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a) Atomic Structure and Mixtures

b) Periodic Table

c) Structure and Bonding

d) Quantitative Chemistry

e) Chemical Changes

f) Energy Changes

Chemical Formulae,Equations and Amount of Substance

a) Calculating Formules Mass

b) Calculating Moles from Masses

c) Calculating Moles from Volume

d) Calculating Moles from Concentration

e) Calculations from Balanced Chemical equations

f) Percentage Yield

g) Atom Economy

h) Titrations

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+447448352272

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RELATIVE FORMUALE MASS

→ It is the sum of relative atomic mass of all the atoms present in a compound.

the ratio of the average mass of one atom compared to 1/12th of the mass of C-12

eg- CO_2 = Mass of C + 2x mass of O
= 12 + (2x16)
= 44g

$Ca(PO_4)_3$ = Mass of C + 3x Mass of P + 12 Mass of O.
= 310g

$CaCO_3$ = Mass of Ca + mass of C + 3(mass of O)
= 40 + 12 + (3x16)
= 100g.

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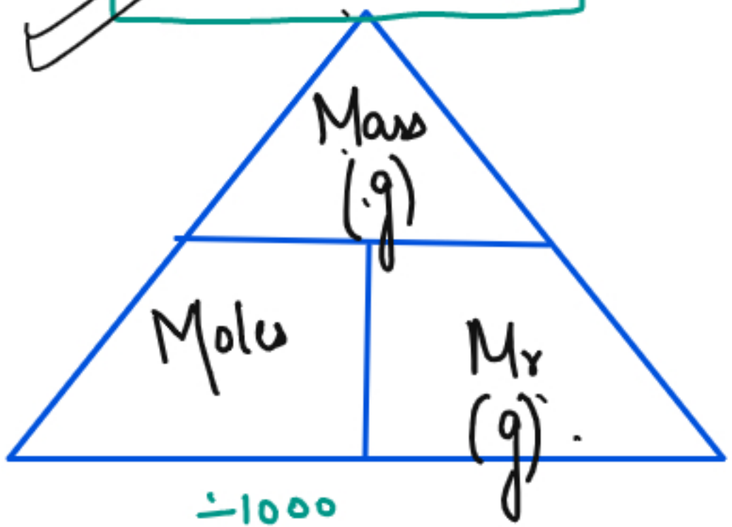
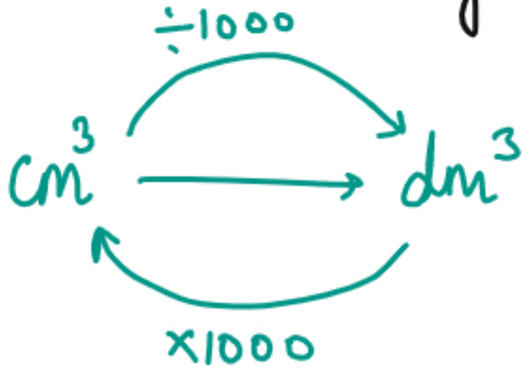
MOLES

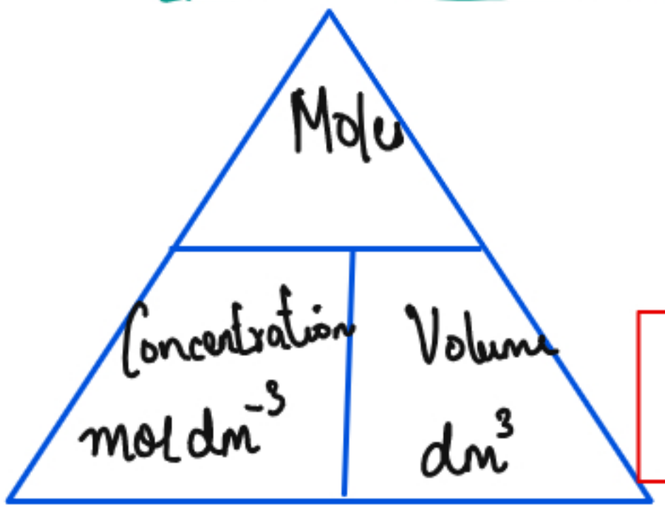
Amount of substance.

Moles and Mass Traingle

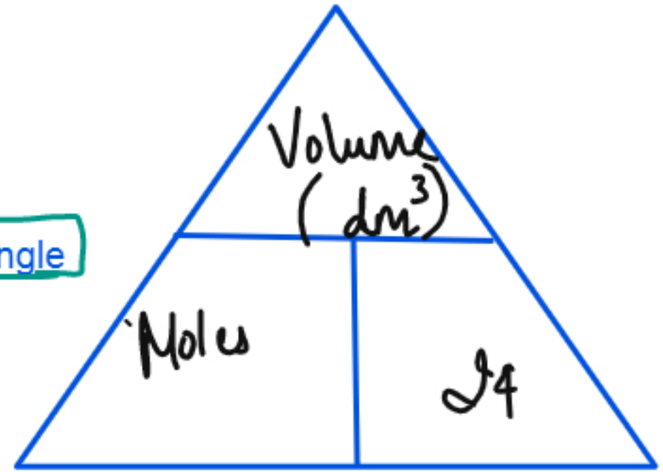




Moles and Concentration Triangle



Moles and Volume Triangle



At n.t.p.

1 mol = Avagadros constant
$= 6.02 \times 10^{23}$ atoms or molecules.

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EXAMPLES

Q1. Calculate the moles of following.

a) 22g of CO_2 ⟶ Moles = $\frac{\text{Mass}}{M_r} = \frac{22}{44} = 0.5$ moles

b) 17 g of NH_3 ⟶ $\frac{\text{Mass}}{M_r} = \frac{17}{17} =$ 1 moles

c) 48 dm^3 of O_2 ⟶ $\frac{\text{Volume}}{24} = \frac{48}{24} =$ 2 moles

d) 24000 cm^3 of CO_2 = $\frac{24000}{1000}$ dm^3 = 24 dm^3 = $\frac{24}{24}$ = 1 moles

e) 20g of NaOH dissolved in 50 cm^3 of solution = Moles = $\frac{20}{40} = 0.5$ mol

Q2 Calculate the mass of :-

a) 2 moles of calcium carbonate ⟶ Mass = Moles × M_r = M_r $CaCO_3$ = 100 = 2 × 100 = 200 g

b) 0.1 moles of hydrochloric acid ⟶ M_r of HCl = 36.5 = 36.5 × 0.1 = 3.65 g

Q3 Calculate the concentration of the following

a) 2 moles of NaOH dissolved in 10 dm3 of solution = Concentration = $\frac{\text{Moles}}{V\,(dm^3)}$ = $\frac{2}{10}$ = 0.2 mol dm^{-3}

b) 20 g of NaOH dissolved in 50 cm3 of solution = Moles of NaOH = $\frac{20}{40}$ = 0.5 moles, $C = \frac{0.5}{0.05}$ mol dm^{-3} = 10 mol dm^{-3}

$V = \frac{50}{1000}$ = 0.05 dm^3

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AVAGADROS CONSTANT !!

1 mole = 6.02×10^{23} atoms

Q1 Calculate the number of molecules in the following :-

a) 49 g of sulphuric acid → M_r of $H_2SO_4 = 98g = \frac{98}{49} = 0.5$ moles.
$= 0.5 \times 6.02 \times 10^{23}$ atoms
$= 3.01 \times 10^{23}$ atoms

b) 8 g of oxygen gas → M_r of $O_2 = 32g = \frac{8}{32} = 0.25$ moles
$= 0.25 \times 6.02 \times 10^{23}$ atoms
$= 1.5 \times 10^{23}$ atoms

c) 48 dm3 of Nitrogen → M_r of $N_2 = \frac{48}{24} = 2$ moles $= 2 \times 6.02 \times 10^{23}$
$= 1.20 \times 10^{24}$ atoms

d) 50 cm3 of 0.1 mol dm3 of sodium hydroxide

Moles = CxV $= \frac{0.1 \times 50}{1000} = 5 \times 10^{-3}$ moles $= 5 \times 10^{-3} \times 6.02 \times 10^{23} = 3.01 \times 10^{21}$ atoms

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BALANCED CHEMICAL EQUATIONS

$$C + O_2 \longrightarrow CO_2$$

One mole of carbon is reacting with one mole of oxygen to form one mole of carbon dioxide.

$$2Al + 3O_2 \longrightarrow 2Al_2O_3$$

2 moles aluminium reacts with 3 moles of oxygen to from 2 moles of aluminium oxide .

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

One mole of magnesium is reacting with 2 moles of hydrochloric acid to form one moles of magnesium chloride and one mole of hydrogen gas.

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CALCULATIONS FROM EQUATIONS !!!

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STEPS

STEP 1: Write the balanced chemical equation.

STEP2: Write known to the left and unknown to the right

STEP3: Write the moles relationship from the balanced chemical equation

STEP4: Convert moles into mass

STEP5: Do the Maths !!!

Calculate the mass of Magnesium oxide produced from 6 g of Magnesium when burned completely in air ?

$2Mg + O_2 \longrightarrow 2MgO$

Mg = MgO

2 moles = 2 moles

48g = 80g

÷ 48 (1g = 80/48) ÷ 48

× 6 (6g = 10g)

So 10g of MgO is formed.

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CALCULATIONS FROM EQUATIONS !!!

STEPS

STEP 1: Write the balanced chemical equation.

STEP2: Write known to the left and unknown to the right

STEP3: Write the moles relationship from the balanced chemical equation

STEP4: Convert moles into mass

STEP5: Do the Maths !!!

Calculate the mass of alumium needs to produce

306 g of Aluminium Oxide ?

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$Al_2O_3 \rightarrow Al$.

2 moles = 4 moles.

204 g → 108

1 g — $\frac{108}{204}$

306 g — $\frac{108}{204} \times 306$

→ 162 g

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LIMITING REAGENTS !!!!

To work out the limiting reagent work out moles of all the reagents and then work from the balanced chemical equation which reagent is in excess and which is in liniting

The reactant that get all used up completely is the limiting reagent. The other reagent which is present in greater quantity than required is in excess.

$$4\,Al + 3\,O_2 \longrightarrow 2\,Al_2O_3$$

$$\text{Moles} = \frac{\text{Mass}}{M_r}$$

13.5 gm Aluminium reacts which 32 g of Oxygen

a) Work out the moles of Aluminium and Oxygen
b) Which reagent is limiting and which is in excess
c) Calculation the mass of aluminium oxide produced ?

a) Moles of Al = $\frac{13.5}{27} = 0.5$ moles.

Moles of O_2 = $\frac{32}{32} = 1$ moles

b) ÷4
4 moles of Alumunium = 3 moles of oxygen
1 moles of aluminum = $\frac{3}{4}$ O_2

0.5mol of aluminium = $\frac{3}{4} \times 0.5 = 0.375$

So 0.375 moles of oxygen is required
hence oxygen is in excess and alumunium is limiting

c)

Al = Al_2O_3
4 moles — 2 moles
1 — $\frac{2}{4}$
0.5 — $\frac{2}{4} \times 0.5$

0.25 moles of Al_2O_3

$0.25 \times 102 = 25.5g$

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PERCENTAGE YIELD !!!!

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

When 28 g of nitrogen combined with hydrogen 30 g of ammonia is made ? Calculate the percentage yield ?

$N_2 = NH_3$

1 mole = 2 mole of ammonia

28 g = 34 g of ammonia

Expected = 34 g

Observed = 30g

% yield = $\frac{30 \times 100}{34}$ = 88.2 %

$$\% \text{ yield} = \frac{\text{observed mass}}{\text{expected mass}} \times 100$$

$$= \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$

When 80 g of iron oxide reacts with carbon, 20 g of iron is produced. Calculate the % yield ?

Fe_2O_3 — Fe

2moles — 4moles

320g — 224g

1g — $\frac{224}{320}$

80g — $\frac{224}{320} \times 80 = 56$g

$\frac{20 \times 100}{56}$ = 35.71%

The percentage yield can never by greater than 100%.
It is very difficult to get 100% percentage yield but scientist always look for that route that gives maximum percentage yield.

- Reason for not getting 100% yield
- The reaction does not go to completion so complete products are not formed.
- Some of the reaction can start moving to the reverse direction if they are reversible
- Some of the reaction can go and form alterative or unwanted product.
- During the reaction some of the reactants can get lost or stick to the reaction vessel so do not react. If the reaction involves gaseous reactants they can escape.
- Some of the products can also get lost in the reaction vessel. If the reaction involves gaseous products they can also escape.
- The reagent might not be pure therefore did not react completely to give the desired yield

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ATOM ECONOMY

Calcium Oxide is produced using the following reaction :-

$$CaCO_3 \longrightarrow CaO + CO_2$$

Calculate the atom economy

Desired product = CaO = 56g

Mass of reactants = $CaCO_3$ = 100g.

Atom Economy = $\frac{56}{100} \times 100 = 56\%$

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Atom Economy

$$= \frac{M_r \text{ of desired product}}{\text{Total } M_r \text{ of all the products}} \times 100$$

Iron Oxide is reduce by carbon to form iron and carbon monoxide.

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$$

Calculate the atom economy

Desired product = 2Fe = 56 × 2 = 112g

Mass of reactants = Mass of Fe2O3 + 3(Mass of C)

= 196g

$$\%\text{ yield} = \frac{112}{196} \times 100 = 57\%$$

REACTIONS WITH 100 % ATOM ECONOMY

- Addition reaction

Reactions with only one product have 100 atom economy

How to increase atom econmy

Chemist should look for reation that produce single product

If the by products are produced they should look for recyling the by products or use them in some other reactions to increase the atom economy .

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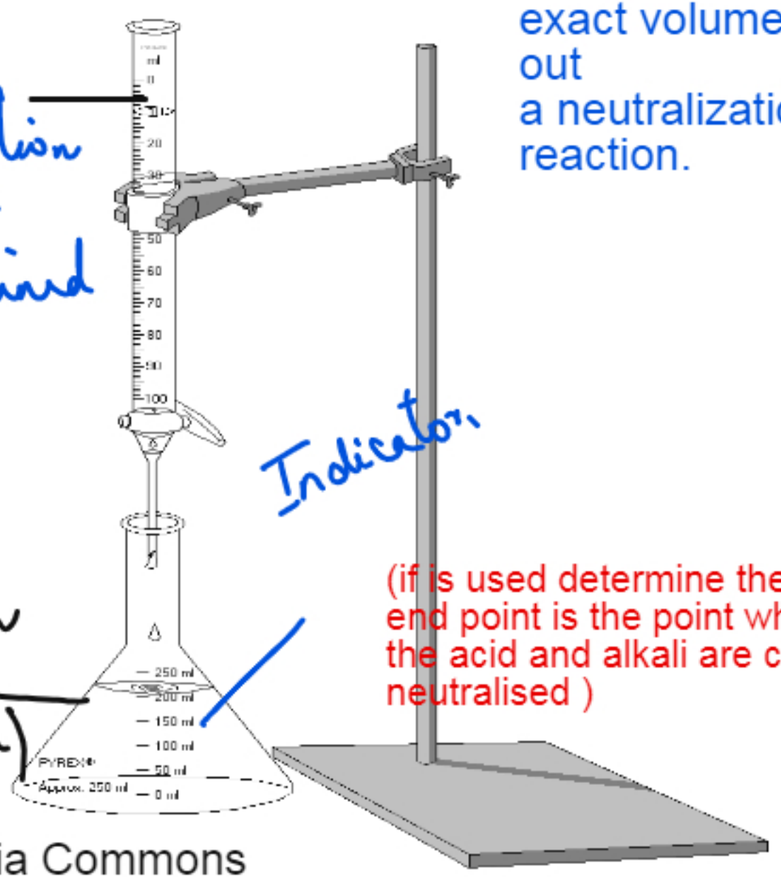
TITRATION

It is the technique used to determine the exact volume of acid and base to carry out a neutralization reaction.

Burette
(unknown Concentration
Solution whose
volume is determined
by titration)

Conical flask
[Solution of Known
Concentration / Volume]



Source: Wikimedia Commons

(if is used determine the end point
end point is the point when
the acid and alkali are completely
neutralised)

Pipette
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TITRATION PROCEDURE

- Known Concentration solution either acid or base is measured by the pipette and is added into the conical flask. For this solution both concentration and volume is known.
- The indicator is also added in the conical flask. When the indicator changes colour the end point is reached i.e the solution gets completely neutralised.
- The unknow concentration solution is added into the buretee. The starting volume is noted from the burette. The tap is then opened and the unknown solution is added dropwise into the conical flask with regular mixing.
- As soon as the indicator changes colour, the tap is closed and the final reading from the burette is noted.
- The entire process is repeated three times and the values are noted in the following format. The concordont reading are taken. The anamolous results are not taken into account. The means of the concordont readings are noted and used in the calculation

Exp No	Initial Reading (cm^3)	Final Reading (cm^3)	Titre (Final-Initial) (cm^3)
1	25.50	49.60	24.10
2	26.90	52.14	25.24
3	27.90	53.24	25.34
4	28.90	54.18	25.29

Mean Titre = $\frac{25.24 + 25.34 + 25.29}{}$

$= 25.29\ cm^3$

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TITRATION EXAMPLE !!!!

10 cm3 of 0.5 mol dm3 of sulphuric acid is titrated with sodium hydroxide. The results are given in the table.

$$2\,NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$$

Calculate the concentration of sodium hydroxide required to completely neutralize the acid ?

Exp No	Initial Reading (cm^3)	Final Reading (cm^3)	Titre (Final-Initial) (cm^3)
1	25.50	49.60	24.10
2	26.90	52.14	25.24
3	27.90	53.24	25.34
4	28.90	54.18	25.29

Steps

a) Write the balanced chemical equation

b) Underneath each equation write the numerical value given for each

c) The quantity that has two value use the concentration triangle to find the moles

d) Use the molar ratio to find the moles of unknown quantity

e) Use titration volume and find the concentration

$2\,NaOH + H_2SO_4 \rightarrow 2\,NaOH + H_2O$

Moles $= 5 \times 10^{-3} \times 2 = 10^{-2}$ moles

$V = 25.$

$V = 10\,cm^3 = 0.01\,dm^3$

$C = 0.5\,mol\,dm^{-3}$

Moles $= C \times V$

$= 0.01 \times 0.5$

$= 5 \times 10^{-3}$ moles

Mean Titre $= \frac{25.24 + 25.34 + 25.29}{3}$

$= 25.29\,cm^3$

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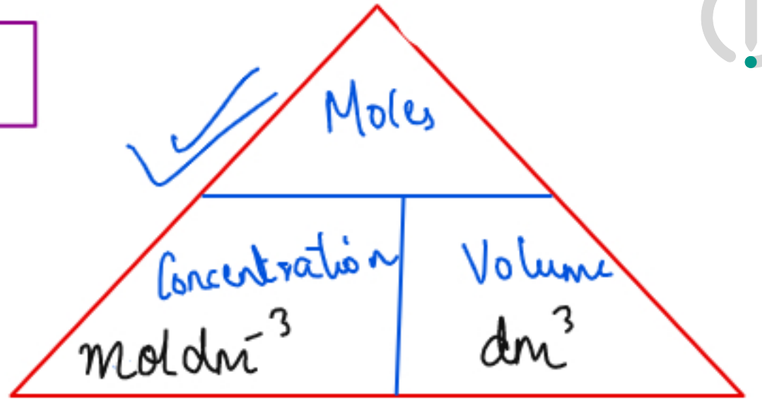
TITRATION EXAMPLE !!!!!



Q1 In a Titration 50 cm3 of 0.1 mol dm3 of potasisum hydroxide is neutralized by 20 cm3 of sulphuric Acid.
Calculate the concentration of sulphuric acid.

a) Write the balanced chemical equation

b) Underneath each equation write the numerical value given for each

c) The quantity that has two value use the concentration triangle to find the moles

d) Use the molar ratio to find the moles of unknown quantity
e) Use titration volume and find the concentration

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

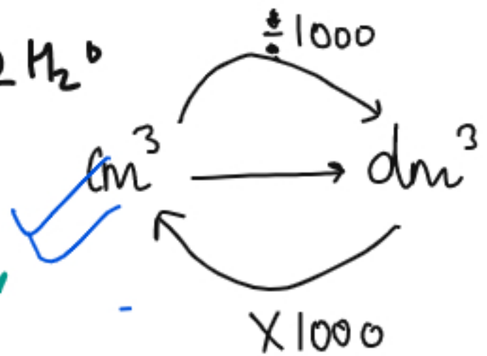
$V = 0.05\ dm^3$

$C = 0.1\ mol\ dm^{-3}$

$= 0.005\ moles$

$V = 0.02\ dm^3$

$n = 0.0025\ mol$



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KEY TERMS !!!!

Relative atomic mass — It is the ratio of the average mass of an atom compared to one twelfth of the mass of carbon-12.

Relative formula mass — It is the sum of relative atomic masses of all the atoms present in a formulae.

Moles — It is the amount of substance that has the same number of particles found in 12 g of carbon-12.

Avogadros Constant — Number of particles present in one mole of the substance.

$1 \text{ mole} = 6.02 \times 10^{23} \text{ atoms}$

Limiting Reagent — It is the reagent that is completely used up in the reaction.

Yield — The mass of desired product obtained in a chemical reaction.

Percentage yield — $\frac{\text{Actual yeild}}{\text{Theoretical Yield}} \times 100$

Atom Economy — $\frac{\text{Mass of the desired product}}{\text{total mass of all the reactants}} \times 100$

Concentration — $\frac{\text{Mass of solute (g)}}{\text{Volume of solution (dm}^3\text{)}}$ g/dm³

Titration — It is the technique used to determine the exact volume of acids and alkali required to carry out complete neutralization.

Neutralization Reaction
Reaction in which acid and base react to form salt and water.

Acids — Substance that has pH less than 7.

Alkali — Soluble bases that has pH greater than 7.

Pipette — It is a glass tube with a bulge in the middle that is used to take out the exact volume of known concentration solution.

Burette —

Concordant

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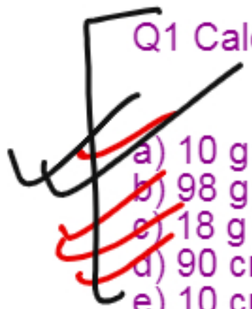
TEST YOURSELF !!!!

H_2SO_4 =

$\frac{0.2 \times 10}{1000} = 0.002$ moles



Q1 Calculate the number of moles in the following

$M_r = CaCO_3 = 100$ — $\frac{10}{100}$ — 0.1 moles — 1 moles 0.1 mol

a) 10 g of calcium carbonate
b) 98 g of sulphuric acid
c) 18 g gluocose
d) 90 cm3 of oxygen gas
e) 10 cm3 of 0.2 mol dm3 sodium hydroxide solution

Q2 What is the mass of magnesium required to form 160 g of magnesium oxide ?

$90\ cm^3 \longrightarrow 1.09\ dm^3 = 0.00375$ moles

Q3 Hydrogen react with chlorine to form hydrogen chloride gas.
When 71 g of chlorine reacts 70 g of hydrogen chloride is obtained.
Calculate the percentage yield.

Q4 Calculate the atom economy of both of these reactions :-

a) $N_2 + 3H_2 \longrightarrow 2NH_3$

b) $CaCO_3 \longrightarrow CaO + CO_2$
(desired product)

Q5 50 cm3 of 0.2 mol dm3 of HCl reacts with 10 cm3 of NaOH.
Determine the concentration of NaOH ?

$\therefore C_6H_{12}O_6 = 180$

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Q1 Calculate the number of moles in the following

a) 10 g of calcium carbonate
b) 98 g of sulphuric acid
c) 18 g gluocose
d) 90 cm3 of oxygen gas
e) 10 cm3 of 0.2 mol dm3 sodium hydroxide solution

$2Mg + O_2 \rightarrow 2MgO$

Q2 What is the mass of magnesium required to form 160 g of magnesium oxide ?

96g.

$Mg^0 = Mg$

1 : 1

x4

40g — 24g

160 —

Q3 Hydrogen react with chlorine to form hydrogen chloride gas. When 71 g of chlorine reacts 70 g of hydrogen chloride is obtained. Calculate the percentage yield.

$H_2 + Cl_2 \rightarrow 2HCl$

$\% \text{ yield} = \frac{70 \times 100}{73}$

$= 95.8\%$

Moles

$Cl_2 \rightarrow HCl$

1 : 2

71g → 73g

Q4 Calculate the atom economy of both of these reactions :-

a) $N_2 + 3H_2 \rightarrow 2NH_3$

$= \frac{100}{28+6} \times 34 = \frac{34}{34}$

b) $CaCO_3 \rightarrow CaO + CO_2$

(desired product)

$= \frac{56 \times 100}{100} = 56$

Q5 50 cm3 of 0.2 mol dm3 of HCl reacts with 10 cm3 of NaOH. Determine the concentration of NaOH ?

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e) 10 cm3 of 0.2 mol dm3 sodium hydroxide solution

$2Mg + O_2 \rightarrow 2MgO$

Q2 What is the mass of magnesium required to form 160 g of magnesium oxide ?

96g.

$MgO = Mg$

1 : 1

x4 (40g − 24)

160 −

Q3 Hydrogen react with chlorine to form hydrogen chloride gas. When 71 g of chlorine reacts 70 g of hydrogen chloride is obtained. Calculate the percentage yield.

$H_2 + Cl_2 \rightarrow 2HCl$

$\frac{70 \times 100}{73}$

% yield =

Moles

$Cl_2 \rightarrow HCl$

1 : 2

71g → 73

Q4 Calculate the atom economy of both of these reactions :-

a) $N_2 + 3H_2 \rightarrow 2NH_3$ $= \frac{100}{34} = \frac{3}{3}$

$28+6$

b) $CaCO_3 \rightarrow CaO + CO_2$

(desired product)

$= \frac{56}{100} \times 100 = 56\%$

Q5 50 cm3 of 0.2 mol dm3 of HCl reacts with 10 cm3 of NaOH. Determine the concentration of NaOH ?

NaOH + HCl

V = 0.01 dm³ V = 0.

moles = 0.1

C = 1 mol C = 0.

mol

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Q1 Calculate the number of moles in the following

a) 10 g of calcium carbonate
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96g.

$Mg^0 = Mg$

1 : 1

x4

40g — 24

160 —

Q3 Hydrogen react with chlorine to form hydrogen chloride gas.
When 71 g of chlorine reacts 70 g of hydrogen chloride is obtained.
Calculate the percentage yield.

$H_2 + Cl_2 \rightarrow 2HCl$

$\frac{70 \times 100}{73}$

Yield =

Moles

$Cl_2 \rightarrow HCl$

1 2

Q4 Calculate the atom economy of both of these reactions :-

a) $N_2 + 3H_2 \rightarrow 2NH_3$ $= \frac{34}{28+6} \times 100 = \frac{34}{34} \times 100$

b) $CaCO_3 \rightarrow CaO + CO_2$ (desired product)

$= \frac{56}{100} \times 100 = 56$

Q5 50 cm3 of 0.2 mol dm3 of HCl reacts with 10 cm3 of NaOH.
Determine the concentration of NaOH ?

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NEXT STEP !!!!!

- Check the specification

- Do Exam Style Questions on this topic

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