

## IIT JAM 2014

- For square matrices  $M$  and  $N$ , if  $MN = M$  and  $NM = N$ , then:
 

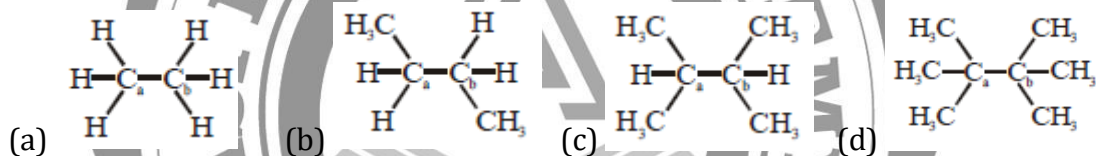
(a) $M^2 = M$ and $N^2 = N$	(b) $N^2 \neq N$ and $M^2 = M$
(c) $M^2 \neq M$ and $N^2 \neq N$	(d) $M^2 \neq M$ and $N^2 = N$
- The energy of an electron in a hydrogenic atom with nuclear charge  $Z$  varies as:
 

(a) $Z$	(b) $Z^2$	(c) $1/Z$	(d) $1/Z^2$
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- The carbonyl stretching frequency ( $\nu_{C=O}$ ) is highest for:



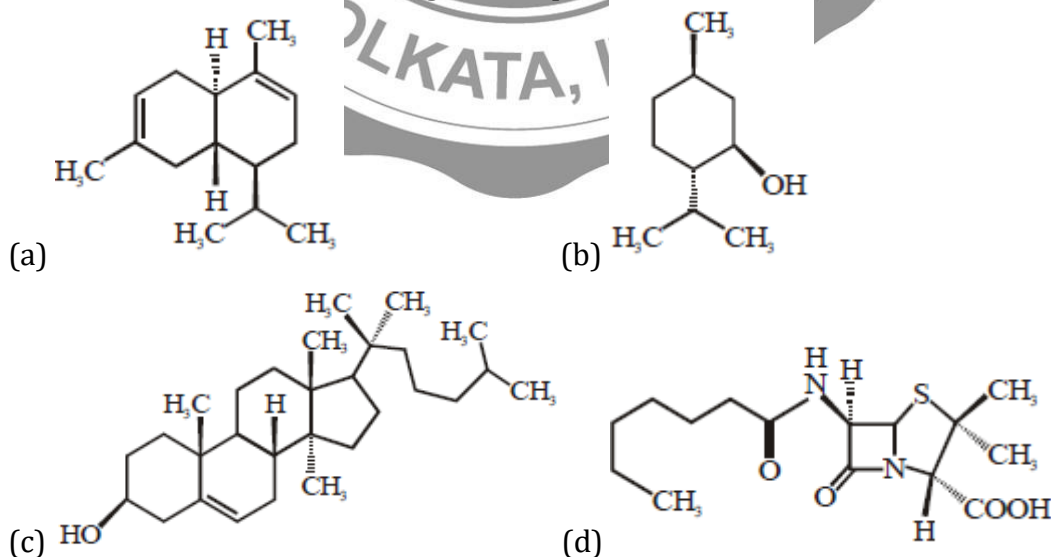
- The homolytic breaking of the  $C_a - C_b$  bond is easiest in:



- Tollen's test will be negative for:

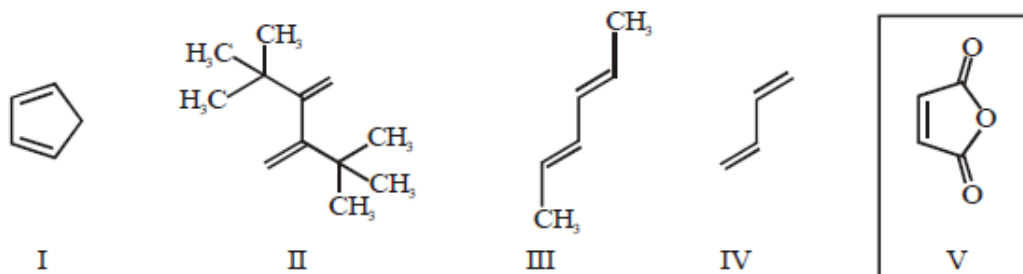


- Which one among the following is a sesquiterpene?

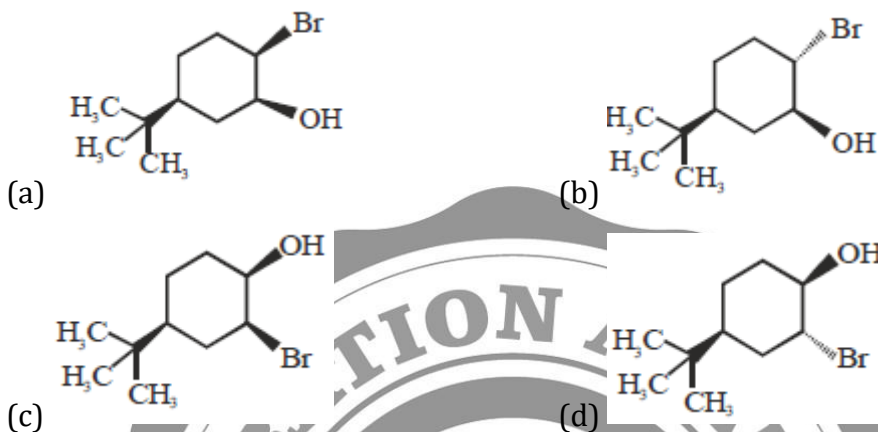
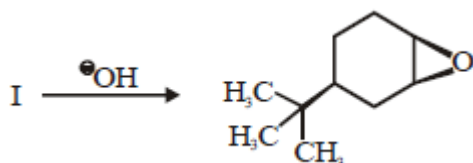




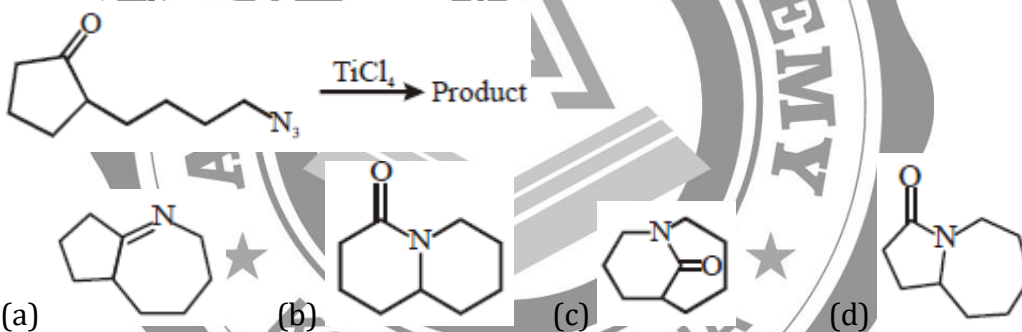
7. The predicted geometry of  $\text{TeF}_4$  by VSEPR theory is:  
(a) Octahedral (b) Square planer  
(c) Tetrahedral (d) trigonal bipyramidal
8. Among the following, the isoelectronic pair is:  
(a)  $\text{NO}$  and  $\text{CO}$  (b)  $\text{O}_2^-$  (superoxide anion) and  $\text{NO}^-$   
(c)  $\text{NO}^+$  and  $\text{CO}$  (d)  $\text{O}_2^-$  (superoxide anion) and  $\text{NO}^+$
9. The metal ion of an enzyme involved in hydration of  $\text{CO}_2$  is:  
(a)  $\text{Cu(II)}$  (b)  $\text{Fe(II)}$  (c)  $\text{Mg(II)}$  (d)  $\text{Zn(II)}$
10. Among the following the element having maximum inert pair effect is:  
[Given: Atomic number of  $\text{Ge} = 30$ ,  $\text{Pb} = 82$ ,  $\text{Si} = 14$  and  $\text{Sn} = 50$ ]  
(a)  $\text{Ge}$  (b)  $\text{Pb}$  (c)  $\text{Si}$  (d)  $\text{Sn}$
11. The reactivity of compounds I-IV with maleic anhydride (V) follows the order:



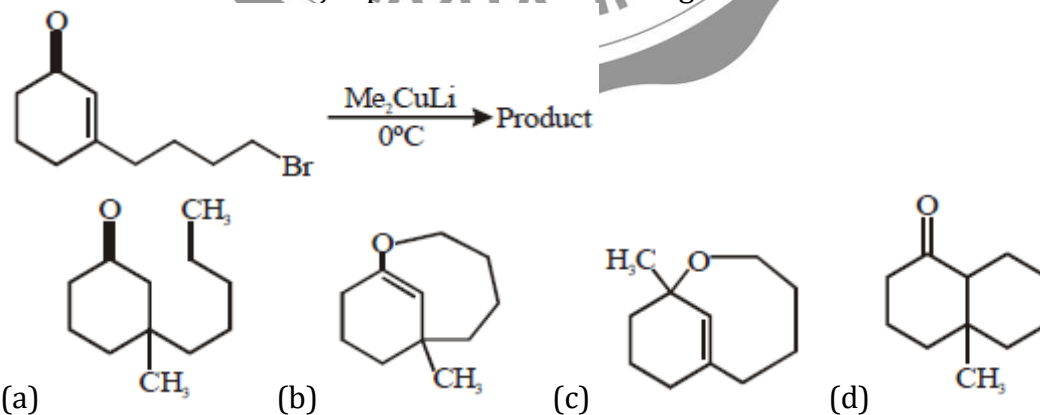
- (a)  $\text{I} < \text{II} < \text{III} < \text{IV}$  (b)  $\text{II} < \text{IV} < \text{III} < \text{I}$  (c)  $\text{II} < \text{I} < \text{III} < \text{IV}$  (d)  $\text{II} < \text{I} < \text{IV} < \text{III}$
12. Which one among the following molecules is chiral?
- (a)
- (b)
- (c)
- (d)
13. Identify the starting material I in the given reaction.



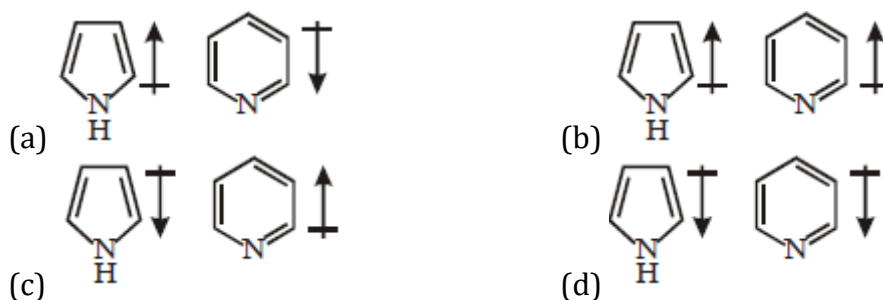
14. The major product for the following reaction is:



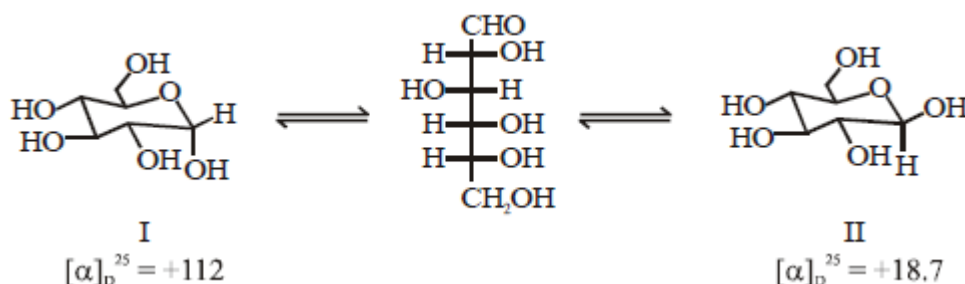
15. The structure of the major product in the following reaction is :



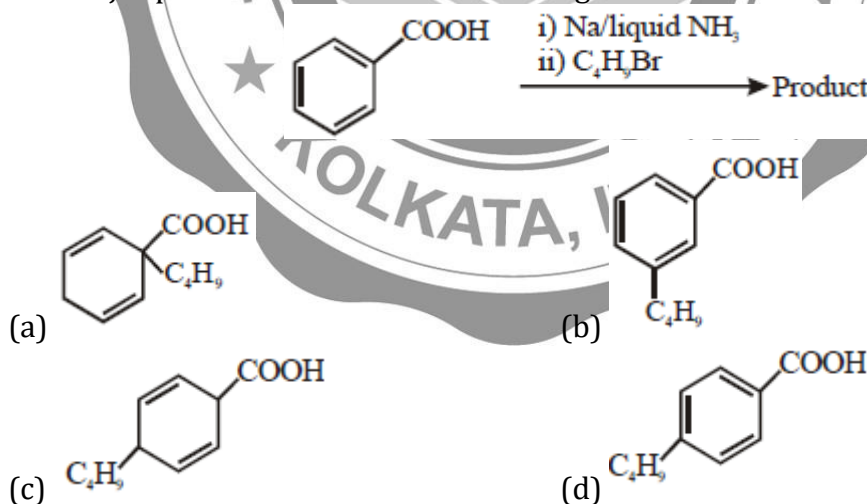
16. The correct orientation of dipoles in pyrrole and pyridine is :



17. Specific rotations of freshly prepared aqueous solutions of I and II are +112 and +18.7, respectively. On standing the optical rotation of aqueous solution of I slowly decreases to give a final value of +52.7 due to equilibrium with II. Under this state of equilibrium, what is the ratio II : I?



- (a) 0.57      (b) 1.00      (c) 1.75      (d) 5.9
18. The major product formed in the following reaction is:

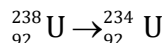


19. In boron neutron capture therapy, the initial boron isotope used and the particle generated after neutron capture respectively are:
- (a)  $^{11}\text{B}$  and  $\alpha$  particle      (c)  $^{10}\text{B}$  and  $\alpha$  particle  
(b)  $^{11}\text{B}$  and  $\beta$  particle      (d)  $^{10}\text{B}$  and  $\beta$  particle





20. The number of  $\alpha$  and  $\beta$  particle(s), generated in the following radioactive decay process, are:



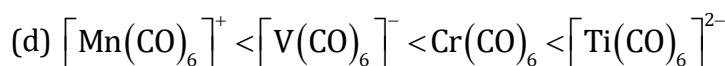
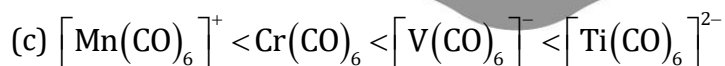
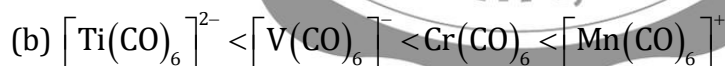
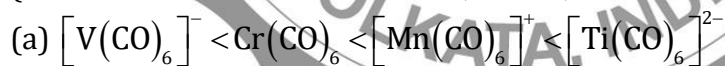
- (a) One  $\alpha$  and two  $\beta$  particles  
(b) two  $\alpha$  and one  $\beta$  particles  
(c) One  $\alpha$  and four  $\beta$  particles  
(d) no  $\alpha$  and four  $\beta$  particles
21. In the measurement of hardness of water by complexometric titration, identify P and Q in the following equation.



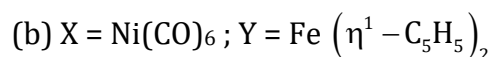
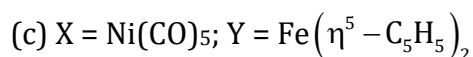
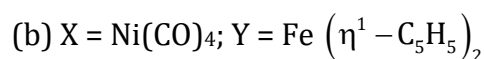
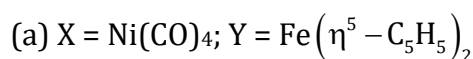
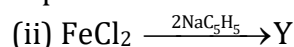
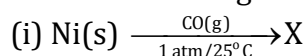
- (a) P = MgY, Q = MgIn  
(b) P = MgY<sub>2</sub>, Q = MgIn<sub>2</sub>  
(c) P = MgIn<sub>2</sub>, Q = MgY<sub>2</sub>  
(d) P = MgIn, Q = MgY
22. An aqueous solution of haemoglobin has a molar absorptivity value of 18,60 mol<sup>-1</sup> cm<sup>-1</sup> for an absorbance value of 0.1 at 540 nm (Given: cell thickness = 1 cm). The concentration (in  $\mu\text{M}$ ) of the haemoglobin solution is:

- (a) 0.537  
(b) 5.37  
(c) 53.7  
(d) 537.0
23. The electronic transitions responsible for the colour of K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and porphine in their solid state respectively are:

- (a) d → d;  $\pi \rightarrow \pi^*$   
(b) M → L charge transfer;  $\pi \rightarrow \pi^*$   
(c) L → M charge transfer;  $\pi \rightarrow \pi^*$   
(d) L → M charge transfer; d → d
24. The correct order of M–C (M = Ti, V, Cr and Mn) bond stretching frequency is: (Given: Atomic number of Ti = 22, V = 23, Cr = 24 and Mn = 25)



25. For the following reactions, the metal complexes X and Y are:





26. The correct order of crystal field strength is : (given: en = ethylenediamine)  
(a)  $\text{Cl}^- < \text{H}_2\text{O} < \text{en} < (\eta^5 - \text{C}_5\text{H}_5)^-$  (b)  $\text{H}_2\text{O} < \text{Cl}^- < (\eta^5 - \text{C}_5\text{H}_5)^- < \text{en}$   
(c)  $\text{H}_2\text{O} < (\eta^5 - \text{C}_5\text{H}_5)^- < \text{en} < \text{Cl}^-$  (d)  $\text{en} < \text{Cl}^- < \text{H}_2\text{O} < (\eta^5 - \text{C}_5\text{H}_5)^-$
27. The carbon-oxygen bond in an organic compound absorbs electromagnetic radiation of frequency  $6 \times 10^{13}$  Hz. This frequency corresponds to the region:  
(a) Infrared (b) Microwave (c) Ultraviolet (d) Visible
28. According to the equipartition principal energy, the molar heat capacity at constant volume for  $\text{CO}_2(\text{g})$ ,  $\text{SO}_2(\text{g})$  and  $\text{H}_2\text{O}(\text{g})$  follows the trend:  
(a)  $\text{CO}_2 = \text{SO}_2 = \text{H}_2\text{O}$  (b)  $\text{CO}_2 > \text{SO}_2 = \text{H}_2\text{O}$   
(c)  $\text{H}_2\text{O} > \text{SO}_2 = \text{CO}_2$  (d)  $\text{CO}_2 = \text{SO}_2 > \text{H}_2\text{O}$
29.  $\left[ \frac{-h^2}{(8\pi^2m)} \frac{d^2}{dx^2} + \frac{h^2\alpha^2x^2}{(2\pi^2m)} \right] \exp(-\alpha x^2) = C \frac{h^2}{(4\pi^2)} \exp(-\alpha x^2)$ , where  $h$ ,  $\pi$ ,  $m$  and  $\alpha$  are constants. Then  $C$  is:  
(a)  $2\alpha/m$  (b)  $\alpha/2m$  (c)  $\alpha/m$  (d)  $\alpha^2/m$
30. Among Ar,  $\text{NH}_4\text{Cl}$ , HF and HCl, the strength of interatomic /intermolecular forces follows the order:  
(a)  $\text{NH}_4\text{Cl} > \text{HF} > \text{HCl} > \text{Ar}$  (b)  $\text{HF} > \text{HCl} > \text{Ar} > \text{NH}_4\text{Cl}$   
(c)  $\text{HCl} > \text{Ar} > \text{NH}_4\text{Cl} > \text{HF}$  (d)  $\text{Ar} > \text{NH}_4\text{Cl} > \text{HF} > \text{HCl}$
31. The number of degrees of freedom in the homogeneous liquid region of two component system with a eutectic point, at one atmosphere pressure, is :  
(a) 0 (b) 1 (c) 2 (d) 3
32. The ionic strength of 0.1 M aqueous solution of  $\text{Fe}_2(\text{SO}_4)_3$  is:  
(a) 0.1 M (b) 0.65 M (c) 1.3 M (d) 1.5 M
33. If the transport number of  $\text{Na}^+$  is 0.463 (dilute solution of NaCl in methanol), the transport number of  $\text{H}^+$  (dilute solution of HCl in methanol) is :  
(Given,  $\Lambda^\infty(\text{NaCl in methanol}) = 96.9 \text{ ohm}^{-1}\text{cm}^2\text{mol}^{-1}$  and  $\Lambda^\infty(\text{HCl in methanol}) = 192 \text{ ohm}^{-1}\text{cm}^2\text{mol}^{-1}$ )

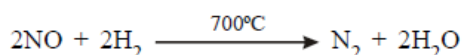


- (a) 0.27                      (b) 0.46                      (c) 0.54                      (d) 0.73
34. Charcoal (1 gram) of surface area  $100 \text{ m}^2$  per gram, absorbs 60mg of acetic acid from an aqueous solution at  $25^\circ\text{C}$  and 1 atmosphere pressure. The number of moles of acetic acid adsorbed per  $\text{cm}^2$  of charcoal surface is :  
(a)  $10^{-2}$                       (b)  $10^{-6}$                       (c)  $10^{-5}$                       (d)  $10^{-9}$
35. The change in entropy for the following transformations is respectively: (+ indicates increase, - indicates decrease and 0 indicates no change)  
(i)  $\text{SO}_2\text{Cl}_2(\text{g}) \xrightarrow{\Delta} \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$   
(ii)  $n\text{CH}_2 = \text{CH}_2(\text{g}) \xrightarrow{\text{Catalyst}} [-\text{CH}_2 - \text{CH}_2 -]_n(\text{s})$   
(iii)  $\text{I}_2(\text{s}) \xrightarrow[1 \text{ atmosphere}]{\Delta} \text{I}_2(\text{v})$   
(iv) Adiabatic reversible expansion of an ideal gas.  
(a) +, -, 0, +                      (b) +, -, 0, 0                      (c) -, +, +, 0                      (d) +, -, +, 0

## PART-II: Descriptive Questions

**Q.36 – Q.43 carry five marks each.**

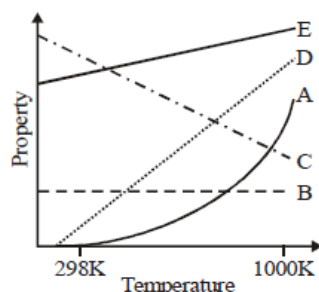
36. Using crystal field theory (CFT), for the  $[\text{Co}(\text{NH}_3)_6]^{3+}$  ion  
(a) draw the d-orbital splitting including their orbital labels (designations) and show their electron occupancy.  
(b) calculate the crystal field stabilization energy (ignore pairing energy) and spin-only magnetic moment values. (Given : atomic number of Co = 27).
37. (a) Write the correct order of lattice energy for LiX, X = F, Cl, Br and I.  
(b) A first order reflection from (111) plane is observed for LiX with  $2\theta = 24.6^\circ$  (X-ray of wavelength  $1.54\text{\AA}$ ). Assuming LiX to be a cubic crystal system, calculate the length of the side of the unit cell in  $\text{\AA}$ .
38. For the reaction:



- (i) Write the expression for the rate of the reaction in terms of the change in concentrations of NO and  $\text{H}_2\text{O}$ .  
(ii) Given the following data for the above reaction, find the order of the reaction with respect to (a) NO and (b)  $\text{H}_2$  and the rate constant of the reaction along with the proper unit.

	$[\text{NO}]_{t=0} (\text{mol dm}^{-3})$	$[\text{H}_2]_{t=0} (\text{mol dm}^{-3})$	Initial rate ( $\text{mol dm}^{-3} \text{s}^{-1}$ )
Experiment 1	0.025	0.01	$2.4 \times 10^{-6}$
Experiment 2	0.025	0.005	$1.2 \times 10^{-6}$
Experiment 3	0.0125	0.01	$0.6 \times 10^{-6}$

39. The vapour pressure of benzene is 5333 Pa at 7.6°C and 53330 Pa at 60.6°C. Calculate the heat of vapourization of benzene and the normal boiling point of benzene.
40. The following graph represents the dependence of certain properties I to V (given below) as a function of temperature.



Property

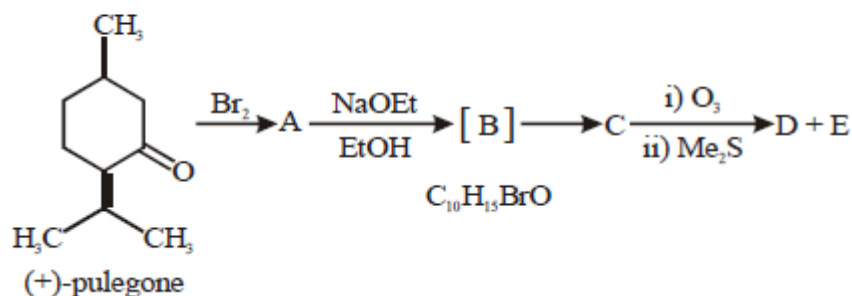
- I The enthalpy change of a gas phase reaction in which the sum of the number of moles of products is greater than the sum of the number of moles of reactants
- II The osmotic pressure of an ideal solution at a given concentration
- III The standard Gibbs free energy of formation of metal oxides
- IV The molar heat capacity at constant volume for an ideal gas, as predicted by the equipartition of energy
- V The rate constant of a reaction with  $E_a = 100 \text{ kJ mol}^{-1}$

The lines / curves A, B, C, D and E corresponding to the appropriate property are:

Answer:

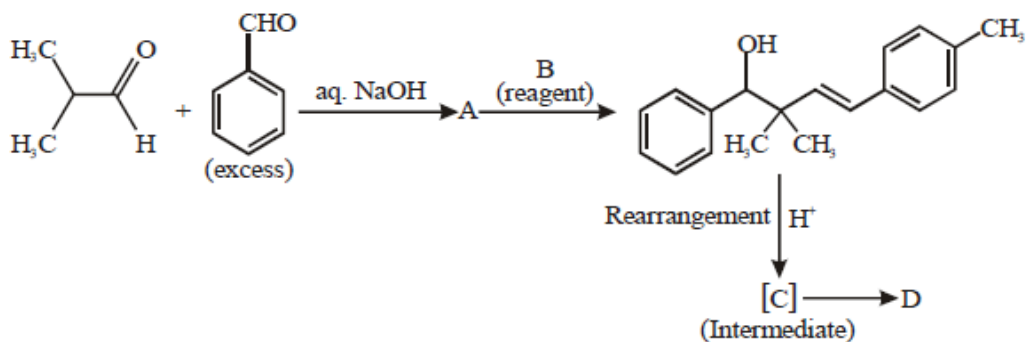
Property	Line/Curve
I	
II	
III	
IV	
V	

41. Draw the structures A-E for the given transformation:





42. In the reaction sequence given below, draw the structures of A, C, D and reagent B.



43. (a) How many  $^1\text{H}$  NMR signals are expected for 2-chlorobut-2-ene? (ignore spin-spin coupling)  
 (b) Write down the iron containing chemical species, E, F and G in the following reactions.

