## Units

Task 1a: Identify which of the following units are written incorrectly and rewrite them. in your PCD.

> 1000Mm
> 5 Candela
> 25.06 ccd
> 94 K
> 74888 m seconds    74888 ms
> 0.004Moles    0.004 moles    mol
> 20 hm
> 12 μm

## Conversion factors

$$\frac{1000\ m}{1} \times \frac{1\ km}{1000\ m} = 1\ km$$

144 km/h

$$\frac{144\ km}{1\ hour} \times \frac{1000\ m}{1\ km} \times \frac{1\ hour}{3600\ s} = ?\ \frac{m}{s}$$

1.1 Intro to the particulate nature of matter and chemical change

**Applications and skills:**

- Deduction of chemical equations when reactants and products are specified.

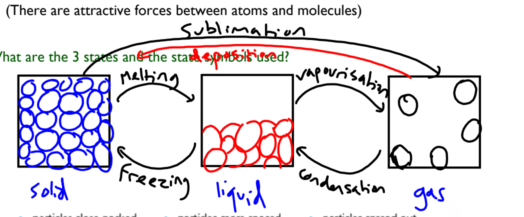
  **Guidance**
  *Balancing of equations should include a variety of types of reactions.*
- Application of the state symbols (s), (l), (g), and (aq) in equations.
- Explanation of observable changes in physical properties and temperature during changes of state.

  **Guidance**
  - *Names of the changes of state – melting, freezing, vaporization (evaporation and boiling), condensation, sublimation and deposition – should be covered.*
  - *The term 'latent heat' is not required.*

What is matter?

- Made up of particles such as atoms and molecules
- Occupies a volume
- Has a mass
- Particles are in constant motion
- (There are attractive forces between atoms and molecules)

What are the 3 states and the state symbols used?




| solid | liquid | gas |
|---|---|---|
| • particles close packed | • particles more spaced | • particles spread out |
| • inter-particle forces strong, particles vibrate in position | • inter-particle forces weaker, particles can slide over each other | • inter-particle forces negligible, particles move freely |
| • fixed shape | • no fixed shape | • no fixed shape |
| • fixed volume | • fixed volume | • no fixed volume |

What are the names of the physical processes between the different states?

0 = 273.15 K
1 = 274.15 K

Which units are commonly used to measure temperature?

°C K

°C → +273.15 → K
K → −273.15 → °C

Kinetic theory

The average kinetic energy of particles is directly proportional to the temperature in Kelvin.

**Worked example**

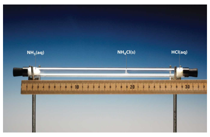
Which of the following has the highest average kinetic energy?

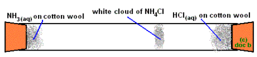
| | | | |
|---|---|---|---|
| A | He at 100 °C | B | $H_2$ at 200 °C |
| C | $O_2$ at 300 °C | D | $H_2O$ at 400 °C |

KE can be calculated using the following formula:

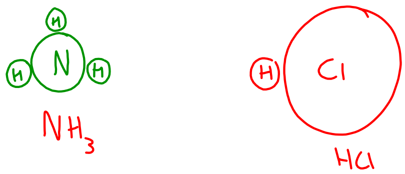
$$KE = \frac{1}{2}mv^2$$

So if different substances are found at the same temperature then there must be an inversely proportional relationship between the mass and velocity.



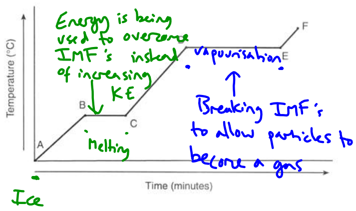


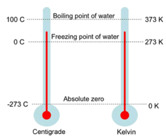

https://www.youtube.com/watch?v=Rf9j0ztzcs4




Kinetic theory - Heating water

Below is a heating curve for water (starting with ice), it shows what happens to the temperature of the water as we heat it continually...



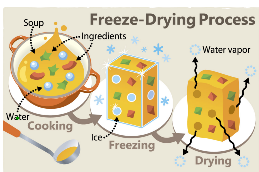

"Intermolecular forces" - small forces of attraction between atoms or molecules.

NOS

How do we use changes of state in industry?

Freeze-drying

1. Food is frozen
2. Subjected to very low pressure
3. This causes sublimation so the food is dehydrated
4. Microbes need moisture to grow




This process can be applied in many other areas of industry. In particular, the storage of pharmaceuticals.

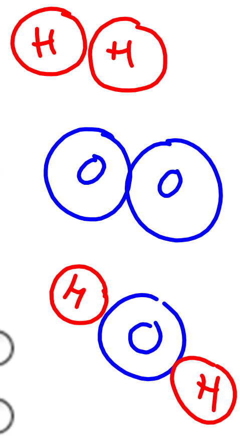
## Chemical equations

As atoms are neither created nor destroyed during a chemical reaction, *the total number of atoms of each element must be the same on both sides of the equation*. This is known as **balancing the equation**, and uses numbers called **stoichiometric coefficients** to denote the number of units of each term in the equation.

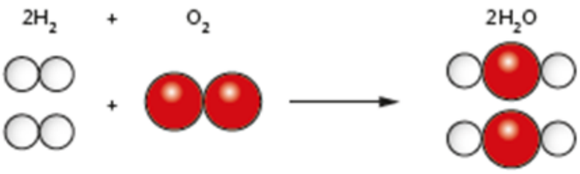
For example: hydrogen + oxygen → water

$$2H_2 + O_2 \rightarrow 2H_2O$$

coefficients

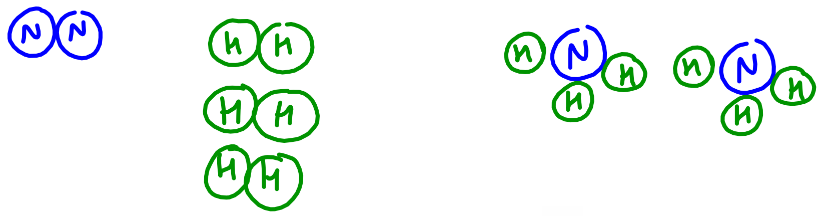


| | total on left side | total on right side |
|---|---|---|
| hydrogen atoms | 4 | 4 |
| oxygen atoms | 2 | 2 |




Note that when the coefficient is 1, this does not need to be explicitly stated.

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



### Worked example

Write an equation for the reaction of thermal decomposition of sodium hydrogencarbonate ($NaHCO_3$) into sodium carbonate ($Na_2CO_3$), water ($H_2O$), and carbon dioxide ($CO_2$).

**Solution**

First write the information from the question in the form of an equation, and then check the number of atoms of each element on both sides of the equation.

$$NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

| | total on left side | total on right side |
|---|---|---|
| sodium atoms | 1 | 2 |
| hydrogen atoms | 1 | 2 |
| carbon atoms | 1 | 2 |
| oxygen atoms | 3 | 6 |

In order to balance this we introduce coefficient 2 on the left.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Finally check that it is balanced for each element.

### NATURE OF SCIENCE

Early ideas to explain chemical change in combustion and rusting included the 'phlogiston' theory. This proposed the existence of a fire-like element that was released during these processes. The theory seemed to explain some of the observations of its time, although these were purely qualitative. It could not explain later quantitative data showing that substances actually gain rather than lose mass during burning. In 1783, Lavoisier's work on oxygen confirmed that combustion and rusting involve combination with oxygen from the air, so overturning the phlogiston theory. This is a good example of how the evolution of scientific ideas, such as how chemical change occurs, is based on the need for theories that can be tested by experiment. Where results are not compatible with the theory, a new theory must be put forward, which must then be subject to the same rigour of experimental test.

## Exercises

**1** Write balanced chemical equations for the following reactions:

**(a)** The decomposition of copper carbonate ($CuCO_3$) into copper(II) oxide ($CuO$) and carbon dioxide ($CO_2$).

**(b)** The combustion of magnesium ($Mg$) in oxygen ($O_2$) to form magnesium oxide ($MgO$).

**(c)** The neutralization of sulfuric acid ($H_2SO_4$) with sodium hydroxide ($NaOH$) to form sodium sulfate ($Na_2SO_4$) and water ($H_2O$).

**(d)** The synthesis of ammonia ($NH_3$) from nitrogen ($N_2$) and hydrogen ($H_2$).

**(e)** The combustion of methane ($CH_4$) to produce carbon dioxide ($CO_2$) and water ($H_2O$).

**2** Write balanced chemical equations for the following reactions:

**(a)** $K + H_2O \rightarrow KOH + H_2$

**(b)** $C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$

**(c)** $Cl_2 + KI \rightarrow KCl + I_2$

**(d)** $CrO_3 \rightarrow Cr_2O_3 + O_2$

**(e)** $Fe_2O_3 + C \rightarrow CO + Fe$

http://www.sciencegeek.net/Chemistry/taters/EquationBalancing.htm

## Atom economy

This describes the efficiency of a chemical reaction by comparing the amount of useful product to useless products:

$$\% \text{ atom economy} = \frac{\text{molar mass of useful products}}{\text{molar mass of products}} \times 100$$

**(a)** $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

**(b)** $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

**(c)** $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

**(d)** $H_2O_2 + N_2H_4 \rightarrow N_2 + H_2O + O_2$

**(e)** $C_2H_7N + O_2 \rightarrow CO_2 + H_2O + N_2$

— = useful

— = useless

$$\% \text{ atom econ} = \frac{4(14.01 + 16.00)}{X + 6(2(1.01) + 16.00)}$$

$$= \frac{120.04}{228.16} \times 100 = 52.61\%$$

$$2C_4H_{10} + 6\tfrac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

(13, 8, 10)

54.04

$$\% \text{ atom economy} = \frac{4(12.01 + (16.00)2)}{X + 5((1.01)2 + 16.00)} \times 100 = 66.1456$$

$= 66.15\%$

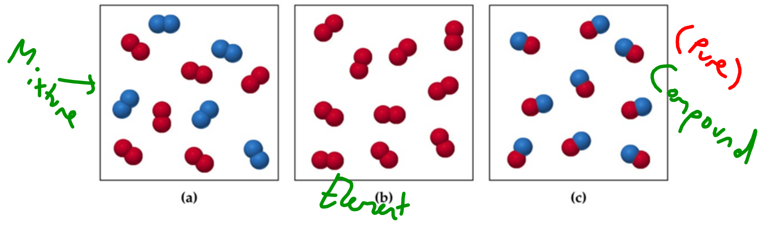
52.63

## Elements, compound and mixtures

Elements - any substance made of 1 type of atom

Compounds - made from 2 or more different atoms that are chemically bonded in a fixed ratio eg. $H_2O$

Mixture - Contains 2 or more elements or compounds that are not chemical bonded.




Which of these are pure substances? (have a constant composition)

Element, compound or mixture?

Pure substance?

a. Pure element

b. Mixture of compounds

c. Pure element

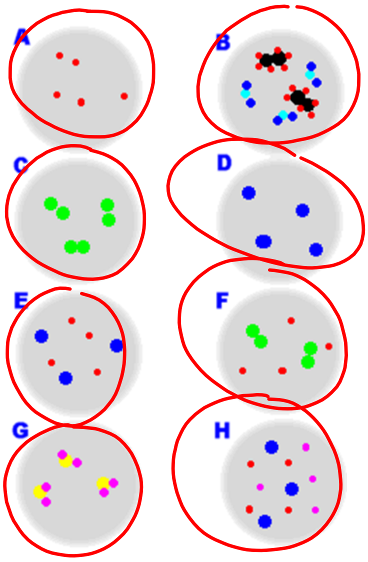
d. Pure element

e. Mixture of elements

f. Mixture of elements

g. Pure compound

h. Mixture

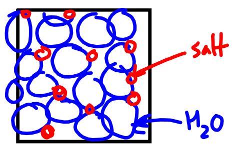



Note: the term molecule can be used to describe something made of 2 or more atoms (of the same type or different) that are chemically bonded together. Therefore sample C is a pure molecule, B is a mixture of molecules but only B contains compounds

There are 2 types of mixture:

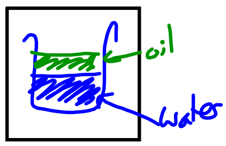
Homogeneous - has a uniform composition and properties throughout. Usually can´t see the individual components.

e.g. salt water, a metal alloy




Heterogeneous - non-uniform composition and varying properties.

e.g. water and oil




## Mixtures can be separated by physical processes

How could we separate the following mixtures?

- Sand and salt
- Different fuels in crude oil
- Iron and sulfur
- Pigments in food colouring
  - ↳ chromatography

pg. 11 • Activity a, b, c

• Quick questions 7, 8, 9