ENTRANCE EXAMINATION FOR ADMISSION, MAY 2013.

M.Sc. (CHEMICAL SCIENCES)

COURSE CODE : 369

Register Number :

Signature of the Invigilator
(with date)

COURSE CODE : 369

Time : 2 Hours   Max : 400 Marks

Instructions to Candidates :

1. Write your Register Number within the box provided on the top of this page and fill in the page 1 of the answer sheet using pen.

2. Do not write your name anywhere in this booklet or answer sheet. Violation of this entails disqualification.

3. Read each of the question carefully and shade the relevant answer (A) or (B) or (C) or (D) in the relevant box of the ANSWER SHEET using HB pencil.

4. Avoid blind guessing. A wrong answer will fetch you –1 mark and the correct answer will fetch 4 marks.

5. Do not write anything in the question paper. Use the white sheets attached at the end for rough works.

6. Do not open the question paper until the start signal is given.

7. Do not attempt to answer after stop signal is given. Any such attempt will disqualify your candidature.

8. On stop signal, keep the question paper and the answer sheet on your table and wait for the invigilator to collect them.

9. Use of Calculators, Tables, etc. are prohibited.

1. Which one of the following molecules contains the oxygen atom with the largest partial charge?

   (A) $H_2C=O$ (B) CH_3-O-CH_3 (C) CH_3-OH (D) HOH

2. When HCO is allowed to stand at room temperature, a white solid is formed, which is known as?

   (A) dioxane   (B) trioxane   (C) hexane   (D) acetaldehyde

3. Consider the formation of a carbon-radical via H-abstraction with a halogen radical. Under which conditions is the radical character on the developing C-radical maximized in the transition state?

   (A) The transition state is early and resembles the product

   (B) The transition state is late and resembles the reagents

   (C) The transition state is late and resembles the product

   (D) The transition state is early and resembles the reagents

4. How many stereoisomers exist for 2,3-dibromobutane?

   (A) only one stereoisomer: the *meso* form

   (B) three stereoisomers: the *meso* form and a pair of enantiomers

   (C) four stereoisomers: two pairs of diastereoisomers

   (D) two stereoisomers: the *meso* form and its enantiomer

5. Why do polar aprotic solvents increase the rates of S_N2 reactions?

   (A) Aprotic solvents always have low polarity

   (B) Aprotic solvents solvate the nucleophile less, and "naked" nucleophiles are more reactive

   (C) Aprotic solvents raise the energy of the products and therefore accelerate the reaction

   (D) Aprotic solvents better solvate the leaving group and therefore accelerate the reaction

6. Consider the dehydrohalogenation of 2-bromo-2-methyl butane with ethoxide and t-butoxide. Which of the following statement is true?

   (A) Saytzeff product is major product in both cases

   (B) Hofmann product is major product in both cases

   (C) Ethoxide gives more, t-butoxide give less Hofmann product

   (D) Ethoxide gives more, t-butoxide gives less Saytzeff product

7. What is product formed in the treatment of cyclopentene with bromine water?

   (A) *cis*-3-bromocyclopentanol   (B) *trans*-3-bromocyclopentanol

   (C) *trans*-2-bromocyclopentanol   (D) *cis*-2-bromocyclopentanol

8. You know that terminal alkynes are stronger acids compared to alkenes and alkanes. Given that, what can you say about the basicity of their corresponding anions?

   (A) Basicity: acetylide < vinyl anion > carbanion

   (B) Basicity: acetylide > vinyl anion > carbanion

   (C) Basicity: acetylide < vinyl anion < carbanion

   (D) Basicity: acetylide > vinyl anion < carbanion

9. The addition of a carbon nucleophile to a carbonyl compound leads to an alkoxide ion. Which statement about the alkoxide ion does not apply?

   (A) The alkoxide can be protonated by dilute acid to the alcohol

   (B) The former carbonyl carbon has been rehybridized from sp^2 to sp^3

   (C) The O-atom carries a negative charge

   (D) The bond between the alkoxide and the metal cation is dominantly covalent

10. What is the oxidative transformation that can be accomplished by the "Swern oxidation"?

    (A) primary alcohol to carboxylic acid

    (B) primary alcohol to aldehyde

    (C) secondary alcohol to ketone

    (D) aldehyde to carboxylic acid

11. What is the "base peak" in a mass spectrum?

    (A) the peak with the lowest intensity

    (B) the peak with the highest m/z value

    (C) the peak that is due to the ionized and non-fragmented molecule

    (D) the peak with the highest intensity

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12. Consider the structure isomers 1-bromopropane and 2-bromopropane. How many kinds of chemically and magnetically nonequivalent hydrogen nuclei are there in each of these isomers?

(A) 1-isomer: 2. 2-isomer: 3
(B) 1-isomer: 3. 2-isomer: 2
(C) 1-isomer: 2. 2-isomer: 8
(D) 1-isomer: 8. 2-isomer: 8

13. The ^{1}H-NMR spectrum of compound X shows methyl and methylene signals in the intensity ratio 3:1. Identify the compound X?

(A) $(CH_3)_2C(CH_2Br)_2$
(B) $(CH_3)_3C-CH_2Br$
(C) $(CH_3)_2CBr-CH_2Br$
(D) $CH_3-C(CH_2Br)_3$

14. What is catalyst used in the bimolecular dehydration of ethyl alcohol to produce diethyl ether?

(A) $Hg(SO_4)$ (B) H_2SO_4 (C) $NaHCO_3$ (D) $NaOH$

15. What is the final product, X, of the following sequence of two reactions?
cyclohexene $\xrightarrow{Cl_2, H_2O} W \xrightarrow{H_2O} X$

(A) 1,2-cyclohexanediol
(B) 1,2-dichlorocyclohexene
(C) epoxycyclohexane
(D) 2-chlorocyclohexanol

16. Which of the following is most effective in stabilizing the transition state of a nucleophilic displacement from an allylic halide or tosylate?

(A) interaction of the nonbonding electrons of the nucleophile with the nonbonding electrons of the leaving group

(B) overlap of the p orbital of the reacting carbon, in the transition state, with the p orbitals of the pi bond

(C) a relief of the steric requirements of the allylic system

(D) none of the above

17. Which one of the following is not a requirement for an aromatic compound?

(A) All the unhybridized p orbitals must overlap in a continuous ring

(B) The electronic energy of the compound must be decreased by delocalization of the pi electrons over the ring

(C) The compound must be cyclic, with conjugated pi bonds

(D) The total number of pi electrons must be evenly divisible by 4

18. What unusual characteristic does a halogen substituent exhibit in electrophilic aromatic substitutions?

(A) It is deactivating but ortho/para directing

(B) It is activating but meta directing

(C) It is activating but exclusively ortho directing

(D) It is deactivating and directs to all positions equally

19. What is product B of the following 2-step reaction?

Step 1 : ethylbenzene + CH_3-CO-Cl, $AlCl_3$, then H_2O → Product A

Step 2 : Product A, Zn(Hg), and aq. HCl → Product B

(A) m-diethylbenzene

(B) o-diethylbenzene

(C) p-ethylacetophenone

(D) p-diethylbenzene

20. What is the product of the reaction of propionic acid with ethyl lithium?

(A) 3-ethyl-3-pentanol

(B) 3-pentanone

(C) ethyl propyl ketone

(D) ethyl acetate

21. What is the product, C, of the following sequence of reactions?

A + CH_3MgBr ⟶ B

B + H_3O^+ ⟶ C
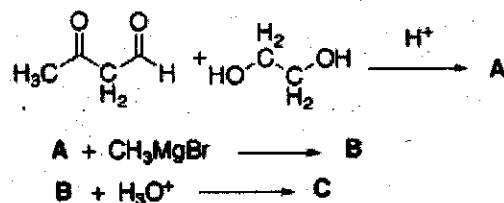
(A)

(B)

(C)

(D)

22. What product results from the reductive amination of acetaldehyde with aniline?

(A) C_6H_5-NH-CH_2-CH_3

(B) C_6H_5-N(CH_2-CH_3)$_2$

(C) $(C_6H_5)_2$-N-CH_2-CH_3

(D) C_6H_5-NH-CO-CH_3

23. Which one of the following contains a *thioester* functional group?

(A) nylon 6,6   (B) erythromycin   (C) coenzyme A   (D) penicillin

24. Addition of a small amount of base to a solution of D-glucose converts it to a solution of D-glucose and two other monosaccharides. What are these other two monosaccharides?

(A) D-mannose and D-fructose   (B) D-mannose and L-mannose

(C) L-glucose and D-galactose   (D) D-erythrose and D-threose

25. What is the product obtained when the Kiliani-Fischer synthesis is carried out on D-glyceraldehyde?

(A) D- and L-erythrose   (B) D- and L-threose

(C) D-threose and D-erythrose   (D) D-ribose

26. What is the purpose of the Edman degradation in peptide analysis?

(A) to locate all -S-S- linkages

(B) to identify the N-terminal amino acid

(C) to identify the C-terminal amino acid

(D) to determine which amino acids make up the peptide

27. Predict the product of the reaction: $C_6H_5N_2Cl + CuCl \rightarrow$? $+ N_2$.

(A) $C_6H_5NH_2$ (B) $C_6H_5NH_2.HCl$ (C) C_6H_5OH (D) C_6H_5Cl

28. What are the products of the reaction of acetophenone with excess I_2 in the presence of base? (Ph- = C_6H_5)

(A) $PhC(O)\text{-}Cl_3$ (B) $PhC(O)\text{-}CHI_2$

(C) *m*-iodoacetophenone   (D) $PhC(O)\text{-}CH_2I$

29. Mention the product from the reaction of glycine with acetic anhydride?

(A) $CH_3\text{-}CO\text{-}NH\text{-}CH_2\text{-}CO_2H$ (B) $H_2N\text{-}CH_2\text{-}CO\text{-}CO\text{-}CH_3$

(C) $H_2N\text{-}CH_2\text{-}CO\text{-}O\text{-}CO\text{-}CH_3$ (D) $H_2N\text{-}CH_2\text{-}CO\text{-}O\text{-}CO\text{-}CH_2\text{-}NH_2$

30. Which of the following is a copolymer?

(A) Natural rubber   (B) Nylon 6,6   (C) Orlon   (D) Teflon

31. Bromine has two naturally occurring isotopes, approximately 50% each of ^{79}Br and ^{81}Br. In the mass spectrum of naturally occurring dibromine, the parent ion will appear as

(A) two peaks of equal intensity

(B) three peaks of equal intensity

(C) three peaks with an approximate intensity ratio 1 : 2 : 1

(D) one peak

32. Find out the product in the autoionization in solvent sulphur dioxide :

$SO_2 + SO_2 \leftrightarrow ? + SO_3^{2-}$

(A) Thionyl ion   (B) Sulphite ion   (C) Sulphide ion   (D) Oxide ion

33. Calculate the dipole moment, μ of a diatomic molecule in which the constituent atoms are separated at a distance of 2 Å apart (electric charge e = 1 x 10^{-10} esu).

(A) 6.7×10^{-28} coulomb.cm

(B) 3.4×10^{-28} coulomb.cm

(C) 6.7×10^{-18} coulomb.cm

(D) 6.7×10^{-28} coulomb.m

34. Consider X_2 molecules for which X = B, C, N, O and F. Which of the following observation provides experimental evidence for the so-called σ-π crossover?

(A) O_2 is paramagnetic

(B) N_2 is diamagnetic

(C) B_2 is paramagnetic

(D) F_2 is diamagnetic

35. The product of the α- decay of $^{234}_{92}U$ is given as

(A) $^{230}_{92}U$ (B) $^{230}_{90}Th$ (C) $^{234}_{93}Np$ (D) $^{234}_{90}Th$

36. The correct order of size of the ions is: Br^-, I^-, Mg^{2+}, Ca^{2+}

(A) $Br^- < I^- > Mg^{2+} < Ca^{2+}$

(B) $Br^- > I^- > Mg^{2+} < Ca^{2+}$

(C) $Br^- < I^- > Mg^{2+} > Ca^{2+}$

(D) $Br^- > I^- > Mg^{2+} > Ca^{2+}$

37. The conjugate acid of $[Ti(OH_2)_5(OH)]^{2+}$ is

(A) $[(H_2O)_4Ti(\mu\text{-}OH)_2Ti(OH_2)_4(OH)]^{4+}$

(B) $[Ti(OH_2)_4(OH)_2]^+$

(C) $[Ti(OH_2)_5O]^+$

(D) $[Ti(OH_2)_6]^{3+}$

38. In which of the following the metal is reduced? (these are not balanced equations.)

(A) $[Fe(CN)_6]^{4-} \longrightarrow [Fe(CN)_6]^{3-}$ 　　　(B) $[MnO_4]^{-} \longrightarrow MnO_2$

(C) $[MnO_4]^{2-} \longrightarrow [MnO_4]^{-}$ 　　　(D) $[Cr_2O_7]^{2-} \longrightarrow [CrO_4]^{-}$

39. Which of the following is a Lewis acid?

(A) $[SbF_6]^{-}$ 　　　(B) $[AlCl_4]^{-}$ 　　　(C) BF_3 　　　(D) NF_3

40. Silane reacts with silver nitrate to produce the following compound

(A) Silicon dioxide 　(B) Silver metal 　(C) Silver ion 　　(D) Silicon

41. What happens when Al dissolves in aqueous NaOH?

(A) Soluble $NaAl(OH)_4$ forms

(B) Al_2O_3 precipitates

(C) $Al(OH)_3$ precipitates

(D) $[Al(OH_2)_6]^{3+}$ forms which releases H^+

42. What is calgon that is useful in softening of hard water?

(A) Silver metaphosphate 　　　(B) Sodium hexa metaphosphate

(C) Calcium phosphate 　　　(D) Magnesium pyrophosphate

43. The substance used in smoke screen is known as

(A) Calcium fluoride 　　　(B) Sodium chloride

(C) Zinc phosphate 　　　(D) Calcium phosphide

44. Which of the following ordering gives the correct sequence of bond enthalpy terms for covalent bonds involving group 14 elements?

(A) C-C < Si-Si < Ge-Ge < Sn-Sn 　　　(B) C-C > Si-Si > Ge-Ge > Sn-Sn

(C) C-C > Si-Si < Ge-Ge > Sn-Sn 　　　(D) C-C < Si-Si < Ge-Ge > Sn-Sn

45. Predict the type of reaction in which the conversion is : H_3PO_4 to $H_4P_2O_7$

(A) Reduction 　(B) Oxidation 　(C) Condensation 　(D) Hydrolysis

46. Which statement about H_2O_2 is *incorrect* ?

    (A) H_2O_2 is kinetically stable with respect to decomposition to H_2O_2 and O_2

    (B) H_2O_2 is thermodynamically stable with respect to decomposition to H_2O_2 and O_2

    (C) H_2O_2 is explosive when in contact with readily oxidized material

    (D) H_2O_2 readily reacts with Cl_2 to release O_2

47. Which of the following *correctly* describes the trends in values of Pauling electronegativities (χ^P) and ionic radii (r_{ion})?

    (A) $\chi^P : F > Cl > Br > I$; $r_{ion} : F > Cl > Br > I$

    (B) $\chi^P : F < Cl < Br < I$; $r_{ion} : F > Cl > Br > I$

    (C) $\chi^P : F > Cl > Br > I$; $r_{ion} : F < Cl < Br < I$

    (D) $\chi^P : F < Cl < Br < I$; $r_{ion} : F < Cl < Br < I$

48. Optical isomerism is shown by octahedral complexes having

    (A) Two trans bidentate ligands   (B) Three bidentate ligand

    (C) Six monodentate ligands   (D) Two trans monodentate ligands

49. "Zn^{2+} complexes are atypical of d-block complexes in general." Which answer below is correct and supports this statement?

    (A) Zn^{2+} complexes are paramagnetic

    (B) Zn^{2+} complexes tend to be colourless

    (C) Zn^{2+} complexes are always octahedral

    (D) Zn^{2+} is one of the several oxidation states of Zn

50. Which statement is *incorrect* about typical metal carbonyl complexes $M(CO)_n$?

    (A) they are likely to obey 18-electron rule

    (B) they contain π-acceptor ligands

    (C) m is in a zero oxidation state

    (D) they are likely to be paramagnetic

51. Which of the following reactions or reaction schemes involves disproportionation?

    (A) $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

    (B) $2Cu + O_2 \rightarrow 2CuO \rightarrow Cu_2O + \frac{1}{2}O_2$

    (C) $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$

    (D) $CuO + 2NH_3(aq) \rightarrow [Cu(NH_3)_2]^+ \rightarrow [Cu(NH_3)_4]^{2+}$

52. Which statement is *incorrect* about the second and third row *d*-block metals?

(A) The highest melting metals in the two rows are, respectively, Mo and W

(B) Each pair of metals in a group (e.g. Nb and Ta, or Rh and Ir) possess approximately the same metallic radius

(C) Enthalpies of atomization are lowest for the group 10 metals

(D) Technetium is a man-made element

53. Which of the following σ-bonded alkyl groups can undergo β-hydrogen elimination?

(A) CH_2CH_3 (B) CH_2Ph (C) CH_3 (D) CH_2SiMe_3

54. Lanthanoid hydrides of formula LnH_2

(A) contain the lanthanoid metal in oxidation state +2

(B) are electrically conducting materials

(C) possess 3-dimensional covalent structures

(D) are mixed valence Ln(I)/Ln(III) compounds

55. To be classed as "nanoscale", an object must have one dimension that is of the order of

(A) 10^{-10} m   (B) 10^{-12} m   (C) 10^{-9} m   (D) 10^{-8} m

56. In oxy haemoglobin, the iron centre is best described by one of the following

(A) high-spin Fe(III)   (B) high-spin Fe(II)

(C) low-spin Fe(III)   (D) low-spin Fe(II)

57. Which statement is *true* about the bonding in B_2H_6?

(A) A localized bonding picture can be developed for B_2H_6 in which each B atom obeys the octet rule

(B) Bonding pictures for B_2H_6 involve multicentre bridge bonds

(C) B-H terminal bonds cannot be considered as 2c-2e interactions

(D) The observed structural parameters in B_2H_6 suggest the presence of a localized B-B interaction

58. The conjugate base of $[H_2PO_4]^-$ is

(A) $[PO_4]^{3-}$ (B) $[HPO_4]^{2-}$ (C) H_3PO_4 (D) $H_3P_2O_7]^-$

59. Consider the following reaction: $Au + O_2 + 3F_2 \rightarrow [O_2]^+[AuF_6]^-$. Which statement is correct about the redox changes in this reaction?

(A) Au is oxidized; O is oxidized; F is reduced

(B) Au is reduced; O is oxidized; F is reduced

(C) Au is oxidized; O does not undergo a redox change; F is reduced

(D) Au is reduced; O is oxidized; F is oxidized

60. Hypochlorous acid and perchloric acid are represented respectively as

(A) $HOCl$ and $HClO_4$ (B) $HOCl$ and $HClO_3$

(C) $HClO_2$ and $HClO_3$ (D) $HClO_2$ and $HClO_4$

61. Gas in a cylindrical cylinder of diameter 12.3 cm expands, pushing back a piston through a distance 3.57 cm. Calculate the change in the volume of the gas.

(A) $4.24 \, m^3$ (B) $17.0 \, m^3$

(C) $4.24 \times 10^{-4} \, m^3$ (D) $17.0 \times 10^{-4} \, m^3$

62. A mixture contains 45.6 g of ethyl acetate, $CH_3COOC_2H_5$, and 71.3 g of toluene, $C_6H_5CH_3$. Calculate the mole fraction of ethyl acetate molecules in the mixture.

(A) 0.564   (B) 0.436   (C) 0.599   (D) 0.401

63. Calculate the magnitude of the electrical work done on an electron when it is accelerated through a distance of 10.0 cm by a uniform electrostatic field of strength $1.25 \, kV \, cm^{-1}$.

(A) 2.00 nJ   (B) 2.00 pJ   (C) 2.00 fJ   (D) 2.00 aJ

64. Use the kinetic theory of gases to determine the root-mean-square speed of phosphine molecules at a temperature of 450°C.

(A) $570 \, m \, s^{-1}$ (B) $23 \, m \, s^{-1}$ (C) $730 \, m \, s^{-1}$ (D) $670 \, m \, s^{-1}$

65. The critical point of ammonia, NH_3, occurs at a pressure of 11.3 MPa, temperature of 406 K and molar volume of $72.5 \, cm^3 \, mol^{-1}$. Determine the compression factor of ammonia at the critical point.

(A) 0.243   (B) 1   (C) 4.12   (D) 0.741

66. Calculate the heat transferred to the system when 1.00 mol of a perfect gas expands reversibly at a constant temperature of 25°C so that its volume doubles.

(A) $-144 \, J$ (B) $-746 \, J$ (C) $-1.72 \, kJ \, mol^{-1}$ (D) 2.48 kJ

67. The constant pressure molar heat capacity of nitrogen gas, N_2, is 29.125 J K^{-1} mol^{-1} at 298.15 K. Calculate the change in the internal energy when 2.00 mol of nitrogen gas is heated so that its temperature increases by 25.0°C. You may assume that the value of the heat capacity does not vary with temperature

    (A)   1.04 kJ   (B)   1.46 kJ   (C)   1.87 kJ   (D)   520 J

68. Calculate the change in the entropy of a large system when 500 J of energy is transferred from the system to the surroundings as heat in an exothermic process at a temperature of 298 K.

    (A) +1.68 J K^{-1} (B) −1.68 J K^{-1} (C) +500 J K^{-1} (D) −500 J K^{-1}

69. The boiling temperature of cyclohexane, C_6H_{12}, is 354 K. Use Trouton's rule to estimate the enthalpy of vaporization of cyclohexane.

    (A)   6.89 kJ mol^{-1} (B)   18.7 kJ mol^{-1} (C)   85 kJ mol^{-1} (D)   30.1 kJ mol^{-1}

70. The densities of white and red phosphorus are 1.823 and 2.340 g cm^{-3} respectively. Calculate the change in the molar volume for the transformation of white into red phosphorus.

    (A) 5.990 m^3 mol^{-1} (B) 5.990 × 10^{-2} m^3 mol^{-1}

    (C) 5.990 × 10^{-6} m^3 mol^{-1} (D) 5.990 × 10^{-4} m^3 mol^{-1}

71. The molar Gibbs energy of tribromomethane, $CHBr_3$, decreases by 4.44 kJ mol^{-1} when the temperature is increased from 288 to 308 K. Determine the molar entropy of tribromomethane.

    (A) −222 J K^{-1} mol^{-1} (B) 222 J K^{-1} mol^{-1}

    (C) 0.222 J K^{-1} mol^{-1} (D) 22.2 J K mol^{-1}

72. When 15.0 cm^3 of benzene, C_6H_6, is added to 125 cm^3 of water, H_2O, at 20°C, the final volume of the liquid mixture is 137 cm^3. Calculate the partial molar volume of benzene in dilute aqueous solutions given that the density of benzene and of water are 0.879 g cm^{-3} and 0.998 g cm^{-3} respectively; and the partial molar volume of water is 17.8 cm^3 mol^{-1} at this temperature.

    (A)   88.9 cm^3 mol^{-1} (B)   81.8 cm^3 mol^{-1}

    (C)   14.6 cm^3 mol^{-1} (D)   86.8 cm^3 mol^{-1}

73. The Henry's law constant for pentan-3-one, $C_2H_5COC_2H_5$, in aqueous solution may be expressed in terms of concentration as 51 kPa mol^{-1} dm^3. Calculate the vapour pressure of pentan-3-one above an aqueous solution that contains 5.23 g of pentan-3-one in 250 cm^3 of solution.

    (A)   12 kPa   (B)   51 kPa   (C)   31 kPa   (D)   3.0 kPa

74. The value of the equilibrium constant for the electrochemical reaction

$MnO_4^-(aq) + 2 H^+(aq) + \frac{1}{2} Cl_2(g) \rightarrow Mn^{2+}(aq) + ClO_3^-(aq) + H_2O(aq)$

Is; 5.88×10^{-5}. What is the value of the equilibrium constant for the reverse reaction?

(A) 5.88×10^{-5} (B) -5.88×10^{-5} (C) 17.0×10^3 (D) -1.70×10^3

75. For sulfur hexafluoride, SF_6, the standard Gibbs energy of formation of is -992 kJ mol^{-1} and the standard entropy of formation is -350 J K^{-1} mol^{-1} at 298 K. Assuming that the values of the enthalpy and entropy of formation vary little with temperature, estimate the standard Gibbs energy of formation of sulfur hexafluoride at 348 K.

(A) -992 kJ mol^{-1} (B) -18 kJ mol^{-1}

(C) -975 kJ mol^{-1} (D) -1010 kJ mol^{-1}

76. Calculate the concentration of hydronium, H_3O^+, ions in a solution with pH $= 11.2$.

(A) 11.2×10^{-3} mol dm^{-3} (B) 1.36×10^{-5} mol dm^{-3}

(C) 1.58×10^{10} mol dm^{-3} (D) 6.3×10^{-12} mol dm^{-3}

77. Calculate the pH of an aqueous solution of sodium hydrogen phosphite, $NaHPO_3$. For phosphorous acid, H_2PO_3, $pK_{a1} = 2.00$ and $pK_{a2} = 6.59$.

(A) 4.30   (B) 2.00   (C) 6.59   (D) 2.29

78. Use the Debye-Hückel limiting law to determine the mean activity coefficient for the Ca^{2+} and NO_3^- ions in a 0.005 mol dm^{-3} aqueous solution of calcium nitrate, $Ca(NO_3)_2$.

(A) 0.94   (B) 0.97   (C) 0.75   (D) 0.12

79. Calculate the limiting molar conductivity of an aqueous solution of sodium phosphate, Na_3PO_4, given that the ionic conductivities of the sodium, Na^+, and phosphate, PO_4^{3-}, ions are 5.01 and 24.0 mS m^2 mol^{-1} respectively.

(A) 29.0 mS m^2 mol^{-1} (B) 77.0 mS m^2 mol^{-1}

(C) 39.0 mS m^2 mol^{-1} (D) 19.0 mS m^2 mol^{-1}

80. The molar absorption coefficient of the $[Cu(NH_3)_4]^{2+}$ complex ion in aqueous solution is 50 dm^3 mol^{-1} cm^{-1} at a wavelength of 590 nm. Determine the transmittance when light of this wavelength passes through an aqueous solution of the ion of molar concentration 0.100 mol dm^{-3} and path length of 1.00 cm.

(A) 10^{-5} (B) 10^{-2} (C) 10^{-6} (D) 10^{-4}

81. The rate constant for the gas-phase reaction $H_2(g)+I_2(g)\to 2\,HI(g)$ has the value of 4.45×10^{-5} mol^{-1} dm^3 s^{-1}. What is the equivalent rate constant in units of molecule^{-1} cm^3 s^{-1}?

(A) 7.39×10^{-28} molecule^{-1} cm^3 s^{-1} (B) 7.39×10^{-29} molecule^{-1} cm^3 s^{-1}

(C) 4.45×10^{-2} molecule^{-1} cm^3 s^{-1} (D) 7.39×10^{-26} molecule^{-1} cm^3 s^{-1}

82. For a solution–phase dimerization reaction, the rate constants for the second-order forward reaction are 2×10^{7} dm^{3}mol^{-1}s^{-1} and for the first order backward reaction is 4×10^{5}s^{-1}. Determine the equilibrium constant.

(A) 0.2×10^{-2} (B) 50   (C) 1×10^{9} (D) 1×10^{-4}

83. The red radiation emitted by a HeNe laser is of wavelength 6328 Å. Calculate the energy of the photons that are emitted.

(A) 3.139×10^{-19} J   (B) 3.139×10^{-29} J

(C) 4.193×10^{-40} J   (D) 4.193×10^{-20} J

84. Ultraviolet radiation of wavelength 121 nm is used to irradiate a sample of potassium metal. The work function of potassium is 2.25 eV. Calculate the speed of the electrons emitted through the photoelectric effect.

(A) 1.89×10^{6} m s^{-1} (B) 1.18×10^{6} m s^{-1}

(C) 0.890×10^{6} m s^{-1} (D) 1.68×10^{6} m s^{-1}

85. The number average and weight average molar masses of a sample of poly(ethylene) are 9.2 kg mol^{-1} and 11.6 kg mol^{-1} respectively. Calculate the heterogeneity index.

(A) 0.79   (B) 0.63   (C) 1.3   (D) 1.0

86. Calculate the root-mean-square separation of the ends of a polyisobutylene chain consisting of 3500 monomer units, each of length 154 pm.

(A) 540 nm   (B) 9.1 Å   (C) 5.4 Å   (D) 9.1 nm

87. Use the following data to calculate the lattice enthalpy at 298 K of lithium fluoride, LiF(s). All values refer to a temperature of 298 K. Enthalpy of sublimation of Li(s): +159 kJ mol^{-1}; Ionization enthalpy of Li(g): +520 kJ mol^{-1}, Enthalpy of dissociation of $F_2(g)$: +155 kJ mol^{-1}, Enthalpy of electron attachment to F(g): –328 kJ mol^{-1}, Enthalpy of formation of LiF(s) from Li(s) and $F_2(g)$: –617 kJ mol^{-1}

(A) 1046 kJ mol^{-1} (B) 1123 kJ mol^{-1} (C) 1702 kJ mol^{-1} (D) 468 kJ mol^{-1}

88. Calculate the Coulombic potential energy of an electron at a distance of 52.9 pm from a lithium, Li^{2+}, nucleus

(A) -4.37×10^{-18} J (B) -1.31×10^{-17} J (C) -5.20×10^{20} J (D) 9.63×10^6 J

89. Estimate the de Broglie wavelength of a neutron that has a kinetic energy of 0.025 eV

(A) 1.8 Å (B) 78 Å (C) 7.0×10^6 m (D) 72×10^{-21} m

90. The rate constant for the gas-phase reaction between hydrogen and iodine, $H_2(g) + I_2(g) \rightarrow 2\,HI(g)$ has the value 4.45×10^{-5} mol^{-1} dm^3 s^{-1}. What is the equivalent rate constant in units of $molecule^{-1}$ cm^3 s^{-1}?

(A) 7.39×10^{-28} $molecule^{-1}$ cm^3 s^{-1} (B) 7.39×10^{-29} $molecule^{-1}$ cm^3 s^{-1}

(C) 4.45×10^{-2} $molecule^{-1}$ cm^3 s^{-1} (D) 7.39×10^{-26} $molecule^{-1}$ cm^3 s^{-1}

91. The orbital angular momentum of an electron is represented using the expression

(A) $\sqrt{l(l+1)}.h/2\pi$ (B) $\sqrt{l(m+1)}.h/2\pi$

(C) $\sqrt{l(s+1)}.h/2\pi$ (D) $\sqrt{l(l+1)}.h^2/2\pi$

92. Potential energy of an electron in hydrogen like atom is given by

(A) $-Z^2e^2/r$ (B) $-Ze^2/r$ (C) $-Ze^2/r^2$ (D) $-Ze^2/kr$

93. The solution for the differential equation $(1+x^2y^2)ydx + (x^2y^2-1)xdy = 0$ is equal to (C is a constant)

(A) $xy = \ln\dfrac{x}{y} + C$ (B) $xy = 2\ln\dfrac{y}{x} + C$

(C) $x^2y^2 = 2\ln\dfrac{y}{x} + C$ (D) $x^2y^2 - 2\ln\dfrac{x}{y} + C$

94. For the matrix $A = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 2 & 1 \\ 2 & 1 & 0 \end{bmatrix}$, which of the following option is correct?

(A) $A^3 + 3A^2 - I = 0$ (B) $A^3 - 3A^2 - I = 0$

(C) $A^3 + 2A^2 - I = 0$ (D) $A^3 - A^2 + I = 0$

95. Let $f(x)$ be a differentiable function in the interval $(0, 2)$, then the value of the definite integral $\int_0^2 f(x)dx$ is equal to

(A) $f(c)$ for at least one $c \in (0,2)$

(B) $2f(c)$ for at least one $c \in (0,2)$

(C) $f'(c)$ for at least one $c \in (0,2)$

(D) $2f'(c)$ for at least one $c \in (0,2)$

96. A curve passes through the point $(2, 0)$ and the slope of the tangent at any point (x, y) is $x^2 - 2x$ for all values of x. The point of maximum ordinate on the curve is

(A) $(0, 4/3)$ (B) $(0, 2/3)$ (C) $(1, 2/3)$ (D) $(2, 4/3)$

97. The total number of solutions of the equation $\sin(\pi x) = \left| \ln|x| \right|$ is

(A) 2   (B) 4   (C) 6   (D) 8

98. For the quadratic equation $x^2 + 2(a+1)x + 9a - 5 = 0$, which of the following are true?

(A) If $2 < a < 5$ then roots are of opposite sign

(B) If $a > 0$ then roots are of opposite sign

(C) If $a < 7$ then roots are negative

(D) If $2 \le a \le 5$ roots are not real

99. Let $S_n = \dfrac{3}{2^1 \cdot 2 \cdot 1} + \dfrac{4}{2^2 \cdot 3 \cdot 2} + \dfrac{5}{2^3 \cdot 4 \cdot 3} + \cdots n$ terms then

(A) $S_n = 2 - \dfrac{1}{2^n(n+1)}$

(B) $S_n = 1 + \dfrac{1}{2^n(n-1)}$

(C) $\lim_{n \to \infty} S_n = 2$

(D) $\lim_{n \to \infty} S_n = 1$

100. Sum of all possible 3 digit numbers (no digit being zero) having the property that all digit are perfect squares is equal to

(A) 6216   (B) 3108   (C) 13986   (D) 7247