

CY:CHEMISTRY

Duration: Three Hours

Maximum Marks:100

Please read the following instructions carefully:

General Instructions:

1. Total duration of examination is 180 minutes (3 hours).
2. The clock will be set at the server. The countdown timer in the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You will not be required to end or submit your examination.
3. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:



You have not visited the question yet.



You have not answered the question.



You have answered the question.



You have NOT answered the question, but have marked the question for review.



You have answered the question, but marked it for review.

The Marked for Review status for a question simply indicates that you would like to look at that question again. ***If a question is answered and Marked for Review, your answer for that question will be considered in the evaluation.***

Navigating to a Question

4. To answer a question, do the following:
 - a. Click on the question number in the Question Palette to go to that question directly.
 - b. Select an answer for a multiple choice type question. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
 - c. Click on **Save and Next** to save your answer for the current question and then go to the next question.
 - d. Click on **Mark for Review and Next** to save your answer for the current question, mark it for review, and then go to the next question.
 - e. **Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on its question number.**
5. You can view all the questions by clicking on the **Question Paper** button. Note that the options for multiple choice type questions will not be shown.

Answering a Question

6. Procedure for answering a multiple choice type question:
 - a. To select your answer, click on the button of one of the options
 - b. To deselect your chosen answer, click on the button of the chosen option again or click on the **Clear Response** button
 - c. To change your chosen answer, click on the button of another option
 - d. To save your answer, you MUST click on the **Save and Next** button

- e. To mark the question for review, click on the **Mark for Review and Next** button. *If an answer is selected for a question that is Marked for Review, that answer will be considered in the evaluation.*
7. Procedure for answering a numerical answer type question:
 - a. To enter a number as your answer, use the virtual numerical keypad
 - b. A fraction (eg., -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point
 - c. To clear your answer, click on the **Clear Response** button
 - d. To save your answer, you **MUST** click on the **Save and Next** button
 - e. To mark the question for review, click on the **Mark for Review and Next** button. *If an answer is entered for a question that is Marked for Review, that answer will be considered in the evaluation.*
8. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
9. Note that **ONLY** Questions for which answers are saved or marked for review after answering will be considered for evaluation.

Paper specific instructions:

1. There are a total of 65 questions carrying 100 marks. Questions are of multiple choice type or numerical answer type. A multiple choice type question will have four choices for the answer with only **one** correct choice. For numerical answer type questions, the answer is a number and no choices will be given. **A number as the answer should be entered** using the virtual keyboard on the monitor.
2. Questions Q.1 – Q.25 carry 1 mark each. Questions Q.26 – Q.55 carry 2 marks each. The 2 marks questions include two pairs of common data questions and two pairs of 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 not attempted, then the answer to the second question in the pair will not be evaluated.
3. Questions Q.56 – Q.65 belong to General Aptitude (GA) section and carry a total of 15 marks. Questions Q.56 – Q.60 carry 1 mark each, and questions Q.61 – Q.65 carry 2 marks each.
4. Questions not attempted will result in zero mark. Wrong answers for multiple choice type questions will result in **NEGATIVE** marks. For all 1 mark questions, $\frac{1}{3}$ mark will be deducted for each wrong answer. For all 2 marks questions, $\frac{2}{3}$ mark will be deducted for each wrong answer. However, in the case of the linked answer question pair, there will be negative marks only for wrong answer to the first question and no negative marks for wrong answer to the second question. There is no negative marking for questions of numerical answer type.
5. Calculator is allowed. Charts, graph sheets or tables are **NOT** allowed in the examination hall.
6. Do the rough work in the Scribble Pad provided.

USEFUL DATA - CY CHEMISTRY**COMMON DATA**

Planck constant	:	$6.626 \times 10^{-34} \text{ J s}$
Avogadro number	:	$6.022 \times 10^{23} \text{ mol}^{-1}$
Speed of light	:	$3 \times 10^8 \text{ m s}^{-1}$
Gas constant	:	$8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
	:	$0.08314 \text{ L bar K}^{-1} \text{ mol}^{-1}$
	:	$2 \text{ cal K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	:	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Faraday constant	:	96500 C mol^{-1}
π	:	3.14
Trouton's rule	:	$\Delta S_{\text{vap}} = 87 \text{ J K}^{-1} \text{ mol}^{-1}$
Atomic Numbers:		
Ca	:	20
V	:	23
Cr	:	24
Mn	:	25
Fe	:	26
Mo	:	42
Xe	:	54
Rn	:	86

Q. 1 – Q. 25 carry one mark each.

Q.1 The point group symmetry of $\text{CH}_2=\text{C}=\text{CH}_2$ is

- (A) D_{2h} (B) C_{2h} (C) C_{2v} (D) D_{2d}

Q.2 Two trial wave functions $\phi_1 = c_1 x(a-x)$ and $\phi_2 = c_1 x(a-x) + c_2 x^2(a-x)^2$ give ground state energies E_1 and E_2 , respectively, for the microscopic particle in a 1-D box by using the variation method. If the exact ground state energy is E_0 , the correct relationship between E_0 , E_1 and E_2 is

- (A) $E_0 = E_1 = E_2$ (B) $E_0 < E_1 < E_2$ (C) $E_0 < E_2 < E_1$ (D) $E_0 > E_2 = E_1$

Q.3 The ground state energies of H atom and H_2 molecule are -13.6 eV and -31.7 eV, respectively. The dissociation energy of H_2 is _____ eV.

Q.4 A 2 L vessel containing 2 g of H_2 gas at 27°C is connected to a 2 L vessel containing 176 g of CO_2 gas at 27°C . Assuming ideal behavior of H_2 and CO_2 , the partial pressure of H_2 at equilibrium is _____ bar.

Q.5 Consider the reaction $2\text{C}(s) + \text{O}_2(g) \rightleftharpoons 2\text{CO}(g)$ at equilibrium.

The equilibrium can be shifted towards the forward direction by

- (A) increasing the amount of carbon in the system.
 (B) decreasing the volume of the system.
 (C) decreasing the pressure of the system.
 (D) increasing the temperature of the system.

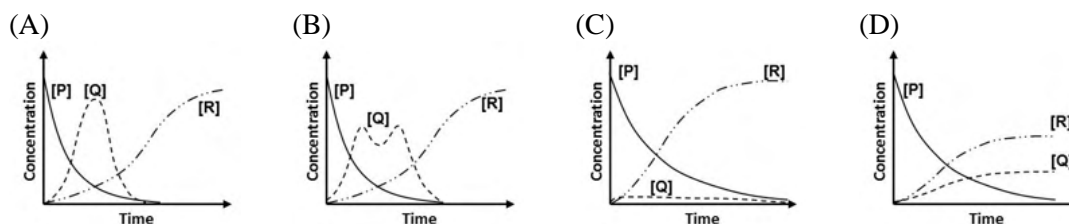
Q.6 A sparingly soluble electrolyte M_2X ionizes as $M_2X \rightleftharpoons 2M^+ + X^{2-}$

The solubility product (K_{sp}), molal solubility (S) and mean molal activity coefficient (γ_{\pm}) are related by

- (A) $K_{sp} = S^2 \gamma_{\pm}^2$ (B) $K_{sp} = S^3 \gamma_{\pm}^3$ (C) $K_{sp} = 4S^3 \gamma_{\pm}^2$ (D) $K_{sp} = 4S^3 \gamma_{\pm}^3$

Q.7 For the first order consecutive reaction $P \rightarrow Q \rightarrow R$,

under steady state approximation to $[Q]$, the variations of $[P]$, $[Q]$ and $[R]$ with time are best represented by

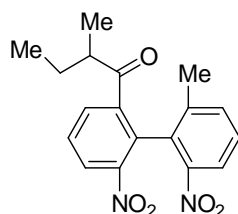


Q.8 At 273 K and 10 bar, the Langmuir adsorption of a gas on a solid surface gave the fraction of surface coverage as 0.01. The Langmuir adsorption isotherm constant is _____ bar^{-1} . (Give the answer to the third decimal place)

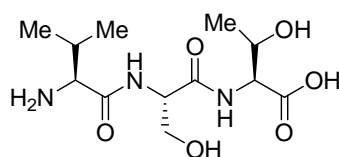
Q.9 Conversion of boron trifluoride to tetrafluoroborate accompanies

- (A) increase in symmetry and bond elongation
 (B) increase in symmetry and bond contraction
 (C) decrease in symmetry and bond contraction
 (D) decrease in symmetry and bond elongation

- Q.10 The correct statement with respect to the bonding of the ligands, Me_3N and Me_3P with the metal ions Be^{2+} and Pd^{2+} is,
- (A) the ligands bind equally strong with both the metal ions as they are dicationic
 (B) the ligands bind equally strong with both the metal ions as both the ligands are pyramidal
 (C) the binding is stronger for Me_3N with Be^{2+} and Me_3P with Pd^{2+}
 (D) the binding is stronger for Me_3N with Pd^{2+} and Me_3P with Be^{2+}
- Q.11 A crystal has the lattice parameters $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^\circ$. The crystal system is
 (A) tetragonal (B) monoclinic (C) cubic (D) orthorhombic
- Q.12 The by-product formed in the characteristic reaction of $(\text{CO})_5\text{Cr}=\text{C}(\text{OMe})(\text{Me})$ with MeNH_2 is
 (A) CO (B) MeOH (C) MeCHO (D) MeCONH_2
- Q.13 The catalyst and co-catalyst used in the Wacker process, respectively, are
 (A) PdCl_2 and Cu (B) CuCl_2 and $[\text{PdCl}_4]^{2-}$
 (C) Pd and CuCl (D) $[\text{PdCl}_4]^{2-}$ and CuCl_2
- Q.14 Oxymyoglobin $\text{Mb}(\text{O}_2)$ and oxyhemoglobin $\text{Hb}(\text{O}_2)_4$, respectively, are
 (A) paramagnetic and paramagnetic (B) diamagnetic and diamagnetic
 (C) paramagnetic and diamagnetic (D) diamagnetic and paramagnetic
- Q.15 Hapticity of cycloheptatriene in $\text{Mo}(\text{C}_7\text{H}_8)(\text{CO})_3$ is _____.
- Q.16 The number of oxygen molecule(s) that a molecule of hemerythrin can transport is _____.
- Q.17 The maximum number of stereoisomers possible for the compound given below is _____.

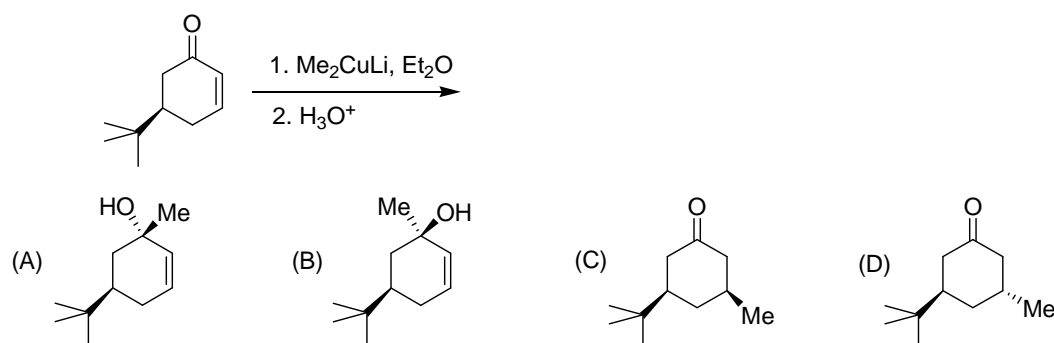


- Q.18 The correct sequence of the amino acids present in the tripeptide given below is

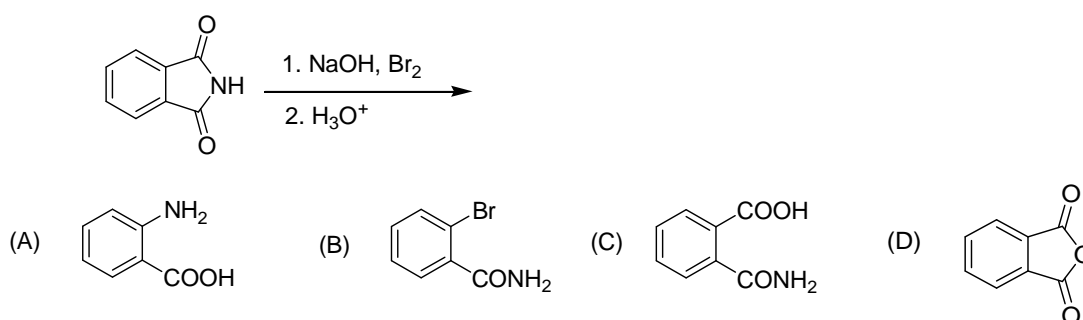


- (A) Val-Ser-Thr (B) Val-Thr-Ser (C) Leu-Ser-Thr (D) Leu-Thr-Ser
- Q.19 Among the compounds given in the options A-D, the one that can be used as a *formyl anion equivalent* (in the presence of a strong base) is
 (A) ethylene (B) nitroethane (C) 1,3-dithiane (D) 1,4-dithiane

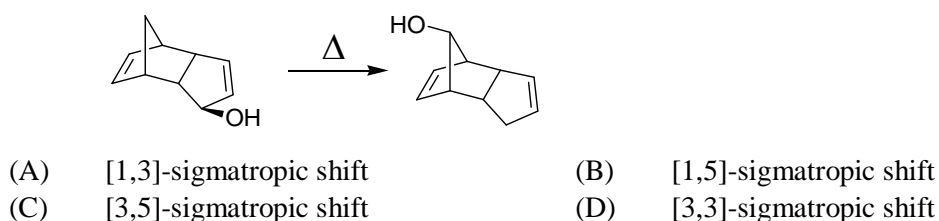
Q.20 The major product formed in the reaction given below is



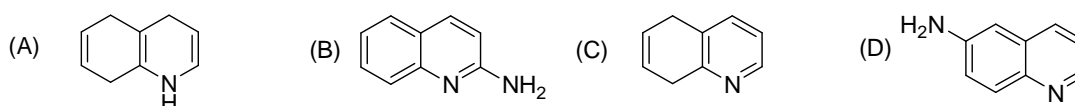
Q.21 The major product formed in the reaction given below is



Q.22 The pericyclic reaction given below is an example of



Q.23 The major product formed in the reaction of quinoline with potassium amide (KNH₂) in liquid ammonia is



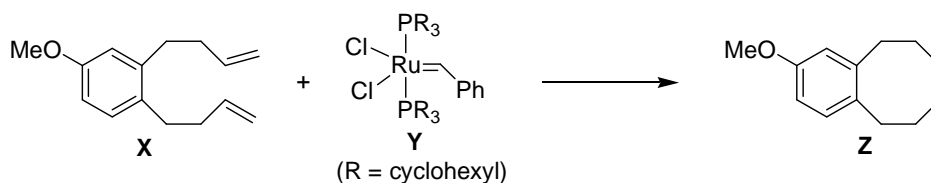
Q.24 The number of signals that appear in the proton decoupled ¹³C NMR spectrum of benzonitrile (C₇H₅N) is _____.

Q.25 Among the compounds given in the options A-D, the one that exhibits a sharp band at around 3300 cm⁻¹ in the IR spectrum is

- (A) 1,2-butadiene (B) 1,3-butadiene (C) 1-butyne (D) 2-butyne

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

- Q.26 In the metathesis reaction given below, 4.32 g of the compound **X** was treated with 822 mg of the catalyst **Y** to yield 2.63 g of the product **Z**. The mol% of the catalyst **Y** used in this reaction is _____. [Atomic weights of Ru = 101; P = 31; Cl = 35.5].



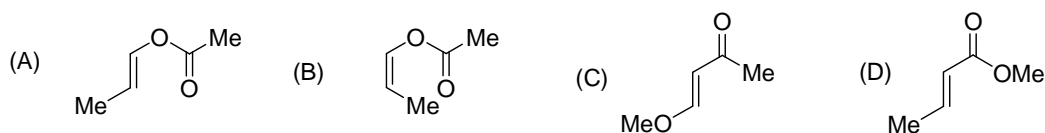
- Q.27 An organic compound **Q** exhibited the following spectral data:

IR: 1760 cm^{-1}

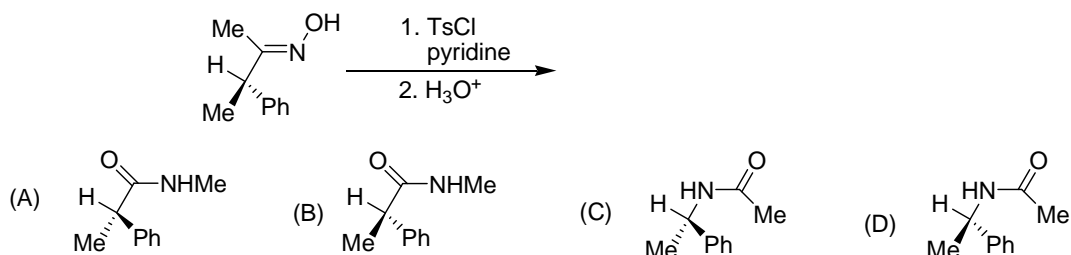
^1H NMR: δ (ppm): 7.2 (1H, d, $J = 16.0$ Hz), 5.1 (1 H, m), 2.1 (3 H, s), 1.8 (3H, d, $J = 7.0$ Hz)

^{13}C NMR: δ (ppm): 170 (carbonyl carbon).

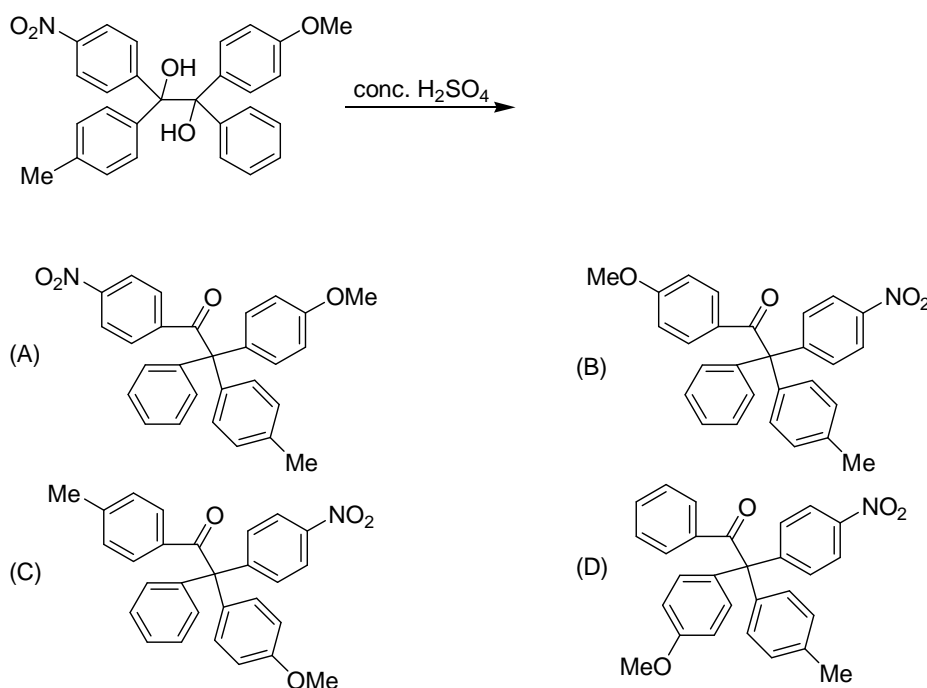
Compound **Q** is



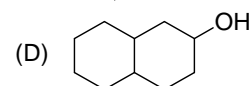
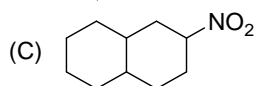
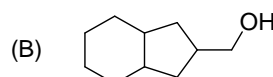
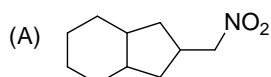
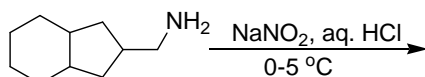
- Q.28 The major product formed in the Beckmann rearrangement of the compound given below is



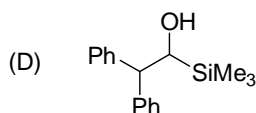
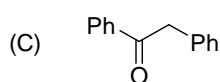
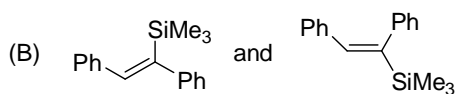
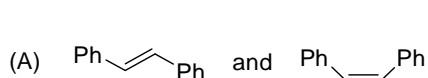
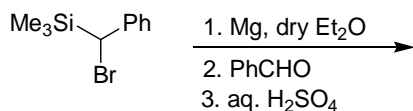
- Q.29 The major product formed in the reaction given below is



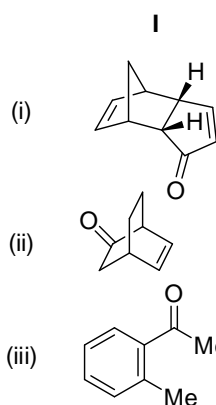
Q.30 The major product formed in the reaction given below is



Q.31 The major product(s) formed in the reaction sequence given below is(are)



Q.32 Match the compounds in the column I with the photochemical reactions that they can undergo given in the column II



II

(p) oxa-di- π -methane rearrangement

(q) Paterno-Buchi reaction

(r) intramolecular [2+2]-cycloaddition

(s) photoenolisation

(A) (i)-(q); (ii)-(s); (iii)-(p)

(B) (i)-(r); (ii)-(p); (iii)-(s)

(C) (i)-(p); (ii)-(r); (iii)-(q)

(D) (i)-(r); (ii)-(q); (iii)-(s)

Q.33 e^{-2x^2} is an eigen function of the operator $\left(\frac{d^2}{dx^2} - 16x^2\right)$. The corresponding eigen value is

(A) + 4

(B) - 4

(C) + 2

(D) - 2

Q.34 The infrared spectrum of HCl gas shows an absorption band centered at 2885 cm^{-1} . The zero point energy of HCl molecule under harmonic oscillator approximation is

(A) $2.8665 \times 10^{-22}\text{ J}$

(B) $2.8665 \times 10^{-20}\text{ J}$

(C) $5.7330 \times 10^{-22}\text{ J}$

(D) $5.7330 \times 10^{-20}\text{ J}$

- Q.35 For the reaction $X_2O_4(l) \longrightarrow 2XO_2(g)$ at 298 K, given the values, $\Delta U = 9 \text{ kJ}$ and $\Delta S = 84 \text{ J K}^{-1}$, ΔG is
 (A) -11.08 kJ (B) $+11.08 \text{ kJ}$ (C) -13.55 kJ (D) $+13.55 \text{ kJ}$
- Q.36 The change in enthalpy when 3 mol of liquid benzene transforms to the vapor state at its boiling temperature (80°C) and at 1 bar pressure is _____ kJ.
- Q.37 The moment of inertia of a homonuclear diatomic molecule is $7.5 \times 10^{-45} \text{ kg m}^2$. Its rotational partition function at 500 K is _____.
- Q.38 For a reaction of the type $X \xrightleftharpoons[k_2]{k_1} Y$, the correct rate expression is
 ($[X]_0$ and $[X]$ correspond to the concentrations of X at time $t=0$ and $t = t$, respectively)
 (A) $-\frac{d[X]}{dt} = k_1[X]_0 - (k_1 + k_2)[X]$ (B) $-\frac{d[X]}{dt} = (k_1 + k_2)[X] - k_2[X]_0$
 (C) $-\frac{d[X]}{dt} = (k_1 + k_2)[X]_0 - k_1[X]$ (D) $-\frac{d[X]}{dt} = (k_1 - k_2)[X] - k_1[X]_0$
- Q.39 The temperature dependence of partition functions are as follows:
 $q_{\text{translation}} \propto T^{3/2}$ $q_{\text{vibration}} \propto T^0$
 $q_{\text{rotation}} \propto T$ (linear molecule) $q_{\text{rotation}} \propto T^{3/2}$ (non-linear molecule)
 According to the conventional transition state theory (CTST), the temperature dependence of the Arrhenius pre-exponential factor for a reaction of the type given below is
 $\text{linear molecule} + \text{linear molecule} \rightleftharpoons \text{non-linear transition state} \rightarrow \text{products}$
 (A) T^{-1} (B) T^0 (C) T^1 (D) T^2
- Q.40 Decarbonylation reaction of $[cis-(CH_3CO)Mn(^{13}CO)(CO)_4]$ yields **X**, **Y** and **Z**, where
 $\text{X} = [(CH_3)Mn(CO)_5]$; $\text{Y} = [cis-(CH_3)Mn(^{13}CO)(CO)_4]$; $\text{Z} = [trans-(CH_3)Mn(^{13}CO)(CO)_4]$
 The molar ratio of the products (**X** : **Y** : **Z**) in this reaction is
 (A) 1 : 1 : 1 (B) 1 : 2 : 1 (C) 1 : 1 : 2 (D) 2 : 1 : 1
- Q.41 According to *polyhedral electron count rule*, the structure of $Rh_6(CO)_{16}$ is
 (A) *closo* (B) *nido* (C) *arachno* (D) *hypho*
- Q.42 The increasing order of melting points of the halides NaCl, CuCl and NaF is
 (A) $CuCl < NaCl < NaF$ (B) $NaF < NaCl < CuCl$
 (C) $NaF < CuCl < NaCl$ (D) $CuCl < NaF < NaCl$
- Q.43 The correct electronic configuration and spin only magnetic moment of Gd^{3+} (at.no. 64) are
 (A) $[Xe]4f^7$ and 7.9 BM (B) $[Xe]4f^7$ and 8.9 BM
 (C) $[Xe]4f^65d^1$ and 7.9 BM (D) $[Rn]5f^7$ and 7.9 BM
- Q.44 Among the following octahedral complexes, the one that has the highest enthalpy of hydration is
 (A) $[Ca(H_2O)_6]^{2+}$ (B) $[Mn(H_2O)_6]^{2+}$ (C) $[V(H_2O)_6]^{2+}$ (D) $[Cr(H_2O)_6]^{2+}$

- Q.45 A metal crystallizes in face-centered cubic lattice with a lattice parameter of 4.20 Å. The shortest atom to atom contact distance in the lattice is
 (A) 4.20 Å (B) 2.97 Å (C) 2.42 Å (D) 2.10 Å
- Q.46 Polarographic method of analysis to obtain individual amounts of Cu^{2+} and Cd^{2+} in a given mixture of the two ions (Cu^{2+} and Cd^{2+}) is achieved by measuring their
 (A) half-wave potentials
 (B) migration currents
 (C) decomposition potentials
 (D) diffusion currents
- Q.47 The ground state term of $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ is
 (A) ${}^3\text{T}_{1\text{g}}$ (B) ${}^3\text{T}_{2\text{g}}$ (C) ${}^3\text{A}_{2\text{g}}$ (D) ${}^4\text{T}_{1\text{g}}$

Common Data Questions

Common Data for Questions 48 and 49:

N,N-Dimethylformamide (DMF) gives different patterns of signals for the methyl protons when its ${}^1\text{H}$ NMR spectrum is recorded at different temperatures.

- Q.48 Match the patterns of the NMR signals given in column **I** with temperatures given in the column **II**.

I		II
(i) Two singlets, for three protons each, at δ 2.87 and 2.97 ppm		(x) 25 °C
(ii) One sharp singlet for six protons at δ 2.92 ppm		(y) 120 °C
(iii) One broad signal for six protons		(z) 150 °C
(A) (i)-(x); (ii)-(y); (iii)-(z)	(B) (i)-(x); (ii)-(z); (iii)-(y)	
(C) (i)-(z); (ii)-(x); (iii)-(y)	(D) (i)-(z); (ii)-(y); (iii)-(x)	

- Q.49 Based on the above data, the calculated difference in the frequencies of the two methyl singlets, if the spectrum is recorded on a 300 MHz spectrometer, is _____ Hz.

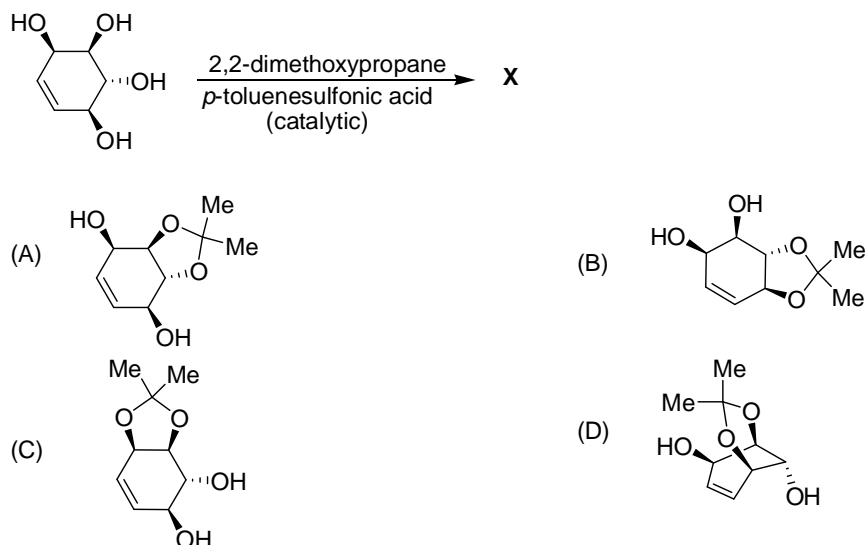
Common Data for Questions 50 and 51:

Heating a mixture of ammonium chloride and sodium tetrahydridoborate gives one liquid product (**X**), along with other products, under ambient conditions.

- Q.50 Compound **X** is
 (A) $\text{NH}_4[\text{BH}_4]$ (B) $[(\text{NH}_3)_2\text{BH}_2][\text{BH}_4]$
 (C) $\text{N}_3\text{B}_3\text{H}_6$ (D) $\text{N}_3\text{B}_3\text{H}_{12}$
- Q.51 Compound **X** is an example of
 (A) ionic liquid (B) saturated heterocycle
 (C) molecular cage (D) unsaturated heterocycle

Linked Answer Questions 52 and 53:

Q.52 The major product **X** formed in the reaction given below is



Q.53 Oxidation of the product **X**, obtained in the above reaction, with active manganese dioxide, followed by acidic hydrolysis gives

**Statement for Linked Answer Questions 54 and 55:**

The standard half-cell reduction potential of $Fe^{3+}(aq) | Fe$ is -0.036 V and that of $OH^{-}(aq) | Fe(OH)_3(s) | Fe$ is -0.786 V.

Q.54 For the determination of solubility product (K_{SP}) of $Fe(OH)_3$, the appropriate cell representation and its *emf* are, respectively,

- (A) $\langle Fe | Fe(OH)_3(s) | OH^{-}(aq) Fe^{3+}(aq) | Fe \rangle$, -0.750 V
- (B) $\langle Fe | Fe^{3+}(aq) OH^{-}(aq) | Fe(OH)_3(s) | Fe \rangle$, -0.750 V
- (C) $\langle Fe | Fe(OH)_3(s) | OH^{-}(aq) Fe^{3+}(aq) | Fe \rangle$, $+0.750$ V
- (D) $\langle Fe | Fe^{3+}(aq) OH^{-}(aq) | Fe(OH)_3(s) | Fe \rangle$, -0.822 V

Q.55 The value of $\log_e (K_{SP})$ for $Fe(OH)_3$ at 298 K is

- (A) -38.2 (B) $+87.6$ (C) -96.0 (D) -87.6

General Aptitude (GA) Questions**Q. 56 – Q. 60 carry one mark each.**

Q.56 If $3 \leq X \leq 5$ and $8 \leq Y \leq 11$ then which of the following options is TRUE?

(A) $\frac{3}{5} \leq \frac{X}{Y} \leq \frac{8}{5}$

(B) $\frac{3}{11} \leq \frac{X}{Y} \leq \frac{5}{8}$

(C) $\frac{3}{11} \leq \frac{X}{Y} \leq \frac{8}{5}$

(D) $\frac{3}{5} \leq \frac{X}{Y} \leq \frac{8}{11}$

Q.57 The Headmaster _____ to speak to you.

Which of the following options is incorrect to complete the above sentence?

(A) is wanting

(B) wants

(C) want

(D) was wanting

Q.58 Mahatma Gandhi was known for his humility as

(A) he played an important role in humiliating exit of British from India.

(B) he worked for humanitarian causes.

(C) he displayed modesty in his interactions.

(D) he was a fine human being.

Q.59 All engineering students should learn mechanics, mathematics and how to do computation.

I

II

III

IV

Which of the above underlined parts of the sentence is not appropriate?

(A) I

(B) II

(C) III

(D) IV

Q.60 Select the pair that best expresses a relationship similar to that expressed in the pair:
water: pipe::

(A) cart: road

(B) electricity: wire

(C) sea: beach

(D) music: instrument

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

Q.61 Velocity of an object fired directly in upward direction is given by $V = 80 - 32t$, where t (time) is in seconds. When will the velocity be between 32 m/sec and 64 m/sec?

- (A) $(1, 3/2)$ (B) $(1/2, 1)$
 (C) $(1/2, 3/2)$ (D) $(1, 3)$

Q.62 In a factory, two machines M1 and M2 manufacture 60% and 40% of the autocomponents respectively. Out of the total production, 2% of M1 and 3% of M2 are found to be defective. If a randomly drawn autocomponent from the combined lot is found defective, what is the probability that it was manufactured by M2?

- (A) 0.35 (B) 0.45 (C) 0.5 (D) 0.4

Q.63 Following table gives data on tourists from different countries visiting India in the year 2011.

Country	Number of Tourists
USA	2000
England	3500
Germany	1200
Italy	1100
Japan	2400
Australia	2300
France	1000

Which two countries contributed to the one third of the total number of tourists who visited India in 2011?

- (A) USA and Japan
 (B) USA and Australia
 (C) England and France
 (D) Japan and Australia

Q.64 If $|-2X + 9| = 3$ then the possible value of $|-X| - X^2$ would be:

- (A) 30 (B) -30 (C) -42 (D) 42

Q.65 All professors are researchers
 Some scientists are professors

Which of the given conclusions is logically valid and is inferred from the above arguments:

- (A) All scientists are researchers
 (B) All professors are scientists
 (C) Some researchers are scientists
 (D) No conclusion follows

END OF THE QUESTION PAPER