5

The Mole Concept

• Type 1 •

Choose the correct option. Only one option is correct.

1. Common salt obtained from sea-water contains 96% NaCl by mass. The approximate number of molecules present in 10.0 g of the salt is
   (a) 10^{21} (b) 10^{22}
   (c) 10^{23} (d) 10^{24}

2. When burnt in air, a 12.0-g mixture of carbon and sulphur yields a mixture of CO_2 and SO_2, in which the number of moles of SO_2 is half that of CO_2. The mass of the carbon the mixture contains is
   (a) 4.08 g (b) 5.14 g
   (c) 8.74 g (d) 1.54 g

3. 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

4. How many moles of $MgIn_2S_4$ can be made from 1.00 g of magnesium (of atomic mass = 24.0), 1.00 g of indium (of atomic mass = 114.8) and 1.00 g of sulphur (of atomic mass = 32.0)?
   (a) 6.74×10^{-4} (b) 3.1×10^{-2}
   (c) 4.17×10^{-2} (d) 8.7×10^{-3}

5. The density of water at 4°C is 1.0×10^3 kg m^{-3}. The volume occupied by one molecule of water is approximately
   (a) 3.0×10^{-23} mL (b) 6.0×10^{-22} mL
   (c) 3.0×10^{-21} mL (d) 9.0×10^{-23} mL

6. When 0.5 mol of $BaCl_2$ is added to 0.2 mol of Na_3PO_4, the number of moles of $Ba_3(PO_4)_2$ formed is
   (a) 0.10 (b) 0.20
   (c) 0.40 (d) 0.15

7. A gaseous mixture contains $CO_2(g)$ and $N_2O(g)$ in a 2 : 5 ratio by mass. The ratio of the number of molecules of $CO_2(g)$ and $N_2O(g)$ is
   (a) 5 : 2 (b) 2 : 5
   (c) 1 : 2 (d) 5 : 4

8. X and Y are two elements which form X_2Y_3 and X_3Y_4. If 0.20 mol of X_2Y_3 weighs 32.0 g and 0.4 mol of X_3Y_4 weighs 92.8 g, the atomic weights of X and Y are respectively
   (a) 16.0 and 56.0 (b) 8.0 and 28.0
   (c) 56.0 and 16.0 (d) 28.0 and 8.0

9. When 1 L of CO_2 is heated with graphite, the volume of the gases collected is 1.5 L. Calculate the number of moles of CO produced at stp.
   (a) $\frac{1}{11.2}$ (b) $\frac{28}{22.4}$
   (c) $\frac{1}{22.4}$ (d) $\frac{14}{22.4}$

10. Sulphur trioxide is prepared by the following two reactions.
$$S_8(s) + 8O_2(g) \longrightarrow 8SO_2(g)$$
$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$
How many grams of SO_3 are produced from 1 mol of S_8?
   (a) 1280.0 (b) 640.0
   (c) 960.0 (d) 320.0

11. A quantity of aluminium has a mass of 54.0 g. What is the mass of the same number of magnesium atoms?
   (a) 12.1 g (b) 24.3 g
   (c) 48.6 g (d) 97.2 g

12. If the atomic weight of carbon is taken to be 6 amu, the value of the Avogadro constant will be
   (a) $12.04 \times 10^{23}\ mol^{-1}$ (b) $3.01 \times 10^{23}\ mol^{-1}$
   (c) $1.5 \times 10^{23}\ mol^{-1}$ (d) $6.02 \times 10^{23}\ mol^{-1}$

13. The charge on 1 gram ion of Al^{3+} is
   (a) $\frac{1}{27} N_A e$ coulomb (b) $\frac{1}{3} \times N_A e$ coulomb
   (c) $\frac{1}{9} N_A e$ coulomb (d) $3 \times N_A e$ coulomb

14. How many moles of HCl will be present in 100 mL of a solution of specific gravity 1.08, containing 20% HCl by mass?

(a) 0.50 (b) 0.60

(c) 0.80 (d) 0.12

15. The density in grams per litre of a mixture containing an equal number of moles of methane and ethane at stp is

(a) 1.03 (b) 1.10

(c) 0.94 (d) 1.20

16. Equal weights of ethane and hydrogen are mixed in an empty vessel at 25°C. The fraction of the total pressure exerted by hydrogen is

(a) $\frac{1}{2}$ (b) $\frac{1}{1}$

(c) $\frac{1}{16}$ (d) $\frac{15}{16}$

17. n mol of N_2 and 0.05 mol of Ar are enclosed in a vessel of capacity 2 L at 1 atm and 27°C. Find n. ($R = 0.082$ L atm mol K^{-1}.)

(a) 0.30 (b) 0.10 (c) 0.03 (d) 0.06

18. 112.0 mL of NO_2 at stp was liquefied, the density of the liquid being 1.15 g mL^{-1}. Calculate the volume of and the number of molecules in the liquid NO_2.

(a) 0.10 mL and 3.01×10^{22} (b) 0.20 mL and 3.01×10^{21}

(c) 0.20 mL and 6.02×10^{23} (d) 0.40 mL and 6.02×10^{21}

19. The mass of 1×10^{22} molecules of $CuSO_4.5H_2O$ is

(a) 4.144 g (b) 8.288 g

(c) 2.648 g (d) 5.295 g

20. A semiconductor $YBa_2Cu_3O_7$ is prepared by a reaction involving Y_2O_3, BaO_2 and CuO. The ratio of their moles should be

(a) 1 : 2 : 4 (b) 1 : 2 : 3

(c) 3 : 2 : 1 (d) 1 : 1.5 : 2.5

21. 254 g of iodine and 142 g of chlorine are made to react completely to give a mixture of ICl and ICl_3. How many moles of each are formed?

(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

22. The number of molecules in 100 mL of 0.02-N H_2SO_4 is

(a) 6.02×10^{20} (b) 6.02×10^{18}

(c) 6.02×10^{21} (d) 6.02×10^{22}

• *Type 2* •

Choose the correct options. More than one option is correct.

39. Which of the following expressions is correct (n = no. of moles of the gas, N_A = Avogadro constant, m = mass of 1 molecule of the gas, N = no. of molecules of the gas)?

(a) $n = mN_A$ (b) $m = nN_A$

(c) $N = nN_A$ (d) $m = mn/N_A$

40. In which of the following pairs do 1 g of each have an equal number of molecules?

(a) N_2O and CO (b) N_2 and C_3O_2

(c) N_2 and CO (d) N_2O and CO_2

41. Among the following, which solutions contain equal numbers of millimoles?

(a) 100 mL of 0.05 M H_2SO_4 (b) 200 mL of 0.05 M NaOH

(c) 100 mL of 0.010 M $Na_2C_2O_4$ (d) 200 mL of 0.025 M KOH

42. 1 mol of $^{14}_{7}N^{-3}$ ions contains

(a) $7N_A$ electrons (b) $7N_A$ protons

(c) $7N_A$ neutrons (d) $14N_A$ protons

43. 11.2 L of a gas at stp weighs 14.0 g. The gas could be

(a) N_2O (b) NO_2

(c) N_2 (d) CO

Answers

1. c	**2.** b	**3.** a	**4.** d	**5.** a
6. a	**7.** b	**8.** c	**9.** c	**10.** b
11. c	**12.** b	**13.** d	**14.** b	**15.** a
16. d	**17.** c	**18.** b	**19.** a	**20.** b
21. b	**22.** a	**23.** c	**24.** a	**25.** b
26. d	**27.** b	**28.** a	**29.** b	**30.** a
31. c	**32.** a	**33.** c	**34.** b	**35.** d
36. a	**37.** b	**38.** a	**39.** b, c	**40.** c, d
41. a, d	**42.** b, c	**43.** c, d		

Hints to More Difficult Problems

4. The number of moles of Mg, In, and S are respectively $\frac{1}{24}$, $\frac{1}{114.8}$ and $\frac{1}{32}$ = 0.0417, 0.0087 and 0.031. The number of moles of the limiting reagent is $0.0087 = 8.7 \times 10^{-3}$.

5. $N = nN_A$.

$1 = n \times 6.02 \times 10^{23}$ or $n = 1.66 \times 10^{-24}$ g

or $\text{wt} = n \cdot (\text{Mol. wt.}) = 1.66 \times 10^{-24}$ mol $\times$ 18.0 g mol^{-1}

$= 3.0 \times 10^{-23}$ g.

8. Molecular weight of $X_2Y_3 = \frac{32.0 \text{ g}}{0.2 \text{ mol}} = 160 \text{ g mol}^{-1}$.

Molecular weight of $X_3Y_4 = \frac{92.8 \text{ g}}{0.4 \text{ mol}} = 232 \text{ g mol}^{-1}$.

Let atomic weight of X be a and that of Y be b. Then $2a + 3b = 160$ and $3a + 4b = 232$.

Solving, we get

$a = 56$ and $b = 16$.

9. $\underset{1-x}{CO_2(g)} + C(s) \longrightarrow \underset{2x}{2CO(g)}$

According to the question,

$$1 - x + 2x = 1.5 \Rightarrow x = 0.5 \text{ L} \Rightarrow 2x = 1.0 \text{ L} = 1/22.4 \text{ mol.}$$

13. 1 gram ion means 1 mole.

$\therefore$ charge $= 3 \times N_A \times e$ coulomb.

14. Wt. of HCl solution $= 100 \times 1.08 = 108.0$ g

Wt. of HCl $= \frac{20}{100} \times 108.0 = 21.6$ g

$\therefore$ no. of moles of HCl $= \frac{21.6}{36.5} \approx 0.6$.

16. Let the total weight be x.

The fraction of the total pressure $= \frac{\frac{1}{2x}}{\frac{1}{2}x + \frac{1}{30}x} = \frac{15}{16}$.

18. $W_{NO_2} = \frac{112.0 \text{ mL} \times 46.0 \text{ g mol}^{-1}}{22400 \text{ mL mol}^{-1}} = 0.23$ g.

$V_{NO_2,l} = \frac{0.23 \text{ g}}{1.15 \text{ g mL}^{-1}} = 0.20$ mL.

$N = mN_A = \frac{0.23}{46} \times 6.02 \times 10^{23} = 3.01 \times 10^{21}$.

22. 100.0 mL of 0.02 $H_2SO_4 = 100 \times 0.02$ m eq. $= 2$ m eq. $= 1$ m mol
$= 1 \times 10^{-3} \times 6.02 \times 10^{23} = 6.02 \times 10^{20}$ molecules.

31. No. of moles of A $= \frac{x}{40}$.

Number of atoms of A $= \frac{x}{40} \times N_A = y$ (say) or $x = \frac{40y}{N_A}$.

No. of moles of B $= \frac{2x}{80}$.

No. of atoms of B $= \frac{2x}{80} N_A = \frac{2}{80} \times \frac{40y}{N_A} N_A = y$

33. Molarity of NaCl $= \frac{5.85}{58.5} = 0.1$ M.

1 mL of NaCl $= 10^{-4}$ mol.
1 mole of NaCl $= 6.02 \times 10^{23}$ molecules of NaCl.
But NaCl molecules are dissociated into two ions (Na^+ and Cl^-).
1 mol of NaCl $= 6.02 \times 10^{23} \times 2$ ions.
1×10^{-4} mole of NaCl $= 1 \times 10^{-4} \times 6.02 \times 10^{23} \times 2$ ions
$= 1.2 \times 10^{20}$ ions.

34. Energy $= 0.0024 \times 931.5$ MeV $= 2.2$ MeV.

35. Mass of 1 mole $= 1.675 \times 10^{-27} \times 6.02 \times 10^{23}$ kg
$= 1.008 \times 10^{-3}$ kg

36. No. of moles of $H_2SO_4 = \frac{0.392}{98} = 0.004$.

$N = nN_A \Rightarrow n = \frac{N}{N_A} = \frac{1.204 \times 10^{21} \text{ molecules}}{6.02 \times 10^{23} \text{ molecules}} = 0.002$.

No. of moles of H_2SO_4 left $= 0.004 - 0.002 = 0.002 = 2.0 \times 10^{-3}$.

38. Let the number of moles of C_2H_4 and C_3H_8 be x and y respectively. Using the formula

$pV = nRT$,

1 atm $\times$ 0.820 L $= (x + y)$ mol $\times$ 0.082 L-atm K^{-1} $mol^{-1} \times 300$ K

or $x + y = \frac{1}{30}$. (i)

Again, $28x + 44y = 0.613$. (ii)

Solving, we get $\frac{y}{x} = 1.54$.

43. Calculate mol. wt. $= \frac{W}{V} \times 22.4 = \frac{14.0}{11.2} \times 22.4 = 28$ g mol^{-1}.

This molecular weight corresponds to $N_2(g)$ and $CO(g)$.

❑

6

Calculations Based on Chemical Equations and Eudiometry

• Type 1 •

Choose the correct option. Only one option is correct.

1. 1.00×10^{-3} mol of Ag^+ and 1.00×10^{-3} mol of CrO_4^{2-} react together to form solid Ag_2CrO_4. Calculate the amount of Ag_2CrO_4 formed ($Ag_2CrO_4 = 331.73$ g mol^{-1}).
   (a) 0.268 g (b) 0.166 g
   (c) 0.212 g (d) 1.66 g

2. 1.00 g of $Cr_2O_7^{2-}$ is oxidized 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 produced for this reaction to occur ($Cr_2O^{2-} = 216$)?
   (a) 0.0231 (b) 0.0282
   (c) 0.0322 (d) 0.0268

3. In an acidic solution, I^- changes to I_2. How many grams of I_2 are produced if, in the same process, 1.5×10^{22} electrons are used up to reduce H_3AsO_4 to H_3AsO_3 (I = 127)?
   (a) 1.6 g (b) 6.4 g
   (c) 4.8 g (d) 3.2 g

4. What would be the weight of the slaked lime required to decompose 8.0 g of ammonium chloride?
   (a) 5.53 g (b) 2.12 g (c) 15.52 g (d) 7.62 g

5. The number of moles of $Cr_2O_7^{2-}$ needed to oxidize 0.136 equivalent of $N_2H_5^+$ through the reaction
   $$N_2H_5^+ + Cr_2O_7^{2-} \longrightarrow N_2 + Cr^{3+} + H_2O$$
   is
   (a) 0.236 (b) 0.087 (c) 0.136 (d) 0.488

6. On being strongly heated, 2.76 g of Ag_2CO_3 yields a residue weighing
   (a) 3.48 g (b) 1.44 g
   (c) 2.16 g (d) 4.16 g

7. An impure sample of silver weighing 2.50 g is dissolved in HNO_3 and the silver is precipitated to yield 2.50 g of AgCl. What is the percentage by weight of silver in the original sample (Ag = 108, Cl = 35.5)?
   (a) 75.26 (b) 100.00
   (c) 50.26 (d) 88.45

8. Sulphuric acid is produced when sulphur dioxide reacts with oxygen and water in the presence of a catalyst.
   $$2SO_2(g) + O_2(g) + 2H_2O(l) \longrightarrow 2H_2SO_4(aq)$$
   If 5.6 mol of SO_2 reacts with 4.8 mol of O_2 and a large excess of water, what is the maximum number of moles of H_2SO_4 that can be obtained?
   (a) 5.6 (b) 11.2
   (c) 2.4 (d) 1.4

9. 8.7 g of pure MnO_2 is heated with an excess of HCl and the gas evolved is passed into a solution of KI. Calculate the weight of the iodine liberated (Mn = 55, Cl = 35.5, I = 127).
   (a) 7.7 g (b) 15.4 g
   (c) 12.7 g (d) 25.4 g

10. Equal weights (1.00 g) of iron and sulphur are heated together and react to form FeS. What fraction of the original weight is left unreacted (Fe = 55.85 g mol^{-1}, S = 32.10 g mol^{-1})?
    (a) 0.225 (b) 0.425
    (c) 0.875 (d) 0.575

11. Pure FeS_2 is burnt with 60% excess air. Calculate the percentage of N_2 by volume after the reaction.
    (a) 81.94 (b) 9.89
    (c) 8.17 (d) 89.26

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

13. An ammonium sulphate solution of concentration 0.05 kg mol^{-1} reacts with calcium hydroxide. How many litres of a solution (specific gravity 0.92) containing 20.5% by weight of ammonia can be prepared using this reaction?
    (a) 12.0 L (b) 9.0 L (c) 18.0 L (d) 4.5 L

14. Calculate the number of millilitres (at stp) of hydrogen sulphide needed to precipitate cupric sulphide completely from 100 mL of a solution containing 0.75 g of $CuCl_2$ in a 1-L solution.
    (a) 21.4 (b) 14.2
    (c) 41.2 (d) 12.4

15. Aluminium metal is prepared by the electrolysis of a solution of Al_2O_3 in molten cryolite (Na_3AlF_6). Assuming that all of the aluminium comes from Al_2O_3, how much of the latter would be needed for each tonne of aluminium produced (Al = 27, O = 16)?
    (a) 1.88 tonne (b) 2.88 tonne
    (c) 1.68 tonne (d) 1.44 tonne

16. $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$
    $3SO_2 + 2HNO_3 + 2H_2O \longrightarrow 3H_2SO_4 + 2NO$
    According to the above sequence of reactions, how much H_2SO_4 will 1146 g of PbS produce?
    (a) 245.2 g (b) 490.4 g
    (c) 484.6 g (d) 409.5 g

17. An alloy of aluminium and copper is treated with aqueous HCl. The aluminium dissolves according to the reaction
    $$Al + 3H^+ \longrightarrow Al^{3+} + \frac{3}{2}H_2$$
    but the copper remains as pure metal. A 0.50-g sample of the alloy gives 560 mL of H_2 at stp. The percentage of aluminium by weight in the alloy is (Al = 27)
    (a) 90 (b) 85
    (c) 78 (d) 96

18. An ore contains 2.0% of the mineral argentite (Ag_2S) by weight. How much of this ore will have to be processed to obtain 1.00 g of pure solid silver (Ag = 108, S = 32)?
    (a) 45.7 g (b) 67.4 g
    (c) 57.4 g (d) 87.6 g

19. An organic compound contains 20 atoms of carbon per molecule, the percentage of carbon by weight being 70. The gram molecular mass of the organic compound is approximately
    (a) 465.0 (b) 365.0
    (c) 415.0 (d) 667.0

20. What is the maximum amount of nitrogen dioxide that can be produced by mixing 4.2 g of NO(g) and 3.2 g of O_2(g)?
    (a) 4.60 g (b) 2.30 g
    (c) 3.22 g (d) 6.44 g

21. Calculate the volume required of a 20.0% HCl solution of density $1.20\ g\ mL^{-1}$ to prepare 363.0 g of $AsCl_3$ according to the equations (As = 75, Cl = 35.5)

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

and $$2As + 3Cl_2 \rightarrow 2AsCl_3$$

is

(a) 2.56 L (b) 0.73 L

(c) 1.46 L (d) 2.92 L

22. 1 L of an acidified solution containing 31.6 g of $KMnO_4$ is decolourized by passing SO_2 through it. How much iron pyrites (FeS_2) has to be roasted to produce the necessary amount of SO_2 (K = 39, Mn = 55, S = 32, Fe = 56)?

(a) 30.0 g (b) 7.5 g

(c) 15.0 g (d) 45.0 g

23. 2.0 g of dolomite was heated to a constant weight of 1.0 g. Calculate the total volume of the CO_2 produced at stp (Ca = 40, Mg = 24, C = 12, O = 16) by this reaction.

(a) 482.4 mL (b) 502.6 mL

(c) 492.8 mL (d) 428.6 mL

24. 1 g of a mixture of $NaHCO_3$ and Na_2CO_3 is heated to 150°C. The volume of the CO_2 produced at stp is 112.0 mL. Calculate the percentage of Na_2CO_3 in the mixture (Na = 23, C = 12, O = 16).

(a) 20 (b) 46

(c) 84 (d) 16

25. 2 g of impure $CaCO_3$ reacts with HCl to produce 410 mL of CO_2 at 1 atmospheric pressure and 27°C. Calculate the percentage purity of the $CaCO_3$ used.

(a) 83.5 (b) 97.5

(c) 87.5 (d) 73.5

26. 60 g of NaOH is converted into NaCl and $NaClO_3$ by the action of Cl_2. The Cl_2 is produced by the reaction between MnO_2 and concentrated HCl. The amount of MnO_2 required for the process (Mn = 55, Na = 23) is

(a) 70.95 g (b) 25.65 g

(c) 65.25 g (d) 75.45 g

27. The atomic weight of Cu is 63.546. There are only two naturally occurring isotopes of copper, ^{63}Cu and ^{65}Cu. The natural abundance of the ^{63}Cu isotope is approximately

(a) 20% (b) 70%

(c) 30% (d) 80%

28. 15.0 mL of N_2O is passed over heated copper. The volume of the $N_2(g)$ obtained is

(a) 15.0 mL (b) 7.5 mL

(c) 30.0 mL (d) 45.0 mL

29. A mixture of CH_4 and C_2H_4 was completely burnt in an excess of oxygen, yielding equal volumes of CO_2 and steam. Calculate the percentages of the compounds in the original mixture.

(a) 25% CH_4 and 75% C_2H_4 (b) 30% CH_4 and 70% C_2H_4

(c) 75% CH_4 and 25% C_2H_4 (d) 50% CH_4 and 50% C_2H_4

30. 1 mol of a gaseous aliphatic compound $C_nH_{3n}O_m$ is completely burnt in an excess of oxygen. The contraction in volume 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) $\left(1+\frac{3}{4}n-\frac{1}{2}m\right)$

31. 10.0 mL of a gaseous organic compound containing C, H and O was mixed with 100.0 mL of oxygen gas, causing an explosion. The volume of the gas after the explosion was 90.0 mL. On treatment with a KOH solution, a further contraction in volume was observed. Calculate the number of moles of the carbon dioxide produced.

(a) 1.0 (b) 3.0

(c) 2.0 (d) 4.0

32. 40.0 mL of a gaseous mixture of CO and C_2H_2 is mixed with 100.0 mL of O_2 and burnt. The volume of the gas after the combustion is 10.5 mL. Calculate the composition of the original mixture.

(a) 25 mL of CO and 15 mL of C_2H_2

(b) 15 mL of CO and 25 mL of C_2H_2

(c) 10 mL of CO and 30 mL of C_2H_2

(d) 20 mL of CO and 20 mL of C_2H_2

33. What is the volume of air required for the complete combustion of 20.0 L of methane?

(a) 840 L (b) 240 L

(c) 240 L (d) 192 L

34. 200.0 mL of oxygen is added to 100.0 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 245.0 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

35. 80 mL of oxygen is added to 50 mL of a mixture of H_2, C_2H_2 and CO, after which the total mixture is burnt. The volume of the cooled mixture after combustion measures 65 mL. This is reduced to 15 mL by treatment with a KOH solution. Calculate the volume of each gas in the original mixture.

(a) 20 mL of H_2, 20 mL of C_2H_2, 10 mL of CO

(b) 10 mL of H_2, 20 mL of C_2H_2, 20 mL of CO

(c) 15 mL of H_2, 15 mL of C_2H_2, 20 mL of CO

(d) 20 mL of H_2, 25 mL of C_2H_2, 5 mL of CO

36. 30 mL of a gaseous hydrocarbon requires 90 mL of O_2 for complete combustion, 60 mL of CO_2 being formed in the process. The molecular formula of the hydrocarbon is

(a) C_2H_2 (b) C_3H_8

(c) C_4H_{10} (d) C_2H_4

37. 50 mL of a mixture of C_2H_4 and C_2H_2 was mixed with 150 mL of O_2 and burnt. The volume of the cooled mixture of gases after the combustion is 112.5 mL. The percentage of C_2H_4 in the original mixture is

(a) 75 (b) 60

(c) 50 (d) 40

38. 12 mL of the vapour of a certain organic compound containing only carbon, hydrogen and oxygen is heated. After being cooled to the original room temperature, its volume becomes 100 mL. Treatment with aqueous KOH removes CO_2, leaving 88 mL of O_2. The empirical formula of the vapour is

(a) C_3H_6O (b) CH_2O

(c) C_2H_4O (d) $C_2H_4O_2$

39. A volume V of a gaseous hydrocarbon was exploded with an excess of oxygen. The observed contraction was $2\frac{1}{2}V$, 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

40. 20 mL of a gaseous hydrocarbon was exploded with 120 mL of oxygen. A contraction of 60 mL was observed, and a further contraction of 60 mL took place when an alkali was added. What is the formula of the hydrocarbon?

(a) C_3H_6 (b) C_3H_8

(c) C_2H_6 (d) C_4H_{10}

41. 2 g of a mixture of Cu_2O and CuO was quantitatively reduced to 1.7 g of metallic copper. Calculate the weight of CuO in the original sample (Cu = 63.5, O = 16)?

(a) 0.85 g (b) 0.55 g (c) 0.75 g (d) 0.95 g

42. A gaseous mixture of ethene and ethyne measuring 50 mL is mixed with 150 mL of O_2 and burnt. After combustion and cooling, the volume of the mixture of gases is 112.5 mL. Calculate the percentage by volume of ethene in the mixture.

(a) 75 (b) 60

(c) 50 (d) 80

43. 50.0 mL of a gaseous mixture of H_2 and HCl is exposed to a sodium amalgam. The volume decreases to 42.5 mL. If 100.0 mL of the same mixture is added to 50.0 mL of gaseous ammonia and then exposed to water, what will be the volume of the final mixture?

(a) 35.0 mL (b) 50.0 mL

(c) 15.0 mL (d) 70.0 mL

44. A gaseous organic compound containing C, H and N, which is completely burnt in an excess of oxyen, produces

(a) x vol. of $CO_2(s) + \frac{y}{2}$ vol. of $H_2O(g)\ \frac{z}{2}$ vol. of $NO_2(g)$

(b) x vol. of $CO_2(g) + \frac{y}{2}$ vol. of $H_2O(l)\ \frac{z}{2}$ vol. of $N_2(g)$

(c) x vol. of $CO_2 + \frac{y}{2}$ vol. of $H_2O(l)$

(d) x vol. of $CO_2(s) + \frac{y}{2}$ vol. of $H_2O(s) + z$ vol. of $N_2(g)$

45. Three volumes of a gaseous hydrocarbon containing carbon, hydrogen and sulphur is burnt in an excess of oxygen to yield three volumes of CO_2, three volumes of SO_2 and six volumes of water vapour. The formula of the compound is

(a) C_6H_6S (b) C_4H_4S (c) CH_4S (d) C_2H_6S

• *Type 2* •

Choose the correct options. More than one option is correct.

46. Calculate the amount of lime (CaO) produced by heating 100 g of 90% pure limestone.

(a) 50.4 g (b) 0.98 mol

(c) 0.90 mol (d) 56.0 g

47. 2 mol of CO_2 is required to prepare

(a) 336 g of $NaHCO_3$ (b) 168 g of $NaHCO_3$

(c) 462 g of $Ca(HCO_3)_2$ (d) 162 g of $Ca(HCO_3)_2$

48. 1.5 g of oxygen is produced by heating $KClO_3$. How much KCl is produced in the reaction?

(a) 4.15×10^{-2} mol (b) 4.33 g

(c) 1.78×10^{-2} mol (d) 1.33 g

49. Which of the following gases are absorbed by an ammoniacal cuprous chloride solution?

(a) NO (b) CO

(c) O_3 (d) C_2H_2

50. 50 millilitres of CO is mixed with 20 mL of oxygen and sparked. After the reaction, the mixture is treated with an aqueous KOH solution. Choose the correct option.

(a) The volume of the CO that reacts = 40 mL.

(b) The volume of the CO_2 formed = 40 mL.

(c) The volume of the CO that remains after treatment with KOH = 10 mL.

(d) The volume of the CO that remains after treatment with KOH = 20 mL.

Answers

1. b	**2.** a	**3.** d	**4.** a	**5.** c
6. c	**7.** a	**8.** a	**9.** d	**10.** b
11. a	**12.** c	**13.** b	**14.** d	**15.** a
16. b	**17.** a	**18.** c	**19.** b	**20.** d
21. c	**22.** a	**23.** c	**24.** d	**25.** a
26. c	**27.** b	**28.** a	**29.** d	**30.** d
31. c	**32.** a	**33.** d	**34.** b	**35.** a
36. d	**37.** c	**38.** b	**39.** a	**40.** b
41. a	**42.** c	**43.** d	**44.** b	**45.** c
46. a, c	**47.** a, d	**48.** c, d	**49.** b, d	**50.** a, b, c

Hints to More Difficult Problems

1. The reaction is $2Ag^+ + CrO_4^{2-} \longrightarrow Ag_2CrO_4$. Using the limiting-reagent concept, no. of moles of $Ag_2CrO_4 = 0.5 \times 10^{-3} \times 331.73 = 0.166$ g.

2. The reaction is

   $Cr_2O_7^{2-} + 3SO_2 + 5H^+ \longrightarrow 3HSO_4^- + 2Cr^{3+} + H_2O$

   No. of moles of $H^+ = \frac{1.0}{216} \times 5 = 0.0231$ $\quad [Cr_2O_7^{2-} = 2 \times 52 + 7 \times 16 = 216]$

4. $2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$

   2×53.5 g $\quad (40 + 34)$ g

   Wt. of $Ca(OH)_2$ required $= \frac{74}{107} \times 8 = 5.53$ g.

7. Since the weights of the sample and the precipitated AgCl are equal, the required amount is given by the

   weight percentate of silver in AgCl $= \frac{108}{108 + 35.5} \times 100 = 75.25$

9. $MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2$

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

   The number of moles of MnO_2 equals that of I_2.

   Thus, 87 g liberates 254 g of I_2.

   Therefore 8.7 g of MnO_2 corresponds to 25.4 g of I_2.

10. Use the limiting-reagent concept.

	Fe	+ S	$\longrightarrow$ FeS
	1/55.85	1/32.1	
no. of moles $\longrightarrow$	0.017905	0.031153	0.017905

    Unreacted sample $= 0.031153 - 0.017905 = 0.013248$

    Weight of unreacted sample $= 0.013248 \times 32.1$ g $= 0.425$ g

12. 100 kg of weak liquor (feed) contains 4 kg of caustic soda. Let the quantity of the lye be x kg. Then the amount of caustic soda in the lye $= 0.25\,x$. However caustic soda does not take part in the evaporation

    $\therefore \quad 0.25\,x = 4 \Rightarrow x = 16$ kg

    The weight of the water that evaporates $= 100.0 - 16.0 = 84.0$ kg

17. 1.5×22400 mL of H_2 at stp $= 27$ g of Al

    560 mL of H_2 at stp $= 0.45$ g of Al

    $\therefore$ Percentage of Al $= \frac{0.45}{0.50} \times 100 = 90$

18. Ag_2S has two atoms of Ag.

    Therefore, 216 g of Ag corresponds to 248 g of Ag_2S.

    1 g of Ag is contained in $= \frac{248}{216}$ g of Ag_2S

wt. of the ore $= \frac{248}{216} \times \frac{100}{2} = 57.4$ g

19. Gram molecular mass of carbon

$$= \frac{\text{no. of atoms} \times \text{At. mass of C} \times 1 \text{ amu} \times N_A}{\text{percentage of carbon}}$$

$$= \frac{20 \times 12 \times 1.66 \times 10^{-24} \text{ g} \times 6.02 \times 10^{23} \text{ mol}^{-1}}{70/100}$$

$$= 365.0 \text{ g mol}^{-1}$$

20. No. of moles of NO $= \frac{4.2 \text{ g}}{30} = 0.14$

No. of moles of $O_2 = \frac{3.2 \text{ g}}{32} = 0.10$

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

Using the limiting reagent concept,

$W_{NO_2} = 0.14 \text{ mol} \times 46 \text{ g mol}^{-1}$

$= 6.44$ g

22. $4FeS_2 + 11O_2 \longrightarrow 2Fe_2O_3 + 8SO_2$

$2KMnO_4 + 5SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2MnSO_4 + 2H_2SO_4$

$\frac{8}{5}(2KMnO_4) \equiv 8SO_2 \equiv 4FeS_2$

$\frac{16}{5}$ mol of $KMnO_4 \equiv 4$ mol of FeS_2

No. of moles of $KMnO_4 = \frac{31.6}{158} = 0.2$

0.2 mol of $KMnO_4 \equiv \frac{4}{16/5} \times 0.2$ mol of FeS_2

$= \frac{1}{4}$ mol of $FeS_2 = \frac{1}{4} \times 120$ g

$= 30.0$ g

23.

$CaCO_3 \longrightarrow$	CaO	$+ CO_2$	$MgCO_3 \longrightarrow$	MgO	$+ CO_2$
100.0 g	56.0 g		84.0 g	40.0 g	
x g	$\frac{56}{100}x$ g		$(2.0 - x)$ g	$\frac{40.0}{84.0}(2.0 - x)$ g	

According to the question,

$\frac{56.0}{100.0}x + \frac{40.0}{84.0}(2.0 - x) = 1 \quad \therefore \quad x = 1.0$ g $\quad 2.0 - x = 1.0$ g

Total no. of moles of $CO_2 = \frac{1.0}{100.0} + \frac{1.0}{84.0} = 0.022$

$= 0.022 \times 22.4 \text{ L} = 492.8 \text{ mL}$

24. $2NaHCO_3 \xrightarrow{150^\circ C} Na_2CO_3 + CO_2 + H_2O$

$\frac{n_{NaHCO_3}}{n_{CO_2}} = \frac{2}{1}$

$n_{NaHCO_3} = 2n_{CO_2} = 2 \times \frac{112}{22400} = 0.01$ mole

$W_{NaHCO_3} = 0.01 \times 84 = 0.84$ g

$W_{Na_2CO_3} = 1.00 - 0.84 = 0.16$ g

% $Na_2CO_3 = 16$

25. $n_{CO_2} = \frac{pV}{RT} = \frac{(1 \text{ atm})(0.410 \text{ L})}{(0.082 \text{ L atm mol}^{-1} \text{ K}^{-1})(300 \text{ K})} = 0.0167$ mol

1 mol of CO_2 accounts for 1 mol of $CaCO_3$ = 100 g of $CaCO_3$

0.0167 mol of CO_2 = 1.67 g of $CaCO_3$

Percentage purity of $CaCO_3 = \frac{1.67}{2.00} \times 100 = 83.5$

26. $[MnO_2 + 4HCl \longrightarrow MnCl_2 + 2H_2O + Cl_2] \times 3$

$3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$

$6NaOH \equiv 3MnO_2$

$6 \times 40 \text{ g} = 3 \times 87 \text{ g}$

3 mol of MnO_2 accounts for 12 mol of HCl and 6 mol of NaOH.

$\frac{60}{40}$ mol of NaOH accounts for 0.75 mol of MnO_2

$= 0.75 \text{ mol} \times 87 \text{ g mol}^{-1}$

$= 65.25$ g

30. $C_nH_{3n}O_m(g) + \left(n + \frac{3}{4}n - \frac{m}{2}\right)O_2(g) \longrightarrow nCO_2(g) + \frac{3}{2}n\,H_2O(l)$

Contraction of volume $= 1 + n + \frac{3}{4}n - \frac{m}{2} - n = \left(1 + \frac{3}{4}n - \frac{m}{2}\right)$

31. $C_xH_yO_z(g) + \left(x + \frac{y}{4} - \frac{z}{2}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

10.0 mL $\quad 10\left(x + \frac{y}{4} - \frac{z}{2}\right)$ mL $\quad 10x$ mL $\quad$ zero

Volume of CO_2 produced $= 10x = 20 \Rightarrow x = 2$

33. $\underset{20.0 \text{ L}}{CH_4(g)} + \underset{40.0 \text{ L}}{2O_2(g)} \longrightarrow CO_2(g) + 2H_2O(l)$

20.8 L of $O_2 \equiv$ 100.0 L of air

40.0 L of $O_2 \equiv$ 192.0 L of air

36. $C_xH_y(g) + \left(x+\frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

mL $\longrightarrow$ 30.0 $\quad 30.0\left(x+\frac{y}{4}\right) \quad 30.0x$

According to the question $30.0\,x = 60.0 \Rightarrow x = 2$

and $30.0\left(x+\frac{y}{4}\right)O_2\text{ mL} = 90.0\text{ mL } O_2$

or $y = 4$

Therefore, the molecular formula of hydrocarbon = C_2H_4.

43. $Na/Hg + \underset{2\text{ mol}}{2HCl(g)} \longrightarrow 2NaCl + \underset{1\text{ mol}}{H_2} + 2Hg$

Contraction in volume = 50.0 – 42.5 = 7.5 mL of $H_2(g)$

1 mol of $H_2(g) \equiv 2$ mol of HCl(g)

7.5 mL of $H_2(g) \equiv 15$ mL of HCl(g)

Volume of H_2 = 50.0 – 15.0 = 35.0 mL

Volume of H_2 in 100.0 mixture = $\frac{100 \times 35}{50} = 70.0$ mL

44. The reaction is

$$C_xH_yN_z(g) + \left(x+\frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l) + \frac{1}{2}zN_2(g)$$

45. The reaction is

$$C_xH_yS_z(g) + \left(x+\frac{y}{4}+z\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(g) + zSO_2(g)$$

50. The reaction is

$$\underset{2\text{ Vol}}{2CO(g)} + \underset{1\text{ Vol}}{O_2(g)} \longrightarrow \underset{2\text{ Vol}}{2CO_2(g)}$$

$\quad 40.0\text{ mL} \quad 20.0\text{ mL} \quad 40.0\text{ mL}$

Volume of CO(g) that reacts = 40.0 mL

Volume of $CO_2(g)$ formed = 40.0 mL

Volume of CO(g) removed after treatment with KOH

= 50 mL – 40 mL = 10.0 mL

❑