

O-level

The mole

A **mole of a substance** is the mass in grams of the substance which is numerically equal to its relative atomic mass or its relative molecular mass.

E.g. One mole of carbon weights 12g, 1 mole of oxygen molecule weights 32g. 1 mole of the compound ammonium sulphate weights 132g.

- A mole of any substance contains the same number of particles. These particles can be molecules, atoms, ions or electrons.

A mole of any substance contains 6.02×10^{23} particles. This number of particles in any mole of a substance (6.02×10^{23}) is called **AVOGADRO'S NUMBER**

There are 6.02×10^{23} carbon atoms in 1 mol (12g) of carbon. There are 6.02×10^{23} oxygen molecules in 1 mol (32g) of oxygen. There are 6.02×10^{23} formula units of ammonium sulphate in 1 mol (132g) of ammonium sulphate.

Example 1

Taking Avogadro's constant equal to 6×10^{23}

How many Cu atoms are there in a copper plate, weighing 48g [Cu = 64]

Solution:

Let the number of moles of Cu that are in 48g be X

1 mole of Cu contain 64g

X moles of Cu contain 48g

$$\therefore X = \frac{1 \times 48}{64}$$

$$= 0.75 \text{ moles}$$

But 1 mole of Cu contain 6×10^{23} atoms

$$\therefore 0.75 \text{ moles of Cu contain } \left[\frac{6 \times 10^{23} \times 0.75}{1} \right] \text{ atoms}$$

$$= 4.5 \times 10^{23} \text{ atoms}$$

Example 2

How many grams of Ag [Ag = 108] contain 1.2×10^{23} atoms

Solution:

Let the number of moles in 1.2×10^{23} atoms be X

1 mole of Ag contain 6×10^{23} atoms

X moles of Ag contain 1.2×10^{23} atoms

$$\therefore \frac{1.2 \times 10^{23} \times 1}{6 \times 10^{23}}$$

$$= 0.2 \text{ moles}$$

But 1 mole of Ag contain 108g

$$\therefore 0.2 \text{ moles of Ag contain } \frac{[108 \times 0.2] \text{ g}}{1} \\ = \mathbf{21.6g}$$

Example 3

How many C atoms are there in a carbon rod weighing 8 g (C = 12)

Solution

12g of carbon contains 6×10^{23} atoms

$$\therefore 8 \text{ g of carbon contain } \frac{8 \times 6 \times 10^{23}}{12} = 4 \times 10^{23} \text{ atoms}$$

Example 4

How many grams of copper (Cu = 64) contain 4.5×10^{23} atoms?

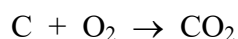
Solution

6×10^{23} atoms of copper weigh 64g

$$\therefore 4.5 \times 10^{23} \text{ atoms contain } \frac{4.5 \times 10^{23} \times 64}{6 \times 10^{23}} = 48g$$

Equations

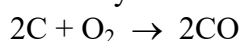
If we consider the following equation:



The equation now may mean

- 1 atom of carbon reacts with 1 molecule of oxygen to yield 1 molecule of carbon dioxide.
 - 12g of carbon react with 32g of oxygen to yield 44g of carbon dioxide
- Or
- 1 mole of carbon atom react with 1 mole. of oxygen molecules to yield one mol of carbon dioxide molecules.

Similarly



The equation means that

- 2 carbon atoms react with 1 oxygen molecule to yield 2 carbon monoxide
 - 24g of carbon react with 32g of oxygen to yield 56g of carbon monoxide.
- or
- 2 mol of carbon atoms reacts with 1 mol of oxygen molecule to yield 2 mol of carbon monoxide molecules.

Example 5

What is the mass of

(a) 0.1 mole of CaSO₄

$$\text{R.F.M CaSO}_4 = 40 + 32 + 4 \times 16 = 136g$$

$$\Rightarrow 1 \text{ mole weighs } 136g$$

$$\Rightarrow 0.1 \text{ mole weigh } 136 \times 0.1 = 13.6g$$

(b) 3 moles of H₂O

$$\text{R.F.M H}_2\text{O} = 18$$

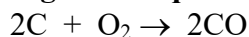
$$\Rightarrow 2 \times 1 + 16 = 18$$



$$\begin{aligned}
 1 \text{ mole of H}_2\text{O} &\rightarrow 18 \\
 3 \text{ moles of H}_2\text{O} &\rightarrow \frac{18 \times 3}{1} \\
 &= \underline{54\text{g}}
 \end{aligned}$$

Example 7:

According to the equation



How many moles of carbon will react with 0.2mol of oxygen?

Solution

From the equation

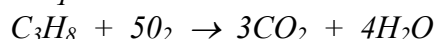
2 mol of C reacted with 1 mol of O₂

⇒ 1 mole of O₂ requires 2 moles of C

∴ 0.2 moles of O₂ requires 2 x 0.2 = 0.4 moles of C

Example 8:

According to the equation



(a) How many moles of CO₂ will be produced in the reaction of 3.2g of O₂?

Solution

Mass of 5 mole of oxygen molecules = 5 (2 x 16) = 160g

∴ 160g of oxygen produce 3 mole of carbon dioxide

⇒ 3.2g of oxygen produce $\frac{3 \times 3.2}{160} = 0.06\text{moles}$

(b) How many grams of propane will react with 0.5moles of O₂?

Solution

Formula mass of propane, C₃H₈ = 12 x 3 + 1 x 8 = 44g

5 moles of oxygen react with 1 mole of propane

∴ 0.5 moles of oxygen react with $\frac{1 \times 0.5}{5} = 0.1 \text{ mole}$ of propane

Calculation involving solutions

Definitions

1. **The concentration of a solution** is the number in gram or number of moles of the solute dissolved or contained in a known volume of solution.

Usually the concentration of a solution is expressed in either number of grams or moles of solute per litre of solution.

2. **Molarity of a solution** is the number of moles of the solute contained in 1 litre, 1dm³ or 1000cm³ of the solution.

3. A two molar solution of sodium hydroxide (2M NaOH) is a solution containing two moles of the NaOH in 1000 cm³ of the solution

4. **Some formulas**



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1000 cm³ of HCl will contain $\left(\frac{0.002}{50} \times 1000\right) \text{ moles} = 0.04 \text{ M}$

Therefore, morality of HCl = 0.04 M

(b) formula mass HCl = 1 + 35.5 = 36.5

1 mole of HCl weighs 36.5g

0.04 moles weigh $36.5 \times 0.4 = \underline{1.46\text{g/L}}$



EXERCISE

1		The volume of 0.1M sodium hydroxide required to react exactly with 25.0cm ³ of 0.02M hydrochloric acid
	A.	12.5cm ³
	B.	25.0cm ³
	C.	50.0cm ³
	D.	75.0cm ³
2.		The mass of nitric acid required to make 200cm ³ of 2M solution is
	A.	31.5g
	B.	25.2g
	C.	15.8g
	D.	12.6g
3		The molarity of solution that contain 40g of sodium hydroxide in 500cm ³ is (Na = 23,
	A.	0.2M
	B.	0.5M
	C.	1M
	D.	2M
4		The volume of a 0.25M hydrochloric acid required to exactly react with 20cm ³ of 0.1M sodium carbonate solution is given by
	A.	$\frac{20.0 \times 0.1}{2 \times 0.25}$
	B.	$\frac{20.0 \times 0.25}{2 \times 0.1}$
	C.	$\frac{2 \times 20.0 \times 0.25}{0.1}$
	D.	$\frac{2 \times 20.0 \times 0.1}{0.25}$
5		A 0.2M solution of X contains 18.25g of X per litre of solution. The relative molecular mass of X is
	A.	18.25
	B.	36.50
	C.	45.63
	D.	91.25
6.		10cm ³ of dibasic was neutralised by 20cm ³ of a 0.2M solution of sodium hydroxide. The molarity of the acid is
	A.	$\frac{2 \times 10}{0.2 \times 20}$
	B.	$\frac{0.2 \times 20}{2 \times 1}$
	C.	$\frac{0.2 \times 10}{2 \times 20}$
	D.	$\frac{2 \times 0.2 \times 20}{10}$

7	$\text{CaCO}_3(\text{s}) \xrightarrow{\text{heat}} \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ The mass, in grams, of calcium oxide formed when 20g of calcium carbonate completely decomposes is (Ca = 40, C = 12, O = 16)
	A. $\frac{20 \times 56}{100}$
	B. $\frac{20 \times 100}{56}$
	C. $\frac{44 \times 56}{100}$
	D. $\frac{20 \times 44}{100}$
8.	What mass, in grams, of sodium carbonate-10-water, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, is contained in 50cm^3 of a 0.1M solution?
	A. $\frac{106 \times 0.1 \times 1000}{50}$
	B. $\frac{106 \times 0.1 \times 50}{1000}$
	C. $\frac{286 \times 0.1 \times 1000}{50}$
	D. $\frac{106 \times 0.1 \times 50}{1000}$
9	2.0g of sodium hydroxide was dissolved in water to make 500cm^3 of solution is (H = 1, O = 16, Na = 23)
	A. 2M B. 0.5M C. 0.1M D. 0.05M
10	Sulphuric acid react with sodium hydroxide according to equation $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \longrightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$ What volume of 0.5M sulphuric acid is required to react completely with 10cm^3 of 2M sodium hydroxide
	A. 5cm^3 B. 10cm^3 C. 20cm^3 D. 30cm^3
11	What mass of sodium hydroxide is in 0.5litre of 2M sodium hydroxide solution
	A. 10g B. 20g C. 40g D. 0.8g
12	The volume of 0.2M sodium hydroxide solution which neutralise 25cm^3 0.1M hydrochloric acid is
	A. 5cm^3 B. 12.5cm^3 C. 25cm^3 D. 50cm^3
13	Which one of the following contains the same number of atoms as 8g of sulphur?
	A. 20g of calcium
	B. 10g of calcium
	C. 12g of carbon
	D. 4 g of carbon

14		What mass of sulphuric acid (Mr 98) in 5cm ³ of 0.2M sulphuric acid solution
	A.	$\frac{98 \times 5}{0.2 \times 1000}$
	B.	$\frac{98 \times 0.2 \times 5}{1000}$
	C.	$\frac{98 \times 0.2}{5 \times 1000}$
	D.	$\frac{9.8 \times 5 \times 1000}{0.2}$
15		25cm ³ of 0.05M sodium carbonate required 22.70cm ³ of hydrochloric acid for complete neutralization. The molarity of the acid given by
	A.	$\frac{0.00125 \times 1000}{2 \times 22.7}$
	B.	$\frac{0.00125 \times 1000}{2 \times 25}$
	C.	$\frac{0.00125 \times 2 \times 1000}{22.7}$
	D.	$\frac{0.00125 \times 1000}{25}$
16		25cm ³ of a 0.25M acid on an acid 25cm ³ of 0.5M sodium hydroxide solution for complete neutralization. The basicity of the acid is
	A.	1 B. 2 C. 2 D. 4
17		Calcium reacts with hydrochloric acid according to the following equation $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \longrightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$ The mass of carbon dioxide formed when 20g of calcium carbonate is completely reacted with hydrochloric acid is (Ca = 40, H = 1, Cl = 35.5, C = 12)
	A.	20 x 44 x 10
	B.	$\frac{44 \times 100}{20}$
	C.	$\frac{20 \times 100}{44}$
	D.	$\frac{20 \times 44}{100}$
18		Copper reacts with oxygen according to the following equation $2\text{Cu}(\text{s}) + \text{O}_2(\text{g}) \longrightarrow 2\text{CuO}(\text{s})$ Calculate the mass of copper (II) sulphate formed when 0.64g of copper powder is completely reacted with oxygen (Cu = 64, O = 16)
	A.	$\frac{0.64 \times 80}{96}$
	B.	$\frac{0.64 \times 64}{80}$

	C.	$\frac{0.64 \times 96}{80}$
	D.	$\frac{0.64 \times 80}{64}$
19		Lead (II) nitrate reacts with potassium iodide according to the following equation $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2\text{KI}(\text{aq}) \longrightarrow \text{PbI}_2(\text{s}) + 2\text{KNO}_3(\text{aq})$ The mass of lead (II) iodide formed when 33.2g of potassium iodide is reacted with excess lead (II) nitrate is (K= 39, I= 127, Pb = 207)
	A.	16 g B. 46.1g C. 66.4g D. 92.2g
20		The concentration in grams per litre, of a 0.05M sodium carbonate solution is (Na = 23, C = 12, O = 16)
	A.	0.05×83 B. 0.05×106 C. $\frac{106}{0.05}$ D. $\frac{83}{0.05}$
21		Copper (II) oxide reacts with hydrogen according to the equation $\text{CuO}(\text{s}) + \text{H}_2(\text{g}) \longrightarrow \text{Cu}(\text{s}) + \text{H}_2\text{O}(\text{l})$ The mass of copper formed when 8.0g of the oxide is reacted with excess hydrogen is (Cu = 63.5, O =16, H = 1)
	A.	$63.5 \times 80 \times 8\text{g}$ B. $\frac{63.5 \times 80}{8}$ C. $\frac{8.0 \times 80}{62.5}$ D. $\frac{63.5 \times 8.0}{80}$
22		Copper (II) sulphate reacts with sodium carbonate according to the following equation. $\text{CuSO}_4(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \longrightarrow \text{CuCO}_3(\text{s}) + \text{Na}_2\text{SO}_4(\text{aq})$ The mass of copper (II) carbonate formed when 200cm ³ of a solution containing 5.3g of sodium carbonate per liter of solution was reacted completely with excess copper (II) sulphate is given by
	A.	$\frac{5.3 \times 200 \times 124}{106 \times 1000} \text{g}$ B. $\frac{5.2 \times 124 \times 1000}{106 \times 200} \text{g}$ C. $\frac{106 \times 200 \times 124}{5.3 \times 1000} \text{g}$ D. $\frac{106 \times 124 \times 100}{5.3 \times 200} \text{g}$
23		15cm ³ of a dibasic acid was neutralised by 30cm ³ of a 0.4M potassium hydroxide solution. The morality of the acid is
	A.	$\frac{2 \times 15}{0.4 \times 30}$ B. $\frac{0.4 \times 30}{2 \times 15}$ C. $\frac{15 \times 0.4}{30 \times 2}$ D. $\frac{2 \times 0.4 \times 30}{15}$
24		Aluminium reacts with copper II ions according to the following equation $3\text{Cu}^{2+}(\text{aq}) + 2\text{Al}(\text{s}) \longrightarrow 3\text{Cu}(\text{s}) + 2\text{Al}^{3+}(\text{aq})$ Which of the following will be the mass of copper formed when copper (II) ions reacted with 2.5g of aluminium? (Al = 27, Cu = 63.5)
	A.	$\frac{2.5 \times 2 \times 63.5}{27 \times 3}$ B. $\frac{2.5 \times 3 \times 27}{63.5 \times 2}$ C. $\frac{2.5 \times 2 \times 27}{63.5 \times 3}$ D. $\frac{2.5 \times 3 \times 63.5}{27 \times 2}$
25		20cm ³ of an acid HX was neutralised by 25cm ³ of a 0.05M sodium carbonate. Which of the following is the morality of the acid?
	A.	$\frac{25 \times 0.05}{20} \text{M}$ B. $\frac{2 \times 25 \times 0.05}{20} \text{M}$ C. $\frac{2 \times 20 \times 0.05}{25} \text{M}$ D. $\frac{25 \times 0.05}{2 \times 2} \text{M}$
26		Hydrochloric acid reacts with calcium hydrogen carbonate according to the following equation $\text{Ca}(\text{HCO}_3)_2(\text{aq}) + 2\text{HCl}(\text{aq}) \longrightarrow \text{CaCl}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) + 2\text{CO}_2(\text{g})$ 25cm ³ of a solution of calcium hydrogen carbonate required 8.0cm ³ of a .05M

	hydrochloric acid for complete neutralization. The concentration of the calcium hydrogen carbonate solution is (Ca = 40; O = 16, C = 12)
	A. $\left(\frac{8.0 \times 0.05 \times 162}{2 \times 25}\right) gl^{-1}$
	B. $\left(\frac{8.0 \times 0.05 \times 162}{25}\right) gl^{-1}$
	C. $\left(\frac{25 \times 0.05 \times 162}{2 \times 8}\right) gl^{-1}$
	D. $\left(\frac{25 \times 0.05 \times 162}{8}\right) gl^{-1}$
27	Lead (II) nitrate reacts with potassium iodide according to the following equation $Pb(NO_3)_2(aq) + 2KI(aq) \longrightarrow PbI_2(s) + 2KNO_3(aq)$ The mass of lead (II) iodide formed when 33.2g of potassium iodide is reacted with excess lead (II) nitrate is (K = 39, I = 127, Pb = 207)
	A. 4.61g B. 9.22g C. 46.1g D. 92.2g
28	6.48 g of calcium hydrogen carbonate, $Ca(HCO_3)_2$ was dissolved in water to make $500cm^3$ of solution. Which of the following is the molarity of the solution? (H = 1; C = 12, O = 16, Ca = 40)
	A. 0.04M B. 0.06M C. 0.08M D. 0.12M
29	Which one of the following solutions contains the same number of moles of sodium ions as $200cm^3$ of 0.5M $NaHSO_4$ solution?
	A. $100cm^3$ of 2M Na_2CO_3 B. $100cm^3$ of 0.5M $NaNO_3$ C. $250cm^3$ of 0.8M $NaHCO_3$ D. $250cm^3$ 0.4M $NaCl$
30	$10cm^3$ of monobasic acid completely reacted with $20cm^3$ of 0.05M sodium carbonate solution. The number of moles of the acid that reacted is
	A. $\left(\frac{20 \times 0.05 \times 2}{1000}\right) moles$ B. $\left(\frac{20 \times 0.05 \times 2}{10}\right) moles$ C. $\left(\frac{20 \times 0.05}{2 \times 1000}\right) moles$ D. $\left(\frac{0.05 \times 2 \times 10}{20 \times 1000}\right) moles$
31	Iron reacts with oxygen to form 0.8g of Iron (III) oxide is [O = 16, Fe = 56]
	A. $\left(\frac{0.8 \times 2 \times 56}{160}\right) g$ B. $\left(\frac{0.8 \times 2 \times 56}{320}\right) g$ C. $\left(\frac{0.8 \times 2}{160 \times 56}\right) g$ D. $\left(\frac{0.8 \times 56}{320 \times 2}\right) g$

32	<p>Nitric acid reacts with copper (II) oxide according to the following equation</p> $\text{CuO(s)} + 2\text{HNO}_3(\text{aq}) \longrightarrow \text{Cu(NO}_3)_2(\text{aq}) + \text{H}_2\text{O(l)}$ <p>0.5g of an impure copper (II) oxide reacted completely with 50cm³ of a 0.1M nitric acid. The mass of copper (II) oxide in a sample is</p> <p>A. 0.20g B. 0.24g C. 0.30g D. 0.40g</p>
33.	<p>Magnesium burns in air according equation</p> $2\text{Mg(s)} + \text{O}_2(\text{g}) \longrightarrow 2\text{MgO(s)}$ <p>The mass of oxygen required to burn 5g of magnesium completely is [O = 16; Mg = 24]</p> <p>A. $\frac{5 \times 16}{24} \text{g}$ B. $\frac{5 \times 16}{48} \text{g}$ C. $\frac{5 \times 32}{24} \text{g}$ D. $\frac{5 \times 32}{48} \text{g}$</p>
34	<p>5.73g of hydrated sodium carbonate, Na₂CO₃.10H₂O, was dissolved in water to make 500cm³ of solution. The molarity of solution is (Na = 23, O = 16, C = 12, H = 1)</p> <p>A. 0.05M B. 0.02M C. 0.04M D. 0.1M</p>
35	<p>Zinc carbonate decomposes according to the following equation when</p> $\text{ZnCO}_3(\text{s}) \longrightarrow \text{ZnO(s)} + \text{CO}_2(\text{g})$ <p>The mass of zinc oxide formed when 2.5g of zinc carbonate is heated is (Zn = 65; O = 16; C = 12)</p> <p>A. 0.41g B. 0.81g C. 1.62g D. 3.24g</p>
36	<p>25.0cm³ of a solution of 0.1M NaOH were exactly neutralised by 20.0cm³ of HCl. Calculate the concentration of the acid as</p>
	(a) Molarity
	(b) in g/dm ³
37	<p>In titration 30cm³ of 0.4 M NaOH required 40cm³ of phosphoric acid, H₃PO₄</p>
	(a) How many moles of NaOH are present in 30cm ³ of solution?
	(b) Calculate the molarity of H ₃ PO ₄ acid.
38.	<p>In an experiment to determine the concentration of dilute sulphuric acid in moles per litre, 25 cm³ of 0.2 m NaOH solution required 24.6 cm³ of the acid. Calculate the molarity of the acid.</p>
39	<p>20cm³ of sodium carbonate solution reacted completely with 25cm³ of 0.8M hydrochloric acid according to the following equation</p> $\text{Na}_2\text{CO}_3(\text{aq}) + 2\text{HCl}(\text{aq}) \longrightarrow \text{NaCl}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O(l)}$ <p>Calculate the concentration of the sodium carbonate in g/l.</p>
40	<p>A sample of 0.106 g of pure sodium carbonate was dissolved in water to make 100cm³ of solution.</p>
	(a) Calculate the mass of sodium carbonate needed to dissolve in one litre of water.
	(b) Calculate the molarity of solution

Answer

		Working
1	C	<p>Mole of hydrochloric acid 1000cm^3 contains 0.02mole $\Rightarrow 25\text{ cm}^3$ contains $\frac{0.02 \times 25}{1000} = 0.005\text{moles}$</p> <p>Equation $\text{NaOH (aq)} + \text{HCl (aq)} \longrightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$</p> <p>Moles of NaOH From equation 1 mole of acid reacts with 1 mole of NaOH \Rightarrow Mole of NaOH = Moles of HCl = 0.005</p> <p>Volume of sodium hydroxide solution 0.1 mole is contained in 1000cm^3 of 0.1M sodium hydroxide solution \therefore 0.005 moles are in $\frac{0.005 \times 1000}{0.1} = 50\text{cm}^3$</p>
2	B	<p>Mole of nitric acid in 200cm^3 of 2M nitric acid 1000cm^3 contain 2mole of nitric acid 200cm^3 contain $\frac{200 \times 2}{1000} = 0.4\text{moles}$</p> <p>Formula mass of nitric acid, $\text{HNO}_3 = 1 + 14 + 16 \times 3 = 63$ 1 mole of nitric acid is equivalent to 63g $\Rightarrow 0.4\text{moles} = 0.4 \times 63\text{g} = 25.2\text{g}$ \therefore the mass of nitric acid required to form 200cm^3 of 2M nitric acid = 25.2g</p>
3.	D	<p>Formula mass of NaOH = $23 + 16 + 1 = 40$ Moles of sodium hydroxide = $\frac{40}{40} = 1\text{mole}$ Morality of sodium hydroxide 500cm^3 contain 1mole $\therefore 1000\text{cm}^3$ contains $\frac{1000 \times 1}{500} = 2\text{M}$ \therefore molarity of a solution that contain 40g of sodium hydroxide in $500\text{cm}^3 = 2\text{M}$</p>
4	D	<p>Mole of sodium carbonate 1000cm^3 contains 0.1mole $\Rightarrow 20\text{ cm}^3$ contains $\frac{0.1 \times 20}{1000} = 0.002\text{moles}$</p> <p>Equation $\text{Na}_2\text{CO}_3 \text{ (aq)} + 2\text{HCl (aq)} \longrightarrow 2\text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$</p> <p>Moles of HCl From equation 1 mole of Na_2CO_3 reacts with 2 moles of HCl \Rightarrow Mole of HCl = $2 \times$ Moles of $\text{Na}_2\text{CO}_3 = 0.002 \times 2 = 0.004$ moles</p> <p>Volume of HCl solution 0.25moles are contained in 1000cm^3 of .25M HCl solution \therefore 0.004 moles are in $\frac{0.004 \times 1000}{0.25} = 16\text{cm}^3$</p>
5	D	<p>0.2 moles of X weigh 18.25g 1mole weigh $\frac{18.25 \times 1}{0.2} = 91.25\text{g}$ \therefore formula mass of X = 91.25</p>

6	B	<p>Moles of sodium hydroxide 1000cm^3 contains 0.02mole $\Rightarrow 20\text{ cm}^3$ contains $\frac{0.02 \times 20}{1000}$</p> <p>Equation $2\text{NaOH (aq)} + \text{H}_2\text{X (aq)} \longrightarrow \text{Na}_2\text{X(aq)} + \text{H}_2\text{O(l)}$</p> <p>Moles of acid From equation 2 mole of NaOH reacts with 1 mole of acid \Rightarrow Mole of acid = $\frac{1}{2} \times \text{mole of NaOH} = \frac{1}{2} \times \frac{0.02 \times 20}{1000}$</p> <p>Molarity of the acid 10 cm^3 contain $\frac{1}{2} \times \frac{0.02 \times 20}{1000}$ 1000cm^3 contain $\frac{1}{2} \times \frac{0.02 \times 20}{1000} \times \frac{1000}{10} = \frac{0.02 \times 20}{2 \times 10} M$</p>
7	A	<p>Formula mass of $\text{CaCO}_3 = 40 + 12 + 16 \times 3 = 100\text{g}$ Formula mass of $\text{CaO} = 40 + 16 = 56$ $\Rightarrow 100\text{g}$ of CaCO_3 produce 56g of CaO $\therefore 20\text{g}$ of CaCO_3 produce $\frac{20 \times 56}{100} \text{ g of CaO}$</p>
8	B	<p>Formula mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} = 23 \times 2 + 12 + 16 \times 3 + 10(1 \times 2 + 16)$ $= 286\text{g}$ Moles $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ in 50cm^3 of 0.1M solution 1000cm^3 contain 0.1 mole 50cm^3 contain $\frac{0.1 \times 50}{1000} \text{ moles}$ Mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ equivalent to $\frac{0.1 \times 50}{1000} \text{ moles}$ 1 mole of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ weigh 286g $\therefore \frac{0.1 \times 50}{1000} \text{ moles}$ of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ weigh $\frac{0.1 \times 50}{1000} \times 286\text{g}$</p>
9	C	<p>Formula mass of $\text{NaOH} = 23 + 16 + 1 = 40$ Moles of sodium hydroxide = $\frac{2}{40} = 0.05\text{moles}$ Molarity of sodium hydroxide 500cm^3 contain 0.05mole 1000cm^3 contain $\frac{0.05 \times 1000}{500} = 0.1 \text{ moles}$ \Rightarrow molarity of sodium hydroxide = 0.1M</p>
10	C	<p>Mole of sodium hydroxide 1000cm^3 contains 2 moles $\Rightarrow 10\text{ cm}^3$ contains $\frac{2 \times 10}{1000} = 0.02\text{moles}$</p> <p>Equation $2\text{NaOH (aq)} + \text{H}_2\text{SO}_4 \text{ (aq)} \longrightarrow \text{Na}_2\text{SO}_4\text{(aq)} + 2\text{H}_2\text{O(l)}$</p> <p>Moles of H_2SO_4 From equation 2 moles of NaOH reacts with 1 mole of H_2SO_4 \Rightarrow Mole of $\text{H}_2\text{SO}_4 = \frac{1}{2} \times \text{Moles of NaOH} = \frac{0.02}{2} = 0.01\text{mole}$</p> <p>Volume of sulphuric acid solution 0.5 Moles are contained in 1000cm^3 $\therefore 0.01$ moles are in $\frac{0.01 \times 1000}{0.5} = 20\text{cm}^3$</p>
11	C	<p>Formula mass of $\text{NaOH} = 23 + 16 + 1 = 40\text{g}$ Mass of sodium hydroxide in 1M solution = $40 \times 2 = 80\text{g}$</p>

		$\therefore 0.5l \text{ contain } \frac{0.5 \times 80}{1} = 40g$
12	B	<p>Mole of hydrochloric acid 1000cm^3 contains 0.1mole $\Rightarrow 25 \text{ cm}^3$ contains $\frac{0.1 \times 25}{1000} = 0.0025\text{moles}$</p> <p>Equation $\text{NaOH (aq)} + \text{HCl (aq)} \longrightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$</p> <p>Moles of NaOH From equation 1 mole of acid reacts with 1 mole of NaOH \Rightarrow Mole of NaOH = Moles of HCl = 0.0025</p> <p>Volume of sodium hydroxide solution 0.2 mole is contained in 1000cm^3 $\therefore 0.0025$ moles are in $\frac{0.0025 \times 1000}{0.2} = 12.5\text{cm}^3$</p>
13	B	<p>Hint: Same number of moles of an element contain the same number of atoms</p> <p>Mole = $\frac{\text{mass}}{\text{relative atomic mass}}$</p> <p>Mole of sulphur in 8g = $\frac{8}{32} = 0.25\text{moles}$</p> <p>Moles calcium in 20g = $\frac{20}{40} = 0.5$ moles</p> <p>Moles calcium in 10g = $\frac{10}{4} = 0.25$ mole</p> <p>Therefore, 8g of sulphur contain the same number of atoms as 10g of calcium</p>
14	B	<p>Formula mass of $\text{H}_2\text{SO}_4 = 1 \times 2 + 32 + 16 \times 4 = 98\text{g}$ Mass of H_2SO_4 in 1000cm^3 of 0.2M solution = $(98 \times 0.2)\text{g}$ $\therefore 5\text{cm}^3$ contain $\frac{0.2 \times 98 \times 5}{1000}\text{g}$</p>
15	C	<p>Mole of sodium carbonate 1000cm^3 contains 0.05mole $\Rightarrow 25 \text{ cm}^3$ contains $\frac{0.05 \times 25}{1000} = 0.00125\text{moles}$</p> <p>Equation $\text{Na}_2\text{CO}_3 \text{ (aq)} + 2\text{HCl (aq)} \longrightarrow 2\text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2\text{(g)}$</p> <p>Moles of HCl From equation 1 mole of Na_2CO_3 reacts with 2 moles of HCl \Rightarrow Mole of HCl = $2 \times$ Moles of $\text{Na}_2\text{CO}_3 = (0.00125 \times 2)$ moles</p> <p>Molarity 22.7cm^3 contain 0.00125×2 mole $\therefore 1000\text{cm}^3$ contain $\frac{0.00125 \times 2 \times 1000}{22.7}$ M</p>
16	C	<p>Mole of acid = $\frac{25 \times 0.25}{1000} = 0.00625$ moles Moles sodium hydroxide = $\frac{25 \times 0.5}{1000} = 0.0125$ moles Basicity of acid = $\frac{\text{moles of sodium hydroxide}}{\text{moles of the acid}} = \frac{0.0125}{0.00625} = 2$</p>

17	D	<p>Formula mass of $\text{CaCO}_3 = 40 + 12 + 16 \times 3 = 100\text{g}$ Formula mass of $\text{CO}_2 = 12 + 16 \times 2 = 44\text{g}$ 100g of CaCO_3 produce 44 g of CO_2 20 g of CaCO_3 produce $\frac{44 \times 20}{100}$ g of CO_2</p>
18	D	<p>(2 x 64) g of Cu produce 2(64 + 16) g of CuO \Rightarrow 0.64g of Cu produce $\frac{0.64 \times 2 \times 80}{2 \times 64} = \frac{0.64 \times 80}{64}$</p>
19	B	<p>Formula mass of KI = 39 + 127 = 166 Formula mass $\text{PbI}_2 = 207 + 127 \times 2 = 461$ 166 x 2g of KI produce 461g of PbI_2 33.2g of KI produce $\frac{461 \times 33.2}{166 \times 2} = 46.1\text{g}$ of PbI_2</p>
20	B	<p>Formula mass of $\text{Na}_2\text{CO}_3 = 23 \times 2 + 12 + 16 \times 3 = 106$ 1mole weighs 106g 0.05mole weigh 0.05×106 \therefore 0.05M sodium carbonate contains (0.05 x 106)g of Na_2CO_3 per litre</p>
21	D	<p>Formula mass of copper oxide (CuO) = 64 + 16 = 80 80g of CuO form 63.5 g of Cu \therefore 8.0g will form $\frac{8.0 \times 63.5}{80}$</p>
22	B	<p>Formula mass of $\text{CuCO}_3 = 64 + 12 + 16 \times 3 = 124$ Formula mass of sodium carbonate $\text{Na}_2\text{CO}_3 = 106$ Mass of sodium carbonate in 200cm³ = $\frac{5.3 \times 200}{1000}$ But 106 g of Na_2CO_3 produce 124g of CuCO_3 $\therefore \frac{5.3 \times 200}{1000}$g of Na_2CO_3 produce $\frac{5.3 \times 200}{1000} \times \frac{124}{106}$</p>
23	B	<p>Moles of potassium hydroxide 1000cm³ contain 0.4 moles 30cm³ contain $\frac{0.4 \times 30}{1000}$ moles Moles of the acid 2mole of KOH react with 1 mole of acid $\frac{0.4 \times 30}{1000}$ of KOH react with $\frac{0.4 \times 30}{1000} \times \frac{1}{2}$ Molarity of the acid 15 cm³ contain $\frac{0.4 \times 30}{1000} \times \frac{1}{2}$ moles 1000cm³ contain $\frac{0.4 \times 30}{1000} \times \frac{1}{2} \times \frac{1000}{15} = \frac{0.4 \times 30}{2 \times 15}$</p>
24	D	<p>(2 x 27) g of aluminium produce (3 x 63.5) g of copper 2.5 g of aluminium will produce $\frac{3 \times 63.5 \times 2.5}{2 \times 27}$</p>

25	B	<p>Moles of sodium carbonate 1000cm^3 contain 0.05 moles 25cm^3 contain $\frac{0.05 \times 25}{1000}$ moles Moles of the acid 1mole of Na_2CO_3 react with 2 moles of acid $\frac{0.05 \times 25}{1000}$ of KOH react with $\frac{0.4 \times 30}{1000} \times 2$ Molarity of the acid 20cm^3 contain $\frac{0.05 \times 25}{1000} \times 2$ moles 1000cm^3 contain $\frac{0.05 \times 25}{1000} \times 2 \times \frac{1000}{20} = \frac{0.05 \times 25 \times 2}{20}$</p>
26	A	<p>Moles of hydrochloric acid 1000cm^3 contain 0.05 moles 8.0cm^3 contain $\frac{0.05 \times 8.0}{1000}$ moles Moles of the $\text{Ca}(\text{HCO}_3)_2$ 2mole of HCl react with 1 mole of $\text{Ca}(\text{HCO}_3)_2$ $\frac{0.05 \times 8.0}{1000}$ of KOH react with $\frac{0.05 \times 8.0}{1000} \times \frac{1}{2}$ Molarity of the $\text{Ca}(\text{HCO}_3)_2$ 25cm^3 contain $\frac{0.05 \times 8.0}{1000} \times \frac{1}{2}$ moles 1000cm^3 contain $\frac{0.05 \times 8.0}{1000} \times \frac{1}{2} \times \frac{1000}{25} = \frac{0.05 \times 8.0}{2 \times 25} \text{M}$ Formula mass of $\text{Ca}(\text{HCO}_3)_2 = 40 + 2(1 + 12 + 16 \times 3) = 162$ \therefore concentration of $\text{Ca}(\text{HCO}_3)_2 = \frac{0.05 \times 8.0}{2 \times 25} \times 162 \text{gl}^{-1}$</p>
27	C	<p>Formula mass of KI = $39 + 127 = 166\text{g}$ Formula mass of $\text{PbI}_2 = 207 + 127 \times 2 = 461\text{g}$ (166×2) g of KI produce 461 g of PbI_2 33.2g of KI will produce $\frac{33.2 \times 461}{332} = 46.1\text{g}$</p>
28	C	<p>Formula mass of $\text{Ca}(\text{HCO}_3)_2 = 40 + 2(1 + 12 + 16 \times 3) = 162\text{g}$ Mas of $\text{Ca}(\text{HCO}_3)_2$ in $1000\text{cm}^3 = \frac{1000 \times 6.48}{500} = 12.96\text{g}$ Molarity of $\text{Ca}(\text{HCO}_3)_2 = \frac{\text{concentration } \text{gl}^{-1}}{\text{formula mass}} = \frac{12.96}{162} = 0.08\text{M}$</p>
29	D	<p>Mole of NaHSO_4 in 200cm^3 of $0.5\text{M} = \frac{0.5 \times 200}{1000} = 0.1\text{M}$ Mole of NaCl in 250cm^3 of $0.4\text{M} = \frac{0.4 \times 250}{1000} = 0.1\text{M}$</p>
30	B	<p>Moles of sodium carbonate 1000cm^3 contain 0.05 moles 20cm^3 contain $\frac{0.05 \times 20}{1000}$ moles Moles of the acid 1mole of Na_2CO_3 react with 2 moles of acid $\frac{0.05 \times 20}{1000}$ of KOH react with $\frac{0.05 \times 20}{1000} \times 2$ Molarity of the acid 10cm^3 contain $\frac{0.05 \times 25}{1000} \times 2$ moles 1000cm^3 contain $\frac{0.05 \times 20}{1000} \times 2 \times \frac{1000}{10} = \frac{0.05 \times 20 \times 2}{10}$</p>

31	A	<p>Formula of $\text{Fe}_2\text{O}_3 = 56 \times 2 + 16 \times 3 = 160$ 160g of Fe_2O_3 require (56 x 2)g of iron 0.8g of Fe_2O_3 require $\frac{56 \times 2 \times 0,8}{160}$</p>
32	A	<p>Moles of nitric acid 1000cm³ contain 0.1moles 50cm³ contain $\frac{0.1 \times 50}{1000}$ 0.005moles Mole of copper oxide that reacted = $\frac{0.005}{2} = 0.0025 \text{ moles of CuO}$ Formula mass of CuO = 63.5 + 16 = 79.5g Mass of 0.0025mole of CuO = 0.0025 x 79.5 = 0.2g</p>
33	D	<p>(2 x 24)g of Mg require (16 x 2)g of oxygen 5g of Mg require $\frac{5 \times 32}{48}$</p>
34	C	<p>Formula mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} = 2 \times 23 + 12 + 16 \times 3 + 10(2 + 16) = 286\text{g}$ Mass of $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ in 1000cm³ = $\frac{5.73 \times 1000}{500} = 11.46$ Molarity = $\frac{\text{concentration } \text{gl}^{-1}}{\text{formula mass}} = \frac{11.46}{286}$</p>
35	C	<p>Formula of $\text{ZnCO}_3 = 65 + 12 + 16 \times 3 = 125$ Formula mass of ZnO = 65 + 16 = 81g 125g of ZnCO_3 produce 81g of ZnO 2.5g of ZnCO_3 produce $\frac{2.5 \times 81}{125} = 1.62$</p>
36	(a)	<p>Moles of NaOH 1000cm³ contain 0.1 moles 25.0cm³ contain $\frac{0.1 \times 25.0}{1000}$ moles Moles of the HCl 1 mole of NaOH react with 1 mole of HCl $\frac{0.1 \times 25.0}{1000}$ of NaOH react with $\frac{0.1 \times 25.0}{1000}$ mole of HCl Molarity of the HCl 20 cm³ contain $\frac{0.1 \times 25}{1000}$ moles 1000cm³ contain $\frac{0.1 \times 25}{1000} \times \frac{1000}{20} = \frac{0.1 \times 25.0}{20} = 0.125\text{M}$</p>
	(b)	<p>Formula mass of HCl = 1 + 35.5 = 36.5 Concentration in gl-1 1mole weigh = 36.5g ∴ 0.125 moles of HCl weigh 0.125 x 36.5 = 4.5625 Therefore, concentration of HCl gl⁻¹ = 4.5625</p>
37	(a)	<p>Moles of NaOH 1000cm³ contain 0.4 moles 30cm³ contain $\frac{0.4 \times 30}{1000} = 0.012$ moles</p>
	(b)	<p>Reaction equation $3\text{NaOH}(\text{aq}) + \text{H}_3\text{PO}_4(\text{aq}) \longrightarrow \text{Na}_3\text{PO}_4(\text{aq}) + 3\text{H}_2\text{O}(\text{l})$ Moles of H_3PO_4</p>

		<p>3moles of NaOH 1 mole of H₃PO₄</p> <p>0.012moles of NaOH react with $\frac{0.012 \times 1}{3} = 0.004 \text{ moles}$</p> <p>40cm³ contain 0.004 moles</p> <p>1000cm³ contain $\frac{0.004 \times 1000}{40} = 0.1M$</p>
38		<p>Moles of NaOH</p> <p>1000cm³ contain 0.2 moles</p> <p>25cm³ contain $\frac{0.2 \times 25}{1000} = 0.005 \text{ moles}$</p> <p>Reaction equation</p> <p>$2\text{NaOH}(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \longrightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$</p> <p>Moles of H₂SO₄</p> <p>2moles of NaOH 1 mole of H₂SO₄</p> <p>0.005moles of NaOH react with $\frac{0.005 \times 1}{2} = 0.0025 \text{ moles}$</p> <p>24.6cm³ contain 0.0025 moles</p> <p>1000cm³ contain $\frac{0.0025 \times 1000}{24.60} = 0.1M$</p>
39		<p>Moles of HCl</p> <p>1000cm³ contain 0.8 moles</p> <p>25cm³ contain $\frac{0.8 \times 25}{1000} = 0.02 \text{ moles}$</p> <p>Reaction equation</p> <p>$2\text{HCl}(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \longrightarrow 2\text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$</p> <p>Moles of Na₂CO₃</p> <p>2moles of HCl 1 mole of Na₂CO₃</p> <p>0.02moles of HCl react with $\frac{0.02 \times 1}{2} = 0.01 \text{ moles}$</p> <p>20cm³ contain 0.01 moles</p> <p>1000cm³ contain $\frac{0.01 \times 1000}{20} = 0.5M$</p> <p>Formula mass of Na₂CO₃ = 2 x 23 + 12 + 16 x 3 = 106</p> <p>mole of Na₂CO₃ weigh 106g</p> <p>0.5moles weigh 106 x 0.5 = 53g</p> <p>∴ the concentration of Na₂CO₃ is 53gl⁻¹</p>
40	(a)	<p>100cm³ contain 0.106g</p> <p>1000cm³ contain $\frac{0.106 \times 1000}{100} = 1.06g$</p>
	(b)	<p>Formula mass of Na₂CO₃ = 23 x 2 + 12 + 16 x 3 = 106</p> <p>Molarity = $\frac{1.06}{106} = 0.001M$</p>