**Relative Atomic Mass**

**In all the questions below, find the relative atomic mass of the relevant element:**

1) In 100 atoms of gallium, 60 atoms are gallium-69 and 40 atoms are gallium-71 **69.8**

2) Antimony consists of 57% antimony-121 and 43% antimony-123. **121.9**

3) In a sample of neon, 9 of neon atoms are neon-20 and one atom is neon-22. **20.2**

4) 123 typical atoms of boron, 23 of these would be Boron-10 and 100 would be Boron-11. **10.8**

**Extension questions – above GCSE**

5) Zirconium has five isotopes, listed below. Calculate the average relative atomic mass to one decimal place.

zirconium-90 51.5% zirconium-91 11.2% zirconium-92 17.1%

zirconium-94 17.4% zirconium-96 2.8% **91.3**

6) Germanium has five isotopes, listed below. Calculate the average relative atomic mass to one decimal place. NB these are not percentages.

Germanium-70 56.4 germanium-72 75.1 germanium-73 21.4

Germanium-74 100 germanium-76 21.1 **72.7**

**Calculating Relative Formula/Molecular Masses**

Have a go at the practice questions below, set your answers out neatly on lined paper.

|  |  |  |
| --- | --- | --- |
| 1. P4  **124**
2. I2 **254**
3. Cl2 **71**
4. H2 **2**
5. SO2 **64**
6. CuSO4  **159.5**
7. C2H6 **30**
8. KBr **119**
9. H2SO4 **98**
 | 1. NH4NO3 **80**
2. FeBr3 **296**
3. Ne **20**
4. CsI **260**
5. CO2 **44**
6. H2O **18**
7. CaCl2 **111**
8. CaCO3  **100**
9. HCl **36.5**
 | 1. HNO3 **63**
2. C2H5OH **46**

Extension1. Ca(NO3)2 **164**
2. Al2(SO4)3 **342**
3. (NH4)2SO4  **132**
4. CuSO4.5H2O **249.5**
5. Na2CO3.10H2O **286**
 |

Questions

1. Which atom has approximately twice the mass of a sulphur atom?

**Sulphur mass 32. Atom with mass closest to 64 is copper.**

1. How heavy is a calcium atom compared to a bromine atom?

**Calcium mass 40, bromine mass 80. Calcium is half the mass of a bromine.**

1. Oxygen can be found as ozone, O3. What is the Mr of ozone?

**3 x 16 = 48**

Extension

4) Calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

 CaCO3 + 2HCl → CaCl2 + H­2O + CO2

 **100 + (2 x 36.5)** → **111 + 18 + 44**

 **173** → **173**

**The Mole - What is the point of moles?**

What is the mass of the following?

1. 0.1 moles of P4 **12.4g**
2. 2 moles of I2 **508g**
3. 0.05 moles of Cl2 **3.5g**
4. 6 moles of H2 **12g**
5. 80 moles of SO2 **5120g**
6. 0.01 moles of CuSO4 **1.595g**
7. 3 moles of C2H6 **90g**
8. 0.5 moles of KBr **59.5g**
9. 1 mole of H2SO4 **98g**

How many moles are in the following?

1. 8 g of NH4NO3 **0.1 mol**
2. 3 g of FeBr3 **0.010 mol (2sf)**
3. 5 g of Ne **0.25 mol**
4. 520g of CsI **2 mol**
5. 0.44g of CO2 **0.01 mol**
6. 180ml of H2O (=180g) **10 mol**
7. 22.2g CaCl2 **0.2 mol**
8. 0.1g CaCO3  **0.001 mol (1 x 10-3)**
9. 0.73g of HCl **0.02 mol**

**Reacting amounts in chemical equations**

Equation: 2Al + Fe2O3 → Al2O3 + 2Fe

Write masses: *x* g 8.0g

Find A*r* or M*r* 27 160

Find moles: 0.1 = $\frac{8.0}{160}$

 = 0.05

Ratio from equation: 2 x 0.05 1 x 0.05 2 x 0.05

Answer mass = 0.1 x 27 = 2.7 g of aluminium powder needed

**Example 2**

What mass of ethanol is formed when 4.5g of glucose is fermented?

Equation: **C6H12O6** → 2C2H5OH + 2CO2

Write masses: 4.5g x

Mr (6 x 12) + (12 x 1) + (6 x 16) (2 x 12) + (5 x 1) + 16 + 1

Find A*r* or M*r*: 180 46

Find moles: =$\frac{4.5}{180}=0.025$ = 2 x 0.025 = 0.05

Ratio from equation: 1 2

**Answer** mass = 0.05 x 46 = 2.3g of ethanol

**Example 3**

Equation: MgCO3 + H2SO4 → MgSO4.7H2O + CO2 + H2O

Write masses: 14.0 excess x ?

Find A*r* or M*r*: 84 98 246

Find moles: 0.16667 0.16667 0.16667

Ratio from equation: 1 1

Answer mass = 0.166667 x 246 = 41g of hydrated magnesium sulphate crystals can be made

**Questions**

In these questions, the balanced equation has been given to you so step 1 has been done for you. Set your work out neatly on lined paper.

1) How much magnesium must be burned in oxygen to make 4.0g of magnesium oxide? 2.4g

 2Mg + O2 → 2MgO

2) What mass of calcium oxide is formed when 25g of calcium carbonate is decomposed by heat? 14g

 CaCO3 → CaO + CO2

3) In the blast furnace, iron (III) oxide is reduced to iron by carbon monoxide:

 Fe2O3 + 3CO → 2Fe + 3CO2

 (a) What mass of carbon monoxide is needed to reduce 16 tonnes of iron(III) oxides? 8.4 tonnes

 (b) What mass of iron is obtained from the reduction of 16 tonnes of the oxide? 11.2 tonnes

4) What mass of coke is consumed in a blast furnace in the production of 2.8 tonnes of carbon monoxide?

 2C + O2 → 2CO 1.2 tonnes

In the following questions, you are given the formulae but you have to write the balanced equation in step 1.

5) What is the loss in mass when 1.25g of blue copper (II) sulphate crystals, CuSO4.5H2O is heated and decomposed to anhydrous copper(II) sulphate, CuSO4? 0.45g

6) What mass of ammonia, NH3, is formed when 12g of hydrogen, H2, combines with nitrogen N2? 68g

7) Lead(II) oxide, PbO, reacts with hydrogen to form lead and steam, H2O. Calculate the mass of lead formed when 446g of lead(II) oxide is reduced in this way. 414g

8) What mass of sulphur is needed to react with 8.0g copper to form copper(I) sulphide, Cu2S? 2.0g

**Limiting Reactants Answers**

1. C3H8 + 5O2 → 3CO2 + 4H2O

How many grams of CO2 will be produced from 39.0g of propane and 11.0g of oxygen?

Moles propane = 39/44 = 0.886…

Moles oxygen = 11/32 = 0.34375

Moles of oxygen needed to fully react with propane = 5 x 0.886… which would be 4.4318 we have less than this **so oxygen is the limiting reactant**…

Moles of carbon dioxide = 0.34375 ÷ 5 x 3 = 0.20625

Mass of carbon dioxide = moles carbon dioxide x RAMS CO2 = 0.020625 x 44 = **9.08g**

1. NaCl + AgNO3 → AgCl + NaNO3

How many grams of AgCl will be produced from 5.00g of NaCl and 103g of AgNO3

Moles NaCl = 5/58.5 = 0.08547

Moles AgNO3 = 103/(108+14+48) = 103/170 = 0.6058

**NaCl is limiting reactant**

Moles AgCl = moles NaCl = 0.08547

Mass AgCl = 0.08547 x (108+35.5) 0.08547 x 143.5 = **12.3g**

1. Mg(OH)2 + 2HCl → MgCl2 + 2H2O

How many grams of MgCl2 will be produced from 12.0g of Mg(OH)2 and 42.0g HCl

Moles Mg(OH)2 = 12/58 = 0.20689…

Moles HCl = 42/36.5 = 1.15068…

Moles HCl is more than double the moles Mg(OH)2 so the **Mg(OH)2 is the limiting reactant**

Moles MgCl2 formed = 0.20689

Mass of MgCl2 = 0.20689 x 95 = **19.7g (3sf)**

1. Mg(OH)2 + 2HCl → MgCl2 + 2H2O

How many grams of MgCl2 will be produced from 16.0g of Mg(OH)2 and 11.0g HCl

Moles Mg(OH)2 = 16/58 = 0.27586…

Moles HCl = 11/36.5 = 0.301369…

Moles HCl is less than double the moles Mg(OH)2 so the **HCl is the limiting reactant**

Moles MgCl2 formed = 0.301369 ÷ 2 = 0.15068

Mass of MgCl2 = 0.15068 x 95 = **14.3g (3sf)**

1. 4Fe + 3O2 → 2Fe2O3

How many grams of Fe2O3 will be produced from 10.0g of Fe and 7g of O2

Moles Fe = 10/56 = 0.17857

Moles O2 = 7/32 = 0.21875

Moles oxygen needed to completely react with the iron = 0.17857 ÷ 4 x 3 = 0.13392

Moles oxygen is more than this, so **iron is the limiting reactant**

Moles Fe2O3 formed = 0.17857/2 = 0.0892…

Mass of Fe2O3 = 0.0892 x 160 = **14.3g**

1. Zn + 2HCl → ZnCl2 + H2

How many grams of ZnCl2 will be produced from 26.0g of Zn and 42.0g of HCl

Moles Zn = 26/65 = 0.4

Moles HCl = 42/36.5 = 1.15068…

Moles HCl is more than double moles of Zn so HCl is in excess and **Zn is limiting reactant**

Moles ZnCl2 = 0.4

Mass ZnCl2 = 0.4 x 136 = **54.4g**

1. 2Na + Cl2 → 2NaCl

How many grams of NaCl will be produced from 33.0g of Na and 34.0g of Cl2?

Moles Na = 1.44

Moles Cl2 = 0.480

Moles of Cl2 needed to react with Na are 0.72 moles of Cl2. Therefore **Cl2 is limiting reactant.**

Moles NaCl produced = 2 x 0.480 = 0.96

Mass of NaCl = 0.96 x 58.5 = **56.1g**

1. Zn + CuCl2 → ZnCl2 + Cu

How many grams of ZnCl2 will be produced from 7.0g of Zn and 8.0g of CuCl2

Moles Zn = 7/65 = 0.1076…

Moles CuCl2 = 8/134.5 = 0.059479

**CuCl2 is the limiting reactant**

Moles ZnCl2 = 0.059479

Mass ZnCl2 = 0.059479 x 136 = **8.09g**

1. CH4 + 2O2 → CO2 + 2H2O

How many grams of CO2 will be produced from 12.0g of methane and 133.0g of oxygen?

Moles methane = 12/16 = 0.75

Moles oxygen = 133/32 = 4.156

Moles of oxygen are more than double moles of CH4 so **CH4 is the limiting reactant**

Moles of carbon dioxide = 0.75

Mass of carbon dioxide = 0.75 x 44 = **33g**

**Percentage yield Answers**

* Impure starting material
* Loss of product during reaction
* Loss of product during transfer between sets of apparatus
* Unwanted reactions happening
* Reaction doesn’t go to completion.

1) In a reaction, 4.0g of magnesium oxide was desired. Only 3.2g was produced.

 2Mg + O2 → 2MgO

 3.2/4.0 \* 100 = **80%**

2) Some Calcium oxide was formed when 25g of calcium carbonate is decomposed by heat? Only 12g was produced.

 CaCO3 → CaO + CO2

 12/14\*100 = **85.7%**

3) In the blast furnace, iron (III) oxide is reduced to iron by carbon monoxide:

 Fe2O3 + 3CO → 2Fe + 3CO2

 16 tonnes of iron(III) oxide was reacted.

 Only 5 tonnes of iron was produced. What was the percentage yield?

 5/11.2 \* 100 = **44.6%**

4) The loss in mass when 1.25g of blue copper (II) sulphate crystals, CuSO4.5H2O is heated and decomposed to anhydrous copper(II) sulphate, CuSO4 was calculated.

The actual mass loss of water was only 0.40g. What was the percentage yield of water?

 0.4/0.45 \* 100 = **88.9%**

5) Ammonia, NH3, 68g is formed when 12g of hydrogen, H2, combines with nitrogen N2. Only 8g was produced.

 8/68 \* 100 = **11.8%**

6) Lead(II) oxide, PbO, reacts with hydrogen to form lead and steam, H2O. 446g of lead(II) oxide was reacting, 414g lead should have been produced. The mass of lead produced was 300g. What was the percentage yield of lead?

 300/414 \* 100 = **72.5%**

7) In a reaction to produce methane, it should have been possible to produce 3.25 tonnes. However only 2.75 tonnes was produced. What was the percentage yield?

 = 2.75/3.25 \* 100 = 84.6%

8) In a reaction to produce sodium chloride from a reaction, it was found that 0.585 grams should have been produced from the reacting amounts. However only 0.4 grams was found to be present. What was the percentage yield?

 0.4/0.585 \* 100 = 68.4%

9) In a reaction to produce dry crystals of magnesium sulphate from a solution of magnesium sulphate, the final step in the method included heating the magnesium sulphate in an evaporating basin until most of the water had evaporated and then leaving it to crystalise. It was expected that 8.3 grams of magnesium sulphate was going to be produced. The mass of the crystals in the basin was found to be 9.6g. Find the percentage yield.

9.6/8.3 \* 100 = 114.7% Yield greater than 100% - not possible. It is because it is not pure and is still wet/not dry.

**Calculating Atom Economy**

Explain why it is important to maximise the atom economy of a reaction

Limit production of waste products, limit need to separate waste products, limit need to dispose of waste products. Limit use of energy and raw materials for mass of product. Maximise product formed.

Explain why having a high atom economy is not the only important consideration when choosing a reaction.

Some reactions can require hazardous starting reactants or produce hazardous products or products which are environmentally damaging/pollutants. The consideration must be whether the extra steps needed to make these safe is worthwhile. **The percentage atom economy for a reaction is calculated using:**



**Q1.** An equation for the reaction is: NiO + C ⟶ Ni + CO

Calculate the percentage atom economy (to 3sf) for the reaction to produce nickel.

Relative atomic masses (*A*r): C = 12  Ni = 59 Relative formula mass (*M*r): NiO = 75 **(3)**

total *M*r of reactants = 87 (percentage atom economy) 59/87 x 100  = 67.8 (%)

**Q2.** Titanium is a transition metal. Titanium is extracted from titanium dioxide in a two-stage industrial process.

Calculate the atom economy to produce Titanium in Stage 2

 Stage 1   TiO2 + 2 C + 2 Cl2 ⟶ TiCl4 + 2 CO

 Stage 2   TiCl4 + 4 Na ⟶ Ti + 4 NaCl **(3)**

*M*r of NaCl = (23 + 35.5) = 58.5 Total *M*r of products = 48 + (4 x 58.5) = 282

Percentage atom economy = 48/282 x 100 = 17.0%

 **Q3.** The equation for the reaction of copper carbonate and sulfuric acid is:

CuCO3 + H2SO4 → CuSO4 + H2O + CO2

 Relative formula masses : CuCO3 = 123.5; H2SO4 = 98.0; CuSO4 = 159.5

 Calculate the percentage atom economy for making copper sulfate from copper carbonate. **(3)**

 Total mass of reactants = 221.5 Percentage atom economy = 159.5/221.5 x 100 = 72.0(%)

 **Q4.** Look at the equations for the two reactions:

   Reaction 1        CuCO3(s) + 2HCl(aq)  →  CuCl2(aq) + H2O(l) + CO2(g)

    Reaction 2             CuO(s) + 2HCl(aq)  →  CuCl2(aq) + H2O(l)

Work out the relative formula masses you need for the calculations above.

CuCO3 = 123.5; CuO = 79.5; HCl = 36.5; CuCl2 = 134.5; H2O = 18; CO2 = 44

Then calculate the percentage atom economy for both Reaction 1 and Reaction 2.

1. Total mass of products = 196.5 Percentage atom economy = 134.5/196.5 x 100 = 68.4(%)
2. Total mass of products = 152.5 Percentage atom economy = 134.5/152.5 x 100 = 88.2(%)

Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference. The atom economy using carbonate is lower because an additional product is made **or** carbon dioxide is made as well

 **Q5.** The reaction to produce ammonium from nitrogen and hydrogen is

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| N2(g) | + | 3H2(g) |  | 2NH3(g) |

What is the atom economy to produce ammonia? 100% (it is the only product formed) **(1)**

**Percentage of an element in a compound**

All answers are %

|  |  |  |
| --- | --- | --- |
| 1. Phosphorous in P4**100**
2. Iodine in I2 **100**
3. Chlorine in Cl2 **100**
4. Hydrogen in H2 **100**
5. Sulfur in SO2 **50**
6. Copper in CuSO4 **39.8**
7. Carbon in C2H6 **80**
8. Potassium in KBr **32.8**
9. Sulfur in H2SO4 **32.7**
 | 1. Nitrogen in NH4NO3 **35**
2. Iron in FeBr3 **18.9**
3. Neon in Ne **100**
4. Iodine in CsI **48.8**
5. Carbon in CO2 **27.3**
6. Hydrogen in H2O **11.1**
7. Calcium in CaCl2 **36**
8. Calcium in CaCO3 **40**
9. Hydrogen in HCl **2.7**
 | 1. Nitrogen in HNO3 **22.2**
2. Carbon in C2H5OH, ethanol **52.2**

Extension1. Calcium in Ca(NO3)2 **24.4**
2. Aluminium in Al2(SO4)3 **15.8**
3. Nitrogen in (NH4)2SO4 **21.2**
4. Copper in CuSO4.5H2O **25.5**
5. Sodium in Na2CO3.10H2O **16.1**
 |

Questions

1. Which out of **water** and hydrogen chloride has the highest percentage of hydrogen?
2. Which out of calcium chloride, **calcium carbonate** and calcium nitrate has the highest percentage of calcium?
3. Which out of **ammonium nitrate** and ammonium sulphate has the highest percentage of nitrogen?
4. On the basis of your answer to Q3, which of the two compounds would you recommend as a fertiliser designed to deliver the maximum amount of nitrogen to a soil? **Ammonium nitrate**

**Concentration Calculation Notes**

You can increase the concentration of a solution by:

Adding more moles or molecules or grams of a substance, or evaporating some of the water

**In the following questions, calculate the concentration of the solution in g/dm3**

1. 4g of sodium hydroxide is dissolved into 1000cm3 of water **4 g/dm3**
2. 120g of potassium hydroxide is dissolved into 3dm3 of water **40** **g/dm3**
3. 4.25g of silvernitrate is dissolved into 250cm3 of water **17 g/dm3**
4. 20.75g of potassium iodide is dissolved into 100cm3 of water **207.5 g/dm3**
5. 600g of calcium nitrate is dissolved into 5dm3 of water **120 g/dm3**

**In the following questions, calculate the mass of solute present in the quantity of solution described**

1. 1000cm3 of a solution of 2.5g/dm3 **2.5 g**
2. 250cm3 of a solution of 1.24g/dm3 **0.31** **g**
3. 1.5 dm3 of a solution of 3.6g/dm3 **5.4 g**
4. 12cm3 of a solution of 6g/dm3 **0.072 g**
5. 225cm3 of a solution of 110g/dm3 **24.75 g**

**What volume of the solution is required below to have the desired mass of solute?**

1. 4g of solute from a 2 g/dm3 solution **2 dm3 /2000 cm3**
2. 25g of solute from a 10 g/dm3 solution **2.5 dm3**
3. 600g of solute from a 12g/dm3 solution **50 dm3**
4. 0.1g of solute from a 10g/dm3 solution **0.01 dm3 / 10 cm3**
5. 15g of solute from a 25g/dm3 solution **0.6 dm3 / 600cm3**

**In the following questions, calculate the concentration of the solution in mol/dm3**

1. 0.4mol of sodium hydroxide is dissolved into 1000cm3 of water **0.4** **mol/dm3**
2. 12mol of potassium hydroxide is dissolved into 3dm3 of water **4** **mol/dm3**
3. 0.425mol of silvernitrate is dissolved into 250cm3 of water **1.7** **mol/dm3**
4. 2.075mol of potassium iodide is dissolved into 100cm3 of water **20.75** **mol/dm3**
5. 60.0mol of calcium nitrate is dissolved into 5dm3 of water **12 mol/dm3**

**In the following questions, calculate the moles of solute present in the quantity of solution described**

1. 25cm3 of 0.5 mol/dm3 potassium iodide solution **0.0125 mol**
2. 100cm3 of 2 mol/dm3 nitric acid **0.2 mol**
3. 500cm3 of 0.0001 mol/dm3 copper(II) sulphate solution **5 x 10-5 mol**
4. 5cm3 of 5.0 mol/dm3 potassium carbonate solution **0.025 mol**
5. 12.5cm3 of 1.0 mol/dm3 hydrochloric acid **0.0125 mol**

**What volume of the solution is required below to have the desired moles of solute?**

1. 0.1 moles from a 1.0 mol/dm3 solution **0.1 dm3 or 100cm3**
2. 0.025 moles from a 1.0 mol/dm3 solution **25 cm3**
3. 0.5 moles from a 2.0 mol/dm3 solution **0.25 dm3 or 250 cm3**
4. 1.5 moles from a 12.5 mol/dm3 solution **120 cm3**
5. 0.001 moles from a 0.01 mol/dm3 solution **100 cm3**

**Finding Unknown Concentrations**

1) 20.0 cm3 of 0.1 mol dm-3 sodium hydroxide was found to neutralise 12.5 cm3 of hydrochloric acid. What is the concentration of the acid? HCl(aq) + NaOH(aq) → NaCl(aq) + H2O(l)

Moles NaOH = 2 x 10-3

Moles HCl = 2 x 10-3

Conc HCl = 2 x 10-3 / 12.5 x 1000 = 0.16 mol dm-3

2) 10.0 cm3 of 0.25 mol dm-3 potassium hydroxide was found to neutralise 15.0 cm3 of nitric acid. What is the concentration of the acid? HNO3(aq) + KOH(aq) → KNO3(aq) + H2O(l)

Moles KOH = 2.5 x 10-3

Moles HNO3 = 2.5 x 10-3

Conc HNO3 = 2.5 x 10-3 / 15 x 1000 = 0.167 mol dm-3

3) What volume of 0.2 mol dm-3 sodium hydroxide solution would be needed to neutralise 10.0 cm3 of hydrochloric acid with a concentration of 0.5 mol dm-3? HCl(aq) + NaOH(aq) → NaCl(aq) + H2O(l)

Moles HCl = 5 x 10-3 Moles NaOH = 5 x 10-3

 Volume NaOH = 5 x 10-3 / 0.2 x 1000 = 25 cm3

4) What volume of 0.025 mol dm-3 potassium hydroxide solution is needed to neutralise 20.0 cm3 of 0.1 mol dm-3 nitric acid? KOH(aq) + HNO3(aq) → KNO3(aq) + H2O(l)

Moles HNO3 = 2 x 10-3

Moles KOH = 2 x 10-3

Volume KOH = 2 x 10-3 / 0.025 x 1000 = 80 cm3

5) What is the concentration of a sodium hydroxide solution if 10.0 cm3 of the solution is neutralised by 15.0 cm3 of 0.4 mol dm-3 sulphuric acid? H2SO4(aq) + 2NaOH(aq) → Na2SO4(aq) + 2H2O(l)

Moles sulphuric acid = 6 x 10-3

Moles NaOH = 2 x moles sulphuric acid = 0.012

Conc NaOH = 0.012 / 10 x 1000 = 1.2 mol dm-3

6) If 25.0 cm3 of 2.5 mol dm-3 sodium hydroxide solution is needed to neutralise 5.0 cm3 of sulphuric acid, what is the concentration of the acid? H2SO4(aq) + 2NaOH(aq) → Na2SO4(aq) + 2H2O(l)

Moles NaOH = 0.0625

Moles H2SO4 = ½ x moles NaOH = 0.03125

Conc H2SO4 = 0.03125/ 5 x 1000 = 6.25 mol dm-3

7) It was found that 4.6 cm3 of 0.005 mol dm-3 sulphuric acid was needed to react with 10.0 cm3 of limewater (calcium hydroxide) solution. What was the concentration of the calcium hydroxide solution?

 H2SO4(aq) + Ca(OH)2(aq) → CaSO4(s) + 2H2O(l)

Moles H2SO4 = 2.3 x 10-5

Moles Ca(OH)2= 2.3 x 10-5

Conc Ca(OH)2 = 2.3 x 10-5/ 10 x 1000 = 2.3 x 10-3 mol dm-3

8) An unknown solution of hydrochloric acid was titrated with 25 cm3 of 0.2 mol dm-3 sodium carbonate solution. 2HCl(aq) + Na2CO3(aq) → 2NaCl(aq) + H2O(l) + CO2(g)

The volumes of hydrochloric acid needed for neutralisation are shown below.



a What volume of hydrochloric acid would you use in further calculations?

b What is the concentration of the hydrochloric acid solution?

a) 14.1 cm3

b) Moles sodium carbonate = 5 x 10-3

Moles HCl = 2 x moles sodium carbonate = 0.01

Conc HCl = 0.01 / 14.1 x 1000 = 0.71 mol dm-3

**Calculations Gas Moles**

**In the following questions, calculate the number of moles of gas in**

1. 24,000 cm3 of carbon dioxide **1 mol**
2. 48 cm3 of hydrogen **0.002 mol**
3. 240,000 cm3 of chlorine **10 mol**
4. 3 dm3 of ammonia **0.125 mol**
5. 72 dm3 of oxygen **3 mol**

**In the following questions, calculate volume of the following at room temperature and pressure**

1. 2 mol of nitrogen **48 dm3 48,000 cm3**
2. 10 mol of hydrogen chloride **240 dm3 240,000 cm3**
3. 0.01 mol of neon **240 cm3 0.240 dm3**
4. 0.000002 mol of carbon dioxide **0.048 cm3 0.000048 dm3**
5. 0.125 mol of helium **3000 cm3 3 dm3**

**In the following questions, first calculate the number of moles of gas, then calculate the mass of this number of moles. You will also need to work out the RAMS/Mr of the molecule.**

1. What is the mass of 12 dm3 of carbon dioxide? **12/24 = 0.5 mol; RAMs CO2 = 44; mass = 22g**
2. What is the volume of 16 g of oxygen? **RAMs O2 = 32; 16/32 = 0.5 mol; volume = 12dm3**
3. What is the mass of 36 dm3 of methane? **36/24 = 1.5 mol; RAMs CH4 = 16; mass = 24g**
4. What is the volume of 7 g of nitrogen? **RAMs N2 = 28; 7/28 = 0.25 mol; volume = 6dm3**
5. Which of the following has the smallest volume?
	1. 8 g of oxygen **RAMs O2 = 32; 8/32 = 0.25 mol; volume = 6 dm3**
	2. 8 g of nitrogen **RAMs N2 = 28; 8/28 = 0.2857 mol; volume = 6.86 dm3**
	3. 8 g of hydrogen **RAMs H2 = 2; 8/2 = 4 mol; volume = 96 dm3**
	4. **8 g of fluorine** **RAMs F2 = 38; 8/38 = 0.2105 mol; volume = 5.05 dm3**
6. Which of the following has the same volume as 66 g of carbon dioxide?

**RAMs CO2 = 44; 66/44 = 1.5 mol; (Not needed for this question, volume = 36dm3)**

* 1. 8 g of helium **RAMs He = 2; 8/2 = 4.0 mol;**
	2. 32 g of oxygen **RAMs O2 = 32; 32/32 = 1.0 mol**
	3. 96 g of sulphur dioxide **RAMs SO2 = 64 96/64 = 1.5 mol**
	4. 32 g of methane **RAMs CH4 = 16 32/16 = 2.0 mol**

**Therefore there are 1.5 mol of SO2 being produced; the same as of the CO2 originally. It isn’t necessary to calculate what volume this is as we just need there to be the same number of moles.**

1. Calcium carbonate reacts with hydrochloric acid producing calcium chloride, water and carbon dioxide gas.

 CaCO3 + 2HCl → CaCl2 + H2O + CO2

 What volume of carbon dioxide would be produced by reacting 10 g of calcium carbonate with excess acid?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | CaCO3 | + 2HCl | → CaCl2 | + H2O | **+ CO2** |
| Grams | 10 | Excess |  |  |  |
| RAMS | 100 |  |  |  |  |
| moles | 10/100 = 0.1 | Excess  |  |  | = 0.1 |

From the balanced equation, 0.1 moles CaCO3 can produce 0.1 moles CO2.

Volume = 0.1 x 24,000 = 2400 cm3

1. When hydrochloric acid is added to sodium sulphite, the following reaction occurs.

 Na2SO3 + 2HCl → 2NaCl + SO2 + H2O

If excess acid is added to 25.2 g of sodium sulphite, what volume of sulphur dioxide gas is formed?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | NaSO3 | + 2HCl | → 2NaCl | **+ SO2**  | + H2O |
| Grams | 25.2 | Excess |  |  |  |
| RAMS | 126 |  |  |  |  |
| moles | 25.2/126 = 0.2 | Excess  |  | = 0.2 |  |

From the balanced equation, 0.2 moles NaSO3 can produce 0.2 moles SO2.

Volume = 0.2 x 24,000 = 4800 cm3

1. What volume of oxygen is needed to burn 1 g of carbon completely according to the equation:

 C(s) + O2(g) → CO2(g)

|  |  |  |  |
| --- | --- | --- | --- |
|  | C | **O2** | → CO2 |
| Grams | 1 |  |  |
| RAMS | 12 |  |  |
| moles | 1/12 = 0.08333 | = 0.08333 |  |

From the balanced equation, 0.08333 moles C requires 0.08333 moles O2 to burn completely

Volume = 0.08333 x 24,000 = 2000 cm3

1. Silver oxide decomposes on heating as shown below.

 2Ag2O (s) → 4Ag (s) + O2 (g)

What mass of silver oxide is needed to produce 12 cm3 of oxygen gas, if all measurements are made at room temperature and pressure and the molar gas volume is 24 dm3mol-1?

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2Ag2O | → 4Ag | + O2 |
| Grams | ?= 232 x 0.001 = 0.232 g |  | 12g |
| RAMS | (2 x 108) + 16 = 232 |  |  |
| moles | 0.0005 = 0.001 |  | 12/24000 = 0.0005 mol |

Moles of oxygen needed = 12/24000 = 0.0005 mol.

From the balanced equation, 0.0005 x 2 = 0.001 moles of Ag2O needed.

Mass = moles x RAMS = 0.001 x 232 = 0.232g