A

2010 – CY

Test Paper Code : CY

Time : 3 Hours **Max. Marks : 300**

INSTRUCTIONS

1. The question-cum-answer booklet has **40** pages and has **44** questions. Please ensure that the copy of the question-cum-answer booklet you have received contains all the questions.
2. Write your **Registration Number, Name and the name of the Test Centre** in the appropriate space provided on the right side.
3. Write the answers to the objective questions against each Question No. in the **Answer Table for Objective Questions,** provided on Page No. **9**. Do not write anything else on this page.
4. Each objective question has **4 choices** for its answer : (A), (B), (C) and (D). Only **ONE** of them is the correct answer. There will be **negative marking** for wrong answers to objective questions. The following marking scheme for objective questions shall be used :
   (a) For each correct answer, you will be awarded **3 (Three)** marks.
   (b) For each wrong answer, you will be awarded **–1 (Negative one)** mark
   (c) Multiple answers to a question will be treated as a wrong answer
   (d) For each un-attempted question, you will be awarded **0 (Zero)** mark.
   (e) Negative marks for objective part will be carried over to total marks.
5. Answer the subjective question only in the space provided after each question.
6. Do not write more than one answer for the same question. In case you attempt a subjective question more than once, please cancel the answer(s) you consider wrong. Otherwise, the answer appearing last only will be evaluated.
7. All answers must be written in blue/black/ blue-black ink only. Sketch pen, pencil or ink of any other colour should not be used.
8. All rough work should be done in the space provided and scored out finally.
9. No supplementary sheets will be provided to the candidates.
10. **Clip board, log tables, slide rule, calculator, cellular phone or electronic gadgets in any form are NOT allowed.**
11. The question-cum-answer booklet must be returned in its entirety to the Invigilator before leaving the examination hall. Do not remove any page from this booklet.

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2010 – CY

READ INSTRUCTIONS ON THE LEFT SIDE OF THIS PAGE CAREFULLY

REGISTRATION NUMBER						

Name :

Test Centre :

Do not write your Registration Number or Name anywhere else in this question-cum-answer booklet.

I have read all the instructions and shall abide by them.

.....

Signature of the Candidate

I have verified the information filled by the Candidate above.

.....

Signature of the Invigilator

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IMPORTANT NOTE FOR CANDIDATES

- **Questions 1-30 (objective questions) carry *three* marks each and questions 31-44 (subjective questions) carry *fifteen* marks each.**
- **Write the answers to the objective questions in the *Answer Table for Objective Questions* provided on page 9 only.**

Q.1 The molar internal energy of a gas at temperature T is $U_m(T)$. The molar internal energy at $T = 0$ is $U_m(0)$. The correct expression that relates these two with appropriate contributions is

(A) $U_m(T) = U_m(0) + 3RT$ [linear molecule; translation only]

(B) $U_m(T) = U_m(0) + \frac{5}{2}RT$ [linear molecule; translation and rotation only]

(C) $U_m(T) = U_m(0) + \frac{3}{2}RT$ [nonlinear molecule; translation and rotation only]

(D) $U_m(T) = U_m(0) + RT$ [nonlinear molecule; translation only]

Q.2 If a particle has linear momentum $\vec{p} = -2\vec{i} + \vec{j} + \vec{k}$ at position $\vec{r} = 3\vec{i} - \vec{j} + \vec{k}$, then its angular momentum is

(A) $\vec{i} + 2\vec{k}$ (B) $-2\vec{i} - 5\vec{j} + \vec{k}$ (C) $5\vec{i} - 2\vec{j}$ (D) $2\vec{i} + 5\vec{j} - \vec{k}$

Q.3 If ψ is the eigenfunction to the Hamiltonian operator with α as the eigenvalue, then α **MUST** be

(A) positive (B) negative (C) an integer (D) real

Q.4 A quantum mechanical particle of mass m free to rotate on the surface of a sphere of radius r is in the state with energy $\frac{10\hbar^2}{mr^2}$. The degeneracy of this state is

(A) 20 (B) 10 (C) 9 (D) 4

Q.5 Choose the **INCORRECT** statement among the following :

(A) When ideal gases are mixed, the entropy of mixing is always positive.

(B) At equilibrium, the chemical potential of a species is the same in all of the phases of the system.

(C) The total pressure of a mixture of ideal gases is equal to the sum of the partial pressure of each gas in the mixture.

(D) When a gas is allowed to expand, the maximum work is obtained when the process is carried out irreversibly.

Q.6 The work done during the free expansion of one mole of an ideal gas at 27°C to twice its original volume is (given: $RT = 2494\ J\ mol^{-1}$, $\ln 2 = 0.7$, $\log 2 = 0.3$)

(A) $1746\ J\ mol^{-1}$ (B) $-1746\ J\ mol^{-1}$ (C) zero (D) $748.2\ J\ mol^{-1}$

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Q.7 Choose the correct order of the diffusion coefficients of the following at 298 K.

P: H^+ in water
Q: OH^- in water
R: H_2O in water
S: Sucrose in water

(A) P > Q > R > S (B) S > R > Q > P (C) S > Q > R > P (D) P > R > Q > S

Q.8 Two matrices are given as $X = \begin{pmatrix} 1 & 5 \\ 3 & 7 \end{pmatrix}$ and $Y = \begin{pmatrix} 2 & 4 \\ 6 & 0 \end{pmatrix}$. If X^T is the transpose of X then what would be X^TY ?

(A) $\begin{pmatrix} 20 & 52 \\ 4 & 20 \end{pmatrix}$ (B) $\begin{pmatrix} 20 & 4 \\ 52 & 20 \end{pmatrix}$ (C) $\begin{pmatrix} 32 & 4 \\ 48 & 12 \end{pmatrix}$ (D) $\begin{pmatrix} 44 & 28 \\ 12 & 12 \end{pmatrix}$

Q.9 Addition of 1.0 g of a compound to 10 g of water increases the boiling point by 0.3°C. The amount of compound needed to prepare a 500 ml of 0.1 M solution is (given: assume negligible dissociation or association of the compound, boiling point constant K_b of water = 0.513 K kg mol^{-1})

(A) 0.855 g (B) 17.1 g (C) 8.55 g (D) 85.5 g

Q.10 The molar conductivity of 0.009 M aqueous solution of a weak acid (HA) is 0.005 S m^2 mol^{-1} and the limiting molar conductivity of HA is 0.05 S m^2 mol^{-1} at 298 K. Assuming activity coefficients to be unity, the acid dissociation constant (K_a) of HA at this temperature is

(A) 1×10^{-4} (B) 0.1 (C) 9×10^{-4} (D) 1.1×10^{-5}

Q.11 The colour of potassium dichromate is due to

(A) d-d transition
(B) transition in K^+ ion
(C) ligand-to-metal charge transfer
(D) metal-to-ligand charge transfer

Q.12 Which one of the following configuration will show Jahn-Teller distortion in an octahedral field?

(A) high spin d^3 (B) high spin d^4 (C) high spin d^5 (D) low spin d^6

Q.13 B_2H_6 and B_4H_{10}, respectively, are examples of

(A) *nido* and *arachno* boranes
(B) *nido* and *closo* boranes
(C) *closo* and *arachno* boranes
(D) *nido* boranes

Q.14 Which of the following has a square planar geometry according to the VSEPR theory? Atomic number: B = 5, S = 16, Xe = 54.

(A) XeO_2F_2 (B) SF_4 (C) BF_4^- (D) XeF_4

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Q.15 The structure of rock salt consists of

(A) a cubic close-packed array of anions with cations in all the octahedral sites
(B) a cubic close-packed array of cations with anions in all the tetrahedral sites
(C) a hexagonal close-packed array of anions with cations in all the octahedral sites
(D) a cubic close-packed array of anions with cations in all the tetrahedral sites

Q.16 Among lithium, nitrogen, carbon and oxygen, which element has the highest first ionization potential?

(A) lithium (B) nitrogen (C) carbon (D) oxygen

Q.17 In which of the following C-H bond has the highest 's' character?

(A) acetylene (B) ethylene (C) methane (D) CH radical

Q.18 Which one of the following is an electron-deficient molecule according to the octet rule?

(A) CH_4 (B) $H_3N{:}BH_3$ (C) AlH_3 (D) GeH_4

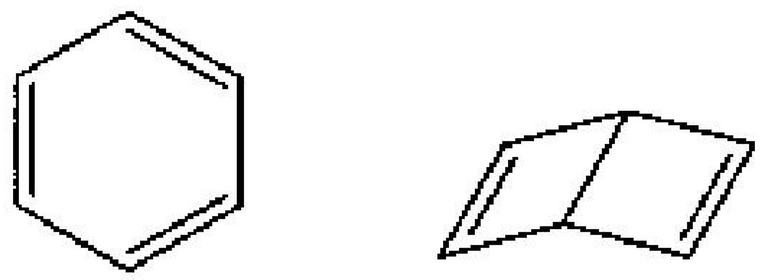
Q.19 Which one of the following has the highest lattice energy?

(A) LiCl (B) $CaCl_2$ (C) LiF (D) KCl

Q.20 At room temperature, HCl is a gas while HF is a liquid because

(A) of a strong bond between H and F in HF
(B) HF is less acidic as compared to HCl
(C) of strong intermolecular H-bonding in HF
(D) HCl is less acidic as compared to HF

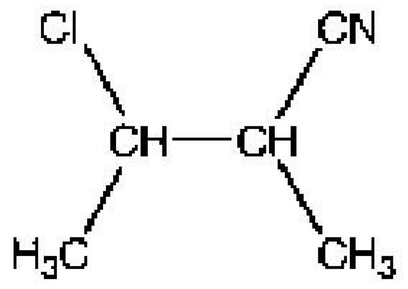
Q.21 Benzene and Dewar benzene are



benzene Dewar benzene

(A) canonical forms (B) structural isomers
(C) tautomers (D) conformational isomers

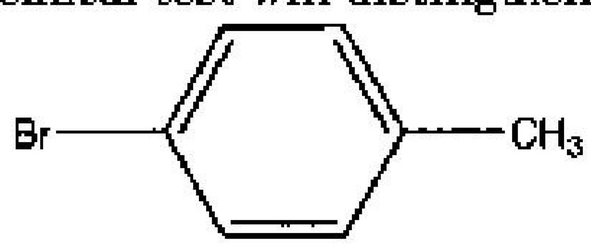
Q.22 The IUPAC name of the following compound is

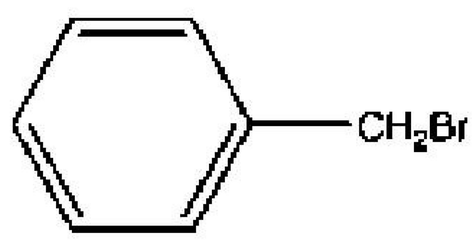


(A) 2-cyano-3-chlorobutane (B) 2-chloro-3-cyanobutane
(C) 2-methyl-3-chlorobutanenitrile (D) 3-chloro-2-methylbutanenitrile

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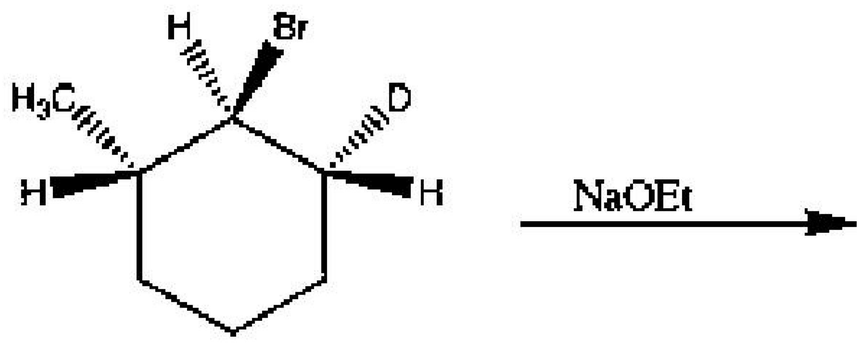
Q.23 Which chemical test will distinguish the compounds shown below?

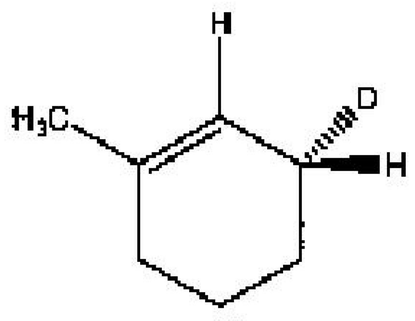


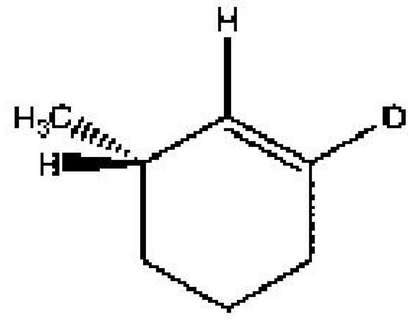


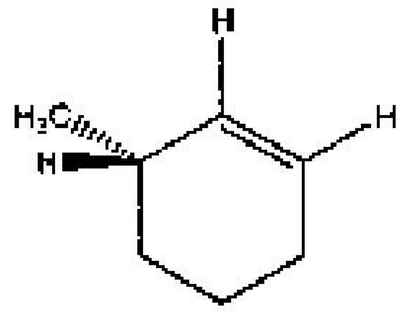
(A) Beilstein's flame test
(B) Ethanolic silver nitrate test
(C) Sodium fusion test
(D) Fehling's test

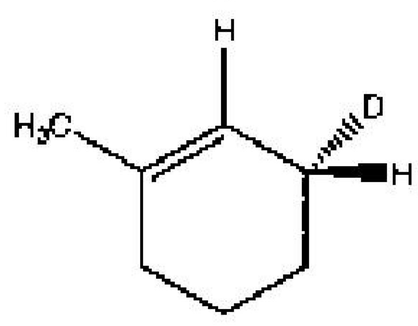
Q.24 The reaction of the bromo compound shown below with sodium ethoxide gives predominantly

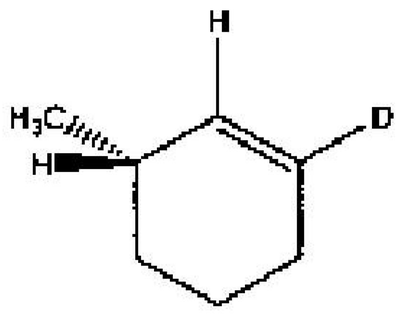


(A)


(B)


(C)


(D)


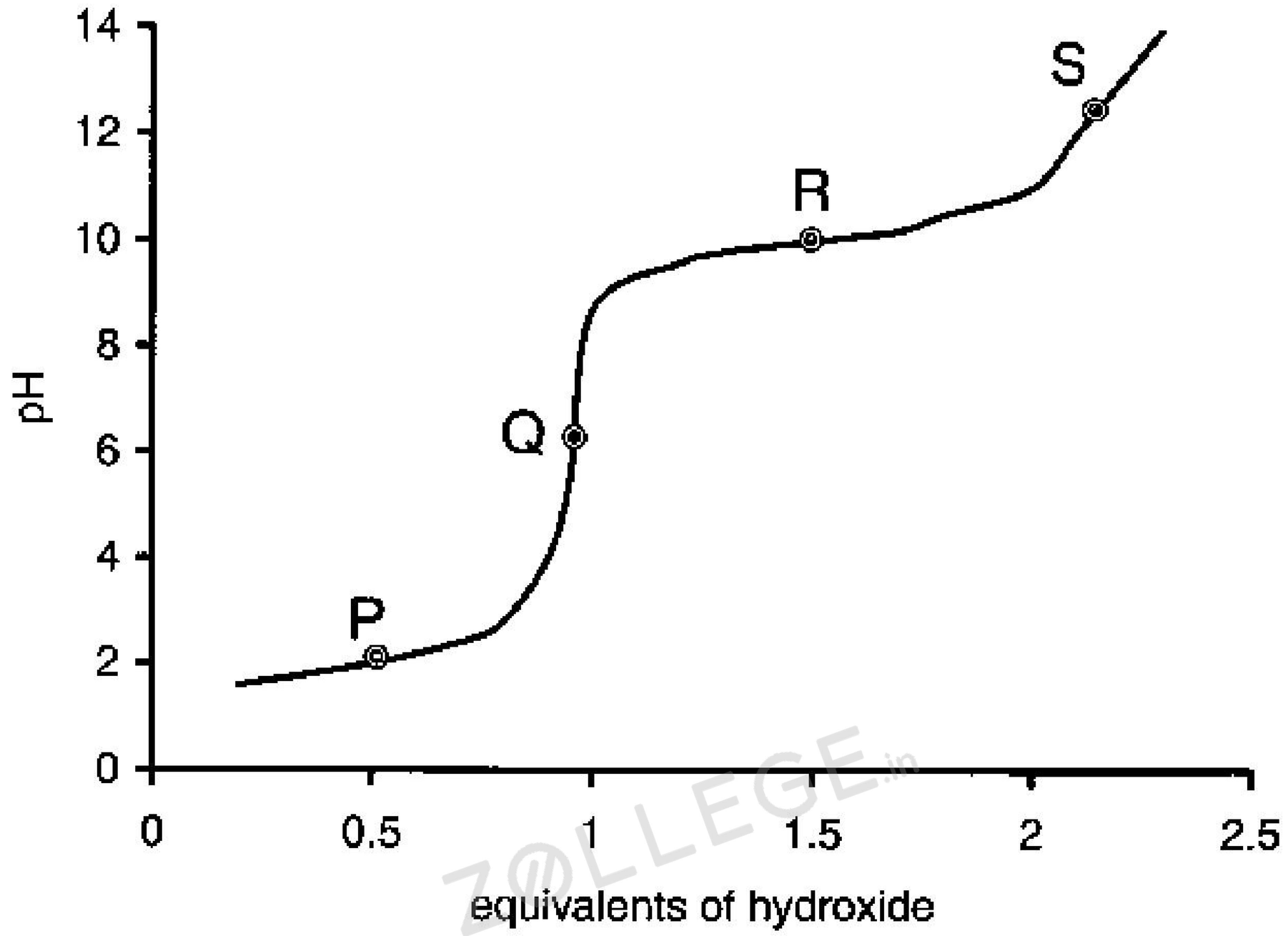
and


Q.25 Choose the correct order of reactivity for dehydration of the given alcohols using concentrated sulfuric acid.

(A) 2-methylpropan-2-ol > 2-butanol > 1-butanol
(B) 2-methylpropan-2-ol > 1-butanol > 2-butanol
(C) 2-butanol > 2-methylpropan-2-ol > 1-butanol
(D) 1-butanol > 2-butanol > 2-methylpropan-2-ol

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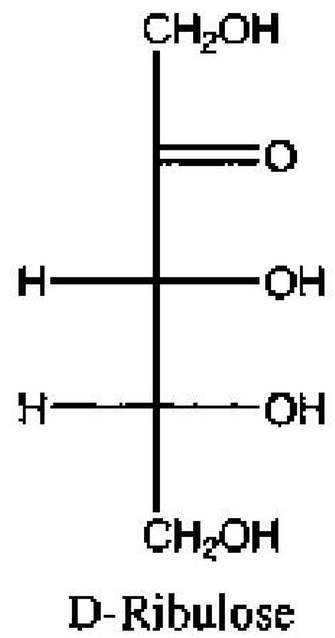
Q.26 The titration curve of alanine hydrochloride is given below.



The position in the graph that corresponds to the isoelectric point of alanine is

(A) **P** (B) **Q** (C) **R** (D) **S**

Q.27 The absolute configurations at the two chiral centers in D- Ribulose are

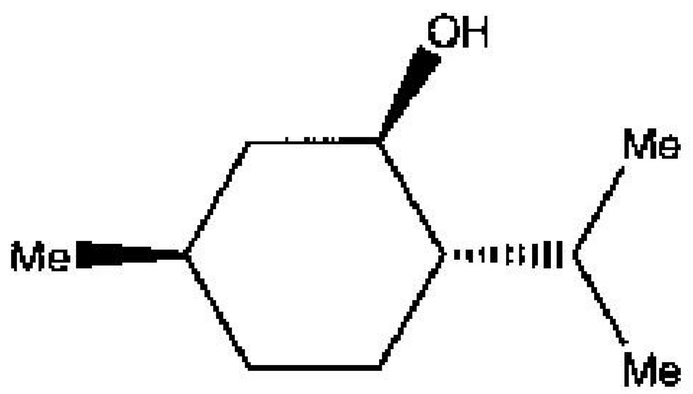


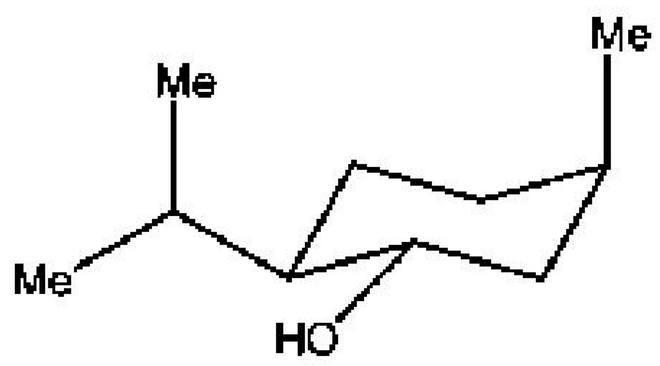
D-Ribulose

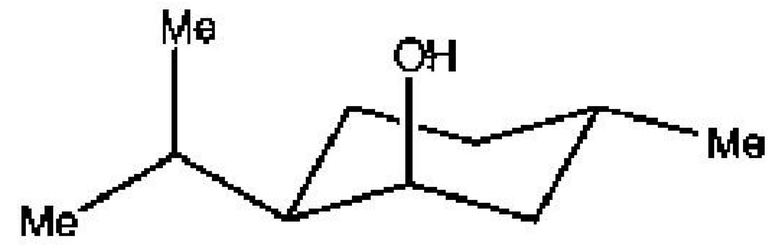
(A) 3R, 4R (B) 3R, 4S (C) 3S, 4R (D) 3S, 4S

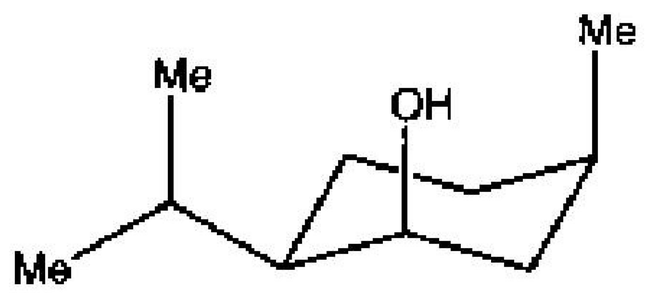
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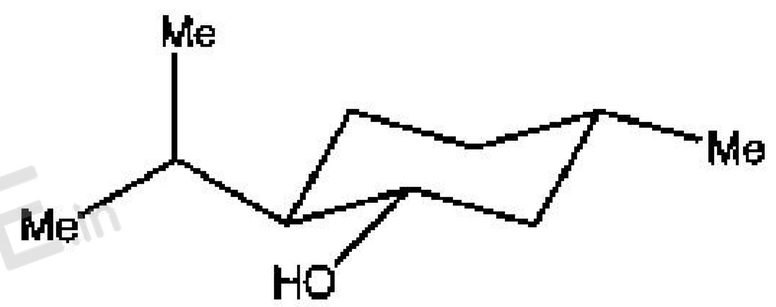
Q.28 The most stable conformation of the molecule shown below is correctly represented by



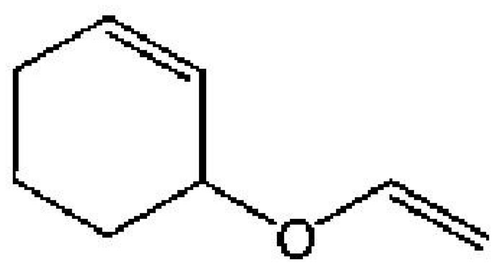
(A) 

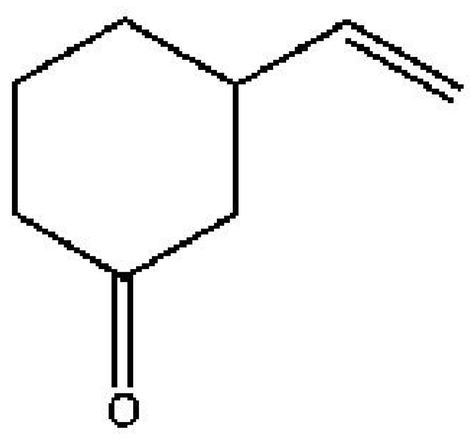
(B) 

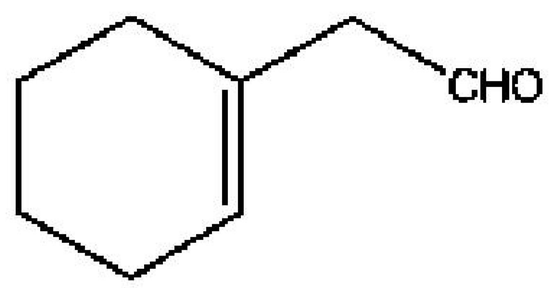
(C) 

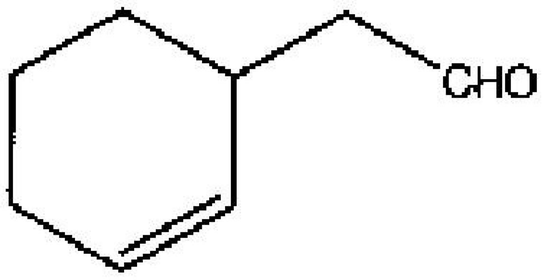
(D) 

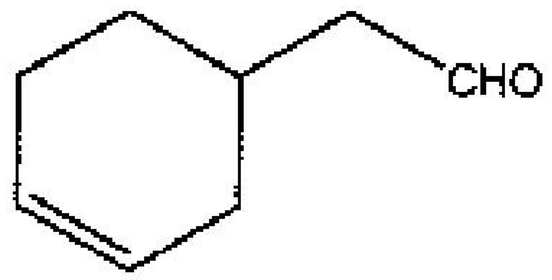
Q.29 Thermal rearrangement of the following compound would give



(A) 

(B) 

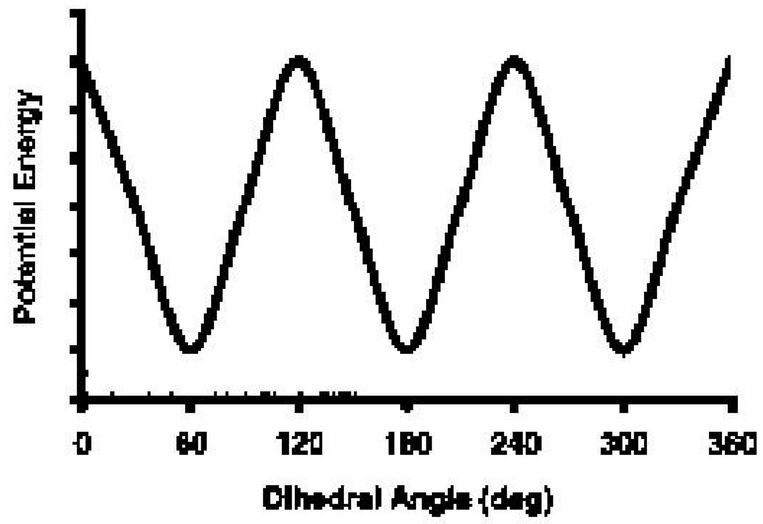
(C) 

(D) 

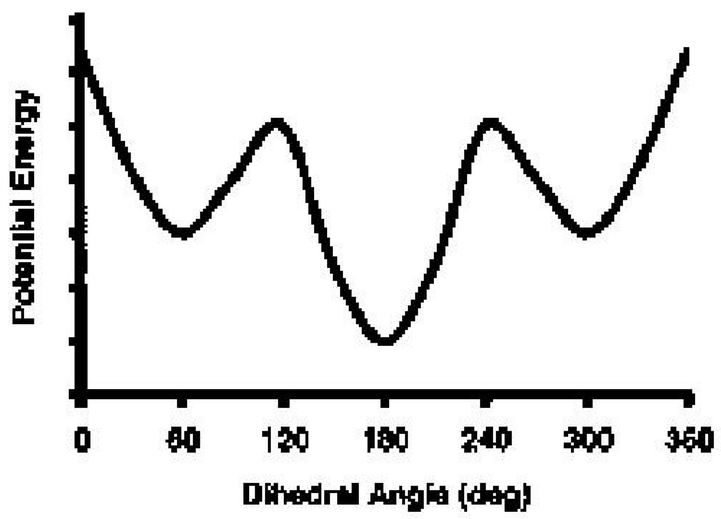
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Q.30 The energy profile diagram that corresponds to 1,2-dihydroxyethane for rotation around the C-C bond is

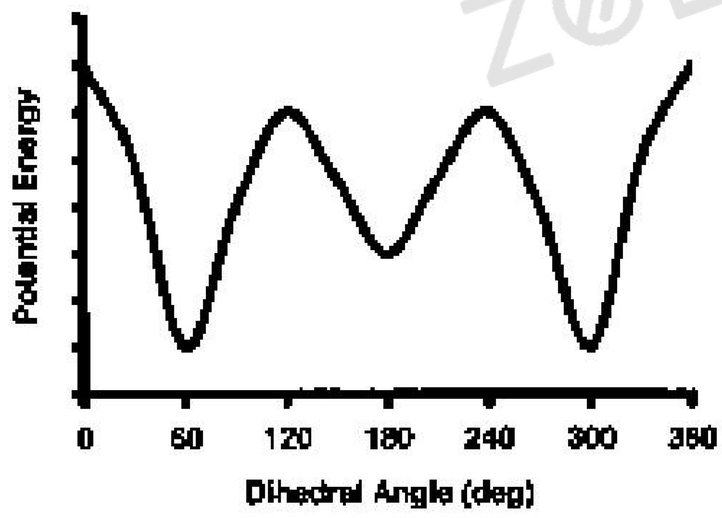
(A)



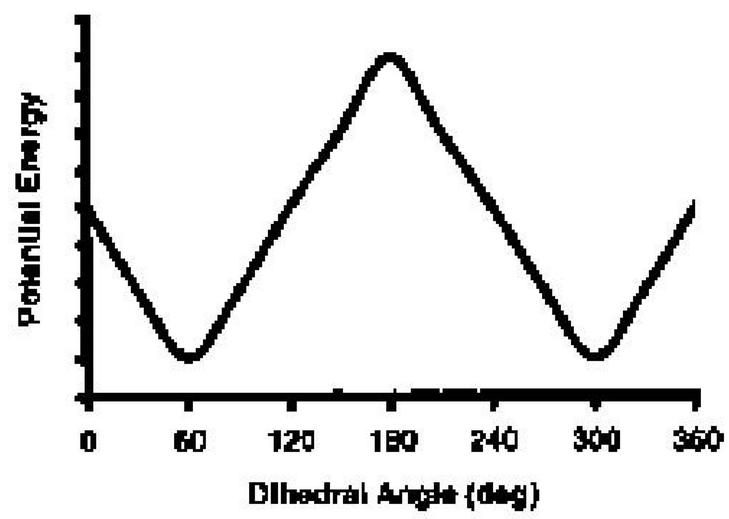
(B)



(C)



(D)



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Space for rough work

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A

Answer Table for Objective Questions

Write the Code of your chosen answer only in the 'Answer' column against each Question No. Do not write anything else on this page.

Question No.	Answer	Do not write in this column	Question No.	Answer	Do not write in this column
01			16		
02			17		
03			18		
04			19		
05			20		
06			21		
07			22		
08			23		
09			24		
10			25		
11			26		
12			27		
13			28		
14			29		
15			30		

FOR EVALUATION ONLY

No. of correct answers		Marks	(+)
No. of incorrect answers		Marks	(–)
Total marks in question nos. 1-30			( )

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Q.31 (a) Equilibrium constant for a reaction doubles as the temperature is increased from 300 K to 600 K. Calculate the standard reaction enthalpy (in kJ mol^{-1}) assuming it to be constant in this temperature range. (given: R = 8.3 J K^{-1} mol^{-1}, ln 2 = 0.7). (9)

(b) A 50 mL solution of 0.1 M monoprotic acid ($K_a = 1 \times 10^{-6}$ at 298 K) is titrated with 0.1 M NaOH at 298 K. Calculate the $[H^+]$ of the solution after the addition of 50 mL of NaOH at this temperature. (given: $K_w = 1 \times 10^{-14}$ at 298 K). (6)

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Q.32 For the reaction

$$H_2(g) + Br_2(g) \longrightarrow 2\,HBr(g)$$

the following mechanism has been proposed.

Initiation:

$$Br_2 + M \xrightarrow{k_i} Br^{\bullet} + Br^{\bullet} + M$$

Propagation:

$$Br^{\bullet} + H_2 \xrightarrow{k_p} HBr + H^{\bullet}$$

$$H^{\bullet} + Br_2 \xrightarrow{k_{p'}} HBr + Br^{\bullet}$$

Retardation:

$$H^{\bullet} + HBr \xrightarrow{k_r} H_2 + Br^{\bullet}$$

Termination:

$$Br^{\bullet} + Br^{\bullet} + M \xrightarrow{k_t} Br_2 + M + \text{energy}$$

where M is the initiator / terminator

(a) Write the differential rate equations for the formation of the two intermediates $H^{\bullet}$ and $Br^{\bullet}$ (6)

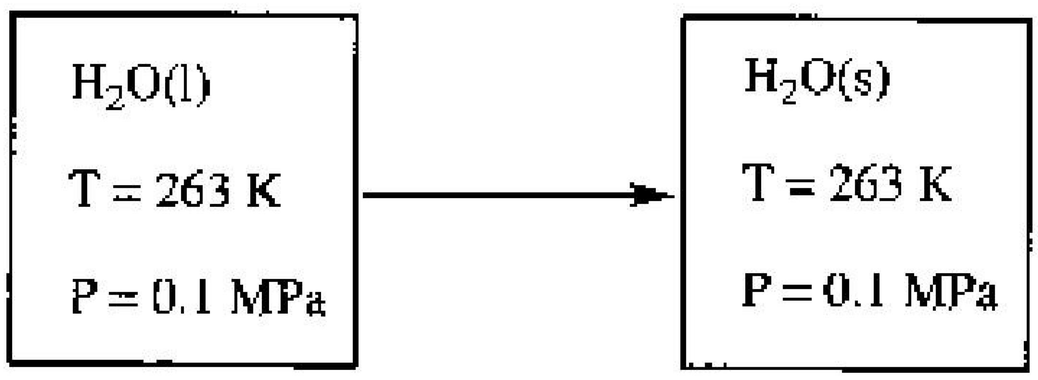
(b) Using the steady-state approximation, calculate the concentrations of the intermediates $H^{\bullet}$ and $Br^{\bullet}$ and obtain the rate law for the formation of HBr. (9)

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Q.33 Calculate ΔH_m and ΔS_m for the process



Assume that at 273 K the molar enthalpy of fusion of ice is 6006 J mol^{-1}, the heat capacity $C_{p,m}(s)$ of ice is 38 J K^{-1} mol^{-1} and the heat capacity $C_{p,m}(l)$ of liquid water is 76 J K^{-1} mol^{-1}. Consider the heat capacities to be constants.
(given: ln 263 = 5.57 and ln 273 = 5.61) (15)

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Q.34 Two beakers, one containing 0.02 M $KMnO_4$, 0.2 M $MnSO_4$ and 0.5 M H_2SO_4, and another containing 0.15 M $FeSO_4$ and 0.05 M $Fe_2(SO_4)_3$, are connected by a salt-bridge. Platinum electrodes are placed in each beaker and these two electrodes are connected via a wire with a voltmeter in between. H_2SO_4 is present in equal volumes in each beaker. Assume H_2SO_4 is completely ionized.

given: $E^0_{Fe^{3+}/Fe^{2+}} = 0.8\ V$, $E^0_{MnO_4^-/Mn^{2+}} = 1.5\ V$, $\frac{2.303\ RT}{F} = 0.06\ V$ and $\log 2 = 0.3$

(a) Write the complete balanced redox reaction for this cell. (6)

(b) What would be the potential of each half-cell after the reaction has reached equilibrium? (9)

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Q.35 An atomic orbital is described by the wavefunction

$\psi(r) = \frac{1}{\sqrt{\pi a_0^3}} e^{-\left(\frac{r}{a_0}\right)}$, where a_0 is the Bohr radius.

Given: $d\tau = r^2 \sin\theta \, dr \, d\theta \, d\phi$ and $\int_0^\infty r^n e^{-\beta r} \, dr = \frac{n!}{\beta^{n+1}}$ (n is a positive integer)

(a) Identify the atomic orbital and calculate the mean or the average radius of this orbital in terms of a_0. (9)

(b) Calculate the most probable radius (in terms of a_0) at which an electron will be found when it occupies this orbital. (6)

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Q.36 Identify **W**, **X**, **Y** and **Z** in the following sequence.

$$Li + W\,(g) \xrightarrow{heat} \underset{(red)}{X} \xrightarrow{H_2O} Y(g) \xrightarrow{\text{alkaline } K_2HgI_4} \underset{(brown)}{Z}$$

Y turns moist litmus paper blue. Write balanced chemical equation for the conversion of **Y** to **Z**. (15)

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Q.37 (a) Draw the crystal field splitting diagram with appropriate labels for $[NiCl_4]^{2-}$. Determine the spin only magnetic moment and the crystal field stabilization energy (CFSE) for this complex. (given: atomic number of Ni = 28). (9)

(b) Write the balanced equations for the reactions involved in the iodometric estimation of Cu^{2+} using thiosulfate. (6)

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Q.38 (a) In the reaction sequence given below **P** is an anionic Fe(II) complex.

$$\mathbf{P} \xrightarrow{\text{aq. } NO_2^-} \underset{\text{(brown)}}{\mathbf{Q}} \xrightarrow{\text{aq. } S^{2-}} \underset{\text{(purple)}}{\mathbf{R}}$$

Identify **P, Q** and **R**. (9)

(b) Draw a properly labeled unit cell diagram of CsCl. Show through calculations that there is only one CsCl per unit cell. (6)

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Q.39 (a) Write the balanced chemical equations for the reactions involved in the synthesis of borazine using ammonium chloride as one of the starting materials. Write the structure of borazine. (9)

(b) Draw Lewis structures of SF_4 and NO_3^-. (6)

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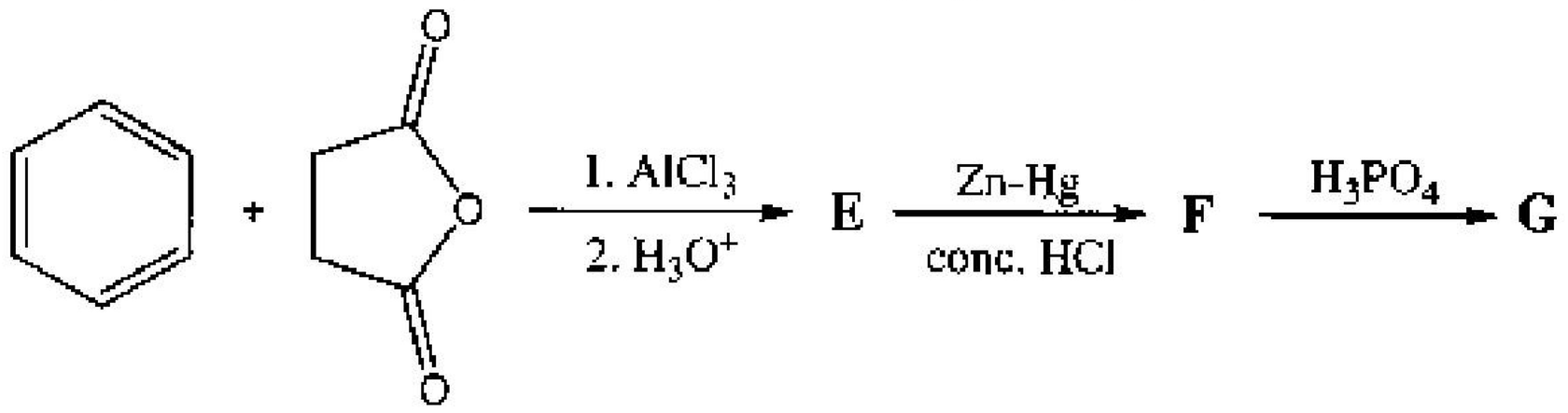
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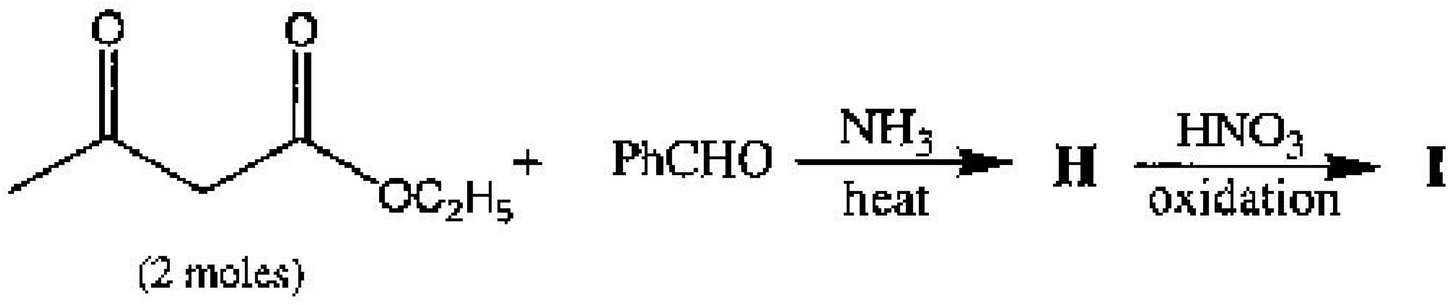
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Q.40 (a) Complete the following sequence by identifying **E, F** and **G**.



(9)

(b) Identify **H** and **I** in the reactions below.



(6)

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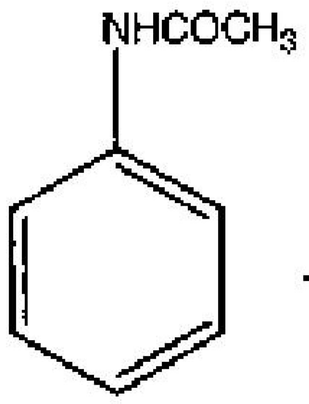
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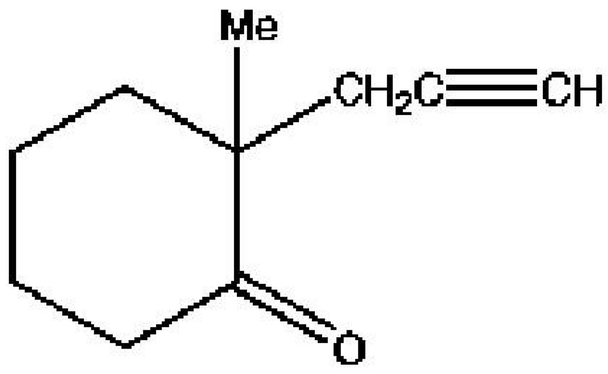
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Q.41 (a) Identify the products **J, K** and **L** in the following reactions. Lassigne's test for **L** shows the presence of **nitrogen** only.



$\xrightarrow{H_2SO_4/\ SO_3}$ **J** $\xrightarrow{\text{excess } HNO_3}$ **K** $\xrightarrow[\text{2. neutralization}]{\text{1. heat/ } H_3O^+}$ **L** (9)

(b) Write the structures of **M** and **N** in the following reactions.



$\xrightarrow[\text{dilute } H_2SO_4]{HgSO_4}$ **M** $\xrightarrow[\text{Heat}]{\text{NaOEt/ EtOH}}$ **N** (6)

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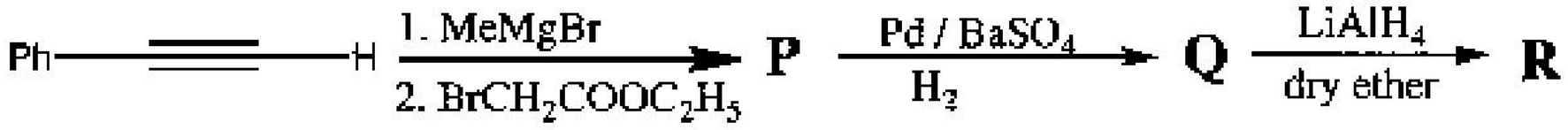
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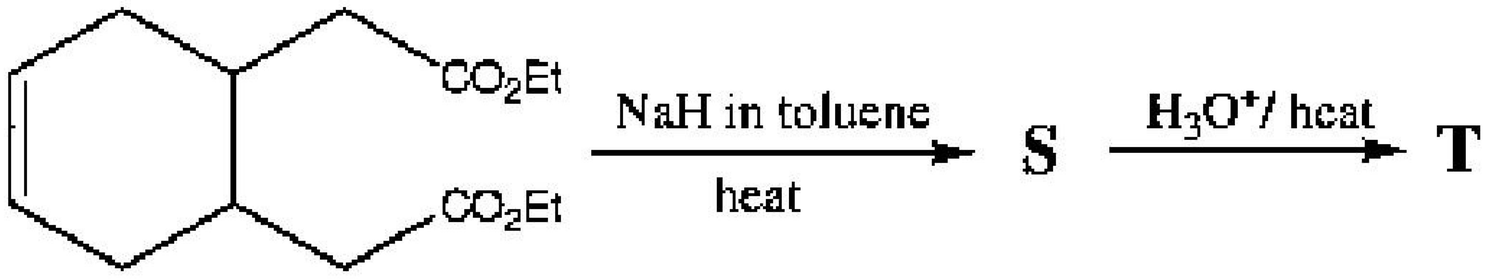
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Q.42 (a) **Write the structures of P, Q and R in the given reaction sequence.** (9)



(b) **Identify S and T in the reactions given below.**



(6)

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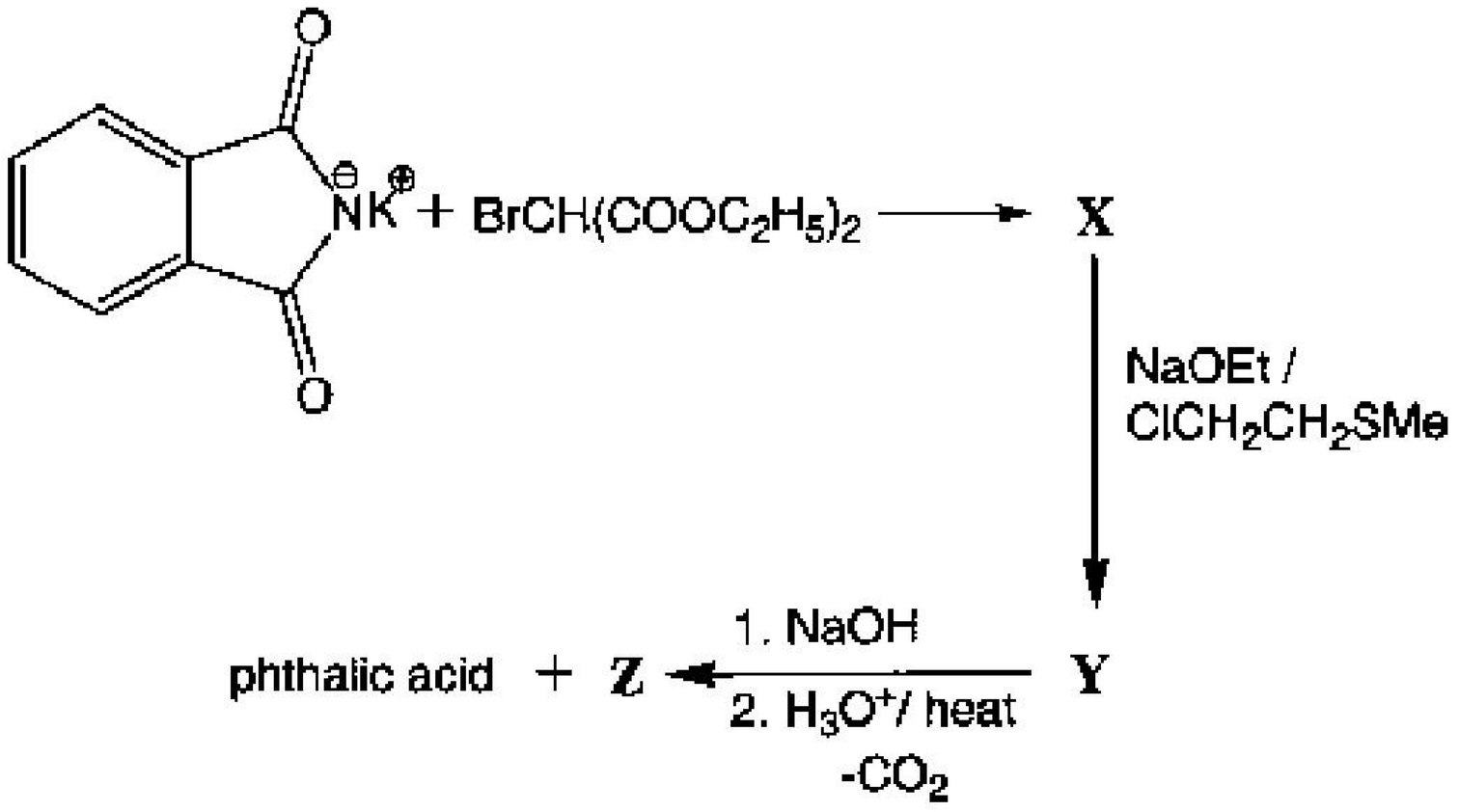
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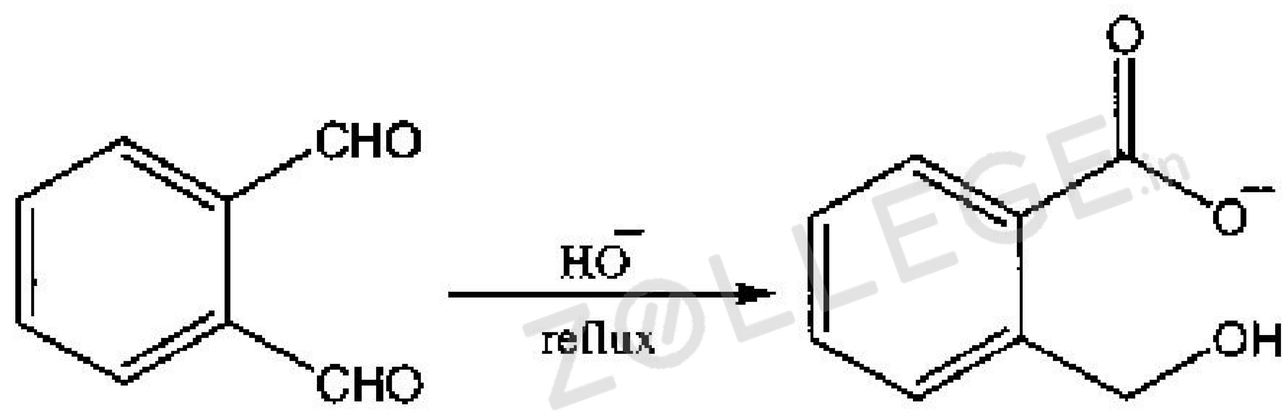
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Q.43 (a) Identify **X**, **Y** and **Z** in the following reactions



(9)

(b) Suggest a suitable **mechanism** for the following reaction.



(6)

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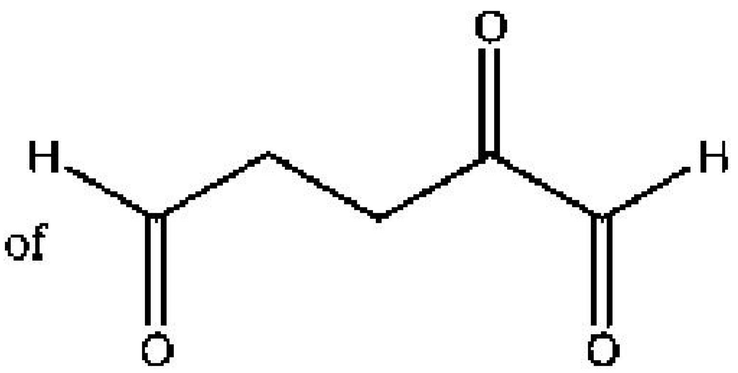
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Q.44 Consider the following reactions for a compound with molecular formula $C_{10}H_{16}$.

$C_{10}H_{16}$ —hydrogenation→ $C_{10}H_{22}$

$C_{10}H_{16}$ —ozonolysis↓

2 moles of HCHO + 1 mole of acetone + 1 mole of



(a) Write structures that are consistent with the above data for the formula $C_{10}H_{16}$. (9)

(b) Given that *myrcene* is a terpene and has the molecular formula $C_{10}H_{16}$, using the isoprene rule identify the correct structure for *myrcene* among the structures elucidated in part (a). (6)

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