

CY: CHEMISTRY

Duration: Three Hours

Maximum Marks: 100

Read the following instructions carefully.

1. Write your name and registration number in the space provided at the bottom of this page.
2. Take out the **Optical Response Sheet (ORS)** from this Question Booklet **without breaking the seal**.
3. Do not open the seal of the Question Booklet until you are asked to do so by the invigilator.
4. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the **ORS**. Also, using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your test paper code (CY).
5. This Question Booklet contains **20** pages including blank pages for rough work. After opening the seal at the specified time, please check all pages and report discrepancy, if any.
6. There are a total of 65 questions carrying 100 marks. All these questions are of objective type. Questions must be answered on the left hand side of the **ORS** by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number. **For each question darken the bubble of the correct answer**. In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as an incorrect response.
7. Questions Q.1 – Q.25 carry 1-mark each, and questions Q.26 – Q.55 carry 2-marks each.
8. Questions Q.48 – Q.51 (2 pairs) are common data questions and question pairs (Q.52, Q.53) and (Q.54, Q.55) are linked answer questions. The answer to the second question of the linked answer questions depends on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is unattempted, then the answer to the second question in the pair will not be evaluated.
9. Questions Q.56 – Q.65 belong to General Aptitude (GA). Questions Q.56 – Q.60 carry 1-mark each, and questions Q.61 – Q.65 carry 2-marks each. The GA questions begin on a fresh page starting from page **14**.
10. Unattempted questions will result in zero mark and wrong answers will result in **NEGATIVE** marks. For Q.1 – Q.25 and Q.56 – Q.60, $\frac{1}{3}$ mark will be deducted for each wrong answer. For Q.26 – Q.51 and Q.61 – Q.65, $\frac{2}{3}$ mark will be deducted for each wrong answer. The question pairs (Q.52, Q.53), and (Q.54, Q.55) are questions with linked answers. There will be negative marks only for wrong answer to the first question of the linked answer question pair, i.e. for Q.52 and Q.54, $\frac{2}{3}$ mark will be deducted for each wrong answer. There is no negative marking for Q.53 and Q.55.
11. Calculator is allowed whereas charts, graph sheets or tables are **NOT** allowed in the examination hall.
12. Rough work can be done on the question paper itself. Additionally, blank pages are provided at the end of the question paper for rough work.

Name									
Registration Number	CY								

SOME USEFUL DATA

Planck constant, $h = 6.626 \times 10^{-34} \text{ J s}$

Avogadro number, $N_A = 6.022 \times 10^{23}$

Speed of light, $c = 3 \times 10^8 \text{ m s}^{-1}$

Gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1} = 0.08314 \text{ L bar K}^{-1} \text{ mol}^{-1} = 2 \text{ cal K}^{-1} \text{ mol}^{-1}$

Boltzmann constant, $k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$

Faraday constant, $F = 96500 \text{ C}$

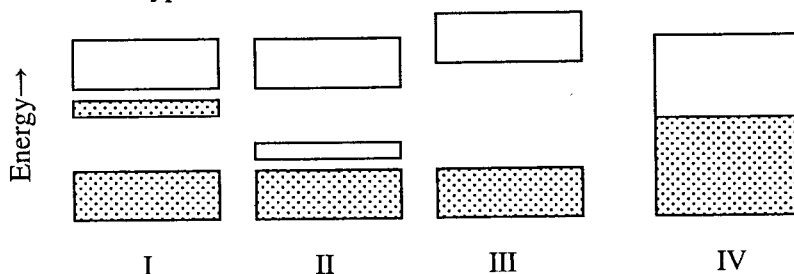
$\pi = 3.14$

Atomic Numbers

B	5	Ti	22
F	9	V	23
Al	13	Cr	24
Si	14	Mn	25
S	16	Co	27
Cl	17	Cu	29
As	33	Ru	44
Xe	54	Pt	78

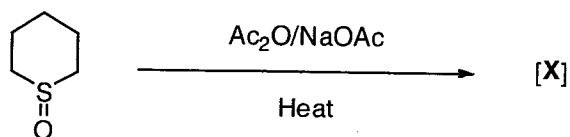
Q. 1 – Q. 25 carry one mark each.

- Q.1 Jahn-Teller distortion of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ acts to
 (A) raise symmetry
 (B) remove an electronic degeneracy
 (C) cause loss of H_2O ligand
 (D) promote a d-electron to an antibonding molecular orbital
- Q.2 Among the following, the group of molecules that undergoes rapid hydrolysis is
 (A) SF_6 , Al_2Cl_6 , SiMe_4
 (B) BCl_3 , SF_6 , SiCl_4
 (C) BCl_3 , SiCl_4 , PCl_5
 (D) SF_6 , Al_2Cl_6 , SiCl_4
- Q.3 The reaction of solid XeF_2 with AsF_5 in 1:1 ratio affords
 (A) XeF_4 and AsF_3
 (B) XeF_6 and AsF_3
 (C) $[\text{XeF}]^+[\text{AsF}_6]^-$
 (D) $[\text{Xe}_2\text{F}_3]^+[\text{AsF}_6]^-$
- Q.4 A well known naturally occurring organometallic compound is
 (A) vitamin B_{12} coenzyme
 (B) chlorophyll
 (C) cytochrome P-450
 (D) myoglobin
- Q.5 The complex that exists as a pair of enantiomers is
 (A) $\text{trans}-[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2\text{Cl}_2]^+$
 (B) $\text{cis}-[\text{Co}(\text{NH}_3)_4\text{Cl}_2]^+$
 (C) $[\text{Pt}(\text{PPh}_3)(\text{Cl})(\text{Br})(\text{CH}_3)]^-$
 (D) $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_3]^{3+}$
- Q.6 The region of electromagnetic spectrum employed in the electron spin resonance (ESR) spectroscopy is
 (A) radiowave
 (B) microwave
 (C) infrared
 (D) visible
- Q.7 The red color of oxyhaemoglobin is mainly due to the
 (A) d-d transition
 (B) metal to ligand charge transfer transition
 (C) ligand to metal charge transfer transition
 (D) intraligand $\pi-\pi^*$ transition
- Q.8 The band structure in an n-type semiconductor is

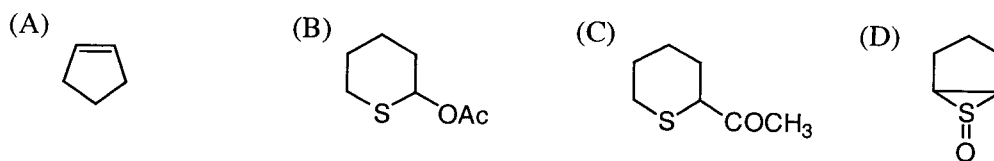


- (A) I (B) II (C) III (D) IV

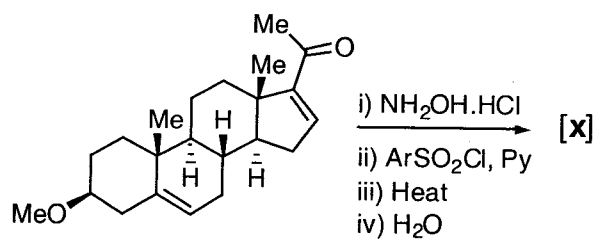
Q.9 In the following reaction



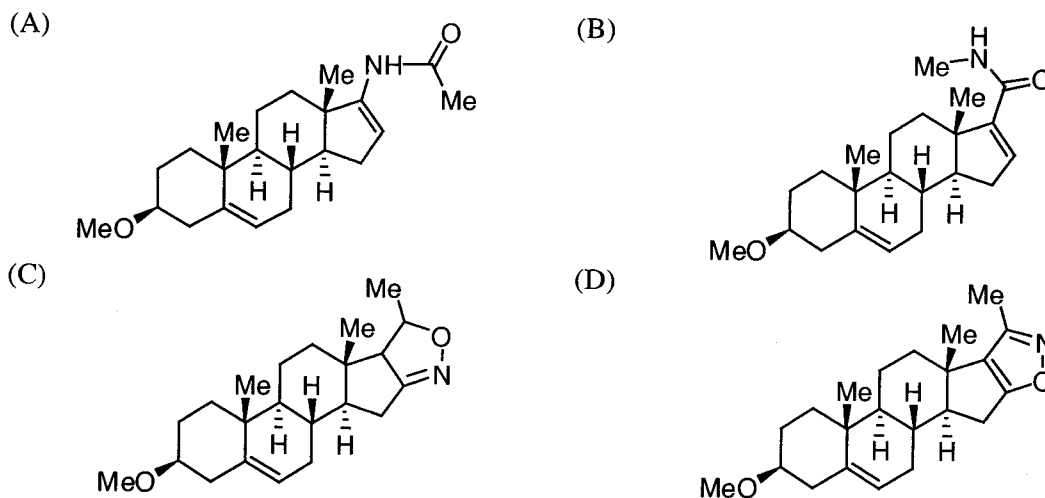
the major product [X] is



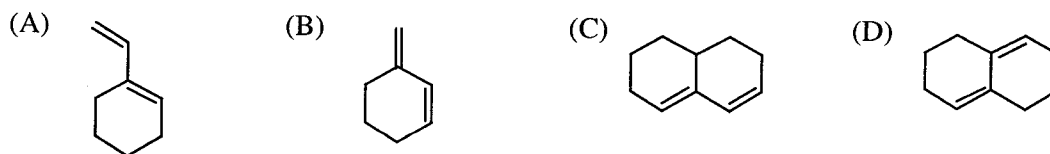
Q.10 In the following reaction sequence



the major product [X] is



Q.11 The diene which undergoes Diels-Alder reaction with maleic anhydride is

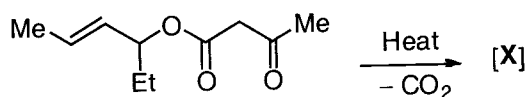


Q.12 The sequence of an mRNA molecule produced from a DNA template strand with the composition

5'-AGCTACACT-3' is

- (A) 5'-AGUGUAGCU-3'
 (B) 5'-UCGAUGUGA-3'
 (C) 5'-AGTGTAGCT-3'
 (D) 5'-TCGATGTGA-3'

Q.13 In the following reaction



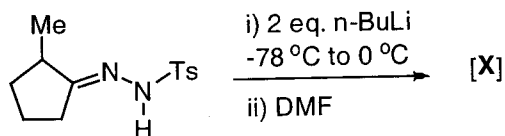
the major product [X] is

- (A)
- (B)
- (C)
- (D)

Q.14 The structure of the dipeptide Ala-Pro derived from the natural amino acids is

- (A)
- (B)
- (C)
- (D)

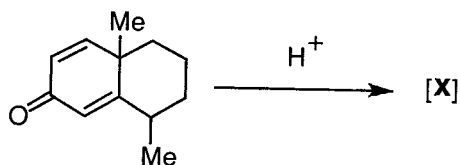
Q.15 In the following reaction



the major product [X] is

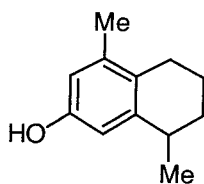
- (A)
- (B)
- (C)
- (D)

Q.16 In the following reaction

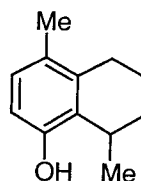


the major product [X] is

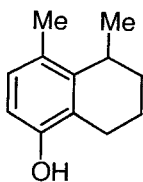
(A)



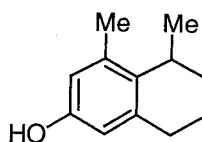
(B)



(C)



(D)



Q.17 For a given first order reaction, the reactant reduces to $1/4^{\text{th}}$ its initial value in 10 minutes. The rate constant of the reaction is

(A) 0.1386 min^{-1}

(B) 0.0693 min^{-1}

(C) $0.1386 \text{ mol L}^{-1} \text{ min}^{-1}$

(D) $0.0693 \text{ mol L}^{-1} \text{ min}^{-1}$

Q.18 The freezing point constant for water is $1.86 \text{ K (mol kg}^{-1})^{-1}$. The change in freezing point when 0.01 mol glucose is added to 1 kg water is

(A) 1.86 K

(B) -1.86 K

(C) 0.186 K

(D) -0.0186 K

Q.19 On the pressure-temperature diagram for a one-component system, the point where the solid-liquid and the liquid-gas curves intersect is

(A) triple point

(B) critical point

(C) melting point

(D) boiling point

Q.20 The wave function for a Harmonic oscillator described by $Nx \exp(-\alpha x^2 / 2)$ has

(A) one maximum only

(B) one maximum, one minimum only

(C) two maxima, one minimum only

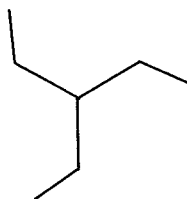
(D) two maxima, two minima only

- Q.21 If an arbitrary wave function is used to calculate the energy of a quantum mechanical system, the value calculated is never less than the true energy.

The above statement relates to

- (A) perturbation theory
 (B) variation principle
 (C) Heisenberg's uncertainty principle
 (D) quantization of energy

- Q.22 The point group symmetry of the given planar shape is

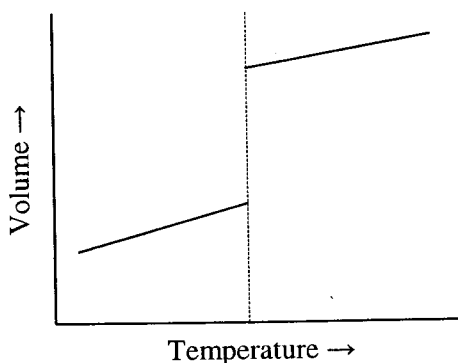


- (A) D_{3h} (B) C_3 (C) C_{3h} (D) C_{3v}

Q.23 $\left(\frac{\partial G}{\partial p}\right)_T =$

- (A) V (B) S (C) $-S$ (D) $-V$

Q.24



According to the Ehrenfest classification of phase transitions, the above diagram refers to

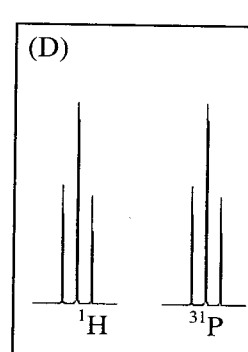
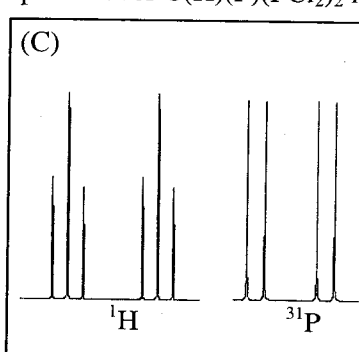
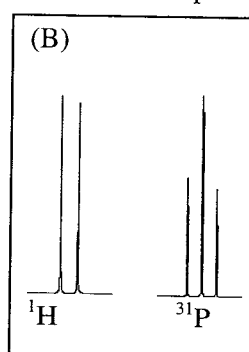
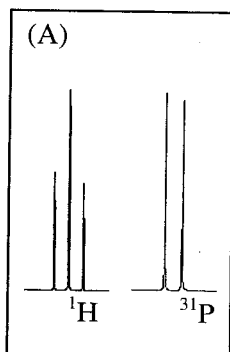
- (A) Zeroth order phase transition
 (B) First order phase transition
 (C) Second order phase transition
 (D) λ transition

- Q.25 According to conventional transition state theory, for elementary bimolecular reactions, the molar entropy of activation $\Delta S^{0\ddagger}$ is

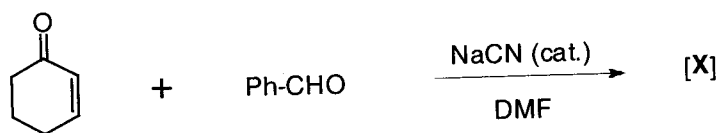
- (A) positive
 (B) zero
 (C) negative
 (D) positive for endothermic and negative for exothermic reactions

Q. 26 to Q. 55 carry two marks each.

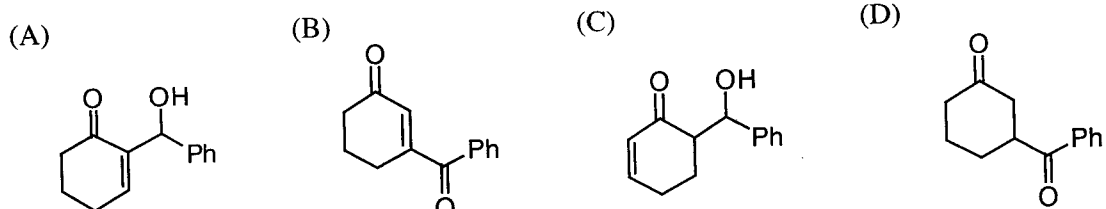
- Q.26 The crystal field stabilization energy (CFSE) value for $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ that has an absorption maximum at 492 nm is
 (A) $20,325 \text{ cm}^{-1}$ (B) $12,195 \text{ cm}^{-1}$ (C) $10,162 \text{ cm}^{-1}$ (D) $8,130 \text{ cm}^{-1}$
- Q.27 For Et_2AlX ($\text{X} = \text{PPh}_2^-, \text{Ph}^-, \text{Cl}^-$ and H^-), the tendency towards dimeric structure follows the order
 (A) $\text{PPh}_2^- > \text{Cl}^- > \text{H}^- > \text{Ph}^-$ (B) $\text{Cl}^- > \text{PPh}_2^- > \text{H}^- > \text{Ph}^-$
 (C) $\text{Ph}^- > \text{H}^- > \text{Cl}^- > \text{PPh}_2^-$ (D) $\text{H}^- > \text{Ph}^- > \text{PPh}_2^- > \text{Cl}^-$
- Q.28 In the isoelectronic series, VO_4^{3-} , CrO_4^{2-} and MnO_4^- , all members have intense charge transfer (CT) transitions. The **INCORRECT** statement is
 (A) CT transitions are attributed to excitations of electrons from ligand (σ) to metal (e)
 (B) MnO_4^- exhibits charge transfer at shortest wavelength among the three
 (C) The wavelengths of transitions increase in the order $\text{VO}_4^{3-} < \text{CrO}_4^{2-} < \text{MnO}_4^-$
 (D) The charge on metal nucleus increases in the order $\text{VO}_4^{3-} < \text{CrO}_4^{2-} < \text{MnO}_4^-$
- Q.29 The increasing order of wavelength of absorption for the complex ions:
 i) $[\text{Cr}(\text{NH}_3)_6]^{3+}$, ii) $[\text{CrCl}_6]^{3-}$, iii) $[\text{Cr}(\text{OH}_2)_6]^{3+}$, iv) $[\text{Cr}(\text{CN})_6]^{3-}$, is
 (A) $\text{iv} < \text{ii} < \text{i} < \text{iii}$ (B) $\text{iv} < \text{iii} < \text{ii} < \text{i}$ (C) $\text{iv} < \text{i} < \text{iii} < \text{ii}$ (D) $\text{ii} < \text{iii} < \text{i} < \text{iv}$
- Q.30 The total number of metal-metal bonds in $\text{Ru}_3(\text{CO})_{12}$ and $\text{Co}_4(\text{CO})_{12}$, respectively, is
 (A) 3 and 6 (B) 4 and 5 (C) zero and 4 (D) 3 and 4
- Q.31 According to VSEPR theory the shapes of $[\text{SF}_2\text{Cl}]^+$ and $[\text{S}_2\text{O}_4]^{2-}$ should be
 (A) trigonal planar for $[\text{S}_2\text{O}_4]^{2-}$ and trigonal pyramidal for $[\text{SF}_2\text{Cl}]^+$
 (B) both trigonal planar
 (C) trigonal pyramidal for $[\text{S}_2\text{O}_4]^{2-}$ and trigonal planar for $[\text{SF}_2\text{Cl}]^+$
 (D) both trigonal pyramidal
- Q.32 The product of the reaction between $\text{CH}_3\text{Mn}(\text{CO})_5$ and ^{13}CO is
 (A) $(\text{CH}_3^{13}\text{CO})\text{Mn}(\text{CO})_5$ (B) $(\text{CH}_3\text{CO})\text{Mn}(\text{CO})_4(^{13}\text{CO})$
 (C) $(^{13}\text{CH}_3\text{CO})\text{Mn}(\text{CO})_5$ (D) $\text{CH}_3\text{Mn}(\text{CO})_4$
- Q.33 The correct pair of ^1H and ^{31}P NMR spectral patterns for $\text{C}(\text{H})(\text{F})(\text{PCl}_2)_2$ is



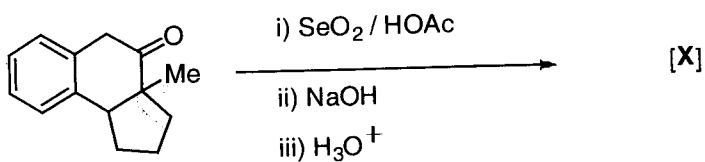
Q.34 In the following reaction



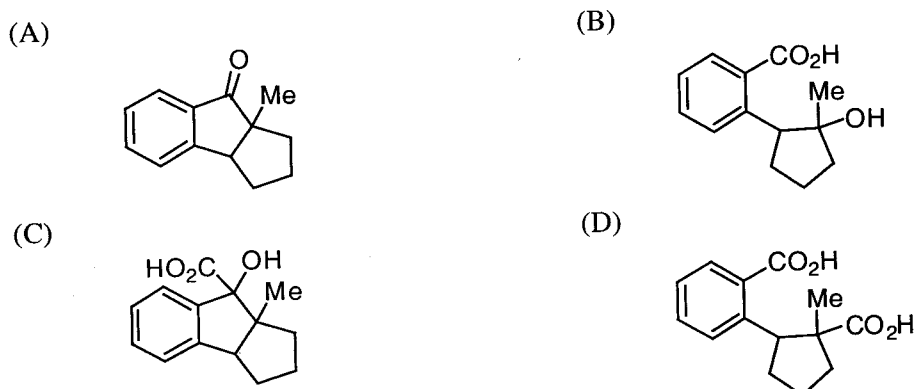
the major product [X] is



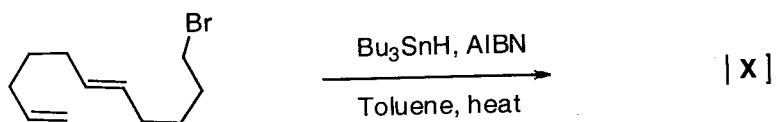
Q.35 In the following reaction



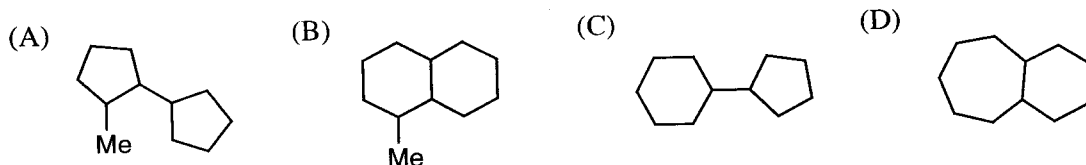
the major product [X] is



Q.36 In the following reaction



the major product [X] is



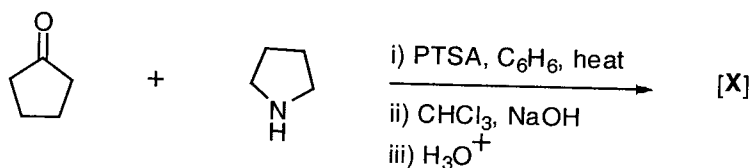
Q.37 The most appropriate sequence of reactions for carrying out the following conversion



is

- (A) (i) Peracid; (ii) H^+ ; (iii) Zn / dil. HCl
 (B) (i) Alkaline $KMnO_4$; (ii) $NaIO_4$; (iii) N_2H_4 / KOH
 (C) (i) Alkaline $KMnO_4$; (ii) H^+ ; (iii) Zn / dil. HCl
 (D) (i) O_3 / Me_2S ; (ii) $NaOEt$; (iii) N_2H_4 / KOH

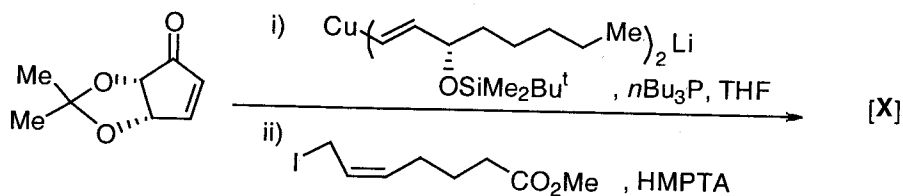
Q.38 In the following reaction sequence



the major product [X] is

- (A) (B) (C) (D)

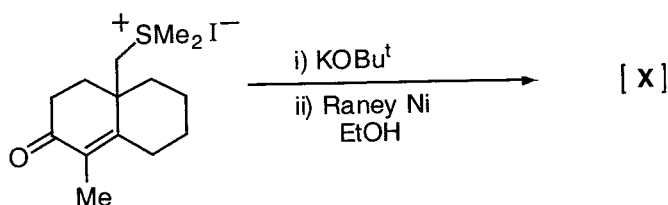
Q.39 In the following conversion



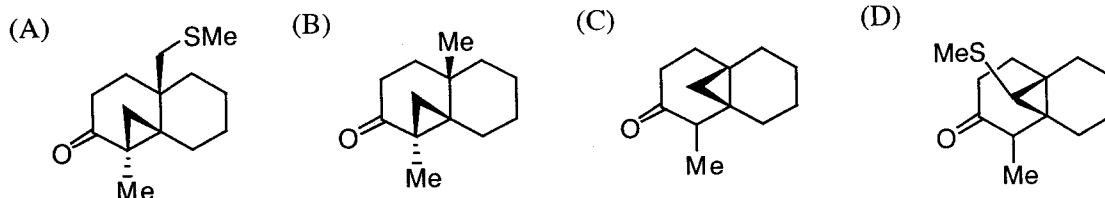
the major product [X] is

- (A) (B) (C) (D)

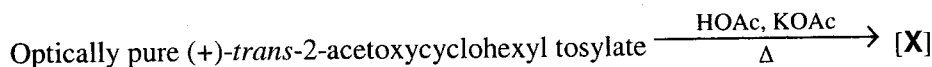
Q.40 In the following reaction



the major product [X] is



Q.41 In the reaction



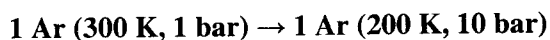
the major product [X] is

- (A) racemic *trans*-1,2-cyclohexanediol diacetate
 (B) optically active *trans*-1,2-cyclohexanediol diacetate
 (C) racemic *cis*-1,2-cyclohexanediol diacetate
 (D) optically active *cis*-1,2-cyclohexanediol diacetate

Q.42 The activity of water at 11 bar and 298 K is

- (A) 1.101 (B) 1.007 (C) 0.998 (D) 0.898

Q.43 For the process



assuming ideal gas behavior, the change in molar entropy is

- (A) $-27.57 \text{ J K}^{-1} \text{ mol}^{-1}$ (B) $+27.57 \text{ J K}^{-1} \text{ mol}^{-1}$
 (C) $-24.20 \text{ J K}^{-1} \text{ mol}^{-1}$ (D) $+24.20 \text{ J K}^{-1} \text{ mol}^{-1}$

Q.44 The wave function for a quantum mechanical particle in a 1-dimensional box of length 'a' is given

$$\text{by } \psi = A \sin \frac{\pi x}{a}$$

The value of 'A' for a box of length 200 nm is

- (A) $4 \times 10^4 \text{ (nm)}^2$ (B) $10\sqrt{2} \text{ (nm)}^{1/2}$ (C) $\sqrt{2}/10 \text{ (nm)}^{-1/2}$ (D) $0.1 \text{ (nm)}^{-1/2}$

Q.45 For 1 mole of a monoatomic ideal gas, the relation between pressure (p), volume (V) and average molecular kinetic energy ($\bar{\epsilon}$) is

(A) $p = \frac{N_A \bar{\epsilon}}{V}$ (B) $p = \frac{N_A \bar{\epsilon}}{3V}$ (C) $p = \frac{2N_A \bar{\epsilon}}{3V}$ (D) $p = \frac{2N_A \bar{\epsilon}}{3V \bar{\epsilon}}$

Q.46 For a 1 molal aqueous NaCl solution, the mean ionic activity coefficient (γ_{\pm}) and the Debye-Hückel Limiting Law constant (A) are related as

(A) $\log \gamma_{\pm} = \sqrt{2} A$ (B) $\log \gamma_{\pm} = -\sqrt{2} A$
 (C) $\gamma_{\pm} = 10^A$ (D) $\gamma_{\pm} = 10^{-A}$

Q.47 For the concentration cell

$M | M^+(\text{aq}, 0.01 \text{ mol dm}^{-3}) || M^+(\text{aq}, 0.1 \text{ mol dm}^{-3}) | M$
 the EMF (E) of the cell at a temperature (T) equals

(A) $2.303 \frac{RT}{F}$ (B) $-2.303 \frac{RT}{F}$
 (C) $E_{M^+/M}^0 + 2.303 \frac{RT}{F}$ (D) $E_{M^+/M}^0 - 2.303 \frac{RT}{F}$

Common Data Questions

Common Data for Questions 48 and 49:

A hypothetical molecule XY has the following properties

Reduced mass: 2×10^{-26} kg

X–Y bond length: 100 pm

Force constant of the bond: $8 \times 10^2 \text{ N.m}^{-1}$

Q.48 The frequency of radiation (in cm^{-1} units) required to vibrationally excite the molecule from $v = 0$ to $v = 1$ state is

(A) 3184.8 (B) 2123.2 (C) 1061.6 (D) 840.0

Q.49 The frequency of radiation (in cm^{-1} units) required to rotationally excite the molecule from $J = 0$ to $J = 1$ state is

(A) 1.4 (B) 2.8 (C) 3.2 (D) 3.6

Common Data for Questions 50 and 51:

Na_2HPO_4 and NaH_2PO_4 on heating at high temperature produce a chain sodium pentaphosphate quantitatively.

Q.50 The ideal molar ratio of Na_2HPO_4 to NaH_2PO_4 is

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

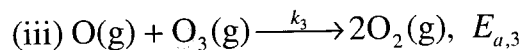
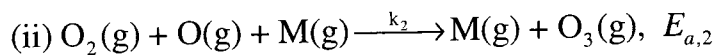
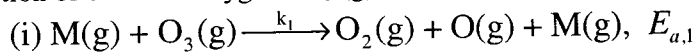
Q.51 The total charge on pentaphosphate anion is

(A) -5 (B) -3 (C) -7 (D) -9

Linked Answer Questions

Statement for Linked Answer Questions 52 and 53:

The decomposition of ozone to oxygen $2\text{O}_3(\text{g}) \rightarrow 3\text{O}_2(\text{g})$ occurs by the mechanism



where, M is the catalyst molecule.

k_i 's are rate constants and $E_{a,i}$'s the activation energies for the elementary steps.

Q.52 Under the steady state approximation for the intermediates, the rate of decomposition of ozone, $-\frac{d[\text{O}_3]}{dt}$, is

$$\text{(A) } \frac{2k_1k_3[\text{O}_3]^2[\text{M}]}{k_2[\text{O}_2][\text{M}] + k_3[\text{O}_3]}$$

$$\text{(B) } \frac{2k_1k_3[\text{O}_3]^2[\text{M}]}{k_2[\text{O}_2][\text{M}] - k_3[\text{O}_3]}$$

$$\text{(C) } \frac{2k_2k_3[\text{O}_3][\text{M}]}{k_2[\text{O}_2][\text{M}] + k_3[\text{O}_3]}$$

$$\text{(D) } \frac{2k_1k_2[\text{O}_3]^2[\text{M}]}{k_2[\text{O}_2][\text{M}] - k_3[\text{O}_3]}$$

Q.53 Assuming $k_3[\text{O}_3] \gg k_2[\text{O}_2][\text{M}]$, the activation energy of the overall reaction is

$$\text{(A) } \frac{E_{a,1}E_{a,3}}{E_{a,2}}$$

$$\text{(B) } E_{a,3} + E_{a,1} - E_{a,2}$$

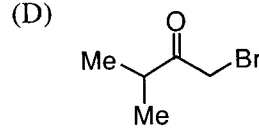
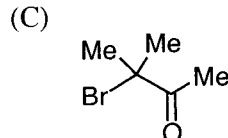
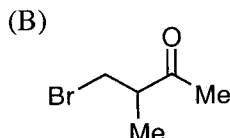
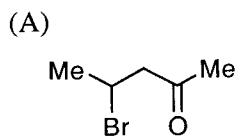
$$\text{(C) } E_{a,2}$$

$$\text{(D) } E_{a,1}$$

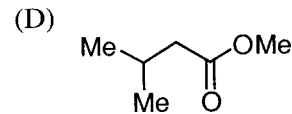
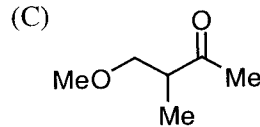
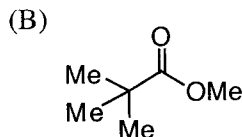
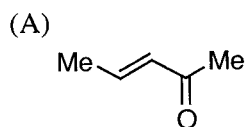
Statement for Linked Answer Questions 54 and 55:

A ketone on treatment with bromine in methanol gives the corresponding monobromo compound [X] having molecular formula $\text{C}_5\text{H}_9\text{BrO}$. The compound [X] when treated with NaOMe in MeOH produces [Y] as the major product. The spectral data for compound [X] are: ^1H NMR: δ 1.17 (d, 6H), 3.02 (m, 1H), 4.10 (s, 2H); ^{13}C NMR: δ 17, 37, 39, 210.

Q.54 The compound [X] is



Q.55 The major product [Y] is



General Aptitude (GA) Questions

Q. 56 – Q. 60 carry one mark each.

- Q.56 The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair:

Gladiator : Arena

- (A) dancer : stage
- (B) commuter : train
- (C) teacher : classroom
- (D) lawyer : courtroom

- Q.57 Choose the most appropriate word from the options given below to complete the following sentence:

Under ethical guidelines recently adopted by the Indian Medical Association, human genes are to be manipulated only to correct diseases for which _____ treatments are unsatisfactory.

- (A) similar
- (B) most
- (C) uncommon
- (D) available

- Q.58 Choose the word from the options given below that is most nearly opposite in meaning to the given word:

Frequency

- (A) periodicity
- (B) rarity
- (C) gradualness
- (D) persistency

- Q.59 Choose the most appropriate word from the options given below to complete the following sentence:

It was her view that the country's problems had been _____ by foreign technocrats, so that to invite them to come back would be counter-productive.

- (A) identified
- (B) ascertained
- (C) exacerbated
- (D) analysed

- Q.60 There are two candidates P and Q in an election. During the campaign, 40% of the voters promised to vote for P, and rest for Q. However, on the day of election 15% of the voters went back on their promise to vote for P and instead voted for Q. 25% of the voters went back on their promise to vote for Q and instead voted for P. Suppose, P lost by 2 votes, then what was the total number of voters?

- (A) 100 (B) 110 (C) 90 (D) 95

Q. 61 to Q. 65 carry two marks each.

- Q.61 **The horse has played a little known but very important role in the field of medicine. Horses were injected with toxins of diseases until their blood built up immunities. Then a serum was made from their blood. Serums to fight with diphtheria and tetanus were developed this way.**

It can be inferred from the passage, that horses were

- (A) given immunity to diseases
- (B) generally quite immune to diseases
- (C) given medicines to fight toxins
- (D) given diphtheria and tetanus serums

Q.62 The sum of n terms of the series $4+44+444+\dots$ is

- (A) $(4/81) [10^{n+1} - 9n - 1]$
 (B) $(4/81) [10^{n-1} - 9n - 1]$
 (C) $(4/81) [10^{n+1} - 9n - 10]$
 (D) $(4/81) [10^n - 9n - 10]$

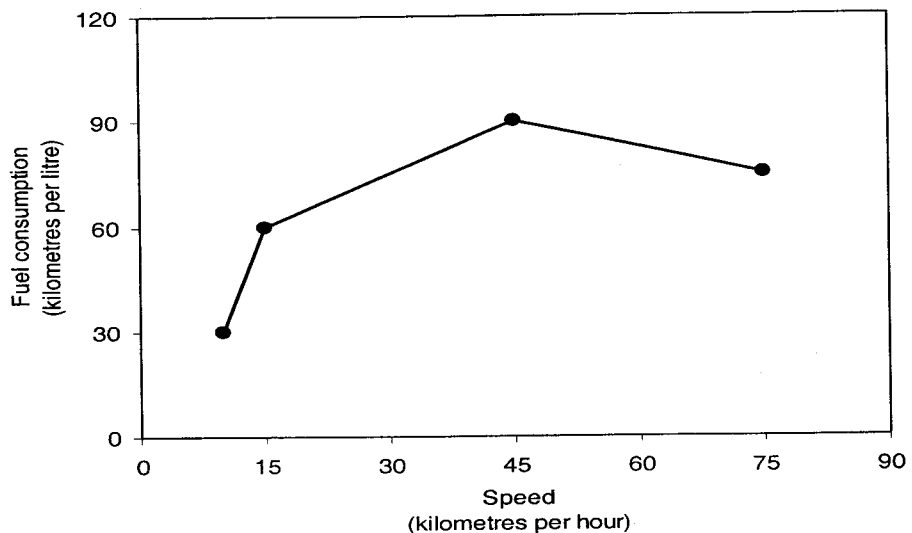
Q.63 Given that $f(y) = |y|/y$, and q is any non-zero real number, the value of $|f(q) - f(-q)|$ is

- (A) 0 (B) -1 (C) 1 (D) 2

Q.64 Three friends, R, S and T shared toffee from a bowl. R took $1/3^{\text{rd}}$ of the toffees, but returned four to the bowl. S took $1/4^{\text{th}}$ of what was left but returned three toffees to the bowl. T took half of the remainder but returned two back into the bowl. If the bowl had 17 toffees left, how many toffees were originally there in the bowl?

- (A) 38 (B) 31 (C) 48 (D) 41

Q.65 The fuel consumed by a motorcycle during a journey while traveling at various speeds is indicated in the graph below.



The distances covered during four laps of the journey are listed in the table below

Lap	Distance (kilometres)	Average speed (kilometres per hour)
P	15	15
Q	75	45
R	40	75
S	10	10

From the given data, we can conclude that the fuel consumed per kilometre was least during the lap

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

END OF THE QUESTION PAPER