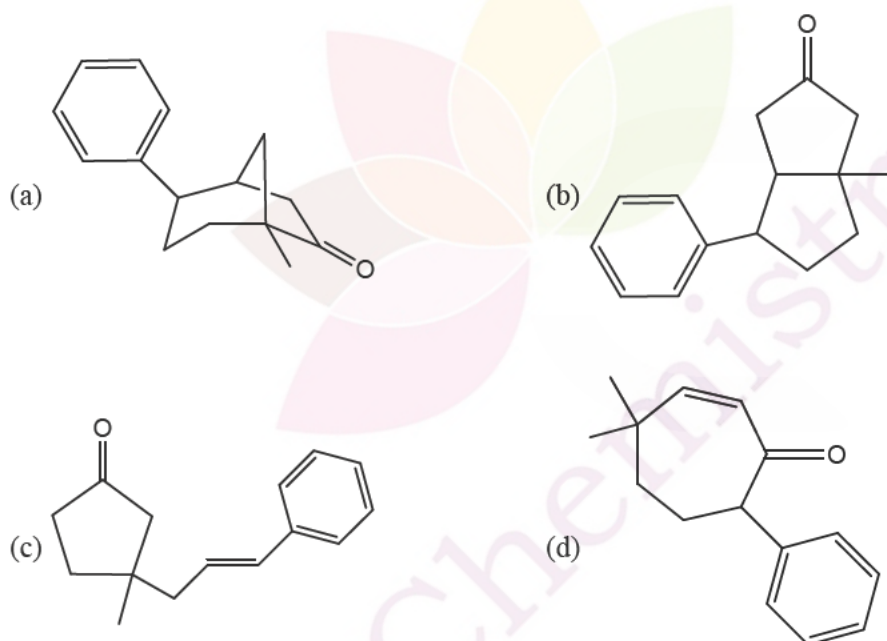
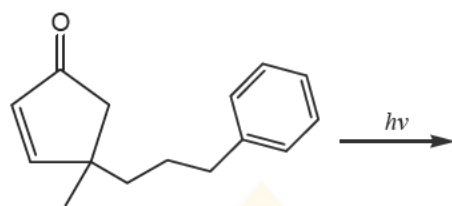
89. The major product formed in the following reaction is



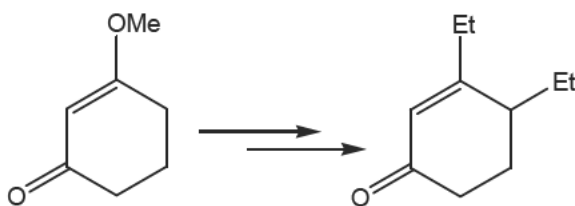




90. The major product formed in the following photochemical reaction is



91. Correct sequence of reagents to be used for the following conversion is

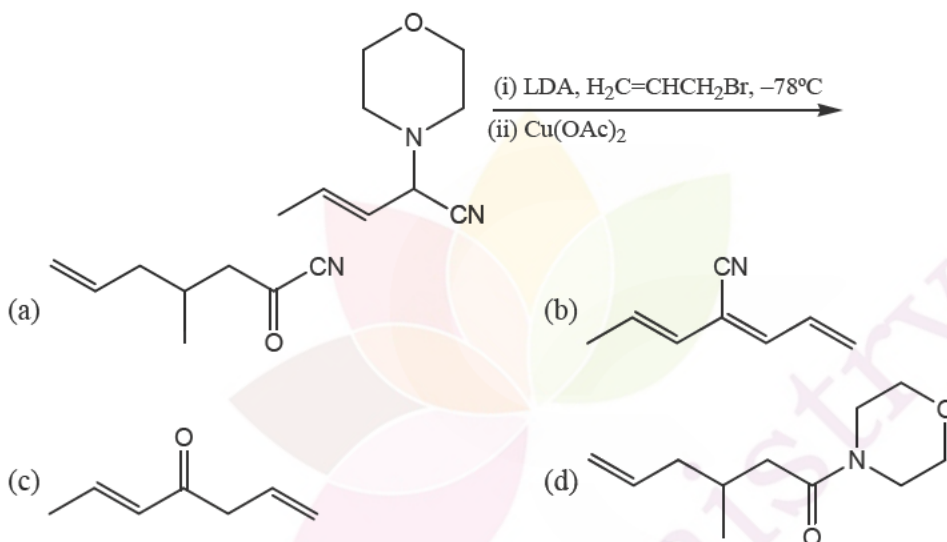


- (a) (I) LDA, EtBr; (II) EtLi; (III)  $\text{H}_3\text{O}^+$       (b) (I) EtLi; (II) LDA, EtBr; (III)  $\text{H}_3\text{O}^+$   
 (c) (I)  $\text{H}_3\text{O}^+$ ; (II) EtLi; (III) LDA, EtBr      (d) (I) EtLi; (II)  $\text{H}_3\text{O}^+$ ; (III) LDA, EtBr

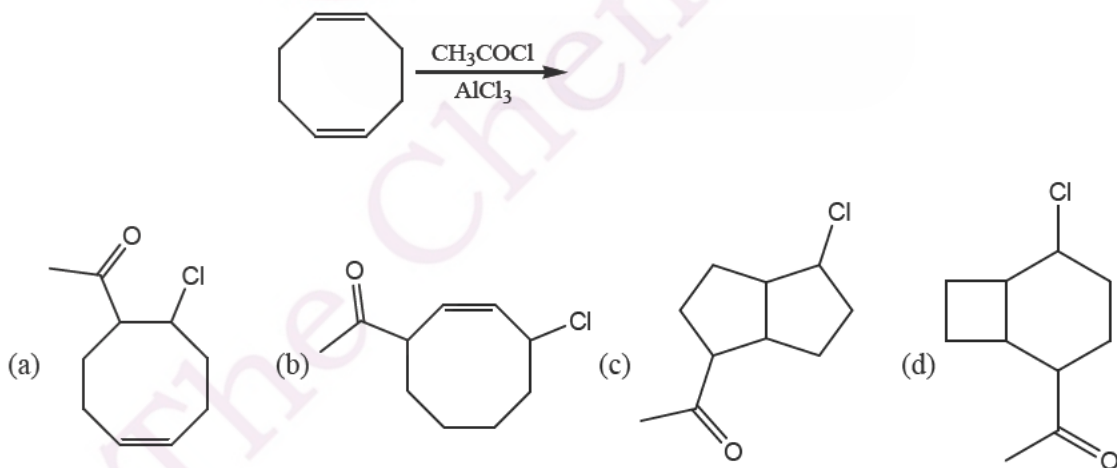
92. Both, 1-chloro-1-phenylpropan-2-one and 1-chloro-3-phenylpropan-2-one give same product (A) when heated in presence of NaOMe. The product (A) is

- (a) methyl 3-phenylpropanoate      (b) methyl 2-phenylpropanoate  
 (c) methyl 2-methoxy-2-phenylacetate      (d) 1-methoxy-3-phenylpropan-2-one

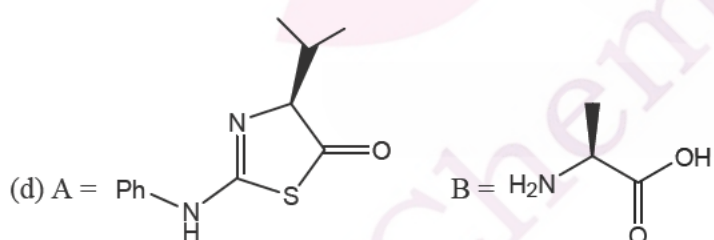
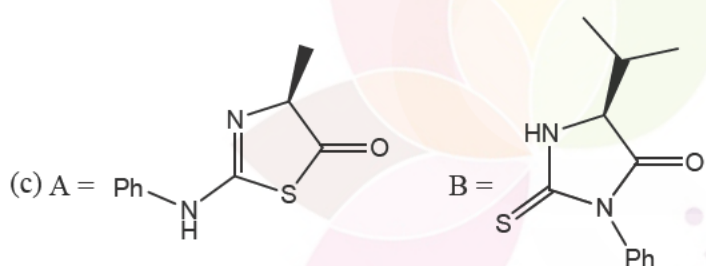
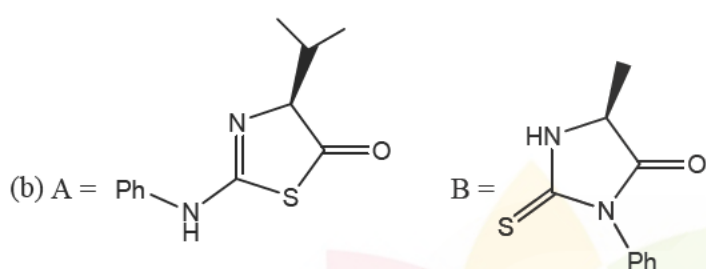
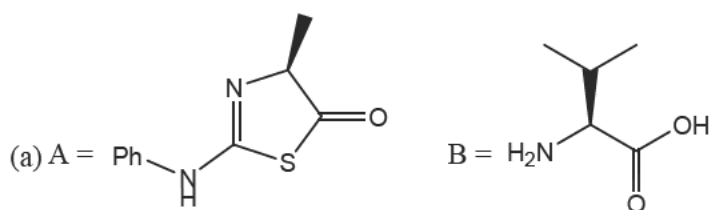
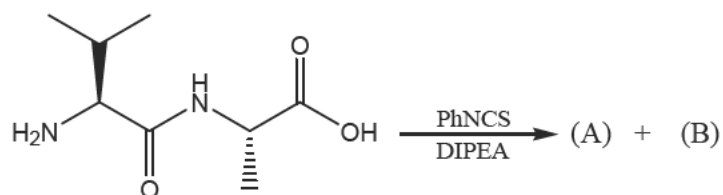
93. The major product formed in the following reaction sequence is



94. The major product formed in the following reaction is



95. The structures of products (A) and (B) formed in the Edman degradation of the dipeptide are



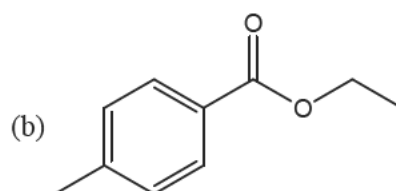
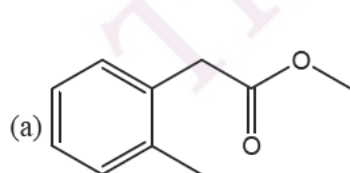
96. Partial spectroscopic data is given below for an organic compound

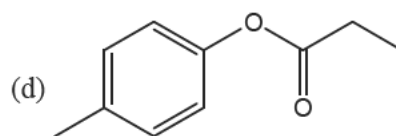
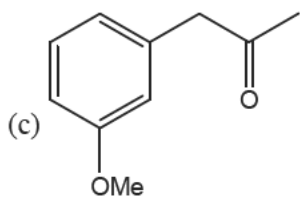
(I) 4 signals between  $\delta$  120-150 ppm in  $^{13}\text{C}$  NMR spectrum

(II) 2 doublets between  $\delta$  6.8-8.5 ppm in  $^1\text{H}$  NMR spectrum

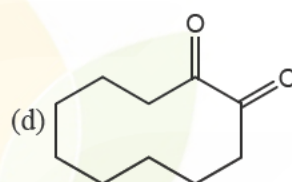
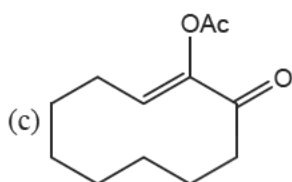
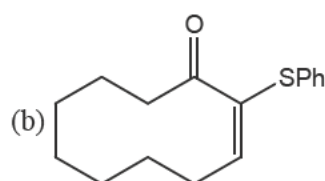
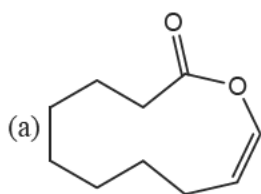
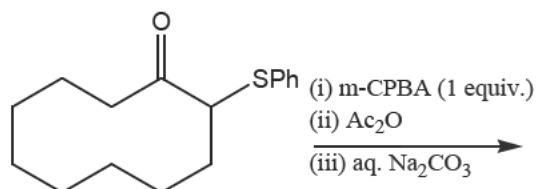
(III) an absorption band at  $1724\text{ cm}^{-1}$  in IR spectrum

The structure of the compound is

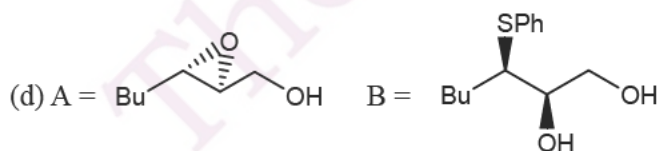
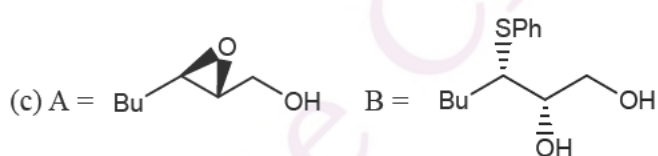
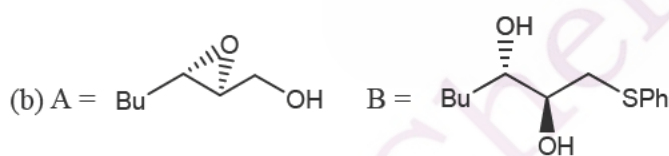
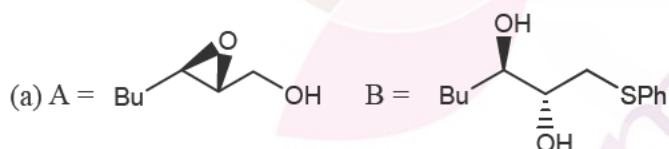
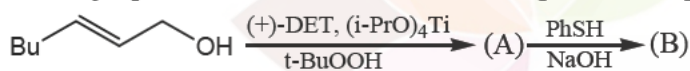




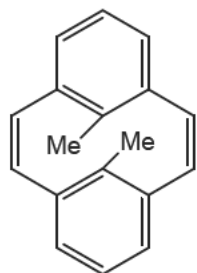
97. The major product formed in the following reaction is



98. The major products (A) and (B) in the following reaction sequence are

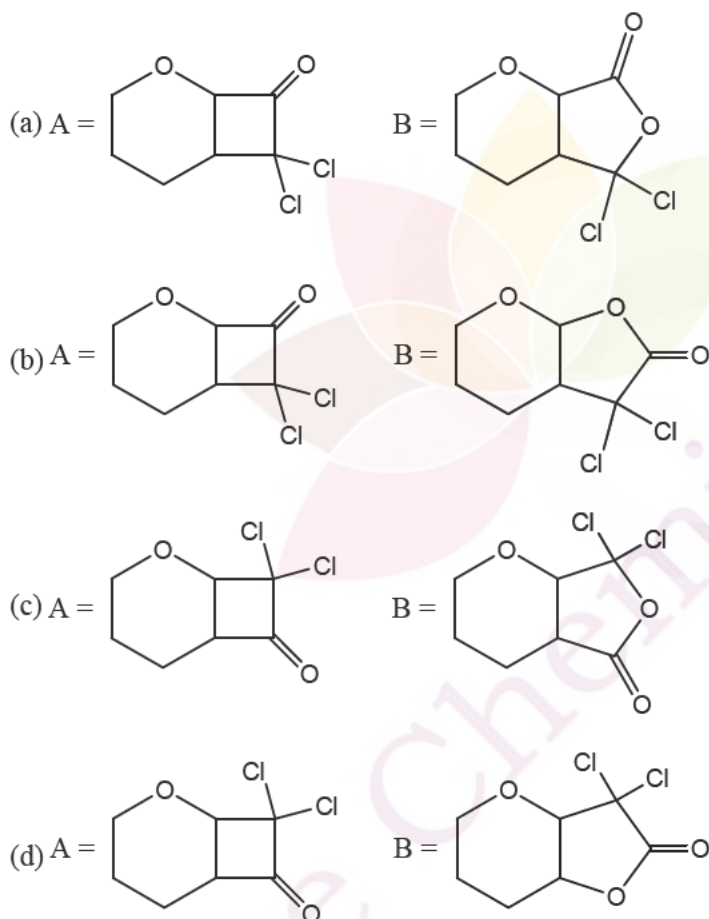
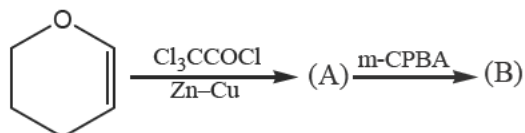


99. The compound P undergoes a pericyclic reaction under photochemical conditions to give compound Q. In compound Q, the relative stereochemistry and <sup>1</sup>H NMR chemical shift values of methyl groups (in δ ppm), respectively, are



- (a) *cis*; -5      (b) *trans*; 17      (c) *cis*; 17      (d) *trans*; -5

100. The major products A and B in the following reaction sequence are



101. Arrange the following molecules in order of increasing fundamental vibrational frequencies

- (a)  $O_2^{2-} < O_2^- < O_2 < O_2^+$       (b)  $O_2 < O_2^+ < O_2^- < O_2^{2-}$   
 (c)  $O_2^{2-} < O_2^- < O_2^+ < O_2$       (d)  $O_2^+ < O_2 < O_2^- < O_2^{2+}$

102. One of the Huckel molecular orbitals of 1, 3-butadiene is

$$\varphi = 0.60\chi_1 + 0.37\chi_2 - 0.37\chi_3 - 0.60\chi_4$$

The energy of this orbital in terms of the coulomb ( $\alpha$ ) and resonance ( $\beta$ ) integrals is

- (a)  $\alpha + 1.62\beta$       (b)  $\alpha + 0.62\beta$       (c)  $\alpha - 0.62\beta$       (d)  $\alpha - 1.62\beta$

103. A molecule  $AB_2$  shows the following IR and Raman spectra

$\bar{\nu}(\text{cm}^{-1})$	IR	Raman
2215	vs, PR	s, depol.
1250	vs, PR	vs, pol.
560	s, PQR	–

The structure of the molecule is

- (a) Linear symmetrical ( $D_{\infty h}$ )      (b) Bent symmetrical ( $C_{2v}$ )  
 (c) Linear asymmetrical ( $C_{\infty v}$ )      (d) Bent asymmetrical ( $C_s$ )

104. For a one-dimensional ( $x$ ) harmonic oscillator perturbed by an  $x^3$  potential, the sum of the first order and second order corrections to the ground state energy is

- (a)  $< 0$       (b) 0      (c)  $> 0$       (d)  $\geq 0$

105. Difference of average values of position  $\langle x \rangle$  for states  $n = 1$  and  $n = 2$  of a particle confined in a one-dimensional ( $x$ ) box of length  $L$  is

- (a)  $L/4$       (b)  $L/2$       (c)  $L/3$       (d) 0

106. The hermitian operator among the following is

- (a)  $i\hbar \frac{d^2}{dx^2}$       (b)  $-i\hbar \frac{d}{dx}$       (c)  $i\hbar x$       (d)  $i\hbar$

107. The translational partition function for Ar confined to a volume of 1 L at 300K, having thermal wavelength of  $1.60 \times 10^{-11}$  m, is closest to

- (a)  $24.4 \times 10^{29}$       (b)  $2.44 \times 10^{29}$       (c)  $0.244 \times 10^{29}$       (d)  $244 \times 10^{29}$

108. Consider a phase transition between two incompressible phases. The correct statement among the following is

- (a) The transition is independent of pressure  
 (b) The transition is independent of temperature  
 (c) The entropy of such transition is always zero  
 (d) The enthalpy of such transition is always non-zero

109. The third and fourth lines in the rotational Raman spectrum of CO are separated by  $8 \text{ cm}^{-1}$ . The CO bond length is given by

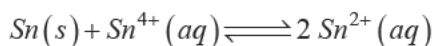
- (a)  $\sqrt{\frac{h}{16\pi^2 \mu c}}$       (b)  $\sqrt{\frac{3h}{32\pi^2 \mu c}}$       (c)  $\sqrt{\frac{h}{32\pi^2 \mu c}}$       (d)  $\sqrt{\frac{5h}{32\pi^2 \mu c}}$

110. Conductivities of water and a saturated solution of a sparingly soluble salt  $AB_2$  are 7 and  $21 \mu\text{S m}^{-1}$ , respectively.

Given,  $\lambda_{A^{2+}}^0 = 12.72 \text{ mS m}^2 \text{ mol}^{-1}$  and  $\lambda_{B^-}^0 = 7.64 \text{ mS m}^2 \text{ mol}^{-1}$ , the solubility of  $AB_2$ , in  $\text{mol m}^{-3}$ , is

- (a)  $5.0 \times 10^{-4}$       (b)  $5.0 \times 10^{-3}$       (c)  $5.0 \times 10^{-5}$       (d)  $5.0 \times 10^{-6}$

111. The equilibrium constant of the following reaction:



at 300K is close to

$$\left( \begin{array}{l} \text{Given : } E_{\text{Sn}^{4+}/\text{Sn}^{2+}}^0 = +0.15\text{V} \text{ and } E_{\text{Sn}^{2+}/\text{Sn}}^0 = -0.15\text{V}, R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}; \\ F = 96485 \text{ Cmol}^{-1} \end{array} \right)$$

- (a)  $10^{6.08}$                       (b)  $10^{8.08}$                       (c)  $10^{10.08}$                       (d)  $10^{12.08}$

112. Langmuir adsorption isotherm for the dissociative adsorption of  $\text{D}_2$  ( $p$  = partial pressure of  $\text{D}_2$  and  $k$  = ratio of rate constants for adsorption and desorption) is

(a)  $\theta = \frac{kp}{1+kp}$                       (b)  $\theta = \frac{k}{1+kp}$                       (c)  $\theta = \frac{(kp)^{1/2}}{1+(kp)^{1/2}}$                       (d)  $\theta = \left( \frac{p}{1+kp} \right)^{1/2}$

113. Entropy of a perfect gas is

- (a) independent of  $V$     (b) proportional to  $V$   
(c) proportional to  $\ln V$     (d) proportional to  $V^2$

114. The contour and root mean square length (in nm) of a polymer chain modelled as a random coil, with  $N = 1000$  and  $l = 150$  pm, are closest to

- (a) 1.50 and 47.4    (b) 15.0 and 4.74  
(c) 150 and 47.4    (d) 150 and 4.74

115. The free energy  $[A - A(0)]$  of a system with 10 non-interacting spins ( $S = 1$ ) is

- (a)  $-k_B T \ln(3)$                       (b)  $-10k_B T \ln(3)$                       (c)  $-k_B T \ln(0.3)$                       (d)  $-10k_B T \ln(0.3)$

**Table-1:**

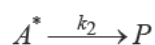
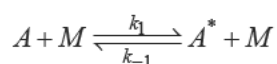
$D_{2h}$	$E$	$C_2(z)$	$C_2(y)$	$C_2(x)$	$i$	$\sigma(xy)$	$\sigma(xz)$	$\sigma(yz)$	
$A_g$	1	1	1	1	1	1	1	1	$x^2, y^2, z^2$
$B_{1g}$	1	1	-1	-1	1	1	-1	-1	$R_z, xy$
$B_{2g}$	1	-1	1	-1	1	-1	1	-1	$R_y, xz$
$B_{3g}$	1	-1	-1	1	1	-1	-1	1	$R_x, yz$
$A_u$	1	1	1	1	-1	-1	-1	-1	
$B_{1u}$	1	1	-1	-1	-1	-1	1	1	$x$
$B_{2u}$	1	-1	1	-1	-1	1	-1	1	$y$
$B_{3u}$	1	-1	-1	1	-1	1	1	-1	$z$

116. The  $\pi_u$ -orbital of ethylene, when placed in the  $xy$ -plane with the  $\text{C}=\text{C}$  bond aligned to the  $x$ -axis, transforms according to the irreducible representation (Use Table-1)

- (a)  $a_u$                       (b)  $b_{1u}$                       (c)  $b_{2u}$                       (d)  $b_{3u}$

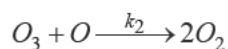
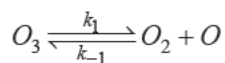
117. The  $b_{1u} \rightarrow b_{2g}$  transition in ethylene is  
 (a) not allowed (b) allowed by  $x$ -polarized light  
 (c) allowed by  $y$ -polarized light (d) allowed by  $z$ -polarized light  
 (Use Table-1)
118. A metal crystallizes with cubic close-packed structure. The  $\sin^2 \theta$  values of Bragg reflections of Miller Planes (200) and (111) are 0.18 and 0.14, respectively. The unit cell length is  
 (a)  $\frac{\lambda}{2}$  (b)  $\frac{\lambda}{0.2}$  (c)  $\frac{\lambda}{0.4}$  (d)  $0.4\lambda$

119.  $k_{uni}$  is the effective first-order rate constant of the following unimolecular reaction



The slope and intercept of the plot of  $1/k_{uni}$  vs.  $1/[M]$  are  $4 \times 10^6$  and  $8 \times 10^{11}$ , respectively. The value of  $k_{-1}/k_2$  is

- (a)  $2 \times 10^5$  (b)  $0.5 \times 10^5$  (c)  $32 \times 10^5$  (d)  $2 \times 10^{-5}$
120. The decomposition mechanism of ozone is



If  $k_{-1}[O_2] \ll k_2[O_3]$ , then the order of the reaction with respect to ozone is

- (a) zero (b) one (c) two (d) complex