

# IIT-GATE: 2019

## Chemistry

### ❖ Question Paper

#### Section-A

**Q.1 - Q.25 carry one mark each.**

Q.1 The incorrect statement about the solid-structure of CsCl and CaF<sub>2</sub> is:

- (a) Cation in both solids exhibit coordination number 8.
- (b) CsCl has *bcc* type structure and CaF<sub>2</sub> has cubic close pack structure.
- (c) Radius ratio for Cs/Cl and Ca/F is 0.93 and 0.73, respectively
- (d) Both exhibit close pack structure.

Q.2 The incorrect statement about the interhalogen compound ICl<sub>3</sub> is:

- (a) It exists as dimer.
- (b) Geometry around the iodine is tetrahedral in solid-state.
- (c) It decomposes as ICl and Cl<sub>2</sub> in gas-phase.
- (d) Liquid ICl<sub>3</sub> conducts electricity.

Q.3 Among the following carbon allotropes, the one with discrete molecular structure is

- (a) Diamond
- (b)  $\alpha$ -Graphite
- (c)  $\beta$ -Graphite
- (d) Fullerene

Q.4 The incorrect statement about the silicones is:

- (a) They thermally unstable because of the Si-C bond.
- (b) They are insoluble in water.
- (c) They are organosilicon polymers.
- (d) They have stable silica-like skeleton (-Si-O-Si-O-Si-)

Q.5 The  $\Delta_o$  values for  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  is  $8500 \text{ cm}^{-1}$ . The  $\Delta_o$  values for  $[\text{NiCl}_6]^{4-}$  and  $[\text{Ni}(\text{NH}_3)_6]^{2+}$  compared to  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  are

- (a) Higher and Lower, respectively. (b) Lower and Higher, respectively.  
(c) Higher in both complex ions. (d) Lower in both complex ions.

Q.6 In Freundlich isotherm, a linear relationship is obtained in plot of

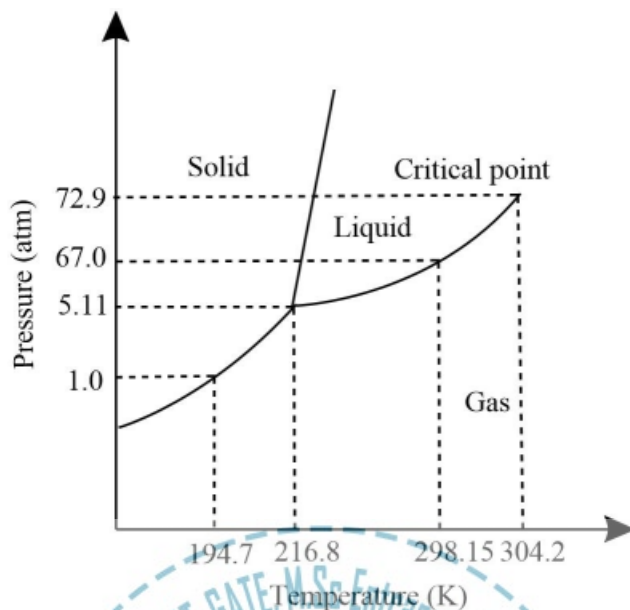
( $\theta$  = surface coverage and  $p$  = partial pressure of gas)

- (a)  $\theta$  vs  $p$ . (b)  $\ln(\theta)$  vs  $\ln(p)$ .  
(c)  $\ln(\theta)$  vs  $p$ . (d)  $\theta$  vs  $\ln(p)$ .

Q.7 Micelle formation is accompanied by the

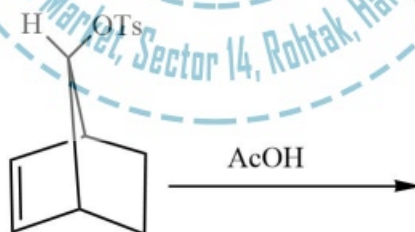
- (a) Decrease in overall entropy due to ordering.  
(b) Increase in overall entropy mostly due to increase solvent entropy.  
(c) Increase in overall entropy mostly due to increase solute entropy.  
(d) Increase in overall entropy and decrease in enthalpy.

Q.8 consider the following phase diagram of  $\text{CO}_2$  (not to scale). At equilibrium, the incorrect statement is:



- (a) At 200K, on increasing the pressure from 1 to 50 atm, CO<sub>2</sub> gas condenses also liquid
- (b) It is not possible to obtain liquid CO<sub>2</sub> from gaseous CO<sub>2</sub> below 5.11 atm.
- (c) Both liquid and gas phase of CO<sub>2</sub> co-exist at 298.15 K and 67 atm.
- (d) With increasing pressure, the melting point of solid CO<sub>2</sub> increases.

Q.9 the major product formed in the following reaction is



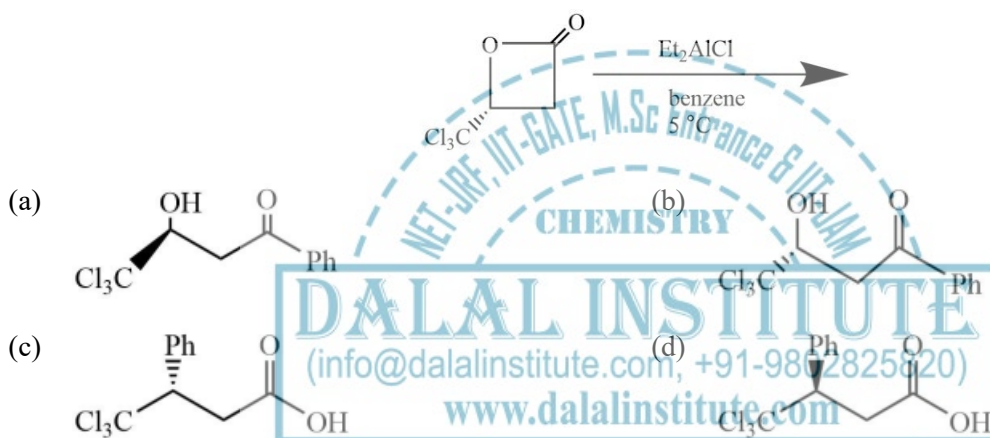
- (a) (b) (c) (d)

Q.10 The Woodward-Hoffmann condition to bring out the following transformation is



- (a)  $\Delta$ , conrotatory (b)  $\Delta$ , disrotatory  
(c)  $h\nu$ , disrotatory (d)  $h\nu$ , conrotatory

Q.11 The major product formed in the following reaction is

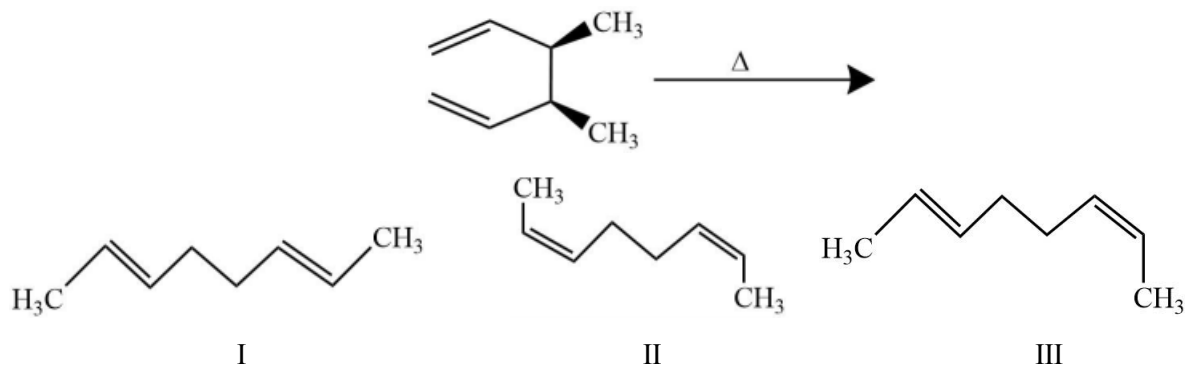


Q.12 In the following reaction, the stereochemistry of the major product is predicted by the



- (a) Cram's model (b) Cram's chelation model  
(c) Felkin model (d) Felkin-Anh model

Q.13 The product(s) formed in the following reaction is (are)

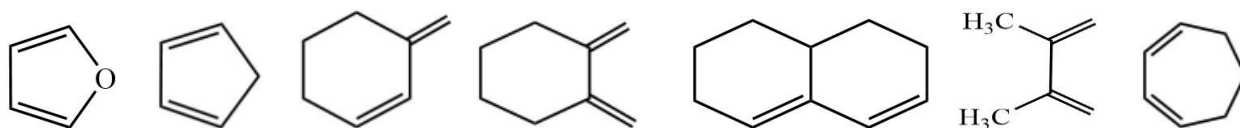


- (a) I only      (b) II only      (c) III only      (d) Mixture of I and II

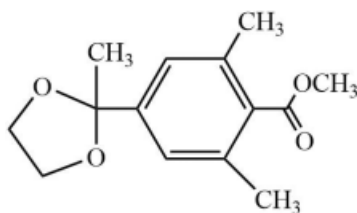
Q.14 Among the following compounds, the number of compounds that do not exhibit optical activity at room temperature is .....



Q.15 The number following diene(s) that undergo Diels-Alder reaction with methyl acrylate is .....



Q.16 The number of  $^1\text{H}$  NMR signals observed for the following compound is .....



Q.17 The number of CO stretching bands in IR spectrum of trigonal bipyramidal  $cis\text{-}M(\text{CO})_3\text{L}_2$  is .....

(M = metal and L = monodentate ligand)

Q.18 On heating a sample of 25 mg hydrated compound (molecular weight = 250 g/mol) in the thermogravimetric analysis, 16 mg of dehydrated compound remains. The number of water molecules lost per molecule of hydrated compound is .....

(Molecular weight of water = 18 g/mol)

Q.19 the total number of  $\alpha$  and  $\beta$  particles emitted in the following radioactive decay is .....



Q.20 An ideal gas occupies an unknown volume V liters (L) at a pressure of 12 atm. The gas is expand isothermally against a constant external pressure of 2 atm so that its final volume becomes 3 L. The work involved for this expansion process is ..... cal. (Round off to two decimal places)

Q.21 The entropy change for melting of 'x' moles of ice (heat of fusion is 80 cal.  $\text{g}^{-1}$ ) at 273 K and 1 atm pressure is 28.80 cal.  $\text{K}^{-1}$ . The value of 'x' is ..... (Round off to two decimal places)

(Molecular weight of water = 18g/mol)

Q.22 consider a two-state system at thermal equilibrium having energies 0 and  $2k_B T$  for which the degeneracies are 1 and 2, respectively. The value of the function at the partition function at the same absolute temperature T is ..... ( $k_B$  is the Boltzmann constant)

Q.23 consider a system of three identical and distinguishable non-interacting particles and three available nondegenerate single particle energy levels having energies 0,  $\epsilon$  and  $2\epsilon$ . The system is in contact with a heat

bath of temperature  $T$  K. A total energy of  $2\epsilon$  is shared by these three particles. The number of ways the particles. The number of ways the particles can be distributed is .....

Q.24 In a 400 MHz  $^1\text{H}$  NMR spectrometer, a proton resonates at 1560 Hz higher than that of tetramethylsilane. The chemical shift value of this proton is ..... ppm. (round off to one decimal place)

(Chemical shift of tetramethylsilane is fixed at zero ppm)

Q.25 Gas phase bond length and dipole moment of a compound (MX) is 3 Å and 10.8 D, respectively. The ionic character in the gas phase MX is .....% (round off to one decimal place)

(1D =  $3.336 \times 10^{-30}$  C m)

Q.26 – Q.55 carry two marks each.

Q.26 The experimentally observed magnetic moment values, which well with the spin-only values for the pair of aqueous ions is

(Atomic number; Cr = 24, Co = 27, Gd = 64, Tb = 65, Dy = 66 and Lu = 71)

- (a) Cr(III) and Gd(III) (b) Co(II) and Gd(III)  
 (c) Cr(III) and Dy(III) (d) Lu(III) and Tb(III)

Q.27 Among the following compounds, a normal spinel is

- (a)  $\text{MgFe}_2\text{O}_4$  (b)  $\text{ZnFe}_2\text{O}_4$   
 (c)  $\text{CoFe}_2\text{O}_4$  (d)  $\text{CuFe}_2\text{O}_4$

Q.28 Following are the examples of silicate minerals

Zircon,  $\text{ZrSiO}_4$

Beryl,  $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$

pyrophyllite,  $\text{Al}_2(\text{OH})_2[(\text{Si}_2\text{O}_5)_2]$

I II III

The correct structural description of the minerals is

- (a) I – Ortho silicate, II – Cyclic silicate, III – Sheet silicate

- (b) I – Ortho silicate, II – Sheet silicate, III – Cyclic silicate  
 (c) I – Cyclic silicate, II – Sheet silicate, III – Ortho silicate  
 (d) I – Sheet silicate, II – Ortho silicate, III – Cyclic silicate

Q.29 In EPR signal of methyl radical, the number of lines and relative intensities, respectively, are

- (a) 1 and 1                      (b) 3 and 1:2:1                      (c) 4 and 1:2:2:1                      (d) 4 and 1:3:3:1

Q.30 The product obtained in the reaction of  $\text{Mn}_2(\text{CO})_{10}$  with  $\text{Br}_2$  is

- (a)  $\text{Mn}(\text{CO})_5\text{Br}$                       (b)  $\text{Mn}_2(\text{CO})_8\text{Br}_2$                       (c)  $\text{Mn}(\text{CO})_4\text{Br}_2$                       (d)  $\text{Mn}_2(\text{CO})_9\text{Br}$

Q.31 The correct molecular representation of  $\text{W}(\text{Cp})_2(\text{CO})_2$  is

(Cp = cyclopentadienyl)

- (a)  $[\text{W}(\eta^1\text{-Cp})(\eta^3\text{-Cp})(\text{CO})_2]$                       (b)  $[\text{W}(\eta^1\text{-Cp})(\eta^5\text{-Cp})(\text{CO})_2]$   
 (c)  $[\text{W}(\eta^3\text{-Cp})(\eta^5\text{-Cp})(\text{CO})_2]$                       (d)  $[\text{W}(\eta^5\text{-Cp})(\text{CO})_2]$

Q.32 Match the metalloprotein with their respective functions.

P	Ferritin	I	Electron transfer
Q	Rubredoxin	II	Acid-base catalysis
R	Cobalamin	III	Metal storage
S	Carbonic anhydrase	IV	Methyl transfer

- (a) P – III; Q – II; R – I; S – IV  
 (b) P – III; Q – I; R – IV; S – II  
 (c) P – IV; Q – I; R – III; S – II  
 (d) P – IV; Q – II; R – I; S – III

Q.33 Suppose the wave function of a one-dimensional system is

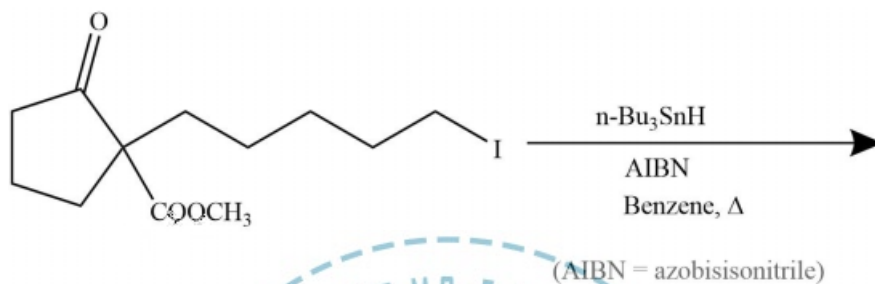


$$\psi = \sin(kx) \exp(3ikx)$$

In an experiment measuring the momentum of the system, one of the expected outcomes is

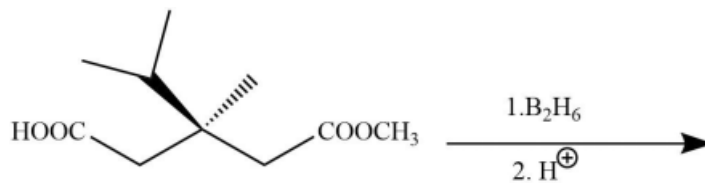
- (a) 0                      (b)  $\hbar$                       (c)  $2\hbar k$                       (d)  $3\hbar k$

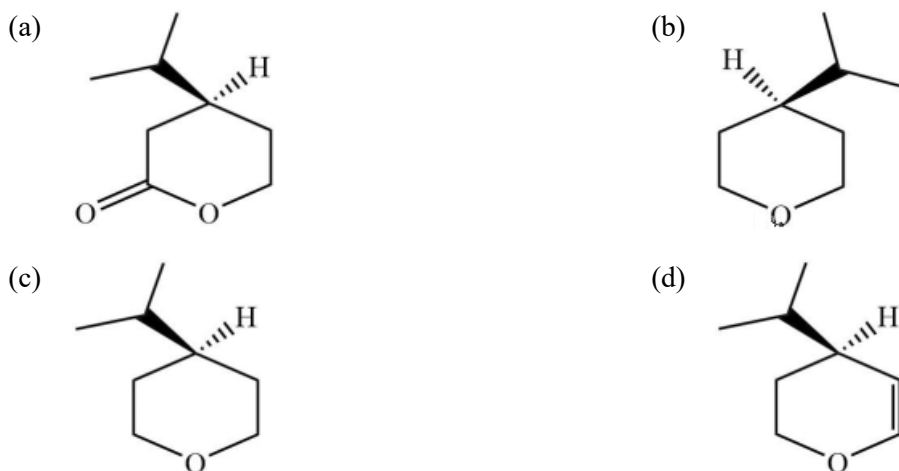
Q.34 The major product formed in the following reaction is



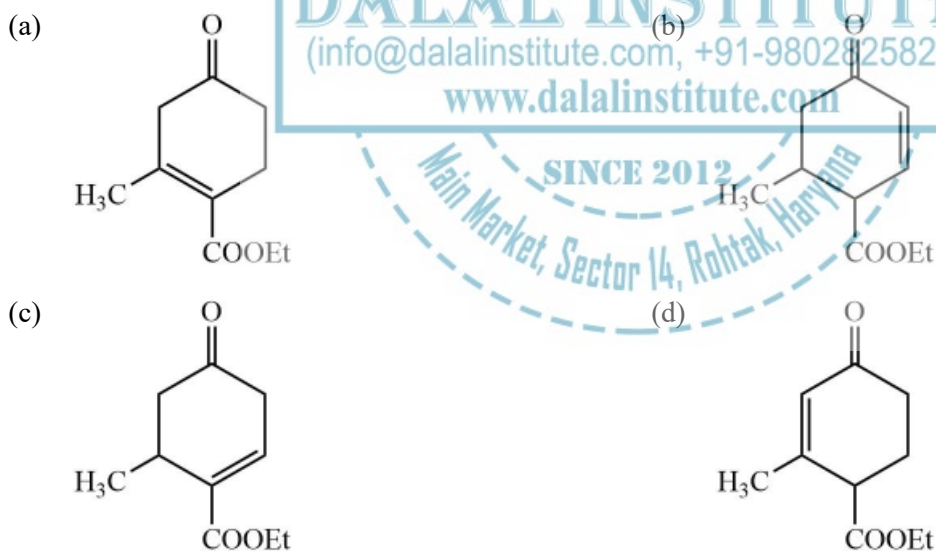
- (a)
- (b)
- (c)
- (d)

Q.35 The major product formed in the following reaction is

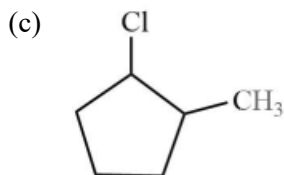
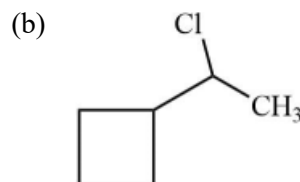
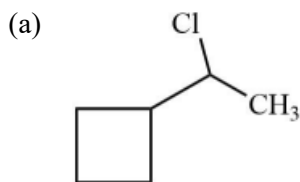
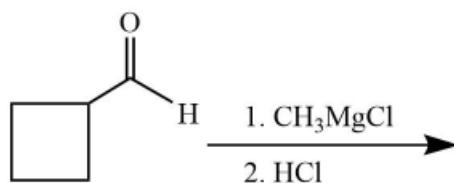




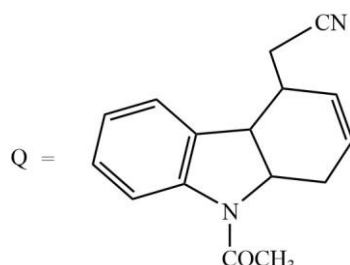
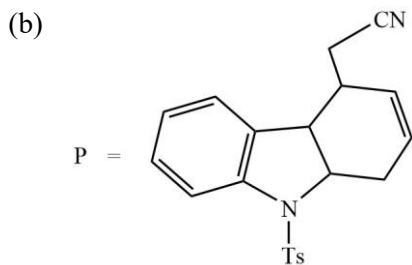
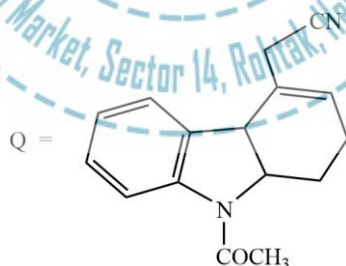
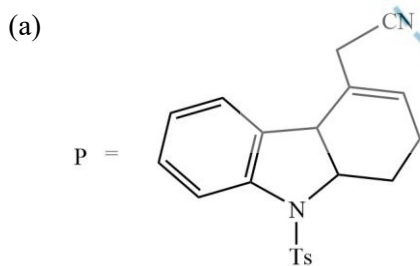
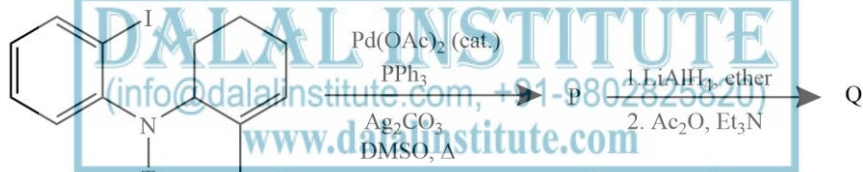
Q.36 The major product formed in the following reaction is



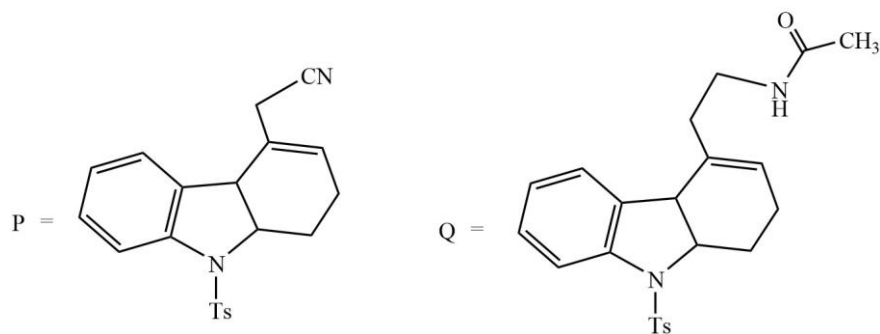
Q.37 The major product of the following reaction is



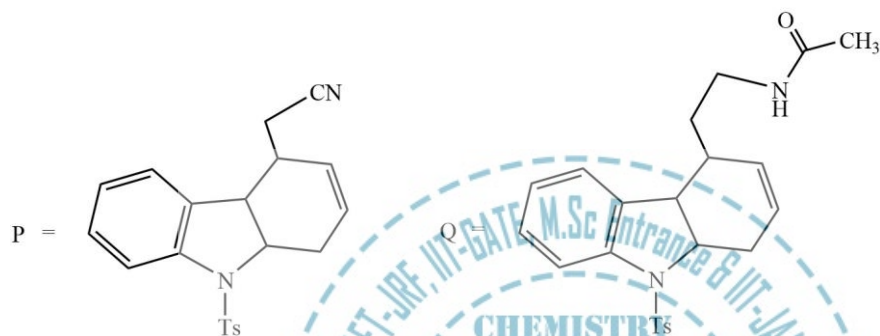
Q.38 In following reaction sequence, the product P and Q are



(c)



(d)

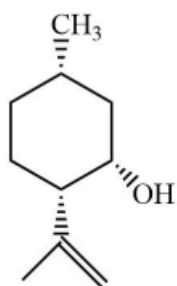


Q.39 The major product formed in the following reaction is

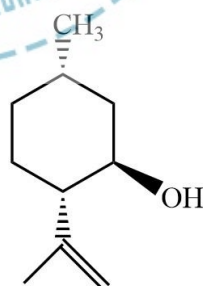


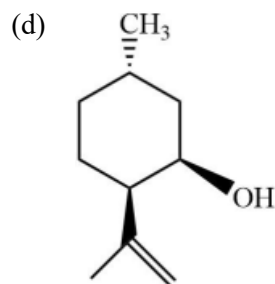
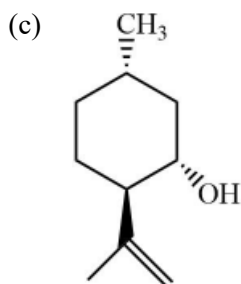
(PCC = pyridinium chlorochromate)

(a)

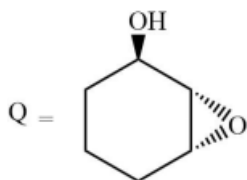
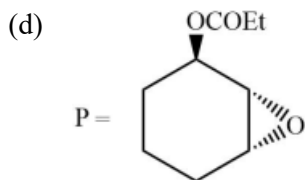
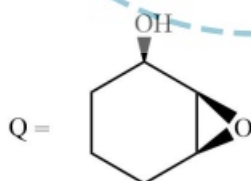
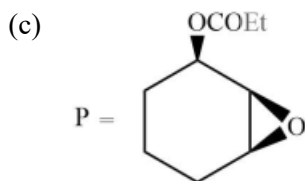
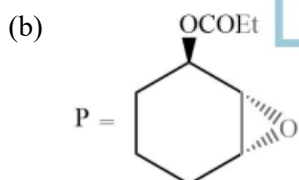
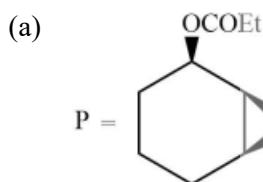
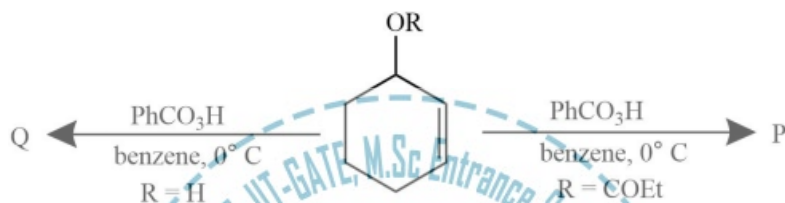


(b)

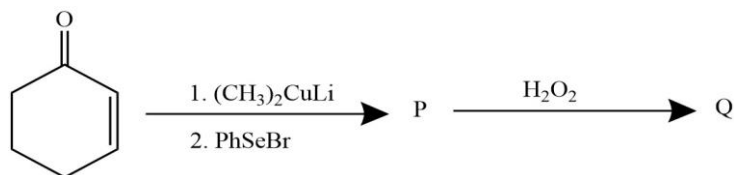




Q.40 In the following reactions, the major product P and Q are

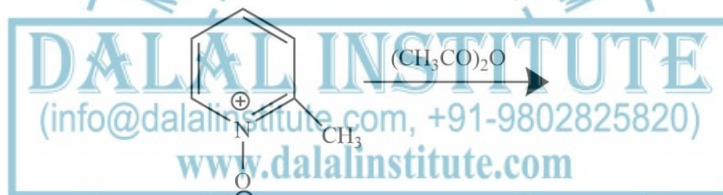


Q.41 In the following reaction sequence, the products P and Q are



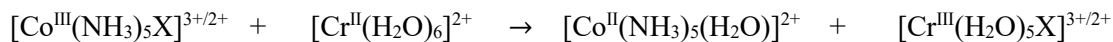
- (a)  $P =$   $Q =$
- (b)  $P =$   $Q =$
- (c)  $P =$   $Q =$
- (d)  $P =$   $Q =$

Q.42 The major product formed in following reaction is



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

Q.43 The rate of the following redox reaction is slow when X is



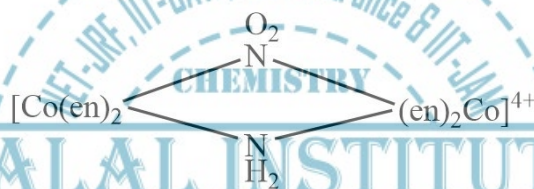
- (a)  $\text{H}_2\text{O}$                       (b)  $\text{NH}_3$                       (c)  $\text{Cl}^-$                       (d)  $\text{N}_3^-$

Q.44 A complex is composed of one chromium ion, three bromides and six water molecules. Upon addition of excess  $\text{AgNO}_3$ , 1.0 g aqueous solution of the complex gave 0.94 g of  $\text{AgBr}$ . The molecular formula of the complex is

(Atomic weight: Cr = 52, Br = 80, Ag = 108, O = 16 and H = 1)

- (a)  $[\text{Cr}(\text{H}_2\text{O})_6] \text{Br}_3$                       (b)  $[\text{Cr}(\text{H}_2\text{O})_5\text{Br}] \text{Br}_2 \cdot \text{H}_2\text{O}$   
 (c)  $[\text{Cr}(\text{H}_2\text{O})_4\text{Br}_2] \text{Br} \cdot 2\text{H}_2\text{O}$                       (d)  $[\text{Cr}(\text{H}_2\text{O})_3\text{Br}_3] \cdot 3\text{H}_2\text{O}$

Q.45 The number of possible optically active isomer(s) for the following complex is .....

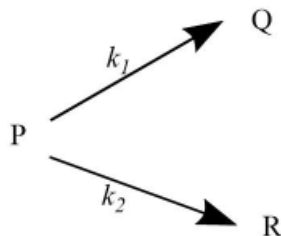


en = ethylenediamine



Q.46 The specific rotation of optically pure (R)-2-bromobutane is  $-112.00$ . A given sample of 2-bromobutane exhibited a specific rotation of  $-82.88$ . The percentage of (S)-(+)-enantiomer present in this sample is .....

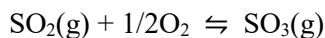
Q.47 Consider the following two parallel irreversible first order reactions at temperature T,



where  $k_1$  and  $k_2$  are the rate constants and their values are  $5 \times 10^{-2}$  and  $15 \times 10^{-2} \text{ min}^{-1}$ , respectively, at temperature T. If the concentration of the reactant 'P' is  $4 \text{ mol L}^{-1}$ , then the concentration of product 'R' after 10 min of reaction is .....  $\text{mol L}^{-1}$ . (Round off to two decimal places)

(Assume only P is present at the beginning of the reaction.)

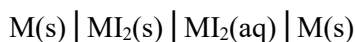
Q.48 consider the following equilibrium



At 298 K, the standard molar Gibbs energies of formation,  $\Delta_f G^\circ$ , of  $\text{SO}_2(\text{g})$  and  $\text{SO}_3(\text{g})$  are  $-300$  and  $-371$  KJ  $\text{mol}^{-1}$ , respectively. The value of the equilibrium constant,  $K_p$ , at this temperature is  $\dots\dots\dots \times 10^{10}$ . (Round off to nearest integer)

(Gas constant  $R = 8.31$  J  $\text{mol}^{-1}$   $\text{K}^{-1}$ )

Q.49 Consider the electrochemical cell



Where 'M' is a metal. At 298 K, the standard reduction potentials are

$E_{\text{M}^{2+}(\text{aq})/\text{M}(\text{s})}^\circ = -0.12$  V,  $E_{\text{MI}_2(\text{s})/\text{M}(\text{s})}^\circ = -0.36$  V and the temperature coefficient is  $\left(\frac{\partial E_{\text{cell}}^\circ}{\partial T}\right)_P = 1.5 \times 10^{-4}$  V  $\text{K}^{-1}$ . At this temperature standard enthalpy change for the overall reaction,  $\Delta_r H^\circ$ , is  $\dots\dots\dots$  kJ  $\text{mol}^{-1}$ . (Round off to two decimal places)

(Faraday constant  $F = 96500$  C  $\text{mol}^{-1}$ )

Q.50 The normal boiling point of a compound (X) is 350 K (heat of vaporization,  $\Delta H_{\text{vap}} = 30$  kJ  $\text{mol}^{-1}$ ). The pressure required to boil 'X' at 300 K is  $\dots\dots\dots$  Torr. (Round off to two decimal places)

(Ignore the temperature variation of  $\Delta H_{\text{vap}}$ ; Gas constant  $R = 8.31$  J  $\text{mol}^{-1}$   $\text{K}^{-1}$  and 1 atm = 760 Torr)

Q.51 For a biomolecular gas phase reaction  $\text{P} + \text{Q} \rightarrow \text{R}$ , the pre-exponential factor is  $1 \times 10^{13}$   $\text{dm}^3$   $\text{mol}^{-1}$   $\text{s}^{-1}$ . The standard entropy of activation at 25 °C is  $\dots\dots\dots$  J  $\text{mol}^{-1}$   $\text{K}^{-1}$ . (Round off to two decimal points)

(The standard concentration  $c^\circ = 1$  mol  $\text{dm}^{-3}$ ; Planck constant  $h = 6.626 \times 10^{-34}$  J s; Boltzmann constant  $k_B = 1.38 \times 10^{-23}$  J  $\text{K}^{-1}$ ; Gas constant  $R = 8.31$  J  $\text{mol}^{-1}$   $\text{K}^{-1}$ )

Q.52 Character table of point group  $D_8$  is given below.

$D_8$	E	$2C_8$	$2C_4$	$2C_8^3$	$C_2$	$4C_2$	$4C_2''$
$A_1$	a	1	1	1	1	1	1
$A_2$	b	1	1	1	1	h	i
$B_1$	c	-1	1	-1	1	1	j



B <sub>2</sub>	d	-1	1	-1	1	-1	1
E <sub>1</sub>	e	$\sqrt{2}$	0	$-\sqrt{2}$	-2	0	0
E <sub>2</sub>	f	0	-2	0	k	0	0
E <sub>3</sub>	g	$-\sqrt{2}$	0	$\sqrt{2}$	-2	0	0

Value of (a + b + c + d + e + f + g + h + i + j + k) is equal to .....

Q.53 If  $\langle \alpha | \hat{S}_x \hat{S}_y - \hat{S}_y \hat{S}_x | \alpha \rangle = ih^2 a$ , where spin angular momentum operators and is spin up eigen function, then the value of 'a' is ..... (Round off to one decimal places)

Q.54 A particle in one dimensional box of length 2a with potential energy

$$V = \begin{cases} 0, & |x| < a \\ \infty, & |x| \geq a \end{cases}$$

is perturbed by the potential  $V = cx$  eV, where c is a constant. The 1<sup>st</sup> order correction to the 1<sup>st</sup> excited state of the system is .....  $\times c$  eV.

Q.55 consider a two-dimensional system harmonic oscillator with angular frequency  $\omega_x = 2\omega_y = 6.5 \times 10^{14}$  rad s<sup>-1</sup>. The wavelength of x-polarised light required for excitation of a particle from its ground state to the next excited state is .....  $\times 10^{-6}$  m. (Round off to one decimal place)

(speed of light =  $3.0 \times 10^8$  m s<sup>-1</sup>)

Section-B

**Q.56 – Q.60 carry one mark each.**

Q.56 John Thomas, an ..... writer, passed away in 2018.

- |              |               |
|--------------|---------------|
| (a) Imminent | (b) Prominent |
| (c) Eminent  | (d) Dominant  |

Q.57.....I permitted him to leave, I wouldn't have had any problem with him being absent, ..... I?

- |                   |                    |
|-------------------|--------------------|
| (a) Had, wouldn't | (b) Have, would    |
| (c) Had, would    | (d) Have, wouldn't |

Q.58 A worker noticed that the hour hand on the factory clock had moved by 225 degrees during her stay at the factory. For how long he did she stay in the factory?

- (a) 3.75 hours (b) 4 hours and 15 mins  
(c) 8.5 hours (d) 7.5 hours

Q.59 The sum and product of two integer are 26 and 165 respectively. The difference these two integer is .....

- (a) 2 (b) 3 (c) 4 (d) 6

Q.60 the minister avoided any mention of the issue of women's reservation in the private sector. He was accused of ..... the issue.

- (a) Collaring (b) Skirting  
(c) Tying (d) Belting

Q.61 – Q.65 carry two mark each.

Q.61 Under a certain legal system, prisoners are allowed to make one statement. If their statement turns out to be true than they are hanged. If the statement turns out to be false, then they are shot. One prisoner made a statement and the judge had no option but to set him free. Which one of the following could be that statement?

- (a) I did not commit the crime  
(b) I committed the crime  
(c) I will be shot  
(d) You committed the crime

Q.62 A person divided an amount of Rs. 100,000 into two parts and invested in two different schemes. In one he got 10 percent profit and in other he got 12 percent. If the profit percentages are interchanged with these investments he would have got Rs.120 less. Find the ratio between his investments in the two schemes.

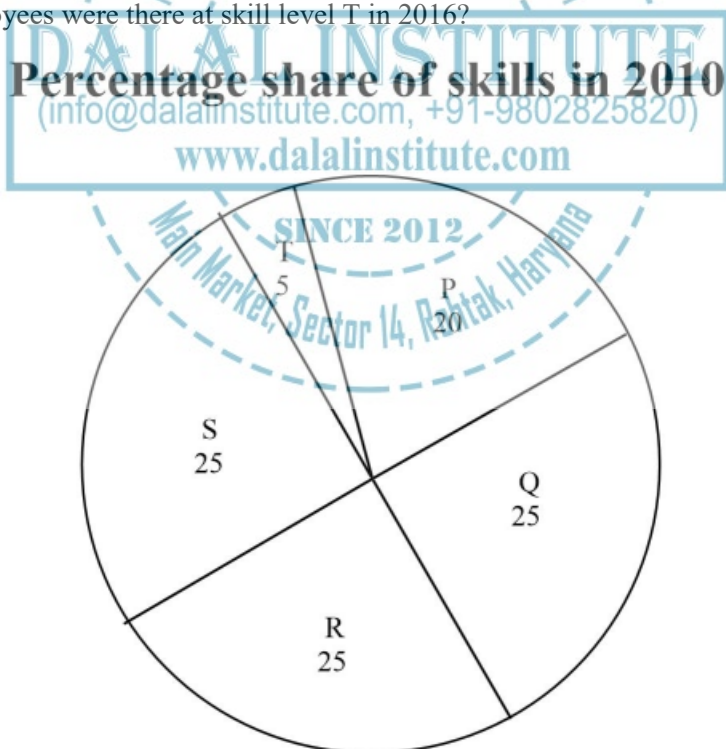
- (a) 9:16 (b) 11:14 (c) 37:63 (d) 47:53

Q.63 Congo was named by European's. Congo's dictator Mobuto later changed the name of the country and river to Zaire with the objective of Africanising names of the persons and spaces. However, the name Zaire was a Portuguese alteration of *Nzadi o Nzere*, a local African term meaning 'River with swallows Rivers'. Zaire was the Portuguese name for the Congo river in the 16<sup>th</sup> and 17<sup>th</sup> centuries.

Which one of the following statements can be informed from the paragraph above?

- (a) Mobuto was not entirely successful in Africanising the name of his country
- (b) The term *Nzadi o Nzere* was of Portuguese origin
- (c) Mobuto's desire to Africanise name was prevented by the Portuguese
- (d) As a dictator Mobuto ordered the Portuguese to alter the name of the river to Zaire

Q.64 A hires employees at five different skills level P, Q, R, S, T. The shares of employment at these skill levels of total employment in 2010 is given in pie chart as shown. There were a total of 600 employees in 2010 and total employment increased by 15% from 2010 to 2016. The total employment at skill levels P, Q and R are remained unchanged during this period. If the employment at skill level S increased by 40% from 2010 to 2016, how many employees were there at skill level T in 2016?



- (a) 30
- (b) 35
- (c) 60
- (d) 72

Q.65 M and N had four children P, Q, R and S. of them, only P and R were married. They had childer X and Y respectively. If Y is a legitimate child of W. which one of the following statements is necessarily FALSE?

- (a) M is the grandmother of Y
- (b) R is the father of Y
- (c) W is wife of R
- (d) W is wife of P



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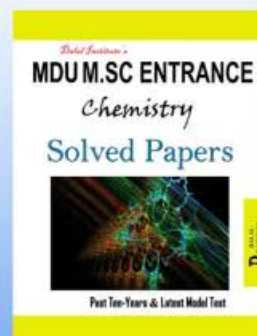
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