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 simultaneously in the 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 A 15.0 ml sample withdrawn from one bottle weighed 22.3 g. The technicians knew that the liquid was either acetone, benzene, chloroform or carbon tetrachloride (which have densities of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 1 atm, 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 an 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 fixed mass of A, masses of B combined for the compounds X and Y 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.

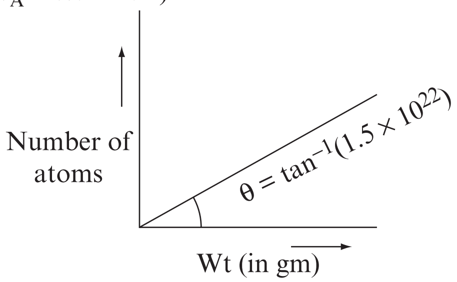
(a) 24 (b) 56
(c) 28 (d) 8

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 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 a 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, then how many atoms are present in '2*a*' g of Q?

(a) *a* (b) *b*
(c) 2*a* (d) 2*b*

15. The molecular formula of a compound is X_4O_9. If the compound contains 40% X by mass, then 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 has three isotopes X^{20}, X^{21} and X^{22}. The percentage abundance of X^{20} is 90% and 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, is

(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, then 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, then 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) 3.27×10^{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? ($N_A = 6 \times 10^{23}$)

(a) 5.45×10^{8} ml (b) 1.83×10^{-9} ml
(c) 9.09×10^{-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 ($N_A = 6 \times 10^{23}$)

(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 16.67%.
(d) decrease by about 16.67%.

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) 9.03×10^{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 a substance, which is 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, then 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, then 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, an average 70 kg human male consumes 16.628 L of oxygen per hour at 27ºC and 100 kPa. How many moles of oxygen are consumed by the 70 kg man while resting for 1 hour?

(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 (27ºC) and a pressure of 760 torr, then 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. The 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? The 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. Therefore, gaseous hydrogen fluoride at room temperature is 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, then 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 is 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 into 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, then 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}, then 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 the 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, then 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 forms two oxides. If for the same mass of iron, the mass of oxygen combined in the first oxide is two-third of the mass of oxygen combined in the second oxide, then 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 a rocket was fuelled with kerosene and liquid oxygen, then 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 of 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 minimum mass of sulphuric acid needed for dissolving 3 g of 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 of $CaSO_3$ 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, then how many tons of 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 of NH_3 and 0.14 of 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, then 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 reacts with water?

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

102. An amount of 2 moles of $KClO_3$ is decomposed completely to produce O_2 gas. How many moles of butene 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 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, then 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, the 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) 82.86 (b) 26.38
(c) 62.38 (d) 28.86

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 yields 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, then 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 1 mole 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 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 semimolar HCl solution, 2.675 g of hydrogen chloride is lost and the volume of the solution shrinks to 750 ml. The molarity of the 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 0.1 M solution of $AgNO_3$ is added to 500 ml of 0.1 M 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, then 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 as well as molarity of the solution becomes equal to 1.0 unit ?

(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 '9.08 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%

EXERCISE II (JEE ADVANCED)

Section A (Only one Correct)

1. A sample of clay contains 50% silica and 10% water. The sample is partially dried by which it loses 8 g water. If the percentage of silica in the partially dried clay is 52, then what is the percentage of water in the partially dried clay?

(a) 2.0% (b) 6.4%
(c) 10.4% (d) 2.4%

2. In the atomic weight determination, Dalton suggested the formula of water as HO and the composition of water as hydrogen = 12.5% and oxygen = 87.5% by weight. What should be the atomic weight of oxygen on H-scale, on the basis of this information?

(a) 16 (b) 8
(c) 14 (d) 7

3. The mercury content of a stream was believed to be above the minimum considered safe limit (1 part per billion, by mass). An analysis indicated that the concentration was 1.68 parts per billion. How many Hg atoms are present in 15 L of water, the density of which is 0.998 g/ml. (Hg = 200)

(a) 7.57×10^{13} (b) 7.57×10^{19}
(c) 7.57×10^{16} (d) 5.37×10^{16}

4. Assume that sodium atoms are spheres of radius 0.2 nm and that they are lined up side by side. How many miles, in length, is the line of atoms present in a 1.15 mg sample of sodium? ($N_A = 6 \times 10^{23}$)

(a) 1.2×10^{10} (b) 1.2×10^{8}
(c) 7.5×10^{8} (d) 7.5×10^{6}

5. The density of gold is 19.7 g/cm^3. The radius of gold atom is [Au = 197, $N_A = 6 \times 10^{23}$, $(10\pi)^{1/3} = 3.15$]

(a) 1.587×10^{-8} m (b) 1.587×10^{-9} m
(c) 1.587×10^{-10} m (d) 1.587×10^{-12} m

6. The average density of the universe as a whole is estimated as 3×10^{-29} g/ml. If we assume that the entire mass is only H atoms, then what is the average volume of space that contains one H atom?

(a) 111.11 L (b) 1.8×10^{-5} L
(c) 55.56 L (d) 3.6×10^{-5} L

7. The waste of nuclear power plant contains C^{12} and C^{14} in the ratio of 4 : 1 by moles. What is the molecular mass of methane gas produced from this disposed waste? Given that the natural abundance of C^{12} and C^{14} are 98% and 2%, respectively.

(a) 15.998 (b) 16.0053
(c) 16 (d) 16.4

8. Two isotopes of an element Q are Q^{97} (23.4% abundance) and Q^{94} (76.6% abundance). Q^{97} is 8.082 times heavier than C^{12} and Q^{94} is 7.833 times heavier than C^{12}. What is the average atomic weight of the element Q?

(a) 94.702 (b) 78.913
(c) 96.298 (d) 94.695

9. The O^{18}/O^{16} ratio in some meteorites is greater than that used to calculate the average atomic mass of oxygen on earth. The average mass of an atom of oxygen in these meteorites is ______ that of a terrestrial oxygen atom?

(a) equal to (b) greater than
(c) less than (d) None of these

10. If the atomic mass were given by as 1/6th part and molecular mass as 1/12th part by mass of one atom of C^{12} isotope, then what would be the molecular mass of water? Suppose atomic masses of hydrogen and oxygen on new scale are 1 and 16, respectively,

(a) 18 (b) 9
(c) 36 (d) Unpredictable

11. Assuming that 1,3,5-hexatriene has only pure double bonds and pure single bonds, how many grams of it contain one mole of double bonds?

(a) 13.3 g (b) 26.7 g
(c) 40 g (d) 80 g

12. In an experiment, it is found that 2.0769 g of pure X produces 3.6769 g of pure X_2O_5. The number of moles of X is

(a) 0.04 (b) 0.06
(c) 0.40 (d) 0.02

13. The volume occupied by 20 g water at 1.2 atm and 4°C is about

(a) 20 ml (b) $\frac{20\times0.082\times227}{18\times1.2}$ L

(c) $\frac{20\times0.082\times4}{18\times1.2}$ L (d) 20 L

14. A quantity of 2.3 g of a mixture of NO_2 and N_2O_4 has a pressure of 0.82 atm, at temperature TK in a container of volume V litres such that the ratio, $T : V$ is 300 : 1 in magnitude. What is the degree of dissociation of N_2O_4?

(a) 0.17 (b) 0.33

(c) 0.67 (d) 0.70

15. When acetylene is passed through red hot metal tubes, some molecules trimerize to form benzene. The molecular mass of the gaseous mixture, when acetylene is passed through the tube is 60. The degree of trimerization of acetylene is

(a) 0.85 (b) 0.60

(c) 0.15 (d) 0.283

16. When a sample of hydrogen fluoride is cooled to 303 K, most of the molecules undergo dimerization. If the vapour density of such a sample is 18, then what per cent of total molecules in the sample are in dimer form? (F = 19)

(a) 88.89 (b) 80.0

(c) 20.0 (d) 11.11

17. Nitrogen (N), phosphorus (P) and potassium (K) are the main nutrients in plant fertilizers. According to an industry convention, the numbers on the label refer to the mass percent of N, P_2O_5 and K_2O in that order. What is N : P : K ratio of a 30 : 10 : 10 fertilizer in terms of moles of each element expressed as x : y : 1.0? (N = 14, P = 31, K = 39)

(a) 10 : 0.66 : 1.0 (b) 20 : 0.66 : 1.0

(c) 8.4 : 1.3 : 1.0 (d) 16.8 : 1.3 : 1.0

18. A certain mixture of MnO and MnO_2 contains 66.67 mol percent of MnO. What is the approximate mass percent of Mn in it? (Mn = 55)

(a) 66.67 (b) 24.02

(c) 72.05 (d) 69.62

19. A sample of impure cuprous oxide contains 66.67% copper by mass. What is the percentage of pure Cu_2O in the sample? (Cu = 63.5)

(a) 66.67 (b) 75

(c) 70 (d) 80

20. Sodium bicarbonate $NaHCO_3$ can be purified by dissolving it in hot water (60ºC), filtering to remove insoluble impurities, cooling to 0ºC to precipitate solid $NaHCO_3$, and then filtering to remove the solid, leaving soluble impurities in solution. Any $NaHCO_3$ that remains in the solution is not recovered. The solubility of $NaHCO_3$ in hot water at 60ºC is 164 g/litre and is 69 g/litre in cold water at 0ºC. What is the percentage yield of $NaHCO_3$, when it is purified by this method?

(a) 57.93% (b) 42.07%

(c) 69% (d) 100%

21. The mineral haematite is Fe_2O_3. Haematite ore contains unwanted material called gangue in addition to Fe_2O_3. If 5 kg of ore contains 2.78 kg of Fe, then what percentage of ore is gangue? (Fe = 56)

(a) 55.6% (b) 44.4%

(c) 20.6% (d) 79.4%

22. A sample of iron ore weighing 0.700 g is dissolved in nitric acid. The solution is then diluted with water, following with sufficient concentrated aqueous ammonia, to quantitative precipitation the iron as $Fe(OH)_3$. The precipitate is filtered, ignited and weighed as Fe_2O_3. If the mass of the ignited and dried precipitate is 0.541 g, then what is the mass percent of iron in the original iron ore sample? (Fe = 56)

(a) 27.0% (b) 48.1%

(c) 54.1% (d) 81.1%

23. The empirical formula of a compound is CH_2O. If 0.0833 moles of the compound contains 1.0 g of hydrogen, then its molecular formula should be

(a) $C_6H_{12}O_6$ (b) $C_5H_{10}O_5$

(c) $C_4H_8O_4$ (d) $C_3H_6O_3$

24. A hydrocarbon C_nH_{2n} yields C_nH_{2n+2} by reduction. In this process, the molar mass of the compound is raised by 2.38%. The value of n is

(a) 8 (b) 4

(c) 6 (d) 5

25. A certain vitamin extracted from plant sources has carbon and hydrogen in 8 : 1 mass ratio. The percentage of oxygen is nearly 7.3. The compound gave no test for nitrogen or sulphur or any other element. What should be the empirical formula of the compound?

(a) $C_{30}H_{45}O_2$ (b) $C_{15}H_{23}O$

(c) $C_{29}H_{45}O_3$ (d) $C_{10}H_{15}O$

26. An unknown oxide of manganese is reacted with carbon to form manganese metal and CO_2. Exactly 31.6 g of the oxide, Mn_xO_y, yielded 13.2 g of CO_2. The simplest formula of the oxide is (Mn = 55)

(a) MnO (b) MnO_2
(c) Mn_2O_3 (d) Mn_4O_6

27. Assume that the atomic mass of oxygen is 7. A sample of 11 g of an oxide of uranium contains 10 g of uranium. Which of the following formula for the oxide is compatible with the data?

(a) Uranium oxide is UO and the atomic mass of U is 70.
(b) Uranium oxide is U_3O_8 and the atomic mass of U is 240.
(c) Uranium oxide is UO_2 and the atomic mass of U is 105.
(d) Uranium oxide is U_3O_2 and the atomic mass of U is 105.

28. A sample of protein was analysed for metal content and analysis revealed that it contained magnesium and titanium in equal amounts, by mass. If these are the only metallic species present in the protein and it contains 0.016% metal, by mass, the minimum possible molar mass of the protein is (Mg = 24, Ti = 48)

(a) 6,00,000 (b) 1,50,000
(c) 3,00,000 (d) 12,00,000

29. One mole of mixture of N_2, NO_2 and N_2O_4 has a mean molar mass of 55.4 g. On heating to a temperature, at which all the N_2O_4 is dissociated into NO_2, the mean molar mass tends to a lower value of 39.6 g. What is the mole ratio of N_2, NO_2 and N_2O_4 in the original mixture?

(a) 5:1:4 (b) 1:1:1
(c) 1:4:5 (d) 1:5:4

30. A protein isolated from a bovine preparation, was subjected to amino acid analysis. The amino acid present in the smallest amount was lysine, $C_6H_{14}N_2O_2$ and the amount of lysine was found to be 365 mg per 100 g protein. What is the minimum molecular mass of the protein?

(a) 40,000,000 (b) 40,000
(c) 40 (d) 4,00,000

31. Cupric ammonium sulphate was found to contain 27.03% water of crystallization by mass. Upon strongly heating, it gave cupric oxide corresponding to 19.89% of starting mass. Find the empirical formula of cupric ammonium sulphate. (Cu = 63.5)

(a) $CuSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$
(b) $CuSO_4 \cdot (NH_4)_2SO_4 \cdot 5H_2O$
(c) $CuSO_4 \cdot 2(NH_4)_2SO_4 \cdot 6H_2O$
(d) $CuSO_4 \cdot (NH_4)_2SO_4 \cdot 8H_2O$

32. A drug, marijuana, owes its activity to tetrahydrocannabinol, which contains 70 per cent as many carbon atoms as hydrogen atoms and 15 times as many hydrogen atoms as oxygen atoms. The number of moles in a gram of tetrahydrocannabinol is 0.00318. Determine its molecular formula.

(a) CH_3O_2 (b) $C_{21}H_{30}O_2$
(c) $C_{15}H_{30}O_2$ (d) $C_{70}H_{15}O$

33. How many millilitres (at 0°C and 1 atm) of hydrogen sulphide are needed to precipitate cupric sulphide completely from 100 ml of a solution containing 2.69 g of $CuCl_2$ in a 1 L solution? (Cu = 63.5)

(a) 448 (b) 4.48
(c) 22.4 (d) 44.8

34. When the hydrocarbon propane is burned in air, carbon dioxide and water are formed. If 0.15 mol of CO_2 is produced, then how many drops of water will be formed, assuming one drop is 0.05 cm^3 and contains 1.70×10^{21} water molecules?

(a) 1.2×10^{23} (b) 4
(c) 53 (d) 70

35. When a hydrocarbon is burnt completely, the ratio of masses of CO_2 and H_2O formed is 44 : 27. The hydrocarbon is

(a) CH_4 (b) C_2H_6
(c) C_2H_4 (d) C_2H_2

36. An aqueous ammonium sulphate solution containing 50 moles of solute reacts with excess of calcium hydroxide. How many litres of a solution (specific gravity 0.85) containing 20% by mass of ammonia can be prepared using this reaction?

(a) 10.0 L (b) 8.5 L
(c) 20.0 L (d) 17.0 L

37. Specialized cells in the stomach release HCl to aid digestion. If they release too much, the excess can be neutralized by antacid tablets. Which of the following should be the more effective active ingredient of antacid tablets?

(a) $Mg(OH)_2$ (b) $Al(OH)_3$
(c) $Ca(OH)_2$ (d) H_2SO_4

38. A metal oxide has the formula M_2O_3. It can be reduced by hydrogen to give free metal and water. 0.1596 g of the metal oxide required 6 mg of hydrogen for complete reduction. The atomic mass of the metal is

(a) 111.60 (b) 159.60
(c) 79.80 (d) 55.80

39. If 0.250 g of an element M reacts with excess fluorine to produce 0.547 g of the hexafluoride, MF_6, the element should be (Cr = 52, Mo = 95.94, S = 32, Te = 127.6, F = 19)

(a) Cr (b) Mo
(c) S (d) Te

40. Fluorine reacts with uranium hexafluoride UF_6 as represented by the following equation.

$U(s) + 3F_2(g) \rightarrow UF_6(g)$

How many fluorine molecules are required to produce 2.0 mg of uranium hexafluoride UF_6 from an excess of uranium? The molar mass of UF_6 is 352.0 g mol^{-1}.

(a) 5.13×10^{18} (b) 1.026×10^{19}
(c) 2.052×10^{19} (d) 1.026×10^{20}

41. What is the total mass of the products formed, when 51 g of H_2S is oxidized by oxygen to produce water and sulphur dioxide?

(a) 72 g (b) 27 g
(c) 123 g (d) 96 g

42. A quantity of 1.08 g of $Cr_2O_7^{2-}$ is reduced in an acidic solution by an excess of SO_2 to form HSO_4^- and Cr^{3+}. What is the minimum number of moles of H^+ that must be present for this reaction to occur? (Cr = 52)

(a) 0.025 (b) 0.020
(c) 0.005 (d) 0.070

43. Diborane tetrachloride was treated with NaOH and the following reaction occurred.

$B_2Cl_4 + NaOH \rightarrow NaBO_2 + H_2O + H_2 + NaCl$

If 1362 ml of hydrogen gas is formed at STP, then how much B_2Cl_4 was consumed? (B = 11)

(a) 9.97 g (b) 9.84 g
(c) 0.0968 g (d) 23.57 g

44. What total volume, in litre at 727°C and 1 atm, could be formed by the decomposition of 16 g of NH_4NO_3?
Reaction: $2NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O(g)$.

(a) 57.47 L (b) 114.94 ml
(c) 41.78 L (d) 24.63 L

45. A compound of iron and chlorine is soluble in water. An excess of silver nitrate was added to precipitate all chloride ions as silver chloride. If a 127 mg sample of the compound gave 287 mg AgCl, then what is the formula of the compound? (Fe = 56, Ag = 108)

(a) $FeCl_2$ (b) $FeCl_3$
(c) FeCl (d) $FeCl_6$

46. From the following reactions,

$2CoF_2 + F_2 \rightarrow 2CoF_3$
$(CH_2)_n + 4n\ CoF_3 \rightarrow (CF_2)_n + 2n\ HF + 4n\ CoF_2$

calculate how much F_2 will be consumed to produce 1 kg of $(CF_2)_n$. (F = 19)?

(a) 1.52 kg (b) 2.04 kg
(c) 0.76 kg (d) 4.56 kg

47. An element 'A' reacts with the compound BO_3 to produce A_3O_4 and B_2O_3. The number of moles of A_3O_4 produced if 1 mole each of A and BO_3 are allowed to react is

(a) 3 (b) 1
(c) 1/3 (d) 2/3

48. A 1.50 g sample of type metal (an alloy of Sn, Pb, Cu and Sb) is dissolved in nitric acid, and metastannic acid, H_2SnO_3, precipitates. This is dehydrated by heating to tin (IV) oxide, which is found to weigh 0.50 g. What percentage of tin was in the original type metal sample? (Sn = 119)

(a) 33.33% (b) 26.27%
(c) 29.38% (d) 52.54%

49. An amount of 5 moles of A, 6 moles of B and excess amount of C are mixed to produce a final product D, according to the following reactions.

$A + 2B \rightarrow I$
$I + C \rightarrow B + D$

What is the maximum moles of D, which can be produced assuming that the products formed can also be reused in the reactions?

(a) 3 moles (b) 4.5 moles
(c) 5 moles (d) 6 moles

50. Hydrogen cyanide, HCN, can be made by a two-step process. First, ammonia is reacted with O_2 to give nitric oxide, NO.

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

Then nitric oxide is reacted with methane, CH_4.

$2NO(g) + 2CH_4(g) \rightarrow 2HCN(g) + 2H_2O(g) + H_2(g)$

When 25.5 g of ammonia and 32.0 g of methane are used, how many grams of hydrogen cyanide can be produced?

(a) 1.5 (b) 2.0
(c) 40.5 (d) 54.0

51. To determine soluble (free) SiO_2 in a rock, an alkaline extraction was carried out, as a result of which there was found 1.52% of SiO_2 in the extract and also 1.02% of Al_2O_3. Considering that, apart from the free SiO_2, the extract also contained the SiO_2 that had passed into it from Kaolin ($2SiO_2{\cdot}Al_2O_3$), the percentage of free SiO_2 in the rock being analysed is (Si = 28, Al = 27)

(a) 1.20 (b) 0.32
(c) 0.50 (d) 1.52

52. A sample of iron oxide has FeO and Fe_2O_3 in the mole ratio 2 : 1. It is partially oxidized to change this ratio to 1 : 2. The number of moles of FeO oxidized per mole of initial mixture is

(a) 0.2 (b) 0.333
(c) 0.4 (d) 0.5

53. When x g carbon is burnt with y g oxygen in a closed vessel, no residue is left behind. Which of the following statement is correct regarding the relative amounts of oxygen and carbon?

(a) y/x must be less than 1.33.
(b) y/x must be greater than 1.33.
(c) y/x must be greater than 2.67.
(d) y/x must lie between 1.33 and 2.67.

54. An amount of 1 mole of calcium cyanamide and 1 mole of water are allowed to react. The number of moles of ammonia produced is

(a) 3.0 (b) 2.0
(c) 1.0 (d) 0.67

55. An amount of 1 mole of N_2 and 4 moles of H_2 are allowed to react in a vessel and after reaction, water is added. Aqueous solution required 1 mole of HCl for complete reaction. Mole fraction of H_2 in the gas mixture after reaction is

(a) 1/6 (b) 5/6
(c) 1/3 (d) 2/3

56. A quantity of 5.08 g of iodine held in suspension in water is slowly acted upon by 460 ml of H_2S measured at 0°C and 1 atm. What weight of sulphur will be liberated? (I = 127)

(a) 0.64 g (b) 0.657 g
(c) 1.297 g (d) 0.017 g

57. A quantity of 27.6 g of K_2CO_3 was treated by a series of reagent so as to convert all of its carbon to $K_2Zn_3[Fe(CN)_6]_2$. The mass of the product formed is (K = 39, Zn = 65.4, Fe = 56)

(a) 139.2 g (b) 11.6 g
(c) 69.6 g (d) 23.2 g

58. What is the volume required of a 20.0% HCl solution of density 1.20 g/ml to prepare 363.0 g of $AsCl_3$ according to the equations? (As = 75, Cl = 35.5)

$2KMnO_4 + 16\ HCl \rightarrow 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$

$2As + 3Cl_2 \rightarrow 2AsCl_3$

(a) 2.56 l (b) 0.73 l
(c) 1.46 l (d) 2.92 l

59. Cyclohexanol is dehydrated to cyclohexene on heating with conc. H_2SO_4. If the yield of this reaction is 75%, then how much cyclohexene will be obtained from 100 g of cyclohexanol?

(a) 61.5 g (b) 82 g
(c) 109.3 g (d) 75 g

60. A sample of pure Cu (4.00 g) heated in a stream of oxygen for some time, gains in weight with the formation of black oxide of copper (CuO). The final mass is 4.90 g. What percent of copper remains unoxidized? (Cu = 64)

(a) 90% (b) 10%
(c) 20% (d) 80%

61. If the yield of chloroform obtainable from acetone and bleaching powder is 75%, then what mass of acetone is required for producing 30 g of chloroform?

(a) 40 g (b) 19.4 g
(c) 10.92 g (d) 14.56 g

62. Pure FeS_2 is burnt with 60% excess air. What is the percentage of N_2, by volume, in the gaseous mixture after the reaction? Air contains 20% O_2 and 80% N_2 by volume.

(a) 81.94 (b) 82.8
(c) 70.4 (d) 89.3

63. A 12 g sample of CH_4 and C_2H_4 yielded 35.2 g of CO_2 on complete oxidation. What was the mean molar mass of the original sample?

(a) 20.0 (b) 22.0
(c) 14.7 (d) 23.0

64. For a hydrocarbon, the ratio of volume O_2 used for complete combustion and the volume of CO_2 formed is independent to the number of carbon atoms present in the hydrocarbon. The hydrocarbon may be

(a) Alkane (b) Alkene
(c) Alkyne (d) Arene

65. A volume of 60 ml of a mixture of nitrous oxide and nitric oxide was exploded with excess hydrogen. If 38 ml of N_2 was formed, the volume of nitrous oxide in the original mixture is

(a) 16 ml (b) 44 ml
(c) 27 ml (d) 33 ml

66. A mixture is made equal volume of CO and air. A spark passed through so that all the oxygen is converted to carbon dioxide. What will be fractional decrease in the total volume of system assuming pressure and temperature remain constant? Air contains 20% oxygen by volume.

(a) 0.1 (b) 0.2
(c) 0.15 (d) 0.3

67. A mixture of formic acid and oxalic acid is heated with conc. H_2SO_4. The gaseous product is passed into KOH solution where the volume decreased by 1/6th. What was the molecular proportion of the organic acids, formic and oxalic acid in the mixture?

(a) 1 : 4 (b) 4 : 1
(c) 1 : 5 (d) 5 : 1

68. A volume of 50 ml of a gas mixed with 70 ml of oxygen gave after explosion 50 ml of CO_2 and after absorption by KOH, 45 ml of oxygen are left. What is the molecular formula of the gas?

(a) CH_4 (b) C_2H_4
(c) CO (d) C_2H_2

69. A human patient suffering from a duodenal ulcer may show a concentration of HCl of 80×10^{-3} molar in gastric juice. If his stomach receives 3 L of gastric juice per day, how much medicine (antacid syrup) containing 2.6 g of $Al(OH)_3$ per 100 ml must he consumes per day to neutralize the acid?

(a) 27 ml (b) 80 ml
(c) 240 ml (d) 120 ml

70. When V ml of 2.2 M – H_2SO_4 solution is mixed with $10V$ ml of water, the volume contraction of 2% takes place. The molarity of diluted solution is

(a) 0.2 M (b) 0.204 M
(c) 0.196 M (d) 0.224 M

71. A quantity of 23.6 g of succinic acid is dissolved in 500 ml of 0.1 M acetic acid solution. Assuming that neither acid is dissociated in solution, calculate the molarity of '–COOH' in the solution.

(a) 0.3 M (b) 0.5 M
(c) 0.9 M (d) 0.8 M

72. Chlorofluorocarbons such as CCl_3F (M = 137.5) and CCl_2F_2 (M = 121) have been linked to ozone depletion in Antarctica. As of 2004, these gases were found in 275 and 605 parts per trillion (10^{12}), by volume. What are the concentrations of these gases under conditions typical of Antarctica stratosphere (200 K and 0.08 atm)? (R = 0.08 l-atm/K-mol)

(a) $[CCl_3F] = 1.375 \times 10^{-12}$ mol l^{-1}, $[CCl_2F_2] = 3.025 \times 10^{-12}$ mol l^{-1}

(b) $[CCl_3F] = 2.75 \times 10^{-14}$ mol l^{-1}, $[CCl_2F_2] = 6.05 \times 10^{-14}$ mol l^{-1}

(c) $[CCl_3F] = 2.75 \times 10^{-10}$ mol l^{-1}, $[CCl_2F_2] = 6.05 \times 10^{-10}$ mol l^{-1}

(d) $[CCl_3F] = 1.375 \times 10^{-13}$ mol l^{-1}, $[CCl_2F_2] = 3.025 \times 10^{-12}$ mol l^{-1}

73. A quantity of 1 kg of 2 m urea solution is mixed with 2 kg of 4 m urea solution. The molality of the resulting solution is

(a) 3.33 m (b) 10 m
(c) 3.29 m (d) 5 m

74. A quantity of 1 kg of 1 m glucose solution is diluted to 5 kg. The molality of the diluted solution should be

(a) 0.2 m (b) 0.02 m
(c) 0.207 m (d) 0.175 m

75. A quantity of 500 g of an aq. urea solution having mole fraction of solute, 0.2 is diluted to 1500 g. The mole fraction of solute in the diluted solution is

(a) 0.05 (b) 0.067
(c) 0.6 (d) 0.1

76. A volume of 20 ml of 8.5% (w/v) H_2O_2 solution is diluted to 50 ml. A volume of 10 ml of the diluted solution is reacted with excess of an oxidant. It will cause liberation of ___ ml of ___ gas at 0^oC and 1 atm.

(a) 56, O_2 (b) 112, O_2
(c) 224, H_2 (d) 224, H_2

77. A volume of 50 ml of '20 vol' H_2O_2 solution is mixed with 50 ml of '10 vol' H_2O_2 solution. The volume strength of the resulting solution is (assume neither expansion nor contraction in volume of solution, on mixing)

(a) '30 vol' (b) '10 vol'
(c) '15 vol' (d) '22.5 vol'

78. In 200 g of a sample of oleum labelled as 109.0%, 12 g water is added. The new labelling of the oleum sample is

(a) 106.0% (b) 103.0%
(c) 102.8% (d) 105.6%

79. When 200 g of an oleum sample labelled as 109% is mixed with 300 g of another oleum sample labelled as 118%, the new labelling of resulting oleum sample becomes

(a) 114.4% (b) 112.6%
(c) 113.5% (d) 127%

80. A sample of oleum is labelled as 112%. In 200 g of this sample, 18 g water is added. The resulting solution will contain

(a) 218 g pure H_2SO_4.
(b) 218 g H_2SO_4 and 6 g free SO_3.
(c) 212 g H_2SO_4 and 6 g free SO_3.
(d) 191.33 g H_2SO_4 and 26.67 g free SO_3.

Section B (One or More than one Correct)

1. A quantity of 0.22 g of a gas occupies a volume of 112 ml at pressure of 1 atm and temperature of 273 K. The gas may be

(a) nitrogen dioxide
(b) nitrous oxide
(c) carbon dioxide
(d) propane

2. The number of hydrogen atoms in 0.9 g glucose, $C_6H_{12}O_6$, is same as

(a) 0.48 g hydrazine, N_2H_4
(b) 0.17 g ammonia, NH_3
(c) 0.30 g ethane, C_2H_6
(d) 0.03 g hydrogen, H_2

3. The composition of universe is approximately 90% hydrogen and 10% helium, by mass. It represents that

(a) there are 18 hydrogen atoms in the universe per atom of helium.
(b) there are 9 hydrogen atoms in the universe per atom of helium.
(c) there are 36 hydrogen atoms in the universe per atom of helium.
(d) the average molar mass of universe is 2.105 g per mole.

4. The vapour density of a sample of hydrogen fluoride gas is measured by an experiment as 20. It may represent that (F = 19)

(a) some molecules of hydrogen fluoride are dissociated.
(b) some molecules of hydrogen fluoride are in dimer form.
(c) all hydrogen fluoride molecules are in dimer form.
(d) some hydrogen fluoride molecules are in trimer form.

5. Which of the following statement(s) is/are correct for water?

(a) H and O are in 2 : 1 atomic ratio.
(b) H and O are in 2 : 1 mass ratio.
(c) H and O are in 1 : 8 mass ratio.
(d) Hydrogen and oxygen gases are combined in 2:1 volume ratio.

6. The atomic mass of a diatomic gaseous element is 19. Which of the following statement(s) is/are correct regarding the element?
   (a) The mass of one atom of the element is 19 amu.
   (b) The mass of N_A molecules of the element is 38 g.
   (c) The volume of N_A atoms of the element is 22.4 L at 0°C and 1 atm.
   (d) The volume of 2 g-molecules of the element is 44.8 L at 0°C and 1 atm.

7. Three isotopes of an element have mass numbers M, $(M + 1)$ and $(M + 2)$. If the mean mass number is $(M + 0.5)$, then which of the following ratio(s) may be accepted for M, $(M + 1)$ and $(M + 2)$ in the order ?
   (a) 1 : 1 : 1 (b) 4 : 1 : 1
   (c) 9 : 6 : 1 (d) 2 : 1 : 1

8. Which of the following statement(s) is/are correct about the Avogadro's number?
   (a) It is the number of atoms contained in one mole of atoms of any element.
   (b) It is the number of electrons required to deposit one mole of atoms of any metallic element from a solution of the metal salt.
   (c) It is the number of grams of any element which contains 6.022×10^{23} atoms of that element.
   (d) It is the number of particles (atoms, molecules or ions) required to make one gram of the substance under consideration.

9. The non-stoichiometric compound, titanium monoxide, has a continuous range of composition from $Ti_{0.75}O$ to $TiO_{0.69}$. Which of the following is/are the correct regarding the possible composition of the compound? [Ti = 48]
   (a) The maximum percentage by mass of oxygen in the compound is 30.8.
   (b) The minimum percentage by mass of titanium in the compound is 69.2.
   (c) The minimum percentage by mass of oxygen in the compound is 18.7.
   (d) The minimum percentage by mass of titanium in the compound is 81.3.

10. Which of the following(s) is/are correct statement?
   (a) The empirical formula of all alkanes is same.
   (b) The empirical formula of all alkenes is same.
   (c) The empirical formula of all the members of any homologous series is same.
   (d) Two different compounds can have the same molecular formula.

11. Which of the following will have the composition (by mass) as similar as that of acetic acid?
   (a) Methyl formate, $HCOOCH_3$
   (b) Glucose, $C_6H_{12}O_6$
   (c) Formaldehyde, HCHO
   (d) Formic acid, HCOOH

12. Four groups of students are studying with different samples of alkali metal halides as given below.

Group A: NaCl	Group B: NaBr
Group C: KCl	Group D: KBr

If all the four groups dissolved 0.1 moles of their salt in some water and then treated with the excess of acidified $AgNO_3$ solution, then which of the following statement(s) is/are correct regarding the mass of precipitate formed?
   (a) All the four groups will obtain the same mass of precipitate.
   (b) Group A and C will obtain the same mass of precipitate.
   (c) Group B and D will obtain the same mass of precipitate.
   (d) Group A and B will obtain the same mass of precipitate.

13. Which of the following is the incorrect conclusion regarding the following reaction.

$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(l)$
   (a) 2 mole of $H_2(g)$ will produce 2 mole of $H_2O(l)$.
   (b) 16 g of $O_2(g)$ will produce 18 g of $H_2O(l)$.
   (c) 2 litre of $O_2(g)$ at 25°C and 1 atm will produce 4 litre of $H_2O(l)$ at 25°C and 1 atm.
   (d) 2 molecules of $H_2O(l)$ is obtained from every 3 molecules of gaseous mixture of H_2 and O_2.

14. A quantity of 8 g CH_4 is mixed with 28 g O_2 and fired. Which of the following is correct about the combustion of CH_4 in this condition?
   (a) 1 g CH_4 will remain left unburned if carbon is quantitatively converted into CO_2.
   (b) 4 g O_2 will remain unused if carbon is quantitatively converted into CO.
   (c) Equal moles of CO and CO_2 are formed if none of the reactants is left and there is no other side reaction.
   (d) 18 g water will form in any possible condition.

15. The oxygen needed for complete combustion of 8 g CH_4 may be obtained from complete decomposition of

(a) 2/3 mole of $KClO_3$
(b) 1 mole of H_2O_2
(c) 2 mole of $NaNO_3$ (up to 300°C)
(d) 2 mole of BaO_2

16. A mixture of propane and benzene is burnt completely in excess of oxygen at 110°C. It results in the production of equal volumes of $CO_2(g)$ and steam (measured under identical pressure and temperature). Which of the following is correct regarding the original mixture?

(a) The mole ratio of propane and benzene is 3 : 1.
(b) The mass ratio of propane and benzene is 22 : 13.
(c) The mole ratio of carbon and hydrogen atoms is 1 : 2.
(d) The mass ratio of carbon and hydrogen atoms is 6 : 1.

17. A quantity of 6 g NaOH and 4.4 g CO_2 is allowed to react to form Na_2CO_3 or $NaHCO_3$ or both. Which of the following is correct statement regarding the reactions?

(a) NaOH is the limiting reagent if there is no any formation of $NaHCO_3$.
(b) NaOH is the limiting reagent if there is no any formation of Na_2CO_3.
(c) Equal masses of Na_2CO_3 and $NaHCO_3$ are formed if none of the reactant is left.
(d) The total mass of reaction mixture will be 10.4 g after the end of reaction, in any possible case.

18. When hydrocarbons are burnt completely in excess of oxygen gas, then

(a) equal moles of CO_2 and H_2O are formed from alkenes.
(b) more moles of H_2O than CO_2 are formed from alkanes.
(c) more moles of CO_2 than H_2O are formed from alkynes.
(d) more moles of CO_2 than H_2O are formed for any kind of hydrocarbon.

19. When hydrocarbons (alkanes, alkenes or alkynes) are burnt completely in excess of oxygen, then

(a) for the same number of carbon atoms, more oxygen is consumed for alkanes.
(b) for the same number of hydrogen atoms, more oxygen is consumed for alkynes.
(c) for the same number of carbon atoms, more water is formed from alkynes.
(d) for the same number of hydrogen atoms, more CO_2 is formed from alkynes.

20. A quantity of 12 g of magnesium is burnt completely in air (O_2 = 20% and N_2 = 80%, by volume). Which of the following is/are correct statement(s) regarding this combustion?

(a) A minimum of 36 g air is needed if all Mg is converted into MgO only.
(b) A minimum of 40 g air is needed if all Mg is converted into MgO only.
(c) A minimum of 4.67 g air is needed if all Mg is converted into Mg_3N_2 only.
(d) If air is consumed completely, then the total mass of products formed is 17.14 g.

21. A mixture contains NaCl and unknown chloride, MCl. When 1 g of this mixture is dissolved in water and excess of $AgNO_3$ solution is added to it, 2.567 g of white precipitate is obtained. In another experiment, 1 g of the same original mixture is heated to 300ºC. Some vapours come out which are absorbed in acidified $AgNO_3$ solution by which 1.341 g of white precipitate is formed. The molecular mass of unknown chloride is

(a) 53.4 (b) 58.5
(c) 44.5 (d) 74.4

22. An amount of 0.15 moles of $K_2Cr_2O_7$ is required to oxidize a mixture of XO and X_2O_3 (total mass = 25.56 g) to form XO_4^- and Cr^{3+}. If 0.21 moles of XO_4^- is formed, then the correct information(s) is/are

(a) Atomic mass of X = 100.
(b) Moles of XO in original mixture = 0.06.
(c) Moles of $Cr_2O_7^{2-}$ combined with X_2O_3 = 0.10.
(d) Total moles of H^+ consumed = 0.99.

23. A volume of 10 ml of a mixture of H_2 and O_2 is exploded. If the final volume becomes 1 ml, the composition of original mixture may be

(a) 7 ml H_2, 3 ml O_2
(b) 6 ml H_2, 4 ml O_2
(c) 5 ml H_2, 5 ml O_2
(d) 3 ml H_2, 7 ml O_2

24. A definite volume of ammonia gas is passed through a series of electric sparks by which the volume becomes 90 ml. On washing with dilute orthophosphoric acid, the volume is reduced to 84 ml. Which of the following statement(s) is/are correct regarding the original ammonia sample?

(a) Its original volume was 45 ml.
(b) Its original volume was 48 ml.
(c) 12.5% of the original ammonia has decomposed.
(d) 87.5% of the original ammonia has decomposed.

25. To what extent must a given solution of concentration of 40 mg silver nitrate per ml be diluted to yield a solution of concentration of 16 mg silver nitrate per ml?

(a) Each ml should be diluted to 2.5 ml.
(b) To each ml of solution, 1.5 ml of water should be added.
(c) To 2.5 ml of solution, 2 ml of water should be added.
(d) To 1.5 ml of solution, 1.5 ml of water should be added.

26. An unknown volume of 40% (w/w) NaOH solution of specific gravity 1.6 is diluted until the specific gravity of the solution becomes 1.1. The strength of the resulting solution is

(a) 12.8% (w/v) (b) 10.67% (w/v)
(c) 11.6% (w/w) (d) 9.7% (w/w)

27. If a definite volume of '20 vol' H_2O_2 solution is diluted such that the volume of diluted solution becomes double than that of original volume, then

(a) the volume strength of diluted solution becomes '40 vol'.
(b) the molarity of solution becomes half of its initial molarity.
(c) the molality of solution becomes half of its initial molality.
(d) the maximum amount of O_2 gas obtainable from the solution remains the same.

28. A volume of 100 ml of M–NaCl solution, 100 ml of 2 M–$MgCl_2$ solution and 300 ml of 4 M–$Mg(NO_3)_2$ solution is mixed together and the mixture is diluted to 2 L. Which of the following is/are the correct final concentration of ions?

(a) $Na^+ = 0.05$ M (b) $Mg^{2+} = 0.7$ M
(c) $Cl^- = 0.15$ M (d) $NO_3^- = 1.2$ M

29. If the ratio of mole fractions of solute and solvent is unity, then the mass percent of solute is (Molar masses of solute and solvent are X and Y, respectively)

(a) 50%

(b) $\frac{X}{X+Y} \times 100\%$

(c) $\frac{X}{Y} \times$ mass per cent of solvent

(d) $\frac{Y}{X} \times$ mass per cent of solvent

30. A quantity of 720 g water is added in 230 g ethanol at a certain temperature to get 1 L of solution. Which of the following is/are correct regarding the solution formed?

(a) The density of solution is 950 kg/m^3.
(b) The mole fraction of ethanol is 0.11.
(c) The molarity of solution is 5 M.
(d) The molality of solution is 6.94 M.

Section C (Comprehensions)

Comprehension I

The first concept of atomic weight was given by Dalton. He defined that the absolute mass of an atom cannot be determined but we may compare the masses of atoms of different elements, perfectly, by knowing the chemical formula and percentage composition by mass of the compound formed by the elements concerned. The chemical or molecular formula can be determined with the help of Avogadro's hypothesis that is, under the similar conditions of pressure and temperature, equal volume of all the gases have equal number of molecules. Dalton defined the atomic weight of an element as the number of times by which one atom of the element is heavier than one atom of hydrogen. In order to determine the atomic weight of nitrogen, the following data are observed by experiments for a compound containing only nitrogen and hydrogen atoms.

Data I: The compound contains 88% nitrogen and 12% hydrogen by mass.

Date II: 10 ml of this gaseous compound exactly gives 10 ml nitrogen and 20 ml hydrogen on complete decomposition. (All volumes are at the same temperature and pressure)

1. What is the molecular formula of the compound if both nitrogen and hydrogen are diatomic?

(a) NH_3 (b) N_2H_4
(c) N_4H_2 (d) N_2H_2

2. What is the atomic weight of nitrogen on this hydrogen scale?

(a) 14 (b) 14.67
(c) 14.33 (d) 13.67

3. What would be the molecular formula of the compound if nitrogen were triatomic and hydrogen were diatomic?

(a) NH_3 (b) N_3H_4
(c) N_4H_3 (d) N_3H_2

Comprehension II

A sample of hydrogen fluoride gas (only HF molecules) is collected in a vessel and left for some time. Then, a constant molar mass of the sample is experimentally determined as 34 g/mole. Assume that this abnormal molar mass is due to dimerization as well as trimerization of some HF molecules (no molecules in any other polymeric forms) and the mole ratio of monomeric and trimeric form of hydrogen fluoride molecules present is 4 : 1.

4. What percentage of hydrogen fluoride molecules is dimerized?

(a) 50 (b) 58.8
(c) 76.47 (d) 17.65

5. What percentage of hydrogen fluoride molecules is trimerized?

(a) 40 (b) 58.8
(c) 76.47 (d) 17.65

6. What per cent of total molecules present in the final sample are H_2F_2 molecules?

(a) 10 (b) 40
(c) 50 (d) 58.8

Comprehension III

The vapour density of a gaseous mixture containing only Ar and N_2O_4 gases is 40. When the mixture is left for some time, the vapour density is decreased and finally becomes 37.5. It happened due to the dissociation of some N_2O_4 into NO_2. (Ar = 40)

7. What is the degree of dissociation of N_2O_4?

(a) 0.087 (b) 0.133
(c) 0.067 (d) 0.0625

8. What is the initial mole ratio of Ar and N_2O_4?

(a) 1 : 1 (b) 3 : 10
(c) 1 : 3 (d) 1 : 5

9. What is the final mole ratio of Ar, N_2O_4 and NO_2?

(a) 1 : 1 : 1 (b) 1 : 3 : 11
(c) 45 : 137 : 26 (d) 4 : 13 : 3

Comprehension IV

When the Bayer's process is used for recovering aluminium from siliceous ores, some aluminium is always lost because of the formation of an unworkable mud having the following average formula: $3Na_2O{\cdot}3Al_2O_3{\cdot}5SiO_2{\cdot}5H_2O$. Since aluminium and sodium ions are always in excess in the solution from which this precipitate is formed, the precipitation of the silicon in the mud is complete. A certain ore contains 13% (by weight) Kaolin, $Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O$ and 87% gibbsite, $Al_2O_3{\cdot}3H_2O$. (Al = 27, Si = 28)

10. What per cent of the total aluminium in this ore is recoverable in the Bayer's process?

(a) 80 (b) 90
(c) 85 (d) 75

11. What is the percentage of silica present in the ore, by weight?

(a) 2.82 (b) 3.02
(c) 46.5 (d) 6.05

12. How many moles of Al_2O_3 are present per mole of ore?

(a) 1.000 (b) 0.083
(c) 0.222 (d) 0.242

Comprehension V

Vitamin C (M = 176) is a compound of C, H and O found in many natural sources, especially citrus fruits. When a 1.0 g sample of vitamin C is placed in a combustion chamber and burned, the following data is obtained.

Mass of CO_2 absorber after combustion = 85.35 g
Mass of CO_2 absorber before combustion = 83.85 g
Mass of H_2O absorber after combustion = 37.96 g
Mass of H_2O absorber before combustion = 37.55 g

13. What is the percentage of carbon by weight in vitamin C ?

(a) 66.67% (b) 40.9%
(c) 20% (d) 60%

14. What is the percentage of hydrogen, by weight in vitamin C?

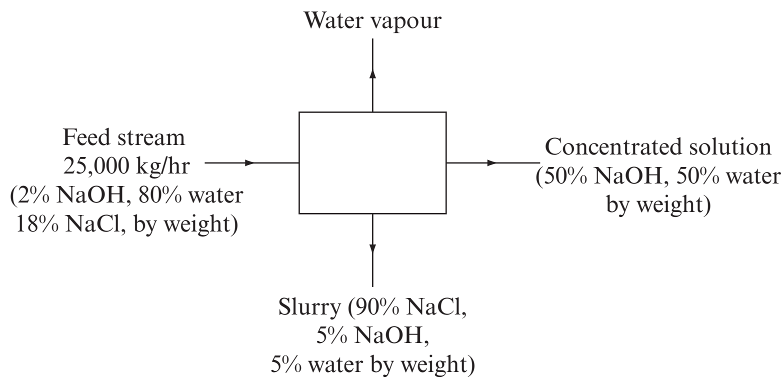
(a) 4.55% (b) 41%
(c) 20.5% (d) 9.11%

15. What is the empirical formula of vitamin C?

(a) CH_2O (b) $C_3H_4O_3$
(c) $C_6H_8O_6$ (d) CHO

Comprehension VI

Figure shows a scheme for concentrating a dilute solution of NaOH.



16. How much water is evaporated per hour?

(a) 5000 kg (b) 500 kg
(c) 19,500 kg (d) 20,000 kg

17. How much concentrated solution is obtained per hour?

(a) 5000 kg (b) 500 kg
(c) 19,500 kg (d) 20,000 kg

18. How much slurry is obtained per hour?

(a) 5000 kg (b) 500 kg
(c) 19,500 kg (d) 20,000 kg

Comprehension VII

A fuel mixture used in the early days of rocketry is composed of two liquids, hydrazine (N_2H_4) and dinitrogen tetraoxide (N_2O_4), which ignite on contact to form nitrogen gas and water vapour. The yield of N_2 gas is found to be less than its expected yield because some nitric oxide (NO) is also formed by a parallel reaction between the reactants. In an experiment, 96 g of N_2H_4 and 184 g of N_2O_4 are taken. It is found that 18 g of NO is formed.

19. The limiting reagent is

(a) N_2H_4
(b) N_2O_4
(c) both the reactants will be used up completely.
(d) cannot predict, because the reactants are giving more than one reaction.

20. What is the highest percentage yield of N_2 that can be expected? The theoretical yield is the quantity of N_2 formed in the absence of parallel reaction.

(a) 96.67% (b) 90%
(c) 85.7% (d) 100%

21. What is the total mass of water vapour formed?

(a) 262 g (b) 140.2 g
(c) 108 g (d) 72 g

Comprehension VIII

A quantity of 1.9145 g of brass containing Cu and Zn reacts with 3 M-HNO_3 solution, the following reactions (unbalanced) take place.

$$Cu(s) + HNO_3(aq) \rightarrow Cu^{2+}(aq) + NO_2(g) + H_2O(l)$$

$$Zn(s) + H^+(aq) + NO_3^-(aq) \rightarrow NH_4^+(aq) + Zn^{2+}(aq) + H_2O(l)$$

The liberated NO_2(g) was found to be 1.23 L at 27°C and 1 atm.

22. What is the percentage of copper in brass?
(a) 17.08% (b) 82.92%
(c) 41.46% (d) 62.19%

23. How many millilitres of 3 M-HNO_3 will be required for complete reaction with brass?
(a) 33.33 ml (b) 37.5 ml
(c) 4.17 ml (d) 18.75 ml

24. How many grams of ammonium nitrate will be formed in the reaction?
(a) 0.1 g (b) 0.2 g
(c) 0.05 g (d) 0.025 g

Comprehension IX

Crude calcium carbide is made in an electric furnace by the following reaction.

$$CaO + 3C \rightarrow CaC_2 + CO\uparrow$$

The product contains 80% CaC_2 and 20% unreacted CaO.

25. How much CaO is to be added to the furnace charge for each 1280 kg of pure CaC_2 produced?
(a) 1120 kg (b) 1440 kg
(c) 1152 kg (d) 1344 kg

26. How much CaO is to be added to the furnace charge for each 1280 kg of crude product?
(a) 1120 kg (b) 1440 kg
(c) 1152 kg (d) 1344 kg

27. What will be the volume of CO gas evolved, measured at 0°C and 1 atm, when 1280 kg of crude product is formed?
(a) 448 m^3 (b) 358.4 m^3
(c) 537.6 m^3 (d) 89.6 m^3

Comprehension X

A certain metal sulphide, MS_n (where *n* is a small integer), is widely used as a high temperature lubricant. The substance is prepared by reaction of the metal pentachloride (MCl_5) with sodium sulphide (Na_2S). Heating the metal sulphide to 700ºC in air gives the metal trioxide (MO_3) and sulphur dioxide (SO_2), which react with Fe^{3+} ion under aqueous acidic conditions to give sulphate ion. Addition of aqueous $BaCl_2$ then forms a precipitate of $BaSO_4$. The chemical reactions (unbalanced) concerned are as follows.

(i) $MCl_5(s) + Na_2S(s) \rightarrow MS_n(s) + S(l) + NaCl(s)$

(ii) $MS_n(s) + O_2(g) \rightarrow MO_3(s) + SO_2(g)$

(iii) $SO_2(g) + Fe^{3+}(aq) \rightarrow Fe^{2+}(aq) + SO_4^{2-}(aq)$

(iv) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

Assume that you begin with 4.55 g of MCl_5 and that reaction (i) proceeds with 90% yield. After oxidation of MS_n produced, oxidation of SO_2, and precipitation of SO_4^{2-} ions, 6.99 g of $BaSO_4$ is obtained. (Ba = 137)

28. How many moles of sulphur are present in the MS_n sample?

(a) 0.01 (b) 0.02
(c) 0.03 (d) 0.04

29. Which of the following may be a permissible value of *n*?

(a) 3 (b) 2
(c) 4 (d) 6

30. If the value of *n* is 2, then the atomic weight of metal *M* is

(a) 95.5 (b) 232.5
(c) 125.8 (d) 187.6

Comprehension XI

Sixty millilitres of a mixture of equal volumes of chlorine and an oxide of chlorine were heated and then cooled back to the original temperature. The resulting gas mixture was found to have a volume of 75 ml. On treatment of caustic soda solution, the volume is contracted to 15 ml. Assuming that all measurements were made at the same temperature and pressure. The oxide of chlorine on heating decomposes quantitatively into oxygen and chlorine.

31. What is the volume of chlorine in the original mixture?

(a) 15 ml (b) 30 ml
(c) 45 ml (d) 40 ml

32. What is the simplest formula of the oxide of chlorine?

(a) ClO_2 (b) Cl_2O
(c) Cl_2O_3 (d) Cl_2O_5

33. The gas finally present is

(a) O_2 (b) Cl_2O
(c) Cl_2 (d) Cl_2O_5

Comprehension XII

A volume of 18 ml of a gaseous mixture consisting of a gaseous organic compound A and just sufficient amount of oxygen is required for complete combustion yielding on burning 8 ml of CO_2, 12 ml of water vapour and 4 ml of N_2. All volumes are measured at the same temperature and pressure. The compound A contains only carbon, hydrogen and nitrogen.

34. How many volumes of oxygen are required for complete combustion?

(a) 4 ml (b) 14 ml
(c) 7 ml (d) 11 ml

35. What is the molecular formula of the compound?

(a) CH_5N (b) C_2H_5N
(c) $C_2H_6N_2$ (d) $C_4H_{10}N_2$

36. What volume of H_2 gas measured at the same temperature and pressure is needed for complete reduction of the same volume of compound A?

(a) 4 ml (b) 8 ml
(c) 28 ml (d) 14 ml

Comprehension XIII

A mixture of CH_4, C_2H_4 and C_2H_2 has a vapour density of 11.3 ml. When 10 ml of this mixture and 30 ml of oxygen are sparked together over aqueous KOH, the volume contracts to 5.5 ml and then disappears when pyrogallol is introduced. All volumes are measured under identical conditions of temperature, pressure and humidity.

37. What was the volume ratio of CH_4, C_2H_4 and C_2H_2 in the original gaseous mixture?

(a) 2 : 2 : 3 (b) 3 : 3 : 4

(c) 4 : 3 : 3 (d) 1 : 1 : 3

38. If the mixture were not sparked over aqueous KOH, what was the total volume of resulting gases after sparking?

(a) 5.5 ml (b) 25.5 ml

(c) 24.5 ml (d) 21.5 ml

39. If the reactions were performed at 0°C and 1 atm, what should be the minimum mass of KOH present in the solution for complete conversion into K_2CO_3?

(a) 0.08 g

(b) 0.04 g

(c) 80 g

(d) 40 g

Comprehension XIV

Gaseous substances $(CHO)_p$ and $(COOH)_q$, when heated, decompose according to the following reactions.

$$(CHO)_p \rightarrow CO + H_2$$

$$(COOH)_q \rightarrow CO_2 + H_2$$

A volume of 10 ml of mixture containing $(CHO)_p$ and $(COOH)_q$ in 1:4 mole ratio was heated for complete decomposition. The resulting gases when passed through KOH, the volume decrease to $9/17^{th}$ of the volume of gaseous mixture passed. Remaining gases on complete combustion showed a contraction of 61 ml.

40. The values of p and q are

(a) $p = 10, q = 6$

(b) $p = 6, q = 10$

(c) $p = 3, q = 5$

(d) $p = 5, q = 3$

41. The volume of O_2 used for combustion is

(a) 27 ml (b) 20 ml

(c) 36 ml (d) 60 ml

42. The increase in volume on decomposition of original mixture was

(a) 20 ml (b) 46 ml

(c) 92 ml (d) 61 ml

Comprehension XV

Once Tom and Jerry entered into a chemistry lab in which a chemist was preparing a solution of H_2SO_4 in a two litre container. He labelled the solution as 'density = 5.96 g/ml, 5m' which occupied half of the volume of the container. Tom saw the solution and a mischief came in his mind. As the chemist left the lab, Tom tried to throw the solution on Jerry. In doing so, some of the solution fell on the floor. Tom added water in the container to fill it up to the original level. The chemist returned back and got astonished to see the result of analysis that showed 'density = 0.4 g/ml and %w/w = 49'.

43. What was the molarity of H_2SO_4 solution present initially in the container?

(a) 5 M (b) 1.92 M

(c) 20 M (d) 10 M

44. How many moles of H_2SO_4 had fallen down on the floor?

(a) 2 (b) 20

(c) 18 (d) 16

45. What volume of water was added to the solution by Tom?

(a) 1000 ml (b) 900 ml

(c) 200 ml (d) 100 ml

Section D (Assertion–Reason)

The following questions consist of two statements. Mark the answer as follows.

(a) If both statements are CORRECT, and **Statement II** is the CORRECT explanation of **Statement I**.

(b) If both statements are CORRECT, and **Statement II** is CORRECT the CORRECT explanation of **Statement I**.

(c) If **Statement I** is CORRECT, but **Statement II** is INCORRECT.

(d) If **Statement I** is INCORRECT, but **Statement II** is CORRECT.

1. **Statement I:** The molecular mass of any substance is the sum of atomic masses of all the atoms present in each molecule of the substance.

Statement II: The atomic as well as molecular masses are defined on the same carbon scale.

2. **Statement I:** The number of atoms in a given mass of dioxygen (oxygen) and trioxygen (ozone) gases is same.

Statement II: The number of atoms depends on atomic mass, not on molecular mass.

3. **Statement I:** During a chemical reaction, the total moles remain constant.

Statement II: During a chemical reaction, the total mass remains constant.

4. **Statement I:** For the reaction,

$2A(g) + 3B(g) \rightarrow 4C(g) + D(g)$,

the vapour density remains constant throughout the progress of reaction.

Statement II: In all the gaseous chemical reactions, the vapour density remains constant.

5. **Statement I:** When any hydrocarbon is burnt, the moles of oxygen needed for complete combustion is always greater than the moles of hydrocarbon burnt.

Statement II: Complete combustion of any substance requires more moles of oxygen than the moles of substance burnt.

6. **Statement I:** When 7.0 g nitrogen and 3.0 g hydrogen are allowed to react to form ammonia as a single product, 10.0 g ammonia is formed.

Statement II: Chemical reactions follow the law of conservation of mass.

7. **Statement I:** The percentage yield of any product may be increased to more than 100% by adding more and more reactants to the reaction mixture.

Statement II: Greater amount of reactants may result the production of greater amount of products.

8. **Statement I:** The mass ratio of reactants remains unchanged during the reaction, if they are taken in their stoichiometric amounts.

Statement II: The mass ratio of products formed (in case of more than one products) is always independent from the relative masses of reactants taken.

9. **Statement I:** For the maximum yield of ammonia, the total amount of mixture of N_2 and H_2 should be taken in 1 : 3 mole ratio.

Statement II: The yield of product becomes maximum when the reactants are taken in their stoichiometric amounts.

10. **Statement I:** Volumes of non-reacting gases are always additive.

Statement II: Gases do not have their own volume.

11. **Statement I:** When a hydrocarbon is burnt and the products of combustion are cooled to the original temperature and pressure, a contraction in volume occurs.

Statement II: The contraction in volume is solely due to the liquefaction of water vapours.

12. **Statement I:** Molarity and molality for very dilute aqueous solution is approximately equal.

Statement II: For all aqueous solution, total mass of solvent is approximately equal to total volume of solution.

13. **Statement I:** Concentration of any solution is independent from the amount of solution, but it depends on the relative amount of solute and solvent.

Statement II: Concentration of any solution has same magnitude in any unit to express concentration.

14. **Statement I:** For very dilute solutions, the strength of solution in w/w percent and in w/v percent have nearly equal value.

Statement II: For very dilute solution, the mass of solution becomes almost equal to the mass of solvent.

15. **Statement I:** One molar aqueous solution has always higher concentration than one molal.

Statement II: The molarity of a solution depends upon the density of the solution whereas molality does not.

Section E (Column Match)

1. Match the columns.

	Column I				Column II
	Atomic masses				Percentage composition of the heavier isotope
	Isotope I	Isotope II	Average		
(A)	$Z-1$	$Z+2$	Z	(P)	33.33% by mole
(B)	$Z+1$	$Z+3$	$Z+2$	(Q)	50% by mole
(C)	Z	$3Z$	$2Z$	(R)	% by mass depends on Z
(D)	$Z-1$	$Z+1$	Z	(S)	75% by mass

2. Match the columns. ($N_A = 6 \times 10^{23}$)

Column I	Column II
(A) 0.875 mole of O_2 gas	(P) 28 g
(B) 1.00 mole of N_2 gas	(Q) 22.4 L at 0°C and 1 atm
(C) 2.00 mole of $NaNO_3$	(R) 1.20×10^{24} atoms of nitrogen
(D) 0.4375 mole of K_2SO_4	(S) 1.05×10^{24} atoms of oxygen
	(T) 76.125 g

3. Match the columns.

Column I	Column II
(A) 3 mole of $Co(NH_3)_4SO_4$	(P) 3 mole of S atom
(B) 1 mole of $FeKCo(NO_2)_6$	(Q) 1 mole of Fe atom
(C) 1.5 mole of $[Fe(H_2O)_5SCN]SO_3$	(R) 12 mole of O atoms
(D) 0.75 mole of $K_2Cu(SCN)_4$	(S) 6 mole of N atoms
	(T) 1.5 mole of K atoms

4. Match the columns.

Column I (Average molecular mass)	Column II (Composition of gas mixture)
(A) $\frac{80}{3}$	(P) CH_4 and SO_3 gases in 1:1 mole ratio
(B) $\frac{62}{3}$	(Q) CH_4 and SO_3 gases in 1:1 mass ratio
(C) 48	(R) CH_4 and SO_3 gases having H and O atoms in 8:3 ratio
(D) $\frac{112}{3}$	(S) CH_4 and C_2H_6 gases having C and H atoms in 2:7 ratio

5. When 1 mole of carbon reacts with 1 mole of oxygen producing 1 mole of CO_2, 100 kcal heat is released and when 1 mole of carbon reacts with 0.5 mole of oxygen producing 1 mole of CO, 25 kcal heat is released. Column I represents some amounts of carbon and oxygen which may react to form CO or CO_2 or both, in such a way that none of the reactant remain left, and Column II represents the heat released. Match the amounts with the corresponding heat released.

Column I	Column II
(A) 36 g of C and 80 g of O_2	(P) 125 kcal
(B) 12 g of C and 24 g of O_2	(Q) 225 kcal
(C) 24 g of C and 48 g of O_2	(R) 150 kcal
(D) 36 g of C and 64 g of O_2	(S) 62.5 kcal

6. Match the columns.

Column I	Column II
(A) Amount of O_2 for complete combustion of 2 mole octane.	(P) 1100 g
(B) Amount of CO_2 produced when 300 g carbon combines with 800 g of oxygen.	(Q) 560 L of 273 K and 1 atm
(C) Amount of NaOH needed for complete neutralization of 1225 g H_2SO_4.	(R) 25 mole
(D) Amount of N_2H_4 formed from 50 mole H_2.	(S) 3.01×10^{25} atoms
	(T) 800 g

7. Match the columns

Column I	Column II
(A) N_2 (3.5 g) + H_2 (1.0 g) $\rightarrow NH_3$	(P) First reactant is the limiting reagent.
(B) H_2 (1.0 g) + O_2 (4.0 g) $\rightarrow H_2O$	(Q) Second reactant is the limiting reagent.
(C) S (4.0 g) + O_2 (6.0 g) $\rightarrow SO_3$	(R) Stoichiometric amounts of reactants.
(D) Fe (11.2 g) + O_2 (3.2 g) $\rightarrow Fe_2O_3$	(S) Mass of reactants > Mass of product formed.

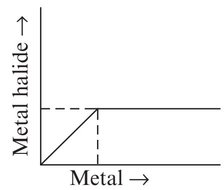
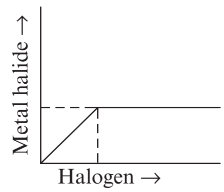
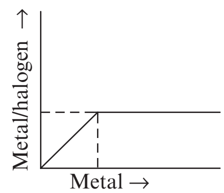
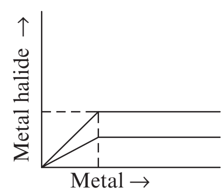
8. Match the columns

Column I Compound	Column II Relative amounts of products on complete combustion
(A) CH_4	(P) Mole of CO_2 < Mole of H_2O
(B) C_2H_4	(Q) Mole of CO_2 = Mole of H_2O
(C) C_2H_2	(R) Mole of CO_2 > Mole of H_2O
(D) C_3H_8	(S) Mass of CO_2 > Mass of H_2O

9. Match the columns.

Column I	Column II
(A) 200 ml of a mixture of 50% H_2, 40% CH_4 and 10% CO would evolve. The volume of CO_2 after combustion is	(P) 10 ml
(B) 100 ml of acetylene (C_2H_2) required oxygen for complete combustion is	(Q) 45 ml
(C) 10 ml of hydrogen sulphide (H_2S) required chlorine for complete decomposition	(R) 250 ml
(D) When a mixture of 30 ml of CO and 30 ml of O_2 was exploded, then the volume of gases produced due to explosion is	(S) 100 ml

10. Match the columns.

Column I Masses of different components	Column II Observation
(A) 	(P) Metal is the limiting reagent.
(B) 	(Q) Halogen is the limiting reagent.
(C) 	(R) Metal and halogen are in stoichiometric amounts.
(D) 	(S) Metal is exhibiting a particular valency in the chloride formation.
	(T) Metal is exhibiting variable valency in the chloride formation.

11. Match the columns.

Section I (Gaseous organic compounds)	Section II (Volume of O_2 needed for complete combustion per volume of compound)
(A) C_xH_{2x+2}	(P) $\frac{3x+1}{2}$
(B) $C_xH_{2x+2}O$	(Q) $\frac{3x}{2}$
(C) $C_xH_{2x+3}N$	(R) $\frac{3(2x+1)}{4}$
(D) $C_xH_{2x+2}S$	(S) $\frac{3(x+1)}{2}$

12. Column I consists of some decomposition reactions and Column II consists of some absorbent for the gases evolved in the reactions given in Column I. Match the gases evolved in Column I with the proper absorbent in Column II.

Column I	Column II
(A) $Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2\uparrow$	(P) CaO
(B) $CaC_2O_4 \xrightarrow{\Delta} CaO + CO\uparrow + CO_2\uparrow$	(Q) Ammonical CuCl
(C) $HCOONa \xrightarrow{\Delta} NaOH(s) + CO\uparrow$	(R) P_4O_{10}
(D) $2KHSO_3 \xrightarrow{\Delta} K_2SO_3 + H_2O\uparrow + SO_2\uparrow$	(S) NaOH solution

13. A volume of 50 ml of the hydrocarbons given in Column I is burnt completely at 400 K and 1 atm and the volumes of products formed at 400 K and 1 atm are given in Column II. Match the hydrocarbons (Column I) with the suitable products (Column II).

Column I	Column II
(A) CH_4	(P) 100 ml of CO_2
(B) C_2H_6	(Q) 100 ml of H_2O
(C) C_2H_4	(R) 150 ml of H_2O
(D) C_3H_4	(S) 150 ml of CO_2
	(T) 50 ml of CO_2

14. Match the columns.

Column I	Column II
(A) 400 g/L NaOH	(P) 6.25m – NaOH ($d_{solution}$ = 1.0 g/ml)
(B) 20% (w/w) NaOH	(Q) 0.166 mole fraction of NaOH ($d_{solution}$ = 1.3 g/ml)
	(R) 10 M-NaOH ($d_{solution}$ = 2 g/ml)
	(S) 7142.5 ppm ($d_{solution}$ = 1 g/ml)

15. Match the columns.

Column I	Column II
(A) 5m of NaOH solution ($d_{solution}$ = 0.6 g/ml) Molarity of solution is	(P) 16 M
(B) 250 ml of H_2O_2 solution provides 64 g of O_2. Molarity of H_2O_2 solution is	(Q) 1 M
(C) 100 ml of 1 M-H_2SO_4 solution ($d_{solution}$ = 1.5 g/ml) is mixed with 400 ml of water, density of final solution = 1.25 g/ml. Molarity of resulting solution is	(R) 2.5 M
(D) 100 ml of 6 M-NaCl solution is mixed with 100 ml of 17% (w/w) $AgNO_3$ solution ($d_{solution}$ = 8 g/ml). Molarity of Ag^+ ions in the resulting solution is	(S) 0.227 M

Section F (Subjective)

Single-digit Integer Type

1. The density of mercury is 13.6 g/ml. The approximate diameter of an atom of mercury (in Å) assuming that each atom of mercury is occupying a cube of edge length equal to the diameter of the mercury atom is (Hg = 200)

2. Atoms of elements A, B and C combine to form a compound in the atomic ratio of 1 : 6 : 2. Atomic masses of A, B and C are 64, 9 and 16 amu, respectively. The maximum mass of the compound (in g) formed from 1.28 g of A, 3.0×10^{23} atoms of B and 0.04 mole atom of C is

3. A compound which contains one atom of X and two atoms of Y for each three atoms of Z is made by mixing 5.0 g of X, 1.15×10^{23} atoms of Y and 0.03 g-atoms of Z. If only 4.40 g of the compound results, then the value of atomic mass of Y divided by 10 is (The atomic masses of X and Z are 60 and 80, respectively.)

4. Recent controversial efforts to generate energy via 'cold fusion' of deuterium atoms have centred on the remarkable ability of palladium metal to absorb as much as 1120 times its own volume of deuterium gas at 1 atm and 0°C. The number of deuterium atoms per 10 atoms of Pd in a piece of fully saturated Pd metal is (Density of Pd = 11.8 g/ml and atomic mass of Pd = 106.2)

5. A solution contains 0.18 g/ml of a substance 'X', whose molecular mass is 64,000. It is found that 0.27 ml of oxygen at 760 mm and 300 K will combine with the amount of 'X' contained in 1 ml of the solution. The number of oxygen molecules combined with each molecule of 'X' is (R = 0.08 L-atm/K-mol)

6. The number of ethoxy groups in an organic compound can be determined by the following reactions.

$$R(OCH_2CH_3)_x + xHI \rightarrow R(OH)_x + xCH_3CH_2I$$

$$CH_3CH_2I + Ag^+ + H_2O \rightarrow CH_3CH_2OH + AgI(s) + H^+$$

When 37 g of organic compound (molar mass = 176 g/mol) was treated as above, 148 g AgI was precipitated out. How many ethoxy groups are present in each molecule of the organic compound? (Ag = 108, I = 127)

7. A given sample of pure iron gains 10% of its weight on partially rusting to form Fe_2O_3. If the fraction of the iron converted to Fe_2O_3 is 'x', then the value of 30 times 'x' is (Fe = 56)

8. A sample of iron ore contains FeS and non-volatile inert impurity only. Roasting of this ore converts all FeS into Fe_2O_3 and a 4% loss in weight was observed. If the mass percent of FeS in the ore is 'x', then the value of $\frac{x}{11}$ is (Fe = 56)

9. A volume of 50 ml of a gaseous mixture of hydrogen and hydrogen chloride was exposed to sodium amalgam. The volume is decreased to 40 ml. If 10 ml of the same mixture is mixed with 5 ml of gaseous ammonia and then exposed to water, then what will be the final volume (in ml) of gas left? All the volumes are measured at the same temperature and pressure.

10. A 1.174 g sample of special grade steel was treated appropriately with Chugaev's reagent by which nickel was precipitated as nickel dimethylglyoxime, $NiC_8H_{14}O_4N_4$. The dried precipitate weighed 0.2887 g. The percentage of nickel in the steel being analysed is (Ni = 58.7)

11. An amount of 2.5×10^{-3} mole of an ion A^{n+} exactly requires 1.5×10^{-3} moles of MnO_4^- for the oxidation of A^{n+} to AO_3^- in acid medium. What is the value of n?

12. A quantity of 1 g dry green algae absorbs 5.0×10^{-3} moles of CO_2 per hour by photosynthesis. If the carbon atoms were all stored after photosynthesis as starch $(C_6H_{10}O_5)_n$, then how long (in hours) would it take for algae to increase its own weight by 81%, assuming that photosynthesis taking place at a constant rate?

13. Consider the production of tetraethyl lead according to the following reaction.

$$4C_2H_5Cl + 4Na\text{–}Pb \rightarrow (C_2H_5)_4Pb + 4NaCl + 3Pb$$

How many kilograms of ethyl chloride is required to produce enough tetraethyl lead (density = $\frac{12.96}{1.29}$ g/ml) needed for 500 litre of aviation fuel using 2 ml of tetraethyl lead per litre of fuel? (Pb = 208)

14. In one process of water proofing, a fibre is exposed to $(CH_3)_2SiCl_2$ vapour. The vapour reacts with hydroxyl groups on the surface of the fabric or with traces of water to form the waterproofing film $[(CH_3)_2SiO]_n$ by the following reaction:

$n(CH_3)_2SiCl_2 + 2nOH^- \rightarrow 2nCl^- + nH_2O + [(CH_3)_2SiO]_n$

Here, n stands for a large integer. The waterproofing film is deposited on the fabric layer upon layer. Each layer is 3.7 Å thick (the thickness of the $(CH_3)_2SiO$ group). How much $(CH_3)_2SiCl_2$ (in g) is needed to waterproofing one side of a piece of fabric, 5.0 m by 4.0 m, with a film 200 layer thick? The density of film is $\frac{150}{129}$ g/ml. (Si = 28)

15. A magnesium ribbon, when burnt in air, left an ash containing MgO and Mg_3N_2. The ash was found to consume 0.6 mole of HCl, when it was taken in solution, according to the following reactions

$MgO + 2HCl \rightarrow MgCl_2 + H_2O$

$Mg_3N_2 + 8HCl \rightarrow 3MgCl_2 + 2NH_4Cl$

The solution so obtained was treated with excess of NaOH, when 0.1 mole of NH_3 was evolved. The mass (in g) of magnesium burnt is

16. A sample of $SF_5OF(g)$ was contained in a glass vessel at 117ºC and a pressure of 380 mm. A quantity of N_2F_4 that was added brought the total pressure to 760 mm. The reaction that occurred produced a variety of products like NF_3, NO, SiF_4 (by the reaction with glass), SF_6, SO_2F_2, SOF_4, SF_5ONF_2 and NO_2. The yield of SF_5ONF_2 was 40 mole percent with respect to the reactant SF_5OF. All of the SF_5OF and N_2F_4 were consumed in the reaction. What was the mass of SF_5ONF_2 produced (in g) if the volume of the vessel was 1.64 L? (F = 19)

17. An amount of 5 millimoles of $LiAlH_4$ was treated with 20 millimoles of *t*-butylalcohol. A total of 15 millimoles of hydrogen was evolved for the following reaction.

$LiAlH_4 + 3(CH_3)_3COH$
$\rightarrow Li[(CH_3)_3CO]_3AlH + 3H_2$

The addition of an excess of another alcohol, methanol, to the above reaction mixture caused the fourth H atom of the $LiAlH_4$ to be replaced according to the following equation.

$Li[(CH_3)_3CO]_3AlH + CH_3OH$
$\rightarrow Li[(CH_3)_3CO]_3(CH_3O)Al + H_2$

How many millimoles of H_2 was evolved due to the addition of CH_3OH?

18. To analyse cast iron for its sulphur content, a 6.4 g portion of the iron was weighed out for analysis and treated , where it was dissolved in hydrochloric acid, the hydrogen sulphide evolved from iron sulphide was distilled off and made to be absorbed by a solution of a cadmium salt, after which CdS was treated with an excess of a solution of $CuSO_4$, and the CuS precipitated formed was ignited. As a result, 0.795 g of an ignited CuO precipitate was obtained. Calculate the percentage content of sulphur in the cast iron. (Cu = 63.5)

19. A mixture containing 1.3 millimoles of HNF_2 gas and equal quantity of chlorine gas, was led into a flask containing 5.0 g of KF and allowed to stand for 18 hours at room temperature. The gas $ClNF_2$ (66.67% yield) and the solid KF-HCl were formed. If the volume percent of $ClNF_2$ in the gaseous mixture present after the reaction is X, then the value of $\frac{X}{10}$ is

20. In 1.885 g sample of a mixture of $MgSO_4 \cdot 7H_2O$ and $MgCl_2{\cdot}6H_2O$ containing some inert impurity was subjected to suitable treatment, as a result of which there were obtained 0.699 g of $BaSO_4$ and 0.888 g of $Mg_2P_2O_7$. The mass percentage of impurity is (Ba = 137, Mg = 24, P = 31)

Four-digit Integer Type

1. A sample of ammonia contains only H^1 and H^2 isotopes of hydrogen in 4 : 1 ratio and N^{14} and N^{15} isotopes of nitrogen in 3 : 1 ratio. How many neutrons are present in 1.785 mg of ammonia? (Answer in the order 10^{18}) ($N_A = 6 \times 10^{23}$)

2. The atomic ratio of H^1 to H^3 in a sample of water is $1 : 8 \times 10^{-8}$. How many H^3 atoms are present in 9.0 g of such water sample? (Answer in the order 10^{15}) ($N_A = 6 \times 10^{23}$)

3. Assume that a polyethylene chain is truly linear. If a polymer chain had a molecular mass of 1×10^6, then what will be the length of one polyethylene molecule (in μm)? A carbon–carbon single bond length is 154 pm.

4. Chemical formula of a chelating agent versene is $C_2H_4N_2(C_2H_2O_2Na)_4$. If each mole of this compound could bind 1 mol of Ca^{2+}, then what would be the rating of pure versene, expressed as mg $CaCO_3$ bound per g of chelating agent? Here, Ca^{+2} is expressed in terms of the amount of $CaCO_3$ it could form.

5. A polymeric substance, tetrafluoroethylene, can be represented by the formula $(C_2F_4)_x$, where x is a large number. The material was prepared by polymerizing C_2F_4 in the presence of a sulphur-bearing catalyst that serves as a nucleus upon which the polymer grew. The final product was found to contain 0.012% S. What is the value of x, if each polymeric molecule contains one sulphur atom? Assume that the catalyst contributes a negligible amount to the total mass of the polymer. (F = 19, S = 32)

6. A compact car gets 20 miles per litre on the highway. Gasoline contains 84.0% carbon by mass and has a density of 0.80 g/ml. The mass of CO_2 produced (in g) during a 50 mile-trip is

7. A quantity of 2.0 g nitrate of univalent metal was heated with excess of previously ignited silica. A loss in weight of 1.08 g took place due to the total expulsion of the nitrate part of the salt as N_2O_5. The mass percentage of NO_3^- group in the salt analysed is

8. A certain metal 'M' forms an insoluble oxalate complex $M_4O_3(C_2O_4)_3\cdot 12H_2O$. If 3.2 g of the complex is formed from 1 g of oxalic acid, then what is the atomic mass of M?

9. The maximum mass (in g) of $AlCl_3$, which may be formed from 321 g of a mixture of Al_2O_3 and HCl is (Al = 27)

10. Chlorine gas can be produced in the laboratory by the following reaction.

$$K_2Cr_2O_7 + 14HCl \rightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$$

If 75 g sample of $K_2Cr_2O_7$, i.e., s 98% pure is allowed to react with 365 ml of HCl solution having density of 1.2 g/ml and containing 28% HCl by mass, 'x' g of chlorine is produced. The value of '100*x*' is

11. A fluorine disposal plant was constructed to carry out the following reactions.

$$2F_2 + 4NaOH \rightarrow 4NaF + 2H_2O + O_2$$

$$2NaF + CaO + H_2O \rightarrow CaF_2 + 2NaOH$$

As the plant operated, excess lime was added to bring about complete precipitation of the fluorides as CaF_2. Over a period of operation, 1900 kg of fluorine was fed into the plant and 10,000 kg of lime was required. What was the percentage utilization of lime? (Ca = 40, F = 19)

12. A sample of chalk contained as impurity a form of clay which losses 20% if its weight as water on strong heating. A 5 g of chalk sample on heating shows a loss in weight by 1.636 g. The mass percentage of $CaCO_3$ in the chalk sample is (Ca = 40)

13. An impure sample of iron pyrite contains 28% iron, the impurity being silica. If 100 g of the sample is roasted to oxidize all the FeS_2 to Fe_2O_3, then what will be the mass of the roasted sample, in g? (Fe = 56)

14. Chlorine samples are prepared for analysis by using NaCl, KCl and NH_4Cl separately or as mixture. What minimum volume (in ml) of 8.5%, by mass, $AgNO_3$ solution (specific gravity = 1.25) must be added to a sample of 10.7 g in order to ensure complete precipitation of chloride in every possible case?

15. A gas mixture contains CH_4 and C_3H_6. When this mixture undergo cracking into C(s) and H_2(g), the total number of moles of H_2(g) obtained is 42. If the total volume of the initial gas mixture at 1.5 atm and 27°C is 246.0 L, then what is the mole per cent of CH_4 gas in the initial mixture?

16. A solid mixture (5.02 g) containing lead nitrate and sodium nitrate was heated below 600ºC until the weight of residue becomes constant. If the loss in weight is 1.4 g, then the amount of lead nitrate (in mg) in the mixture is (Pb = 208)

17. Octane is a component of gasoline. Complete combustion of octane leads to CO_2 and H_2O while incomplete combustion produces CO and H_2O, which not only reduces the efficiency of the engine using the fuel but it is also toxic. In a certain test run, one gallon of octane is burned in an engine. The total mass of CO, CO_2 and H_2O produced is 9.768 kg. Calculate the efficiency of the process, i.e., calculate the percentage of octane converted to CO_2. The density of octane is 2.28 kg/gallon.

18. A volume of 100 ml of water gas containing some CO_2 was mixed with 100 ml of oxygen and mixture exploded. The volume after explosion was 100 ml. On introducing NaOH, the volume was reduced to 52.5 ml. If the volume ratio of CO, H_2 and CO_2 in the original sample is ab : cd : 2, then the value of 'abcd' is

19. When 10 ml of acetic acid (density = 0.8 g/ml) is mixed with 40 ml of water (density = 1 g/ml) at a certain temperature, the final solution is found to have a density of $\frac{96}{98}$ g/ml. The percent change in total volume on mixing is (Answer as 'abcd' where the value of 'a' is 1 in case of increase in volume and 2 in case of decrease in volume, and 'bcd' is the magnitude of percentage change in volume)

20. The enzyme carbonic anhydrase catalyses the hydration of CO_2. The reaction $CO_2 + H_2O \rightarrow H_2CO_3$ is involved in the transfer of CO_2 from tissues to the lungs through the bloodstream. One enzyme molecule hydrates 10^6 molecules of CO_2 per second. How many grams of CO_2 are hydrated in 1 hour by 10 ml of 10^{-6} M enzyme?

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. (c) 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)

Answer Keys — Exercise II

Section A (Only one Correct)

1. (b)	2. (d)	3. (c)	4. (d)	5. (c)	6. (c)	7. (d)	8. (d)	9. (b)	10. (c)
11. (b)	12. (a)	13. (a)	14. (b)	15. (a)	16. (b)	17. (a)	18. (c)	19. (b)	20. (a)
21. (c)	22. (c)	23. (a)	24. (c)	25. (a)	26. (c)	27. (a)	28. (a)	29. (a)	30. (b)
31. (a)	32. (b)	33. (d)	34. (d)	35. (b)	36. (a)	37. (b)	38. (d)	39. (b)	40. (b)
41. (c)	42. (a)	43. (b)	44. (a)	45. (a)	46. (a)	47. (c)	48. (b)	49. (c)	50. (c)
51. (b)	52. (c)	53. (d)	54. (d)	55. (b)	56. (a)	57. (b)	58. (c)	59. (a)	60. (b)
61. (b)	62. (b)	63. (a)	64. (b)	65. (a)	66. (a)	67. (b)	68. (c)	69. (c)	70. (b)
71. (c)	72. (a)	73. (c)	74. (d)	75. (a)	76. (c)	77. (c)	78. (c)	79. (a)	80. (d)

Section B (One or More than one Correct)

1. (b), (c), (d)	2. (a), (c)	3. (c), (d)	4. (c), (d)
5. (a), (c), (d)	6. (a), (b), (d)	7. (b), (c)	8. (a)
9. (a), (b), (c)	10. (b), (d)	11. (a), (b), (c)	12. (b), (c)
13. (c), (d)	14. (a), (b), (c)	15. (a), (c), (d)	16. (a), (b), (c), (d)
17. (a), (d)	18. (a), (b), (c)	19. (a), (b), (d)	20. (a), (d)
21. (a)	22. (b)	23. (a), (b)	24. (b), (d)
25. (a), (b)	26. (b), (d)	27. (b), (d)	28. (a), (b), (d)
29. (b), (c)	30. (a), (b), (c), (d)		

Section C

Comprehension I

1. (b) 2. (b) 3. (b)

Comprehension II

4. (b) 5. (d) 6. (c)

Comprehension III

7. (a) 8. (b) 9. (c)

Comprehension IV

10. (b) 11. (d) 12. (a)

Comprehension V

13. (b) 14. (a) 15. (b)

Comprehension VI

16. (c) 17. (b) 18. (a)

Comprehension VII

19. (a) 20. (a) 21. (c)

Comprehension VIII

22. (b) 23. (b) 24. (a)

Comprehension IX

25. (b) 26. (c) 27. (b)

Comprehension X

28. (c) 29. (b) 30. (a)

Comprehension XI

31. (b) 32. (b) 33. (a)

Comprehension XII

34. (b) 35. (c) 36. (a)

Comprehension XIII

37. (c) 38. (d) 39. (a)

Comprehension XIV

40. (a) 41. (a) 42. (c)

Comprehension XV

43. (c) 44. (c) 45. (b)

Section D (Assertion – Reason)

1. (a) 2. (a) 3. (d) 4. (c) 5. (c) 6. (d) 7. (d) 8. (b) 9. (a) 10. (d)
11. (c) 12. (c) 13. (c) 14. (d) 15. (d)

Section E (Column Match)

1. A $\rightarrow$ P, R; B $\rightarrow$ Q, R; C $\rightarrow$ Q, S; D $\rightarrow$ Q, R
2. A $\rightarrow$ P, S; B $\rightarrow$ P, Q, R; C $\rightarrow$ R; D $\rightarrow$ S, T
3. A $\rightarrow$ P, R; B $\rightarrow$ Q, R, S; C $\rightarrow$ P, R; D $\rightarrow$ P, T
4. A $\rightarrow$ Q; B $\rightarrow$ S; C $\rightarrow$ P; D $\rightarrow$ R,
5. A $\rightarrow$ Q; B $\rightarrow$ S; C $\rightarrow$ P; D $\rightarrow$ R
6. A $\rightarrow$ Q, R, S, T; B $\rightarrow$ P, Q, R; C $\rightarrow$ R; D $\rightarrow$ Q, R, T
7. A $\rightarrow$ P, S; B $\rightarrow$ Q, S; C $\rightarrow$ R; D $\rightarrow$ Q, S
8. A $\rightarrow$ P, S; B $\rightarrow$ Q, S; C $\rightarrow$ R, S; D $\rightarrow$ P, S
9. A $\rightarrow$ Q, S; B $\rightarrow$ P, S; C $\rightarrow$ R, S; D $\rightarrow$ Q, T
10. A $\rightarrow$ S; B $\rightarrow$ R; C $\rightarrow$ P; D $\rightarrow$ Q
11. A $\rightarrow$ P; B $\rightarrow$ Q; C $\rightarrow$ R; D $\rightarrow$ S
12. A $\rightarrow$ P, S; B $\rightarrow$ P, Q, S; C $\rightarrow$ Q; D $\rightarrow$ P, R, S
13. A $\rightarrow$ Q, T; B $\rightarrow$ P, R; C $\rightarrow$ P, Q; D $\rightarrow$ Q, S
14. A $\rightarrow$ Q, R; B $\rightarrow$ P, R
15. A $\rightarrow$ R; B $\rightarrow$ P; C $\rightarrow$ S; D $\rightarrow$ Q

Section F (Subjective)

Single-digit Integer Type

1. (3) 2. (3) 3. (7) 4. (9) 5. (4) 6. (3) 7. (7) 8. (4) 9. (6) 10. (5)
11. (2) 12. (6) 13. (8) 14. (3) 15. (6) 16. (2) 17. (5) 18. (5) 19. (5) 20. (7)

Four-digit Integer Type

1. (0471) 2. (0048) 3. (0011) 4. (0263) 5. (2667)
6. (6160) 7. (0062) 8. (0084) 9. (0267) 10. (5112)
11. (0028) 12. (0053) 13. (0080) 14. (0320) 15. (0020)
16. (3320) 17. (0080) 18. (1721) 19. (0002) 20. (1584)

HINTS AND EXPLANATIONS

EXERCISE I (JEE MAIN)

Laws of Chemical Combinations

1. Mass of CO_2 formed = 27.5 g

From mass conservation, mass of water formed

$= 10 + 40 - 27.5 = 22.5$ g

2. Total mass of reactants taken

$= 10.8 + (50 \times 1.2) = 70.8$ g

Hence, mass of H_2S gas released

$= 70.8 - 65.2 = 5.6$ g

Hence, volume of H_2S gas released

$= \frac{5.6}{1.4} = 4.0$ L

3. Mass of Iron(III) oxide left

$= (5.4 + 18.5) - (11.2 + 10.2) = 2.5$ g

4. Density of the liquid in bottle $= \frac{22.3}{15} = 1.487$ g/cm^3

5. Let the mass of ethanol in the solution be 'x' g.

As, $V_{solution} = V_{ethanol} + V_{water}$.

$55.0 = \frac{x}{0.8} + \frac{50-x}{1.0} \Rightarrow x = 20$

Hence, mass per cent of water $= \frac{20}{50} \times 100 = 40$

6. In 100 g of weak liquor, the mass of caustic soda present = 4 g. As on evaporation, only loss in mass of water will occur, the final mass of solid must be 4 g. If 'x' g water is evaporated, then

$$(100 - x) \times \frac{25}{100} = 4 \Rightarrow x = 84.$$

7. Mass of water molecules in 1 litre of steam = $0.0006 \times 1000 = 0.6$ g. As for H_2O system, the most condensed state is liquid water, we may assume that in liquid water, the intermolecular space is negligible in comparison to the volume occupied by the liquid molecule. Hence, the volume occupied by the water molecules $= \frac{0.6}{1.0} = 0.6$ mL.

8. Mass of butter should be taken per day

$$= \frac{2.0 \times 10^{-3}}{5.5 \times 10^{-6}} = 363.6 \text{ g}$$

9. Aluminium has a variable valency.

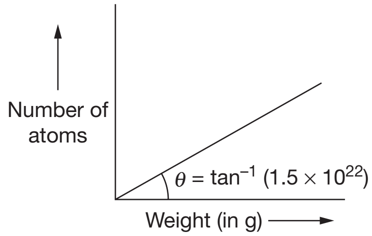
10. In compund 'Y', 4 g of A will combine with $\frac{7}{3} \times 12$ = 28 g of B, and hence, 8 g of A will combine with $2 \times 28 = 56$ g of B.

Atomic Mass

11. Atomic mass of the element

$= \frac{8.0 \times 10^{-18}}{3.2 \times 10^{5}} \times 6 \times 10^{23} = 15$

12.



Slope $= \frac{N_A}{\text{Atomic mass}} = 1.5 \times 10^{22}$

$\Rightarrow$ Atomic mass = 40

13. Number of C-atoms $= \frac{3.0 \times 10^{-10}}{12} \times 6 \times 10^{23}$

$= 1.5 \times 10^{13}$

14. As the mole of atoms is same, the number of atoms is also same.

15. $\frac{4}{9} = \frac{40 / A_X}{60/16} \Rightarrow$ Atomic mass of X, $A_X = 24$

16. $\frac{1}{A_X + 12 + 3 \times 16} = \frac{1.11}{A_X + 2 \times 35.5}$

$\Rightarrow$ Atomic mass of X, $A_X = 40$.

17. $20.18 = \frac{20 \times 90 + x \times 21 + (10 - x) \times 22}{100} \Rightarrow x = 2$

18. Number of neutrons $= \frac{3}{1} \times 6.022 \times 10^{23} \times \frac{1}{6001}$

$= 3.01 \times 10^{20}$

19. Average atomic mass of C $= \frac{12\times98+14\times2}{100} = 12.04$

Number of C^{14} atoms

$= \frac{2}{100} \times \frac{12}{12.04} \times 6.022 \times 10^{23} = 1.20 \times 10^{22}$

20. Average mass number $= 0.6 \times 35 + 0.4 \times 37 = 35.8$

Molecular Mass

21. $20 \times 80 = N \times 32 \Rightarrow N = 50$

22. $\frac{w}{44} = \frac{20}{32} \Rightarrow w = 27.50$ g

23. $\frac{2\times10^{21}}{6\times10^{23}}\times 45 + \frac{3\times10^{21}}{6\times10^{23}}\times M_Q = 0.6 \Rightarrow M_Q = 90$

24. Volume of each virus particle

$= \pi r^2 l = \pi\left(\frac{170}{2}\times10^{-8}\ \text{cm}^2\right)\times(3000\times10^{-8}\ \text{cm})$

$= 6.806 \times 10^{-17}$ cm^3

Mass of each virus particle

$= \frac{6.806\times10^{-17}}{12.5} = 5.4448 \times 10^{-18}$

$\therefore$ Molecular mass of virus

$= 5.4448 \times 10^{-18} \times 6 \times 10^{23} = 3.27 \times 10^6$

25. Volume of each molecule

$= \frac{\text{Mass}}{\text{Density}} = \frac{6\times10^8}{6\times10^{23}\times1.1} = 9.09 \times 10^{-16}$ mL

26. If the atomicity of mercury is 'x', then $200x$

$= 6.92 \times 29 \Rightarrow x \approx 1.$

27. Molecular mass $= 1.2 \times 30 = 36$

28. Molecular mass $= 7 \times 12 + 2 \times 16 + (9.96 \times10^{-24} \times 6 \times 10^{23}) \approx 122$

29. New molecular mass of $H_2O = 2\times0.5 + 1\times20 = 21$

Percentage increase in molecular mass of H_2O

$= \frac{21-18}{18} \times 100 = 16.67$ %

30. Same mass of same element, hence same number of atoms.

31. Number of electrons

$= (2 \times 6 + 4 \times 8 + 2) \times \frac{4.4}{88} \times N_A = 2.3\ N_A$

32. Number of valence electrons

$= (2 \times 6 + 2) \times \frac{6.4}{32} \times N_A = 2.8\ N_A$

33. Number of F^- ions $= \frac{4.2}{27+3\times19} \times 6.02 \times 10^{23} \times 3$

$= 9.03 \times 10^{22}$

34. Number of electrons lost $= \frac{13.5}{27} \times 6.02 \times 10^{23} \times 3$

$= 9.03 \times 10^{22}$

35. Number of iodide ions $= \frac{0.02}{166} \times 6 \times 10^{23}$

$= 7.23 \times 10^{19}$

Calculation of Mole

36. $n = \frac{w}{M} = \frac{1}{153} = 0.00654$

37. $V = \frac{w}{d} = \frac{1.2\times46}{0.8} = 69$ mL

38. Volume of 18 g of water is 18 mL. Hence, the mass of one drop of water $= \frac{1}{20} = 0.05$ g.

Number of water molecules in one drop

$= \frac{0.05}{18} \times 6 \times 10^{23} = 1.67 \times 10^{21}$

39. $3.72 = 0.02 \times M_X + 0.04 \times 48 \Rightarrow M_X = 90$

40. Loschmidt number $= \frac{1}{22400} \times 6 \times 10^{23} = 2.688 \times 10^{19}$

41. $M = \frac{0.25}{50} \times 22400 = 112$ g/mol

42. 6 moles of chlorine atoms is 3 moles of chlorine molecules and hence, the volume = $3 \times 22.7 = 68.1$ L

43. $n = \frac{PV}{RT} = \frac{100 \times 10^3 \times 16.628 \times 10^{-3}}{8.314 \times 300} = 0.67$

44. $\frac{1}{M} \times 4 = \frac{1 \times (1.642/1000)}{0.0821 \times 300} \Rightarrow M = 60000$

45. $\frac{2}{3A} = \frac{1 \times (448/1000)}{0.0821 \times 273} \Rightarrow$ Atomic mass, A = $\frac{100}{3}$

Hence, mass of each atom = $\frac{100}{3} \times 1.66 \times 10^{-24}$
$= 5.53 \times 10^{-23}$ g

46. Number of g-atoms of chlorine

$$= \frac{1.4 \times 10^{21} \times 19}{35.5} = 7.49 \times 10^{20}$$

47. Number of g-atoms left = $\frac{2 \times 10^{-3}}{40} - \frac{1.2 \times 10^{19}}{6.0 \times 10^{23}}$
$= 3 \times 10^{-5}$

48. Number of g-molecules of oxygen

$$= \frac{6.022 \times 10^{24}}{6.022 \times 10^{23}} \times \frac{1}{2} = 5$$

49. $V_{O_2} : V_{H_2} : V_{CH_4} = n_{O_2} : n_{H_2} : n_{CH_4}$

$$= \frac{w}{32} : \frac{w}{2} : \frac{w}{16} = 1 : 16 : 2$$

50. $\frac{w_{O_2}}{32} = \frac{w_{SO_2}}{64} \Rightarrow w_{O_2} = \frac{1}{2} \times w_{SO_2}$

Average Molecular Mass

51. As the molar mass of H_2O is less than that of O_2 and N_2, the molar mass of moist air is less than that of dry air.

52. The average molar mass of H_2F_2 and H_3F_3 may be 50.

53. $37.60 = \frac{70 \times 28 + 30 \times M}{100} \Rightarrow M = 60$

54. $\frac{100}{M} = \frac{90}{2} + \frac{10}{4} \Rightarrow M = 2.105$

55. Average molar mass of the mixture

$$= \frac{22400}{4480} \times 10 = 50$$

Now, $\frac{100}{50} = \frac{x}{30} + \frac{100 - x}{70}$

$\Rightarrow$ Mass per cent of C_2H_6, $x = 30$

56. Average molar mass of the mixture = $\frac{16 + 30}{2} = 23$

Hence, the density of mixture = $\frac{23}{22.4} = 1.03$

57. $(n + 0.05) = \frac{1 \times 6}{0.08 \times 300} \Rightarrow n = 0.20$

58. Average molar mass of the mixture

$$= \frac{40 \times 2 + 60 \times 4}{100} = 3.2$$

Number of moles of gases present = $\frac{10}{3.2} = 3.125$

59. $0.4 = \frac{48 - M}{\left(\frac{3}{2} - 1\right) M} \Rightarrow M = 40$

60. $\alpha = \frac{80 - 56}{\left(\frac{3}{2} - 1\right) 56} = \frac{6}{7}$

Percentage Composition

61. Mass of hydrogen = $\frac{8 \times 1}{9 \times 12} \times 0.968 = 0.0717$ g

62. Moles of O-atoms = 9 × Moles of Cu

63. $x \times (+3) + (0.93 - x) \times (+2) + 1 \times (-2) = 0$

$\Rightarrow x = 0.14$

Percentage of iron as Fe(III) = $\frac{0.14}{0.93} \times 100$
$= 15.05\%$

64. $\frac{1.8}{18n} = \frac{5 - 1.8}{160} \Rightarrow n = 5$

65. $69.98 = \frac{12 \times 21}{M} \times 100 \Rightarrow M = 360.1$

66. $10.46 = \frac{3\times 80}{314+108n}\times 100 \Rightarrow n \approx 19$

67. $36 = \frac{2\times 12}{M}\times 100 \Rightarrow M = \frac{200}{3}$

Hence, moles of compound $= \frac{10}{\left(\frac{200}{3}\right)} = 0.15$

68. $M_{\min} = \frac{100}{4}\times 16 = 400$

69. Mass of nitrogen in the compound

$$= \frac{28}{22400}\times 28 = 0.035 \text{ g}$$

Percentage of nitrogen in the compound

$$= \frac{0.035}{0.2}\times 100 = 17.5\%$$

70. Mass per cent of carbon

$$= \frac{12}{44}\times\frac{0.147}{0.2}\times 100 = 20.05$$

Mass per cent of hydrogen

$$= \frac{2}{18}\times\frac{0.12}{0.2}\times 100 = 6.67$$

Hence, mass per cent of oxygen

$$= 100 - (20.05 + 6.67) = 73.28\%$$

Empirical and Molecular Formula

71. $V_{gas} = \frac{1}{2}\times V_{nitrogen} \Rightarrow n_{gas} = \frac{1}{2}\times n_{nitrogen}$

$\Rightarrow \frac{w}{M_{gas}} = \frac{1}{2}\times\frac{w}{28} \Rightarrow M_{gas} = 56$

Now, $56 = 14 \times n \Rightarrow n = 4$

Hence, the molecular formula of compound

$$= (CH_2)_4 = C_4H_8$$

72. Molecular mass of the compound

$$= \frac{1}{6.06\times 10^{-3}} \approx 165$$

Empirical formula mass $= 3\times 12 + 3\times 1 + 1\times 16$

$= 55$

Now, $n = \frac{165}{55} = 3$ and hence, the molecular formula $= (C_3H_3O)_3 = C_9H_9O_3$.

73. $n = \frac{170\pm 5}{12\times 3+4+16} \approx 3$

$\Rightarrow$ Molecular formula $= (C_3H_4O)_3 = C_9H_{12}O_3$

74. $1.25\times 22.4 = (1\times 12 + 2\times 1)\times n \Rightarrow n = 2$

$\Rightarrow$ Molecular formula $= (CH_2)_2 = C_2H_4$

75. Mass per cent of hydrogen $= \frac{2}{18}\times\frac{1.8}{1.4}\times 100 = \frac{100}{7}$

and mass per cent of carbon $= 100 - \frac{100}{7} = \frac{600}{7}$

Now, atomic ratio of C and H

$$= \frac{600/7}{12} : \frac{100/7}{1} = 1 : 2$$

Hence, the empirical formula $= CH_2$

76. Mass per cent of oxygen

$$= 100 - (40 + 6.67) = 53.33$$

Now, $N_C : N_H : N_O = \frac{40}{12} : \frac{6.67}{1} : \frac{53.33}{16} = 1 : 2 : 1$

$\Rightarrow$ Empirical formula $= CH_2O$

77. $N_X : N_Y = \frac{1}{1} : \frac{4}{2} = 1 : 2$

$\Rightarrow$ Empirical formula $= XY_2$

78. $N_A : N_B : N_C = \frac{w}{20} : \frac{w}{40} : \frac{w}{60} = 6 : 3 : 2$

$\Rightarrow$ Empirical formula $= A_6B_3C_2$

79. Molecular mass of oxide $= \frac{100}{30.4}\times 14 = 46.05$

Hence, density of oxide relative to oxygen,

$$\frac{d_{oxide}}{d_{oxygen}} = \frac{M_{oxide}}{M_{oxygen}} = 1.44$$

80. Let the oxides be Fe_2O_x and Fe_2O_y. From question,

$x \times 16 = \frac{2}{3}\times y \times 16 \Rightarrow x : y = 2 : 3$

Stoichiometry

81. $C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O$

8×44 g $\quad 9 \times 18$ g

$\therefore 7.04$ g $\quad \frac{9\times18}{8\times44}\times7.04 = 3.24$ g

82. $C_{14}H_{30} + \frac{43}{2}O_2 \rightarrow 14\,CO_2 + 15\,H_2O$

198 g $\quad \frac{43}{2}\times 32$ g

$\therefore 792$ g $\quad \frac{43\times16}{198}\times792 = 2752$ g

83. $CH_4 + 2O_2 \rightarrow CO_2 + 2\,H_2O$

16 g $\quad 2 \times 22.4$ L at 0°C and 1 atm

$\therefore 80$ g $\quad \frac{2\times22.4}{16}\times80 = 224$ L

Hence, the volume of air needed

$$= \frac{100}{20}\times224 = 1120 \text{ L}$$

84.

$$\underset{\substack{42\text{ g}\\ \therefore 420\text{ kg}}}{C_3H_6(g)} + \frac{3}{2}NO(g) \rightarrow \underset{\substack{53\text{ g}\\ 530\text{ kg}}}{C_3H_3N(g)} + \frac{3}{2}H_2O(g) + \frac{1}{4}N_2(g)$$

85. $2Ag_2CO_3 \rightarrow 4Ag + 2CO_2\uparrow + O_2\uparrow$

2×276 g $\quad 4\times108$ g

$\therefore 2.76$ g $\quad \frac{4\times108}{2\times276}\times2.76 = 2.16$ g

86. Detonating gas is the mixture of H_2 and O_2 gases.

$2H_2O \rightarrow 2H_2 + O_2$

2 mole $\quad (2 + 1) = 3$ mole $\Rightarrow 3\times22.4$ L

$\therefore 0.1$ mole $\quad \frac{3\times22.4}{2}\times0.1 = 3.36$ L

87. Total moles of gases $= \frac{1\times8.96}{0.0821\times546} = 0.2$

Hence, the mass of ammonium carbonate

$$= \frac{78}{3}\times0.2 = 5.2 \text{ g}$$

88. $MgCO_3 + H_2SO_4 \rightarrow MgSO_4 + CO_2 + H_2O$

84 g $\quad$ 98 g

$\therefore 3.0$ g $\quad \frac{98}{84}\times3 = 3.5$ g

89. $2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

90. $CaO + H_2O \rightarrow Ca(OH)_2$

56 g $\quad$ 18 g

$\therefore 1000$ g $\quad \frac{18}{56}\times1000 = 321.4$ g

91. $Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$

160 g $\quad 6\times36.5$ g

$\therefore 20$ g $\quad \frac{6\times36.5}{160}\times20 = 27.375$ g

Hence, the mass of unreacted HCl

$$= 50 - 27.375 = 22.625 \text{ g}$$

92. $CaSO_3 + SO_2 + H_2O \rightarrow Ca(HSO_3)_2$

120 g $\quad$ 1 mole

93. $N_2 + 3H_2 \rightarrow 2NH_3$

a mole	b mole	0
$(a - x)$ mole	$(b - 3x)$ mole	$2x$ mole
= 2 mole	= 2 mole	= 2 mole

Hence, $x = 1$, $a = 3$ and $b = 5$.

94. Molecular mass of $Ag_2S = 2\times108 + 32 = 248$

Now, $w \times \frac{2.296}{100}\times\frac{216}{248} = 1.0 \Rightarrow w = 50.0$ g

95. Mass of $SO_2 = 500 \times \frac{1.5}{100}\times\frac{64}{32} = 15.0$ g

Limiting Reagent Based

96. $2Ag^+ + CrO_4^{2-} \rightarrow Ag_2CrO_4$

10^{-3} mole (LR) 10^{-3} mole $\frac{332}{2} \times 10^{-3} = 0.166$ g

97. $3SrCl_2 + 2K_3PO_4 \rightarrow Sr_3(PO_4)_2 + 6KCl$

0.3 mole 0.2 mole 0.6 mole

98. $NH_3 + \frac{5}{4}O_2 \rightarrow NO + \frac{3}{2}H_2O$

For 0.12 mole of NH_3, 0.15 mole of O_2 is required. As O_2 is the only 0.14 mole, it is a limiting reagent.

99. $Fe + S \rightarrow FeS$

56 g 32 g

Hence, the excess reactant is sulphur and the mass fraction of sulphur remained $= \frac{56-32}{56} = 0.4285$.

100. $2NH_3(g) + 3O_2(g) + 2CH_4(g) \xrightarrow{Pt} 2HCN(g) + 6H_2O(g)$

$\frac{n_{NH_3}}{2} = \frac{11.5/17}{2} = 0.338$; $\frac{n_{O_2}}{3} = \frac{10/32}{3} = 0.104$;

$\frac{n_{CH_4}}{2} = \frac{10.5/16}{2} = 0.328$

Hence, O_2 is limiting reagent.

Mass of HCN formed $= \frac{2}{3} \times \frac{10}{32} \times 27 = 5.625$ g

Sequential and Parallel Reactions

101. $2Na_2O_2 + 2H_2O \rightarrow 4NaOH + O_2$

$CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$

2 mole of $Na_2O_2 \equiv 1$ mole of $O_2 \equiv \frac{1}{3}$ mole CS_2

2×78 g $\frac{1}{3} \times 76$ g

$\therefore 325$ g $\frac{76}{3 \times 2 \times 78} \times 325 = 52.78$ g

102. $2KClO_3 \rightarrow 2KCl + 3O_2$

$C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

2 mole of $KClO_3 \equiv 3$ mole of $O_2 \equiv 0.5$ mole of C_4H_8

103. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

$\frac{2}{3}$ mole $\frac{2}{3}$ mole 1 mole

$4KClO_3(s) \rightarrow 3KClO_4(s) + KCl(s)$

$\frac{1}{3}$ mole $\frac{1}{4}$ mole $\frac{1}{12}$ mole

Mole fraction of $KClO_4$

$$= \frac{1/4}{1/4 + (2/3 + 1/12)} = 0.25$$

104. $C + \frac{1}{2}O_2 \rightarrow CO$

x mole $0.5x$ mole $x \times 28$ g

$C + O_2 \rightarrow CO_2$

$(1-x)$ mole $(1-x)$ mole $(1-x) \times 44$ g

From question, $[28x + 44(1-x)] \times \frac{40}{100} = 28x$

$\Rightarrow x = 0.5116$

$\therefore$ Mass of O_2 used $= [0.5x + (1-x)] \times 32 = 23.8$ g

105. $I_2 + Cl_2 \rightarrow 2ICl$ and $I_2 + 3Cl_2 \rightarrow 2ICl_3$

Percentage Based

106. $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

$Cl_2 + 2KI \rightarrow 2KCl + I_2$

1 mole of $I_2 \equiv 1$ mole of $Cl_2 \equiv 1$ mole of MnO_2

254 g 87 g

$\therefore$ 6.35 g $\frac{87}{254} \times 6.35 = 2.175$ g

Hence, the percentage purity of pyrolusite ore

$$= \frac{2.175}{4.3} \times 100 = 50\%$$

107. $2NaCl \rightarrow Na_2SO_4$

2×58.5 g 142 g

$\therefore 250 \times \frac{95}{100}$ g $\frac{142}{2 \times 58.5} \times (250 \times 0.95) = 288.248$ g

Hence, mass of 90 per cent pure Na_2SO_4 sample produced = $288.248 \times \frac{100}{90} = 320.275$ g.

108. $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$

100 g 22400 cm^3 at 0°C and 1 atm

$\frac{100}{22400} \times 1120 = 5$ g $\leftarrow$ 1120 cm^3

Hence, percentage of $CaCO_3$ in the marble

$$= \frac{5}{10} \times 100 = 50\%$$

109. $2KHCO_3 \rightarrow K_2CO_3 + CO_2\uparrow + H_2O\uparrow$

2×100 g (44 + 18) = 62 g

$\therefore 1.50 \times \frac{80}{100} = 1.20$ g $\quad \frac{62}{200} \times 1.20 = 0.372$ g

110. Theoretical yield of $N_2H_4 = \frac{32}{51.5} \times 1000 = 621.36$ g.

Hence, the percentage yield

$$= \frac{473}{621.36} \times 100 = 76.12\ \%$$

111. Overall percentage yield = $90 \times \frac{80}{100} = 72\ \%$

112. $C_6H_5NH_2 + HNO_2 + HCl$

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

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

Theoretical yield of $C_6H_5I = \frac{204}{93} \times 9.3 = 20.4$ g

Hence, the percentage yield = $\frac{16.32}{20.4} \times 100 = 80\%$

113. $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

2×40 g 1 mole

$\therefore$ 20 g $\quad \frac{1}{80} \times 20 = 0.25$ mole

On oxidation, the rest of 0.75 mole of CO will produce 0.75 mole of CO_2 on oxidation, which will require $0.75 \times 80 = 60$ g of NaOH.

114. $2a \times 12 + a \times 32 = 14$

$\Rightarrow$ Moles of carbon = $2a = 0.5$

115. $2NaI \rightarrow Na_2SO_4$

2×150 g 142 g

$\therefore$ x g $\quad \frac{142}{300} \times x$ g

$2NaCl \rightarrow Na_2SO_4$

2×58.5 g 142 g

$\therefore$ $(100 - x)$ g $\quad \frac{142}{117} \times (100 - x)$ g

From the question, $\frac{142}{300} \times x + \frac{142}{117} \times (100 - x) = 100$

Hence, the percentage of NaI in the mixture = 28.86%

Eudiometry

116. $2H_2 + O_2 \rightarrow 2H_2O$

2V vol V vol

From question, 2V + V + 0.003 = 0.03

$\Rightarrow V = 0.009$

$\therefore$ Percentage of oxygen

$$= \frac{0.009 + 0.003}{0.03} \times 100 = 40\%$$

117. $2NO + O_2 \rightarrow 2NO_2$

42 mL 21 mL

Hence, volume per cent of nitrogen = 79%

118. $CH_4 \rightarrow CO_2$ and $C_2H_6 \rightarrow 2CO_2$

$ax + bx = 30$ and $ax + 2bx = 40$

$\Rightarrow ax = 20, bx = 10 \Rightarrow a : b = 2 : 1$

For $b : a$ ratio, CH_4 = 10 mL and C_2H_6 = 20 mL

$\Rightarrow CO_2$ formed = 10 + 2 × 20 = 50 mL

119. $CS_2 + 3O_2 \rightarrow CO_2 + 2SO_2$

V mL 3V mL V mL 2V mL

$2CO + O_2 \rightarrow 2CO_2$

(100 − V) mL $\quad \frac{1}{2}$(100 − V) mL $\quad$ (100 − V) mL

Total contraction in volume,

$$V + \frac{1}{2}(100 - V) = (100 + 200) - 245 \Rightarrow V = 10.$$

Hence, the volume of O_2 remained

$$= 200 - [3V + \frac{1}{2}(100 - V)] = 125 \text{ mL}$$

120. $2H_2 + O_2 \rightarrow 2H_2O$

10 mL 5 mL

Hence, $N_2 = 25 - 5 = 20$ mL $= \frac{20}{25} \times 100 = 80\%$

121. $C_4H_x + (4+\frac{x}{4})\,O_2 \rightarrow 4CO_2 + \frac{x}{2}H_2O$

10 mL $10(4+\frac{x}{4}) = 55 \Rightarrow x = 6$

122. $CO_2 + C(s) \rightarrow 2CO$

V mL 2V mL

Hence, increase in volume is

$2V - V = 700 - 500 \Rightarrow V = 200$

123. Volume of CO_2 formed

$= 3 \times 36.5 + (100 - 36.5) = 173$ mL

124. $C_nH_{3n}O_m + \left(\frac{7n}{4} - \frac{m}{2}\right)O_2 \rightarrow nCO_2 + \frac{3n}{2}H_2O(l)$

1 mL $\left(\frac{7n}{4} - \frac{m}{2}\right)$ mL n mL 0

Hence, contraction in volume

$= \left(1 + \frac{7n}{4} - \frac{m}{2}\right) - n = \left(1 + \frac{3n}{4} - \frac{m}{2}\right)$ mL

125. $N_xO_y + H_2 \rightarrow N_2 + H_2O(g)$

1 vol 1 vol 1 vol 1 vol

Hence, $x = 2$ and $y = 1$.

126. $C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \rightarrow nCO_2 + (n+1)H_2O$

From question, $\left(\frac{3n+1}{2}\right) : n = 7 : 4$

$\Rightarrow n = 2 \Rightarrow$ Alkane $= C_2H_6$

127. $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

V ml $V\left(x + \frac{y}{4}\right)$ mL Vx mL 0

Volume contraction, $\left[V + V\left(x + \frac{y}{4}\right)\right] - Vx = 2.5V$

and $Vx = 2V \Rightarrow x = 2$ and $y = 6 \Rightarrow C_2H_6$

128. $\frac{x}{2}Cl_2 + \frac{y}{2}O_2 \rightarrow Cl_xO_y$

10 mL $10\frac{y}{x}$ mL $= 25$ mL $\frac{20}{x}$ ml $= 10$ mL

Hence, $x = 2$ and $y = 5 \Rightarrow Cl_2O_5$

129. $N_xO_y + yH_2 \rightarrow \frac{x}{2}N_2 + yH_2O$

10 mL $10y$ mL $5x$ mL 0

Contraction in volume, $(10 + 10y) - 5x = 28 - 18$

$\Rightarrow x = 2y$

Volume of H_2 unreacted $= (28 - 10) - 10y$

$= (18 - 10y)$ mL

$2H_2 + O_2 \rightarrow 2H_2O$

$(18 - 10y)$ mL $(9 - 5y)$ mL 0

Contraction in volume, $27 - 15y = 27 - 15$

$\Rightarrow y = 1$ and $x = 2 \Rightarrow N_2O \Rightarrow$ Molecular mass $= 44$

130. $C_3O_2 + 2O_2 \rightarrow 3CO_2$

1 vol 2 vol 3 vol

Concentration Terms

131. $\frac{w+100}{1.2} \times \frac{5}{100} = w \Rightarrow w = 4.35$ g

132. Volume of solution $= \frac{100}{10} \times 180 = 1800$ ml

133. $(75 \times d) \times \frac{60}{100} = 50 \Rightarrow d = 1.11$ g/mL

134. $d = \frac{25}{20} = 1.25$ g/mL

135. Mass of $Ca(NO_3)_2 = \frac{2.35}{10^6} \times 50 \times \frac{164}{40}$

$= 4.8175 \times 10^{-4}$ g

136. Mass of $CO = \frac{35}{10^6} \times 1.3 = 4.55 \times 10^{-5}$ g

137. $V \times 0.8 \times 3 + 50 \times 0.2 \times 2 = (V + 50) \times 0.6$

$\Rightarrow V = 5.56$ ml

138. Molarity $= \dfrac{5\times1000}{180\times100}\times1.08 = 0.3$ M

139. $\dfrac{w\times1000}{208\times250}\times2 = \dfrac{3.78\times1000}{58.5\times100}\times1 \Rightarrow w = 16.8$ g

140. Initial mass of HCl $= \dfrac{1}{2}\times36.5 = 18.25$ g

Final molarity of solution

$$= \frac{(18.25-2.675)\times1000}{36.5\times750} = 0.569 \text{ M}$$

141. $[NO_3^-] = \dfrac{500\times0.1}{1000} = 0.05$ M

142. Volume of solution $= \dfrac{1200}{1.2} = 1000$ mL

Hence, molarity of solution $= \dfrac{12}{60} = 0.2$ M

143. Mass of 1 mole solution $= 0.1 \times 40 + 0.9 \times 18$

$= 20.2$ g

Volume of solution $= \dfrac{20.2}{1.4}$ mL

Hence, molarity of solution

$$= \frac{0.1}{\left(\frac{20.2}{1.4}\right)}\times1000 = 6.93 \text{ M}$$

144. Mass of solvent (in g) = Volume of solution (in ml)

$(1000 \times d - 1 \times 60) = 1000 \Rightarrow d = 1.06$ g/mL

145. Mass of solvent is same in all.

146. Mole of solvent is minimum for benzene.

147. $\chi_{glucose} = \dfrac{\frac{1}{180}}{\frac{1}{180}+\frac{3}{60}+\frac{10}{18}} = \dfrac{1}{110}$

148. Molarity of solution $= \dfrac{9.08}{11.35} = 0.8$ M

Hence, mass of $H_2O_2 = \dfrac{250\times0.8}{1000}\times34 = 6.8$ g

149. Percentage of free $SO_3 = \dfrac{80}{18}\times4.5 = 20\%$

150. Maximum limiting labelling of oleum is 122.5%

EXERCISE II (JEE ADVANCED)

Section A (Only one Correct)

1. $\dfrac{\text{Mass of silica}}{\text{Mass of all components other than water}}$

= Constant

or $\dfrac{50}{90} = \dfrac{52}{100-x} \Rightarrow$ Mass per cent of water in partially dried clay, $x = 6.4\%$

2. Atomic mass of oxygen $= \dfrac{87.5}{12.5} = 7$

3. Mass of mercury present

$$= \frac{1.68}{10^9}\times(15000\times0.998) = 2.515\times10^{-5} \text{ g}$$

Number of Hg-atoms $= \dfrac{2.515\times10^{-5}}{200}\times6\times10^{23}$

$= 7.545\times10^{16}$

4. Number of Na-atoms

$$= \frac{1.15\times10^{-3}}{23}\times6\times10^{23} = 3\times10^{19}$$

$\therefore$ Length of Na-atoms

$$= 3\times10^{19}\times(2\times0.2\times10^{-9})\times\frac{1}{1600}$$

$= 7.5\times10^6$ miles

5. $\dfrac{4}{3} \quad ^3 \quad \dfrac{197}{6 \quad 10^{23} \quad 19.7}$ cm $\Rightarrow \quad = 1.587\times10^{-}$ cm

6. Volume of one H-atom

$$= \frac{1}{6\times10^{23}\times3\times10^{-29}} = 5.56\times10^4 \text{ ml}$$

7. Average atomic mass of carbon

$$= \frac{4\times12+1\times14}{5} = 12.4$$

$\therefore$ Average molecular mass of CH_4

$$= 12.4 + 4 \times 1 = 16.4$$

8. Average atomic mass of Q

$$= \frac{23.4\times8.082\times12+76.6\times7.833\times12}{100}$$

$= 94.695$

9. Average atomic mass of oxygen in meteorites is greater.

10. Molecular mass of H_2O

$$= \frac{2\times M_{\text{H-atom}}}{\frac{1}{12}\times M_{C^{12}\text{-atom}}} + 1\times\frac{M_{\text{O-atom}}}{\frac{1}{12}\times M_{C^{12}\text{-atom}}}$$

$$= 2\times\left(\frac{2\times M_{\text{H-atom}}}{\frac{1}{6}\times M_{C^{12}\text{-atom}}} + \frac{1\times M_{\text{O-atom}}}{\frac{1}{6}\times M_{C^{12}\text{-atom}}}\right)$$

$$= 2 \times (2 \times 1 + 1 \times 16) = 36$$

11. $CH_2 = CH - CH = CH - CH = CH_2$

For 1 mole double bond, $\frac{1}{3}$ mole $= \frac{1}{3} \times 80 =$ 26.7 g compound is needed.

12. $\frac{2.0767 / A_x}{1.6/16} = \frac{2}{5} \Rightarrow A_x = 20.769\times2.5$

$\therefore$ Moles of $x = \frac{2.0769}{20.769\times2.5} = 0.04$

13. At 4°C, H_2O is liquid.

14. $M = \frac{WRT}{PV} = \frac{2.3\times0.082}{0.82}\times\frac{300}{1} = 69$

Now, $\alpha = \frac{M_o - M}{(n-1).\ M} = \frac{92-69}{(2-1)\times69} = 0.33$

15. $\alpha = \frac{M_o - M}{(n-1).\ M} = \frac{26-60}{\left(\frac{1}{3}-1\right)\times60} = 0.85$

16. $\alpha = \frac{M_o - M}{(n-1).\ M} = \frac{20-36}{\left(\frac{1}{2}-1\right)\times36} = \frac{8}{9}$

$\therefore$ Percentage of total molecules in dimer form

$$= \frac{\alpha/2}{1-\alpha/2}\times100 = 80\%$$

17. $n_N : n_P : n_K = \frac{30}{14} : \frac{10}{142}\times2 : \frac{10}{94}\times2$

$= 10.07 : 0.66 : 1.00$

18. Mass per cent of Mn

$$= \frac{1\times55}{\frac{2}{3}\times71+\frac{1}{3}\times87}\times100 = 72.05\%$$

19. Mass per cent of $Cu_2O = \frac{143}{127}\times66.67 = 75.06\%$

20. Percentage yield of $NaHCO_3$

$$= \frac{164-69}{164}\times100 = 57.93\%$$

21. Mass of Fe_2O_3 in the ore $= \frac{160}{2\times56}\times2.78 = 3.97$ kg

$\therefore$ Percentage of gangue $= \frac{5-3.97}{5}\times100 = 20.6\%$

22. Mass of Fe $= \frac{2\times56}{160}\times0.541 = 0.3787$ g

$\therefore$ Percentage of Fe in the ore

$$= \frac{0.3787}{0.7}\times100 = 54.1\%$$

23. Let molecular formula $= C_x H_{2x} O_x$

As, $0.0833 \times 2x = 1 \Rightarrow x = 6$

$\Rightarrow$ Molecular formula $= C_6H_{12}O_6$

24. $\frac{(14n+2)-14n}{14n}\times100 = 2.38 \Rightarrow n = 6$

25. Mass per cent of C $= \frac{8}{9}\times92.7 = 82.4\%$

Mass per cent of H $= \frac{1}{9}\times92.7 = 10.3\%$

Now, $N_C : N_H : N_O = \frac{82.4}{12} : \frac{10.3}{1} : \frac{7.3}{16} = 30 : 45 : 2$

26. $Mn_x O_y + \frac{y}{2}\ C \rightarrow x\ Mn + \frac{y}{2}\ CO_2$

$(55x + 16y)$g $\qquad \frac{y}{2}\times 44$ g

$\therefore$ 31.6 gm $\qquad \frac{22y}{55x+16y}\times31.6 = 13.2$

$\Rightarrow x : y = 2 : 3$

27. (a) $\frac{10}{70} : \frac{1}{7} = 1 : 1 \Rightarrow$ Formula = UO

(b) $\frac{10}{240} : \frac{1}{7} = 7 : 24 \Rightarrow$ Formula $= U_7O_{24}$

(c), (d) $\frac{10}{105} : \frac{1}{7} = 2 : 3 \Rightarrow$ Formula $= U_2O_3$

28. From Mg, $M_{min} = \frac{100}{0.08} \times 24 = 300000$

From Ti, $M_{min} = \frac{100}{0.08} \times 48 = 600000$

If M = 300000, the number of Ti-atoms in each molecule $= \frac{1}{2}$, which is not possible.

29. Let $N_2 = a$ mole, $NO_2 = b$ mole and $N_2O_4 = c$ mole.

$a + b + c = 1$ (1)

$28 \times a + 46 \times b + 92 \times c = 55.4$ (2)

$(a + b + 2c) \times 39.6 = 55.4$ (3)

Hence, $a = 0.5$, $b = 0.1$, $c = 0.4$

30. $M_{min} = \frac{100}{365 \times 10^{-3}} \times 146 = 40000$

31. $CuSO_4 \cdot x(NH_4)SO_4 \cdot y\, H_2O \xrightarrow{\Delta} CuO$

(159.5 + 132x + 18y) g 79.5 g

From question, (159.5 + 132x + 18y) × (159.5 + 132x + 18y) × $\frac{19.89}{100} = 79.5$ (1)

and (159.5 + 132x + 18y) × $\frac{27.03}{100}$ = 18 y (2)

Hence, $x = 1$, $y = 6$

32. Molecular formula of tetrahydrocannabinol = $C_{10.5x}H_{15x}O_x$

As $\frac{1.0}{157x} = 0.00318 \Rightarrow x = 2$

33. $CuCl_2 + H_2S \rightarrow CuS \downarrow + 2HCl$

$\frac{2.69}{134.5} = 0.02$ mole

Hence, volume of H_2S needed

$= 0.02 \times 22400 = 448$ mL

34. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

0.15 mole 0.20 mol

∴ Number of water droplets

$$= \frac{0.2 \times 6 \times 10^{23}}{1.7 \times 10^{21}} = 70.6 = 70$$

35. $C_xH_y + (x + \frac{y}{4})\, O_2 \rightarrow xCO_2 + \frac{y}{2}\, H_2O$

44x g $\frac{y}{2} \times 18 = 9y$ g

From question, $\frac{44x}{9y} = \frac{44}{27} \Rightarrow \frac{x}{y} = \frac{1}{3}$

36. $(NH_4)_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2NH_3 + 2H_2O$

50 mole 100 mole

Now, $(V \times 0.85) \times \frac{20}{100} = 100 \times 17$

$\Rightarrow V = 10000$ mL

37. For 1 mole of HCl, 29 g of $Mg(OH)_2$ or 26 g of $Al(OH)_3$ or 37 g of $Ca(OH)_2$ is needed.

38. $M_2O_3 + 3H_2 \rightarrow 2M + 3H_2O$

(2A + 48)g 6 g

$\therefore 0.1596$ g $\frac{6}{2A + 48} \times 0.1596 = 6 \times 10^{-3}$

$\Rightarrow A = 55.8.$

39. $M + 3F_2 \rightarrow MF_6$

A g ($A + 6 \times 19$)g

∴ 0.25 g $\frac{A + 114}{A} \times 0.25 = 0.547$

$\Rightarrow A = 95.96$

40. $U + 3F_2 \rightarrow UF_6$

$3 \times 6.022 \times 10^{23}$ molecule 352 g

∴ Number of F_2 molecules needed

$$= \frac{3 \times 6.022 \times 10^{23}}{352} \times 2 \times 10^{-3}$$

$= 1.026 \times 10^{19}$

41. $H_2S + \frac{3}{2}O_2 \rightarrow H_2O + SO_2$

34 g $\frac{3}{2} \times 32$ g

∴ 51 g $\frac{48}{34} \times 51 = 72$ g

∴ Total mass of product formed = 51 + 72 = 123 g

42. $Cr_2O_7^{2-} + 5H^+ + 3SO_2 \rightarrow 2Cr^{3+} + 3HSO_4^- + H_2O$

$\frac{1.08}{216} = 0.005$ mole $= 5 \times 0.005 = 0.025$ mole

43. $B_2Cl_4 + 6NaOH \rightarrow 2NaBO_2 + 2H_2O + H_2 + 4NaCl$

164 g 22700 mL at STP

∴ Mass of B_2Cl_4 needed $= \frac{164}{22700} \times 1362 = 9.84$ g

44. $2NH_4NO_3 \rightarrow 2N_2 + O_2 + 4H_2O(g)$

2×80 g Total 7 mole gases

$\therefore 16$ g 0.7 mole

$\therefore$ Volume, $V = \dfrac{0.7 \times 0.082 \times 900}{1} = 57.4$ L

45. $FeCl_x + xAgNO_3 \rightarrow xAgCl \downarrow + Fe(NO_3)x$

$(56 + 35.5x)$g $x \times 143.5$ g

$\therefore$ 127 mg $\dfrac{143.5x}{56+35.5x} \times 127 = 287 \Rightarrow x = 2$

46. 1 mole of $F_2 \equiv 2$ mole of Co $F_3 \equiv \dfrac{1}{2n}$ mole $(CF_2)_n$

$= 38$ g $= \dfrac{1}{2n} \times 50n = 25$ g

$\therefore$ Mass of F_2 needed $= \dfrac{38}{25} \times 1 = 1.52$ kg

47. $9A + 8BO_3 \rightarrow 3A_3O_4 + 4B_2O_3$

9 mole 3mole

(L.R.)

$\therefore$ 1 mole $\dfrac{3}{9} = \dfrac{1}{3}$ mole

48. Mass of tin $= \dfrac{119}{151} \times 0.5 = 0.394$ g

$\therefore$ Mass per cent of tin $= \dfrac{0.394}{1.5} \times 100 = 26.27\%$.

49. Overall reaction: A + B + C $\rightarrow$ D

5 moles 6 moles excess 5 moles

L.R.

50. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

$\dfrac{25.5}{17} = 1.5$ mole 1.5 mole

$2NO + 2CH_4 \rightarrow 2HCN + 2H_2O$

1.5 mole 2 mole 1.5 mole

L.R. $= 1.5 \times 27 = 40.5$ g

51. $Al_2O_3 \cdot 2SiO_2 = 102 + 2 \times 60$

$\therefore$ SiO_2 in combined state $= \dfrac{120}{102} \times 1.02 = 1.20$ g

Hence, percentage of free SiO_2

$= 1.52 - 1.20 = 0.32\%$

52. $2FeO \rightarrow Fe_2O_3$

$2a$ mole a mole

$(2a - 2x)$mole $(a + x)$mole

From question, $\dfrac{a+x}{2a-2x} = \dfrac{2}{1} \Rightarrow x = \dfrac{3}{5}a$

Hence, moles of FeO oxidized per mole of mixture

$= \dfrac{2x}{3a} = \dfrac{2}{3} \times \dfrac{3}{5} = 0.4$

53. $C + \dfrac{1}{2}O_2 \rightarrow CO$

12 g 16 g

$\therefore$ x g $1.33x$ g

$C + O_2 \rightarrow CO_2$

12 g 32 g

$\therefore x$ g $2.67x$ g

Hence, $1.33x \le y \le 2.67x$

54. $Ca(NCN) + 3\,H_2O \rightarrow Ca\,CO_3 + 2NH_3$

1 mole 1 mole $\dfrac{2}{3}$ mole

L.R.

55. $N_2 + 3H_2 \rightarrow 2\,NH_3$

$\dfrac{1}{2}$ mole $\dfrac{3}{2}$ mole 1 mole

$NH_3 + HCl \rightarrow NH_4Cl$

1 mole 1 mole (given)

Gases remained: $N_2 = 1 - \dfrac{1}{2} = \dfrac{1}{2}$ mole

$H_2 = 4 - \dfrac{3}{2} = \dfrac{5}{2}$ mole

56. $I_2 + H_2S \rightarrow 2HI + S$

$\dfrac{5.08}{254}$ $\dfrac{460}{22400}$ 0.02 mole

$= 0.02$ mole $= 0.0205$ mole 0.02×32

(L.R.) $= 0.64$ g

57. $12K_2CO_3 \rightarrow K_2\,Zn_3[Fe(CN)_6]_2$

12×138 g 698.2 g

$\therefore$ 27.6 g $\dfrac{698.2}{12 \times 138} \times 27.6 = 11.64$ g

58. 2 mole of $AsCl_3 \equiv 3$ mole of $Cl_2 \equiv \frac{16}{5} \times 3$ mole of HCl

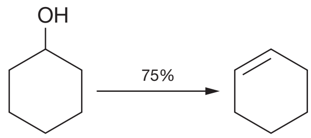
$= 2 \times 181.5$ g $\qquad = \frac{48}{5} \times 36.5$ g

$\therefore 363$ g $\qquad 350.4$ g

$\therefore$ Volume of HCl solution needed

$$= \frac{350.4 \times \frac{100}{20}}{1.2} = 1460 \text{ mL}$$

59.



$(C_6H_{12}O)$ $\qquad$ (C_6H_{10})

100 g $\qquad$ $82 \text{ g} \times \frac{75}{100} = 61.5$ g

60. Cu $\rightarrow$ CuO

64 g $\qquad$ 80 g

$\therefore x$ g $\qquad \frac{80}{64} \times x = 1.25x$ g

Increase in mass, $1.25x - x = 4.90 - 4.00 \Rightarrow x = 3.6$

$\therefore$ Percentage of copper unoxidized

$$= \frac{4 - 3.6}{4} \times 100 = 10\%$$

61. $2CH_3COCH_3 + 6Ca(OCl)Cl \xrightarrow{75\%} 2CHCl_3 + (CH_3COO)_2Ca + 3CaCl_2 + 2Ca(OH)_2$

2×58 g $\qquad$ 2×119.5 g

$\therefore$ For 30 g $CHCl_3$, mass of CH_3COCH_3 needed

$$= \frac{2 \times 58}{2 \times 119.5} \times 30 \times \frac{100}{75} = 19.4 \text{ g}$$

62. $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2(g)$

4 mole (say) $\quad$ 11 mole $\qquad$ 8 mole

Final composition of gases:

$O_2 = 11 \times \frac{60}{100} = 6.6$ mole

$N_2 = (11 + 6.6) \times \frac{80}{20} = 70.4$ mole

$SO_2 = 8.0$ mole

$\therefore$ Total moles of gases $= 6.6 + 70.4 + 8.0 = 85$

$\therefore$ Volume per cent of $N_2 = \frac{70.4}{85} \times 100 = 82.82\%$

63. Let $CH_4 = x$ mole and $C_2H_4 = y$ mole

From question, $x \times 16 + y \times 28 = 12$ $\qquad$ (1)

and from CO_2, $(x + 2y) \times 44 = 35.2$ $\qquad$ (2)

Hence, $x = 0.4$ and $y = 0.2$

Now, $M_{av} = \frac{x + 16 + y \times 28}{x + y} = 20$

64. $C_xH_y + \left(x + \frac{y}{4}\right) O_2 \rightarrow xCO_2 + \frac{y}{2} H_2O$

From question, $\frac{(x + \frac{y}{4})}{x} =$ Independent of x.

For alkene, $y = 2x$.

65. $N_2O + H_2 \rightarrow N_2 + H_2O$

x mL $\qquad$ x mL

$NO + H_2 \rightarrow \frac{1}{2} N_2 + H_2O$

$(60 - x)$ mL $\qquad \frac{1}{2}(60 - x)$ mL

From question, $x + \frac{1}{2}(60 - x) = 38 \Rightarrow x = 16$

66. $CO + \frac{1}{2}O_2 \rightarrow CO$

0.4V mL $\quad$ 0.2V mL $\quad$ 0.4V mL

Decrease in volume $= (0.4V + 0.2V) - 0.4V = 0.2V$

$\therefore$ Fractional decrease in volume $= \frac{0.2V}{2V} = 0.1$

67. $HCOOH \xrightarrow[\Delta]{\text{conc. } H_2SO_4} CO(g) + H_2O(l)$

a mole $\qquad$ a mole

$H_2C_2O_4 \xrightarrow{\text{conc. } H_2SO_4} CO(g) + CO_2(g) + H_2O(l)$

b mole $\qquad$ b mole $\quad$ b mole

From question, $(a + 2b) \times \frac{1}{6} = b \Rightarrow a : b = 4 : 1$

68. O_2 consumed $= 70 - 45 = 25$ mL

For any hydrocarbon, volume of O_2 used in combustion must be greater than the volume of hydrocarbon.

69. $3HCl + Al(OH)_3 \rightarrow AlCl_3 + 3H_2O$

3 mole $\qquad$ 78 g

$\therefore 3 \times 80 \times 10^{-3}$ mole $\frac{78}{3} \times 3 \times 80 \times 10^{-3} = 7.8 \times 0.8$ g

∴ Volume of antacid syrup needed

$$= \frac{100}{2.6} \times (7.8 \times 0.8) = 240 \text{ mL}$$

70. $V \times 2.2 = \left(11\,V \times \frac{98}{100}\right) \times M_{final} \Rightarrow M_{final} = 0.204\text{ M}$

71. Moles of succinic acid $= \frac{23.6}{118} = 0.2$

∴ Final molarity of –COOH group

$$= \frac{0.2 \times 2}{500} \times 1000 + 0.1 \times 1 = 0.9\text{ M}$$

72. $[CCl_3F] = \frac{275 \times 0.08}{0.08 \times 200} \times 10^{-12} = 1.375 \times 10^{-12}\text{ M}$

$[CCl_2F_2] = \frac{605 \times 0.08}{0.08 \times 200} \times 10^{-12} = 3.025 \times 10^{-12}\text{ M}$

73. $2 = \frac{x \times 1000}{60 \times (1000 - x)}$ and $4 = \frac{y \times 1000}{60 \times (2000 - y)}$

∴ Molality of resulting solution

$$= \frac{(x+y) \times 1000}{60 \times [3000 - (x+y)]} = 3.29\text{ m}$$

74. $1 \times \left(\frac{1000}{1000 + 1 \times 180} \times 1000\right)$

$= x \times \left(\frac{1000}{1000 + x \times 180} \times 5000\right) \Rightarrow x = 0.175\text{ m}$

75. $0.2 \times \left(\frac{50}{0.2 \times 60 + 0.8 \times 18}\right)$

$= x \times \left(\frac{1500}{x \times 60 + (1-x) \times 18}\right) \Rightarrow x = 0.0508$

76. Mass of H_2O_2 in 10 mL diluted solution

$$= \frac{1}{5} \times \left(20 \times \frac{8.5}{100}\right) = \frac{8.5}{25}\text{ g}$$

As 1 mole of H_2O_2 will produce 1 mole of O_2 on reaction with the oxidant, volume of O_2 gas produced at 0°C and 1 atm

$$= \frac{8.5/25}{34} \times 22400 = 224\text{ mL}$$

77. $50 \times 20 + 50 \times 10 = 100 \times V \Rightarrow V = 15$

78. 200 g of 109% oleum requires 18 g of water for complete conversion into H_2SO_4. On adding 12 g of water, the resulting 212 g oleum is still requiring 6 g of water. Hence, the new labelling is

$$\left(100 + \frac{6}{212} \times 100\right) = 102.83\%$$

79. $200 \times 109 + 300 \times 118 = 500 \times x \Rightarrow x = 114.4$

80. Resulting oleum is still requiring (24 – 18) = 6 g of water.

H_2O +	$SO_3 \rightarrow$	H_2SO_4
18 g	80 g	
∴ 6 g	26.67 g	

Final composition: $SO_3 = 26.67$ g

and $H_2SO_4 = 218 - 26.6 = 191.33$ g

Section B (One or More than one Correct)

1. Molar mass of gas $= \frac{0.22}{112} \times 22400 = 44$

2. Mole of H-atoms in glucose $= \frac{0.9}{180} \times 12 = 0.06$

Mole of H-atoms in hydrazine $= \frac{0.48}{32} \times 4 = 0.06$

Mole of H-atoms in ammonia $= \frac{0.17}{17} \times 3 = 0.03$

Mole of H-atoms in ethane $= \frac{0.30}{30} \times 6 = 0.06$

Mole of H-atoms in hydrogen $= \frac{0.03}{1} = 0.03$

3. Moles of H-atoms $= \frac{90}{1} = 90$

Moles of He-atoms $= \frac{10}{4} = 2.5$

∴ $N_H : N_{He} = 90 : 2.5 = 36 : 1$

And $M_{av} = \frac{100}{\frac{90}{2} + \frac{10}{4}} = 2.105$

4. $M = 20 \times 2 = 40$

Hence, either all HF molecules are in dimer form or some molecules may be in trimer form.

5. $2H_2 + O_2 \rightarrow 2H_2O$

6. Volume of N_A molecules = 22.4 L at 0°C and 1 atm.

7. (b) $\frac{4\times M+1\times(M+1)-1(M+2)}{4+1+1} = M+0.5$

Similarly, try for other options.

8. Theoretical

9. For $Ti_{0.75}O = 0.75 \times 48 + 16 = 52$

$\therefore$ Percentage of $Ti = \frac{36}{52} \times 100 = 69.23\%$

and percentage of O = 30.8%

For $TiO_{0.69} = 48 + 16 \times 0.69 = 59.04$

$\therefore$ Percentage of $Ti = \frac{48}{59.04} \times 100 = 81.3\%$

and percentage of O = 18.7%

10. Isomers

11. Same empirical formula $\Rightarrow$ Same composition

12. Group A and C $\Rightarrow$ 0.1 mole AgCl

Group B and D $\Rightarrow$ 0.1 mole AgBr

13. (c) H_2O is in liquid state.

(d) $2H_2 + O_2 \rightarrow 2H_2O$

14. (a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

16 g 64 g

7 g $\leftarrow$ 28 g

(b) $CH_4 + \frac{3}{2} O_2 \rightarrow CO + 2H_2O$

16 g 48 g

$\therefore$ 8 g 24 g

(c), (d) $\frac{1}{2}CH_4 + \frac{7}{8}O_2 \rightarrow \frac{1}{4}CO_2 + \frac{1}{4}CO + H_2O$

18 g

15. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

16 g 2 mole

$\therefore$8 g 1 mole

$2KClO_3 \rightarrow 2KCl + 3O_2$

$2H_2O_2 \rightarrow 2H_2O + O_2$

$2NaNO_3 \rightarrow 2NaNO_2 + O_2$

$2BaO_2 \rightarrow 2BaO + O_2$

16. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O(g)$

x mole 3x mole 4x mole

$C_6H_6 + \frac{15}{2} O_2 \rightarrow 6CO_2 + 3H_2O(g)$

y mole 6y mole 3y mole

From question, $3x + 6y = 4x + 3y \Rightarrow x : y = 3 : 1$

and $n_C : n_H = (3x + 6y) : (8x + 6y) = 1 : 2$

17. (a) $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

2×40 g 44 g

8 g $\leftarrow$ 4.4 g

But NaOH is only 6 g and hence, L.R.

(b) $NaOH + CO_2 \rightarrow NaHCO_3$

40 g 44 g

4 g $\leftarrow$ 4.4 g

But NaOH is 6 g (excess). Hence, CO_2 is L.R.

18. $C_nH_{2n+2} + \left(\frac{3n+1}{2}\right) O_2 \rightarrow n\,CO_2 + (n+1)\,H_2O$

Alkane

$C_nH_{2n} + \frac{3n}{2} O_2 \rightarrow n\,CO_2 + n\,H_2O$

Alkene

$C_nH_{2n-2} + \left(\frac{3n-1}{2}\right) O_2 \rightarrow n\,CO_2 + (n-1)\,H_2O$

Alkyne

19. Reactions of question number 18.

20. (a) $Mg + \frac{1}{2}O_2 \rightarrow MgO$

$\frac{1}{2}$ mole $\frac{1}{4} \times 32 = 8$ g

$\therefore$ Mass of air needed $= 8 + 1 \times 28 = 36$ g

(c) $3Mg + N_2 \rightarrow Mg_3N_2$

$\frac{1}{2}$ mole $\frac{1}{6}$ mole

$\therefore$ Mass of air needed $= \frac{1}{6} \times 28 + \frac{1}{24} \times 32 = 6$ g

(d) $Mg + \frac{1}{2}O_2 \rightarrow MgO$

x mole $\frac{x}{2}$ mole

$3Mg + N_2 \rightarrow Mg_3N_2$

$\left(\frac{1}{2}-x\right)$ mole $\frac{1}{3}\left(\frac{1}{2}-x\right)$ mole

From question: $\frac{1}{3}\left(\frac{1}{2}-x\right) = 4 \times \frac{x}{2} \Rightarrow x = \frac{1}{14}$

$\therefore$ Mass of air needed $= \frac{x}{2} \times 32 + \frac{1}{3}\left(\frac{1}{2}-x\right) \times 28$

$= 5.14$ g

Final mass of products $= 12 + 5.14 = 17.14$ g

21. NaCl $\rightarrow$ AgCl and MCl $\rightarrow$ AgCl

x mole x mole y mole y mole

$\therefore (x + y) \times 143.5 = 2.567$ (1)

From the second expression: MCl $\rightarrow$ AgCl

y mole y mole

$\therefore y \times 143.5 = 1.341$ (2)

Hence, $x = \frac{1.226}{143.5}, y = \frac{1.341}{143.5}$

Now, $x \times 58.5 + y \times M = 1 \Rightarrow M = 53.5$

22. $5Cr_2O_7^{2-} + 6\,XO + 34H^+ \rightarrow 10Cr^{3+} + 6\,XO_4^- + 17H_2O$

x mole $\frac{6}{5}x$ mole $\frac{6}{5}x$ mole

$4Cr_2O_7^{2-} + 3X_2O_3 + 26H^+ \rightarrow 8Cr^{3+} + 6\,XO_4^- + 13H_2O$

$(0.15 - x)$ mole $\frac{3}{4}(0.15 - x)$ mole $\frac{6}{4}(0.15 - x)$ mole

From question, $\frac{6}{5}x + \frac{6}{4}(0.15 - x) = 0.21$

$\Rightarrow x = 0.05.$

Now, $\frac{6}{5}x \times (A + 16) + \frac{3}{4}(0.15 - x) \times (2A + 48)$

$= 25.56 \Rightarrow A = 100.$

23. $2H_2 + O_2 \rightarrow 2H_2O$

L.R. may be H_2 or O_2.

24. Volume of undecomposed $NH_3 = 90 - 84 = 6$ mL

$2NH_3 \rightarrow N_2 + 3H_2$

V mL $\frac{V}{2}$ mL $\frac{3V}{2}$ mL

As $\frac{V}{2} + \frac{3V}{2} = 84 \Rightarrow V = 42$

Hence, initial volume of $NH_3 = 42 + 6 = 48$ mL

25. $V_1 \times 40 = V_2 \times 16 \Rightarrow \frac{V_2}{V_1} = \frac{2.5}{1}$.

26. $(V_1 \times 1.6) \times \frac{40}{100} = (V_1 + V_2) \times 1.1 \times \frac{x}{100}$

and $V_1 \times 1.6 + V_2 \times 1.0 = (V_1 + V_2) \times 1.1$

$\therefore$ Strength of final solution, $x = 9.7\%$ (w/w) and 10.67% (w/v).

27. $V \times 20 = 2V \times S \Rightarrow S = 10$ vol.

28. For Na^+: $2000 \times M_{Na+} = 100 \times 1 \Rightarrow M_{Na+} = 0.05$ M

For Mg^{2+}: $2000 \times M_{Mg^{2+}} = 100 \times 2 + 300 \times 4$

$\Rightarrow M_{Mg^{2+}} = 0.7$ M.

For Cl^-: $2000 \times M_{Cl^-} = 100 \times 1 + 100 \times 2 \times 2$

$\Rightarrow M_{Cl^-} = 0.25$ M

For NO_3^- : $2000 \times M_{NO_3^-} = 300 \times 4 \times 2$

$\Rightarrow M_{NO_3^-} = 1.2$ M

29. Mass of solute $= n \times x$ g

Mass of solvent $= n \times y$ g

$\therefore$ Mass per cent of solute $= \frac{x}{x + y} \times 100\%$

30. $d = \frac{950}{1000}\frac{gm}{cm^3} = 950\ kg/m^3$

$X_{C_2H_{50}H} = \frac{230/46}{230/46 + 720/18} = \frac{1}{9}$

$M_{C_2H_{50}H} = 5$ M

and $M_{C_2H_{50}H} = \frac{5}{720} \times 1000 = 6.94$ M

Section C (Comprehensions)

Comprehension I

1. $N_x H_y \rightarrow \frac{x}{2} N_2 + \frac{y}{2} H_2$

10 mL $5x = 10$ $5y = 20$

$\therefore x = 2$ $\therefore y = 4$

$\therefore$ Formula of compound $= N_2H_4$

2. $\frac{88 / A_N}{12 / 1} = \frac{2}{4} \Rightarrow A_N = 14.67$

3. $N_xH_y \rightarrow \frac{x}{3} N_3 + \frac{y}{2} H_2$

10 mL $\frac{10x}{3} = 10$ $5y = 20$

$\therefore x = 3$ $\therefore y = 4$

$\therefore$ Formula of compound $= N_3H_4$

Comprehension II

$2HF \rightarrow H_2F_2$ $\qquad$ $3HF \rightarrow H_3F_3$

$a-(2x+3y) \quad x$ $\qquad$ $a-(3y+2x) \quad y$

From question, $\dfrac{y}{a-(2x+3y)} = \dfrac{1}{4}$ (1)

and $[\{a-(2x+3y)\} + x + y] \times 34 = a \times 20$ (2)

From (1) and (2): $a = 17y = \dfrac{17}{5}x$

$\therefore$ Percentage of molecules in dimer form

$$= \frac{x}{a-x-2y} \times 100 = 50\%$$

Percentage of HF molecules trimerized

$$= \frac{3y}{a} \times 10 = 17.647\%$$

Percentage of HF molecules dimerized

$$= \frac{2x}{a} \times 100 = 58.82\%$$

Comprehension III

Let the initial composition be Ar = a mole and $N_2O_4 = b$ mole.

Now, $a \times 40 + b \times 92 = (a+b) \times 40 \times 2$

$\Rightarrow a : b = 3 : 10$

$N_2O_4 \rightarrow 2NO_2$

$(b-x)$mole $\qquad$ $2x$ mole

Now, $80 \times (a+b) = (a+b+x) \times 37.5 \times 2$

$\therefore$ Degree of dissociation of $N_2O_4 = \dfrac{x}{b} = 0.087$

And final mole ratio, $n_{Ar} : n_{N_2O_4} : n_{NO_2}$

$$= a : (b-x) : 2x = 45 : 137 : 26$$

Comprehension IV

Ore = 100 g (say)

- Kaolia = 13 g, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$
  - $Al = \dfrac{54}{258} \times 13 = 2.721$ g
  - $Si = \dfrac{56}{258} \times 13 = 2.822$ g
- Gibbsite = 87 g, $Al_2O_3 \cdot 3H_2O$ $\Rightarrow$ $Al = \dfrac{54}{156} \times 87 = 30.115$ g

Total mass of Al present

$$= 2.725 + 30.115 = 32.836 \text{ g.}$$

Mass of Al lost in mud $= \dfrac{6 \times 27}{5 \times 28} \times 2.822$

$$= 3.265 \text{ g}$$

$\therefore$ Percentage of Al recoverable

$$= \frac{(32.836 - 3.265)}{32.836} \times 100 = 90.06\%$$

Now, percentage of $SiO_2 = \dfrac{2 \times 60}{258} \times 13 = 6.05$

Comprehension V

Mass of CO_2 produced = 85.35 – 83.85 = 1.5 g

$\therefore$ Percentage of C $= \dfrac{12}{44} \times \dfrac{1.5}{1.0} \times 100 = 40.9\%$

Mass of H_2O produced = 37.96 – 37.55 = 0.41 g

$\therefore$ Percentage of H $= \dfrac{2}{18} \times \dfrac{0.41}{1.0} \times 100 = 4.56\%$

Hence, percentage of oxygen

$$= 100 - (40.9 + 4.56) = 54.54\%$$

Now, $N_C : N_H : N_O = \dfrac{40.9}{12} : \dfrac{4.56}{1} : \dfrac{54.54}{16}$

$$= 3 : 4 : 3$$

Comprehension VI

Let slurry = x kg, concentrated solution = y kg, water vapour = z kg.

NaCl: $25000 \times \frac{18}{100} = x \times \frac{90}{100} \Rightarrow x = 5000$

NaOH: $25000 \times \frac{2}{100} = x \times \frac{5}{100} + y \times \frac{50}{100} \Rightarrow y =$ 500

and $z = 25000 - (x + y) = 19500$

Comprehension VII

$$2N_2H_4 \quad + \quad N_2O_4 \quad \rightarrow \quad 3N_2 \quad + \quad 4H_2O$$

$(3 - 0.1)$ $(2 - 0.2)$ $\frac{3}{2} \times 2.9$ 2×2.9 mole

= 2.9 mole =1.8 mole = 4.35 mole

L.R.

$$N_2H_4 \quad + \quad 2N_2O_4 \quad \rightarrow \quad 6NO \quad + \quad 2H_2O$$

0.1 mole 0.2 mole $\frac{18}{30} = 0.6$ mole 0.2 mole

Total H_2O formed = 6 mole = 108 g

Theoretical yield of $N_2 = 4.5$ mole

$\therefore$ Percentage yield $= \frac{4.35}{4.5} \times 100 = 96.67\%$

Comprehension VIII

$$Cu + 4HNO_3 \rightarrow Cu\,(NO_3)_2 + 2NO_2 + 2H_2O$$

0.025 mole $\frac{1 \times 1.23}{0.082 \times 300} = 0.05$

$= 0.025 \times 63.5$

$= 1.5875$ g

$\therefore$ Percentage of Cu $= \frac{1.5875}{1.9145} \times 100 = 82.92\%$

and Zn present = (1.9145 – 1.5875) = 0.327 g

$= \frac{0.327}{65.4} = 0.005$ mole

$$Cu \quad + \quad 4HNO_3 \rightarrow Cu\,(NO_3)_2 + 2NO_2 + 2H_2O$$

0.025 mole 0.1 mole

$$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$$

0.005 mole 0.0125 mole 0.00125×80

= 0.1 g

Now, moles of HNO_3, $\frac{V \times 3}{100} = 0.1125$

$\therefore$ V = 37.5 mL

Comprehension IX

25. $CaO + 3C \rightarrow CaC_2 + CO$

56 g 64 g

$\frac{56}{64} \times 1280 \leftarrow$ 1280 kg

= 1120 kg

And CaO unreacted $= \frac{20}{80} \times 1280 = 320$ kg

$\therefore$ Total CaO needed = 1120 + 320 = 1440 kg

26. Mass of CaC_2 formed $= 1280 \times \frac{80}{100} = 1024$ kg

Mass of CaO reacted $= \frac{56}{64} \times 1024 = 896$ kg

$\therefore$ Total CaO needed $= 986 + 1280 \times \frac{20}{100} = 1152$ kg

27. Moles of CO formed $= \frac{1}{64} \times (1024 \times 10^3) = 16 \times 10^3$

$\therefore$ Volume of CO produced $= 16 \times 10^3 \times 22.4$ L

$= 358.4\ m^3$

Comprehension X

Moles of S = Moles of $BaSO_4 = \frac{6.99}{233} = 0.03$

$MS_n + \left(\frac{2n+3}{2}\right) O_2 \rightarrow MO_3 + nSO_2$

$2MCl_5 + 5Na_2S \rightarrow 2MS_n + (5 - 2n)S + 10NaCl$

2 mole of $MCl_5 \equiv 2 \times \frac{90}{100} = 1.8$ mole of $MS_n \equiv 1.8n$

Mole of $SO_2 \equiv 1.8n$ mole of $BaSO_4 \leftarrow 0.03$ mole

$$\frac{2}{1.8n} \times 0.03 = \frac{4.55}{A + 35.5 \times 5}$$

If $n = 2$, then $A = 95.5$.

Comprehension XI

$Cl_2 = 30$ mL, $Cl_xO_y = 30$ mL

$Cl_xO_y \rightarrow \frac{x}{2} Cl_2 + \frac{y}{2} O_2$

30 mL $15x$ mL $15y$ mL

From the question, $30 + 15x + 15y = 75 \Rightarrow x + y = 3$

and $30 + 15x = 75 - 15 \Rightarrow x = 2, y = 1$.

Comprehension XII

$C_xH_yN_z + (x + \frac{y}{4})O_2 \rightarrow CO_2 + \frac{y}{2} H_2O + \frac{z}{2} N_2$

V ml $V(x + \frac{y}{4})$ mL Vx mL $\frac{Vy}{2}$ mL $\frac{Vz}{2}$ mL

$= (18 - V)$ mL $= 8$ mL $= 12$ mL $= 4$ mL

$\therefore x = 2, y = 6, z = 2$ and $V = 4$

Now $C_2H_6N_2 + H_2 \rightarrow C_2H_8N_2$

4 mL 4 mL

Comprehension XIII

Volume of O_2 used $= 30 - 5.5 = 24.5$ mL

Let the original mixture be $CH_4 = x$ mL, $C_2H_4 = y$ mL and $C_2H_2 = z$ mL.

From question, $x + y + z = 10$ (1)

$$\frac{16 \times x + 28 \times y + 26 \times z}{x + y + z} = 11.3 \times 2 \quad (2)$$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

x mL $2x$ mL x mL

$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

y mL $3y$ mL $2y$ mL

$C_2H_4 + \frac{5}{2} O_2 \rightarrow 2CO_2 + H_2O$

z mL $\frac{5z}{2}$ mL $2z$ mL

$$2x + 3y + \frac{5z}{2} = 24.5 \quad (3)$$

$\therefore x = 4, y = 3, z = 3$

Volume of CO_2 formed $= x + 2y + 2z = 16$ mL

$\therefore$ Final volume in the absence of KOH

$= 5.5 + 16 = 21.5$ mL

$CO_2 + 2KOH \rightarrow K_2CO_3 + H_2O$

$\frac{16}{22400}$ mole $2 \times \frac{16}{22400} \times 56$

$= 0.08$ g

Comprehension XIV

$(CHO)P \rightarrow PCO + \frac{P}{2} H_2$

2 mL $2p$ mL p mL

$(COOH)_q \rightarrow qCO_2 + \frac{q}{2} H_2$

8 mL $8q$ mL $4q$ mL

Volume of CO_2 formed $= 8q = \frac{8}{17}(3p + 12q)$

$\Rightarrow 5q = 3p$ (1)

$$H_2 \quad + \quad \frac{1}{2} O_2 \quad \Rightarrow \quad H_2O$$

$(p + 4q)$ mL $\frac{1}{2}$ $(p + 4q)$ mL 0

$$CO + \frac{1}{2} O_2 \rightarrow CO_2$$

$2p$ mL p mL $2p$ mL

$\therefore$ Contraction in volume = $\frac{3}{2}$ $(p + 4q) + p = 61$

$\Rightarrow 5p + 12q = 122$ (2)

From equations (1) and (2), we get $p = 10$ and $q = 6$.

Volume of O_2 used in combustion = $\frac{1}{2}$ $(p + 4q) + p = 27$ mL

The increase in volume in initial decomposition

$= (3p - 2) + (12q - 8) = 92$ mL

Comprehension XV

Original solution: V = 1000 mL, mass = 5960 g.

5 m solution $\Rightarrow$ 1000 g water + 5×98 g of H_2SO_4 = 1490 g

$\therefore$ Moles of H_2SO_4 = $\frac{5}{1490} \times 5960 = 20$ and molarity = 20 M.

Final solution: V = 1000 ml and mass = 400 g

Moles of $H_2SO_4 = \frac{\frac{49}{100} \times 400}{98} = 2$

$\Rightarrow$ Molarity = 2 M

$\therefore$ Moles of H_2SO_4 fallen down on the floor

$= 20 - 2 = 18$

Now, $V \times 20 = 1000 \times 2$

$\Rightarrow$ Volume of solution left = 100 mL

$\therefore$ Volume of water added = 1000 – 100 = 900 mL

Section D (Assertion–Reason)

1. If they were not on the same scale, the sum of atomic masses will not be equal to the molecular mass.
2. Same mass, same element and hence, same number of atoms.
3. Mass is conserved. Moles may or may not change.
4. In the given reaction, the total moles of gases is constant during the reaction.
5. $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow x\,CO_2 + \frac{y}{2}\,H_2O$

   and $(x + \frac{y}{4}) > 1$

   $CO + \frac{1}{2} O_2 \rightarrow CO_2$

   and $n_{O_2} < n_{CO}$
6. N_2 is a limiting reagent. H_2 is in excess.
7. Percentage yield can never be more than 100%
8. | | aP + | $bQ \rightarrow cR + dS$ |
   |---|---|---|
   | $t = 0$ | x mole | y mole |
   | $t = t$ | $(x - z)$ mole | $(y - \frac{b}{a}z)$ mole |

   If $\frac{x}{y} = \frac{x - z}{y - \frac{b}{a}z} \Rightarrow \frac{x}{y} = \frac{a}{b}$

   and product will always form in $c : d$ mole ratio.
9. For maximum product formation, none of the reactant should be left.
10. Volume of non-reacting gases is additive only when all the volumes are given at the same P and T.
11. $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

    Contraction in volume $= (1 + x + \frac{y}{4}) - x = (1 + \frac{y}{4})$

    and the contraction is not due to $H_2O(l)$. It is due to the change in moles of gases.
12. For very dilute aqueous solution, the volume of solution is nearly equal to the mass of solvent because the density of water is almost equal to 1.0 g/mL.
13. On changing the unit, the numerical value of concentration may change.
14. w/w and w/v may be equal only when the density of the solution is 1.0 g/mL.
15. Mass is conservative but not the volume.

Section E (Column Match)

1. (A) $Z = \frac{x(z-1)+(100-x)(z+2)}{100}$

$\therefore x = \frac{200}{3} \Rightarrow$ mole per cent of heavier isotope

$= \frac{100}{3}\%$

and mass per cent of heavier isotope

$= \frac{\frac{100}{3}\times(z+2)}{100\times z} \times 100 = \frac{100}{3}\ (1 + \frac{2}{z})\%$

Similarly check other options.

2. (A) mass $= 0.875 \times 32 = 28$ g

Volume $= 0.875 \times 22.4$ L at 0°C and 1 atm.

Number of O-atoms $= 0.875 \times 2 \times 6.0 \times 10^{23}$

$= 1.05 \times 10^{24}$

Similarly check other options.

3. (A) 3 moles of $Co(NH_3)_4SO_4$ contains 3 moles of Co-atoms, 12 moles of N-atoms, 36 moles of H-atoms, 3 moles of S-atoms and 12 moles of O-atoms.

Similarly check other options.

4. a mole of CH_4 + b mole of C_2H_6

Mole ratio of C to H: $\frac{a+2b}{4a+6b} = \frac{2}{7} \Rightarrow \frac{a}{b} = \frac{2}{1}$

$\therefore M_{av} = \frac{2\times16+1\times30}{3} = \frac{62}{3}$

5. Given: $C + O_2 \rightarrow CO_2$ + 100 kcal

$C + \frac{1}{2}\ O_2 \rightarrow CO$ + 25 kcal

(A) $3C + \frac{5}{2}O_2 \rightarrow CO + 2CO_2$

$\therefore$ Heat released $= 1 \times 25 + 2 \times 100 = 225$ kcal

(B) $C + \frac{3}{4}\ O_2 \rightarrow \frac{1}{2}\ CO + \frac{1}{2}\ CO_2$

$\therefore$ Heat released $= \frac{1}{2} \times 25 + \frac{1}{2} \times 100 = 62.5$ kcal

Similarly, check the other options.

6 (A) $C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O$

2 mole 25 mole

$= 25 \times 32 = 800$ g

$= 560$ L at 273 K and 1 atm

$= 25 \times 6.02 \times 10^{23} \times 2 = 3.01 \times 10^{25}$ atoms

Check similarly the other options.

7. $N_2 + 3H_2 \rightarrow 2NH_3$

$\frac{n_{N_2}}{1} = \frac{3.5}{28} = \frac{1}{8}$ and $\frac{n_{H_2}}{3} = \frac{1}{3} \times \frac{1}{2} = \frac{1}{6} > \frac{1}{8}$

Hence, N_2 is L.R.

As H_2 is in excess, the total mass of reactants taken is greater than the mass of NH_3 formed.

Similarly check other options.

8. (A) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1 mole 2 mole

= 44 g $= 2 \times 18 = 36$ g

Similarly check other options.

9. (A) On increasing the mass of metal, the mass of metal halide is increasing but it acquires a maximum value. It is possible only after the complete consumption of halogen. Hence, halogen is L.R.

10. (A) $CH_4 + 20_2 \rightarrow CO_2 + 2H_2O$

80 mL   80 mL

$2CO + O_2 \rightarrow 2CO_2$

20 mL   20 mL

(B) $C_2H_2 + \frac{5}{2}O_2 \rightarrow 2CO_2 + H_2O$

100 mL 250 mL

(C) $H_2S + Cl_2 \rightarrow 2HCl + S$

10 mL 10 mL

(D) $2CO + O_2 \rightarrow 2CO_2$

30 mL 15 mL 30 mL

11. (A) $C_xH_{2x+2} + \frac{3x+1}{2} O_2 \rightarrow xCO_2 + (x+1)H_2O$

(B) $C_xH_{2x+2}O + \frac{3x}{2} O_2 \rightarrow xCO_2 + (x+1)H_2O$

(C) $C_xH_{2x+3}N + \frac{3(2x+1)}{4} O_2$

$\rightarrow xCO_2 + \left(\frac{2x+3}{2}\right)H_2O + \frac{1}{2}N_2$

(D) $C_xH_{2x+2}S + \frac{3(x+1)}{2} O_2$

$\rightarrow xCO_2 + (x+1)H_2O + SO_2$

12. $CO_2, SO_2 \rightarrow CaO$, NaOH

$CO \rightarrow$ Ammoniacal CuCl

$H_2O \rightarrow P_4O_{10}$

13. At 400 K and 1 atm, H_2O will be in vapour form.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O(g)$

50 mL 50 mL 100 mL

14. (P) 1000 g of water + 6.25 × 40 g of NaOH = 1250 g solution

= 1250 mL solution.

$\therefore$ Concentration in g/L $= \frac{250}{1250} \times 1000 = 200$

and concentration in % (w/w) $= \frac{250}{1250} \times 100 = 20$

(Q) 1 mole solution $\equiv \frac{1}{6}$ mole of NaOH + $\frac{5}{6}$ mole of H_2O

$= \frac{1}{6} \times 40 + \frac{5}{6} \times 18 = \frac{130}{6}$ g solution

$\equiv \frac{130/6}{1.3} = \frac{100}{6}$ mL solution

$\therefore$ Concentration in g/L $= \frac{40/6}{100/6} \times 1000 = 400$

and concentration in % (w/w) $= \frac{40/6}{130/6} \times 100$

$= \frac{400}{13}$

15. (A) 1000 g of water + 5 × 40 g of NaOH = 1200 of solution

$\equiv \frac{1200}{0.6} = 2000$ mL solution

$\therefore$ Molarity $= \frac{5}{2000} \times 1000 = 2.5$ M

(D) $Ag^+ + Cl^- \rightarrow AgCl(s)$

$\frac{800 \times \frac{17}{100}}{170} = 0.8$ mole $\quad \frac{100 \times 6}{1000} = 0.6$ mole

Final 0.8 – 0.6 = 0.2 mole 0

$\therefore [Ag^+]_{final} = \frac{0.2}{200} \times 1000$

= 1 M

Section F (Subjective)

Single-digit Integer Type

1. $l^3 = \frac{200}{13.6 \times 6.022 \times 10^{23}}$ cm$^3 \Rightarrow l = 2.90$ Å

2. Moles of A-atoms $= \frac{1.28}{64} = 0.02$

Moles of B-atoms $= \frac{3.0 \times 10^{23}}{6.0 \times 10^{23}}$ 0.5

Moles of C-atoms = 0.04

From the given atomic ratio, A and C are L.R.

$\therefore$ Maximum mass of AB_6C_3 formed

= 1.28 + (0.02 × 6 × 9) + (0.04 × 16) = 3.0 g

3. Moles of X-atoms $= \frac{5.0}{60} = 0.083$

Moles of Y-atoms $= \frac{1.15 \times 10^{23}}{6 \times 10^{23}} = 0.192$

Moles of Z-atoms = 0.03

Hence, L.R. is Z and 0.01 mole of XY_2Z_3 will be formed.

$0.01 = \frac{4.40}{60 + 2A_y + 3 \times 80} \Rightarrow A_y = 70$

4. $\frac{N_D}{N_{Pd}} = \frac{\left(\frac{1120V}{22400} \times N_A\right) \times 2}{\left(\frac{V \times 11.8}{106.2} \times N_A\right)} = \frac{9}{10}$

5. $\dfrac{N_{O_2}}{N_X} = \dfrac{\left(\dfrac{1\times 0.27}{0.08\times 1000\times 300}\times N_A\right)\times 2}{\left(\dfrac{0.18}{64000}\times N_A\right)} = 4$

6. $R(OEt)_x \equiv x$ Et I $\equiv x$ AgI

$\dfrac{37}{176}$ mole $\qquad x\times\dfrac{37}{176} = \dfrac{148}{235} \Rightarrow x \approx 3$

7. $2Fe + \dfrac{3}{2}O_2 \rightarrow Fe_2O_3$

2×56 g $\quad \dfrac{3}{2}\times 32$ g

$\therefore x$ g $\quad \dfrac{3\times 16}{2\times 56}\, x$ g (x = Fraction of iron rusted)

From the question, $\dfrac{3\times 16}{2\times 56}x = 0.1 \Rightarrow x = \dfrac{7}{30}$

8. $2FeS + \dfrac{7}{2}O_2 \rightarrow Fe_2O_3 + 2SO_2\uparrow$

2×88 g $\qquad$ 160 g

From 176 g of FeS, only 160 g of Fe_2O_3 is produced. Hence, the loss in mass = 176 – 160 = 16 g

Now, for 16 g of loss in mass, the mass of FeS in ore = 176 g

$\therefore$ For 4 g of loss, mass of FeS = $\dfrac{176}{6}\times 4 = 44$ g

9. $Na-Hg + HCl(g) \rightarrow NaCl + Hg + \dfrac{1}{2}H_2(g)$

V mL $\qquad \dfrac{V}{2}$ mL

From question, $V - \dfrac{V}{2} = 50 - 40 \Rightarrow V = 20$

Now, 10 mL of mixture will contain HCl(g)

$= \dfrac{20}{50}\times 10 = 4$ mL

and $H_2 = 10 - 4 = 6$ mL

$H_2 + NH_3(g) + HCl(g)$

$\rightarrow H_2 + NH_4Cl(g) \xrightarrow{\text{Water}} H_2(g)$

6 mL

10. Mass of nickel in $NiC_8H_{14}O_4N_4$

$= \dfrac{58.7}{288.7}\times 0.2887 = 0.0587.$

$\therefore$ Percentage of nickel in steel

$\dfrac{0.0587}{1.174}\times 100 = 5\%$

11. $5A^{n+} + (5-n)\ MnO_4^- + (10-8n)H^+ \rightarrow (5-n)\ Mn^{2+} + 5\ AO_3^- + (5-4n)\ H_2O$

5 mole $\quad (5-n)$ mole

$\therefore 2.5\times 10^{-3}$mole MnO_4^- $\dfrac{5-n}{5}\times 2.5\times 10^{-3}$

$= 1.5\times 10^{-3} \Rightarrow n = 2$

12. $6nCO_2 + 5nH_2O \rightarrow (C_6H_{10}O_5)_n + 6nO_2$

$6n$ mole $\qquad 162n$ g

$\dfrac{6n}{162n}\times 0.81 \leftarrow 0.81$g

= 0.03 mole.

$\therefore$ Required time = $\dfrac{0.03}{5\times 10^{-3}} = 6$ hours.

13. Mass of tetraethyl lead needed

$= 500\times 2\times\dfrac{12.96}{1.29}$ g

$4C_2H_5Cl + 4NaPb \rightarrow (C_2H_5)_4Pb + 4NaCl + 3Pb$

4×64.5 g $\qquad$ 324 g

$\therefore$ Mass of ethyl chloride needed

$= \dfrac{4\times 64.5}{324}\times\left(1000\times\dfrac{12.96}{1.29}\right) = 8000$ g = 8 kg

14. Mass of waterproofing film of $[(CH_3)_2SiO]_n$ needed

$= \dfrac{150}{129}\times(500\times 400\times 200\times 3.7\times 10^{-8})$

$= \dfrac{150\times 1.48}{129}$ g

$n(CH_3)_2SiCl_2 + 2nOH^- \rightarrow 2nCl^- + nH_2O + [(CH_3)_2SiO]_n$

$n\times 129$ g $\qquad 74n$ g

$\dfrac{n\times 129}{74n}\times\dfrac{150\times 1.48}{129} = 3$ g $\leftarrow \dfrac{150\times 1.48}{129}$ g

15. Let x moles of MgO and y moles of Mg_3N_2 be formed. From the given reactions,

$2x + 8y = 0.6$ (1)

and $2y = 0.1$ (2)

$y = 0.05,\ x = 0.1$

$\therefore$ Mass of Mg burnt = $(x + 3y)\times 24 = 6$ g

16. Moles of SF_5OF taken $= \frac{PV}{RT} = \frac{0.5 \times 1.642}{0.082 \times 390} = \frac{1}{39}$

$\therefore$ Mass of SF_5ONF_2 produced $= \frac{1}{39} \times \frac{40}{100} \times 195 = 2$ g

17. $LiAlH_4 + 3(CH_3)_3COH \rightarrow Li[(CH_3)_3CO]_3\ AlH + 3H_2$

5 millimole 20 millimole 5 millimole 15 millimole
excess

$Li[(CH_3)_3CO]_3\ AlH + CH_3OH$
$\rightarrow Li[(CH_3)_3\ CO]_3\ [CH_3O]\ Al + H_2$

5 millimole excess 5 millimole

18. Cast iron $\xrightarrow{HCl} H_2S \xrightarrow{Cd^{2+}} CdS \xrightarrow{CuSO_4} CuS \xrightarrow{\text{ignition}} CuO$

Moles of S in iron sample = Moles of CuO

$= \frac{0.795}{79.5} = 0.01$

$\therefore$ Percentage of S in cast iron $= \frac{0.01 \times 32}{6.4} \times 100 = 5\%$

19. $HNF_2(g) + Cl_2(g) + KF(s) \rightarrow ClNF_2(g) + KF\text{-}HCl(s)$

1.3 millimole = a 1.3 millimole = a excess

Final $a - \frac{2}{3}a$ $a - \frac{2}{3}a$ $\frac{2}{3}a$

$= \frac{a}{3}$ $= \frac{a}{3}$

$\therefore$ Volume per cent of $ClNF_2$ (g) in the gaseous mixture after the reaction $= \frac{2/3a}{4/3a} \times 100 = 50\%$

20. Let the sample contains x mole of $MgSO_4 \cdot 7H_2O$ and y mole of $MgCl_2 \cdot 6H_2O$.

Now, $x = \frac{0.699}{233} = 3 \times 10^{-3}$

and $\frac{x}{2} + \frac{y}{2} = \frac{0.888}{222} = 4 \times 10^{-3} \Rightarrow y = 5 \times 10^{-3}$.

Now, the sum of masses of $MgSO_4 \cdot 7H_2O$ and $MgCl_2 \cdot 6H_2O$

$= 3 \times 10^{-3} \times 246 + 5 \times 10^{-3} \times 203 = 1.753$ g

Four digit Integer type

1. Average molecular mass of NH_3

$= 1 \times \left(\frac{3 \times 14 + 1 \times 15}{4}\right) + 3 \times \left(\frac{4 \times 1 + 1 \times 2}{5}\right)$

$= 17.85$

and average number of neutrons per molecule

$= 1 \times \left(\frac{3 \times 7 + 1 \times 8}{4}\right) + 3 \times \left(\frac{4 \times 0 + 1 \times 1}{5}\right) = 7.85$

$\therefore$ Total number of neutrons

$= \frac{1.785 \times 10^{-3}}{17.85} \times 6 \times 10^{23} \times 7.85$

$= 471 \times 10^{18}$

2. Number of H^3-atoms

$= \left(\frac{9.0}{18} \times 6 \times 10^{23}\right) \times 2 \times \left(\frac{8 \times 10^{-8}}{1 + 8 \times 10^{-8}}\right) \approx 48 \times 10^{15}$

3. Number of $-CH_2-CH_2-$ units in a molecule $= \frac{10^6}{28}$

$\therefore$ Length of each polymer molecule

$= \left(2 \times \frac{10^6}{28} - 1\right) \times 154 \times 10^{-12}$ m $= 11 \times 10^{-6}$ m

4. Rating $= \frac{100 \times 1000}{380} = 263.16$

5. Molecular mass of $(C_2F_4)x$

$\Rightarrow 100x = \frac{100}{0.012} \times 32 \Rightarrow x = 2666.6$

6. Mass of carbon burnt $= \frac{50}{20} \times 1000 \times 0.8 \times \frac{84}{100}$

$= 1680$ g

$\therefore$ Mass of CO_2 produced $= \frac{44}{12} \times 1680 = 6160$ g

7. Mole of NO_3^- present $= \frac{1.08}{108} \times 2 = 0.02$

$\therefore$ Mass percentage of NO_3^- group

$= \frac{0.02 \times 62}{2} \times 100 = 62\%$

8. $3H_2C_2O_4 \rightarrow M_4O_3(C_2O_4)_3 \cdot 12H_2O$

3×90 g $(4A + 528)$ g

$\therefore 1$ g $\frac{4A + 528}{270} \times 1 = 3.2 \Rightarrow A = 84$

9. $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

102 g 6×36.5 g 2×133.5 g

Total mass of reactant = $(102 + 6 \times 36.5) = 321$ g

$\therefore$ Mass of $AlCl_3$ formed = $2 \times 133.5 = 267$ g

10. $n_{K_2Cr_2O_7} = \dfrac{75 \times \frac{98}{100}}{294} = 0.25$

and $\dfrac{n_{HCl}}{14} = \dfrac{1}{14} \times \dfrac{365 \times 1.2 \times \frac{28}{100}}{36.5} = 0.24$

Hence, HCl is a limiting reagent.

$\therefore$ Mass of Cl_2 produced = $\dfrac{3 \times 71}{14} \times (0.24 \times 14)$

$= 51.12$ g

11. 2 mole of $F_2 \equiv 4$ mole of $NaF \equiv 2$ mole of CaO

2×38 g 2×56 g

$\therefore$ 1900 kg $\dfrac{2 \times 56}{2 \times 38} \times 1900 = 2800$ kg

$\therefore$ Percentage utilization of lime

$= \dfrac{2800}{10000} \times 100 = 28\%$

12. Let the sample contains x g of $CaCO_3$.

$CaCO_3 \rightarrow CaO + CO_2\uparrow$

100 g   44 g

$\therefore x$ g $\dfrac{44}{100}\, x$ g

Total loss in weight $\Rightarrow 0.44x + (5 - x) \times \dfrac{20}{100}$

$= 1.636 \Rightarrow x = 2.65$

$\therefore$ Percentage of $CaCO_3$ in chalk

$= \dfrac{2.65}{5} \times 100 = 53\%$

13. $2FeS_2 + \dfrac{11}{2} O_2 \rightarrow Fe_2O_3 + 4SO_2$

Mass of Fe_2O_3 formed = $XO_4^- \times 28 = 40$ g.

Mass of SiO_2 present = $100 - \left(\dfrac{120}{56} \times 28\right) = 40$ g

$\therefore$ Final mass of roasted sample = $40 + 40 = 80$ g

14. Maximum moles of NaCl present = $\dfrac{10.7}{58.5}$

Maximum moles of KCl present = $\dfrac{10.7}{74.5}$

Maximum moles of NH_4Cl present = $\dfrac{10.7}{53.5} = 0.2$

Hence, maximum moles of Cl^- ion in the sample in every possible case = 0.2

$Cl^- \;+\; AgNo_3 \;\rightarrow\; AgCl\downarrow \;+\; NO_3^-$

0.2 mole 0.2 mole

$= 0.2 \times 170 = 34$ g

Hence, minimum mass of $AgNo_3$ needed = 34 g

or $(V_{min} \times 1.25) \times \dfrac{8.5}{100} = 34 \Rightarrow V_{min} = 320$ mL

15. Let $CH_4 = x$ mole, $C_2H_6 = y$ mole

From question: $2x + 3y = 42$ (1)

and $x + y = \dfrac{1.5 \times 246}{0.082 \times 300} = 15$ (2)

$\therefore x = 3$ and $y = 12$

Mole per cent of $CH_4 = \dfrac{3}{15} \times 100 = 20\%$

16. $2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2\uparrow + O_2\uparrow$

2×332 g 2×224 g

$\therefore x$ g $\dfrac{224}{332}\, x$ g

$2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2\uparrow$

2×85 g 2×69 g

$\therefore (5 - x)$ g $\dfrac{69}{85} \times (5.02 - x)$ g

From question, $\dfrac{224}{332} x + \dfrac{69}{85} (5.02 - x)$

$= (5.02 - 1.4) \Rightarrow x = 3.32$ g

17. Mass of octane burnt = 2.28 kg

$C_8H_{18} + \dfrac{25}{2} O_2 \rightarrow 8CO_2 + 9H_2O$

114 g $\dfrac{25}{2} \times 32$ g

$\therefore x$ g $\dfrac{25 \times 16}{114}\, x$ g

$$C_8H_{18} \quad + \quad \frac{17}{2} O_2 \quad \rightarrow \quad 8CO \quad + \quad 9H_2O$$

$$114 \text{ g} \qquad \frac{17}{2} \times 32 \text{ g}$$

$$\therefore (2280 - x) \text{ g} \qquad \frac{17 \times 16}{114} (2280 - x) \text{ g}$$

From the question,

$$2280 + \frac{25 \times 16}{114} x + \frac{17 \times 16}{114} (2280 - x) = 9768$$

$\Rightarrow x = 1824$ g

$\therefore$ Percentage of octane converted into CO_2

$$= \frac{1824}{2280} \times 100 = 80\%$$

18. Let CO = x mL, H_2 = y mL

$$CO \quad + \quad \frac{1}{2} O_2 \quad \rightarrow \quad CO_2$$

$$x \text{ mL} \qquad \frac{x}{2} \text{ mL} \qquad x \text{ mL}$$

$$H_2 \quad + \quad \frac{1}{2} O_2 \quad \rightarrow \quad H_2O$$

$$y \text{ mL} \qquad \frac{y}{2} \text{ mL} \qquad 0$$

Contraction in volume, $\frac{x}{2} + \frac{3y}{2} = (100 + 100) - 100$

or $x + 3y = 200$ (1)

and total volume of CO_2, $[100 - (x + y)] + x = 100 - 52.5$

$\therefore y = 52.5$ and $x = 42.5$

Hence, $V_{CO} : V_{H_2} : V_{CO_2} = 42.5 : 52.5 : 5 = 17 : 21 : 2$.

19. $M_{sol} = M_{acetic}$ acid + M_{water}

or $V_{sol} \times \frac{96}{98} = 10 \times 0.8 + 40 \times 1.0$

$\Rightarrow V_{sol} = 49$ mL

$\therefore$ Percentage decrease in volume

$$= \frac{50 - 49}{50} \times 100 = 2\%$$

20. Number of enzyme molecules

$$= \frac{10 \times 10^{-6}}{1000} N_A = 10^{-8} N_A$$

Hence, number of CO_2 molecules hydrated per hour = $10^{-8} N_A \times 10^6 \times 3600$

$\therefore$ Mass of CO_2 hydrated per hour

$$= \frac{36 N_A}{N_A} \times 44 = 1584 \text{ g}$$