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, a toms, ions or electrons.

A mole of any substance contains 6.02×10^{23} particles. These 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 6×10^3 atoms

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

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

Example 2
How many grams of Ag [Ag = 108] contain 1. 2 x 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

∴ 0.2 moles of Ag contain $\frac{[108 \times 0.2]\ g}{1}$

= **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 x10^{23} atoms

∴ 8g of carbon contain $\frac{8\ x\ 6\ x\ 10^{23}}{12} = 4\ x\ 10^{23}\ atoms$

Example 4

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

Solution

6 x10^{23} atoms of copper weigh 64g

∴ *4.5 x 10^{23} atoms contain* $\frac{4.5\ x\ 10^{23}\ x\ 64}{6\ x\ 10^{23}} = 48g$

Equations

If we consider the following equation:

$C + O_2 \rightarrow CO_2$

The equation now may mean

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

Similarly

$2C + O_2 \rightarrow 2CO$

The equation means that

a. 2 carbon atoms react with 1 oxygen molecule to yield 2 carbon monoxide
b. 24g of carbon react with 32g of oxygen to yield 56g of carbon monoxide.
   or
c. 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 CaSO**4**

R.F.M $CaSO_4 = 40 + 32 + 4\ X\ 16 = 136g$

=> 1 mole weighs 136g

⇨ 0.1mole weigh $136 \times 0.1 = 13.6g$

(b) 3 moles of H_2O

R.F.M H_2O = 18

⇒ $2 \times 1 + 16 = 18$

1 mole of $H_2O \rightarrow 18$

3 moles of $H_2O \rightarrow \frac{18 \times 3}{1}$

$= 54g$

Example 7:

According to the equation

$2C + O_2 \rightarrow 2CO$

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 O_2

=> 1 mole of O_2 requires 2 moles of C

∴ 0.2 moles of O_2 requires 2 x 02 = 0.4 moles of C

Example 8:

According to the equation

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

(a) How many moles of CO_2 will be produced in the reaction of 3.2g of O_2?

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 $\frac{3 \times 3.2}{160} = 0.06 moles$

(b) How many grams of propane will react with 0.5moles of O_2?

Solution

Formula mass of propane, $C_3H_8 = 12 \times 3 + 1 \times 8 = 44g$

5 moles of oxygen react with 1 mole of propane

∴ 0.5 moles of oxygen react with $\frac{1 \times 0.5}{5} = 0.1\ mole$ 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. **Morality of a solution** is the number of moles of the solute contained in 1 litre, $1dm^3$ or $1000cm^3$ of the solution.

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

4. **Some formulas**

Morality = $\frac{\text{Concentration in gm/L}}{\text{R.F.M}}$ (units for morality mol dm^{-3})

Or morality = $\frac{\text{No. of moles x 1000}}{\text{Volume}}$

Mole = $\frac{\text{grams/mass}}{\text{R.F.M}}$

Example 1

$20cm^3$ of 0.1M NaOH completely reacted with $50cm^3$ of dilute HCl. Calculate the Morality of the acid and concentration of the acid in g/l

Solution

Reacting equation

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Given: 20 cc 50cc
0.1M ?

Moles of NaOH that reacted:

$1000cm^3$ of NaOH contained 0.1moles

1 cm^3 of NaOH will contain $\left(\frac{0.1}{1000}\right) moles$

$20cm^3$ of NaOH will contain $\left(\frac{0.1}{1000} x20\right) moles$

= 0.002 moles of NaOH

Moles of HCl. that reacted
From the equation mole ratio of NaOH: HCl
1 : 1
Therefore 1 mole of NaOH reacted with 1 mole of HCl

Therefore, moles of HCl = 0.002 moles

Morality of HCl
50 cm^3 of HCl contained 0.002 moles

1 cm^3 of HCl will contain $\left(\frac{0.002}{50}\right) moles$

1000 cm^3 of HCl will contain $\left(\frac{0.002}{50} x 1000\right) moles$ = 0.04 M

Therefore, morality of HCl = 0.04 M

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

1 mole of HCl weighs 36.5g
0.04moles weigh 36.5 x 0.4 = <u>1.46g /L</u>

EXERCISE

1		The volume of 0.1M sodium hydroxide required to react exactly with 25.0cm3 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.	$\frac{20.0 \; x \; 0.1}{2 \; x \; 0.25}$
	B.	$\frac{20.0 \; x \; 0.25}{2 \; x \; 0.1}$
	C.	$\frac{2 \; x \; 20.0 \; x \; 0.25}{0.1}$
	D.	$\frac{2 \; x \; 20.0 \; x \; 0 \; .1}{0.25}$
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.	$\frac{2 \; x \; 10}{0.2 \; x \; 20}$
	B.	$\frac{0.2 \; x \; 20}{2 \; x \; 1}$
	C.	$\frac{0.2 \; x \; 10}{2 \; x \; 20}$
	D.	$\frac{2 \; x \; 0.2 \; x \; 20}{10}$

7		$CaCO_3$ (s) $\xrightarrow{heat}$ CaO(s) + CO_2(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, $Na_2CO_3.10H_2O$, 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 500cm3 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 $H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$ 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. $30\ cm^3$
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 25cm3 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.	$\frac{98 \, x \, 5}{0.2x \, 1000}$
	B.	$\frac{98 \, x \, 0.2 \, x5}{1000}$
	C.	$\frac{98 \, x \, 0.2}{5 \, x \, 1000}$
	D.	$\frac{9.8 \, x \, 5 \, 1000}{0.2}$
15		$25cm^3$ of 0.05M sodium carbonate required $22.70cm^3$ of hydrochloric acid for complete neuralization. Th mority of the acid given by
	A.	$\frac{0.00125 \, x \, 1000}{2 \, x \, 22.7}$
	B.	$\frac{0.00125 \, x \, 1000}{2 \, x \, 25}$
	C	$\frac{0.00125 \, x \, 2 \, x \, 1000}{22.7}$
	D.	$\frac{0.00125 \, x \, 1000}{25}$
16		$25cm^3$ of a 0.25M 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 $CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$ The mass of carbon dioxide formed when 20g od 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	$\frac{44 \, x \, 100}{20}$
	C.	$\frac{20 \, x \, 100}{44}$
	D.	$\frac{20 \, x \, 44}{100}$
18		Copper reacts with oxygen according to the following equation $2Cu(s) + O_2(g) \longrightarrow 2CuO(s)$ Calculate the mass of copper (II) sulphate formed when 0.64g of copper powder is completely reacted with oxygen (Cu = 64, O =16)
	A.	$\frac{0.64 \, x \, 80}{96}$
	B.	$\frac{0.64 \, x \, 64}{80}$

	C.	$\frac{0.64\ x\ 96}{80}$
	D.	$\frac{0.64\ x\ 80}{64}$
19		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 pf 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 x 83 B. 0.05 x 106 C. $\frac{106}{0.05}$ D $\frac{83}{0.05}$
21		Copper (II) oxide reacts with hydrogen according to the equation CuO(s) + H_2(g) $\longrightarrow$ Cu(s) + H_2O(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 x 80 x 8g B. $\frac{63.5\ x\ 80}{8}$ C. $\frac{8.0\ x\ 8o}{62.5}$ D. $\frac{63.5\ x\ 8.0}{80}$
22		Copper (II) sulphate reacts with sodium carbonate according to the following equation. $CuSO_4$(aq) + Na_2CO_3(aq) $\longrightarrow$ $CuCO_3$(s) + Na_2SO_4(aq) The mass of copper (II) carbonate formed when 200cm3 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.	$\frac{5.3\ x\ 200\ x\ 124}{106\ x\ 1000}g$ B. $\frac{5.2\ x\ 124\ x\ 1000}{106\ x\ 200}g$ C. $\frac{106\ x\ 200\ x\ 124}{5.3\ x\ 1000}g$ D. $\frac{106\ x\ 124\ x\ 100}{5.3\ x\ 200}g$
23		$15cm^3$ of a dibasic acis was neutralised by $30cm^3$ of a 0.4M potassium hydroxide solution. The morality of the acid is A. $\frac{2\ x\ 15}{0.4\ x\ 30}$ B. $\frac{0.4\ x\ 30}{2\ x\ 15}$ C. $\frac{15\ x\ 0.4}{30\ x\ 2}$ D. $\frac{2\ x\ 0.4\ 30}{15}$
24		Aluminium reacts with copper II ions according to the following equation $3Cu^{2+}$(aq) + 2Al (s) $\longrightarrow$ 3Cu(s) + $2Al^{3+}$(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.	$\frac{2.5\ x\ 2\ x63.5}{27\ x\ 3}$ B. $\frac{2.5\ x\ 3\ x\ 27}{63.5\ x\ 2}$ C. $\frac{2.5\ x\ 2\ x\ 27}{63.5\ x\ 3}$ D. $\frac{2.5\ x\ 3\ x\ 63.5}{27\ x\ 2}$
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. $\frac{25\ x\ 05}{20}$M B. $\frac{2\ x\ 25\ x\ 0.05}{20}$M C. $\frac{2\ x\ 20\ x\ 0.05}{25}$M D. $\frac{25\ x\ 0.05}{2\ x\ 2}$M
26		Hydrochloric acid reacts with calcium hydrogen carbonate according to the following equation $Ca(HCO_3)_2$ (aq) + 2HCl(aq) $\longrightarrow$ $CaCl_2$(aq) + $2H_2O$(l) + $2CO_2$(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 $\left(\frac{8.0\ x\ 0.05\ x\ 162}{2\ x\ 25}\right) gl^{-1}$
		B. $\left(\frac{8.0\ x\ 0.05\ x\ 162}{25}\right) gl^{-1}$
		C. $\left(\frac{25\ x\ 0.05\ x\ 162}{2\ x\ 8}\right) gl^{-1}$
		D. $\left(\frac{25\ x\ 0.05\ x\ 162}{8}\right) gl^{-1}$
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 pf 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 morality 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 o.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. $\left(\frac{20\ x\ 0.05\ x\ 2}{1000}\right) moles$ B. $\left(\frac{20\ x\ 0.05\ x\ 2}{10}\right) moles$ C. $\left(\frac{20\ x\ 0.05}{2\ x1000}\right) moles$ D. $\left(\frac{0.05\ x\ 2\ x\ 10}{20\ x\ 1000}\right) moles$
31		Iron react with oxygen to form 0.8g of Iron (III) oxide is [O = 16, Fe = 56] A. $\left(\frac{0.8\ x\ 2\ x\ 56}{160}\right) g$ B. $\left(\frac{0.8\ x\ 2\ x\ 56}{320}\right) g$ C. $\left(\frac{0.8\ x\ 2}{160\ x\ 56}\right) g$ D. $\left(\frac{0.8\ x\ 56}{320\ x\ 2}\right) g$

32		Nitric acid reacts with copper (II oxide according to the following equation $CuO(s) + 2HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + H_2O(l)$ 0.5g of an impure copper (II) oxide reacted completely with $50cm^3$ of a 0.1M nitric acid. The mass of copper (II) oxide in a sample is A. 0.20g B. 0.24g C. 0.30g D. 0.40g
33.		Magnesium burns in air according equation $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$ The mass of oxygen required to burn 5g of magnesium completely is [O = 16; Mg = 24] A. $\frac{5\,x\,16}{24}g$ B. $\frac{5\,x\,16}{48}g$ C. $\frac{5\,x\,32}{24}g$ D. $\frac{5\,x\,32}{48}g$
34		5.73g of hydrated sodium carbonate, $Na_2CO_3.10H_2O$, was dissolved in water to make $500cm^3$ of solution. The morality of solution is (Na = 23, O = 16, c = 12, H = 1) A. 0.05M B. 0.02M C. 0.04M D. 0.1M
35		Zinc carbonate decomposes according to the following equation when $ZnCO_3(s) \longrightarrow ZnO(s) + CO_2(g)$ The mass of zinc oxide formed when 2.5g of zinc carbonate is heat is (Zn = 65; O = 16; C = 12) A. 0.41g B. 0.81g C. 1.62g D. 3.24g
36		$25.0cm^3$ of a solution of 0.1M NaOH were exactly neutralised by $20.0cm^3$ of HCl. Calculate the concentration of the acid as
	(a)	Molarity
	(b)	in g/dm^3
37		In attrition $30cm^3$ of 0.4 M NaOH required $40cm^3$ of phosphoric acid, H_3PO_4
	(a)	How many moles of NaOH are present in $30cm^3$ of solution?
	(b)	Calculate the molarity of H_3PO_4 acid.
38.		In an experiment to determine the concentration of dilute sulphuric acid in moles per litre, 25 cm^3 of 0.2 m NaOH solution required 24.6 cm^3 of the acid. Calculate the molarity of the acid.
39		$20cm^3$ of sodium carbonate solution reacted completely with $25cm^3$ of 0.8M hydrochloric acid according to the following equation $Na_2CO_3(aq) + 2HCl\ (aq) \longrightarrow NaCl(aq) + CO_2(g) + H_2O(l)$ Calculate the concentration of the sodium carbonate in g/l.
40		A sample of 0.106 g of pure sodium carbonate was dissolved in water to make $100cm^3$ of solution.
	(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	Mole of hydrochloric acid $1000cm^3$ contains 0.02mole ⇨ $25\ cm^3$ contains $\frac{0.02\ x\ 25}{1000} = 0.005moles$ Equation $NaOH\ (aq) + HCl\ (aq) \longrightarrow NaCl(aq) + H_2O(l)$ Moles of NaOH From equation 1 mole of acid reacts with 1 mole of NaOH ⇨ Mole of NaOH = Moles of HCl = 0.005 Volume of sodium hydroxide solution 0.1 mole is contained in $1000cm^3$ of 0.1M sodium hydroxide solution ∴ 0.005 moles are in $\frac{0.005\ x\ 1000}{0.1} = 50cm^3$
2	B	Mole of nitric acid in $200cm^3$ of 2M nitric acid $1000cm^3$ contain 2mole of nitric acid $200cm^3$ contain $\frac{200\ x\ 2}{1000} = 0.4moles$ Formula mass of nitric acid, HNO_3 = 1 + 14 + 16 x3 = 63 1 mole of nitric acid is equivalent to 63g ⇨ 0.4moles = 04 x 63g = 25.2g ∴ the mass of nitric acid required to form $200cm^3$ of 2M nitric acid = 25.2g
3.	D	Formula mass of NaOH = 23 + 16 +1 = 40 Moles of sodium hydroxide = $\frac{40}{40} = 1mole$ Morality of sodium hydroxide $500cm^3$ contain 1mole ∴ $1000cm^3$ contains $\frac{1000\ x\ 1}{500} = 2M$ ∴ molarity of a solution that contain 40g of sodium hydroxide in $500cm^3$ = 2M
4	D	Mole of sodium carbonate $1000cm^3$ contains 0.1mole ⇨ $20\ cm^3$ contains $\frac{0.1\ x\ 20}{1000} = 0.002moles$ Equation $Na_2CO_3\ (aq) + 2HCl\ (aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$ Moles of HCl From equation 1 mole of Na_2CO_3 reacts with 2 moles of HCl ⇨ Mole of HCl = 2 x Moles of Na_2CO_3 = 0.002 x 2 = 0.004 moles Volume of HCl solution 0.25moles are contained in $1000cm^3$ of .25M HCl solution ∴ 0.004 moles are in $\frac{0.004\ x\ 1000}{0.25} = 16cm^3$
5	D	0.2 moles of X weigh 18.25g 1mole weigh $\frac{18.25\ x\ 1}{0.2} = 91.25g$ ∴ formula mass of X = 91.25

6	B	Moles of sodium hydroxide 1000cm^3 contains 0.02mole ⇨ 20 cm^3 contains $\frac{0.02\ x\ 20}{1000}$ Equation 2NaOH (aq) + H_2X (aq) ⟶ Na_2X(aq) + H_2O(l) Moles of acid From equation 2 mole of NaOH reacts with 1 mole of acid ⇨ Mole of aid $= \frac{1}{2}\ x\ mole\ of\ NaOH = \frac{1}{2}\ x\ \frac{0.02\ x\ 20}{1000}$ Molarity of the acid 10 cm^3 contain $\frac{1}{2}\ x\ \frac{0.02\ x\ 20}{1000}$ 1000cm^3 contain $\frac{1}{2}\ x\ \frac{0.02\ x\ 20}{1000}\ x\ \frac{1000}{10} = \frac{0.02\ x\ 20}{2\ x\ 10} M$
7	A	Formula mass of $CaCO_3$ = 40 +12 + 16 x 3 = 100g Formula mass of CaO = 40 + 16 = 56 ⇨ 100g of $CaCO_3$ produce 56g of CaO ∴ 20g of $CaCO_3$ produce $\frac{20\ x\ 56}{100}\ g\ of\ CaO$
8	B	Formula mass of $Na_2CO_3.10H_2O$ = 23 x 2 + 12 + 16 x 3 + 10(1 x 2 + 16) = 286g Moles $Na_2CO_3.10H_2O$ in 50cm^3 of 0.1M solution 1000cm^3 contain 0.1 mole 50cm^3 contain $\frac{0.1\ x\ 50}{1000}\ moles$ Mass of $Na_2CO_3.10H_2O$ equivalent to $\frac{0.1\ x\ 50}{1000}\ moles$ 1 mole of $Na_2CO_3.10H_2O$ weigh 286g ∴ $\frac{0.1\ x\ 50}{1000}\ moles$ of $Na_2CO_3.10H_2O$ weigh $\frac{0.1\ x\ 50}{1000} x286g$
9	C	Formula mass of NaOH = 23 + 16 + 1 = 40 Moles of sodium hydroxide = $\frac{2}{40} = 0.05 moles$ Molarity of sodium hydroxide 500cm^3 contain 0.05mole 1000cm^3 contain $\frac{0.05\ 1000}{500} = 0.1\ moles$ ⇨ molarity of sodium hydroxide = 0.1M
10	C	Mole of sodium hydroxide 1000cm^3 contains 2 moles ⇨ 10 cm^3 contains $\frac{2\ x\ 10}{1000} = 0.02 moles$ Equation 2NaOH (aq) + H_2SO4 (aq) ⟶ Na_2SO_4(aq) + 2H_2O(l) Moles of H_2SO_4 From equation 2 moles of NaOH reacts with 1 mole of H_2SO_4 ⇨ Mole of $H_2SO_4 = \frac{1}{2}$ x Moles of NaOH $= \frac{0.02}{2} = 0.01 mole$ Volume of sulphuric acid solution 0.5 Moles are contained in 1000cm^3 ∴ 0.01 moles are in $\frac{0.01\ x\ 1000}{0.5} = 20 cm^3$
11	C	Formula mass of NaOH = 23 + 16 + 1 = 40g Mass of sodium hydroxide in 1l of 2M solution = 40 x 2 = 80g

		∴ 0.5l contain $\frac{0.5\ x\ 80}{1} = 40g$
12	B	Mole of hydrochloric acid 1000cm^3 contains 0.1mole ⇨ 25 cm^3 contains $\frac{0.1\ x\ 25}{1000} = 0.0025moles$ Equation NaOH (aq) + HCl (aq) ⟶ NaCl(aq) + H_2O(l) Moles of NaOH From equation 1 mole of acid reacts with 1 mole of NaOH ⇨ Mole of NaOH = Moles of HCl = 0.0025 Volume of sodium hydroxide solution 0.2 mole is contained in 1000cm^3 ∴ 0.0025 moles are in $\frac{0.0025\ x\ 1000}{0.2} = 12.5cm^3$
13	B	Hint: Same number of moles of an element contain the same number of atoms Mole = $\frac{mass}{ralative\ atomic\ mas}$ Mole of sulphur in 8g = $\frac{8}{32} = 0.25$moles Moles calcium in 20g = $\frac{20}{40} = 0.5$ moles Moles calcium in 10g = $\frac{10}{4} = 0.25$ mole Therefore, 8g of sulphur contain the same number of atoms as 10g of calcium
14	B	Formula mass of H_2SO_4 = 1 x 2 + 32 + 16 x 4 = 98g Mass of H_2SO_4 in 1000cm^3 of 0.2M solution = (98 x 0.2)g ∴ 5cm^3 contain $\frac{0.2\ x\ 98\ x\ 5}{1000}$g
15	C	Mole of sodium carbonate 1000cm^3 contains 0.05mole ⇨ 25 cm^3 contains $\frac{0.05\ x\ 25}{1000} = 0.00125moles$ Equation Na_2CO_3 (aq) + 2HCl (aq) ⟶ 2NaCl(aq) + H_2O(l) + CO_2(g) Moles of HCl From equation 1 mole of Na_2CO_3 reacts with 2 moles of HCl ⇨ Mole of HCl = 2 x Moles of Na_2CO_3 = (0.00125 x 2) moles Molarity 22.7cm^3 contain 0.00125 x 2 mole ∴ 1000cm^3 contain $\frac{0.00125\ x\ 2\ x\ 1000}{22.7}$ M
16	C	Mole of acid = $\frac{25\ x\ 0.25}{1000} = 0.00625$ moles Moles sodium hydroxide = $\frac{25\ x\ 0.5}{1000} = 0.0125\ moles$ Basicity of acid = $\frac{moles\ of\ sodium\ hydroxide}{moles\ of\ the\ acid} = \frac{0.0125}{0.00625} = 2$

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

25	B	Moles of sodium carbonate 1000cm^3 contain 0.05 moles 25cm^3 contain $\frac{0.05\ x\ 25}{1000}$ moles Moles of the acid 1mole of Na_2CO_3 react with 2 moles of acid $\frac{0.05\ x\ 25}{1000}$ of KOH react with $\frac{0.4\ x\ 30}{1000}\ x\ 2$ Molarity of the acid 20 cm^3 contain $\frac{0.05\ x\ 25}{1000}\ x\ 2$ moles 1000cm^3 contain $\frac{0.05\ x\ 25}{\cancel{1000}}\ x\ 2\ x\ \frac{\cancel{1000}}{20} = \frac{0.05\ x\ 25\ x\ 2}{20}$
26	A	Moles of hydrochloric acid 1000cm^3 contain 0.05 moles 8.0cm^3 contain $\frac{0.05\ x\ 8.0}{1000}$ moles Moles of the $Ca(HCO_3)_2$ 2mole of HCl react with 1 mole of $Ca(HCO_3)_2$ $\frac{0.05\ x\ 8.0}{1000}$of KOH react with $\frac{0.05\ x\ 8.0}{1000}\ x\ \frac{1}{2}$ Molarity of the $Ca(HCO_3)_2$ 25 cm^3 contain $\frac{0.05\ x\ 8.0}{1000}\ x\ \frac{1}{2}$ moles 1000cm^3 contain $\frac{0.05\ x\ 8.0}{\cancel{1000}}\ x\ \frac{1}{2}\ x\ \frac{\cancel{1000}}{25} = \frac{0.05\ x\ 8.0}{2\ x\ 25}$M Formula mass of $Ca(HCO_3)_2$ = 40 + 2(1 + 12 + 16 x 3) = 162 ∴ concentration of $Ca(HCO_3)_2 = \frac{0.05\ x\ 8.0}{2\ x\ 25}\ x\ 162 gl^{-1}$
27	C	Formula mass of KI = 39 + 127 = 166g Formula mass of PbI_2 = 207 + 127 x 2 = 461g (166 x 2) g of KI produce 46 1g of PbI_2 33.2g of KI will produce $\frac{33.2\ x\ 461}{332} = 46.1g$
28	C	Formula mass of $Ca(HCO_3)_2$ = 40 + 2(1 + 12 + 16 x 3) = 162g Mas of $Ca(HCO_3)_2$ in 1000cm^3 = $\frac{1000\ x\ 6.48}{500} = 12.96g$ Molarity of $Ca(HCO_3)_2$ $\frac{concentration\ gl^{-1}}{formula\ mass} = \frac{12.96}{162}\ 0.08M$
29	D	Mole of $NaHSO_4$ in 200cm^3 of 0.5M = $\frac{0.5\ x\ 200}{1000} = 0.1M$ Mole of NaCl in 250cm^3 of 0.4M = $\frac{0.4\ x\ 250}{1000} = 0.1M$
30	B	Moles of sodium carbonate 1000cm^3 contain 0.05 moles 20cm^3 contain $\frac{0.05\ x\ 20}{1000}$ moles Moles of the acid 1mole of Na_2CO_3 react with 2 moles of acid $\frac{0.05\ x\ 20}{1000}$ of KOH react with $\frac{0.05\ x\ 20}{1000}\ x\ 2$ Molarity of the acid 10 cm^3 contain $\frac{0.05\ x\ 25}{1000}\ x\ 2$ moles 1000cm^3 contain $\frac{0.05\ x\ 20}{\cancel{1000}}\ x\ 2\ x\ \frac{\cancel{1000}}{10} = \frac{0.05\ x\ 20\ x\ 2}{10}$

31	A	Formula of Fe_2O_3 = 56 x 2 + 16 x 3 = 160 160g of Fe_2O_3 require (56 x 2)g of iron 0.8g of Fe_2O_3 require $\frac{56\ x\ 2\ x\ 0{,}8}{160}$
32	A	Moles of nitric acid 1000cm^3 contain 0.1moles 50cm^3 contain $\frac{0.1\ x\ 50}{1000}$ 0.005moles Mole of copper oxide that reacted = $\frac{0.005}{2} = 0.0025 moles\ of\ CuO$ Formula mass of Cuo = 63.5 + 16 =79.5g Mass of 0.0025mole of CuO = 0.0025 x 79.5 =0.2g
33	D	(2 x 24)g of Mg require (16 x 2)g of oxygen 5g of Mg require $\frac{5\ x\ 32}{48}$
34	C	Formula mass of $Na_2CO_3.10H_2O$ = 2 x 23+ 12 + 16 x 3 + 10(2+ 16) = 286g Mass of $Na_2CO_3.10H_2O$ in 1000cm^3 = $\frac{5.73\ x\ 1000}{500} = 11.46$ Molarity = $\frac{concentration\ gl^{-1}}{formula\ mass} = \frac{11.46}{286}$
35	C	Formula of $ZnCO_3$ = 65 + 12 + 16 x 3 = 125 Formula mass of ZnO = 65 + 16 = 81g 125g of $ZnCO_3$ produce 81g of ZnO 2.5g of $ZnCO_3$ produce $\frac{2.5\ x\ 81}{125} = 1.62$
36	(a)	Moles of NaOH 1000cm^3 contain 0.1 moles 25.0cm^3 contain $\frac{0.1\ x\ 25.0}{1000}$ moles Moles of the HCl 1 mole of NaOH react with 1 mole of HCl $\frac{0.1\ x\ 25.0}{1000}$of NaOH react with $\frac{0.1\ x\ 25.0}{1000}$ mole of HCl Molarity of the HCl 20 cm^3 contain $\frac{0.1\ x\ 25}{1000}$ moles 1000cm^3 contain $\frac{0.1\ x\ 25}{\cancel{1000}}\ x\ \frac{\cancel{1000}}{20} = \frac{0.1\ x\ 25.0}{20} = 0.125M$
	(b)	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
37	(a)	Moles of NaOH 1000cm^3 contain 0.4 moles 30cm^3 contain $\frac{0.4\ x\ 30}{1000} = 0.012$ moles
	(b)	Reaction equation $3NaOH(aq) + H_3PO_4(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$ Moles of H_3PO_4

		3moles of NaOH 1 mole of H_3PO_4 $0.012 moles$ of NaOH react with $\frac{0.012\ x\ 1}{3} = 0.004\ moles$ $40cm^3$ contain 0.004 moles $1000cm^3$ contain $\frac{0.004\ x\ 1000}{40} = 0.1M$
38		Moles of NaOH $1000cm^3$ contain 0.2 moles $25cm^3$ contain $\frac{0.2\ x\ 25}{1000} = 0.005$ moles Reaction equation $2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$ Moles of H_2SO_4 2moles of NaOH 1 mole of H_2SO_4 $0.005 moles$ of NaOH react with $\frac{0.005\ x\ 1}{2} = 0.0025\ moles$ $24.6cm^3$ contain 0.0025 moles $1000cm^3$ contain $\frac{0.0025\ x\ 1000}{24.60} = 0.1M$
39		Moles of HCl $1000cm^3$ contain 0.8 moles $25cm^3$ contain $\frac{0.8\ x\ 25}{1000} = 0.02$ moles Reaction equation $2HCl(aq) + Na_2CO_3(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$ Moles of Na_2CO_3 2moles of HCl 1 mole of Na_2CO_3 $0.02 moles$ of HCl react with $\frac{0.02\ x\ 1}{2} = 0.01\ moles$ $20cm^3$ contain 0.01 moles $1000cm^3$ contain $\frac{0.01\ x\ 1000}{20} = 0.5M$ Formula mass of Na_2CO_3 = 2 x 23 + 12 + 16 x 3 = 106 mole of Na_2CO_3 weigh 106g 0.5moles weigh 106 x 0.5 = 53g ∴ the concentration of Na_2CO_3 is $53gl^{-1}$
40	(a)	$100cm^3$ contain 0.106g $1000cm^3$ contain $\frac{0.106\ x\ 1000}{100} = 1.06g$
	(b)	Formula mass of Na_2CO_3 = 23 x 2 + 12 + 16 x 3 =106 Molarity = $\frac{1.06}{106} = 0.001M$