CHEMISTRY
(Inorganic Section)

1. Which of the following statements is *incorrect* ?

    (A) The ground state of an atom will be the one having the greatest spin multiplicity

    (B) The product of the uncertainty in the energy of an excited state and the lifetime of an excited state is greater than $h/2\pi$

    (C) The number of nodal surfaces passing through the nucleus is equal to the value of n, the principal quantum number

    (D) A radial distribution function (P), gives the probability that an electron will be found at a given distance from the nucleus regardless of the direction and is equal to $4\pi r^2 \psi^2$.

2. As a result of the combined effects of penetration and shielding, the order of energy levels in an electron atom is :

    (A) $ns < np < nd < nf$

    (B) $nf < nd < np < ns$

    (Q) $ns < nd < np < nf$

    (D) $ns < np < nf < nd$

3. Using a Boron Haber cycle, and the given data, determine which of the following is the correct value of the lattice enthalpy ΔH_L° of KCl (s) :

    Data :

    $$\left[\begin{array}{l} \Delta H^\circ \text{ (sublimation of K(s))} = +89 \text{ kJ mol}^{-1}, \\ \Delta H^\circ \text{ (ionisation of K(g))} = +425 \text{ kJ mol}^{-1}, \\ \Delta H^\circ \text{ (dissociation of Cl}_2\text{(g))} = +244, \\ \Delta H^\circ \text{ (electron gain by Cl(g))} = -355, \\ \Delta H^\circ \text{ (formation of KCl(s))} = -438 \end{array}\right]$$
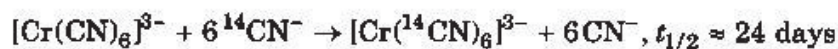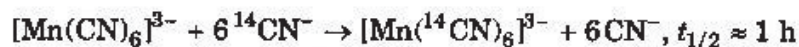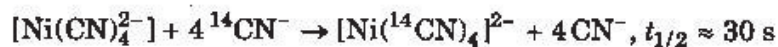
    (A) 310 kJ mol^{-1}

    (B) 524 kJ mol^{-1}

    (C) 719 kJ mol^{-1}

    (D) 905 kJ mol^{-1}

4. Bond order of NO and NO^+ are respectively :

   (A) 2.5 and 3

   (B) 2 and 4

   (C) 3.5 and 2.5

   (D) 3 and 2

5. The configuration of superoxide ion O_2^- is :

   (A) $\sigma_g^2, 1\sigma_u^2, 2\sigma_g^2, 1\pi_u^4, 1\pi_g^2$

   (B) $1\sigma_g^2, 1\sigma_u^2, 2\sigma_g^2, 1\pi_u^4, 1\pi_g^3$

   (C) $1\sigma_g^2, 1\sigma_u^2, 2\sigma_g^2, 1\pi_u^4, 1\pi_g^4$

   (D) None of the above

6. The standard reduction potential of Cu^{2+}, Zn^{2+}, Sn^{2+} and Ag^+ are 0.34, -0.76, -0.14 and 0.80 V respectively, the storage that is possible without any reaction is for :

   (A) $CuSO_4$ solution in a zinc vessel

   (B) $AgNO_3$ solution in a zinc vessel

   (C) $AgNO_3$ solution in a tin vessel

   (D) $CuSO_4$ solution in a silver vessel

7. Consider various species generated when H_3PO_4 is dissolved in water. Among these, the conjugate acid of HPO_4^{2-} is :

   (A) H_3PO_4

   (B) $H_2PO_4^-$

   (C) PO_4^{3-}

   (D) H_3O^+

8. The reaction of XeF_4 with the Lewis base F^- in cyanomethane solution produces the XeF_5^- ion which has :

   (A) square pyramidal shape

   (B) planar-pentagonal shape

   (C) trigonal bipyramidal shape

   (D) distorted octahedral shape

9. The diagonal relationship of elements in the periodic table arises because of similarity in :

   (A) ionic radius

   (B) electronic configuration

   (C) crystal structure

   (D) charge/radius ratio of the corresponding ion

10. According to Wade's rules boron hydrides of formula B_nH_{n+4} and $n + 2$ pairs of skeletal electron have :

   (A) Closo structure

   (B) Nido structure

   (C) Arachno structure

   (D) Hypho structure

11. Which pseudo-halogen does *not* have dimeric nature ?

   (A) cyanogen

   (B) azide

   (C) thiozene

   (D) selenothigen

12. Identify the *incorrect* statement :

   (A) The largest change in stability of highest oxidation state of an element on descending a group occurs between 3d and 4d series of the d-block elements

   (B) The 4d and 5d elements often have higher coordination numbers than their 3d congeners

   (C) The conversion of an aquoligand to an oxoligand is favoured by a high pH and by a high oxidation state of the central metal atom

   (D) Oxidation state +2 is more common for the 3d metal from the middle to the left of the block

13. The theory which utilises pure electrostatic bonding between metal and ligand is :

   (A) valence bond theory

   (B) molecular orbital theory

   (C) crystal field theory

   (D) ligand field theory

14. The theoretical value of the magnetic moment of $[Fe(H_2O)_6]^{3+}$ at 273 K is :

   (A) 2.83 B.M.

   (B) 3.87 B.M.

   (C) 4.90 B.M.

   (D) 5.92 B.M.

15. Eriochrome Black T is used as indicator in the quantitative estimation of Mg with EDTA titration. The pH of the solution should be maintained at :

   (A) pH 3

   (B) pH 6.7

   (C) pH 10

   (D) pH 01

16. Consider the following cyanide exchange reactions :

$[Ni(CN)_4^{2-}] + 4\,^{14}CN^- \rightarrow [Ni(^{14}CN)_4]^{2-} + 4\,CN^-, t_{1/2} \approx 30$ s

$[Mn(CN)_6]^{3-} + 6\,^{14}CN^- \rightarrow [Mn(^{14}CN)_6]^{3-} + 6\,CN^-, t_{1/2} \approx 1$ h

$[Cr(CN)_6]^{3-} + 6\,^{14}CN^- \rightarrow [Cr(^{14}CN)_6]^{3-} + 6\,CN^-, t_{1/2} \approx 24$ days

All the above three cyanide complexes are thermodynamically stable but not equally inert, which one is the most labile :

(A) $[Ni(CN)_4]^{2-}$

(B) $[Mn(CN)_6]^{3-}$

(C) $[Cr(CN)_6]^{3-}$

(D) None of the above

17. The methods of separation of lanthanides include :

(A) fractional crystallisation, ion exchange and solvent extraction

(B) only ion exchange and solvent extraction

(C) solvent extraction only

(D) fractional crystallisation

18. Haemoglobin, Haemocyanin and Cytochromes are :

(A) storage metalloproteins

(B) transport metalloproteins

(C) enzymes

(D) none of the above

19. Transport of oxygen is an important function of blood. Partial pressure of oxygen is the highest and the lowest in :

(A) Muscles and Heart

(B) Lungs and Muscles

(C) Heart and Lungs

(D) Muscles and Lungs

20. Gadolinium (^{153}Gd) which has a half-life of 242 days, is used to detect osteoporosis. The percentage of ^{153}Gd left in a patient's system after 2 years will be :

(A) 33.0

(B) 25.0

(C) 12.5

(D) 6.25

(Organic Section)

21. Give the *correct* order of strength of the following carboxylic acids :

(i) CH_3CH_2COOH, (ii) $(CH_3)_2CHCOOH$

(iii) $Cl-CH_2.COOH$ (iv) $Br-CH_2COOH$

(A) (i) > (ii) > (iii) > (iv)

(B) (iii) > (iv) > (i) > (ii)

(C) (iv) > (iii) > (ii) > (i)

(D) (ii) > (i) > (iv) > (iii)

22. Which of the following is a *wrong* statement ?

(A) Inductive effect is a permanent effect and involves π electrons

(B) A singlet carbene being paramagnetic, can be detected by ESR

(C) Due to presence of lone pair of electrons on nitrogen, nitrenes act as Lewis bases

(D) All the statements are wrong

23. Stereoisomers that are *not* mirror images of each other are called as :

   (A) Anomers

   (B) Enantiomers

   (C) Diastereoisomers

   (D) Epimers

24. The relationship that exist between the following compounds is that of :
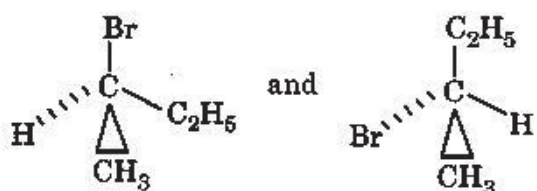
   (A) Enantiomers

   (B) Same compound

   (C) Conformational isomers

   (D) Position isomers

25. Hydroxylation of alkenes, with alk. $KMnO_4$ and OsO_4 produce :

   (A) Syn 1, 2 diols

   (B) Syn 1, 3, diols

   (C) Anti 1, 2, diols

   (D) Anti 1, 3, diols

26. Order of stability of cyclopropene(1), salt of cyclopropenyl cation(2), and salt of cyclopropenyl anion(3) is :

   (A) 1 > 2 > 3

   (B) 1 > 3 > 2

   (C) 2 > 1 > 3

   (D) 2 > 3 > 1

27. Rate of S_N^1 reaction of alkyl halides does *not* depend on :
   (A) Structure of alkyl halide
   (B) Nature of leaving group
   (C) Polarity of solvent
   (D) Strength of nucleophile

28. For the reaction :

$$\text{Phenol} + CCl_4 \xrightarrow[(ii) \ H_3O^+]{(i) \ NaOH, \Delta} \text{`A', the main product `A'}$$
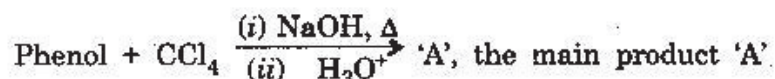
   will be :
   (A) salicyldehyde
   (B) *p*-hydroxybenzaldehyde
   (C) salicyclic acid
   (D) *m*-hydroxybenzoic acid

29. The reaction between an aldehyde or a ketone with a phosphorous ylide to give a substituted alkene is called as :
   (A) Mannich reaction
   (B) Wittig reaction
   (C) Perkin reaction
   (D) Cannizzaro's reaction

30. When benzaldehyde is heated with an ethanolic solution of KCN, the product obtained is :
   (A) Benzoic acid
   (B) Benzoin
   (C) Benzil
   (D) Benzamide

31. Which of the following carboxylic acids does *not* have any stereocentre ?
   (A) Malic acid
   (B) Tartaric acid
   (C) Oxalic acid
   (D) Citric acid

32. Carbylamine or Isocyanide test is used to distinguish :

(A)   1° amine from 2° and 3° amines

(B)   2° amine from 1° and 3° amines

(C)   3° amine from 1° and 2° amines

(D)   Aromatic amines from aliphatic amines

33. Order of basicity of the following is :

(A)   Pyridine > Piperidine > Pyrrole

(B)   Piperidine > Pyridine > Pyrrole

(C)   Pyrrole > Pyridine > Piperidine

(D)   None of the above

34. Which of the following absorptions in the IR region represent carbonyl group absorption of amides ?

(A) $1685 \ cm^{-1}$

(B) $1725 \ cm^{-1}$

(C) $1760 \ cm^{-1}$

(D) $1700 \ cm^{-1}$

35. A compound shows ^1HNMR peak at 270 Hz downfield from TMS peak in a spectrometer operating at 60 MHz. The value of chemical shift δ in PPM is :

(A)   2.7

(B)   6.0

(C)   4.5

(D)   5.7

36. Vinylic protons which are trans to each other have a coupling constant (J) of the order of :

(A)   0–2 Hz

(B)   2–5 Hz

(C)   6–14 Hz

(D)   11–18 Hz

37. Sulphur containing amino acid is :
(A) Histidine
(B) Methionine
(C) Serine
(D) Proline

38. Which of the following nitrogenous bases is 6-aminopurine ?
(A) Guanine
(B) Uracil
(C) Thymine
(D) Adenine

39. Which of the following is a disaccharide of D-glucose and D-fructose ?
(A) Maltose
(B) Lactose
(C) Sucrose
(D) Amylose

40. Choose the *wrong* statement :
(A) For basic amino acids, the isoelectric point is at pH higher than 6, while as for acidic amino acids it is less than 6
(B) Salting out of proteins is a reversible process
(C) All natural amino acids belong to L-series
(D) Sanger's method is used for determination of G-terminal amino acid residue of polypeptide chain

(Physical Section)

41. The decimal equivalents of the binary numbers $(10111)_2$ and $(0.0101)_2$ are :
(A) 32, 0.312
(B) 23, 0.3125
(C) 23, 0.452
(D) 3.2, 0.0312

42. According to Bohr's model, the energy of the $1s$ electron in hydrogen atom is -13.6 eV. What is the energy of the $2s$ electron in lithium atom ?
(A) 30.6 eV
(B) 13.6 eV
(C) 3.4 eV
(D) 122.4 eV

Chem. 10

43. For a particle in a one-dimensional box of length l, what are the number of nodes in the wave function and where is the maximum probability in the first excited level ?

(A) $1, \dfrac{l}{2}$

(B) $2, \dfrac{l}{2}$

(C) $0, \dfrac{l}{4}$ and $\dfrac{l}{2}$

(D) $1, \dfrac{l}{4}$ and $\dfrac{3l}{4}$

44. Which of the following molecules can be regarded as the best example of a particle in one-dimensional box ?

(A) Ethane

(B) Butane

(C) Ethylene

(D) 1, 3, butadiene

45. Which of the following two molecular pairs will give both a rotational and vibrational spectrum ?

(A) HCl and CO_2

(B) CO_2 and O_2

(C) HCl and H_2O

(D) CO_2 and H_2O

46. The selection rules for spectral transitions in atomic spectra are :

(i) $\Delta x = 1, 2, 3, 4....$

(ii) $\Delta l = \pm 1$

Determine, which of the following transitions are allowed :

(A) $1s \rightarrow 3p$

(B) $3p \rightarrow 3d$

(C) $3p \rightarrow 4p$

(D) All of the above three

47. The quantum yield for the photochemical combination of $H_2(g)$ and $Cl_2(g)$ to form $HCl(g)$ is 1.0×10^5 at a wavelength of 600 nm. What is the number of moles of HCl produced per joule of radiant energy absorbed ?
   (A) 5.01
   (B) 0.501
   (C) 50.0
   (D) 10.02

48. Using equipartition principles, what are the average energies of these molecules : He, H_2 and CO_2.

   (A) $\frac{3}{2}RT, \frac{7}{2}RT, \frac{15}{2}RT$

   (B) $\frac{3}{2}RT, \frac{5}{2}RT, \frac{7}{2}RT$

   (C) $\frac{5}{2}RT, \frac{7}{2}RT, 9\,RT$

   (D) $\frac{5}{2}RT, \frac{5}{2}RT, \frac{7}{2}RT$

49. The root mean square speed of the molecules of a perfect gas at 27°C is 0.4 ms^{-1}. What is the speed at 327°C ?
   (A) 0.80 ms^{-1}
   (B) 1.20 ms^{-1}
   (C) 0.125 ms^{-1}
   (D) 0.565 ms^{-1}

50. The van der Waals constant a for the gases N_2, O_2, NH_3 and CH_4 are : 1.39, 1.36, 4.0 and 2.25 dm^{+6} atm. mol^{-2}. Which of the gases can most easily be liquefied ?
   (A) N_2
   (B) NH_3
   (C) CH_4
   (D) O_2

51. The edge length of the unit cell in a cubic crystal is a. What is the spacing between (100) planes ?
   (A) a
   (B) $a\sqrt{2}$
   (C) $\frac{a}{\sqrt{3}}$
   (D) $a\sqrt{3}$

52. For an adiabatic process, which of the following statements is *true* ?

    (A) $\Delta T = 0$

    (B) $q = 0$

    (C) $q = $ constant

    (D) $w = 0$

53. The value of K_p for the reaction :

    $$2A(g) + 2B(g) \rightleftharpoons 4C(g) + D(g)$$

    at 500 K is 0.4 atm. Assuming $R = 0.081$ atm. K^{-1} mol, the value of K_c will be :

    (A) 10^{-4} mol L^{-1}

    (B) 0.16 mol L^{-1}

    (C) 9.8×10^{-3} mol L^{-1}

    (D) 1.6 mol L^{-1}

54. Equal volumes of two gases are mixed at constant temperature and pressure. The changes in enthalpy and entropy respectively are :

    (A) $0, 0$

    (B) $0, 5.76$ JK^{-1} mol^{-1}

    (C) 5.76 J $mol^{-1}, 0$

    (D) -10.0 J $mol^{-1}, 5.76$ JK^{-1}

55. The rate of a gaseous reaction is doubled when the temperature is raised from 27° to 40°C. The activation energy of the reaction (in kJ mol^{-1}) is :

    (A) 50.15

    (B) 65.50

    (C) 100.20

    (D) 86.65

56. Identify the reaction order in each of the following rate constant expressions :

    $$k_1 = 5.6 \times 10^{-4} \text{ mol } dm^{-3} \text{ s}^{-1}, \quad k_2 = 3.2 \times 10^{-3} \text{ s}^{-1}$$
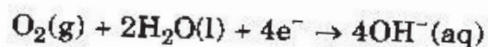
    (A) $0, 1$

    (B) $1, 0$

    (C) $1, 2$

    (D) $2, 1$

57. 10 g of each of the following substances are dissolved in 1 kg of water :

$$NaCl, C_6H_{12}O_6, Co(NH_2)_2 \text{ and } CH_3OH$$

Which will produce the highest depression in the freezing point ?

(A) CH_3OH

(B) $NaCl$

(C) $Co(NH_2)_2$

(D) $C_6H_{12}O_6$

58. The number of degrees of freedom in the water system at its triple point and freezing point are :

(A) 1, 0

(B) 0, 0

(C) 0, 1

(D) 1, 1

59. When the pH of the solution in the standard hydrogen electrode is increased by one pH unit, its electrode potential :

(A) decreases by 59 mV

(B) increases by 59 mV

(C) decreases by 29.5 mV

(D) becomes zero

60. For the oxygen half cell reaction :

$$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

$\Delta G°/FE°$ is equal to :

(A) 1

(B) 2

(C) 4

(D) -4