IIT-JAM: 2019

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 – Q.10 carry ONE marks each

Q.1 For the reaction of type A + B → Products, the unit of the rate constant is mol L^{-1} s^{-1}. The overall order of the reaction is

(a) 0 (b) 1 (c) 2 (d) 3

Q.2 The thermodynamic criterion for spontaneity of a process in a system under constant volume and temperature and in the absence of any work other than expansion work (If any) is

(a) Change in entropy is positive
(b) Change in enthalpy is negative
(c) Change in Helmholtz free energy is negative
(d) Change in Gibbs free energy is negative

Q.3 The number of vibrational mode(s) of a carbon dioxide molecule that can be detected using infrared spectroscopy is

(a) 1 (b) 2 (c) 3 (d) 4

Q.4 For three non-coplanar vector a, b and c, the expression a·(b×c) can be written as

(a) (a×b)·c (b) (a×b)·(a×c) (c) (a·b) × (a·c) (d) (a·b)×c

Q.5 Correct trend in the bond order is

(a) $O_2^+ > O_2^{2-} > O_2^-$ (b) $O_2^- > O_2^+ > O_2^{2-}$ (c) $O_2^{2-} > O_2^- > O_2^+$ (d) $O_2^+ > O_2^- > O_2^{2-}$

Q.6 The correct option for the metal ion present in the active site of myoglobin, haemocyanin and vitamin B_{12}, respectively, is

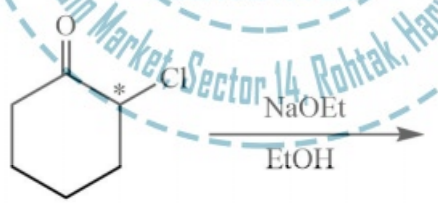
(a) iron, iron and zinc (b) molybdenum, iron and copper

(c) iron, copper and cobalt (d) molybdenum, copper and cobalt

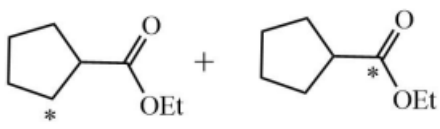
Q.7 The correct order of wavelength(λ_{max}) of the halide to metal charge-transfer band of $[Co(NH_3)_5Cl]^{2+}$ (I), $[Co(NH_3)_5Br]^{2+}$ (II), $[Co(NH_3)_5I]^{2+}$ (III), is

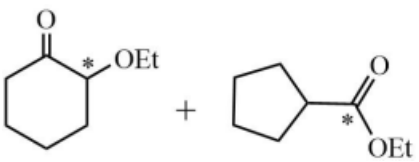
(a) III < II < I (b) I < II < III (c) II < III < I (d) I< III < II

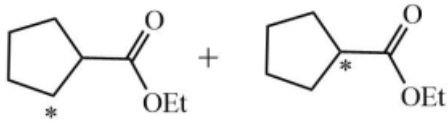
Q.8 The correct option for the major products of the following reaction is

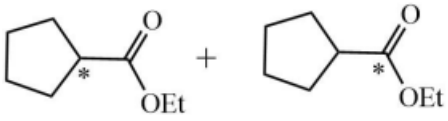


(* represents isotopically laballed carbon atom)

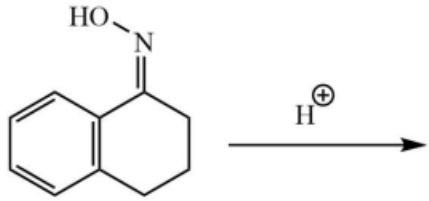
(a) 

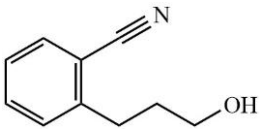
(b) 

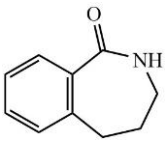
(c) 

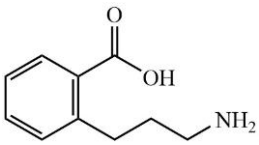
(d) 

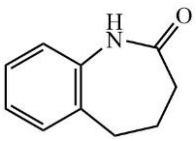
Q.9 The major product formed in the following reaction is



(a) 

(b) 

(c) 

(d) 

Q.10 The complementary strand for the following single strand of DNA is

Q.11 – Q.30 carry two marks each.

Q.11 The function $f(x) = x\,e^{-x^2}$ has a minimum at

(a) $x = \sqrt{2}$ (b) $x = -\sqrt{2}$ (c) $x = 1/\sqrt{2}$ (d) $x = -1/\sqrt{2}$

Q.12 The correct option for the number of bending modes of vibration in each of H_2O, CS_2 and SO_2 molecules, respectively, is

(a) 1, 2 and 2 (b) 2, 2 and 1 (c) 2, 1 and 2 (d) 1, 2 and 1

Q.13 The total number of degrees of freedom of an HBr molecule that is constrained to translate along straight line but does not have any constraints for its rotation and vibration is

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

Q.14 According to the kinetic theory of gases, the ratio of the root mean square velocity of molecular oxygen and molecular hydrogen at 300K is

(a) 1:1 (b) $1:2\sqrt{2}$ (c) 1:4 (d) 1:16

Q.15 The half-life of the chemical reaction, A → Product, for initial reactant concentrations of 0.1 and 0.4 mol L^{-1} are 200 and 50 s, respectively. The order of the reaction is

(a) 0 (b) 1 (c) 2 (d) 3

Q.16 The ratio of the nearest neighbour atomic distances in body-centred cubic (bcc) and face-centred cubic (fcc) crystals with the same unit cell edge length is

(a) $\sqrt{\frac{3}{2}}$ (b) $\frac{\sqrt{3}}{2}$ (c) $\frac{1}{\sqrt{2}}$ (d) $\frac{1}{2}$

Q.17 The correct trend in the rate of substitution of Cl^- by pyridine in the following complexes is

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

Q.18 In quantitative inorganic analysis of metal ions, the ion which precipitates as sulphide in the presence of H_2S in warm dilute HCl is

(a) Cr^{3+} (b) Al^{3+} (c) Co^{3+} (d) Bi^{3+}

Q.19The correct statement regarding the observed magnetic properties of NO, O_2, B_2 and C_2 in their ground state is

(a) NO, B_2 and C_2 are paramagnetic (b) B_2, O_2 and NO are paramagnetic

(c) O_2, C_2 and NO are paramagnetic (d) O_2, B_2 and C_2 are paramagnetic

Q.20 The observed magnetic moments of octahedral Mn^{3+}, Fe^{3+} and Co^{3+} complexes are 4.95, 6.06 and 0.00 BM, respectively. The correct option for the electronic configuration of Mn^{3+}, Fe^{3+} and Co^{3+} metal ions in these complexes, respectively, is

(a) $t_{2g}^4 e_g^0, t_{2g}^3 e_g^2$ *and* $t_{2g}^4 e_g^2$

(b) $t_{2g}^3 e_g^1, t_{2g}^5 e_g^0$ *and* $t_{2g}^6 e_g^0$

(c) $t_{2g}^3 e_g^1, t_{2g}^3 e_g^2$ *and* $t_{2g}^6 e_g^0$

(d) $t_{2g}^3 e_g^1, t_{2g}^3 e_g^2$ *and* $t_{2g}^4 e_g^2$

Q.21 Among the following compounds, the one having the lowest boiling point is

(a) $SnCl_2$ (b) $GeCl_4$ (c) $SiCl_4$ (d) CCl_4

Q.22 The correct option having one complex from each of the following pairs which is more reactive towards the oxidative addition reaction by hydrogen molecule is

Pair 1: $IrCl(PMe_3)_3$ (I) and $IrCl(CO)(PMe_3)_2$ (II)

Pair 2: $IrCl(CO)(PMe_3)_2$ (III) and $IrClCl_3(PMe_3)$ (IV)

(a) (I) and (III) (b) (I) and (VI) (c) (II) and (III) (d) (II) and (VI)

Q.23 Among the following, the correct statement is

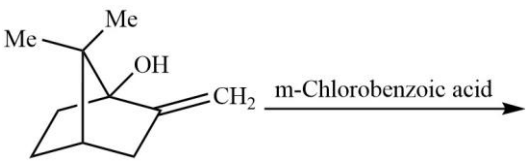
(a) The density follows the order, Cs > Rb > Li > Na.

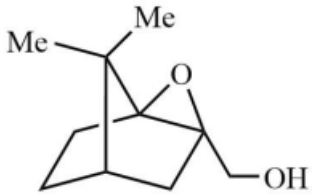
(b) The solubility in water follows the order, $Cs_2CO_3 > K_2CO_3 > Na_2CO_3 > Li_2CO_3$.

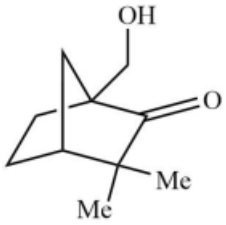
(c) The first ionization potential follows the order, Li > K > Na > Cs.

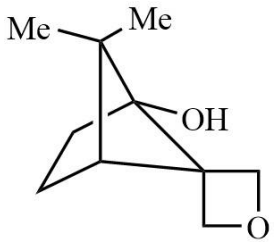
(d) The melting point follows the order, $MgCl_2 > BeCl_2 > CaCl_2 > SrCl_2$.

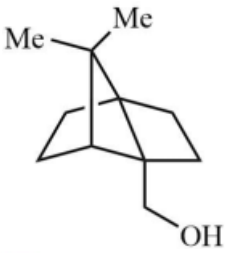
Q.24 The major product of the following reaction is



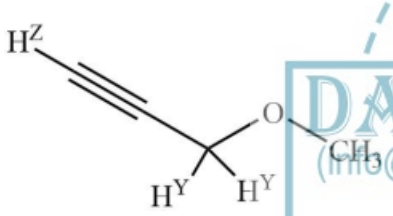
(a) 

(b) 

(c) 

(d) 

Q.25 In ^1H NMR spectrum of the given molecule, the correct order of chemical shifts of the labelled protons (H^X, H^Y, H^Z) is



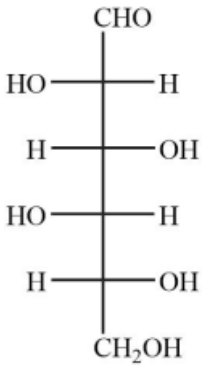
(a) $H^Z > H^X > H^Y$ (b) $H^Z > H^Y > H^X$ (c) $H^X > H^Y > H^Z$ (d) $H^Y > H^X > H^Z$

Q.26 In the following reaction of (D)-Glucose, a product P is formed.

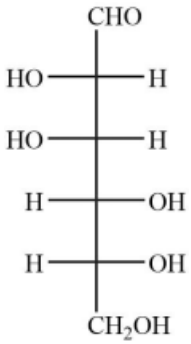
$$\text{(D)-Glucose} \xrightarrow[2.\ H_2O_2,\ Fe_2(SO_4)_3]{1.\ Br_2/H_2O} P$$

Among the following compounds, the one which will give the same product (P) under identical reaction condition is

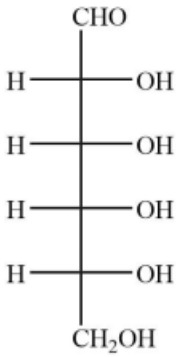
(a)



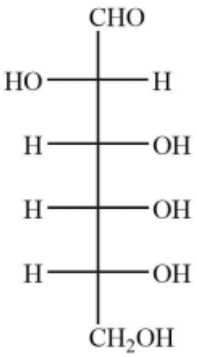
(b)



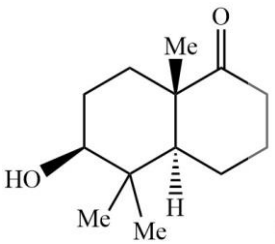
(c)



(d)

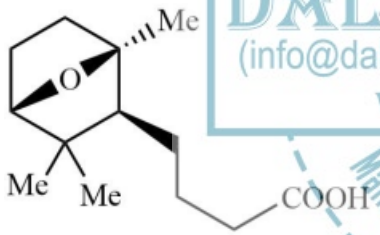


Q.27 The major product of the following reaction is



Trifluoroacetic anhydride/H_2O_2

(a)



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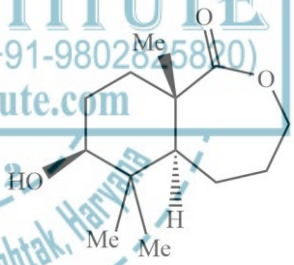
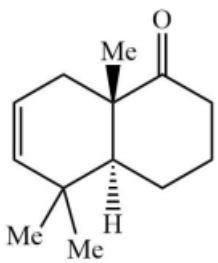
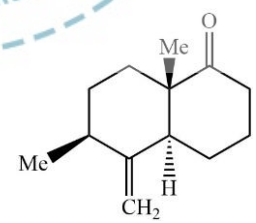


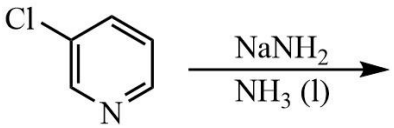
(c)

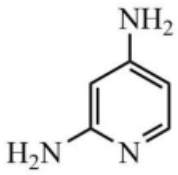


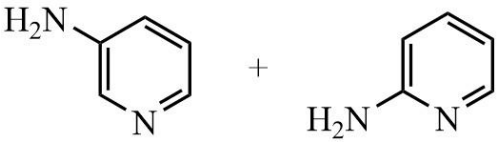
(d)

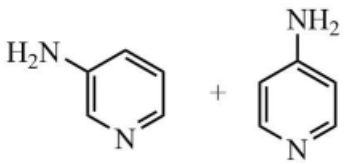


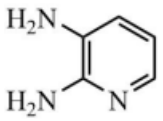
Q.28 The correct option for the product(s) of the following reaction is



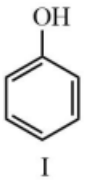
(a) 

(b) 

(c) 

(d) 

Q.29 The increasing order of acidity of the given molecule in aqueous media is



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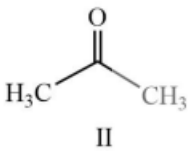


II

III

IV

(a) IV < I < II < III (b) II < I < IV < III

(c) II < IV < I < III (d) IV < II < I < III

Q.30 The compound formed upon subjecting an aliphatic amine to Lassaigne's test is

(a) $NaNH_2$ (b) $NaNO_2$ (c) NaCN (d) NaN_3

Section-B: Multiple Select Questions (MSQ)

Q.31 – Q.40 carry two marks each.

Q.31 The eigenvalue(s) of the matrix $\begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$ is/are

(a) –1 (b) 1 (c) 2 (d) 3

Q.32 The unit of the constant '*a*' in van der Waals equation of state of a real gas can be expressed as

(a) m^6 Pa mol^{-2} (b) m^6 J mol^{-2} (c) m^3 Pa mol^{-2} (d) m^3 J mol^{-2}

Q.33 Among the following, microwave active molecule(s) is/are

(a) Trans-dichloroethane

(b) 1,2-dinitrobenzene

(c) 3-methylphenol

(d) Para-aminophenol

Q.34 The true statement(s) regarding the brown ring test carried out in the laboratory for the detection of NO_3^- is/are

(a) Brown ring is due to the formation of the iron nitrosyl complex.

(b) Concentrated nitric acid is used for the test.

(c) The complex formed in the reaction is $[Fe(CN)_5NO]^{2-}$

(d) The brown coloured complex is paramagnetic in nature.

Q.35 The true statement(s) regarding the carbonic anhydrase enzyme is/are

(a) It is involved in peptide bond cleavage.

(b) Redox inactive Zn^{2+} ion is involved in the catalytic activity of this enzyme.

(c) Activated M-OH_2(M = metal ion) acts as the nucleophile in the enzyme.

(d) The metal ion is coordinated to the side chain of histidine.

Q.36 The correct statement(s) about NO_2, NO_2^+ and CO_2 is/are

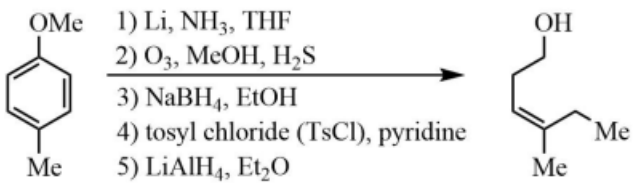
(a) Both NO_2 and CO_2 are paramagnetic.

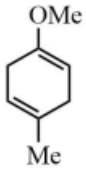
(b) NO_2 is paramagnetic and NO_2^+ is diamagnetic.

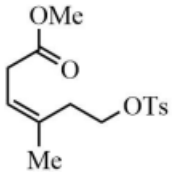
(c) Both CO_2 and NO_2^+ have linear geometry.

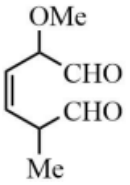
(d) CO2 and NO_2^+ are isoelectronic.

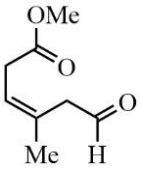
Q.37 The compound(s) formed as intermediate(s) in the following reaction sequence is/are



(a) 

(b) 

(c) 

(d) 

Q.38 The correct statement(s) among the following is/are

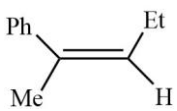
(a) Secondary structure of a polypeptide describes the number and type of amino acid residues.

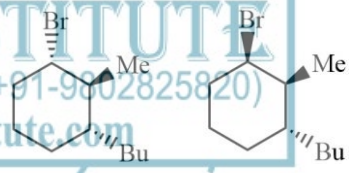
(b) Uracil is a pyrimidine nucleobase.

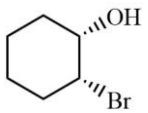
(c) Natural fatty acids have odd number of carbon atoms.

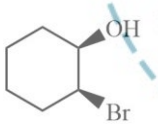
(d) Reaction of (D)-glucose with $Ca(OH)_2$ gives a product mixture containing (D)-fructose, (D)-mannose and (D)- glucose.

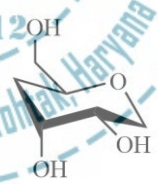
Q.39 The diastereomeric pair(s) among the following option(s) is/are

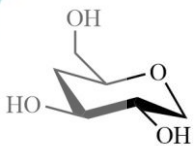
(a) 

(b) 

(c) 



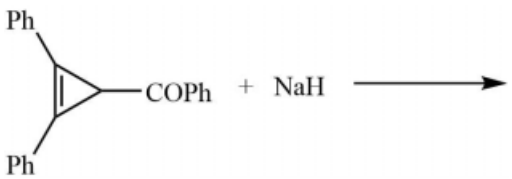
(d) 

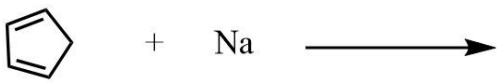


Q.40 The reaction(s) that result(s) in the formation of aromatic species is/are

(a) 

(b) 

(c) 

(d) 

Section-C: Numerical Answer Type (NAT)

Q.41 – Q.50 carry one mark each.

Q.41 The bond order of ion N_2^+ is ……. (Round off to one decimal place)

Q.42 One litre of a buffer solution contains 0.0004 mole of acetic acid (pK_a = 4.76) and 0.4 mole of sodium acetate. The *pH* of the solution is ……. (Round off to two decimal places)

Q.43The limiting molar conductivity of $La^{3+}$and Cl^- ions in aqueous medium a 298 K are 209.10×10^{-4} and 76.35×10^{-4} S m^2 mol^{-1}, respectively. The transport number of Cl^- in an infinitely dilute aqueous solution of $LaCl_3$ at 298K is …….. (Round off to two decimal places)

Q.44 The magnetic field strength required to exile an isolated to its higher spin state with an electromagnetic radiation of 300 MHz is ……. Tesla (T). (Round off to two decimal places)

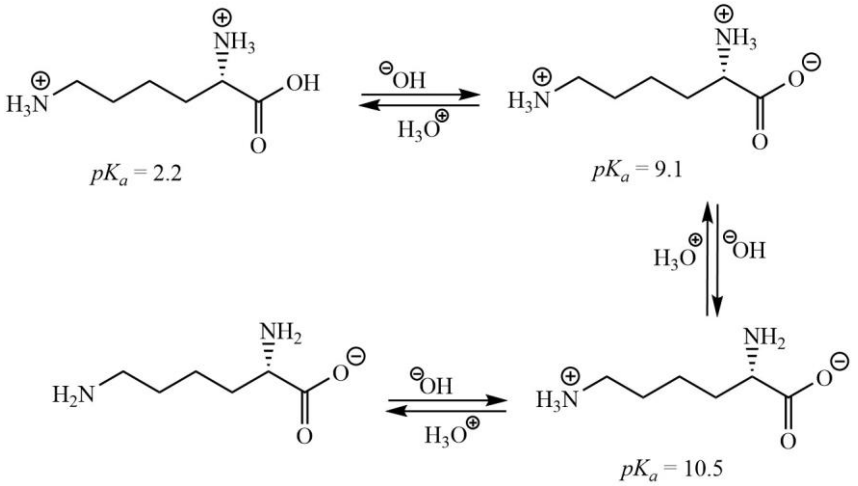
[Magnetogyric ratio of proton is 26.75×10^7 rad T^{-1} s^{-1}]

Q.45 The value of n for the complex $[Fe(CO)_4(SiMe_3)]^n$ satisfying the 18-electron rule is ……

Q.46 In the structure of P_4O_{10}, the number of P-O-P bond(s) is ……..

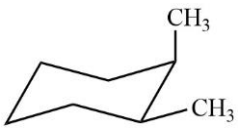
Q.47 Number of vertices in an icosahedral *closo*-borane is ……

Q.48 Based on the information given below, he isoelectric point (*pI*) of lysine is ……. (Round off to one decimal place)



Q.49 (*R*)-2-methyl-1-butanol has a specific rotation of +13.5°. The specific rotation of 2-methyl-1-butnol containing 40% of the (*S*)-enantiomer is …….°(Round off to one decimal place)

Q.50 The number of guache-butane interaction(s) in the following compound is ……



Q.51 – Q.60 carry one marks each.

Q.51 The ionization energy of hydrogen atom is 13.6 eV and the first ionization energy of sodium atom is 5.1 eV. The effective nuclear charge experienced by the valance electron of sodium atom is ……. (Round off to one decimal place)

Q.52One mole of an ideal gas is subjected to an isothermal increase in pressure from 100 kPa to 1000 kPa at 300 K. The change in Gibbs free energy of the system is ……. kJ mol^{-1}. (Round off to one decimal place)

[Given: Gas constant (R) is 8.314 J K^{-1} mol^{-1}]

Q.53 One litre of an aqueous urea solution contains 6g of urea. The osmotic pressure of the solution at 300K (assuming ideal behaviour) is ……. kPa. (Round off to one decimal place)

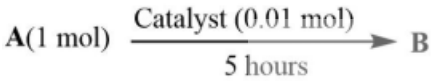
[Given: Molecular weight of the urea is 60, gas constant (R) is 8.314 J K^{-1} mol^{-1}]

Q.54 A first order reflection of X-ray from {220} plane of copper crystal is observed at a glancing angle of 22.the wavelength of the X-ray used is ……pm. (Round off to one decimal place)

[Given: Copper forms fcc crystal with unit cell edge length of 361 pm.]

Q.55 The collision flux of a monoatomic gas on copper surface is 3.0 10^{18} m^{-2} s^{-1}. Note that copper surface forms a square lattice with lattice constant of 210 pm. If the sticking coefficient of the atom with copper is 1.0, the time taken by the gas to form a complete monolayer on the surface is ……s. (Round off to one decimal place)

Q.56 The turnover frequency (TOF) for the catalytic reaction,

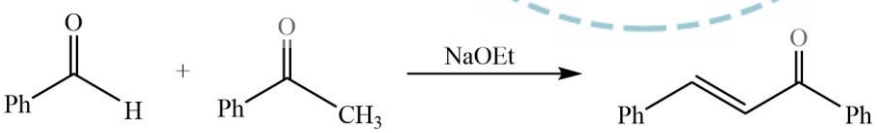


with 90% yield of the product is …… $hour^{-1}$. (Round off to the nearest integer)

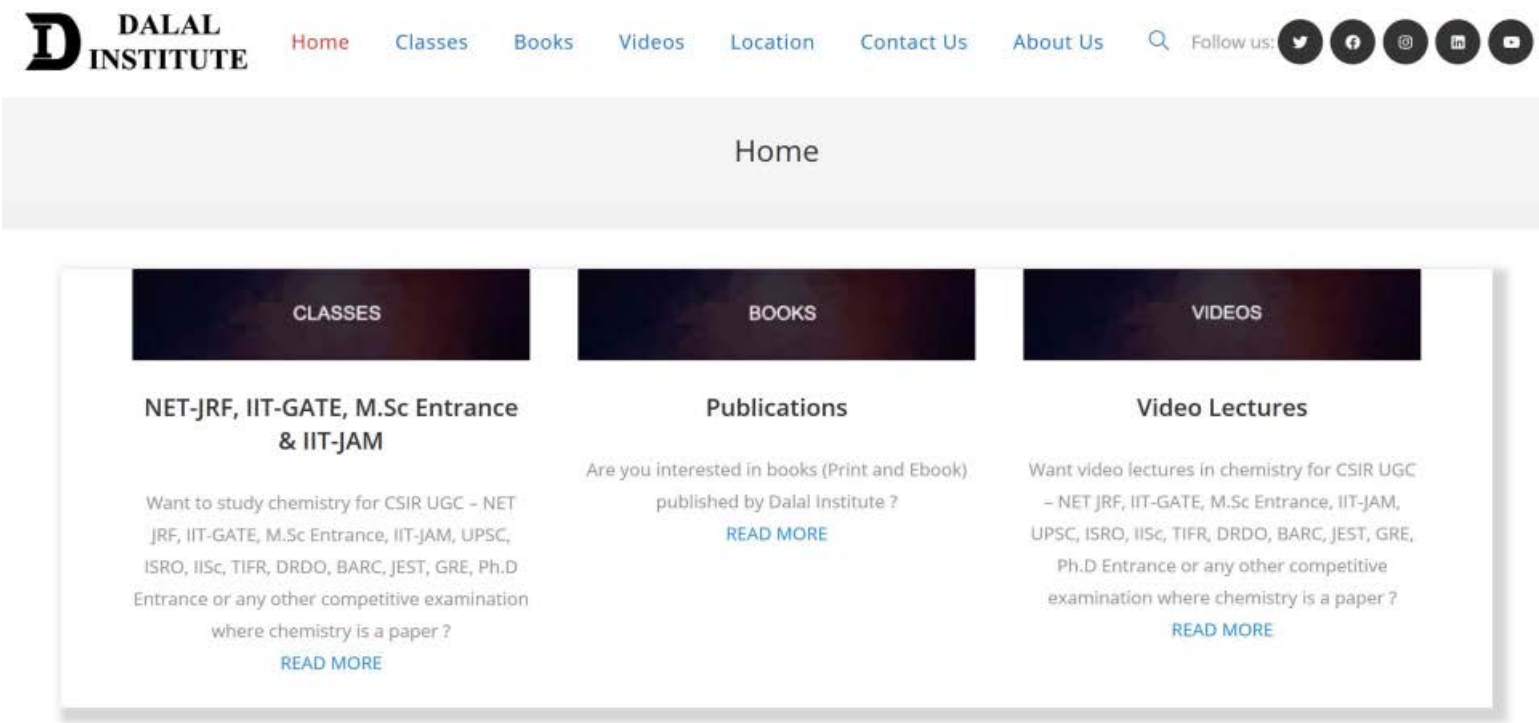
Q.57 A radioactive sample decays to 10% of its initial amount in 4600 minutes. The rate constant of this process is ……$hour^{-1}$. (Round off to two decimal places)

Q.58 Given that the radius of the first Bohr orbit of hydrogen atom is 53 pm, the radius of its third Bohr orbit is …….pm. (Round off to the nearest integer)

Q.59 5.3g of benzaldehyde was reacted with an excess of acetophenone to product 5.2g of the enone product as per the reaction shown below. The yield of the reaction is ……..%.(Round off to the nearest integer)



Q.60 Assume that the reaction of MeMgBr with ethylacetate proceeds with 100% conversion to give tert-butanol. The volume of 0.2 M solution of MeMgBr required to convert 10mL of a 0.025 M solution of ethylacetate to tert-butanol is ……mL. (Round off to one decimal place)



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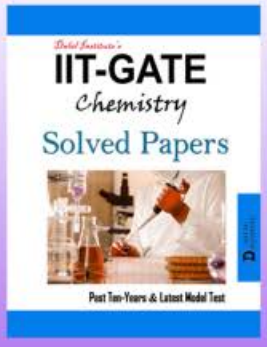

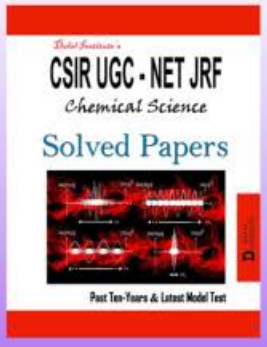

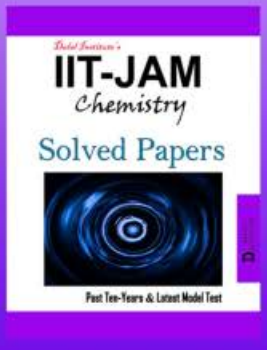

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