A

2009 – CY

Test Paper Code : CY

Time : 3 Hours Maximum 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 **Roll 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. **7**. 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, pager and 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.

A

2009 – CY

READ INSTRUCTIONS ON THE LEFT SIDE OF THIS PAGE CAREFULLY

ROLL NUMBER						

Name :

Test Centre :

Do not write your Roll 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

A

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 7 only.**

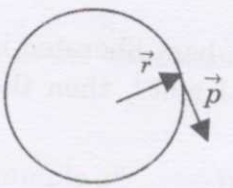
Q.1 For an ideal gas, the plot that is NONLINEAR is

(A) PV vs. T
(B) PV vs. P, at constant T
(C) P vs. V, at constant T
(D) $\ln P$ vs. $\ln V$, at constant T

Q.2 Consider two identical containers, one with 1 mole of H_2 and the other with 1 mole of He. If the root-mean-square (RMS) velocities of the two gases are the same, then the ratio of the temperatures, $T(H_2)/T(He)$ is

(A) 1/2 (B) 2 (C) $1/\sqrt{2}$ (D) $\sqrt{2}$

Q.3 An electron moves around the nucleus in a circular orbit, according to the Bohr model. The radial vector $\vec{r}$ and the instantaneous linear momentum vector $\vec{p}$ are shown in the diagram below.



The direction of the angular momentum vector is

(A) along $\vec{r}$
(B) along $\vec{p}$
(C) opposite to $\vec{p}$
(D) perpendicular to both $\vec{r}$ and $\vec{p}$

Q.4 X and Y are transformed co-ordinates obtained from p and q as follows :

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} a_1 & a_3 \\ a_2 & a_4 \end{pmatrix} \begin{pmatrix} p \\ q \end{pmatrix}$$

The correct set of linear equations that represent X and Y are

(A) $X = a_1 p + a_2 q$
$Y = a_3 p + a_4 q$

(B) $X = a_1 p + a_3 q$
$Y = a_2 p + a_4 q$

(C) $X = a_2 p + a_4 q$
$Y = a_1 p + a_3 q$

(D) $X = a_1 p + a_4 q$
$Y = a_2 p + a_3 q$

Q.5 Which of the following is NOT a solution of the equation :

$$\frac{d^2x}{dt^2}+\omega^2 x=0$$

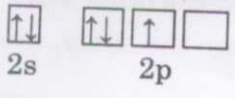
(A) $x=A\cos\omega t$ (B) $x=A\sin\omega t$

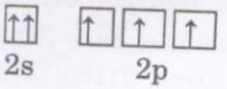
(C) $x=At^2$ (D) $x=A\left(e^{i\omega t}+e^{-i\omega t}\right)$

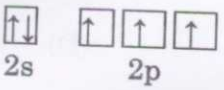
Q.6 An electron is found in an orbital with one radial node and two angular nodes. Which orbital the electron is in?

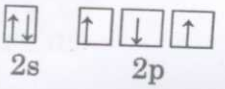
(A) 1s (B) 2p (C) 3d (D) 4d

Q.7 The acceptable valence shell electronic arrangement is :

(A) 

(B) 

(C) 

(D) 

Q.8 If K_{sp} is the solubility product of a sparingly soluble salt A_3X_2, then its solubility is

(A) $(K_{sp}/108)^{1/5}$ (B) $(K_{sp})^{1/5}$ (C) $(K_{sp}/72)^{1/5}$ (D) $(K_{sp})^{1/2}$

Q.9 For the formation of B from A, heat liberated is 20 kJ mol^{-1}. If the activation energy for the reaction B → A is 100 kJ mol^{-1}, then the activation energy (in kJ mol^{-1}) for the reaction A → B is

(A) 120 (B) 100 (C) 80 (D) 60

Q.10 For the reaction $A+B\rightarrow Z$, the concentration of Z at time t is given by $[Z]=[A]_{t=0}\left(1-e^{-kt}\right)+[Z]_{t=0}$, where k is the rate constant. The rate law is :

(A) $-\frac{d[Z]}{dt}=k[A]$ (B) $\frac{d[Z]}{dt}=k[A]$

(C) $\frac{d[Z]}{dt}=k[Z]$ (D) $\frac{d[Z]}{dt}=k[A][B]$

Q.11 Identify the correct option :

In the Periodic Table, on moving from left to right along a period,

(A) the atomic size of the element increases
(B) the first ionization potential of the element decreases
(C) the oxide of the element becomes less basic
(D) the oxide of the element becomes more basic

Q.12 Among the following, the INCORRECT statement is :

(A) Diamond and graphite are two allotropes of carbon
(B) In diamond, each carbon is sp^3 hybridized
(C) In graphite, each carbon is sp^2 hybridized
(D) Graphite shows high electrical conductivity in one direction only

Q.13 The pH of a 1×10^{-8} M HCl solution is close to

(A) 8.0 (B) 7.1 (C) 6.9 (D) 6.0

Q.14 The indicator phenolphthalein changes colour at pH ~ 9. This indicator is NOT suitable for accurate determination of the end point in the titration of

(A) CH_3COOH with NaOH (B) HCl with NH_4OH
(C) HCl with NaOH (D) HCl with KOH

Q.15 In the thermite process, iron oxide is reduced to molten iron by aluminium powder because

(A) the melting point of iron is low
(B) the reaction is highly endothermic
(C) large amount of heat is liberated in the formation of Al_2O_3
(D) aluminium is an amphoteric element

Q.16 The number of P=O bonds present in the tetrabasic acid $H_4P_2O_7$ is

(A) three (B) two (C) one (D) none

Q.17 Egyptian blue $CaCuSi_4O_{10}$ is an example of

(A) sheet silicate (B) cyclic silicate
(C) pyrosilicate (D) chain silicate

Q.18 The formal charges on the nitrogen atom from left to right in the azide anion, $[N=N=N]^-$ are

(A) +1, –1, –1 (B) –1, +1, –1
(C) –1, –1, +1 (D) –2, +1, 0

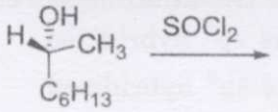
Q.19 The unit cell of diamond can be obtained from the unit cell of

(A) ZnS (B) NaCl (C) CsCl (D) AgCl

Q.20 Calgon used for water softening is $Na_2[Na_4(PO_3)_6]$ and it is prepared by heating microcosmic salt. The microcosmic salt is

(A) Na_2HPO_3 (B) NaH_2PO_4
(C) Na_2HPO_4 (D) $Na(NH_4)HPO_4$

Q.21 The major product obtained in the following reaction



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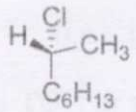
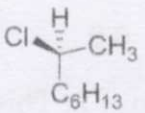


(A)



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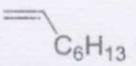

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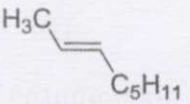
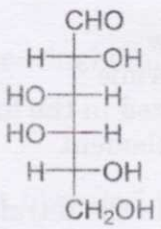
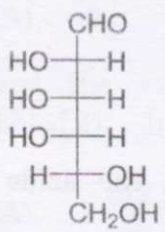


(D)

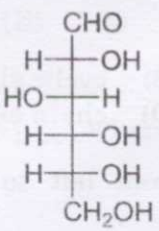
Q.22 The structure of D-galactose is



Which one of these structures is L-galactose?



(A)



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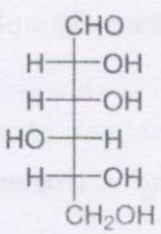

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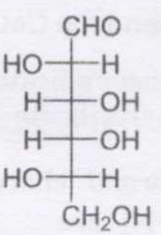
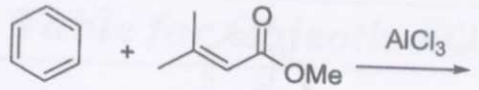


(D)

Q.23 The maximum number of stereoisomers possible for 4-phenylbut-3-en-2-ol is

(A) 1 (B) 2 (C) 3 (D) 4

Q.24 The major product of the reaction



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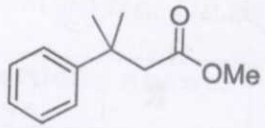
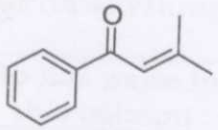
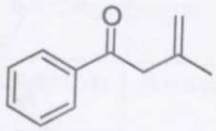


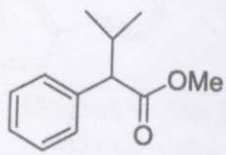
(A)



(B)



(C)

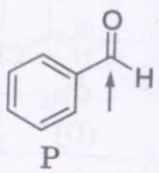


(D)

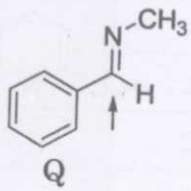
Q.25 Which of the following is achiral?

(A) alanine (B) glycine (C) proline (D) phenylalanine

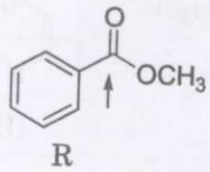
Q.26 The reactivity order of the indicated functional groups towards a nucleophile



P



Q

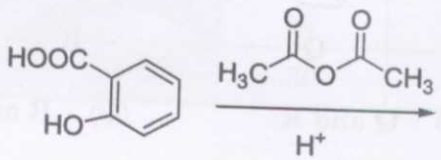


R

is

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

Q.27 The major product formed in the reaction



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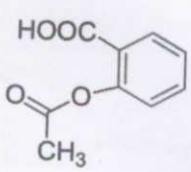
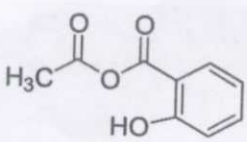
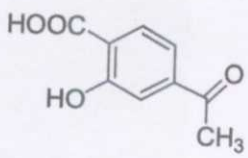


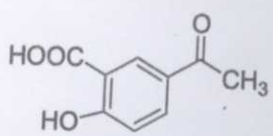
(A)



(B)

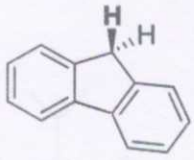


(C)

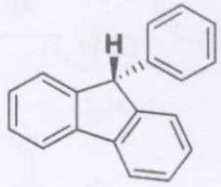


(D)

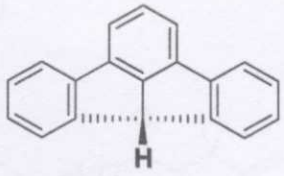
Q.28 Arrange the following in the correct order of acidity of the hydrogen indicated in bold.



P



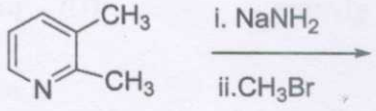
Q

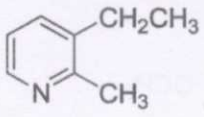


R

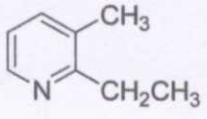
(A) **P > Q > R** (B) **R > Q > P** (C) **Q > R > P** (D) **P > R > Q**

Q.29 Among the following the major product obtained in the reaction below is





(A)



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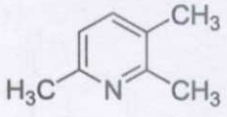
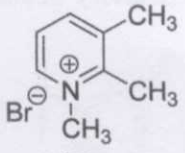
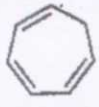


(C)

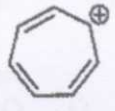


(D)

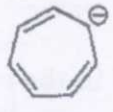
Q.30 Which of the following are aromatic?



P



Q



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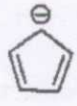


S

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

Q.31 (a) A container is partitioned into two compartments, one of which contains 2 moles of He while the other contains 3 moles of Ar. The gases are ideal. The temperature is 300 K and the pressure is 1 bar.

$R = 0.083$ L bar mol^{-1} K^{-1}, ln (2/5) = – 0.92, ln (3/5) = – 0.51.

(i) What is the total Gibbs free energy of the two gases?

(ii) If the partition between the two compartments is removed and the gases are allowed to mix, then what is the Gibbs free energy of the mixture?

(iii) What is the change in enthalpy in this process? (9)

(b) Obtain (i) the molar heat of formation of $CH_4(g)$ and (ii) the average C–H bond energy, to the nearest kilojoule (kJ), from the given data :

		ΔH (kJ mol^{-1})
(1)	$CH_4(g) \rightarrow CH_3(g) + H(g)$	435
(2)	$CH_3(g) \rightarrow CH_2(g) + H(g)$	444
(3)	$CH_2(g) \rightarrow CH(g) + H(g)$	444
(4)	$CH(g) \rightarrow C(g) + H(g)$	339
(5)	$C(graphite) \rightarrow C(g)$	717
(6)	$H_2(g) \rightarrow 2\ H(g)$	436

(6)

Q.32 (a) (i) Draw the P-T phase diagram of water.

(ii) Label the different regions in this diagram.

(iii) On the diagram, show the liquid-vapour equilibrium for a dilute solution of NaCl, with the help of a dashed curve. (9)

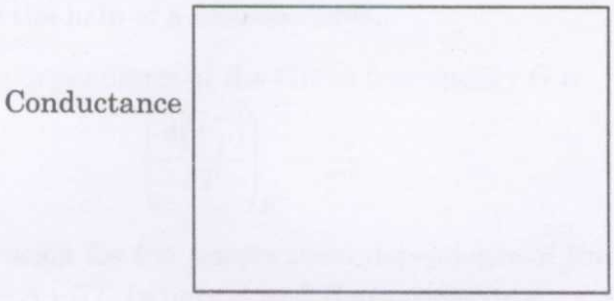
(b) The temperature dependence of the Gibbs free energy G is :

$$\left(\frac{\partial\left(G/T\right)}{\partial T}\right)_P = -\frac{H}{T^2}.$$

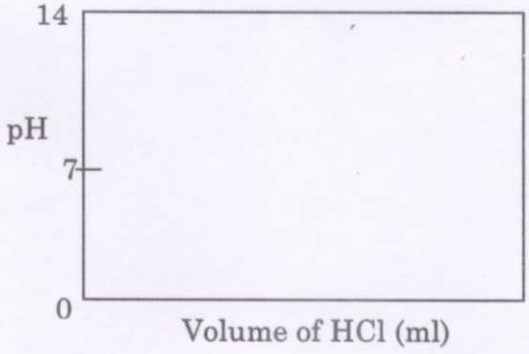
Obtain the expression for the temperature dependence of the equilibrium constant K given that $\Delta H^\theta = A + BT$ (where A and B are constants). (6)

Q.33 (a) In the space provided, plot :

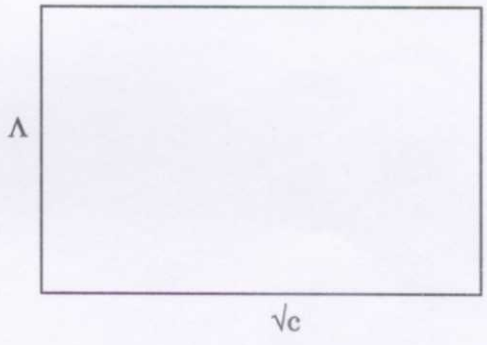
(i) Conductometric titration curve of 0.1 M $AgNO_3$ with 1 M NaCl, extended beyond the end point ($\lambda^0_{Na^+} \approx \lambda^0_{Ag^+}$).



(ii) pH vs. Volume of HCl, for a potentiometric titration of 0.1 (N) NH_4OH with 0.1 N HCl.



(iii) Variation of the molar conductivity of NaCl with the square root of its concentration.



(9)

(b) The $Zn^{2+}|Zn$ half cell ($E^{\theta} = -0.762$ V) is connected to a $Cu^{2+}|Cu$ half cell ($E^{\theta} = 0.340$ V). What is the value of E^{θ}_{cell} for spontaneous conversion of chemical energy to electrical energy? What is the value of $\log_{10} K$, where K is the equilibrium constant? Use (2.303 RT/F) = 0.06. (6)

Q.34 (a) The following initial rate data were obtained for the reaction

$2NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$

	Partial pressure of		Initial rate
	NO	O_2	
Run 1	p_{NO}	p_{O_2}	v
Run 2	$2\ p_{NO}$	p_{O_2}	$4v$
Run 3	p_{NO}	$2\ p_{O_2}$	$2v$

(i) What is the rate law for this reaction?

(ii) One of the mechanisms proposed for this reaction is

$$NO(g) + O_2(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} NO_3(g)$$

$$NO_3(g) + NO(g) \xrightarrow{k_2} 2\ NO_2(g)$$

Obtain the rate law predicted for this mechanism, assuming a steady state concentration of NO_3.

(iii) Predict the rate law for this mechanism, if the first equilibrium step is established quickly and the second step is slow. (9)

(b) (i) Write the expression for the vibrational contribution to the total energy of $CH_4(g)$ at 500 K. All the vibrational modes are active at this temperature.

(ii) Calculate the total internal energy of 1 mole of the gas at this temperature. $R = 8.314\ J\ mol^{-1}\ K^{-1}$. (6)

Q.35 (a) In the Bohr model of a hydrogen-like atom with atomic number Z,

- the angular momentum of an electron (of mass m_e and charge e) is a non-zero integral (n) multiple of $h/2\pi$, where h is the Planck's constant, and
- the electrostatic attraction exerted by the nucleus on the electron is balanced by the centrifugal force experienced by the electron.

(i) Write mathematical expressions for the above statements.

(ii) Hence obtain the expression for the radius r of the Bohr orbit of the electron in terms of e, n, and Z. (9)

(b) Complete the following nuclear reactions : (6)

(i) ${}^{14}_{7}\mathrm{N} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{1}_{1}\mathrm{H} + ---$

(ii) ${}^{7}_{3}\mathrm{Li} + {}^{1}_{1}\mathrm{H} \rightarrow ----$

Q.36 (a) Highly pure nickel metal can be prepared from its sulphide ore *via* $Ni(CO)_4$. Write the chemical equations involved. (9)

(b) Addition of excess of aqueous NH_3 followed by ethanolic solution of dimethylglyoxime to a dilute aqueous solution of nickel sulphate changes the solution colour from green to blue to red. Write the structures of the metal complexes corresponding to green, blue and red colours. (6)

Q.37 The element **E** on burning in the presence of O_2 gives **F**. Compound **F** on heating with carbon in an electric furnace gives **G**. On passing nitrogen over a heated mixture of **F** and carbon produces **H**. Steam can decompose **H** to produce boric acid and a colourless gas that gives white fumes with HCl. Identify **F**, **G** and **H** and give balanced equations for their formation. (15)

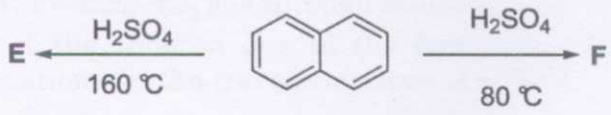
Q.38 (a) Provide IUPAC names for the following complexes :

(i) $[CoCl(NH_3)_5]Cl_2$ (ii) $K_2[PdCl_4]$ (6)

(b) The magnetic moment of $[Mn(H_2O)_6](NO_3)_2$ is approximately $6.0\,\mu_B$. Find the number of unpaired electrons, show crystal field splitting and calculate the CFSE. (9)

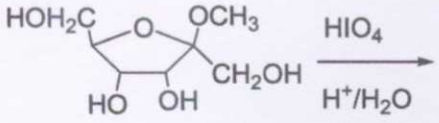
Q.39 A metal salt on heating with a mixture of KCl and conc. H_2SO_4 yields a deep red vapour **J**. The vapour on passing through an aqueous solution of KOH gives a yellow solution of compound **K**. Passing SO_2 gas through acidified solution (with H_2SO_4) of **K** leads to green colouration of the solution due to the formation of **M**. Identify **J**, **K** and **M** giving balanced equations for the transformations, **J** → **K** and **K** → **M**. (15)

Q.40 (a) Identify **E** and **F** in the following reactions and suggest a suitable reason for their formation (9)

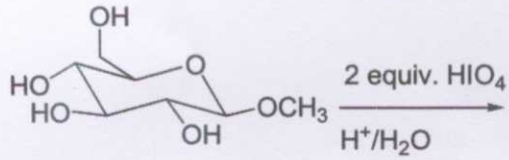


(b) Predict the products in each of the following reactions. (6)

(i)

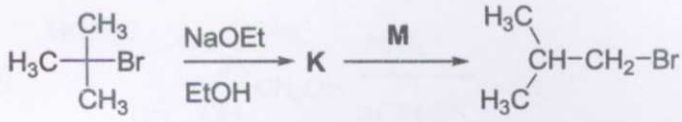


(ii)

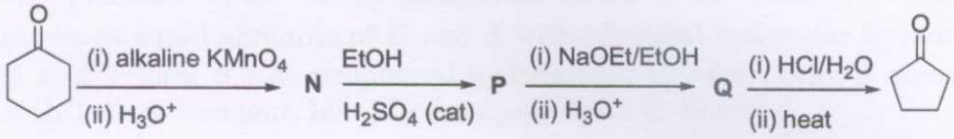


Q.41 (a) A compound **G** having molecular formula C_6H_{12} decolourises both permanganate and bromine water. **G** on ozonolysis followed by reductive work-up (Zn/H_3O^+) produces equal amounts of **H** and **J** with identical molecular formula C_3H_6O. Both **H** and **J** form 2,4-dinitrophenyl hydrazones, however, only **J** shows positive test with Tollens' reagent. Identify the compounds **G**, **H** and **J**. (9)

(b) Identify **K** and **M** in the following reaction sequence. (6)

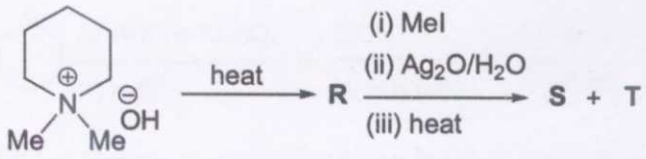


Q.42 (a) Identify **N**, **P** and **Q** in the following synthetic transformation. (9)

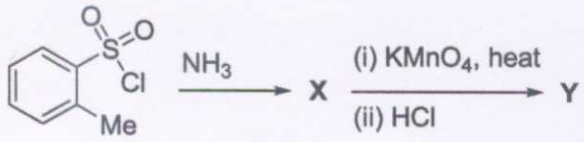


(b) Draw the most as well as the least stable chair conformations of *trans*-1-*tert*-butyl-4-methylcyclohexane. (6)

Q.43 Identify **R**, **S**, **T**, **X** and **Y** in the following reaction sequences.

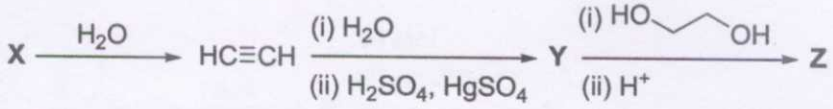
(a) 

(9)

(b) 

(6)

Q.44 (a) Complete the following reaction sequence with the structures of **X**, **Y** and **Z**.



(9)

(b) Calculate the isoelectric point (pI) of lysine. Given the pK_a of α-NH_3 is 8.95, pK_a of side chain NH_3 is 10.53 and pK_a of α-COOH is 2.18. (6)