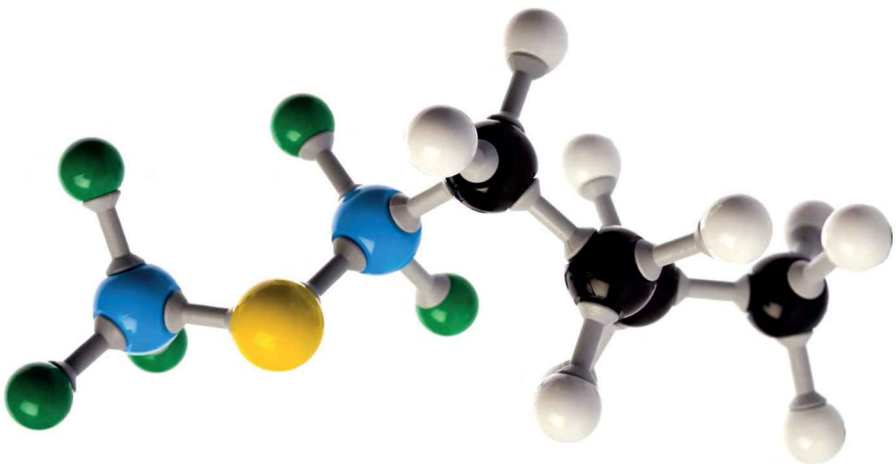
ADVANCED PROBLEMS IN PHYSICAL CHEMISTRY FOR COMPETITIVE EXAMINATIONS



NEERAJ KUMAR

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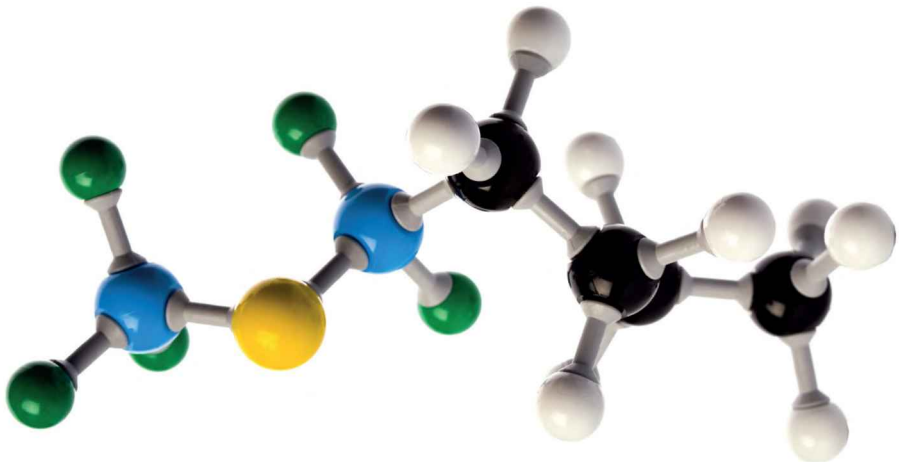

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Advanced Problems in Physical Chemistry

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Neeraj Kumar

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Delhi • Chennai

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Contents

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Preface

Advanced Problems in Physical Chemistry for Competitive Examinations has been conceived to meet the specific requirements of the students preparing for IIT-JEE, Olympiad and other competitive examinations. The best way to ensure that students understand the concepts of physical chemistry is to solve as many problems on each topic. Students should attempt a variety of different problems, rather than spending too much time with the same problem again and again. Students should also ensure to read each problem carefully, since a small variation in the wording of a problem can make huge difference in its solution.

The book has ample number of problems of different profiles to help students to get a grip on the subject quickly. The number of problems given in every exercise will definitely aid the purpose.

Each chapter of this book has two exercises, except Chapter 14 (Nuclear Chemistry). Exercise I is for IIT-JEE Mains and Exercise II is for IIT-JEE Advance, Olympiad, and other competitive examinations.

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Acknowledgement

I am grateful to Pearson Education for keeping faith in me. I would like to thank Jitendra Kumar, from the editorial division, for regularly motivating me. Without his kind support, bringing out this book would not have been possible.

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My special thanks goes to my wife Sweta, and daughter Shrija, for their encouragement, patience, sacrifice and constant support.

As an author, I have tried to touch the goodness of my father, Suresh Prasad. Without his blessings and motivation, it would not have been possible.

I heartily welcome suggestions from the readers for further improvement of this book. Please feel free to contact me at neerajnca@gmail.com

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About the Author

Neeraj Kumar is a civil engineer from Bihar College of Engineering, Patna (now NIT, Patna). He has been teaching IIT-JEE aspirants since 1992. He established Neeru's Chemistry Arena at Musallahpur Hat, Patna. He worked for Career Point (2002–04), Sri Chaitanya IIT Academy (2004–07), AMBITION (2007–09). Presently, he is working as the Head of the Department of Physical and Inorganic Chemistry at Bansal Classes.

The author strongly believes that cracking any competitive examination demands theoretical knowledge. Even the current trends of IIT-JEE support the theoretical and analytical approach.

Neeraj Kumar has written a good number of books for IIT-JEE as well as for schools. He has co-authored several books and contributed papers in reputed educational magazines such as *Chemistry Patron and Junior Science Refresher.*

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CHAPTER 1

Mole Concept

EXERCISE I (JEE MAIN)

Laws of Chemical Combinations

1. A quantity of 10 g of a hydrocarbon exactly requires 40 g oxygen for complete combustion. The products formed are CO_2 and water. When CO_2 gas formed is absorbed completely in lime water, the mass of solution increases by 27.5 g. What is the mass of water formed in combustion?
   (a) 22.5 g (b) 27.5 g
   (c) 50 g (d) 10 g

2. Zinc ore (zinc sulphide) is treated with sulphuric acid, leaving a solution with some undissolved bits of material and releasing hydrogen sulphide gas. If 10.8 g of zinc ore is treated with 50.0 ml of sulphuric acid (density 1.2 g/ml), 65.2 g of solution and undissolved material remains. In addition, hydrogen sulphide (density 1.4 g/l) is evolved. What is the volume (in litres) of this gas?
   (a) 4.0 (b) 5.6
   (c) 7.84 (d) 4.4

3. When a mixture of aluminium powder and iron (III) oxide is ignited, it produces molten iron and aluminium oxide. In an experiment, 5.4 g of aluminium was mixed with 18.5 g of iron (III) oxide. At the end of the reaction, the mixture contained 11.2 g of iron, 10.2 g of aluminium oxide, and an undetermined amount of unreacted iron (III) oxide. No aluminium was left. What is the mass of the iron (III) oxide left?
   (a) 2.5 g
   (b) 7.3 g
   (c) 8.3 g
   (d) 2.9 g

4. Some bottles of colourless liquids were being labelled when the technicians accidentally mixed them up and lost track of their contents. A 15.0 ml sample withdrawn from one bottle weighed 22.3 g. The technicians knew that the liquid was either acetone, benzene, chloroform or carbon tetrachloride (which have densities of 0.792 g/cm^3, 0.899 g/cm^3, 1.489 g/cm^3, and 1.595 g/cm^3, respectively). What was the identity of the liquid?
   (a) Carbon tetrachloride
   (b) Acetone
   (c) Chloroform
   (d) Benzene

5. A sample of an ethanol–water solution has a volume of 55.0 cm^3 and a mass of 50.0 g. What is the percentage of ethanol (by mass) in the solution? Assume that there is no change in volume when the pure compounds are mixed. The density of ethanol is 0.80 g/cm^3 and that of water is 1.00 g/cm^3.
   (a) 20% (b) 40%
   (c) 60% (d) 45.45%

6. In a textile mill, a double-effect evaporator system concentrates weak liquor containing 4% (by mass) caustic soda to produce a lye containing 25% solids (by mass). What is the weight of water evaporated per 100 g feed in the evaporator?
   (a) 125.0 g (b) 50.0 g
   (c) 84.0 g (d) 16.0 g

7. At 373 K and 1atm, if the density of liquid water is 1.0 g/ml and that of water vapour is 0.0006 g/ml, then the volume occupied by water molecules in 1 litre of steam at that temperature is
   (a) 6 ml (b) 60 ml
   (c) 0.6 ml (d) 0.06 ml

8. A person needs on average of 2.0 mg of riboflavin (vitamin B_2) per day. How many grams of butter should be taken by the person per day if it is the only source of riboflavin? Butter contains 5.5 μg riboflavin per g.
   (a) 363.6 g
   (b) 2.75 mg
   (c) 11 g
   (d) 19.8 g

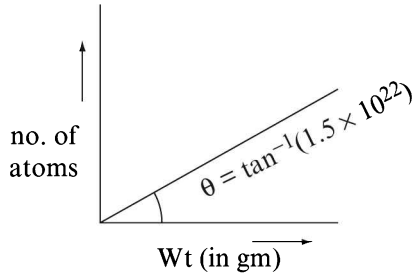
9. Law of multiple proportions is not applicable for the oxide(s) of
   (a) carbon
   (b) iron
   (c) nitrogen
   (d) aluminium

10. Two elements A and B combine to form compound X and Y. For the fix mass of A, masses of B combined for the compounds A and B are in 3:7 ratio. If in compound X, 4 g of A combines with 12 g B, then in compound Y, 8 g of A will combine with ..... g of B.
   (a) 24 (b) 56
   (c) 28 (d) 8

Atomic Mass

11. The mass of 3.2×10^5 atoms of an element is 8.0×10^{-18} g. The atomic mass of the element is about ($N_A = 6 \times 10^{23}$)
   (a) 2.5×10^{-22}
   (b) 15
   (c) 8.0×10^{-18}
   (d) 30

12. A graph is plotted for an element, by putting its mass on X-axis and the corresponding number of number of atoms on Y-axis. What is the atomic mass of the element for which the graph is plotted? ($N_A = 6.0 \times 10^{23}$)



   (a) 80
   (b) 40
   (c) 0.025
   (d) 20

13. If **'NEERAJ KUMAR'** is written by graphite pencil, it weighs 3.0×10^{-10} g. How many carbon atoms are present in it? ($N_A = 6 \times 10^{23}$)
(a) 1.5×10^{13} (b) 5×10^{12}
(c) 2×10^{33} (d) 1.5×10^{10}

14. The atomic masses of two elements P and Q are 20 and 40, respectively. If 'a' g of P contains 'b' atoms, how many atoms are present in '$2a$' g of Q?
(a) a (b) b
(c) $2a$ (d) $2b$

15. The molecular formula of a compound is X_4O_9. If the compound contains 40% X, by mass, what is the atomic mass of X?
(a) 24 (b) 12
(c) 26 (d) 13

16. A quantity of 1 g of metallic carbonate XCO_3 is completely converted into a chloride XCl_2 weighing 1.11 g. The atomic mass of the element 'X' is
(a) 10 (b) 20
(c) 30 (d) 40

17. An element, X, have three isotopes X^{20}, X^{21} and X^{22}. The percentage abundance of X^{20} is 90% and its average atomic mass of the element is 20.18. The percentage abundance of X^{21} should be
(a) 2% (b) 8%
(c) 10% (d) 0%

18. A sample of hydrogen gas is collected and it is observed that it contains only hydrogen and deuterium atoms in the atomic ratio 6000:1. The number of neutrons in 3.0 g of such a sample should be nearly
(a) 0.0005
(b) 3.01×10^{20}
(c) 1.80×10^{24}
(d) 1.0

19. If isotopic distribution of C^{12} and C^{14} is 98.0% and 2.0%, respectively, then the number of C^{14} atoms in 12 g of carbon is
(a) 1.032×10^{22}
(b) 1.20×10^{22}
(c) 5.88×10^{23}
(d) 6.02×10^{23}

20. The fractional abundance of Cl^{35} in a sample of chlorine containing only Cl^{35} (atomic weight = 34.9) and Cl^{37} (atomic weight = 36.9) isotopes, is 0.6. The average mass number of chlorine is
(a) 35.7 (b) 35.8
(c) 18.8 (d) 35.77

Molecular Mass

21. Twenty molecules of SO_3 will weigh as much as ..... molecules of oxygen.
(a) 100 (b) 50
(c) 15 (d) 8

22. The mass of CO_2 that must be mixed with 20 g of oxygen such that 27 ml of a sample of the resulting mixture would contain equal number of molecules of each gas
(a) 13.75 g
(b) 27.50 g
(c) 41.25 g
(d) 55 g

23. A mixture of 2×10^{21} molecules of P and 3×10^{21} molecules of Q weighs 0.60 g. If the molecular mass of P is 45, the molecular mass of Q will be ($N_A = 6 \times 10^{23}$)
(a) 45 (b) 180
(c) 90 (d) 270

24. The shape of tobacco mosaic virus (TMV) is cylindrical, having length 3000 Å and diameter 170 Å. If the specific volume of virus is 12.5 ml/g, the molecular mass of TMV is ($N_A = 6 \times 10^{23}$)
(a) 3.28 (b) 5.44×10^{-24}
(c) 5.44×10^{-18} (d) 3.28×10^{6}

25. The density of a DNA sample is 1.1g/ml and its molar mass determined by cryoscopic method was found to be 6×10^8 g/mole. What is the volume occupied by one DNA molecule? ($N_A = 6\times10^{23}$)
(a) 5.45×10^8 ml
(b) 1.83×10^{-9} ml
(c) 9.06×10^{-16} ml
(d) 1.09×10^{-13} ml

26. How many atoms do mercury vapour molecules consist of if the density of mercury vapour relative to air is 6.92? The average mass of air is 29 g per mole. (Hg = 200)
(a) 1
(b) 2
(c) 4
(d) Infinite

27. Vapour density of a volatile substance is 1.2 ($C_2H_6 = 1$). Its molecular mass would be
(a) 1.2
(b) 2.4
(c) 36
(d) 72

28. A compound contains 7 carbon atoms, 2 oxygen atoms and 9.96×10^{-24} g of other elements. The molecular mass of compound is ($N_A = 6\times10^{23}$)
(a) 122
(b) 116
(c) 148
(d) 154

29. If the mass of neutron is doubled and that of proton is halved, the molecular mass of H_2O containing only H^1 and O^{16} atoms, will
(a) increase by about 25%
(b) decrease by about 25%
(c) increase by about 14%
(d) decrease by about 14%

30. Out of 1.0 g dioxygen, 1.0 g atomic oxygen and 1.0 g ozone, the maximum number of oxygen atoms are contained in
(a) 1.0 g of atomic oxygen
(b) 1.0 g of ozone
(c) 1.0 g of oxygen gas
(d) All contain the same number of atoms

31. Total number of electrons present in 4.4 g oxalate ion ($C_2O_4^{2-}$) is
(a) $0.05N_A$
(b) $2.3N_A$
(c) $2.2N_A$
(d) $2.1N_A$

32. Total number of valence electrons present in 6.4 g peroxides ion (O_2^{2-}) is
(a) $0.2N_A$ (b) $3.2N_A$
(c) $3.6N_A$ (d) $2.8N_A$

33. The number of F^- ions in 4.2 g AlF_3 is (Al = 27, F = 19)
(a) 0.05
(b) 9.03×10^{22}
(c) 3.01×10^{22}
(d) 0.15

34. A quantity of 13.5 g of aluminium when changes to Al^{3+} ion in solution, will lose (Al = 27)
(a) 18.0×10^{23} electrons
(b) 6.02×10^{23} electrons
(c) 3.01×10^{23} electrons
(d) 9.1×10^{23} electrons

35. If an iodized salt contains 1% of KI and a person takes 2 g of the salt every day, the iodine ions going into his body everyday would be approximately (K = 39, I = 127)
(a) 7.2×10^{21} (b) 7.2×10^{19}
(c) 3.6×10^{21} (d) 9.5×10^{19}

Calculation of Mole

36. Dopamine is a neurotransmitter, a molecule that serves to transmit message in the brain. The chemical formula of dopamine is $C_8H_{11}O_2N$. How many moles are there in 1 g of dopamine?
(a) 0.00654
(b) 153
(c) 0.0654
(d) None of these

37. Ethanol is the substance commonly called alcohol. The density of liquid alcohol is 0.8 g/ml at 293 K. If 1.2 moles of ethanol is needed for a particular experiment, what volume of ethanol should be measured out?
(a) 55.2 ml (b) 57.5 ml
(c) 69 ml (d) 47.9 ml

38. The volume of one mole of water at 277 K is 18 ml. One ml of water contains 20 drops. The number of molecules in one drop of water will be ($N_A = 6 \times 10^{23}$)
(a) 1.07×10^{21}
(b) 1.67×10^{21}
(c) 2.67×10^{21}
(d) 1.67×10^{20}

39. A given mixture consists only of pure substance X and pure substance Y. The total mass of the mixture is 3.72 g. The total number of moles is 0.06. If the mass of one mole of Y is 48 g and there is 0.02 mole of X in the mixture, what is the mass of one mole of X?
(a) 90 g (b) 75 g
(c) 45 g (d) 180 g

40. Number of gas molecules present in 1 ml of gas at 0°C and 1 atm is called Loschmidt number. Its value is about
(a) 2.7×10^{19} (b) 6×10^{23}
(c) 2.7×10^{22} (d) 1.3×10^{28}

41. A quantity of 0.25 g of a substance when vaporized displaced 50 cm^3 of air at 0°C and 1 atm. The gram molecular mass of the substance will be
(a) 50 g (b) 100 g
(c) 112 g (d) 127.5 g

42. An amount of 6 moles of Cl-atoms at STP occupies a volume of
(a) 134.4 l (b) 67.2 l
(c) 68.1 l (d) 136.2 l

43. While resting, the average 70 kg human male consumes 16.628 l of oxygen per hour at 27°C and 100 kPa. How many moles of oxygen are consumed by the 70 kg man while resting for 1hour?
(a) 0.67 (b) 66.7
(c) 666.7 (d) 67.5

44. One molecule of haemoglobin will combine with four molecules of oxygen. If 1.0 g of haemoglobin combines with 1.642 ml of oxygen at body temperature (27°C) and a pressure of 760 torr, what is the molar mass of haemoglobin?
(a) 6,00,000 (b) 1,50,000
(c) 15,000 (d) 60,000

45. A quantity of 2.0 g of a triatomic gaseous element was found to occupy a volume of 448 ml at 76 cm of Hg and 273 K. The mass of its each atom is
(a) 100 amu
(b) 5.53×10^{-23} g
(c) 33.3 g
(d) 5.53 amu

46. Most abundant element dissolved in sea water is chlorine at a concentration of 19 g/kg of sea water. The volume of earth's ocean is 1.4×10^{21} l. How many g-atoms of chlorine are potentially available from the oceans? Density of sea water is 1 g/ml. ($N_A = 6 \times 10^{23}$)
(a) 7.5×10^{20} (b) 27×10^{21}
(c) 27×10^{24} (d) 7.5×10^{19}

47. From 2 mg calcium, 1.2×10^{19} atoms are removed. The number of g-atoms of calcium left is (Ca = 40)
(a) 5×10^{-5}
(b) 2×10^{-5}
(c) 3×10^{-5}
(d) 5×10^{-6}

48. The number of g-molecules of oxygen in 6.023×10^{24} CO molecules is
(a) 1 g-molecule
(b) 0.5 g-molecule
(c) 5 g-molecules
(d) 10 g-molecules

49. Equal masses of oxygen, hydrogen and methane are taken in identical conditions. What is the ratio of the volumes of the gases under identical conditions?
(a) 16:1:8 (b) 1:16:2
(c) 1:16:8 (d) 2:16:1

50. A pre-weighed vessel was filled with oxygen at NTP and weighed. It was then evacuated, filled with SO_2 at the same temperature and pressure, and again weighed. The weight of oxygen is
(a) the same as that of SO_2
(b) $\frac{1}{2}$ that of SO_2
(c) twice that of SO_2
(d) $\frac{1}{4}$ that of SO_2

Average Molecular Mass

51. Molecular mass of dry air is
(a) less than moist air
(b) greater than moist air
(c) equal to moist air
(d) may be greater or less than moist air

52. At room temperature, the molar volume of hydrogen fluoride gas has a mass of about 50 g. The formula weight of hydrogen fluoride is 20. Gaseous hydrogen fluoride at room temperature is therefore, probably a mixture of
(a) H_2 and F_2
(b) HF and H_2F_2
(c) HF and $H_{2.5}F_{2.5}$
(d) H_2F_2 and H_3F_3

53. A gaseous mixture contains 70% N_2 and 30% unknown gas, by volume. If the average molecular mass of gaseous mixture is 37.60, the molecular mass of unknown gas is
(a) 42.2
(b) 60
(c) 40
(d) 50

54. The mass composition of universe may be given as 90% H_2 and 10% He. The average molecular mass of universe should be
(a) 2.20 (b) 2.10
(c) 3.80 (d) 3.64

55. A quantity of 10 g of a mixture of C_2H_6 and C_5H_{10} occupy 4480 ml at 1 atm and 273 K. The percentage of C_2H_6 by mass, in the mixture is
(a) 30% (b) 70%
(c) 50% (d) 60%

56. The density (in g/l) of an equimolar mixture of methane and ethane at 1 atm and 0°C is
(a) 1.03 (b) 2.05
(c) 0.94 (d) 1.25

57. '*n*' mol of N_2 and 0.05 mol of Ar are enclosed in a vessel of capacity 6 l at 1 atm and 27°C. The value of '*n*' is ($R = 0.08$ l atm mol^{-1} K^{-1})
(a) 0.25
(b) 0.20
(c) 0.05
(d) 0.4

58. A gaseous mixture contains 40% H_2 and 60% He, by volume. What is the total number of moles of gases present in 10 g of such mixture?
(a) 5 (b) 2.5
(c) 3.33 (d) 3.125

59. A sample of ozone gas is found to be 40% dissociated into oxygen. The average molecular mass of sample should be
(a) 41.60 (b) 40
(c) 42.35 (d) 38.40

60. The vapour density of a sample of SO_3 gas is 28. Its degree of dissociation in to SO_2 and O_2 is
(a) 1/7
(b) 1/6
(c) 6/7
(d) 2/5

Percentage Composition

61. The commonly used pain reliever, aspirin, has the molecular formula $C_9H_8O_4$. If a sample of aspirin contains 0.968 g of carbon, what is the mass of hydrogen in the sample?
(a) 0.717 g (b) 0.0717 g
(c) 8.000 g (d) 0.645 g

62. For $CuSO_4 \cdot 5H_2O$, which is the correct mole relationship?
(a) 9 × mole of Cu = mole of O
(b) 5 × mole of Cu = mole of O
(c) 9 × mole of Cu = mole of O_2
(d) mole of Cu = 5 × mole of O

63. The percentage of Fe(III) present in iron ore $Fe_{0.93}O_{1.00}$ is (Fe = 56)
(a) 94 (b) 6
(c) 21.5 (d) 15

64. A quantity of 5 g of a crystalline salt when rendered anhydrous lost 1.8 g of water. The formula mass of the anhydrous salt is 160. The number of molecules of water of crystallization in the salt is
(a) 3 (b) 5
(c) 2 (d) 1

65. Cortisone is a molecular substance containing 21 atoms of carbon per molecule. The mass percentage of carbon in cortisone is 69.98%. What is the molecular mass of cortisone?
(a) 180.05 (b) 360.1
(c) 312.8 (d) 205.8

66. A polystyrene of formula $Br_3C_6H_2(C_8H_8)_n$ was prepared by heating styrene with tribromobenzyl peroxide in the absence of air. It was found to contain 10.46% bromine, by mass. The value of n is (Br = 80)
(a) 20 (b) 21
(c) 19 (d) 22

67. A compound contains 36% carbon, by mass. If each molecule contains two carbon atoms, the number of moles of compound in its 10 g is
(a) 66.67 (b) 0.15
(c) 0.30 (d) 1.5

68. The percentage of oxygen in a compound is 4%. Its minimum molecular mass will be
(a) 100 (b) 400
(c) 200 (d) 32

69. In Dumas method, 0.2 g of an organic nitrogenous compound gave 28 ml of N_2 (volume reduced to 0°C and 1 atm). What is the percentage of nitrogen, by mass, in the compound?
(a) 17.5 (b) 8.75
(c) 35.0 (d) 14.0

70. A quantity of 0.2 g of an organic compound containing, C, H and O, on combustion yielded 0.147 g CO_2 and 0.12 g water. The percentage of oxygen in it is
(a) 73.29% (b) 78.45%
(c) 83.23% (d) 89.50%

Empirical and Molecular Formula

71. The empirical formula of an organic gaseous compound containing carbon and hydrogen is CH_2. The volume occupied by certain mass of this gas is exactly half of the volume occupied by the same mass of nitrogen gas under identical conditions. The molecular formula of the organic gas is

(a) C_2H_4 (b) CH_2
(c) C_6H_{12} (d) C_4H_8

72. A compound has carbon, hydrogen, and oxygen in 3:3:1 atomic ratio. If the number of moles in 1 g of the compound is 6.06×10^{-3}, the molecular formula of the compound will be

(a) C_3H_3O
(b) $C_6H_6O_2$
(c) $C_9H_9O_3$
(d) $C_{12}H_{12}O_4$

73. A compound having the empirical formula, C_3H_4O, has a molecular weight of 170 ± 5. The molecular formula of the compound is

(a) C_3H_4O
(b) $C_6H_8O_2$
(c) $C_6H_{12}O_3$
(d) $C_9H_{12}O_3$

74. It was found from the chemical analysis of a gas that it has two hydrogen atoms for each carbon atom. At 0°C and 1 atm, its density is 1.25 g per litre. The formula of the gas would be

(a) CH_2 (b) C_2H_4
(c) C_2H_6 (d) C_4H_8

75. A quantity of 1.4 g of a hydrocarbon gives 1.8 g water on complete combustion. The empirical formula of hydrocarbon is

(a) CH
(b) CH_2
(c) CH_3
(d) CH_4

76. An organic compound contains 40% carbon and 6.67% hydrogen by mass. Which of the following represents the empirical formula of the compound?

(a) CH_2
(b) CH_2O
(c) C_2H_4O
(d) CH_3O

77. A compound contains elements X and Y in 1:4 mass ratio. If the atomic masses of X and Y are in 1:2 ratio, the empirical formula of compound should be

(a) XY_2 (b) X_2Y
(c) XY_4 (d) X_4Y

78. A compound contains equal masses of the elements A, B and C. If the atomic masses of A, B and C are 20, 40 and 60, respectively, the empirical formula of the compound is

(a) A_3B_2C
(b) AB_2C_3
(c) ABC
(d) $A_6B_3C_2$

79. A gaseous oxide contains 30.4% of nitrogen, one molecule of which contains one nitrogen atom. The density of the oxide relative to oxygen, under identical conditions, is about

(a) 0.69 (b) 1.44
(c) 0.35 (d) 2.88

80. Iron form two oxides. If for the same mass of iron, mass of oxygen combined in the first oxide is two-third of the mass of oxygen combined in the second oxide, the ratio of valency of iron in first and second oxide is

(a) 1:1
(b) 2:3
(c) 3:2
(d) 2:5

Stoichiometry

81. When a certain amount of octane, C_8H_{18}, is burnt completely, 7.04 g CO_2 is formed. What is the mass of H_2O formed, simultaneously?

(a) 1.62 g (c) 6.48 g
(c) 3.24 g (d) 2.28 g

82. If rocket were fuelled with kerosene and liquid oxygen, what mass of oxygen would be required for every litre of kerosene? Assume kerosene to have the average composition $C_{14}H_{30}$ and density, 0.792 g/ml.

(a) 5.504 kg (b) 2.752 kg
(c) 1.376 kg (d) 3.475 kg

83. Air contains 20% O_2, by volume. What volume of air is needed at 0°C and 1 atm for complete combustion of 80 g methane?

(a) 10 l (b) 50 l
(c) 224 l (d) 1120 l

84. Acrylonitrile, C_3H_3N, is the starting material for the production of a kind of synthetic fibre (acrylics). It can be made from propylene, C_3H_6, by reaction with nitric oxide, NO.

$C_3H_6(g) + NO(g) \rightarrow C_3H_3N(g) + H_2O(g) + N_2(g)$ (Unbalanced)

How many grams acrylonitrile may be obtained from 420 kg of propylene and excess NO?

(a) 265 kg (b) 530 kg
(c) 1060 kg (d) 795 kg

85. A quantity of 2.76 g of silver carbonate on being strongly heated yields a residue weighing (Ag = 108)

(a) 2.16 g (b) 2.48 g
(c) 2.32 g (d) 2.64 g

86. How many litres of detonating gas may be produced at 0°C and 1 atm from the decomposition of 0.1 mole of water, by an electric current?

(a) 2.24 l (b) 1.12 l
(c) 3.36 l (d) 4.48 l

87. What mass of solid ammonium carbonate $H_2NCOONH_4$, when vaporized at 273°C, will have a volume of 8.96 l at 760 mm of pressure. Assume that the solid completely decomposes as

$H_2NCOONH_4(s) \rightarrow CO_2(g) + 2NH_3(g)$

(a) 15.6 g (b) 5.2 g
(c) 46.8 g (d) 7.8 g

88. The mass of sulphuric acid needed for dissolving 3 g magnesium carbonate is

(a) 3.5 g (b) 7.0 g
(c) 1.7 g (d) 17.0 g

89. Samples of 1.0 g of Al are treated separately with an excess of sulphuric acid and an excess of sodium hydroxide. The ratio of the number of moles of the hydrogen gas evolved is

(a) 1:1 (b) 3:2
(c) 2:1 (d) 9:4

90. The minimum mass of water needed to slake 1 kg of quicklime, assuming no loss by evaporation, is

(a) 243.2 g (b) 642.8 g
(c) 160.7 g (d) 321.4 g

91. When 20 g Fe_2O_3 is reacted with 50 g of HCl, $FeCl_3$ and H_2O are formed. The amount of unreacted HCl is (Fe = 56)

(a) 27.375 g (b) 22.625 g
(c) 30 g (d) 4.75 g

92. SO_2 gas is slowly passed through an aqueous suspension containing 12 g $CaSO_3$ till the milkiness just disappears. What amount of SO_2 would be required?

(a) 6.4 mole (b) 0.3 mole
(c) 0.1 mole (d) 0.2 mole

93. A mixture of N_2 and H_2 is caused to react in a closed container to form NH_3. The reaction ceases before either reactant has been totally consumed. At this stage, 2.0 moles each of N_2, H_2 and NH_3 are present. The moles of N_2 and H_2 present originally were, respectively,

(a) 4 and 4 moles
(b) 3 and 5 moles
(c) 3 and 4 moles
(d) 4 and 5 moles

94. An ore contains 2.296% of the mineral argentite, Ag_2S, by mass. How many grams of this ore would have to be processed in order to obtain 1.00 g of pure solid silver? (Ag = 108)

(a) 1.148 g (b) 0.026 g
(c) 50 g (d) 2.296 g

95. A power company burns approximately 500 tons of coal per day to produce electricity. If the sulphur content of the coal is 1.5%, by mass, how many tons SO_2 are dumped into the atmosphere, every day?

(a) 15.0
(b) 7.5
(c) 30.0
(d) 18.75

Limiting Reagent Based

96. An amount of 1.0×10^{-3} moles of Ag^+ and 1.0×10^{-3} moles of CrO_4^{2-} reacts together to form solid Ag_2CrO_4. What is the amount of Ag_2CrO_4 formed? (Ag = 108, Cr = 52)

(a) 0.332 g (b) 0.166 g
(c) 332 g (d) 166 g

97. An amount of 0.3 mole of $SrCl_2$ is mixed with 0.2 mole of K_3PO_4. The maximum moles of KCl which may form is

(a) 0.6 (b) 0.5
(c) 0.3 (d) 0.1

98. Large quantities of ammonia are burned in the presence of a platinum catalyst to give nitric oxide, as the first step in the preparation of nitric acid.

$$NH_3(g) + O_2(g) \xrightarrow{Pt} NO(g) + H_2O(g)$$ (Unbalanced)

Suppose a vessel contains 0.12 moles NH_3 and 0.14 moles O_2. How many moles of NO may be obtained?

(a) 0.120 (b) 0.112
(c) 0.140 (d) 0.070

99. Equal masses of iron and sulphur are heated together to form FeS. What fraction of the original mass of excess reactant is left unreacted? (Fe = 56, S = 32)

(a) 0.22 (b) 0.43
(c) 0.86 (d) 0.57

100. Hydrogen cyanide, HCN, is prepared from ammonia, air and natural gas (CH_4) by the following process.

$$2NH_3(g) + 3O_2(g) + 2CH_4(g) \xrightarrow{Pt} 2HCN(g) + 6H_2O(g)$$

If a reaction vessel contains 11.5 g NH_3, 10.0 g O_2, and 10.5 g CH_4, what is the maximum mass, in grams, of hydrogen cyanide that could be made, assuming the reaction goes to completion?

(a) 18.26 g (b) 5.625 g
(c) 17.72 g (d) 16.875 g

Sequential and Parallel Reactions

101. What mass of carbon disulphide, CS_2 can be completely oxidized to SO_2 and CO_2 by the oxygen liberated when 325 g of Na_2O_2 react with water?

(a) 316.67 g (b) 52.78 g
(c) 633.33 g (d) 211.11 g

102. An amount of 2 moles $KClO_3$ is decomposed completely to produce O_2 gas. How many moles of butane, C_4H_8 can be burnt completely by the O_2 gas produced?

(a) 0.5 (b) 1.0
(c) 2.0 (d) 3.0

103. On heating $KClO_3$ at a certain temperature, it is observed that one mole of $KClO_3$ yields one mole of O_2. What is the mole fraction of $KClO_4$ in the final solid mixture containing only KCl and $KClO_4$, the latter being formed by the parallel reaction?

(a) 0.50 (b) 0.25
(c) 0.33 (d) 0.67

104. When 12 g graphite is burnt in sufficient oxygen, CO as well as CO_2 is formed. If the product contains 40% CO and 60% CO_2 by mass and none of the reactant is left, what is the mass of oxygen gas used in combustion?

(a) 24.0 g (b) 21.33 g
(c) 23.8 g (d) 15.6 g

105. A mixture of 254 g of iodine and 142 g of chlorine is made to react completely to give a mixture of ICl and ICl_3. How many moles of each product are formed? (I = 127, Cl = 35.5)

(a) 0.1 mol of ICl and 0.1 mol of ICl_3
(b) 1.0 mol of ICl and 1.0 mol of ICl_3
(c) 0.5 mol of ICl and 0.1 mol of ICl_3
(d) 0.5 mol of ICl and 1.0 mol of ICl_3

Percentage Based

106. A quantity of 4.35 g of a sample of pyrolusite ore, when heated with conc. HCl, gave chlorine. The chlorine, when passed through potassium iodide solution, liberated 6.35 g of iodine. The percentage of pure MnO_2 in the pyrolusite ore is (Mn = 55, I = 127)

(a) 40 (b) 50
(c) 60 (d) 70

107. How many grams of 90% pure Na_2SO_4 can be produced from 250 g of 95% pure NaCl?

(a) 640.6 g (b) 288.2 g
(c) 259.4 g (d) 320.3 g

108. A quantity of 10 g of a piece of marble was put into excess of dilute HCl acid. When the reaction was complete, 1120 cm^3 of CO_2 was obtained at 0°C and 1 atm. The percentage of $CaCO_3$ in the marble is

(a) 5%
(b) 25%
(c) 50%
(d) 2.5%

109. A 1.50 g sample of potassium bicarbonate having 80% purity is strongly heated. Assuming the impurity to be thermally stable, the loss in weight of the sample, on heating, is

(a) 3.72 g
(b) 0.72 g
(c) 0.372 g
(d) 0.186 g

110. Hydrazine N_2H_4 (used as a fuel in rocket system) can be produced according to the following reaction:

$$ClNH_2 + 2NH_3 \rightarrow N_2H_4 + NH_4Cl$$

When 1.0 kg $ClNH_2$ is reacted with excess of NH_3, 473 g of N_2H_4 is produced. What is the percentage yield?

(a) 76.12 (b) 67.21
(c) 26.17 (d) 16.72

111. Two successive reactions, A → B and B → C, have yields of 90% and 80%, respectively. What is the overall percentage yield for conversion of A to C?

(a) 90% (b) 80%
(c) 72% (d) 85%

112. Iodobenzene is prepared from aniline ($C_6H_5NH_2$) in a two-step process as shown here:

$$C_6H_5NH_2 + HNO_2 + HCl \longrightarrow$$

$$C_6H_5N_2^+Cl^- + 2H_2O$$

$$C_6H_5N_2^+Cl^- + KI \rightarrow C_6H_5I + N_2 + KCl$$

In an actual preparation, 9.30 g of aniline was converted to 16.32 g of iodobenzene. The percentage yield of iodobenzene is (I = 127)

(a) 8% (b) 50%
(c) 75% (d) 80%

113. One mole of a mixture of CO and CO_2 requires exactly 20 g of NaOH in solution for complete conversion of all the CO_2 into Na_2CO_3. How many grams more of NaOH would it require for conversion into Na_2CO_3 if the mixture (one mole) is completely oxidized to CO_2?

(a) 60 g (b) 80 g
(c) 40 g (d) 20 g

114. When burnt in air, 14.0 g mixture of carbon and sulphur gives a mixture of CO_2 and SO_2 in the volume ratio of 2:1, volume being measured at the same conditions of temperature and pressure. Moles of carbon in the mixture is

(a) 0.25 (b) 0.40
(c) 0.5 (d) 0.75

115. A mixture of NaI and NaCl on reaction with H_2SO_4 gave Na_2SO_4 equal to the weight of original mixture taken. The percentage of NaI in the mixture is (I = 127)

(a) 82.38 (b) 26.38
(c) 62.38 (d) 28.38

Eudiometry

116. When 0.03 l of a mixture of hydrogen and oxygen was exploded, 0.003 l of oxygen remained. The initial mixture contains (by volume)

(a) 60% O_2 (b) 40% O_2
(c) 50% O_2 (d) 30% O_2

117. A volume of 100 ml of air containing only oxygen and nitrogen is a taken in a jar over water. NO is slowly passed till no more brown fumes appear in the gas jar. It is found that 42 ml of NO is required. The percentage of nitrogen in the air would be

(a) 42% (b) 79%
(c) 21% (d) 39.5%

118. A mixture of methane and ethylene in the ratio of a:b by volume occupies 30 ml. On complete combustion, the mixture yield 40 ml of CO_2. What volume of CO_2 would have been obtained if the ratio would have been b:a?

(a) 50 ml
(b) 30 ml
(c) 40 ml
(d) 60 ml

119. A volume of 200 ml of oxygen is added to 100 ml of a mixture containing CS_2 vapour and CO, and the total mixture is burnt. After combustion, the volume of the entire mixture is 245 ml. Calculate the volume of the oxygen that remains

(a) 67.5 ml
(b) 125.0 ml
(c) 200.0 ml
(d) 100.0 ml

120. A volume of 10 ml hydrogen requires 25 ml air for complete combustion. The volume per cent of N_2 in air is

(a) 20%
(b) 80%
(c) 79%
(d) 5%

121. A volume of 10 ml of gaseous C_4H_x exactly requires 55 ml O_2 for complete combustion. The value of 'x' is

(a) 4
(b) 6
(c) 8
(d) 10

122. When 500 ml CO_2 gas is passed through red hot charcoal, the volume becomes 700 ml. The volume of CO_2 converted into CO is

(a) 200 ml
(b) 300 ml
(c) 350 ml
(d) 500 ml

123. The percentage by volume of C_3H_8 in a mixture of C_3H_8, CH_4 and CO is 36.5. The volume of CO_2 produced when 100 ml of the mixture is burnt in excess of O_2, is

(a) 153 ml
(b) 173 ml
(c) 193 ml
(d) 213 ml

124. A volume of 1 ml of a gaseous aliphatic compound $C_nH_{3n}O_m$ is completely burnt in an excess of oxygen. The contraction in volume (in ml) is

(a) $\left(1+\frac{1}{2}n-\frac{3}{4}m\right)$

(b) $\left(1+\frac{3}{4}n-\frac{1}{4}m\right)$

(c) $\left(1-\frac{1}{2}n-\frac{3}{4}m\right)$

(d) $\left(1+\frac{3}{4}n-\frac{1}{2}m\right)$

125. The explosion of a mixture consisting of one volume of a gas being studied and one volume of H_2 yielded one volume water vapour and one volume of N_2. The formula of gas being studied, is

(a) NO (b) NO_2
(c) N_2O (d) N_2O_3

126. A gaseous alkane is exploded with oxygen. The volume of O_2 for complete combustion to the volume of CO_2 formed is in 7:4 ratio. The molecular formula of alkane is

(a) CH_4 (b) C_3H_8
(c) C_2H_6 (d) C_4H_{10}

127. A volume V of a gaseous hydrocarbon was exploded with an excess of oxygen. The observed contraction was $2.5V$, and on treatment with potash, there was a further contraction of $2V$. What is the molecular formula of the hydrocarbon?

(a) C_2H_6 (b) C_3H_6
(c) C_4H_{12} (d) C_2H_4

128. A volume of 10 ml chlorine gas combines with 25 ml of oxygen gas to form 10 ml of a gaseous compound. If all the volumes are measured at the same pressure and temperature, what is the molecular formula of compound formed?

(a) Cl_2O
(b) Cl_2O_7
(c) ClO_2
(d) Cl_2O_5

129. A volume of 10 ml of an oxide of nitrogen was taken in a eudiometer tube and mixed with hydrogen until the volume was 28 ml. On sparking, the resulting mixture occupied 18 ml. To this mixture, oxygen was added when the volume came to 27 ml and on explosion again, the volume fall to 15 ml. Find the molecular weight of the oxide of nitrogen originally taken in eudiometer tube. All measurements were made at STP.

(a) 22 (b) 44
(c) 88 (d) 176

130. V_1 ml of unknown gas (A) + V_2 ml of O_2 $\rightarrow$ (V_1 + V_2) ml of CO_2.
Gas 'A' may be

(a) CO
(b) (CO + CO_2) in equal proportion
(c) $C_{12}O_9$
(d) C_3O_2

Concentration Terms

131. How many grams of solute should be added in 100 g water to get a solution of density 1.2 g/ml and strength 5% (w/v)?

(a) 5 g (b) 6 g
(c) 4.17 g (d) 4.35 g

132. An aqueous solution of glucose is 10% (w/v). The volume in which 1mole of glucose is dissolved, will be

(a) 18 l (b) 9 l
(c) 0.9 l (d) 1.8 l

133. A quantity of 50 g of water is saturated with HCl gas to get 75 ml of solution containing 40% HCl, by mass. The density of solution formed is

(a) 1.11 g/ml (b) 0.4 g/ml
(c) 0.9 g/ml (d) 0.99 g/ml

134. The concentration of same aqueous solution of glucose is determined by two students—Sawan and Gautam. Sawan reported the concentration as 20% (w/w) and Gautam reported the concentration as 25% (w/v). If both the concentrations are correct, then the density of solution is

(a) 0.8 g/ml
(b) 1.0 g/ml
(c) 1.25 g/ml
(d) 1.33 g/ml

135. How much $Ca(NO_3)_2$, in mg, must be present in 50 ml of a solution with 2.35 ppm of Ca?

(a) 0.1175 (b) 770.8
(c) 4.7 (d) 0.48

136. The legal limit for human exposure to CO in the work place is 35 ppm. Assuming that the density of air is 1.3 g/l, how many grams of CO are in 1.0 l of air at the maximum allowable concentration?

(a) 4.55×10^{-5} g
(b) 3.5×10^{-5} g
(c) 2.69×10^{-5} g
(d) 7.2×10^{-5} g

137. What volume of 0.8 M-$AlCl_3$ solution should be mixed with 50 ml of 0.2 M-$CaCl_2$ solution to get a solution of chloride ion concentration equal to 0.6 M?

(a) 5.56 ml (b) 100 ml
(c) 50 ml (d) 4.89 ml

138. D5W refers to one of the solutions used as an intravenous fluid. It is a 5% by mass solution of dextrose, $C_6H_{12}O_6$ in water. The density of D5W is 1.08 g/ml. The molarity of the solution is

(a) 0.3 M (b) 0.6 M
(c) 0.28 M (d) 0.26 M

139. How much $BaCl_2$ would be needed to make 250 ml of a solution having the same concentration of Cl^- as one containing 3.78 g NaCl per 100 ml? (Ba = 137)

(a) 16.8 g (b) 67.2 g
(c) 33.6 g (d) 22.4 g

140. Upon heating a litre of semi-molar HCl solution, 2.675 g of hydrogen chloride is lost and the volume of the solution shrinks to 750 ml. The molarity of resultant solution is

(a) 0.569 M (b) 0.5 M
(c) 0.42 M (d) 1.707 M

141. A volume of 500 ml of a 0.1M solution of $AgNO_3$ added to 500 ml of 0.1M solution of KCl. The concentration of nitrate ion in the resulting solution is

(a) 0.05 M
(b) 0.1 M
(c) 0.2 M
(d) Reduced to zero

142. In 1200 g solution, 12 g urea is present. If density of the solution is 1.2 g/ml, then the molarity of the solution is

(a) 0.2 M (b) 10 M
(c) 0.167 M (d) 12 M

143. Mole fraction of solute in an aqueous solution of NaOH is 0.1. If the specific gravity of the solution is 1.4, the molarity of the solution is

(a) 6.93 (b) 0.1
(c) 71.4 (d) 0.14

144. What should be the density of an aqueous solution of urea (molar mass = 60 g/mol) such that the molality and molarity of the solution become equal?

(a) 1.0 g/ml (b) 1.6 g/ml
(c) 1.06 g/ml (d) 1.16 g/ml

145. A quantity of 10 g of acetic acid is dissolved in 100 g of each of the following solvents. In which solvent, the molality of solution is maximum? Assume no any dissociation or association of acetic acid in the solvent.

(a) Water
(b) Ethanol
(c) Benzene
(d) Same in all solvents

146. A quantity of 10 g of acetic acid is dissolved in 100 g of each of the following solvents. In which solvent, the mole fraction of solute is maximum? Assume no any dissociation or association of acetic acid in the solvent.

(a) Water
(b) Ethanol
(c) Benzene
(d) Same in all solvents

147. An aqueous solution has urea and glucose in mass ratio 3:1. If the mass ratio of water and glucose in the solution is 10:1, then the mole fraction of glucose in the solution is

(a) $\frac{1}{110}$ (b) $\frac{9}{110}$
(c) $\frac{3}{110}$ (d) $\frac{100}{110}$

148. The volume strength of a sample of H_2O_2 is '8.96 vol'. The mass of H_2O_2 present in 250 ml of this solution is

(a) 0.4 g
(b) 27.2 g
(c) 6.8 g
(d) 108.8 g

149. What is the percentage of 'free SO_3' in a sample of oleum labelled as '104.5%'?

(a) 20% (b) 40%
(c) 60% (d) 80%

150. Which of the following percentage strength is not possible for a sample of oleum?

(a) 104% (b) 109%
(c) 118% (d) 127%

Answer Keys – Exercise I

Laws of Chemical Combinations

1. (a) 2. (a) 3. (a) 4. (c) 5. (b) 6. (c) 7. (c) 8. (a) 9. (d) 10. (b)

Atomic Mass

11. (b) 12. (b) 13. (a) 14. (b) 15. (a) 16. (d) 17. (a) 18. (b) 19. (b) 20. (b)

Molecular Mass

21. (b) 22. (b) 23. (c) 24. (d) 25. (c) 26. (a) 27. (c) 28. (a) 29. (c) 30. (d)
31. (b) 32. (d) 33. (b) 34. (d) 35. (b)

Calculation of Mole

36. (a) 37. (c) 38. (b) 39. (a) 40. (a) 41. (c) 42. (c) 43. (a) 44. (d) 45. (b)
46. (a) 47. (c) 48. (c) 49. (b) 50. (b)

Average Molecular Mass

51. (b) 52. (d) 53. (b) 54. (b) 55. (a) 56. (a) 57. (b) 58. (d) 59. (b) 60. (c)

Percentage Composition

61. (b) 62. (a) 63. (d) 64. (b) 65. (b) 66. (c) 67. (b) 68. (b) 69. (a) 70. (a)

Empirical and Molecular Formula

71. (d) 72. (c) 73. (d) 74. (b) 75. (b) 76. (b) 77. (a) 78. (d) 79. (b) 80. (b)

Stoichiometry

81. (c) 82. (b) 83. (d) 84. (b) 85. (a) 86. (c) 87. (b) 88. (a) 89. (a) 90. (d)
91. (b) 92. (c) 93. (b) 94. (c) 95. (a)

Limiting Reagent Based

96. (b) 97. (a) 98. (b) 99. (b) 100. (b)

Sequential and Parallel Reactions

101. (b) 102. (a) 103. (b) 104. (c) 105. (b)

Percentage Based

106. (b) 107. (d) 108. (a) 109. (c) 110. (a) 111. (c) 112. (d) 113. (a) 114. (c) 115. (d)

Eudiometry

116. (b) 117. (b) 118. (a) 119. (b) 120. (b) 121. (b) 122. (a) 123. (b) 124. (d) 125. (c)
126. (c) 127. (a) 128. (d) 129. (b) 130. (d)

Concentration Terms

131. (d) 132. (d) 133. (a) 134. (c) 135. (d) 136. (a) 137. (a) 138. (a) 139. (a) 140. (a)
141. (a) 142. (a) 143. (a) 144. (c) 145. (d) 146. (c) 147. (a) 148. (c) 149. (a) 150. (d)