IIT JAM 2019 Chemistry (CY) Question Paper

Time Allowed :3 Hours	**Maximum Marks :**100	**Total questions :**60

General Instructions

General Instructions:

i) All questions are compulsory. Marks allotted to each question are indicated in the margin.

ii) Answers must be precise and to the point.

iii) In numerical questions, all steps of calculation should be shown clearly.

iv) Use of non-programmable scientific calculators is permitted.

v) Wherever necessary, write balanced chemical equations with proper symbols and units.

vi) Rough work should be done only in the space provided in the question paper.

Q1. For a reaction of the type A + B $\rightarrow$ 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

Q2. 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

Q3. 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

Q4. For three non-coplanar vectors a, b and c, the expression $\mathbf{a} \cdot (\mathbf{b} \times \mathbf{c})$ can be written as

(A) $(a \times b) \cdot c$

(B) $(a \times b) \cdot (a \times c)$

(C) $(a \cdot b) \times (a \cdot c)$

(D) $(a \cdot b) \times c$

Q5. Correct trend in the bond order is

(A) O^{2+} ¿ O_2^{2-} ¿ O_2

(B) O_2^{2-} ¿ O_2^{+} ¿ O_2^{2-}

(C) O_2^{2-} ¿ O_2 ¿ O^{2+}

(D) O_2^{2-} ¿ O_2^{2+} ¿ O_2^{+}

Q6. The correct option for the metal ion present in the active site of myoglobin, hemocyanin and vitamin B12, respectively, is

(A) iron, iron and zinc

(B) molybdenum, iron and copper

(C) iron, copper and cobalt

(D) copper, copper and cobalt

Q7. 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) and $[Co(NH_3)_5I]^{2+}$ (III), is

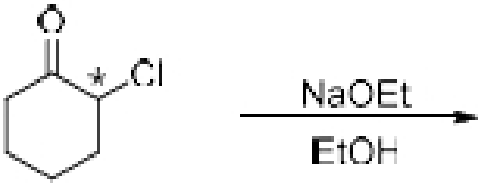
(A) III $<$ II $<$ I

(B) I $<$ II $<$ III

(C) II $<$ III $<$ I

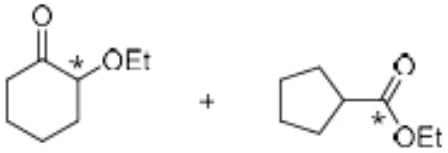
(D) I $<$ III $<$ II

Q8. The correct option for the major products of the following reaction is



(A)

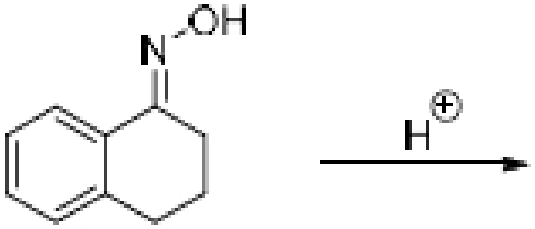
(B)



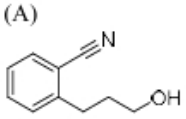
(C)

(D)

Q9. The major product formed in the following reaction is



(A)



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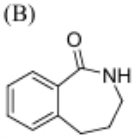

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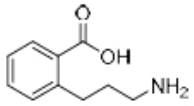

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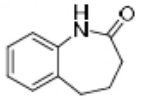
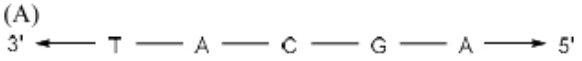
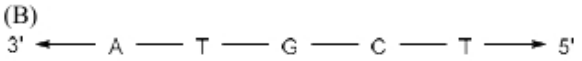


Q10. The complementary strand for the following single strand of DNA is

(A)



(B)



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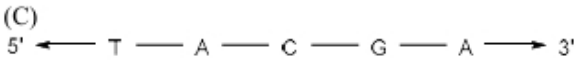

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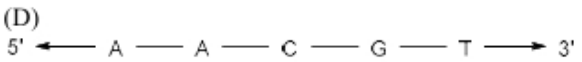


Q11. The function $f(x) = xe^{-x^2}$ has a minimum at

(A) $x = \sqrt{2}$

(B) $x = -\sqrt{2}$

(C) $x = \frac{1}{\sqrt{2}}$

(D) $x = -\frac{1}{\sqrt{2}}$

Q12. 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

Q13. The total number of degrees of freedom of an HBr molecule that is constrained to translate along a straight line but does not have any constraints for its rotation and vibration is

(A) 6

(B) 5

(C) 4

(D) 3

Q14. According to the kinetic theory of gases, the ratio of the root mean square velocity of molecular oxygen and molecular hydrogen at 300 K is

(A) 1 : 1

(B) 1 : $2\sqrt{2}$

(C) 1 : 4

(D) 1 : 16

Q15. The half-life of the chemical reaction, A $\rightarrow$ 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

Q16. The ratio of the nearest neighbor atomic distances in body-centered cubic (bcc) and face-centered cubic (fcc) crystals with the same unit cell edge length is

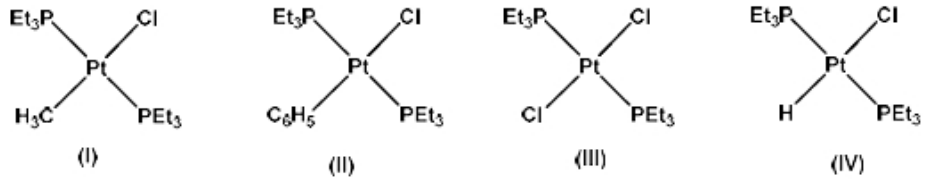
(A) $\frac{\sqrt{3}}{2}$

(B) $\frac{\sqrt{3}}{2}$

(C) $\frac{1}{\sqrt{2}}$

(D) $\frac{1}{2}$

Q17. The correct trend in the rate of substitution of Cl^- by pyridine in the following complexes is



(A) III < II < IV

(B) II < III < IV

(C) I < III < IV

(D) I < II < IV

Q18. In qualitative inorganic analysis of metal ions, the ion which precipitates as sulfide in the presence of H_2S in warm dilute HCl is

(A) Cr^{3+}

(B) Al^{3+}

(C) Co^{2+}

(D) Bi^{3+}

Q19. The 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) O_2, O and NO are paramagnetic

(C) O_2, C_2 and NO are paramagnetic

(D) O_2, B_2 and C_2 are paramagnetic

Q20. 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) $t_{2g}^6\ e_g^0$, $t_{2g}^5\ e_g^1$ and $t_{2g}^6\ e_g^0$

(B) $t_{2g}^6\ e_g^1$, $t_{2g}^5\ e_g^0$ and $t_{2g}^6\ e_g^1$

(C) $t_{2g}^6\ e_g^0$, $t_{2g}^6\ e_g^1$ and $t_{2g}^5\ e_g^1$

(D) $t_{2g}^5\ e_g^1$, $t_{2g}^6\ e_g^1$ and $t_{2g}^6\ e_g^0$

Q21. Among the following compounds, the one having the lowest boiling point is

(A) $SnCl_4$

(B) $GeCl_4$

(C) $SiCl_4$

(D) CCl_4

Q22. 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

(A) (I) and (III)

(B) (I) and (IV)

(C) (II) and (III)

(D) (II) and (IV)

Q23. Among the following, the correct statement is

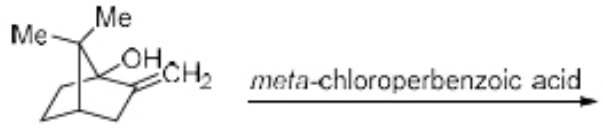
(A) The density follows the order, Cs^+ ¿ Rb^+ ¿ Li^+ ¿ Na^+

(B) The solubility in water follows the order, Cs_2CO_3 ¿ K_2CO_3 ¿ Na_2CO_3 ¿ Li_2CO_3

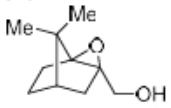
(C) The first ionization potential follows the order, Li^+ ¿ K^+ ¿ Na^+ ¿ Cs^+

(D) The melting point follows the order, $MgCl_2$ ¿ $BeCl_2$ ¿ $CaCl_2$ ¿ $SrCl_2$

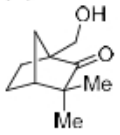
Q24. The major product of the following reaction is



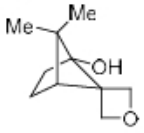
(A)



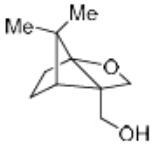
(B)



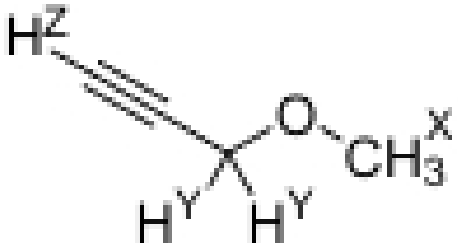
(C)



(D)



Q25. 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



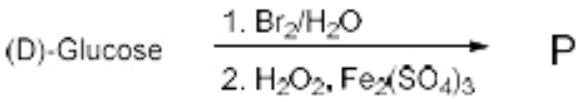
(A) H^Z ¿ H^X ¿ H^Y

(B) H^Z ¿ H^Y ¿ H^X

(C) H^X ¿ H^Y ¿ H^Z

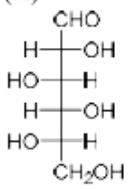
(D) H^Y ¿ H^X ¿ H^Z

Q26. In the following reaction of (D)-Glucose, a product P is formed.

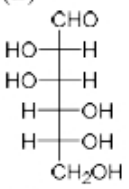


Among the following compounds, the one which will give the same product (P) under identical reaction conditions is

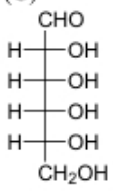
(A)



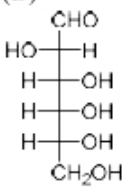
(B)



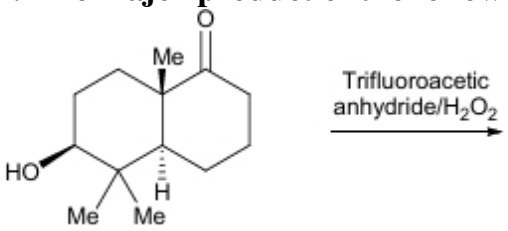
(C)



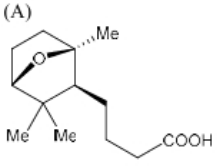
(D)



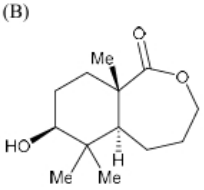
Q27. The major product of the following reaction is



(A)



(B)



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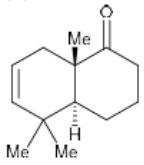

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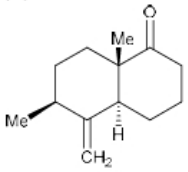
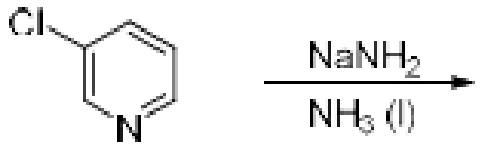
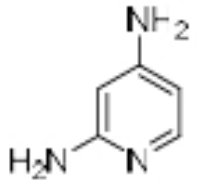


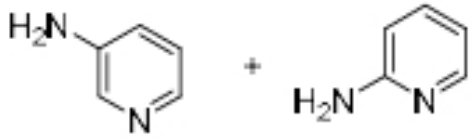
Q28. The correct option for the product(s) of the following reaction is



(A)



(B)



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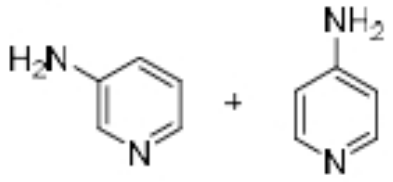
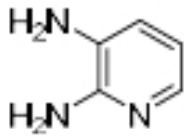
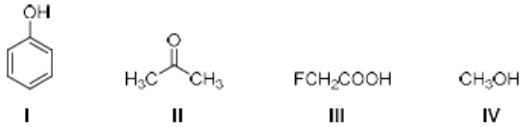


(D)



Q29. The increasing order of acidity of the given molecules in aqueous media is



(A) IV < I < II < III

(B) II < I < IV < III

(C) II < IV < I < III

(D) IV < II < I < III

Q30. The compound formed upon subjecting an aliphatic amine to Lassaigne's test is

(A) $NaNH_2$

(B) $NaNO_2$

(C) NaCN

(D) NaN_3

Q31. The eigenvalue(s) of the matrix

$$\begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$$ is/are

(A) -1

(B) 1

(C) 2

(D) 3

Q32. 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^3 J mol^{-2}

(C) m^3 Pa mol^{-2}

(D) m^3 J mol^{-2}

Q33. Among the following, microwave active molecule(s) is/are

(A) trans-dichloroethene

(B) 1,2-dinitrobenzene

(C) 3-methylphenol

(D) para-aminophenol

Q34. 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)]NO^2.

(D) The brown colored complex is paramagnetic in nature.

Q35. 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 (M = metal ion) acts as the nucleophile in the enzyme.

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

Q36. The correct statement(s) about NO_2, NO_2^+ and CO_2 is/are

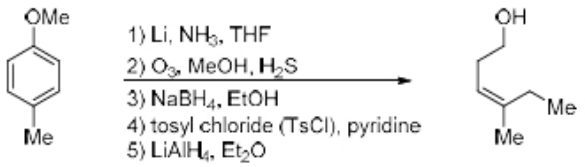
(A) Both NO_2 and CO_2 are paramagnetic.

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

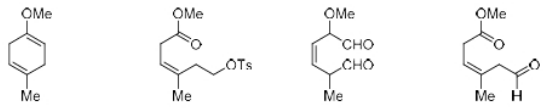
(C) Both CO_2 and NO_2^+ have linear geometry.

(D) CO_2 and NO_2^+ are isoelectronic.

Q37. The compound(s) formed as intermediate(s) in the following reaction sequence is/are



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



Q38. The correct statement(s) among the following is/are

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

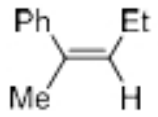
(B) Uracil is a pyrimidine nucleobase.

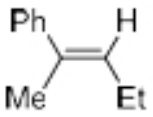
(C) Natural fatty acids have odd number of carbon atoms.

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

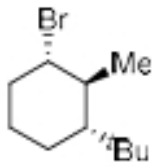
Q39. The diastereomeric pair(s) among the following option(s) is/are

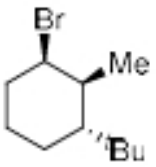
(A)



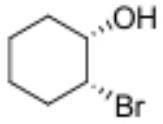


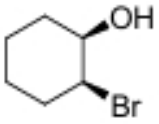
(B)



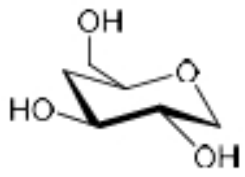


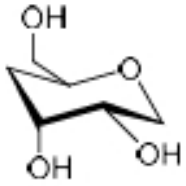
(C)





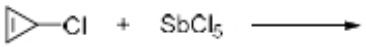
(D)





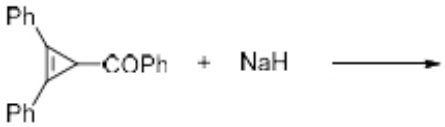
Q40. The reaction(s) that result(s) in the formation of aromatic species is/are

(A)

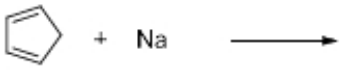


(B)

(C)



(D)



Q41. The bond order of N_2^+ ion is _____. (Round off to one decimal place)

Q42. One liter of a buffer solution contains 0.004 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)

Q43. The limiting molar conductivity of La^{3+} and Cl^- ions in aqueous medium at 298 K are 209.10 $\times 10^{-4}$ and 76.35 $\times 10^{-4}$ S m^2 mol^{-1}, respectively. The transport number of Cl^- in an infinitely dilute aqueous solution of $LaCl_3$ at 298 K is _____. (Round off to two decimal places)

Q44. The magnetic field strength required to excite an isolated proton to its higher spin state with an electromagnetic radiation of 300 MHz is _____ Tesla. (Round off to two decimal places)

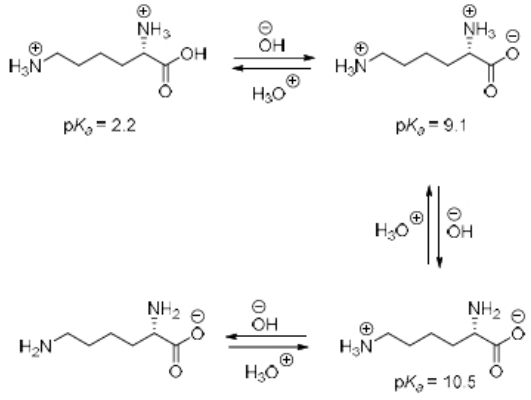
[Magnetogyric ratio of proton is 26.75×10^7 rad T^{-1} s^{-1}]

Q45. The value of n for the complex [$Fe(CO)_4(SiMe_3)]^n$ satisfying the 18-electron rule is _____

Q46. In the structure of P_4O_{10}, the number of P-O-P bond(s) is _____

Q47. Number of vertices in an icosahedral closo-borane is _____

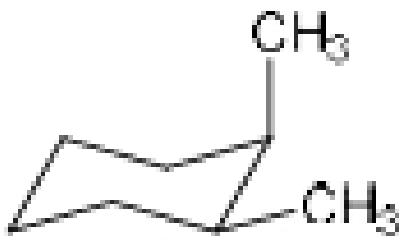
Q48. Based on the information given below, the isoelectric point (pI) of lysine is _____**. (Round off to one decimal place)**



The pK_a1 = 2.2 and pK_a2 = 9.1 and pK_a3 = 10.5.

Q49. (R)-2-methyl-1-butanol has a specific rotation of +13.5°. The specific rotation of 2-methyl-1-butanol containing 40% of the (S)-enantiomer is _____**. (Round off to one decimal place)**

Q50. The number of gauche-butane interaction(s) in the following compound is _____



Q51. 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 valence electron of sodium atom is _____. (Round off to one decimal place)

Q52. One 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) = 8.3 J K^{-1} mol^{-1}]

Q53. One liter of an aqueous urea solution contains 6 g of urea. The osmotic pressure of the solution at 300 K (assuming an ideal behavior) is _____ kPa. (Round off to one decimal place)

[Given: Molecular weight of urea = 60, gas constant (R) = 8.3 J K^{-1} mol^{-1}]

Q54. 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.]

Q55. The collision flux of a monoatomic gas on copper surface is 3.0×10^{18} $\mathbf{m^{-}2\ s^{-1}}$. 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)

Q56. The turnover frequency (TOF) for the catalytic reaction,

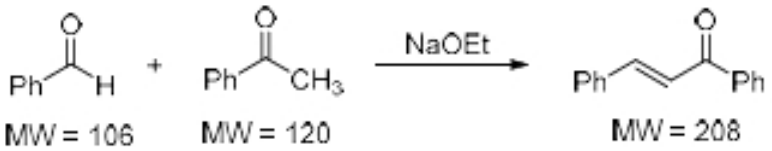
A (1 mol) $\xrightarrow{\text{Catalyst (0.01 mol)}}$ B

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

Q57. 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)

Q58. 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)

Q59. 5.3 g of benzaldehyde was reacted with an excess of acetophenone to produce 5.2 g of the enone product as per the reaction shown below. The yield of the reaction is _____ %. (Round off to the nearest integer)



(MW = Molecular weight)

Q60. 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 10 mL of a 0.025 M solution of ethylacetate to tert-butanol is _____ mL. (Round off to one decimal place)
