

# 5

## The Mole Concept

### • Type 1 •

Choose the correct option. Only one option is correct.

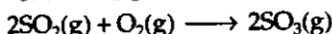
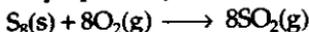
- Common salt obtained from sea-water contains 96% NaCl by mass. The approximate number of molecules present in 10.0 g of the salt is
  - $10^{21}$
  - $10^{22}$
  - $10^{23}$
  - $10^{24}$
- When burnt in air, a 12.0-g mixture of carbon and sulphur yields a mixture of  $\text{CO}_2$  and  $\text{SO}_2$ , in which the number of moles of  $\text{SO}_2$  is half that of  $\text{CO}_2$ . The mass of the carbon the mixture contains is
  - 4.08 g
  - 5.14 g
  - 8.74 g
  - 1.54 g
- In an experiment, it is found that 2.0769 g of pure X produces 3.6769 g of pure  $\text{X}_2\text{O}_5$ . The number of moles of X is
  - 0.04
  - 0.06
  - 0.40
  - 0.02
- How many moles of  $\text{MgIn}_2\text{S}_4$  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)?
  - $6.74 \times 10^{-4}$
  - $3.1 \times 10^{-2}$
  - $4.17 \times 10^{-2}$
  - $8.7 \times 10^{-3}$
- The density of water at  $4^\circ\text{C}$  is  $1.0 \times 10^3 \text{ kg m}^{-3}$ . The volume occupied by one molecule of water is approximately
  - $3.0 \times 10^{-23} \text{ mL}$
  - $6.0 \times 10^{-22} \text{ mL}$
  - $3.0 \times 10^{-21} \text{ mL}$
  - $9.0 \times 10^{-23} \text{ mL}$

6. When 0.5 mol of  $\text{BaCl}_2$  is added to 0.2 mol of  $\text{Na}_3\text{PO}_4$ , the number of moles of  $\text{Ba}_3(\text{PO}_4)_2$  formed is
- (a) 0.10 (b) 0.20  
(c) 0.40 (d) 0.15
7. A gaseous mixture contains  $\text{CO}_2(\text{g})$  and  $\text{N}_2\text{O}(\text{g})$  in a 2 : 5 ratio by mass. The ratio of the number of molecules of  $\text{CO}_2(\text{g})$  and  $\text{N}_2\text{O}(\text{g})$  is
- (a) 5 : 2 (b) 2 : 5  
(c) 1 : 2 (d) 5 : 4
8. X and Y are two elements which form  $\text{X}_2\text{Y}_3$  and  $\text{X}_3\text{Y}_4$ . If 0.20 mol of  $\text{X}_2\text{Y}_3$  weighs 32.0 g and 0.4 mol of  $\text{X}_3\text{Y}_4$  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  $\text{CO}_2$  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.



How many grams of  $\text{SO}_3$  are produced from 1 mol of  $\text{S}_8$ ?

- (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)  $12.04 \times 10^{23} \text{ mol}^{-1}$  (b)  $3.01 \times 10^{23} \text{ mol}^{-1}$   
(c)  $1.5 \times 10^{23} \text{ mol}^{-1}$  (d)  $6.02 \times 10^{23} \text{ mol}^{-1}$

13. The charge on 1 gram ion of  $\text{Al}^{3+}$  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  $3.01 \times 10^{22}$  (b) 0.20 mL and  $3.01 \times 10^{21}$   
(c) 0.20 mL and  $6.02 \times 10^{23}$  (d) 0.40 mL and  $6.02 \times 10^{21}$
19. The mass of  $1 \times 10^{22}$  molecules of  $CuSO_4 \cdot 5H_2O$  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)  $6.02 \times 10^{20}$  (b)  $6.02 \times 10^{18}$   
(c)  $6.02 \times 10^{21}$  (d)  $6.02 \times 10^{22}$

• 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  $^{14}_7N^{-3}$  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 |          |          |



22.  $100.0 \text{ mL of } 0.02 \text{ H}_2\text{SO}_4 = 100 \times 0.02 \text{ m eq.} = 2 \text{ m eq.} = 1 \text{ m mol}$   
 $= 1 \times 10^{-3} \times 6.02 \times 10^{23} = 6.02 \times 10^{20} \text{ molecules.}$

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 =  $\frac{5.85}{58.5} = 0.1 \text{ M.}$

1 mL of NaCl =  $10^{-4} \text{ mol.}$

1 mole of NaCl =  $6.02 \times 10^{23}$  molecules of NaCl.

But NaCl molecules are dissociated into two ions ( $\text{Na}^+$  and  $\text{Cl}^-$ ).

1 mol of NaCl =  $6.02 \times 10^{23} \times 2$  ions.

$1 \times 10^{-4} \text{ mole of NaCl} = 1 \times 10^{-4} \times 6.02 \times 10^{23} \times 2$  ions  
 $= 1.2 \times 10^{20}$  ions.

34. Energy =  $0.0024 \times 931.5 \text{ MeV} = 2.2 \text{ MeV.}$

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

36. No. of moles of  $\text{H}_2\text{SO}_4 = \frac{0.392}{98} = 0.004$ .

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

No. of moles of  $\text{H}_2\text{SO}_4$  left =  $0.004 - 0.002 = 0.002 = 2.0 \times 10^{-3}$ .

38. Let the number of moles of  $\text{C}_2\text{H}_4$  and  $\text{C}_3\text{H}_8$  be  $x$  and  $y$  respectively. Using the formula

$pV = nRT,$

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

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

This molecular weight corresponds to  $\text{N}_2(\text{g})$  and  $\text{CO}(\text{g})$ .

# 6

## Calculations Based on Chemical Equations and Eudiometry

### • Type 1 •

*Choose the correct option. Only one option is correct.*

1.  $1.00 \times 10^{-3}$  mol of  $\text{Ag}^+$  and  $1.00 \times 10^{-3}$  mol of  $\text{CrO}_4^{2-}$  react together to form solid  $\text{Ag}_2\text{CrO}_4$ . Calculate the amount of  $\text{Ag}_2\text{CrO}_4$  formed ( $\text{Ag}_2\text{CrO}_4 = 331.73 \text{ g mol}^{-1}$ ).
 

(a) 0.268 g	(b) 0.166 g
(c) 0.212 g	(d) 1.66 g
  
2. 1.00 g of  $\text{Cr}_2\text{O}_7^{2-}$  is oxidized in an acidic solution by an excess of  $\text{SO}_2$  to form  $\text{HSO}_4^-$  and  $\text{Cr}^{3+}$ . What is the minimum number of moles of  $\text{H}^+$  that must be produced for this reaction to occur ( $\text{Cr}_2\text{O}_7^{2-} = 216$ )?
 

(a) 0.0231	(b) 0.0282
(c) 0.0322	(d) 0.0268
  
3. In an acidic solution,  $\text{I}^-$  changes to  $\text{I}_2$ . How many grams of  $\text{I}_2$  are produced if, in the same process,  $1.5 \times 10^{22}$  electrons are used up to reduce  $\text{H}_3\text{AsO}_4$  to  $\text{H}_3\text{AsO}_3$  ( $I = 127$ )?
 

(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?
 

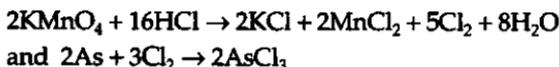
(a) 5.53 g	(b) 2.12 g	(c) 15.52 g	(d) 7.62 g
------------	------------	-------------	------------
  
5. The number of moles of  $\text{Cr}_2\text{O}_7^{2-}$  needed to oxidize 0.136 equivalent of  $\text{N}_2\text{H}_5^+$  through the reaction
 
$$\text{N}_2\text{H}_5^+ + \text{Cr}_2\text{O}_7^{2-} \longrightarrow \text{N}_2 + \text{Cr}^{3+} + \text{H}_2\text{O}$$
 is
 

(a) 0.236	(b) 0.087	(c) 0.136	(d) 0.488
-----------	-----------	-----------	-----------

6. On being strongly heated, 2.76 g of  $\text{Ag}_2\text{CO}_3$  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  $\text{HNO}_3$  and the silver is precipitated to yield 2.50 g of  $\text{AgCl}$ . What is the percentage by weight of silver in the original sample ( $\text{Ag} = 108, \text{Cl} = 35.5$ )?
- (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.
- $$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{H}_2\text{SO}_4(\text{aq})$$
- If 5.6 mol of  $\text{SO}_2$  reacts with 4.8 mol of  $\text{O}_2$  and a large excess of water, what is the maximum number of moles of  $\text{H}_2\text{SO}_4$  that can be obtained?
- (a) 5.6 (b) 11.2  
(c) 2.4 (d) 1.4
9. 8.7 g of pure  $\text{MnO}_2$  is heated with an excess of  $\text{HCl}$  and the gas evolved is passed into a solution of  $\text{KI}$ . Calculate the weight of the iodine liberated ( $\text{Mn} = 55, \text{Cl} = 35.5, \text{I} = 127$ ).
- (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  $\text{FeS}$ . What fraction of the original weight is left unreacted ( $\text{Fe} = 55.85 \text{ g mol}^{-1}, \text{S} = 32.10 \text{ g mol}^{-1}$ )?
- (a) 0.225 (b) 0.425  
(c) 0.875 (d) 0.575
11. Pure  $\text{FeS}_2$  is burnt with 60% excess air. Calculate the percentage of  $\text{N}_2$  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  $0.05 \text{ kg mol}^{-1}$  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  $\text{CuCl}_2$  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  $\text{Al}_2\text{O}_3$  in molten cryolite ( $\text{Na}_3\text{AlF}_6$ ). Assuming that all of the aluminium comes from  $\text{Al}_2\text{O}_3$ , how much of the latter would be needed for each tonne of aluminium produced ( $\text{Al} = 27, \text{O} = 16$ )?
- (a) 1.88 tonne (b) 2.88 tonne (c) 1.68 tonne (d) 1.44 tonne
16.  $2\text{PbS} + 3\text{O}_2 \longrightarrow 2\text{PbO} + 2\text{SO}_2$   
 $3\text{SO}_2 + 2\text{HNO}_3 + 2\text{H}_2\text{O} \longrightarrow 3\text{H}_2\text{SO}_4 + 2\text{NO}$   
 According to the above sequence of reactions, how much  $\text{H}_2\text{SO}_4$  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
- $$\text{Al} + 3\text{H}^+ \longrightarrow \text{Al}^{3+} + \frac{3}{2}\text{H}_2$$
- but the copper remains as pure metal. A 0.50-g sample of the alloy gives 560 mL of  $\text{H}_2$  at stp. The percentage of aluminium by weight in the alloy is ( $\text{Al} = 27$ )
- (a) 90 (b) 85 (c) 78 (d) 96
18. An ore contains 2.0% of the mineral argentite ( $\text{Ag}_2\text{S}$ ) by weight. How much of this ore will have to be processed to obtain 1.00 g of pure solid silver ( $\text{Ag} = 108, \text{S} = 32$ )?
- (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  $\text{NO}(\text{g})$  and 3.2 g of  $\text{O}_2(\text{g})$ ?
- (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  $1.20 \text{ g mL}^{-1}$  to prepare 363.0 g of  $\text{AsCl}_3$  according to the equations ( $\text{As} = 75$ ,  $\text{Cl} = 35.5$ )



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  $\text{KMnO}_4$  is decolourized by passing  $\text{SO}_2$  through it. How much iron pyrites ( $\text{FeS}_2$ ) has to be roasted to produce the necessary amount of  $\text{SO}_2$  ( $\text{K} = 39$ ,  $\text{Mn} = 55$ ,  $\text{S} = 32$ ,  $\text{Fe} = 56$ )?
- (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  $\text{CO}_2$  produced at stp ( $\text{Ca} = 40$ ,  $\text{Mg} = 24$ ,  $\text{C} = 12$ ,  $\text{O} = 16$ ) 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  $\text{NaHCO}_3$  and  $\text{Na}_2\text{CO}_3$  is heated to  $150^\circ\text{C}$ . The volume of the  $\text{CO}_2$  produced at stp is 112.0 mL. Calculate the percentage of  $\text{Na}_2\text{CO}_3$  in the mixture ( $\text{Na} = 23$ ,  $\text{C} = 12$ ,  $\text{O} = 16$ ).
- (a) 20 (b) 46  
(c) 84 (d) 16
25. 2 g of impure  $\text{CaCO}_3$  reacts with HCl to produce 410 mL of  $\text{CO}_2$  at 1 atmospheric pressure and  $27^\circ\text{C}$ . Calculate the percentage purity of the  $\text{CaCO}_3$  used.
- (a) 83.5 (b) 97.5  
(c) 87.5 (d) 73.5
26. 60 g of NaOH is converted into NaCl and  $\text{NaClO}_3$  by the action of  $\text{Cl}_2$ . The  $\text{Cl}_2$  is produced by the reaction between  $\text{MnO}_2$  and concentrated HCl. The amount of  $\text{MnO}_2$  required for the process ( $\text{Mn} = 55$ ,  $\text{Na} = 23$ ) 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,  $^{63}\text{Cu}$  and  $^{65}\text{Cu}$ . The natural abundance of the  $^{63}\text{Cu}$  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 oxygen, 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  $\text{KClO}_3$ . How much  $\text{KCl}$  is produced in the reaction?
- (a)  $4.15 \times 10^{-2}$  mol                      (b) 4.33 g  
(c)  $1.78 \times 10^{-2}$  mol                      (d) 1.33 g
49. Which of the following gases are absorbed by an ammoniacal cuprous chloride solution?
- (a)  $\text{NO}$     (b)  $\text{CO}$   
(c)  $\text{O}_3$     (d)  $\text{C}_2\text{H}_2$
50. 50 millilitres of  $\text{CO}$  is mixed with 20 mL of oxygen and sparked. After the reaction, the mixture is treated with an aqueous  $\text{KOH}$  solution. Choose the correct option.
- (a) The volume of the  $\text{CO}$  that reacts = 40 mL.  
(b) The volume of the  $\text{CO}_2$  formed = 40 mL.  
(c) The volume of the  $\text{CO}$  that remains after treatment with  $\text{KOH}$  = 10 mL.  
(d) The volume of the  $\text{CO}$  that remains after treatment with  $\text{KOH}$  = 20 mL.

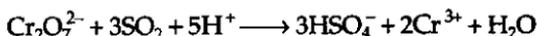
### Answers

- |          |          |          |          |             |
|----------|----------|----------|----------|-------------|
| 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  $2\text{Ag}^+ + \text{CrO}_4^{2-} \longrightarrow \text{Ag}_2\text{CrO}_4$ . Using the limiting-reagent concept, no. of moles of  $\text{Ag}_2\text{CrO}_4 = 0.5 \times 10^{-3} \times 331.73 = 0.166 \text{ g}$ .

2. The reaction is



$$\text{No. of moles of H}^+ = \frac{1.0}{216} \times 5 = 0.0231 \quad [\text{Cr}_2\text{O}_7^{2-} = 2 \times 52 + 7 \times 16 = 216]$$

4.  $2\text{NH}_4\text{Cl} + \text{Ca}(\text{OH})_2 \longrightarrow \text{CaCl}_2 + 2\text{NH}_3 + 2\text{H}_2\text{O}$

$$2 \times 53.5 \text{ g} \quad (40 + 34) \text{ g}$$

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

7. Since the weights of the sample and the precipitated  $\text{AgCl}$  are equal, the required amount is given by the

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

9.  $\text{MnO}_2 + 4\text{HCl} \longrightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$

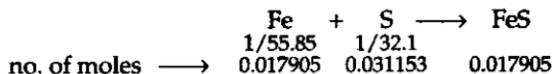


The number of moles of  $\text{MnO}_2$  equals that of  $\text{I}_2$ .

Thus, 87 g liberates 254 g of  $\text{I}_2$ .

Therefore 8.7 g of  $\text{MnO}_2$  corresponds to 25.4 g of  $\text{I}_2$ .

10. Use the limiting-reagent concept.



$$\text{Unreacted sample} = 0.031153 - 0.017905 = 0.013248$$

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

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 =  $0.25x$ . However caustic soda does not take part in the evaporation

$$\therefore 0.25x = 4 \Rightarrow x = 16 \text{ kg}$$

$$\text{The weight of the water that evaporates} = 100.0 - 16.0 = 84.0 \text{ kg}$$

17.  $1.5 \times 22400 \text{ mL}$  of  $\text{H}_2$  at stp = 27 g of Al

$$560 \text{ mL of H}_2 \text{ at stp} = 0.45 \text{ g of Al}$$

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

18.  $\text{Ag}_2\text{S}$  has two atoms of Ag.

Therefore, 216 g of Ag corresponds to 248 g of  $\text{Ag}_2\text{S}$ .

$$1 \text{ g of Ag is contained in} = \frac{248}{216} \text{ g of Ag}_2\text{S}$$

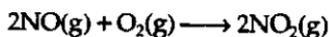
$$\text{wt. of the ore} = \frac{248}{216} \times \frac{100}{2} = 57.4 \text{ g}$$

19. Gram molecular mass of carbon

$$\begin{aligned} &= \frac{\text{no. of atoms} \times \text{At. mass of C} \times 1 \text{ amu} \times N_A}{\text{percentage of carbon}} \\ &= \frac{20 \times 12 \times 1.66 \times 10^{-24} \text{ g} \times 6.02 \times 10^{23} \text{ mol}^{-1}}{\frac{70}{100}} \\ &= 365.0 \text{ g mol}^{-1} \end{aligned}$$

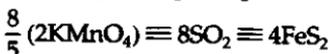
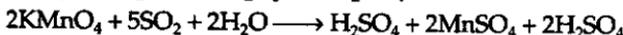
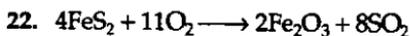
20. No. of moles of NO =  $\frac{4.2 \text{ g}}{30} = 0.14$

No. of moles of O<sub>2</sub> =  $\frac{3.2 \text{ g}}{32} = 0.10$



Using the limiting reagent concept,

$$\begin{aligned} W_{\text{NO}_2} &= 0.14 \text{ mol} \times 46 \text{ g mol}^{-1} \\ &= 6.44 \text{ g} \end{aligned}$$



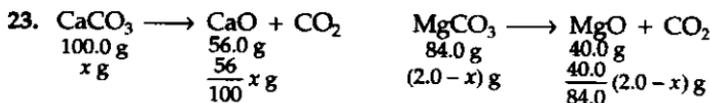
$$\frac{16}{5} \text{ mol of KMnO}_4 \equiv 4 \text{ mol of FeS}_2$$

No. of moles of KMnO<sub>4</sub> =  $\frac{31.6}{158} = 0.2$

$$0.2 \text{ mol of KMnO}_4 \equiv \frac{4}{16/5} \times 0.2 \text{ mol of FeS}_2$$

$$= \frac{1}{4} \text{ mol of FeS}_2 = \frac{1}{4} \times 120 \text{ g}$$

$$= 30.0 \text{ g}$$

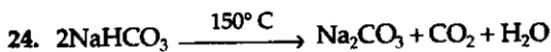


According to the question,

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

$$\text{Total no. of moles of CO}_2 = \frac{1.0}{100.0} + \frac{1.0}{84.0} = 0.022$$

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



$$\frac{n_{\text{NaHCO}_3}}{n_{\text{CO}_2}} = \frac{2}{1}$$

$$n_{\text{NaHCO}_3} = 2n_{\text{CO}_2} = 2 \times \frac{112}{22400} = 0.01 \text{ mole}$$

$$W_{\text{NaHCO}_3} = 0.01 \times 84 = 0.84 \text{ g}$$

$$W_{\text{Na}_2\text{CO}_3} = 1.00 - 0.84 = 0.16 \text{ g}$$

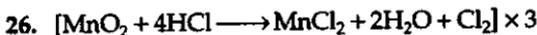
$$\% \text{Na}_2\text{CO}_3 = 16$$

$$25. n_{\text{CO}_2} = \frac{pV}{RT} = \frac{(1 \text{ atm})(0.410 \text{ L})}{(0.082 \text{ L atm mol}^{-1} \text{ K}^{-1})(300 \text{ K})} = 0.0167 \text{ mol}$$

1 mol of  $\text{CO}_2$  accounts for 1 mol of  $\text{CaCO}_3 = 100 \text{ g}$  of  $\text{CaCO}_3$

0.0167 mol of  $\text{CO}_2 = 1.67 \text{ g}$  of  $\text{CaCO}_3$

$$\text{Percentage purity of } \text{CaCO}_3 = \frac{1.67}{2.00} \times 100 = 83.5$$



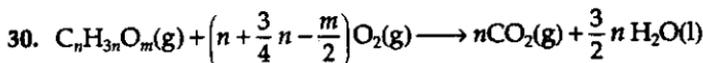
$$6 \times 40 \text{ g} = 3 \times 87 \text{ g}$$

3 mol of  $\text{MnO}_2$  accounts for 12 mol of  $\text{HCl}$  and 6 mol of  $\text{NaOH}$ .

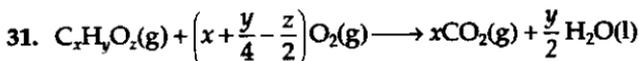
$$\frac{60}{40} \text{ mol of NaOH accounts for } 0.75 \text{ mol of MnO}_2$$

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

$$= 65.25 \text{ g}$$

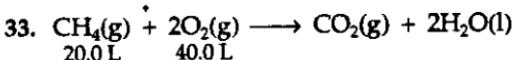


$$\text{Contraction of volume} = 1 + n + \frac{3}{4}n - \frac{m}{2} - n = \left(1 + \frac{3}{4}n - \frac{m}{2}\right)$$



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

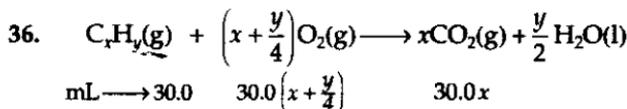
$$\text{Volume of } \text{CO}_2 \text{ produced} = 10x = 20 \Rightarrow x = 2$$



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

20.8 L of  $\text{O}_2 \equiv 100.0 \text{ L}$  of air

40.0 L of  $\text{O}_2 \equiv 192.0 \text{ L}$  of air

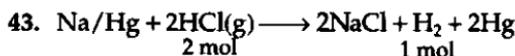


According to the question  $30.0x = 60.0 \Rightarrow x = 2$

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

$$\text{or } y = 4$$

Therefore, the molecular formula of hydrocarbon =  $C_2H_4$ .



Contraction in volume =  $50.0 - 42.5 = 7.5 \text{ mL of } H_2(g)$

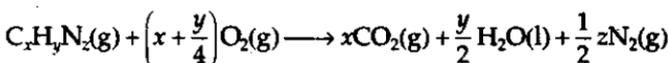
1 mol of  $H_2(g) \equiv 2 \text{ mol of } HCl(g)$

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

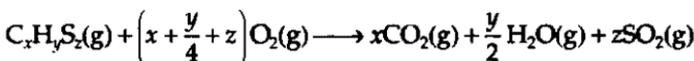
Volume of  $H_2 = 50.0 - 15.0 = 35.0 \text{ mL}$

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

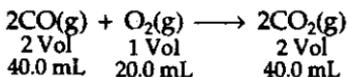
44. The reaction is



45. The reaction is



50. The reaction is



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  $KOH$

$$= 50 \text{ mL} - 40 \text{ mL} = 10.0 \text{ mL}$$

□