IIT-JAM: 2016

Chemistry

1. *Section-A contains 30 Multiple Choice Questions (MCQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which ONLY ONE is correct. Form Q.1 to Q.10 carries 1 Marks and Q.11 to Q.30 carries 2 Marks each.*

2. *Section-B contains 10 Multiple Select Questions (MSQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which ONE or MORE than ONE is/are correct. For each correct answer you will be awarded 2 Marks.*

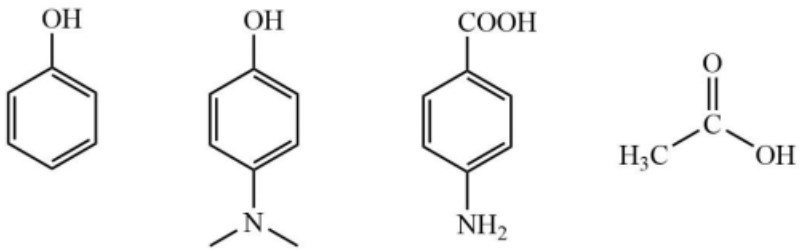
3. *Section-C contains 20 Numerical Answer Type (NAT) questions. Form Q.41 to Q.50 carries 1 Marks each and Q.51 to Q.60 carries 2 Marks each. For each NAT type question, the value of answer in between 0 to 9.*

4. *In all sections, questions not attempted will result in zero mark. In Section-A (MCQ), wrong will be deducted for each wrong answer. For all 1 marks questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In Section-B (MSQ), there is no negative and no partial marking provisions. There is no negative marking in Section-C (NAT) as well.*

❖ Question Paper

SECTION-A : MCQ

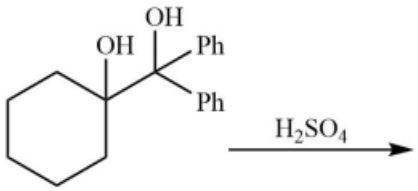
Q.1 The correct order of pK_a for the following compounds is

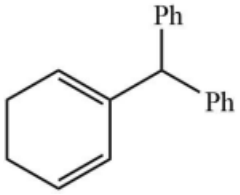


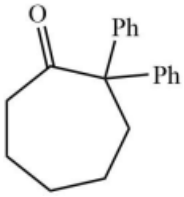
(I) **(II)** **(III)** **(IV)**

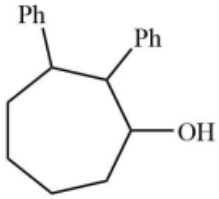
(a) II > I > III > IV (b) II > I > IV > III (c) III > IV > I > II (d) IV > II > I > III

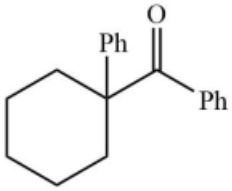
Q.2The major product formed in the following reaction is



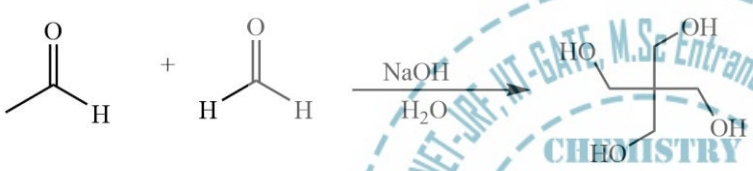
(a) 

(b) 

(c) 

(d) 

Q.3 The mechanism of the following transformation involves



(a) Aldol reaction and Cannizzaro reaction

(b) Aldol reaction and Claisen-Schmidt reaction

(c) Knoevenagel reaction and Cannizzaro reaction

(d) Stobbe condensation and Cannizzaro reaction

Q.4 The most basic amino acid of the following is

(a) tyrosine (b) methionine (c) arginine (d) glutamine

Q.5 The crystal field stabilization energy (CFSE) in $[Mn(H_2O)_6]^{2+}$ is

(a) $0\ \Delta_0$ (b) $2.0\ \Delta_0 + 2P$ (c) $0.4\ \Delta_0 - 2P$ (d) $2.0\ \Delta_0$

Q.6 Indicator used in redox titration is

(a) Eriochrome black T (b) Methyl orange (c) Phenolphthalein (d) Methylene blue

Q.7 Among the following, the compound that has the lowest degree of ionic character is

(a) NaCl (b) $MgCl_2$ (c) $AlCl_3$ (d) $CaCl_2$

Q.8 The correct order of entropy for various states of CO_2 is

(a) $CO_2(s) > CO_2(l) > CO_2(g)$ (b) $CO_2(l) > CO_2(s) > CO_2(g)$

(c) $CO_2(g) > CO_2(l) > CO_2(s)$ (d) $CO_2(g) > CO_2(s) > CO_2(l)$

Q.9 The coordination numbers of Cs^+ and Cl^- ions in the CsCl structure, respectively, are

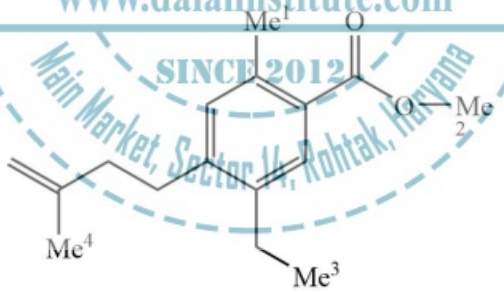
(a) 4, 4 (b) 4, 8 (c) 6, 6 (d) 8, 8

Q.10 Determinant of a square matrix is always

(a) A square matrix (b) A column matrix (c) A row matrix (d) A number

Q.11 – Q.30 carry TWO marks each

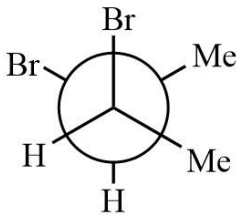
Q.11 The correct order of ^1H NMR chemical shift (δ) values for the labelled methyl groups in the following compound is

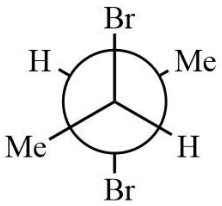


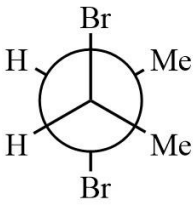
(a) $Me^1 < Me^2 < Me^3 < Me^4$ (b) $Me^3 < Me^4 < Me^1 < Me^2$

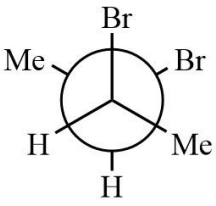
(c) $Me^3 < Me^1 < Me^4 < Me^2$ (d) $Me^2 < Me^4 < Me^3 < Me^1$

Q.12 Among the following, most stable configuration of meso-2,3- dibromobutane is

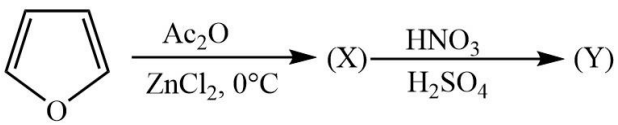
(a) 

(b) 

(c) 

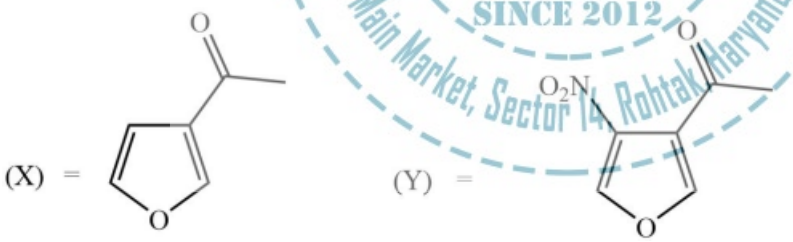
(d) 

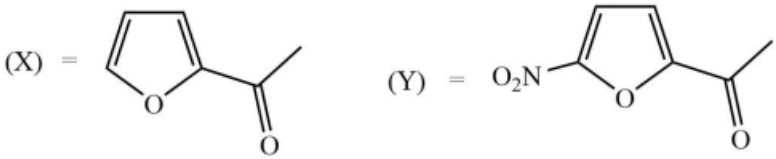
Q.13 The major products X and Y in the following reaction sequence are



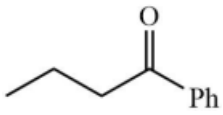
(a) 

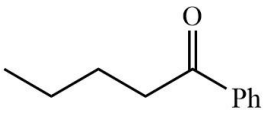
(b) 

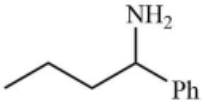
(c) 

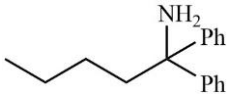
(d) 

Q.14 The major product formed in the reaction of butanenitrile with phenylmagnesium bromide followed by acidification is

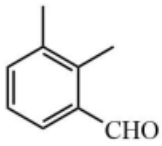
(a) 

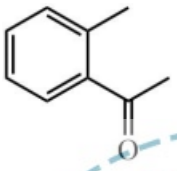
(b) 

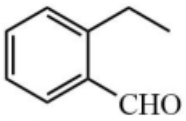
(c) 

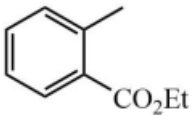
(d) 

Q.15 An organic compound on reaction with 2, 4-dinitrophenylhydrazine (2, 4-DNP) gives a yellow precipitate. It also gives silver mirror on reaction with ammonical $AgNO_3$. It gives an alcohol and sodium salt of a carboxylic acid on reaction with concentrated NaOH. It yields benzene-1,2-dicarboxylic acid on heating with alkaline $KMnO_4$. The structure of the compound among the following is

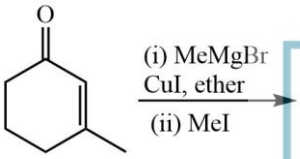
(a) 

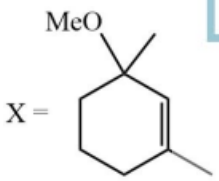
(b) 

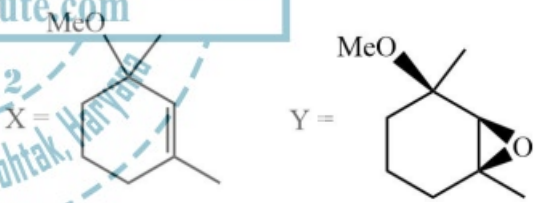
(c) 

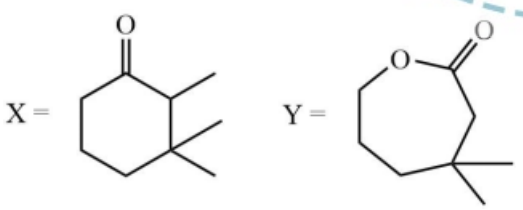
(d) 

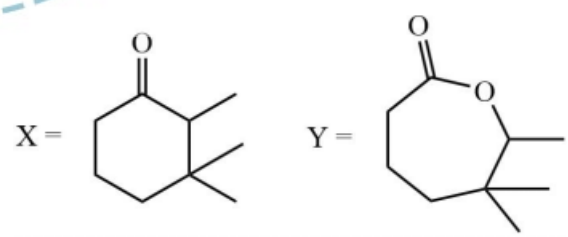
Q.16 The major products X and Y formed in the following reaction sequence are



(a) 

(b) 

(c) 

(d) 

Q.17 The true statement about $[Cu(H_2O)_6]^{2+}$ is

(a) All Cu-O bond lengths are equal

(b) One Cu-O bond length is shorter than the remaining five

(c) Three Cu-O bond length is shorter than the remaining three

(d) Four Cu-O bond length is shorter than the remaining two

Q.18 The complexes $[Pt(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$, respectively, are

(a) Paramagnetic, Paramagnetic (b) Diamagnetic, Diamagnetic

(c) Paramagnetic, Diamagnetic (d) Diamagnetic, Paramagnetic

Q.19 The value of 'x' in $[Cu(CO)_x]^+$ such that it obeys the 18 electron rule is

(a) 6 (b) 5 (c) 4 (d) 3

Q.20 The correct order of ν_{NO} (cm^{-1}) in the following compounds is

(a) $NO^+ > NO > [NiCp(NO)] > [Cr(Cp)_2(NO)_4]$ (b) $[Cr(Cp)_2(NO)_4] > [NiCp(NO)] > NO^+ > NO$

(c) $NO^+ > [Cr(Cp)_2(NO)_4] > NO > [NiCp(NO)]$ (d) $[NiCp(NO)] > NO > [Cr(Cp)_2(NO)_4] > NO^+$

Q.21 The red colour of ruby is due to

(a) d-d transition of Cr^{3+} ion in Cr_2O_3 lattice (b) d-d transition of Cr^{3+} ion in Al_2O_3 lattice

(c) ligand to metal charge transfer transition (d) metal to ligand charge transfer transition

Q.22 The final product in the reaction of BF_3 with water are

(a) $B(OH)_3$ and OF_2 (b) H_3BO_3 and HBF_4 (c) B_2O_3 andHBF_4 (d) B_2H_6 and HF

Q.23 The correct order of bond angles in BF_3, NH_3, NF_3 and PH_3 is

(a) $BF_3 > NH_3 > NF_3 > PH_3$ (b) $PH_3 > BF_3 > NF_3 > NH_3$

(c) $BF_3 > PH_3 > NH_3 > NF_3$ (d) $NH_3 > NF_3 > BF_3 > PH_3$

Q.24 The maximum of a function Ae^{-ax^2} ($A > 0$; $a > 0$) at x =

(a) 0 (b) $+\infty$ (c) $-\infty$ (d) $\frac{1}{\sqrt{a}}$

Q.25 At 298K, 0.1 mol of ammonium acetate and 0.14 mol of acetic acid are dissolved in 1 L of water. The pH of the resulting solution is [Given: pK_a of acetic acid is 4.75]

(a) 4.9 (b) 4.6 (c) 4.3 (d) 2.3

Q.26 An electrochemical cell consists of two half-cell reactions

$AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$

$Cu(s) \rightarrow Cu^{2+} + 2e^-$

The mass of copper (in grams) dissolves on passing 0.5A current for 1 hour is

[Given: atomic mass of Cu is 63.6: F = 96500C mol^{-1}]

(a) 0.88 (b) 1.18 (c) 0.29 (d) 0.59

Q.27For a zero order reaction, the half-life depends on the initial concentration $[C_0]$ of the reactant as

(a) $[C_0]$ (b) $[C_0]^0$ (c) $[C_0]^{-1}$ (d) $[C_0]^{1/2}$

Q.28 The effective nuclear charge of helium atom is 1.7. The first ionisation energy of helium atom in eV is

(a) 13.6 (b) 23.1 (c) 39.3 (d) 27.2

Q.29 The relationship between the van der waals 'b' coefficient of N_2 and O_2 is

(a) $b(N_2) = b(O_2) = 0$ (b) $b(N_2) = b(O_2) \neq 0$ (c) $b(N_2) > b(O_2)$ (d) $b(N_2) < b(O_2)$

Q.30 FFrom the kinetic theory of gases, the ratio of most probable speed (C_{mp}) to root mean square speed (C_{rms}) is

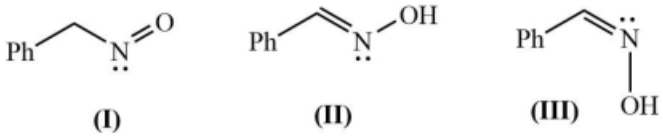
(a) $\sqrt{3}$ (b) $\sqrt{2}/\sqrt{3}$ (c) $\sqrt{3}/\sqrt{2}$ (d) $3/\sqrt{2}$

Section-B

Multiple select Questions (MSQ)

Q.31 – Q.40 carry TWO marks each.

Q.31 The correct statements about the following species is (are)



(I) (II) (III)

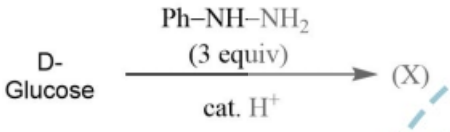
(a) I and II are resonance structures

(b) II and III are resonance structures

(c) II and III are diastereomers

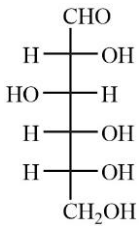
(d) III is a tautomer of I

Q.32 Consider the following reaction:

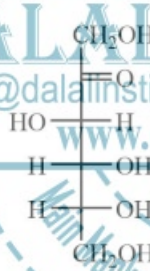


Among the following, the compound(s) whose osazone derivative(s) will have the same mwlting point as that of x is(are)

(a)

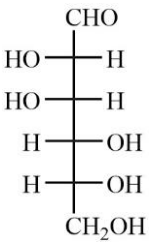


(b)

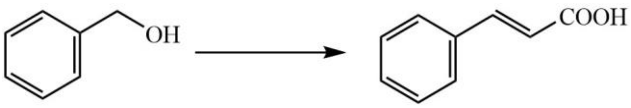


(c)

(d)



Q.33The appropriate reagents required for carrying out the following transformation are



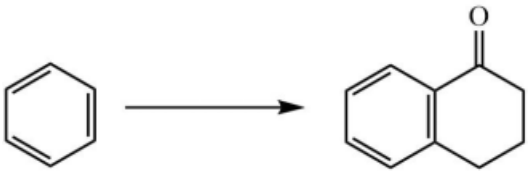
(a) (i) PCC, CH_2Cl_2; (ii) $Ph_3P{=}CHCO_2Et$; (iii) aq. NaOH, heat, then acidify

(b) (i) CrO_3, H_2SO_4, aq. Acetone (ii) Ac_2O, NaOAc

(c) (i) MnO_2; (ii) $CH_2(CO_2H)_2$, piperidine, pyridine

(d) (i) PCC; CH_2Cl_2; (ii) BrCHCOC(CH), Zn (iii) H_3O^+, heat

Q.34 The appropriate reagents required for carrying out the following transformation are



(a) (i) succinic anhydride, $AlCl_3$; (ii) Zn/Hg, HCl; (iii) polyphosphoric acid

(b) (i) maleic anhydride, $AlCl_3$; (ii) $NH_2 - NH_2$, KOH; (iii) H_2SO_4

(c) (i) succinic anhydride, $FeCl_3$; (ii) $LiAlH_4$; (iii) H_2SO_4

(d) (i) phthalic anhydride, $F_3B.OEt_2$; (ii) $HS(CH_2)_2SH$, H^+; (iii) Raney Ni; (iv) polyphosphoric acid

Q.35 The proteins that belong to the class of blue copper proteins is(are)

(a) ceruloplasmin (b) Superoxide dismutase (c) hemocyanin (d) azurin

Q.36 The ions that exhibit only charge transfer bands in the absorption spectra (UV-visible region) is/are

(a) $[Cr(C_2O_4)_3]^{3-}$ (b) $[CrO_4]^{2-}$ (c) $[ReO_4]^-$ (d) $[NiO_2]^{2-}$

Q.37 The type(s) of interaction(s) that hold layers of graphite together is(are)

(a) π-π stacking (b) Van der Waals (c) Hydrogen bonding (d) Coulombic

Q.38 True statements about Langmuir isotherm is/are

(a) Valid for monolayer coverage

(b) All absorption sites are equal

(c) There is a dynamic equilibrium between free gas and adsorbed gas

(d) Adsorption probability is independent of occupancy at the neighboring sites

Q.39 The $3P_z$ orbital has

(a) One radial node (b) two radial nodes (c) One angular node (d) two angular nodes

Q.40 The diatomic molecules that has two π-type bonds is/are

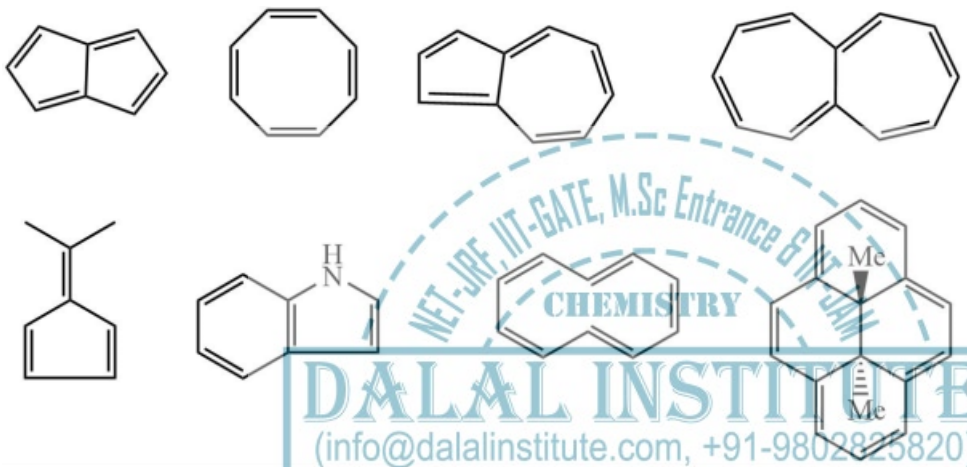
(a) B_2 (b) C_2 (c) N_2 (d) O_2

Seaction – C

Numerical Answer Type (NAT)

Q.41 – Q.50 carry ONE marks each.

Q.41 Among the following, the number of molecules that are aromatic is



Q.42 The number of all possible isomers for the molecular formula C_6H_6 is ……..

Q.43 Hydrolysis of 15.45g of benzonitrile produced 10.98 g of benzoic acid. The percentage yield of acid formed is ……

Q.44 Acetic acid content in commercial vinegar was analysed by titrating against 1.5 M NaOH solution. A 20 mL vinegar sample required 18 mL of titrant to give endpoint. The concentration of acetic acid in the vinegar (in mol L^{-1}) is ……

Q.45 The bond order of Be_2 molecule is …….

Q.46 The number of P-H bonds in hypophosphorous acid is ……

Q.47 The isotope $^{217}_{84}Po$ undergoes one alpha and one beta particle emission sequentially to form an isotope "X" is ……

Q.48 In a diffraction experiment with X-rays of wavelength 1.54Å, a diffraction line corresponding to 2θ = 20.8° is observed. The inter-planar separation in Å is ……

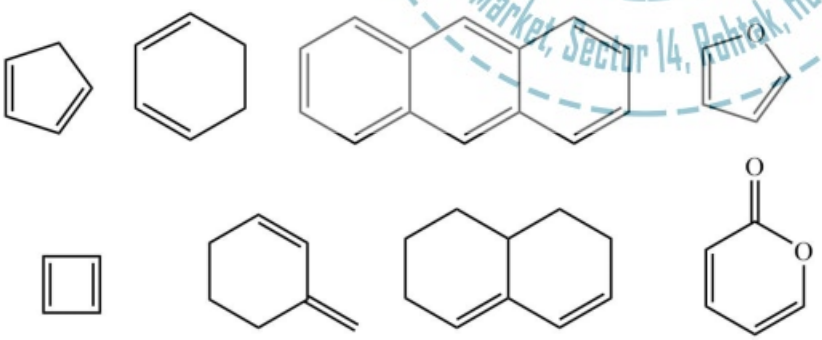
Q.49 The potential energy of interaction between two ions in an ionic compound is given by $U = 1389.4\left[\frac{Z_1 Z_2}{r/\text{Å}}\right]$ kJ mol^{-1}. Assuming that $CaCl_2$ is colinear molecule of length 5.6Å, the potential energy for $CaCl_2$ molecule in kJ mol^{-1} is ……..

Q.50 The enthalpy of formation for $CH_4(g)$, C(g), and H(g) are –75, 717 and 218 kJ mol^{-1}, respectively. The enthalpy of the C-H bond in kJ mol^{-1} ……..

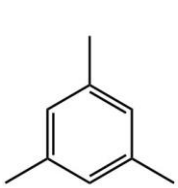
Q.51 – Q.60 carry TWO marks each.

Q.51 Specific rotation of the (R)-enantiomer of a chiral compound is 48°. The specific rotation of a sample of this compound which contains 25% of (S)-enantiomer is ……

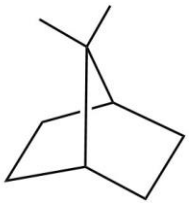
Q.52 Among the following, the number of compounds, which can participates as 'diene' component in a Diels-Alder reaction is ……



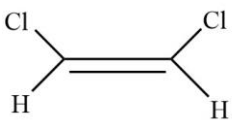
Q.53 Among the following, the number of molecules that possess C_2 axis of symmetry is ……

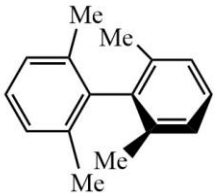


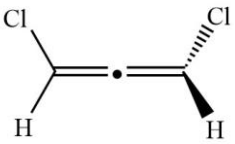
BF_3



$CHCl_3$







2,5-dimethylthiophene

Q.54 Effective nuclear charge for 3d electron in vanadium (atomic number = 23) according to Slater's rule is …….

Q. 55 The total number of isomers possible for the molecule $[Co(NH_3)_4Cl(NO_2)]^+$ is ……..

Q.56 The bond angle in PBr_3 is 101°. The percent 's' character of the central atom is …….

Q.57 $Cu(s) + 4H^+(aq) + 2NO_3^- \rightarrow 2NO_2(g) + Cu^{2+}(aq) + 2\,H_2O(\ell)$

In the above reaction at 1 atm and 298K, if 6.36 g of copper is used. Assuming ideal gas behaviour, the volume of NO_2 produced in litres is ……..

[Given: atomic mass of Cu is 63.6; R = 0.0821 L atm K^{-1} mol^{-1}]

Q.58 The ΔH^0 for the reaction $CO(g) + 1/2O_2(g) \rightarrow CO_2(g)$ at 400K in kJ mol^{-1} is ……..

Given at 298K :

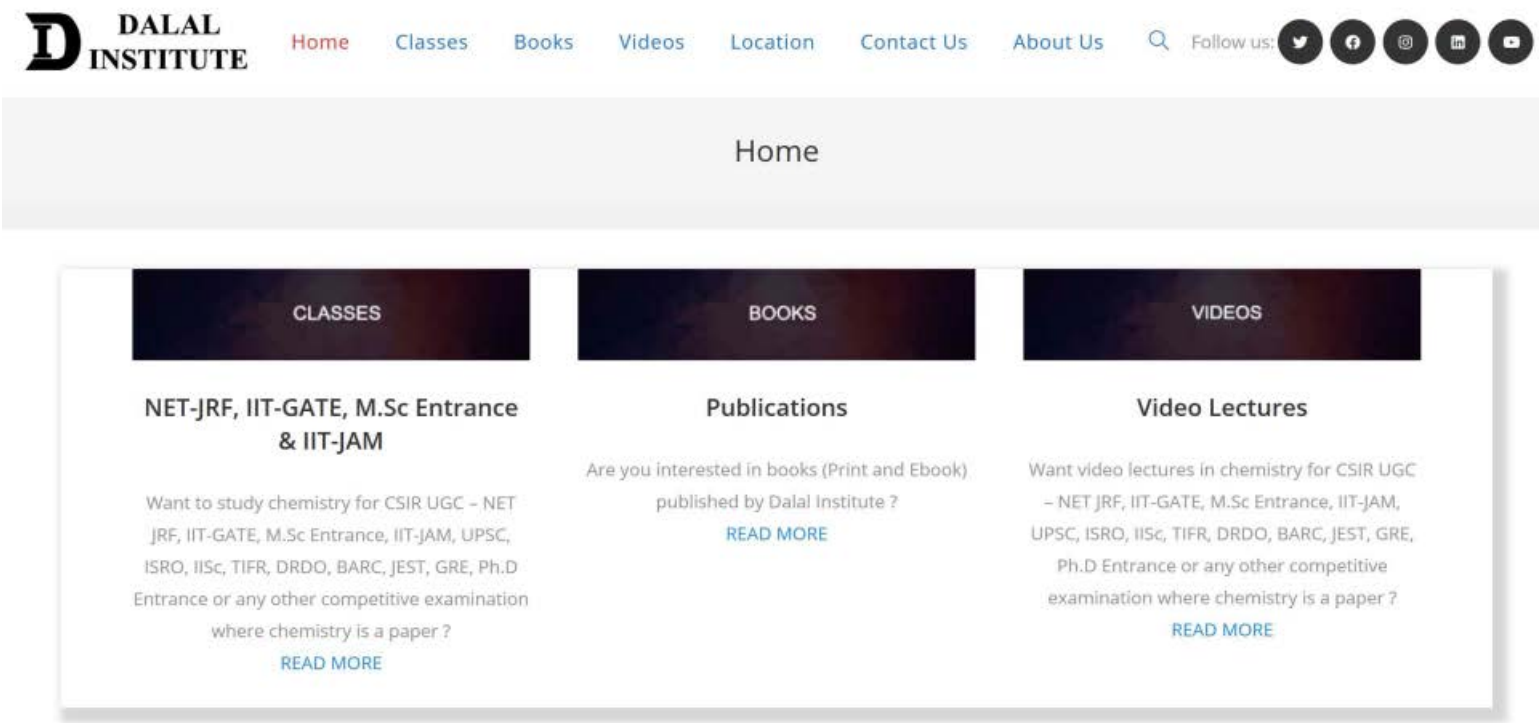
	ΔH_f^0	C_P^0
	kJ mol^{-1}	J mol^{-1} K^{-1}
O_2	0	29.4
CO	–110	29.1
CO_2	–394	37.1

Q.59 the rate constant for a reaction at 300K are 8 and 160 L mol^{-1} s^{-1}, respectively. The activation energy of the reaction in kJ mol^{-1} is …….

[Given: R = 8.314 JK^{-1} mol^{-1}].

Q.60 A 10 L flask containing 10.8 g of N_2O_5 is heated to 373K, which leads to its decomposition according to the equation $2\ N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$. if the final pressure in the flask is 0.5atm, then the partial pressure of $O_2(g)$ in atm is ……...

[Given: R = 0.0821 L atm K^{-1} mol^{-1}]



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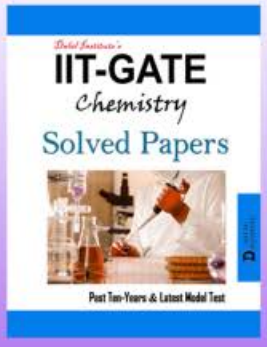

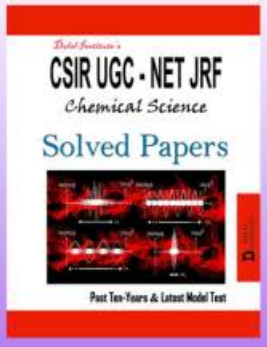

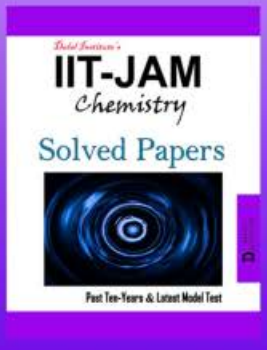

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