MINISTRY OF EDUCATION. SCIENCE AND TECHNOLOGY
SENGEREMA SECONDARY SCHOOL
FORM FIVE CHEMISTRY HOME PACKAGE
DECEMBER 2024

1. (a) Define the following terms;
   (i) Quantum orbitals
   (ii) Quantum numbers
   (iii) Quantization of energy
   (iv) Wave particles duality of matter
2. Give the postulates of Bohr's atomic model?
3. What are the shortcomings of Bohr's atomic models?
4. Calculate the frequency of radiation produced by the transition from n=5 to n= 2 in visible region
5. (a) Define the following terms
   (i) Quantization of angular momentum
   (ii) Azimuthal quantum number
   (iii) Degenerate orbital
   (iv) Line spectrum
6. Calculate the wave number of the longest wavelength transition in Balmer series of atomic hydrogen.
   Given the quantum number n = 3.
7. List all possible orbitals present in this quantum number.
8. Write possible values of ml and ms for this quantum number.
9. (a)Define the following terms as applied to general chemistry i. Orbital ii. Mass spectrometry iii. Convergence limit
   (i) State two significances of convergence limit.
   (ii) Describe the concept that, as the particle size gets smaller, determination of the momentum and position simultaneously becomes diffracted.
10. Find the wavelength, frequency and energy of third line of Balmer series
    (04 marks)

11. Do the orbitals of different atoms undergo hybridization? Explain.
12. What are hybrid orbitals? And what are its characteristics (any two).
13. How electrons are going to be filled in the hybrid orbitals?
14. What type of bonds form from hybrid orbitals sigma or pi? Explain.
    (b) For each of the following molecules, write a Lewis structure, predict the molecular structure (include the bond angles), give the expected hybrid orbitals on the central atom, and predict the overall polarity. (i) CF4 (ii) NH3 (iii) BeH4 (iv) CO2 (v) PCl5 (5 marks)
15. Suggest the important type of intermolecular attractive interaction in the following pair of species.
    (i) n-hexane and n-octane
    (ii) NaClO4 and water.
    (iii) Methanol and acetone.
    (iv) Acetonitrile and acetone.

    Define the following
    i. Cryscopic constant of a solvent. ii. Ebrilioscopic constant of a solvent
16. How many litres of ethylene glycol (molar mass 62g/mol and density 1.1 g/cm3) must be added to 10 litres of car radiator water in order to lower its freezing point to −50℃. (Kf for water =1.86℃kg/mol, density of water=
    1g/cm3)
17. The vapor pressure of water at 50℃ was 92 mmHg. When 19.10 g of an organic substance K were dissolved in 100g of water, the vapour pressure dropped by 5 mmHg. Calculate the 8. (a) A 2L flask containing nitrogen at 60cm pressure is put into communication with 4L flask containing carbon monoxide at 48cm pressure. If the temperature is kept constant, calculate the final pressure of the mixture.
18. A flask of 1.5 L capacity contains 400mg of O2 and 60mg of H2 at 100℃. Calculate the total pressure of the gaseous mixture. If the mixture is permitted to react to form water vapour at 100℃, what material will be left and what will be their partial pressures
19. (a) (i) Give the meaning of osmotic pressure of a solution.
    (ii) Briefly explain in terms of vapour pressure why the freezing point of a solution is lower than that of a pure solvent.
20. When water and ice are mixed the temperature of the mixture is 0℃, but if methanol (CH3OH) and ice are mixed, a temperature of 10℃ is readily attained. Explain why the two mixtures show such different temperature behaviours.
21. Calculate the molar mass of Y given that a solution of 60 g of Y in 1dm3 of water exerts an osmotic pressure of 4.31 x 105 N/m2 at 25℃. (02 marks) (d) 0.003 kg of acetic acid (CH3COOH) is added to 500 cm3 of water. If 23% of the acetic acid is dissociated, what will be the depression in freezing point?
22. (Kf for water =1.86℃kg/mol, density of water = 0.997 g/cm3, dissociation constant for acetic acid = 1.8 x 10-5m) (02 marks)

23. What transition in the hydrogen spectrum would have the same wavelength as the Balmer
24. transition n = 4 to n = 2 of He+ transition?
    (a) State postulates of Bohr's theory of an atom and derive an expression for radius of Bohr orbit of hydrogen atom.
    (b) Give any four limitations of Bohr's theory of an atom.
25. Describe Rutherford's model of the atom. How was it improved by Bohr?
26. Atomic hydrogen is excited to the 4th energy level from the ground state. Determine (a) the number of lines emitted and (b) the shortest wavelength present in the emission spectrum.
    (RH = 109677 cm–1)
27. Radius of the first Bohr orbit of H-atom is 0.529 Å. Find the radii of the first and second Bohr orbit of Li2+ ion.
28. If the energy difference between the ground state of an atom and its excited state is 4.4×10^{-19} J, what is the wavelength of the photon required to produce this transition?
29. Calculate the wavelength and energy of radiations emitted for the electronic transition from infinity ( ) to stationary state of the hydrogen atom. (R = 1.09678 × 107 m–1; h = 6.625 × 10–34 Joule sec and c = 2.9979 × 108 m sec–1)
30. The energy transition in hydrogen atom occurs from n = 3 to n = 2 energy level. (R = 1.097 × 107 m–1).
    (i) Calculate the wavelength of the emitted electron.
    (ii) Will this electron be visible?
    (iii) Which spectrum series does this photon belong to?
31. Calculate the energy emitted when electrons of 1.0 g of hydrogen undergo transition giving the spectral line of lowest energy in the visible region of its atomic spectrum (R = 1.1 × 107 m–1; c = 3 × 108 m sec–1; h = 6.62 × 10–34 J sec)
32. In hydrogen atom the energy of the electron in first Bohr's orbit is – 1312 × 105 J mol–1. What is the energy required for the excitation of second Bohr's orbit ?
33. Calculate the wavelength in Å of the photon that is emitted when an electron in Bohr orbit n = 2 returns to the orbit n = 1 in the hydrogen atom. The ionisation potential in the ground state of hydrogen atom is 2.17 × 10–11 erg per atom.
34. A line at 434 nm in Balmer series of spectrum corresponds to a transition of an electron from the nth to 2nd Bohr orbit. What is the value of n ?
35. The energy transition in hydrogen atom occurs from n = 3 to n = 2 energy level. (R = 1.097 × 107 m–1).
    (i) Calculate the wavelength of the emitted electron
    (ii) (ii) Will this electron be visible?
    (iii) Which spectrum series does this photon belong to ?
36. The energy of the electron in the second and third Bohr orbits of the hydrogen atom is – 5.42 × 10–12 erg and – 2.41 × 10–12 erg respectively. Calculate the wavelength of the emitted radiation when the electron drops from third to second orbit.
37. Calculate the wavelength of the first line in Balmer series of hydrogen spectrum. (R = 109677 cm–1)
    Answer. 1215 Å
    (a) How does Bohr's theory explain the spectrum of hydrogen atom?
    (b) Calculate the wavelength associated with an electron moving with a velocity of 1 × 108 cm sec–1. Mass of an electron = 9.1 × 10–28 g
38. A line at 434 nm in Balmer series of spectrum corresponds to a transition of an electron from the nth to 2nd Bohr orbit. What is the value of n?

39. Explain the structure and hybridization of $SO4^{2-}$ ion.
40. Why the bond angle in H_2S is less than H_2O?
41. Explain the structure and various bond angles in IF_7.
42. Why is the bond angle of OF_2 smaller than that of Cl_2O?

43. . What pressure is exerted by a mixture of 2.00 g of H2 and 8.00 gof N2 at 273 K in a 10 litre vessel?
44. A sample of oxygen is collected by the downward displacement of water from an inverted bottle. The water level inside the bottle is equalized with that in the trough. Barometeric pressure is found to be 757 mm Hg, and the temperature of water is 23.0°C. What is the partial pressure of O2 ? Vapour pressure of H2O at 23°C = 19.8 mm Hg. = **737.2mmhg**
45. . If a gas diffuses at a rate of one-half as fast as O2, find the molecular mass of the gas.
46. 50 ml of gas A effuse through a pin-hole in 146 seconds. The same volume of CO2 under identical conditions effuses in 115 seconds. Calculate the molecular mass of A
47. Calculate the root mean square velocity of CO2 molecule at 1000°C
48. Oxygen at 1 atmosphere pressure and 0°C has a density of 1.4290 grams per litre. Find the RMS velocity of oxygen molecules.
49. Calculate the pressure exerted by 1.00 mole of methane (CH4) in a250 mL container at 300 K using van der Waals equation. What pressure will be predicted by ideal gas equation ? a = 2.253 L2 atm mol–2, b = 0.0428 L mol–1; R = 0.0821 L atm mol–1 K
50. One mole of water vapour is confined to a 20 litre flask at 27°C. Calculate its pressure using van der Waal's equation
51. Ideal gas equation Given that a = 5.464 litre2 atm mol–1 b = 0.0305 litre mol–1 R = 0.0821 litre atm. deg–1 mol–1
52. . Two moles of NH3 are enclosed in a five litre flask at 27°C. Calculate the pressure exerted by the gas assuming that the gas behaveslike an ideal gas.
53. the gas behaves like a real gas a=4.14 and b=0.037

(a) What are the limitations of the equation PV = RT? What improvements have been suggested by van der Waal?

54. How van der Waal's equation can be applied for the calculation of Boyle's temperature? Also define Boyle's temperature.
55. Show that van der Waal's equation reduces to ideal gas equation at Boyle's temperature

56. At a pressure of 760 mm, a mixture of nitrobenzene ($C_6H_5NO_2$) and water boils at 99°C. The vapour pressure of water at this temperature is 733 mm. Find the proportion of water and nitrobenzene in the distillate obtained by steam distillation of impure $C_6H_5NO_2$
57. . A mixture of water and bromobenzene (C_6H_5Br) distills at 95°C,and the distillate contains 1.6 times as much C_6H_5Br as water by mass.At 95°C the vapour pressure of water and C_6H_5Br are 640 mm Hg and 120 mm Hg respectively. Calculate the molecular weight of bromobenzene
58. Nitrobenzene is completely immiscible with water. A mixture of thetwo liquids boils at 99°C and 753 torr pressure. The vapour pressure of water is 733 torr at this temperature. Find out the weight composition of liquid mixture.
59. . A solid X is added to a mixture of benzene and water. After shaking well and allowing to stand, 10 ml of the benzene layer was found to contain 0.13 g of X and 100 ml of water layer contained 0.22 gof X. Calculate the value of distribution coefficient. **=5.9**
60. An aqueous solution of succinic acid at 15ºC, containing 0.07 g in10 ml is in equilibrium with an ethereal solution which has 0.013 g in10 ml. The acid has its normal molecular weight in both the solvents. What is the concentration of the ethereal solution which is in equilibrium with an aqueous solution containing 0.024 g in 10 ml?
61. At 25º C an aqueous solution of iodine containing 0.0516 g litre–1 is in equilibrium with a carbon tetrachloride (CCl4) solution containing 4.412 g litre–1. The solubility of iodine in water at 25ºC is 0.34 g litre–1. Find the solubility of iodine in carbon tetrachloride.
62. The distribution coefficient of X for benzene and water is 10. Findthe amount of X extracted if 1 g of it dissolved in 100 ml of water is equilibrated in a separatory funnel with 100 ml of benzene.

63. One mole of PCl5 is heated in a closed two-litre vessel. At equilibrium 40% of the PCl5 is dissociated. Calculate the equilibriumconstant of the reaction.

64. For the reaction CO2(g) + H2(g) ⟷ CO(g) + H2O(g) the equilibrium constant at 1000 K is 0.53.
If a mixture at equilibrium in a 1 dm3 vessel contains 0.25 mole of CO_2 and 0.6 mole of H_2, how many moles of H2O are there in the vessel?

65. 5 moles of inert gas are added to the equilibrium mixture containing1 mole of H2 and 1 mole of CO2 in 1 dm3 vessel. Predict equilibrium concentration of CO2 and H2O.

66. What is standard free energy change? Derive a relationship between standard free energy change and equilibrium constant of a reaction at a given temperature.

67. The equilibrium constant Kp for the reaction: N2(g) + 3H2(g) 2NH3(g) is 1.64 × 10–4 at 673 K and 0.144 × 10–4 at 773 K. Calculatethe mean heat of formation of ammonia from its elements in this temperature range.

68. Write a short note on "Le Chatelier's Principle"

(a) Define equilibrium constant and show that it can have two different values depending on how you express concentration. Derive relationship between these two values.

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69. (a) Derive the relation between Kp and Kc .

On heating in a closed vessel PCl5 dissociates into PCl3 and Cl2. At 200°C the vapour
density of the gaseous mixture is 75.5. Calculate the degree of dissociation of PCl5. (P =31, Cl = 35.5)

70. Alcohol and acetic acid were mixed in equimolar proportions in aqueous medium at room temperature. At equilibrium 50% alcohol is converted into ester. Calculate how much ester will be formed if 2 moles of acetic acid and 1 mole of alcohol were mixed.

71. At 25 ºC and 1 atm pressure the partial pressure in an equilibrium mixture of N2 O4 and NO2 are 0.7 and 0.3 atm respectively. Calculate the partial pressures of these gases when they are in equilibrium at 25 ºC and a total pressure of 5