Quantitative Analysis
ANSWERS

Reaction Ratios

Reaction Ratios
STOP AND CHECK (PAGE 7)

- You can find the ratio between two molecules by looking at the number in front of the molecules and comparing them. Remember, when there's no number, it means there's 1!

Reaction Ratios
QUICK QUESTIONS (PAGE 7)

- $B_2H_6 + \mathbf{3}O_2 \rightarrow B_2O_3 + 3H_2O$
  - $\mathbf{1}B_2H_6 : \mathbf{3}O_2$
  - $\mathbf{3}O_2 : \mathbf{1}B_2O_3$
- $SnCl_2 + \mathbf{2}H_2O \rightarrow \mathbf{2}HCl + Sn(OH)_2$
  - $\mathbf{1}H_2O : \mathbf{1}HCl$
  - $\mathbf{1}SnCl_2 : \mathbf{1}Sn(OH)_2$
- $MgO + \mathbf{2}HCl \rightarrow H_2O + MgCl_2$
  - $\mathbf{1}MgO : \mathbf{2}HCl$
  - $\mathbf{2}HCl : \mathbf{1}MgCl_2$
- $NH_3 + HBr \rightarrow NH_4Br$
  - $\mathbf{1}NH_3 : \mathbf{1}HBr$
  - $\mathbf{1}NH_4Br : \mathbf{1}NH_3$

The Mole

The Mole

STOP AND CHECK (PAGE 10)

- A mole tells us the weight of atoms and represents Avargadro's number. You can think of it like a dozen of something. It helps us represent the weights of atoms and so we can measure the amount of a compound that is present, or that we need to undergo a reaction.
- Mass numbers represent the weight (in grams) of one mole of the atom.
- Molar mass:
    - Hydrogen: 1
    - Iron: 55.8
    - Bromine: 79.9
    - Magnesium: 24.3

      Note: Your periodic table may round these to integers (whole numbers).

Molar Masses of Compounds

STOP AND CHECK (PAGE 14)

- Mass numbers represent the weight (in grams) of one mole of the atom.
- The unit of molar mass is gram per mole, $gmol^{-1}$.

A Note on Rounding

STOP AND CHECK (PAGE 13)

- Rounding:
    - 82300
    - 0.00345
    - 0.338
    - 95.4
    - 0.00123
- Molar masses:

- NH_3: 17gmol^{-1}
- **H_2:** 2gmol^{-1}
- **O_2F_2:** 70gmol^{-1}
- **Fe_2O_3:** 159.8gmol^{-1}
- **MgO:** 40.3gmol^{-1}
- **Na_2O:** 39gmol^{-1}
- **V_2O_5:** 181.8gmol^{-1}
- **C_6H_6O:** 46gmol^{-1}

Converting Between Mass and Moles

STOP AND CHECK (PAGE 16)

- $n = \frac{m}{M}$
  - Where n is the number of moles, m is the mass, and M is the molar mass.

The Mole

QUICK QUESTIONS (PAGE 16)

- The number of moles in:
  - 30g of N_2 = 1.07mol
  - 60g of C = 5mol
  - 3g of Fe_2O_3 = 0.0188mol
  - 246g of PH_3 = 7.24mol
  - 0.56g of H_2SO_4 = 0.00571mol
  - 1.78g of HCl = 0.488mol
- The mass of:
  - 1.34 moles of Si = 37.654g
  - 32 moles of CO_2 = 1408g
  - 0.76 moles of PCl_5 = 77.52g
  - 2.5 moles of V_2O_5 = 454.5g
  - 0.0054 moles of $SOCl_2$ = 0.643g
  - 0.043 moles of $ZnBr_2$ = 9.684g

Percentage Mass

Percentage Mass

STOP AND CHECK (PAGE 18)

- To find the percentage mass, divide the mass of the atom you're after by the molar mass of the whole compound.

Percentage Mass

QUICK QUESTIONS (PAGE 18)

- **H_2O**
  - $\frac{2}{18}$ = 0.111, or 11.1%.
- **SF_6**
  - $\frac{32.1}{146.1}$ = 0.220, or 22%.
- **Fe_3O_4**
  - $\frac{167.7}{231.7}$ = 0.724, or 72.4%.
- **C_6H_6O**
  - $\frac{72}{94}$ = 0.766, or 76.6%
- **C_2H_4**
  - $\frac{24}{28}$ = 0.857, or 85.7%.
- **C_4H_8**
  - $\frac{48}{56}$ = 0.857, or 85.7%
- The final two molecules share the same percentage mass of carbon to hydrogen. This is because the ratio (1 : 2) remains the same between them.

Empirical Formulas

QUICK QUESTIONS (PAGE 26)

	H	C
% mass	17.2%	82.8%
Mass in 100g	17.2g	82.2g
Molar mass	1	12
Number of moles in 100g	17.2	6.85
Ratio	$\frac{17.2}{6.85} = 2.51$ 5	$\frac{6.85}{6.85} = 1$ 2

- Molar mass: $58gmol^{-1}$ which is C_4H_{10}

	N	O	H
% mass	29.8%	68.1%	2.1%
Mass in 100g	28.8g	68.1g	2.1g
Molar mass	14	16	1
Number of moles in 100g	2.05714	4.25625	2.1
Ratio	$\frac{2.05714}{2.05714} = 1$ 1	$\frac{4.25625}{2.05714} = 2.069$ 2	$\frac{2.1}{2.05714} = 1.021$ 1

- Molar mass: $141gmol^{-1}$ which is $N_3O_6H_3$

Concentration and Volume

Concentration and Volume

STOP AND CHECK (PAGE 29)

- The equation is $n = c \times v$
- The units for volume are litres (L).

Concentration and Volume

QUICK QUESTIONS (PAGE 29)

- $\frac{3.4}{6.5} = 0.5231 mol L^{-1}$
- $0.055 \times 0.34 = 0.0187$ moles
- First, find the number of moles in 3g of B_2O_3, then find the concentration:
  - $\frac{3}{69.62} = 0.0431 moles$
  - $\frac{0.0431}{0.017} = 2.54 mol L^{-1}$
- Again, find the number of moles in $MgSO_4$ first, then find the concentration:
  - $\frac{0.87}{120.366} = 0.00722795 moles$
  - $\frac{0.00722795}{0.785} = 0.00921 mol L^{-1}$

Putting it All Together

STOP AND CHECK (PAGE 38)

- The three steps are:
    1. Convert the substance you know about to moles.
    2. Use the mole ratio from the reaction to find the number of moles of the unknown substance.
    3. Convert back from moles to the variable you are solving for.

Putting it All Together

QUICK QUESTIONS (PAGE 38)

- First, find the number of moles of $NaHCO_3$:
    - $n = \frac{m}{M}$
    - $n = \frac{5.05}{84}$
    - $n = 0.6011905mol$

  Look to the ratio between the known and unknown:
    - 2 $NaHCO_3$: 1 CO_2 so half the number of CO_2 moles are produced.
    - $n(CO_2) = \frac{0.6011905}{2}$
    - $n(CO_2) = 0.30059525mol$

  Now, solve for CO_2 mass using the number of moles and molar mass:
    - $0.30059525 \times 44.0 = 13.226191g$

- First, find the number of moles of $AgNO_3$:
    - $n = c \times v$
    - $n = 0.194 \times 0.023$
    - $n = 0.004462mol$

  Look to the ratio between the known and unknown:
    - 1 $AgNO_3$: 1 AgCl so the same number of AgCl moles are produced.

  Now, solve for AgCl mass using the number of moles and molar mass:
    - $0.004462 \times 143.3 = 0.639g$ (3 s.f.)

- First, find the number of moles of NaOH:
    - n = c × v
    - n = 0.136 × 0.451
    - n = 0.61336mol

  Look to the ratio between the known and unknown:
    - 2 NaOH : 1 H_2SO_4 so half the number of H_2SO_4 moles are needed to neutralise.

  Now, solve for H_2SO_4 volume using the number of moles and molar mass:
    - v = $\frac{n}{c}$
    - v = $\frac{0.30668}{0.239}$
    - v = 1.283L

- First, find the number of moles of C_3H_8:
    - n = $\frac{m}{M}$
    - n = $\frac{0.56}{44.1}$
    - n = 0.0126984 1mol

  Look to the ratio between the known and unknown:
    - 1 C_3H_8 : 4 H_2O so there are 4 moles of water produced for every mole of propane.

  Now, solve for H_2O mass using the number of moles and molar mass:
    - m = n × M
    - m = 0.05079365 × 18.0
    - m = 0.914g (3 s.f.)

- First, find the number of moles of H_3PO_4:
    - n = c × v
    - n = 0.0195 × 0.250
    - n = 0.004875mol

  Look to the ratio between the known and unknown:
    - 2 H_3PO_4 : 3 $Mg_3(PO_4)_2$

  Multiply the number of moles by 1.5 to find the 2:3 ratio, then solve for the volume of $Mg_3(PO_4)_2$:
    - v = $\frac{n}{c}$
    - v = $\frac{0.0073125}{0.067}$
    - v = 1.09L

Titrations

The Theory

STOP AND CHECK (PAGE 42)

- Titrations are an experiment we can do to figure out the concentration of something we don't know.
- The kinds of titrations performed in this internal are acid-base (neutralisation) reactions.

Titrations

QUICK QUESTIONS (PAGE 50)

$$NaOH + HBr \rightarrow NaBr + H_2O$$

	NaOH	HBr
n (mol)	0.0007718	0.0007718
c ($molL^{-1}$)	**0.03859**	0.034
v (L)	0.02	0.0227

- The concentration of NaOH is 0.0386$molL^{-1}$ (3 s.f.)

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

	H_2SO_4	NaOH
n (mol)	0.0120037	0.0240074
c ($molL^{-1}$)	**1.20037**	0.782
v (L)	0.01	0.0307

- The concentration of H_2SO_4 is 1.200molL^{-1} (3 s.f.)

