# 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 $6.02 \times 10^{23}$ particles. These number of particles in any mole of a substance ($6.02 \times 10^{23}$) is called **AVOGADRO'S NUMBER**

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

***Example 1***
*Taking Avogadro's constant equal to $6 \times 10^{23}$*
*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 $6 \times 10^3$ 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 $1.2 \times 10^{23}$ atoms be X
1 mole of Ag contain $6 \times 10^{23}$ atoms
X moles of Ag contain $1.2 \times 10^{23}$ 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 x$10^{23}$ 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 x$10^{23}$ 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. | 12.5$cm^3$ |
| | B. | 25.0$cm^3$ |
| | C. | 50.0$cm^3$ |
| | D. | 75.0$cm^3$ |
| 2. | | The mass of nitric acid required to make 200$cm^3$ 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 500$cm^3$ 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 20$cm^3$ 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. | | 10$cm^3$ of dibasic was neutralised by 20$cm^3$ 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. | $\frac{2 \; x \; 0.2 \; x \; 20}{10}$ |

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| 7 | | $CaCO_3$ (s) $\xrightarrow{heat}$ CaO(s) + $CO_2$(g)<br>The mass, in grams of calcium oxide formed when 20g of calcium carbonate completely decomposes is<br>(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<br>$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$<br>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 |

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| 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<br>$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$<br>The mass of carbon dioxide formed when 20g od calcium carbonate is completely reacted with hydrochloric acid is<br>(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<br>$2Cu(s) + O_2(g) \longrightarrow 2CuO(s)$<br>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. | $\frac{0.64 \, x \, 64}{80}$ |

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| | 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<br>$Pb(NO_3)_2$ (aq) + 2KI (aq) $\longrightarrow$ $PbI_2$(s) + $2KNO_3$(aq)<br>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<br>CuO(s) + $H_2$(g) $\longrightarrow$ Cu(s) + $H_2O$(l)<br>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.<br>$CuSO_4$(aq) + $Na_2CO_3$(aq) $\longrightarrow$ $CuCO_3$(s) + $Na_2SO_4$(aq)<br>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<br>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<br>$3Cu^{2+}$(aq) + 2Al (s) $\longrightarrow$ 3Cu(s) + $2Al^{3+}$(aq)<br>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?<br>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<br>$Ca(HCO_3)_2$ (aq) + 2HCl(aq) $\longrightarrow$ $CaCl_2$(aq) + $2H_2O$(l) + $2CO_2$(g)<br>$25cm^3$of a solution of calcium hydrogen carbonate required $8.0cm^3$ of a .05M |

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| | | hydrochloric acid for complete neutralization. The concentration of the calcium hydrogen carbonate solution is<br>(Ca = 40; O = 16, C =12)<br><br>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<br>$Pb(NO_3)_2$ (aq) + 2KI (aq) $\longrightarrow$ $PbI_2$(s) + 2$KNO_3$(aq)<br>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 500$cm^3$ of solution. Which of the following is the morality of the solution? (H = 1; C = 12, O = 16, Ca = 40)<br><br>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 200$cm^3$ of o.5M $NaHSO_4$ solution?<br>A. 100$cm^3$ of 2M $Na_2CO_3$<br>B. 100$cm^3$ of 0.5M $NaNO_3$<br>C. 250$cm^3$ of 0.8M $NaHCO_3$<br>D. 250$cm^3$ 0.4M NaCl |
| 30 | | 10$cm^3$ of monobasic acid completely reacted with 20$cm^3$ of 0.05M sodium carbonate solution. The number of moles of the acid that reacted is<br>A. $\left(\frac{20\ x\ 0.05\ x\ 2}{1000}\right) moles$<br>B. $\left(\frac{20\ x\ 0.05\ x\ 2}{10}\right) moles$<br>C. $\left(\frac{20\ x\ 0.05}{2\ x1000}\right) moles$<br>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]<br>A. $\left(\frac{0.8\ x\ 2\ x\ 56}{160}\right) g$<br>B. $\left(\frac{0.8\ x\ 2\ x\ 56}{320}\right) g$<br>C. $\left(\frac{0.8\ x\ 2}{160\ x\ 56}\right) g$<br>D. $\left(\frac{0.8\ x\ 56}{320\ x\ 2}\right) g$ |

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| 32 | | Nitric acid reacts with copper (II oxide according to the following equation<br>$CuO(s) + 2HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + H_2O(l)$<br>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<br>A. 0.20g B. 0.24g C. 0.30g D. 0.40g |
| 33. | | Magnesium burns in air according equation<br>$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$<br>The mass of oxygen required to burn 5g of magnesium completely is<br>[O = 16; Mg = 24]<br>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<br>(Na = 23, O = 16, c = 12, H = 1)<br>A. 0.05M B. 0.02M C. 0.04M D. 0.1M |
| 35 | | Zinc carbonate decomposes according to the following equation when<br>$ZnCO_3(s) \longrightarrow ZnO(s) + CO_2(g)$<br>The mass of zinc oxide formed when 2.5g of zinc carbonate is heat is<br>( Zn = 65; O = 16; C = 12)<br>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<br>$Na_2CO_3(aq) + 2HCl\ (aq) \longrightarrow NaCl(aq) + CO_2(g) + H_2O(l)$<br>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<br>$1000cm^3$ contains 0.02mole<br>⇨ $25\ cm^3$ contains $\frac{0.02\ x\ 25}{1000} = 0.005moles$<br>Equation<br>$NaOH\ (aq) + HCl\ (aq) \longrightarrow NaCl(aq) + H_2O(l)$<br>Moles of NaOH<br>From equation 1 mole of acid reacts with 1 mole of NaOH<br>⇨ Mole of NaOH = Moles of HCl = 0.005<br>Volume of sodium hydroxide solution<br>0.1 mole is contained in $1000cm^3$ of 0.1M sodium hydroxide solution<br>∴ 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<br>$1000cm^3$ contain 2mole of nitric acid<br>$200cm^3$ contain $\frac{200\ x\ 2}{1000} = 0.4moles$<br>Formula mass of nitric acid, $HNO_3$ = 1 + 14 + 16 x3 = 63<br>1 mole of nitric acid is equivalent to 63g<br>⇨ 0.4moles = 04 x 63g = 25.2g<br>∴ 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<br>Moles of sodium hydroxide = $\frac{40}{40} = 1mole$<br>Morality of sodium hydroxide<br>$500cm^3$ contain 1mole<br>∴ $1000cm^3$ contains $\frac{1000\ x\ 1}{500} = 2M$<br>∴ molarity of a solution that contain 40g of sodium hydroxide in $500cm^3$ = 2M |
| 4 | D | Mole of sodium carbonate<br>$1000cm^3$ contains 0.1mole<br>⇨ $20\ cm^3$ contains $\frac{0.1\ x\ 20}{1000} = 0.002moles$<br>Equation<br>$Na_2CO_3\ (aq) + 2HCl\ (aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$<br><br>Moles of HCl<br>From equation 1 mole of $Na_2CO_3$ reacts with 2 moles of HCl<br>⇨ Mole of HCl = 2 x Moles of $Na_2CO_3$ = 0.002 x 2 = 0.004 moles<br>Volume of HCl solution<br>0.25moles are contained in $1000cm^3$ of .25M HCl solution<br>∴ 0.004 moles are in $\frac{0.004\ x\ 1000}{0.25} = 16cm^3$ |
| 5 | D | 0.2 moles of X weigh 18.25g<br>1mole weigh $\frac{18.25\ x\ 1}{0.2} = 91.25g$<br>∴ formula mass of X = 91.25 |

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

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

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| 17 | D | Formula mass of $CaCO_3$ = 40 + 12 + 16 x 3 = 100g<br>Formula mass of $CO_2$ = 12 + 16 x 2 = 44g<br>100g of $CaCO_3$ produce 44 g of $CO_2$<br>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<br>⇨ 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<br>Formula mass $PbI_2$ = 207 + 127 x 2 =461<br>166 x 2g of KI produce 461g of $PbI_2$<br>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<br>1mole weighs 106g<br>0.05mole weigh 0.05 x 106<br>∴ 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<br>80g of CuO form 63.5 g of Cu<br>∴ 8.0g will form $\frac{8.0\ x\ 63.5}{80}$ |
| 22 | B | Formula mass of $CuCO_3$ = 64 + 12 + 16 x 3 = 124<br>Formula mass of sodium carbonate $Na_2CO_3$ = 106<br>Mass of sodium carbonate in 200cm3 = $\frac{5.3\ x\ 200}{1000}$<br>But 106 g of $Na_2CO_3$ produce 124g of $CuCO_3$<br>∴ $\frac{5.3\ x\ 200}{1000}$g of $Na_2CO_3$ produce $\frac{5.3\ x\ 200}{1000}\ x\ \frac{124}{106}$ |
| 23 | B | Moles of potassium hydroxide<br>1000$cm^3$ contain 0.4 moles<br>30$cm^3$ contain $\frac{0.4\ x\ 30}{1000}$ moles<br>Moles of the acid<br>2mole of KOH react with 1 mole of acid<br>$\frac{0.4\ x\ 30}{1000}$ of KOH react with $\frac{0.4\ x\ 30}{1000}\ x\ \frac{1}{2}$<br>Molarity of the acid<br>15 $cm^3$ contain $\frac{0.4\ x\ 30}{1000}\ x\ \frac{1}{2}$ moles<br>1000$cm^3$ 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<br>2.5 g of aluminium will produce $\frac{3x\ 63.5\ x\ 2.5}{2\ x\ 27}$ |

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| 25 | B | Moles of sodium carbonate<br>1000cm$^3$ contain 0.05 moles<br>25cm$^3$ contain $\frac{0.05\ x\ 25}{1000}$ moles<br>Moles of the acid<br>1mole of $Na_2CO_3$ react with 2 moles of acid<br>$\frac{0.05\ x\ 25}{1000}$ of KOH react with $\frac{0.4\ x\ 30}{1000}\ x\ 2$<br>Molarity of the acid<br>20 cm$^3$ contain $\frac{0.05\ x\ 25}{1000}\ x\ 2$ moles<br>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<br>1000cm$^3$ contain 0.05 moles<br>8.0cm$^3$ contain $\frac{0.05\ x\ 8.0}{1000}$ moles<br>Moles of the $Ca(HCO_3)_2$<br>2mole of HCl react with 1 mole of $Ca(HCO_3)_2$<br>$\frac{0.05\ x\ 8.0}{1000}$of KOH react with $\frac{0.05\ x\ 8.0}{1000}\ x\ \frac{1}{2}$<br>Molarity of the $Ca(HCO_3)_2$<br>25 cm$^3$ contain $\frac{0.05\ x\ 8.0}{1000}\ x\ \frac{1}{2}$ moles<br>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<br>Formula mass of $Ca(HCO_3)_2$ = 40 + 2(1 + 12 + 16 x 3) = 162<br>∴ 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<br>Formula mass of $PbI_2$ = 207 + 127 x 2 = 461g<br>(166 x 2) g of KI produce 46 1g of $PbI_2$<br>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<br><br>Mas of $Ca(HCO_3)_2$ in 1000cm$^3$ = $\frac{1000\ x\ 6.48}{500} = 12.96g$<br>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 = $\frac{0.5\ x\ 200}{1000} = 0.1M$<br>Mole of NaCl in 250cm$^3$ of 0.4M = $\frac{0.4\ x\ 250}{1000} = 0.1M$ |
| 30 | B | Moles of sodium carbonate<br>1000cm$^3$ contain 0.05 moles<br>20cm$^3$ contain $\frac{0.05\ x\ 20}{1000}$ moles<br>Moles of the acid<br>1mole of $Na_2CO_3$ react with 2 moles of acid<br>$\frac{0.05\ x\ 20}{1000}$ of KOH react with $\frac{0.05\ x\ 20}{1000}\ x\ 2$<br>Molarity of the acid<br>10 cm$^3$ contain $\frac{0.05\ x\ 25}{1000}\ x\ 2$ moles<br>1000cm$^3$ contain $\frac{0.05\ x\ 20}{\cancel{1000}}\ x\ 2\ x\ \frac{\cancel{1000}}{10} = \frac{0.05\ x\ 20\ x\ 2}{10}$ |

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| 31 | A | Formula of $Fe_2O_3$ = 56 x 2 + 16 x 3 = 160<br>160g of $Fe_2O_3$ require (56 x 2)g of iron<br>0.8g of $Fe_2O_3$ require $\frac{56\ x\ 2\ x\ 0{,}8}{160}$ |
| 32 | A | Moles of nitric acid<br>1000cm$^3$ contain 0.1moles<br>50cm$^3$ contain $\frac{0.1\ x\ 50}{1000}$ 0.005moles<br>Mole of copper oxide that reacted = $\frac{0.005}{2} = 0.0025 moles\ of\ CuO$<br>Formula mass of Cuo = 63.5 + 16 =79.5g<br>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<br>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<br>Mass of $Na_2CO_3.10H_2O$ in 1000cm$^3$ = $\frac{5.73\ x\ 1000}{500} = 11.46$<br>Molarity = $\frac{concentration\ gl^{-1}}{formula\ mass} = \frac{11.46}{286}$ |
| 35 | C | Formula of $ZnCO_3$ = 65 + 12 + 16 x 3 = 125<br>Formula mass of ZnO = 65 + 16 = 81g<br>125g of $ZnCO_3$ produce 81g of ZnO<br>2.5g of $ZnCO_3$ produce $\frac{2.5\ x\ 81}{125} = 1.62$ |
| 36 | (a) | Moles of NaOH<br>1000cm$^3$ contain 0.1 moles<br>25.0cm$^3$ contain $\frac{0.1\ x\ 25.0}{1000}$ moles<br>Moles of the HCl<br>1 mole of NaOH react with 1 mole of HCl<br>$\frac{0.1\ x\ 25.0}{1000}$of NaOH react with $\frac{0.1\ x\ 25.0}{1000}$ mole of HCl<br>Molarity of the HCl<br>20 cm$^3$ contain $\frac{0.1\ x\ 25}{1000}$ moles<br><br>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<br><br>Concentration in gl-1<br>1mole weigh = 36.5g<br>∴ 0.125 moles of HCl weigh 0.125 x 36.5 =4.5625<br>Therefore, concentration of HCl gl$^{-1}$ = 4.5625 |
| 37 | (a) | Moles of NaOH<br>1000cm$^3$ contain 0.4 moles<br>30cm$^3$ contain $\frac{0.4\ x\ 30}{1000} = 0.012$ moles |
| | (b) | Reaction equation<br>$3NaOH(aq) + H_3PO_4(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$<br>Moles of $H_3PO_4$ |

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