IIT-GATE: 2014

Chemistry

❖ Question Paper

Section-A

Q.1 – Q.25 carry one mark each.

Q.1 The maximum non-PV work that a system can perform at constant P is

(a) ΔH (b) ΔG (c) ΔS (d) ΔA

Q.2 Consider the reaction:

$$A + B \rightleftharpoons C$$

The unit of the thermodynamic equilibrium constant for the reaction is

(a) mol L^{-1} (b) L mol^{-1} (c) mol^2 L^{-2} (d) Dimensionless

Q.3 The number of IR active vibrational normal modes of CO_2 is _____

Q.4 The number of C_2 axes in CCl_4 is _____

Q.5 The value of the magnetic quantum number of a p_x orbital is

(a) −1 (b) 0 (c) +1 (d) undefined

Q.6 The molecular partition function for a system in which the energy levels are equispaced by ε, is

(a) $\frac{1}{1+e^{\beta\varepsilon}}$ (b) $\frac{1}{1-e^{\beta\varepsilon}}$ (c) $\frac{1}{1+e^{-\beta\varepsilon}}$ (d) $\frac{1}{1-e^{-\beta\varepsilon}}$

Q.7 A monoatomic gas, X, adsorbed on a surface, follows Langmuir adsorption isotherm. A plot of the fraction of surface coverage, θ, against the concentration of the gas [X], for VERY LOW concentration of the gas, is described by the equation

(a) $\theta = K[X]$ (b) $1 - \theta = \frac{1}{K[X]}$ (c) $\theta = K^{1/2}[X]^{1/2}$ (d) $\theta = \frac{K[X]}{1 - K[X]}$

Q.8 At a given temperature and pressure, the ratio of the average speed of hydrogen gas to that of helium gas is approximately _____

Q.9 An example of nido-borane from the following is

(a) B_4H_{10} (b) B_6H_{10} (c) B_6H_{12} (d) B_8H_{14}

Q.10 The geometries of $Ni(CO)_4$ and $[NiCl_4]^{2-}$, respectively, are

(a) Tetrahedral and square planar (b) Square planar and tetrahedral

(c) Tetrahedral and tetrahedral (d) Square planar and square planar

Q.11 The number of S–S bonds in $H_2S_5O_6$ is _____

Q.12 In atomic absorption spectroscopy, the atomization process utilizes

(a) Flame (b) Electric field (c) Magnetic field (d) Electron beam

Q.13 At room temperature, the number of singlet resonances observed in the ^1H NMR spectrum of $Me_3CC(O)NMe_2$ (N, N-dimethyl pivalamide) is _____

Q.14 Amongst the following, the metal that does NOT form homoleptic polynuclear metal carbonyl is

(a) Mn (b) Fe (c) Cr (d) Co

Q.15 The reaction of $[Cp_2TaMe_2]I$ ($Cp = C_5H_5^-$) with NaOMe yields

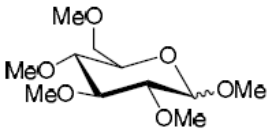
(a) $[Cp_2Ta(OMe)_2]I$ (b) $[Cp_2Ta(Me)OMe]I$

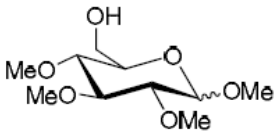
(c) $Cp_2Ta(Me)=CH_2$ (d) $Cp_2Ta(OMe)=CH_2$

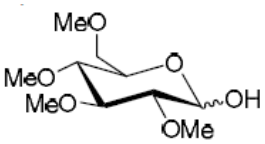
Q.16 The complexes $[Co(H_2O)_4Cl_2]NO_2$ and $[Co(H_2O)_4Cl(NO_2)]Cl$ are

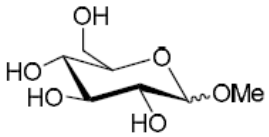
(a) Linkage isomers (b) Positional isomers (c) Ionization isomers (d) Optical isomers

Q.17 The major product of the following reaction is

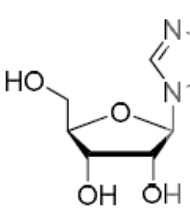
(a) 

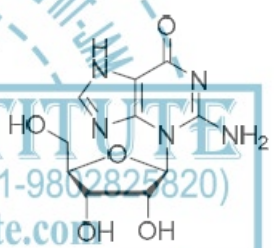
(b) 

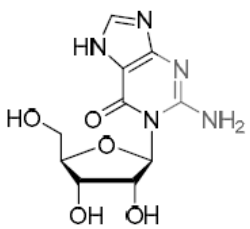
(c) 

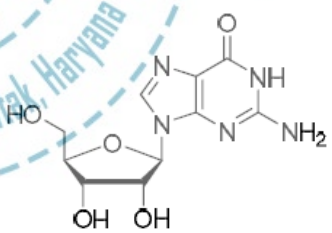
(d) 

Q.18 Amongst the following, the structure of guanosine is

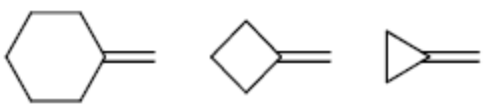
(a) 

(b) 

(c) 

(d) 

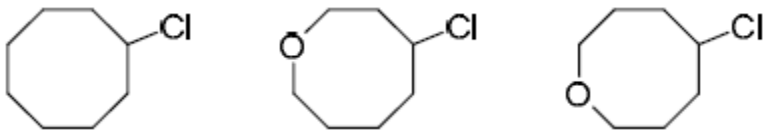
Q.19 The correct order of IR stretching frequency of the C=C in the following olefins is



I II III

(a) I > II > III (b) II > III > I (c) III > II > I (d) III > I > II

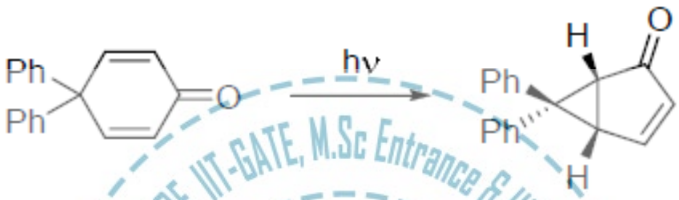
Q.20 The correct order of the rate of solvolysis for the following chlorides in acetic acid is



I II III

(a) II > I > III (b) III > II > I (c) III > I > II (d) I > III > II

Q.21 Formation of the product in the following photochemical reaction involves



(a) di-π-methane rearrangement (b) Paterno-Buchi reaction

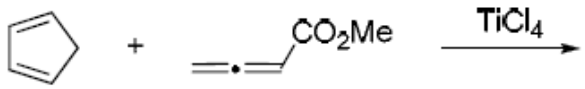
(c) [2,3]-sigmatropic rearrangement (d) Norrish type I reaction

Q.22 The correct order of stability for the following conformations of cyclohexane is

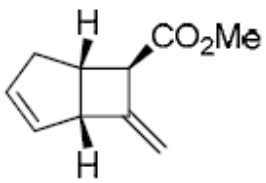
I II III

(a) I > II > III (b) I > III > II (c) II > I > III (d) III > I > II

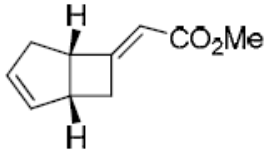
Q.23 The major product formed in the following reaction is

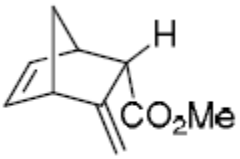


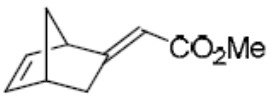
(a)



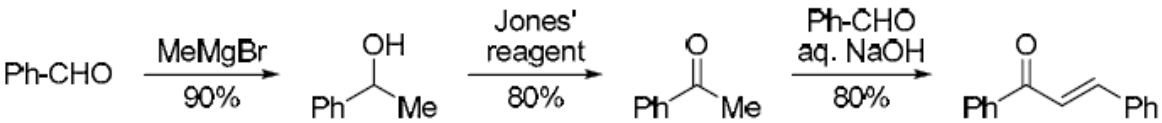
(b)



(c) 

(d) 

Q.24 The overall yield (in %) for the following reaction sequence is _____



Q.25 The most suitable reagent combination to effect the following conversion is

(a) i. NaH, CS_2, then MeI; ii. Bu_3SnH, AIBN, C_6H_6, reflux.

(b) i. I_2, PPh_3, imidazole; ii. H_2, 10% Pd-C, AcOH, high pressure.

(c) i. Me_3SiCl, pyridine, DMAP; ii. Bu_3SnH, AIBN, C_6H_6, reflux.

(d) i. MsCl, pyridine, DMAP; ii. $LiAlH_4$, THF, reflux.

Q.26 – Q.55 carry two marks each.

Q.26 $\psi = Nr(6 - Zr)e^{-Zr/3}\cos\theta$, is a proposed hydrogenic wavefunction, where Z = Atomic number, r = radial distance from the nucleus, θ = azimuthal angle, N is a constant. The INCORRECT statement about ψ is

(a) $\psi = 0$ in the xy-plane.

(b) Two radial nodes are present in ψ.

(c) One angular node is present in ψ

(d) The size of the orbital decreases with increase in atomic number.

Q.27 The van der Waals constants a and b of CO_2 are 3.64 L^2 bar mol^{-2} and 0.04 L mol^{-1}, respectively. The value of R is 0.083 bar dm^3 mol^{-1} K^{-1}. If one mole of CO_2 is confined to a volume of 0.15 L at 300 K, then the pressure (in bar) exerted by the gas, is _____

Q.28 A plot of osmotic pressure against concentration (g L^{-1}) of a polymer is constructed. The slope of the plot

(a) Increases with increase in temperature.

(b) Increases with increase in molar mass of the polymer.

(c) Decreases with decrease in concentration of the polymer

(d) Decreases with increase in temperature

Q.29 A platinum electrode is immersed in a solution containing 0.1 M Fe^{2}+ and 0.1 M Fe^{3+}. Its potential is found to be 0.77 V against SHE. Under standard conditions and considering activity coefficients to be equal to unity, the potential of the electrode, when the concentration of Fe^{3+} is increased to 1 M, is _____ .

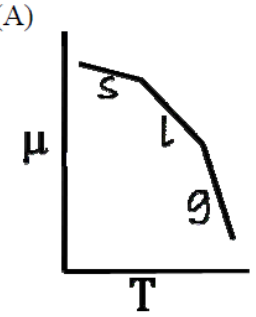
Q.30 Molybdenum crystallizes in a *bcc* structure with unit cell dimensions of 0.314 nm. Considering the atomic mass of molybdenum to be 96, its density (in kg m^{-3}) is _____.

Q.31 The ratio of molecules distributed between two states is 9.22×10^{6} at 300 K. The difference in Energy (in kJ mol^{-1}) of the two states is _____.

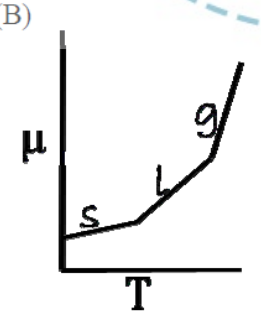
Q.32 A Carnot engine operates at 55% efficiency. If the temperature of reject steam is 105 °C, then the absolute temperature of input steam is _____ .

Q.33 Of the following plots, the correct representation of chemical potential(μ) against absolute temperature (7) for a pure substance is (*s*, *l* and g denote solid, liquid and gas phases, respectively)

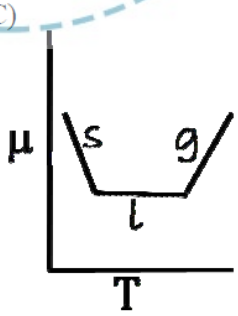
(A)



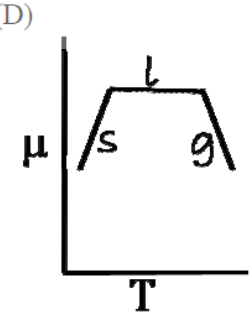
(B)



(C)



(D)



Q.34 The enthalpy of fusion of ice at 273 K is 6.01 kJ mol^{-1} and the enthalpy of vaporization of water at 273 K is 44.83 kJ mol^{-1}. The enthalpy of sublimation (in kJ mol^{-1}) of ice at 273 K, is _____

Q.35 Suppose Ψ_1 and Ψ_2, are two hybrid orbitals:

$\Psi_1 = 0.12\ \Psi_{3s} + 0.63\ \Psi_{3px}, + 0.77\ \Psi_{3py}$

and

$\Psi_2 = 0.12\ \Psi_{3s} - 0.63\ \Psi_{3px}, - 0.77\ \Psi_{3py}$

The angle (in degrees) between them is _____.

Q.36 BCl_3 and NH_4Cl were heated at 140 °C to give compound X, which when treated with $NaBH_4$ gave another compound Y. Compounds X and Y are

(a) $X = B_3N_3H_3Cl_3$ and $Y = B_3N_3H_6$ (b) $X = B_3N_3H_9Cl_3$ and $Y = B_3N_3H_6$

(c) $X = B_3N_3H_3Cl_3$ and $Y = B_3N_3H_{12}$ (d) $X = B_3N_3Cl_6$ and $Y = B_3N_3H_6$

Q.37 The number of microstates in term ^1G is _____

Q.38 The set of protons (underlined) in $CH_3CH_2CH_2OCH_3$ that would exhibit different splitting patterns in high (500 MHz) and low (60 MHz) field ^1H NMR, is

(a) $C\underline{H_3}CH_2CH_2OCH_3$ (b) $CH_3C\underline{H_2}CH_2OCH_3$

(c) $CH_3CH_2C\underline{H_2}OCH_3$ (d) $CH_3CH_2CH_2OC\underline{H_3}$

Q.39 Amongst the following, the complex ion that would show strong Jahn-Teller distortion is

(a) $[Cr(H_2O)_6]^{2+}$ (b) $[Ti(H_2O)_6]^{3+}$ (c) $[Co(H_2O)_6]^{2+}$ (d) $[Fe(H_2O)_6]^{2+}$

Q.40 Amongst the following, the metal carbonyl species having the highest ν_{CO} stretching frequency is

(a) $[Mn(CO)_6]^+$ (b) $Cr(CO)_6$ (c) $[V(CO)_6]^-$ (d) $[Fe(CO)_4]^{2-}$

Q.41 The correct order of thermal stability for the given compounds is

(a) $TiMe_4 > Ti(CH_2CMe_3)_4 > TiEt_4$ (b) $TiEt_4 > Ti(CH_2CMe_3)_4 > TiMe_4$

(c) $TiMe_4 > TiEt_4 > Ti(CH_2CMe3)_4$ (d) $Ti(CH_2CMe_3)_4 > TiMe_4 > TiEt_4$

Q.42 Amongst the following, the complex ion that is expected to show the highest magnetic moment at room temperature is

(a) $[Ni(CN)_4]^{2-}$ (b) $[Fe(CN)_6]^{3-}$ (c) $[Cu(H_2O)_6]^{2+}$ (d) $[Co(CN)_6]^{3-}$

Q.43 $MnCr_2O_4$ is

(a) Normal spinel with total CFSE of −15.5 Dq.

(b) Inverse spinel with total CFSE of −15.5 Dq.

(c) Normal spinel with total CFSE of −24 Dq.

(d) Inverse spinel with total CFSE of −24 Dq.

Q.44 Mg^{2+} is preferred in photosynthesis by chlorophyll because

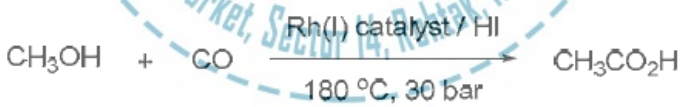
(a) It has strong spin-orbit coupling.

(b) It has weak spin-orbit coupling.

(c) It is a heavy metal.

(d) It binds strongly with chlorophyll.

Q.45 In Monsanto acetic acid process shown below, the role of HI is



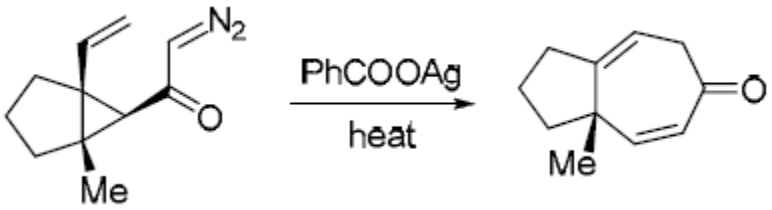
(a) To covert CH_3OH to a stronger nucleophile (CH_3O^-).

(b) To reduce the Rh(I) catalyst to a Rh(0) species.

(c) To reduce a Rh(III) active species to a Rh(I) species in the catalytic cycle.

(d) To convert CH_3OH to CH3I.

Q.46 Formation of the ketone II from the diazoketone I involves



I II

(a) Generation of carbene and a [2,3]-sigmatropic rearrangement

(b) Generation of carbene and an electrocyclic ring closing reaction.

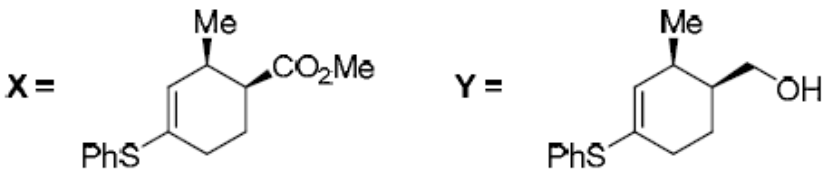
(c) Generation of ketene and a [2+2] cycloaddition.

(d) Generation of ketene and a [3,3]-sigmatropic rearrangement.

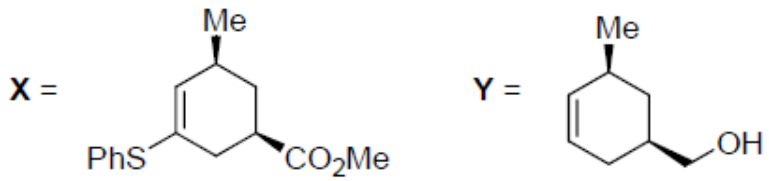
Q.47 The major products X and Y formed in the following reaction sequence are

(a)

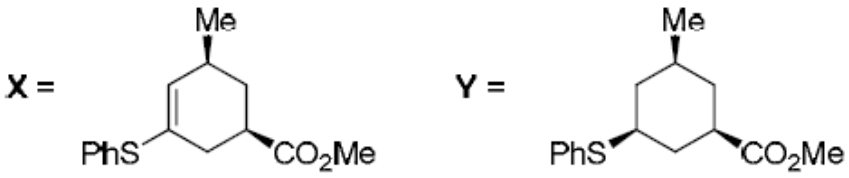
(b)



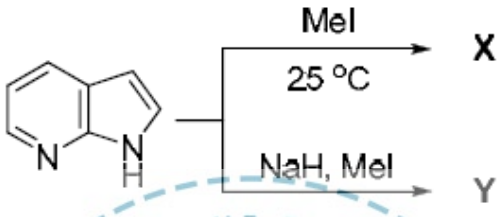
(c)



(d)



Q.48 The major products X and Y formed in the following reactions are

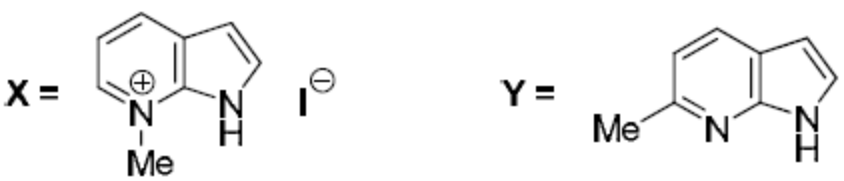


(a)

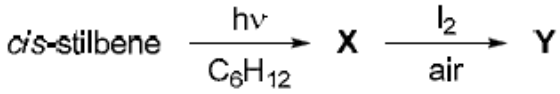
(b)

(c)

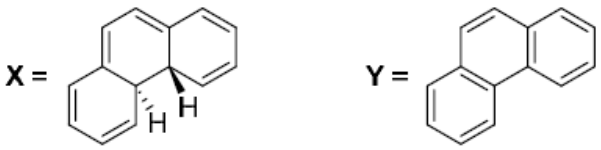
(d)



Q.49 The major products X and Y formed in the following reaction sequence are



(a)



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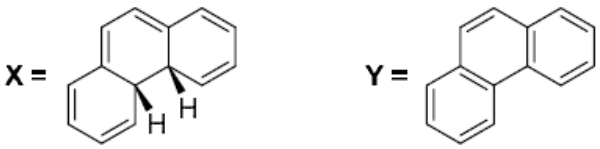
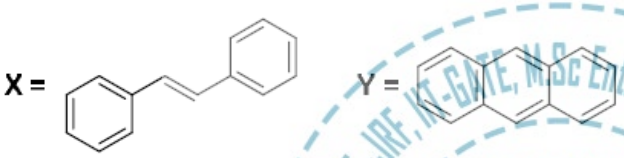
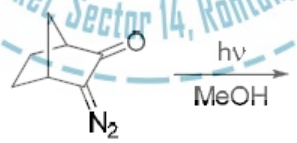


(c)

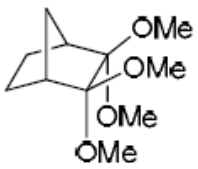


(d)

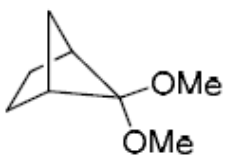
Q.50 The product of the following reaction gave 6 line ^{13}C NMR spectrum with peaks at δ 175, 52, 50, 46, 37, 33 ppm. The structure of the product is



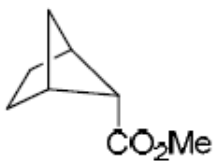
(a)



(b)



(c)



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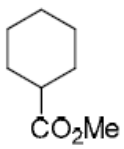
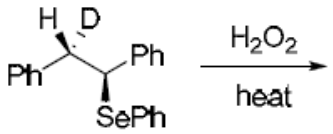
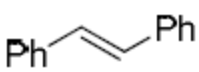
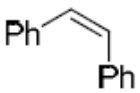
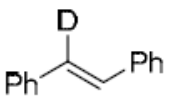


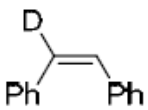
Q.51 The major product formed in the following reaction is



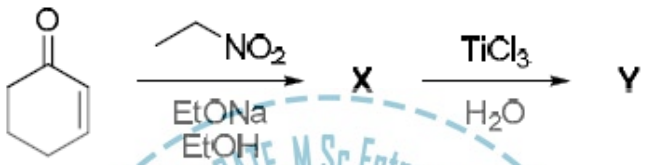
(a) 

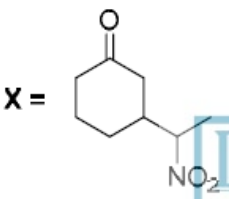
(b) 

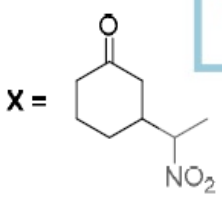
(c) 

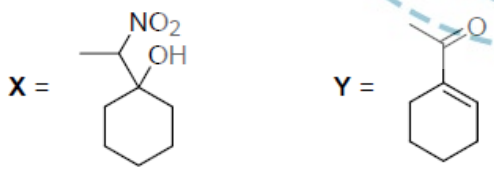
(d) 

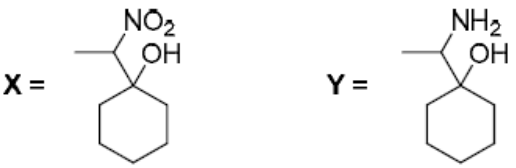
Q.52 The major products X and Y formed in the following reaction sequence are



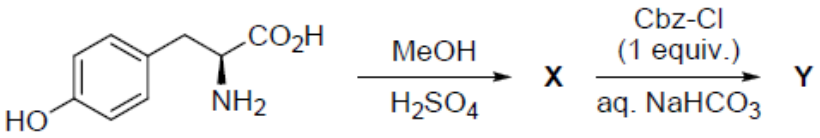
(a) 

(b) 

(c) 

(d) 

Q.53 The major products X and Y formed in the following reaction sequence are



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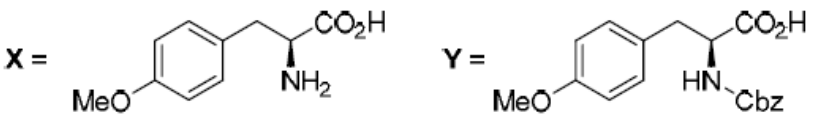

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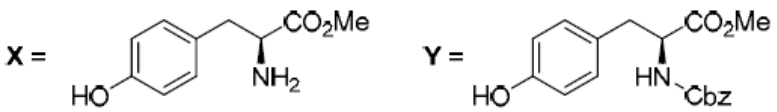

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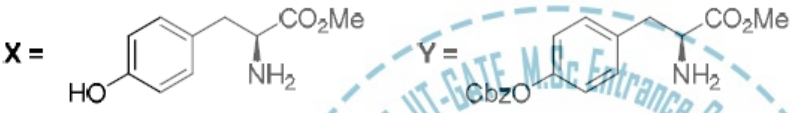

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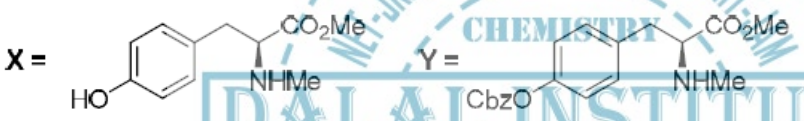
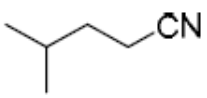


Q.54 Given the fact that 1,3-butadiene has a UV absorption of 217 nm, the absorption wavelength (in nm) for the conjugated system shown below is _____.

(Use these absorption values for auxochromic groups:

alkyl: +5; exo-cyclic double bond: +5; every additional conjugated C = C: +30)

Q.55 The m/z value of the detectable fragment formed by McLafferty like rearrangement of the following compound in mass spectrometer is _____.



Section-B

Q.56 – Q.60 carry one mark each.

Q.56 A student is required to demonstrate a high level of comprehension of the subject, especially in the social sciences. The word closest in meaning to comprehension is

(a) Understanding (b) Meaning (c) Concentration (d) Stability

Q.57 Choose the most appropriate word from the options given below to complete the following sentence. One of his biggest _____ was his ability to forgive.

(a) Vice (b) Virtues (c) Choices (d) Strength

Q.58 Rajan was not happy that Sajan decided to do the project on his own. On observing his unhappiness, Sajan explained to Rajan that he preferred to work independently.

Which one of the statements below is logically valid and can be inferred from the above sentences?

(a) Rajan has decided to work only in a group.

(b) Rajan and Sajan were formed into a group against their wishes.

(c) Sajan had decided to give in to Rajan's request to work with him.

(d) Rajan had believed that Sajan and he would be working together.

Q.59 If $y = 5x^2 + 3$, then the tangent at $x = 0$, $y = 3$

(a) Passes through $x = 0$, $y = 0$ (b) Has a slope of +1

(c) Is parallel to the x-axis (d) Has a slope of −1

Q.60 A foundry has a fixed daily cost of Rs 50,000 whenever it operates and a variable cost of Rs 800Q, where Q is the daily production in tones. What is the cost of production in Rs per ton for a daily production of 100 tones?

Q.61 – Q.65 carry two marks each.

Q.61 Find the odd one in the following group: ALRVX, EPVZB, ITZDF, OYEIK

(a) ALRVX (b) EPVZB (c) ITZDF (d) OYEIK

Q.62 Anuj, Bhola, Chandan, Dilip, Eswar and Faisal live on different floors in a six-storied building (the ground floor is numbered 1, the floor above it 2, and so on). Anuj lives on an even-numbered floor. Bhola does not live on an odd numbered floor. Chandan does not live on any of the floors below Faisal's floor. Dilip does not live on floor number 2. Eswar does not live on a floor immediately above or immediately below Bhola. Faisal lives three floors above Dilip. Which of the

following floor-person combinations is correct?

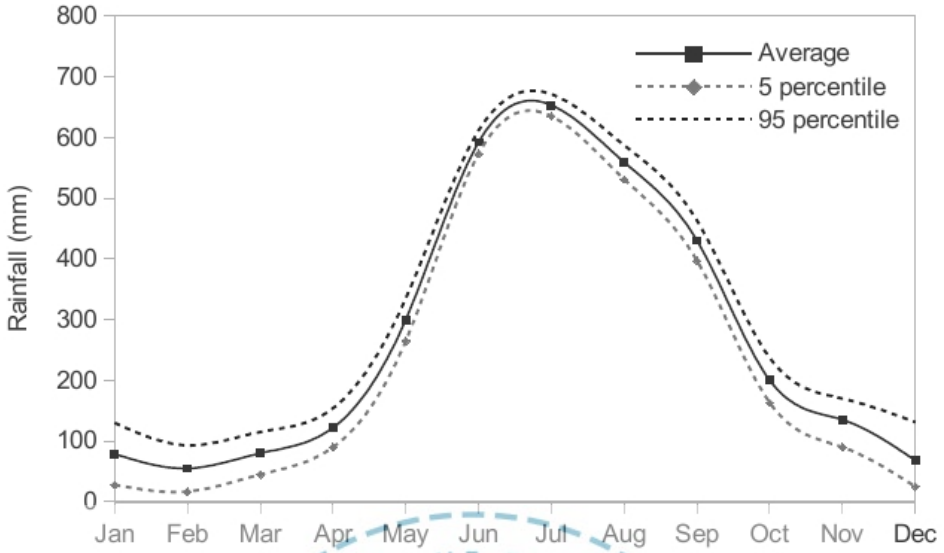
	Anuj	Bhola	Chandan	Dilip	Eswar	Faisal
A	6	2	5	1	3	4
B	2	6	5	1	3	4
C	4	2	6	3	1	5
D	2	4	6	1	3	5

Q.63 The smallest angle of a triangle is equal to two thirds of the smallest angle of a quadrilateral. The ratio between the angles of the quadrilateral is 3:4:5:6. The largest angle of the triangle is twice its smallest angle. What is the sum, in degrees, of the second largest angle of the triangle and the largest angle of the quadrilateral?

Q.64 One percent of the people of country X are taller than 6 ft. Two percent of the people of country Y are taller than 6 ft. There are thrice as many people in country X as in country Y. Taking both countries together, what is the percentage of people taller than 6 ft.?

(a) 3.0 (b) 2.5 (c) 1.5 (d) 1.25

Q.65 The monthly rainfall chart based on 50 years of rainfall in Agra is shown in the following figure. Which of the following are true? (k percentile is the value such that k percent of the data fall below that value)



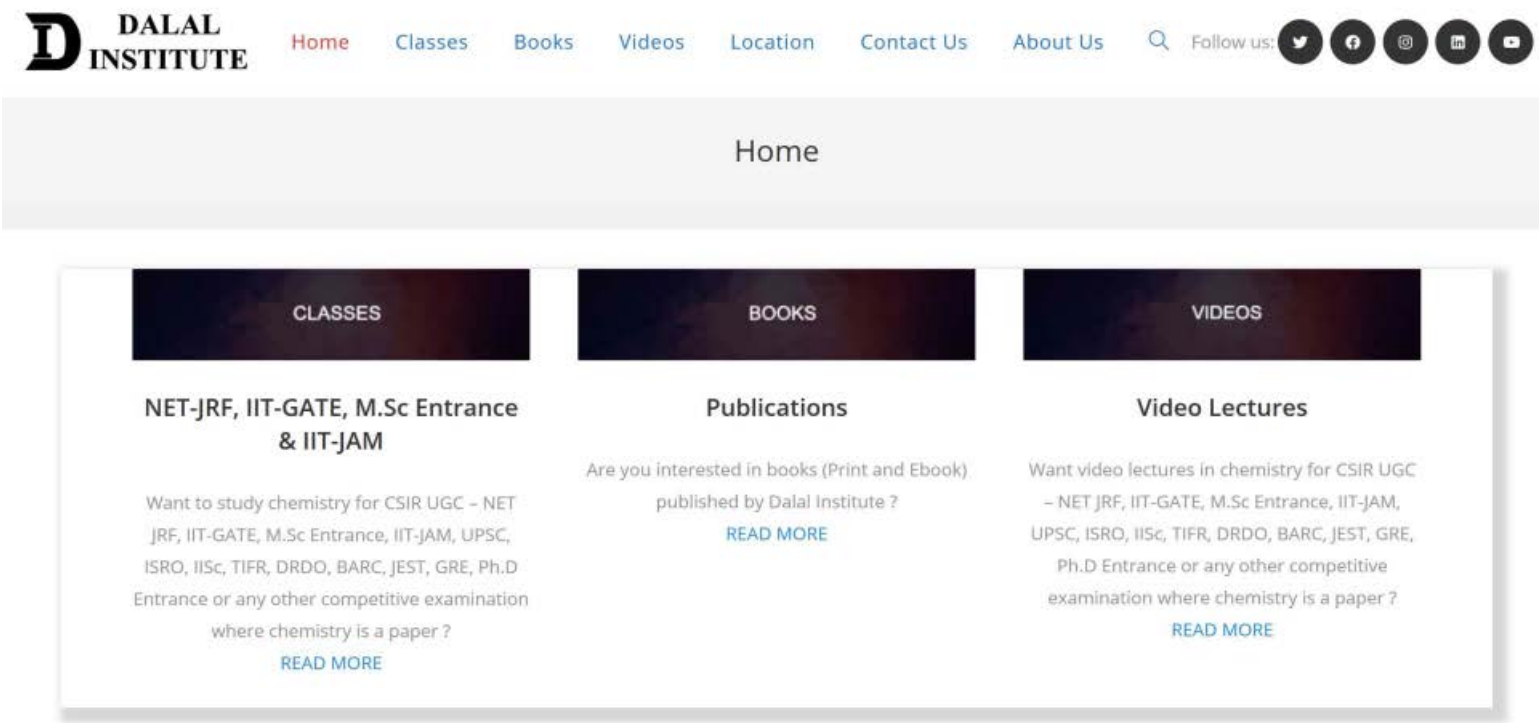
(i) On average, it rains more in July than in December.

(ii) Every year, the amount of rainfall in August is more than that in January.

(iii) July rainfall can be estimated with better confidence than February rainfall.

(iv) In August, there is at least 500 mm of rainfall.

(a) (i) and (ii) (b) (i) and (iii) (c) (ii) and (iii) (d) (iii) and (iv)



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