



**INDIAN INSTITUTE OF SCIENCE
BANGALORE - 560012**

ENTRANCE TEST FOR ADMISSIONS - 2008

**Program : Research
Entrance Paper : Chemistry
Paper Code : CY**

**Day & Date
SUNDAY, 27TH APRIL 2008**

**Time
9.00 A.M. TO 12.00 NOON**

INSTRUCTIONS

CHEMISTRY

1. This question paper consists of only objective type questions for a total of 100 marks
2. Four options are provided for each question
3. Answer all questions. A correct answer gets +1 mark and a wrong answer gets -1/3 mark.
4. Some useful physical constants
 - (a) Universal gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
 - (b) Planck's constant, $h = 6.626 \times 10^{-34} \text{ J.s}$
 - (c) Acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$
 - (d) Speed of light in vacuum, $c = 2.988 \times 10^8 \text{ m s}^{-1}$
 - (e) Avagadro number, $N (N_0) = 6.023 \times 10^{23} \text{ mol}^{-1}$
 - (f) Boltzman constant, $k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$
 - (g) Electronic charge, $e = 1.602 \times 10^{-19} \text{ C}$
 - (h) Electronic mass, $m = 9.109 \times 10^{-31} \text{ Kg}$
 - (i) Permittivity of vacuum, $\epsilon_0 = 8.854 \times 10^{-12} \text{ F m}^{-1}$
 - (j) Faraday constant. $F = 96500 \text{ C mol}^{-1}$
 - (k) 1 calorie = 4.184 J
 - (l) 1 atm = 760 Torr

Abbreviations used:

Me – methyl, Ph - Phenyl

1. Myoglobin is a
 - (A) catalyst for epoxidation reaction
 - (B) component in photosynthetic system
 - (C) nitrogen fixation enzyme
 - (D) di-oxygen binding metalloprotein

2. The number of d-d electronic band spectra for the high-spin Fe(III) octahedral system is
 - (A) Zero
 - (B) Two
 - (C) Three
 - (D) One

3. Which of the following shows NORMAL spinel structure
 - (A) Fe_3O_4
 - (B) Mn_3O_4
 - (C) NiAl_2O_4
 - (D) La_2CuO_4

4. Which of the following is diamagnetic in nature
 - (A) $\text{Hg}[\text{Co}(\text{NCS})_4]$
 - (B) $\text{K}_3[\text{Fe}(\text{CN})_6]$
 - (C) K_2PtCl_4
 - (D) $[\text{Cu}_2(\text{OAc})_4(\text{H}_2\text{O})_2]$

5. The ground state term for $t_{2g}^6 e_g^2$ in octahedral field is
 - (A) ${}^3A_{2g}$
 - (B) 8E_g
 - (C) ${}^4T_{1g}$
 - (D) ${}^2A_{1g}$

6. The base hydrolysis of $[\text{CoCl}(\text{NH}_3)_5]^{2+}$ proceeds in a
- (A) S_N^1
 - (B) $\text{S}_\text{N}^1\text{CB}$
 - (C) S_N^2
 - (D) S_E^2
7. The correct formulation for tetra(cyclopentadienyl) titanium(IV) complex is
- (A) $[\text{Ti}(\eta^5\text{-C}_5\text{H}_5)_4]$
 - (B) $[\text{Ti}(\eta^1\text{-C}_5\text{H}_5)_4]$
 - (C) $[\text{Ti}(\eta^5\text{-C}_5\text{H}_5)(\eta^1\text{-C}_5\text{H}_5)_3]$
 - (D) $[\text{Ti}(\eta^5\text{-C}_5\text{H}_5)_2(\eta^1\text{-C}_5\text{H}_5)_2]$
8. The oxidation state of iron in $[\text{Fe}(\eta^5\text{-Cp})_2][\text{BF}_4]$ is
- (A) +1
 - (B) 2
 - (C) +3
 - (D) +4
9. A complex of Ni(II), $[\text{NiCl}_2(\text{PPh}_3)_2]$ is paramagnetic. The analogous Pd(II) complex is diamagnetic. The number of isomers that will exist for the nickel and the palladium complexes are
- (A) One, One
 - (B) One, Two
 - (C) Two, One
 - (D) Two, Two
10. The bond angle in ClO_4^- is
- (A) 45°
 - (B) 90°
 - (C) 107.5°
 - (D) 109.5°

11. Which of the following molecules is paramagnetic?
- (A) F_2
 - (B) B_2
 - (C) O_2^{2-}
 - (D) N_2
12. The hydration energies of the alkaline earth metal ions are significantly **GREATER** than for the alkali metal ions because of
- (A) larger size and smaller charge
 - (B) larger size and greater charge
 - (C) smaller size and smaller charge
 - (D) smaller size and greater charge
13. The order of increasing Lewis acidity of the silicon halides is
- (A) $SiF_4 < SiCl_4 < SiBr_4 < SiI_4$
 - (B) $SiCl_4 < SiBr_4 < SiI_4 < SiF_4$
 - (C) $SiBr_4 < SiI_4 < SiF_4 < SiCl_4$
 - (D) $SiI_4 < SiBr_4 < SiCl_4 < SiF_4$
14. The effects on the non-metal when it combines with a metal are
- (A) Gain in electrons and increase in size
 - (B) Loss of electrons and increase in size
 - (C) Gain in electrons and decrease in size
 - (D) Loss of electrons and decrease in size
15. The hybridization of the xenon atom in XeF_4 is
- (A) sp^2
 - (B) sp^3
 - (C) sp^3d
 - (D) sp^3d^2

16. The quaternary structure of human hemoglobin is best described as a

- (A) Dimer of two myoglobin dimers
- (B) Tetramer of identical subunits
- (C) Tetramer of two different subunits
- (D) Tetramer of four different subunits

17. Inverse crown ethers act as hosts for:

- (A) Cations
- (B) Anions
- (C) Alkali metals
- (D) Lanthanides

18. $C_2B_{n-2}H_n$ is an isoelectronic analogue of

- (A) B_nH_n
- (B) $B_nH_n^-$
- (C) $B_nH_n^{3-}$
- (D) $B_nH_n^{2-}$

19. The ionic radius is smaller than the atomic radius for

- (A) neon
- (B) nitrogen
- (C) sodium
- (D) sulfur

20. Carbon monoxide DOES NOT act as a reducing agent in

- (A) $2CO(g) + O_2(g) = 2CO_2(g)$
- (B) $CO(g) + H_2O(g) = CO_2(g) + H_2(g)$
- (C) $3CO(g) + Fe_2O_3(s) = 3CO_2(g) + 3Fe(s)$
- (D) $4CO(g) + Ni(s) = Ni(CO)_4(g)$

21. Phosphoric and phosphorous acid
- (A) Have zero and one P-H bond
 - (B) have no P-H bonds
 - (C) are both triprotic
 - (D) are both diprotic
22. At 25 °C, $K_p = 6.8 \times 10^5$ for $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$. The K_c for this reaction is
- (A) 1.7×10^2
 - (B) 0.17
 - (C) 4.1×10^8
 - (D) 1.1×10^3
23. Which of the following has the smallest bond enthalpy
- (A) Si-H
 - (B) C-H
 - (C) Ge-H
 - (D) Pb-H
24. The structure of CsCl transforms to NaCl under high pressure. During this process the coordination number of Cs and Cl change from
- (A) 8:8
 - (B) 6:6
 - (C) 12:12
 - (D) 8:6
25. The symmetry elements present in *p*-difluorobenzene are
- (A) E, C_2 , $2\sigma_v$, σ_h , i
 - (B) E, C_2 , σ_h , $2\sigma_v$, i
 - (C) E, $3C_2$, $2\sigma_v$, σ_h , i
 - (D) E, $3C_2$, $2\sigma_v$, $2\sigma_h$, i

26. A powder diffraction pattern has the first three peaks at $2\theta = 9.66, 12.54$ and 28.39° , respectively, when recorded using $\text{MoK}\alpha$ radiation ($\lambda = 0.7107\text{\AA}$). If the wavelength is changed to $\text{CuK}\alpha$ ($\lambda = 1.542\text{\AA}$), the three peaks will
- (A) Shift to lower angles
 (B) Shift to higher angles
 (C) Stay at the same position
 @) The first two shifts to lower angles and the third shifts to higher angles
27. For the presumed equilibrium at 25°C , $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$, $\Delta H = -802\text{ kJ}$. The equilibrium constant of this process would be
- (A) shifted to the right by increasing the temperature
 (B) shifted to the left by increasing pressure
 (C) unaffected by change in pressure
 (D) shifted to the right by increasing pressure
28. The number of radial nodes in the $4s$ orbital of the H-atom in a finite distance from the nucleus is
- (A) 6
 (B) 4
 (C) 2
 (D) 3
29. If a compound is formed in a FCC lattice with M atoms at the corners of the unit cell N atoms at the face centers, the formula of the compound will be
- (A) MN
 (B) MN_3
 (C) M_3N
 (D) M_2N_2
30. Bulk CdS has a band gap of 2.6 eV and its optical absorption edge lies at $\sim 475\text{ nm}$. What will happen to the absorption edge when you make CdS in nanometer dimensions?
- (A) The absorption edge will shift to smaller wavelengths
 (B) The absorption edge will shift to longer wavelengths
 (C) There will be no change in the position of the absorption edge
 (D) The absorption edge will disappear

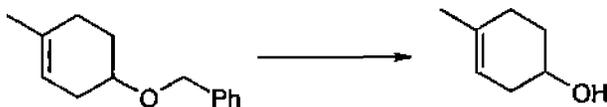
31. Which of the following pair of 4f elements can exhibit +2 oxidation state

- (A) La & Lu
- (B) Ce & Gd
- (C) Er & Yb
- (D) Sm & Tm

32. Calculate the lattice enthalpy of KCl(s) in kJ/mole using a Born-Haber cycle (AH for the following are given in kJ/mol: sublimation of K(s) = +89, ionization of K(g) = +425; dissociation of Cl₂(g) = +244, electron gain by Cl(g) = -355, formation of KCl(s) = 438).

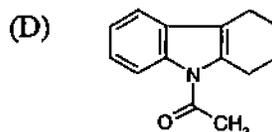
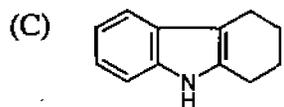
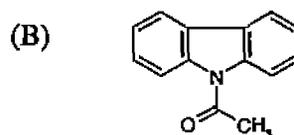
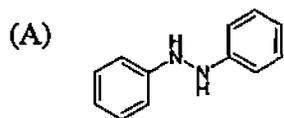
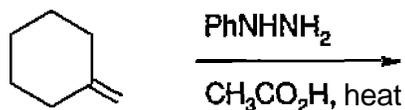
- (A) 0(zero)
- (B) 719
- (C) -719
- (D) 1438

33. Indicate the suitable reagent to carry out the following transformation:

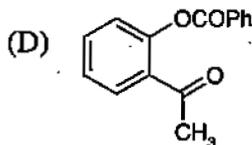
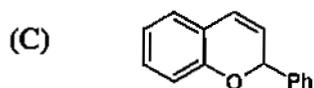
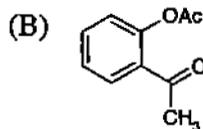
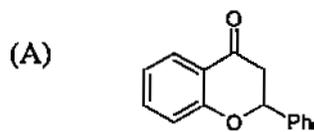


- (A) Pd-C/H₂
- (B) Li/NH₃
- (C) DDQ
- (D) HBr

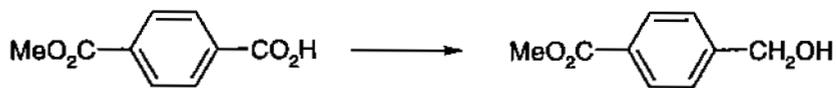
34. Identify the MAJOR product in the following reaction.



35. The MAJOR product in the reaction between o-hydroxyacetophenone and benzaldehyde in the presence of NaOH is

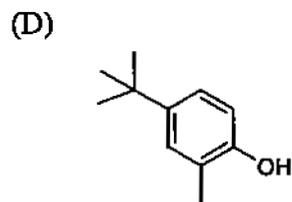
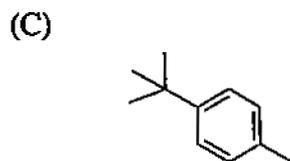
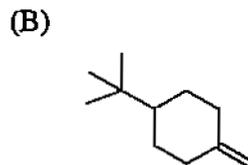
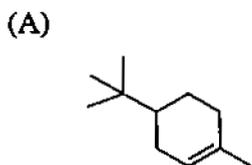
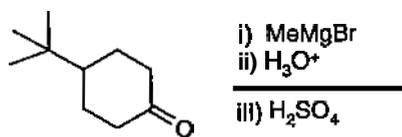


36. Which reagent is suitable to carry out the following transformation

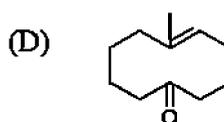
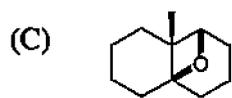
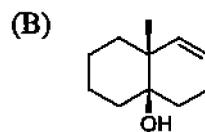
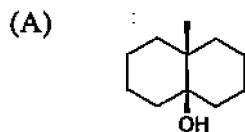
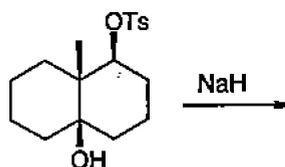


- (A) NaBH_4
 (B) LiAlH_4
 (C) BH_3
 (D) DIBAL-H

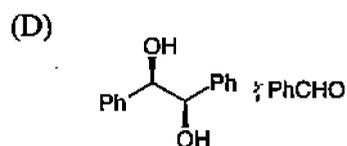
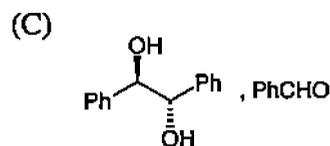
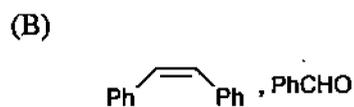
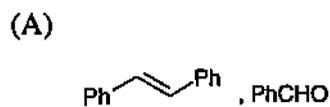
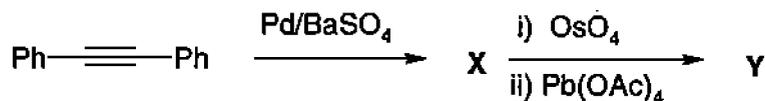
37. Identify the MAJOR product in the following transformation:



38. The MAJOR product in the following reaction is



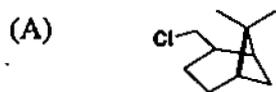
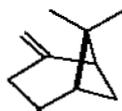
39. Identify the products (X, Y) in the following sequence:



40. How many signals will be observed in the proton decoupled ^{13}C NMR for hexamethylbenzene?

- (A) 1
- (B) 2
- (C) 3
- (D) 4

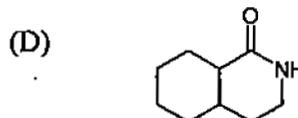
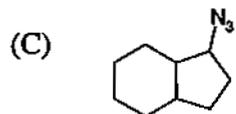
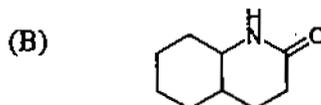
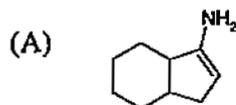
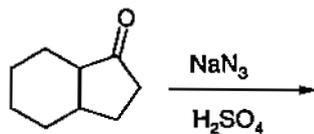
41. Identify the MAJOR product obtained when the compound shown below is treated with HCl.



42. The ^1H NMR spectrum of an organic compound of molecular formula C_4H_8 exhibited only a singlet at $\delta = 1.9$ ppm. The compound is:

- (A) 1-butene
 (B) *cis*-2-butene
 (C) *trans*-2-butene
 (D) cyclobutane

43. Identify the MAJOR product formed in the following reaction:

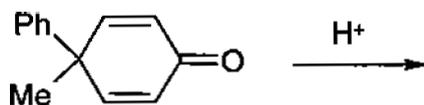


44. Which reagent would facilitate the following transformation.

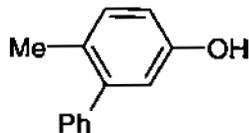


- (A) Li/NH_3
- (B) $n\text{-BuLi}$
- (C) dil. NaOH
- (D) TMSI

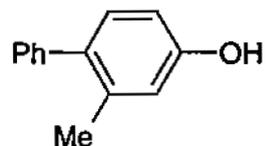
45. Identify the MAJOR product in the following reaction:



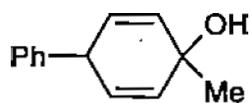
(A)



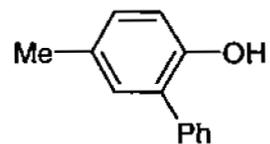
(B)



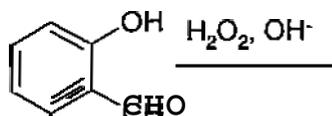
(C)



(D)



46. What is the product of the following reaction

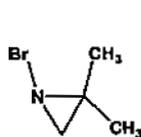


- (A) catechol
- (B) salicylic acid
- (C) *o*-benzoquinone
- (D) salicyl alcohol

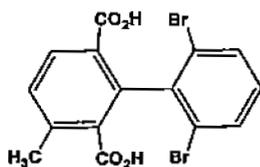
47. Which reagent is used for the conversion of benzil to benzilic acid?

- (A) conc. HCl
- (B) conc. KOH
- (C) TiCl_4
- (D) KMnO_4

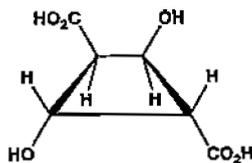
48. Which of the following molecules are NOT optically active?



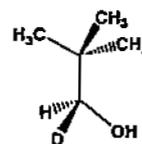
A



B



C



D

- (A) A, B
- (B) B, C
- (C) C, D
- (D) D, A

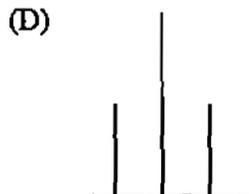
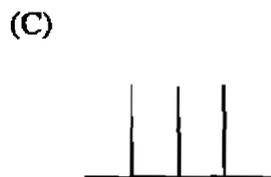
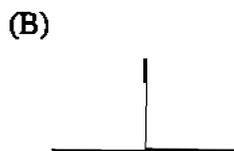
49. Which technique would you use to quickly distinguish methyl benzoate from phenyl acetate?
- (A) ^1H NMR
 - (B) Mass spectrometry
 - (C) Vapor pressure osmometry
 - (D) Elemental analysis
50. Acetone and acetone- d_6 (hexadeuterated acetone) may be readily distinguished by:
- (A) Thin layer chromatography
 - (B) UV-Visible (absorption) spectroscopy
 - (C) ^{13}C NMR spectroscopy
 - (D) Mass spectrometry
51. In a Grignard reaction, which of the following dry solvents CAN be used as replacement for anhydrous ether
- (A) Acetone
 - (B) Ethyl acetate
 - (C) Tetrahydrofuran
 - (D) Isopropanol
52. In which polymer is $-(\text{CF}_2\text{-CF}_2)_n-$ the repeating unit?
- (A) Polystyrene
 - (B) Polyvinyl chloride
 - (C) Teflon
 - (D) Hyaluronic acid

53. The strength of the coupling between geminal protons in the following molecules



- (A) Increases as the size of the ring increases
 (B) Decreases as the size of the ring increases
 (C) Remains the same
 (D) No relation between the size of the ring and the coupling

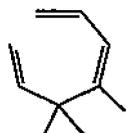
54. The expected spectral pattern in the proton coupled ^{13}C NMR spectrum of a mixture of equal weights of CHCl_3 and $^{13}\text{CHCl}_3$ would be



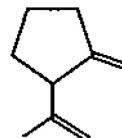
55. Identify the product of the reaction



(A)



(B)



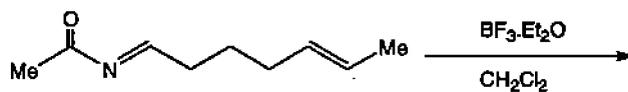
(C)



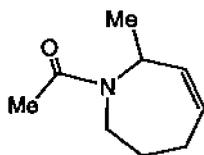
(D)



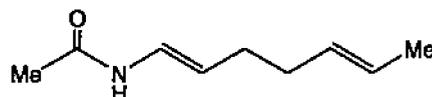
56. What is the product of the following reaction:



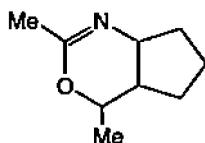
(A)



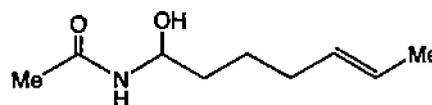
(B)



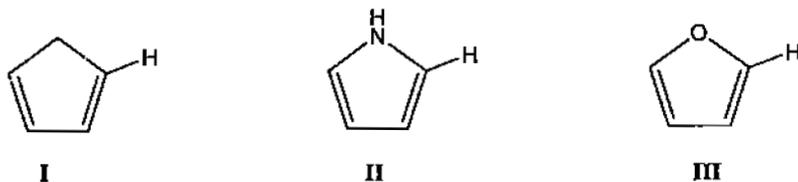
(C)



(D)

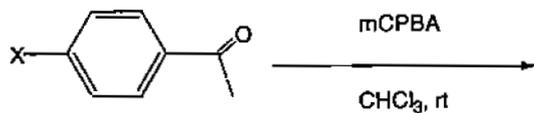


57. The increasing order of the chemical shift of the indicated proton in the following series of compounds is:



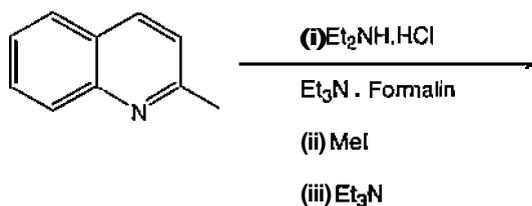
- (A) I < II < III
 (B) III < II < I
 (C) I < III < II
 (D) II < III < I

58. What is the sequence for the rate of oxidation in the following reaction

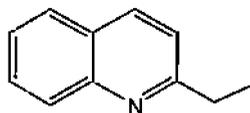


- (A) X = H > X = CN > X = OCH₃ > X = Cl
 (B) X = CN > X = Cl > X = H > X = OCH₃
 (C) X = OCH₃ > X = H > X = Cl > X = CN
 (D) X = OCH₃ > X = CN > X = Cl > X = H

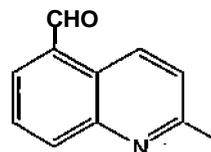
59. Identify the product of the reaction



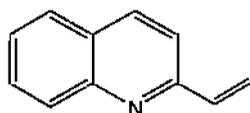
(A)



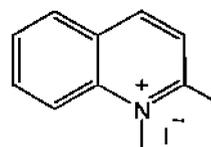
(B)



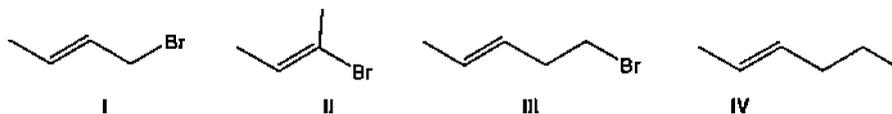
(C)



(D)

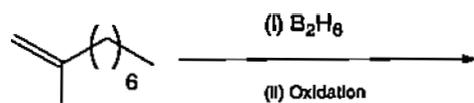


60. The relative ease of the reduction of the following substrate with N_2H_4

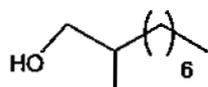


- (A) $\text{I} > \text{IV} > \text{III} > \text{II}$
 (B) $\text{IV} > \text{I} > \text{II} > \text{III}$
 (C) $\text{I} > \text{IV} > \text{II} > \text{III}$
 (D) $\text{IV} > \text{III} > \text{I} > \text{II}$

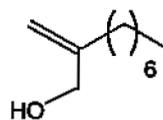
61. Identify the MAJOR product of the reaction



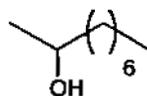
(A)



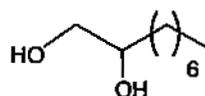
(B)



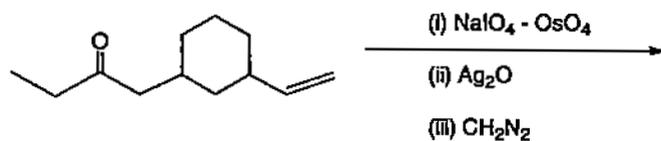
(C)



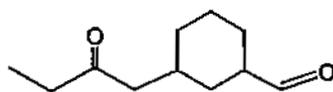
(D)



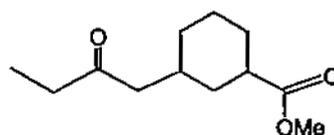
62. The product of the following reaction is



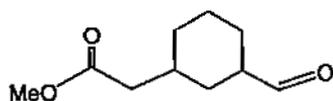
(A)



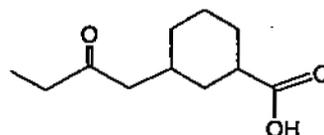
(B)



(C)

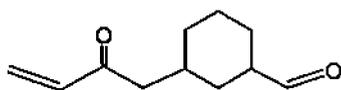


(D)

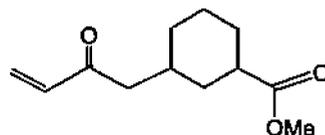


63. The product of the above reaction (Q. No.62) undergoes further reaction with Br_2/AcOH , followed by reaction with LiOH/DMF to give another product, which exhibits characteristic IR peaks at 1732 and 1680 cm^{-1} . This product is:

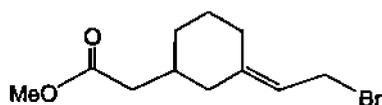
(A)



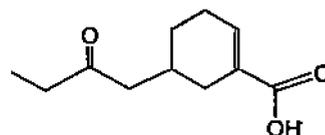
(B)



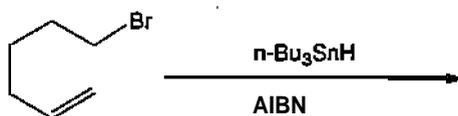
(C)



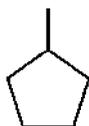
(D)



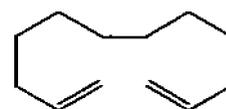
64. Identify the MAJOR product of the reaction



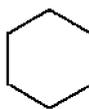
(A)



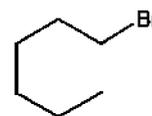
(B)



(C)



(D)



65. The selection rules for the allowed rotation Raman lines is
- (A) $\Delta J = 0, \pm 2$
 - (B) $\Delta J = \pm 1$
 - (C) $\Delta J = 0$
 - (D) $\Delta J = 0, \pm 1$ and ± 2
66. The defect that results when electrons are trapped in an ionic crystal lattice in place of an anion vacancy is known as
- (A) Frenkel defect
 - (B) Schottky defect
 - (C) F-Center
 - (D) Dislocations
67. Colloidal particles in soap solution carry
- (A) Negative charge
 - (B) Positive charge
 - (C) No charge
 - (D) Either positive or negative charge
68. Which of the following DOES NOT contain any asymmetric carbon but can show enantiomerism
- (A) Lactic acid
 - (B) 1,3-pentadiene
 - (C) Tartaric acid
 - (D) 2,3-pentadiene
69. The vibrational stretching frequency of N_2 can be determined using
- (A) Infrared Spectroscopy
 - (B) Microwave spectroscopy
 - (C) Raman Spectroscopy
 - (D) NMR spectroscopy

70. Consider a reaction: $A \rightarrow$ products. It is experimentally found to follow first order kinetics with respect to the reactant $[A]$. Which of the following statements need not be TRUE
- (A) The rate of the reaction will increase linearly with $[A]$.
 - (B) The reaction is unimolecular.
 - (C) The concentration of $[A]$ will decay exponentially with time.
 - (D) The time taken for $[A]$ to reduce by a factor of 2 will be independent of $[A]$
71. If the concentration vs time plot is found to be linear with a negative slope, the order of the reaction is
- (A) 0
 - (B) 1
 - (C) 2
 - (D) can not be determined
72. In collision theory for chemical reactions, which of the following statement is TRUE?
- (A) The molecules are assumed to have $3N - 6$ vibrational degrees of freedom one of which leads to the reaction
 - (B) The molecules have only translational degrees of freedom and only the relative translational energy of the two colliding partners is important for the reaction
 - (C) One of the rotational degrees of freedom for the molecule leads to the reaction
 - (D) Motion of the electrons in the reactants lead to the reaction
73. What is the pH of an aqueous solution of H^+ concentration equal to 5.4×10^{-9} mol litre⁻¹
- (A) 5.4
 - (B) 9.0
 - (C) 8.3
 - (D) 9.5

74. Electrolysis of a solution of CuSO_4 for 60 min using 10.0 Amp current results in 11.20 g of Cu metal on the cathode. The efficiency of this electrodeposition process is (Atomic mass of Cu = 63.5)
- (A) 9.45 %
 (B) 94.5 %
 (C) 47.25 %
 (D) 100 %
75. Standard reduction potentials at 25 °C are:
 $\text{CuI} + e^- = \text{Cu} + \text{I}^-$ ($E^\circ = -0.17 \text{ V}$); $\text{Zn}^{2+} + 2e^- = \text{Zn}$ ($E^\circ = -0.76 \text{ V}$)
 The voltage of the cell $\text{Zn}/\text{Zn}^{2+}(1\text{M})/\text{I}^-(1\text{M})/\text{CuI}$ is
- (A) 0.42 V
 (B) 0.59 V
 (C) 1.35 V
 (D) 1.18 V
76. Standard reduction potential of $\text{Fe}^{3+} + e^- = \text{Fe}^{2+}$ is 0.77 V. What is the potential of a Pt electrode immersed in an aqueous solution containing 2.0 M Fe^{2+} and 0.2 M Fe^{3+}
- (A) 0.71 V
 (B) 0.071 V
 (C) 7.1 V
 (D) 0.355 V
77. Using classical equipartition of energy between different modes, the ratio C_p/C_v of the heat capacities at constant pressure and volume, respectively of an ideal diatomic gas, will be
- (A) 5/3
 (B) 7/5
 (C) 3/2
 (D) 9/7

78. The total entropy (S) and Helmholtz free energy (A) changes in a spontaneous process at a constant temperature and volume would be
- (A) $\Delta S < 0$ and $\Delta A > 0$
 - (B) $\Delta S > 0$ and $\Delta A = 0$
 - (C) $\Delta S > 0$ and $\Delta A < 0$
 - (D) $\Delta S = 0$ and $\Delta A = 0$
79. One mol of an ideal gas at 300 K and 2.4618 atm is isothermally and reversibly expanded to twice its volume. The change in entropy for this process is
- (A) 0
 - (B) 5.76 JK^{-1}
 - (C) 2.88 JK^{-1}
 - (D) 8.64 JK^{-1}
80. Five moles of an ideal gas at $P = 10 \text{ atm}$. and $T = 300 \text{ K}$ expanded irreversibly and isothermally against an external pressure of 2 atm. until equilibrium is attained. The work done in the process is
- (A) -9.86 litre atm
 - (B) -98.8 litre atm
 - (C) -19.7 litre atm
 - (D) -39.4 litre atm
81. The number of IR active vibrational modes in ammonia is
- (A) 6
 - (B) 4
 - (C) 2
 - (D) 3
82. Replacement of hydrogen by deuterium atom bound to a heavy atom X in a polyatomic molecule would reduce the vibrational frequency of the ...X-H stretching by a factor of
- (A) 2
 - (B) $\sqrt{2}$
 - (C) 4
 - (D) 1.3

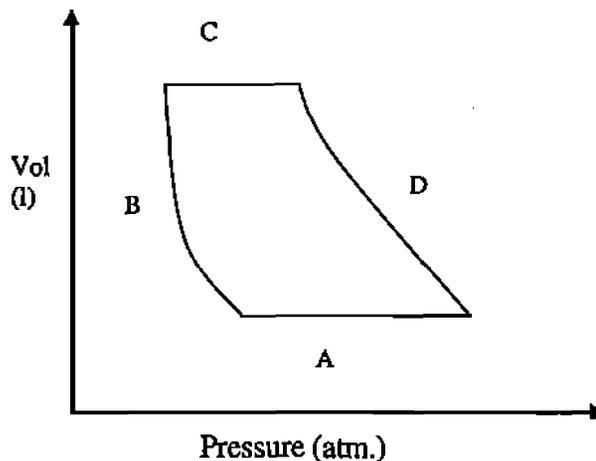
83. The solubility of $\text{Fe}(\text{OH})_3$ in an aqueous solution of pH 7 is, (K_{sp} of $\text{Fe}(\text{OH})_3 = 1.0 \times 10^{-36}$)
- (A) $1.0 \times 10^{-15} \text{ M}$
 (B) $1.0 \times 10^{-9} \text{ M}$
 (C) $1.0 \times 10^{-7} \text{ M}$
 (D) $1.0 \times 10^{-6} \text{ M}$
84. How many electrons per second pass through a cross section of a metal wire carrying a current of 10^{-9} ampere ?
- (A) 625 e /sec
 (B) 625×10^7 e/sec
 (C) 1×10^9 e/sec
 (D) 1.6×10^{10} e/sec
85. The vapor pressure of crystalline zirconium chloride follows the equation $\log p$ (in mm) = $-5400/T + 11.766$. The heat of sublimation (in kcal mol⁻¹) at 437°C is
- (A) 24700
 (B) 24.7
 (C) 103.2
 (D) 4.7
86. CS_2 (mol. wt. 76) has a dielectric constant of 2.64 and a density of 1.26 gcm^{-3} at 20°C. The molar refraction of CS_2 is
- (A) 0.213 cm^3
 (B) 2.13 cm^3
 (C) 21.3 cm^3
 (D) 213 cm^3
87. The specific conductivity of a saturated solution of AgCl at 25°C is $3.41 \times 10^{-6} \text{ S.cm}^{-1}$ and that of water is $1.60 \times 10^{-6} \text{ S.cm}^{-1}$. The molar conductivity at infinite dilution is 138.3 S.cm^2 , What is the solubility of AgCl in water in moles/l at 25°C
- (A) 1.3×10^{-5}
 (B) 1.15×10^{-5}
 (C) 1.15×10^5
 (D) 1.31×10^5

88. The van der Waal's equation of state for a real gas can be expressed in the "reduced" form

$$\pi = \frac{8\tau}{3\phi - 1} - \frac{3}{\phi^2} \quad (1)$$

where $\pi = P/P_c$, $\tau = T/T_c$ and $\phi = V/V_c$ with P, T and V denoting the pressure, temperature and volume respectively, and the subscript c refers to the corresponding critical values. With reference to the above equation which of the following statement is NOT TRUE.

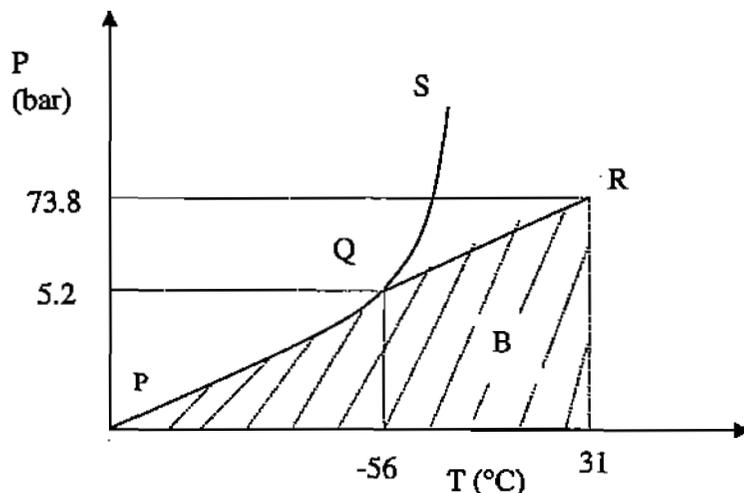
- (A) Two gases at the same reduced temperature and under the same reduced pressure occupy the same reduced volume
 - (B) If a gas obeying Equation (1) occupies a volume three times its critical volume at some T and P, its reduced temperature exceeds its reduced pressure by 1/3
 - (C) If a gas obeying Equation (1) is at its critical temperature and volume, it has the remaining degree of freedom, viz, the pressure
 - (D) When a gas obeying Equation (1) is at its critical temperature and pressure, $(\phi-1)^3 = 0$
89. The working of an automobile engine can be approximated by a four-step thermodynamic cycle in which a gaseous mixture of fuel and air undergoes two adiabatic steps in alternation with two constant volume steps as shown in the Figure below.



In the first step of the cycle the gaseous mixture is compressed, in the second step it is ignited, in the third step it performs mechanical work and in the fourth step it is released as exhaust and replaced with a fresh fuel/air mixture. Which step would MOST CLOSELY correspond to the ignition process

- (A) Step A
- (B) Step B
- (C) Step C
- (D) Step D

90. The figure shows the phase diagram of CO₂ (not to scale)



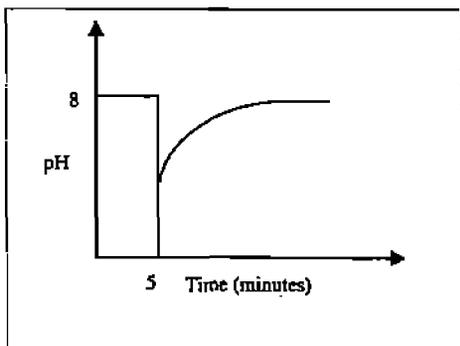
Which of the following statement about this diagram is NOT TRUE?

- (A) In the shaded region marked B, CO₂ exists as a gas
 - (B) Along the Line QR, liquid and vapour coexist in equilibrium
 - (C) Along the line PQ, the condition of equilibrium is defined by the relation $\mu_s = \mu_g$ where μ is the chemical potential and the subscript refers to solid (s) and gas (g), respectively
 - (D) Gibbs phase rule predicts that two intensive variables can be varied independently along QS
91. Two colorless liquids X and Y can react reversibly in equilibrium to form a colored compound Z releasing protons. The reaction can be written as:

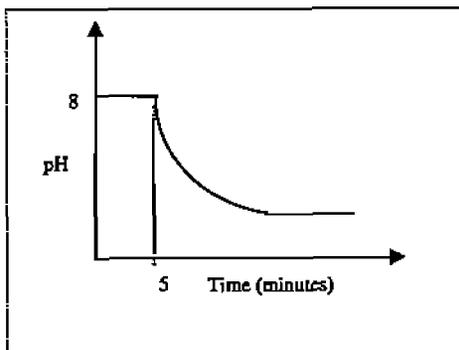


At equilibrium (pH = 8) and after 5 min., a small quantity of HCl is added. The pH vs. time graph that best describes this system over a period of time is

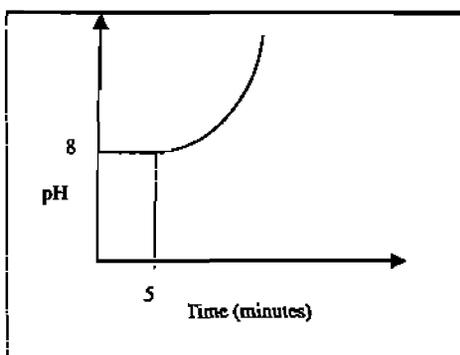
(A)



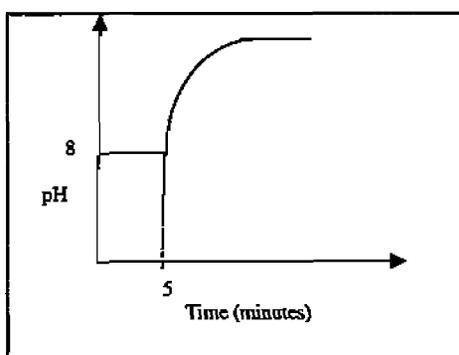
(B)



(C)



(D)



92. Calculate the fraction of the volume of Al (f.c.c) occupied by its atoms

- (A) 0.255
- (B) 0.740
- (C) 0.414
- (D) 0.875

93. The composition of a sample of iron oxide is $\text{Fe}_{0.93}\text{O}$. What percentage of Fe is in 3+?

- (A) 0.07 %
- (B) 7.0%
- (C) 30%
- (D) 15.1 %

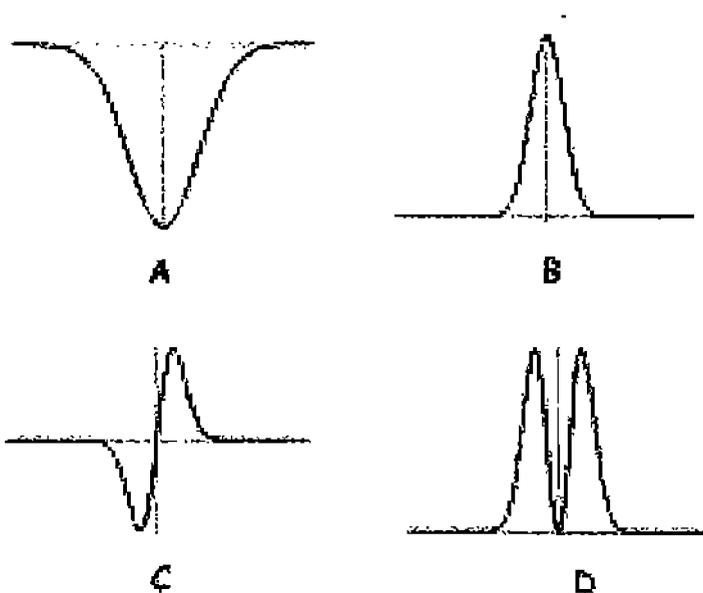
94. Among, the following wave functions, which one is acceptable for an electron, bound to a nucleus? (r , θ , ϕ) denote the spherical polar coordinates of the electron, with respect to the nucleus, r is in atomic units.

- (A) $[N \exp(-r)]/r$
- (B) $N \exp(-r)\cos(\phi/2)$
- (C) $N \exp(-r)\cos(2\phi)$
- (D) $N \exp(r)\cos(2\phi)$

95. A particle is confined to a one dimensional box, and is in the lowest possible stationary state. Which one of the following statements is correct?

- (A) It has a nonzero energy and hence its average value of momentum is not zero.
- (B) It has a zero energy and hence its average value of momentum is zero.
- (C) It has a non zero energy and its average value of momentum is zero.
- (D) It has a zero of energy but its average value of momentum is not zero.

96. Among the pictures, chose the one that you think is the best representation of the wave function for the first excited state of a harmonic oscillator. The wave function is plotted in the vertical direction and is represented by a thicker line.



97. A π electron (mass m) in a naphthalene may be modeled as a particle in a TWO DIMENSIONAL box of dimensions a and $2a$. The expression for the allowed energy levels of the particle are (n_1 and n_2 are quantum numbers that take values 1,2,3...):

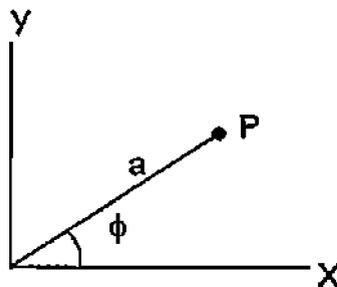
(A) $\frac{\hbar^2 \pi^2}{2m} \left(\frac{n_1^2}{a^2} + \frac{n_2^2}{2a^2} \right)$

(B) $\frac{\hbar^2 \pi^2}{2m} \left(\frac{n_1^2}{a^2} + \frac{n_2^2}{4a^2} \right)$

(C) $\frac{\hbar^2 \pi^2}{2m} \left(\frac{n_1^2}{a^2} + \frac{4n_2^2}{a^2} \right)$

(D) $\frac{\hbar^2 \pi^2}{2m} \left(\frac{n_1^2}{a^2} + \frac{2n_2^2}{a^2} \right)$

98. The wave function for a particle P confined to a ring of radius $r = a$ (see Figure) is $N \exp(i\phi)$, ϕ being the angle co-ordinate representing its position along the ring. The value of N is



- (A) $1/\sqrt{2\pi}$
 (B) $\sqrt{\pi}$
 (C) $\sqrt{2/\pi}$
 (D) 1

99. The partition function for translational motion of a particle of mass m , confined to a one dimensional box of length L , at a temperature T is:

(A) $\sum_{n=1}^{\infty} \exp\left(-\frac{n^2 \pi^2 \hbar^2}{2mL^2 kT}\right)$

(B) $\sum_{n=-\infty}^{\infty} \exp\left(-\frac{n^2 \pi^2 \hbar^2}{2mLkT}\right)$

(C) $\sum_{n=0}^{\infty} \exp\left(-\frac{n^2 \pi^2 \hbar^2}{2mL^2}\right)$

(D) $\sum_{n=1}^{\infty} \exp\left(-\frac{n^2 \pi^2 \hbar^2}{2mLkT}\right)$

100. Which of the following pair of $4f$ elements can exhibit +2 oxidation state

- (A) La & Lu
(B) Ce & Gd
(C) Eu & Yb
(D) Sm & Tm

End of the Question Paper