Calculations Revision materials – Foundation

Content will be tested in Chemistry Paper 1 and Paper 2

Checklist

Key points:	☺	☹
Calculations Revision		
How to calculate the mean		
How to calculate % change		
How to work out range		
Work out conversation of units		
Work out standard form		
Relative masses and moles		
How to work out relative formula mass		
How to work out % of an element in a compound		
How to work out concentration		

Calculating Mean

Key Knowledge

- To calculate the **mean** you **add up** all of the numbers and then **divide** them by how many pieces of data you have.
- If there are any anomalous results, remove them before calculating the mean.

Worked examples

Work out the mean of the data below

12, 13, 14, 11,12, 12, 13

Step 1- Total

12+13+14+11+12+12+13= **87**

Step 2- Divide total by number of pieces of data

87 ÷ 7 = **12.4**

The mean is 12.4

Exam practice 1

1. Calculate the mean reaction time.

person	**1**	**2**	**3**	**4**	**5**
reaction time/seconds	0.258	0.685	0.236	0.246	0.268

Mean =

2. Calculate the mean ADH level in people without diabetes.

people without diabetes insipidus	**ADH level in blood / µg per dm^3**
A	5.2
B	2.8
C	4.9
D	3.5
Mean ADH level:	

Mean ADH levels =

3. Calculate the most appropriate mean volume of oxygen produced at pH 7.

	volume of oxygen produced in cm^3				
pH	**repeat 1**	**repeat 2**	**repeat 3**	**repeat 4**	**mean**
1	1.2	1.6	1.4	1.8	1.5
4	37.7	48.3	38.1	39.9	38.6
7	53.0	51.2	52.8	61.0	
10	29.0	28.5	29.6	28.7	29.3
12	5.2	1.8	1.0	1.4	1.4

Mean at pH 7 =

4. Why do we calculate a mean?

………

………

<u>Calculating percentage change</u>

Key Knowledge

- Equation

$$\frac{\textbf{Final value – starting value}}{\textbf{starting value}} \times 100$$

Worked example

A willow tree initially has a mass of **2.27kg**. After 5 years it has a mass of **76.74kg**

$$\frac{76.74 - 2.27}{2.27} \times 100 = 3281$$

= 3281 %   increase

Exam practice 2

1. Calculate the percentage change in mass for chip 5.

chip	concentration of sucrose solution mol per dm^{-3}	starting mass of beetroot chip in grams	end mass of beetroot chip in grams
1	0.0 (water)	2.56	3.89
2	0.2	2.47	2.88
3	0.4	1.99	2.00
4	0.6	2.30	2.12
5	0.8	2.15	1.84
6	1.0	2.22	1.62

2. Suggest why calculating a percentage change is more useful than calculating the change in mass in this investigation

……

……

……

3. Calculate the missing percentage change in mass.

concentration of salt solution / %	mass / g			percentage change / %
	start	after 1 hour	change	
0	10.2	13.1	+2.9	+28.4
10	9.8	11.4	+1.6	+16.3
20	10.3	9.8	−0.5	
30	10.1	8.9	−1.2	−11.9
40	9.7	7.7	−2.0	−20.6

% change =

Range

Key Knowledge

The range is the difference between the highest and lowest values in a set of data.

Worked example

Example 1

Find the range of these numbers: 6, 4, 6, 5, 3.
First put them in order to make it easier to see the lowest and highest.
3, 4, 5, 6, 6

The lowest number is 3 and the highest is 6.

Find the difference. Subtract 3 from 6.

6 - 3 = 3 The range of this set of data is 3.

Exam practice 3

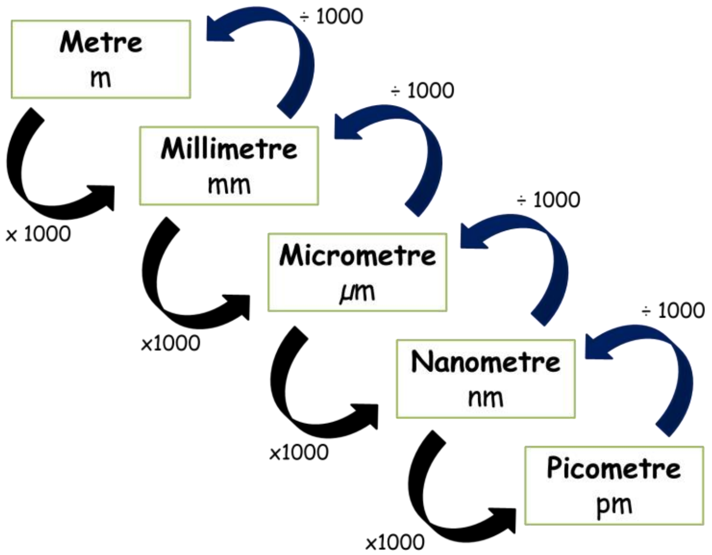
1. Find the range of these numbers: 16, 17, 16,19, 13.

2. Find the range of these numbers: 89, 78, 90, 76, 42.

3. Compare the range of temperatures for Cardiff and London for a week in July.
   Temperatures are given in the table in degrees centigrade.
   Sun Mon Tue Wed Thu Fri Sat

Cardiff 19° 19° 20° 20° 20° 18° 18°
London 20° 22° 22° 21° 20° 21° 19°

Converting Units



Worked example

To convert your units do the calculation shown in the diagram
e.g. going from mm to m you divide the number by 1000
6mm = 0.006m

Exam practice 4

1. Convert 34 millimetres into metres.

2. Convert 1034 nanometres into picometres.

3. Convert 6 000 000 seconds into microseconds.

4. Convert 87 nanoseconds into milliseconds.

5. The answer you get to a question is 0.15mm.

   Give your answer in a) m   b) µm c) nm

Standard form

Key information

We show figures as numbers between 1 and 10 multiplied by a power of 10
The index number tells us how many place values to move the digit.

Index number

$A \times 10^n$

For numbers greater than 0, count how many times you need to move the unit to the right until you form a number between 1 and 10.

Write this number as the power of 10, insert the decimal point and remove the zeros.

1 2 3 4 5 6

$1150000 = 1.15 \times 10^6$

You do the reverse for a number smaller than 0 and end up with a negative power.

Exam practice 5

1. Hydrochloric acid with a concentration of 0.001mol/dm^3 is used in a chemical reaction. Give the concentration of the acid in stand form.

   .... mol/dm^3

2. In a factory, 134000dm^3 of a chemical are added to a reaction vessel. Write the volume used in standard form

   ....dm^3

3. A biologist measures a cell that she is viewing under a microscope.

The width of the cell is 0.00125mm. Write the width in standard form.

......................mm

Relative masses and moles

Key Knowledge Relative atomic masses

- The mass of a single atom is so tiny that it is not practical to use it in experiments or calculations, that is why we use relative masses.
- For relative atomic masses the carbon-12 ($^{12}_{6}C$) atom is used as the standard atom. The masses of all other atoms are a comparison of their mass to the mass of the carbon-12 atom, e.g. hydrogen has a relative atomic mass of 1, which means most of its atoms have a mass that is $\frac{1}{12}$ of the mass of a $^{12}_{6}C$ atom.
- The symbol for relative atomic mass is A_r
- In the periodic table, the bigger number by each element is its relative atomic mass.
- Relative atomic mass takes into account the relative abundance (proportions) of any isotopes of the element found naturally. That is why some elements have a relative mass with decimals (e.g. chlorine A_r = 35.5).

Worked example:

Chlorine has two principle isotopes, $^{35}_{17}Cl$ and $^{37}_{17}Cl$. Their percentage abundances are 76% and 24%.

To calculate the mean relative mass you need to:

1. Multiply each of the isotopes' masses by their percentage abundance
2. Add the answers from step 1
3. Divide the number from step 2 by 100.

A_r (Cl) = $\frac{(35\times76)+(37\times24)}{100}$ = 35.48 $\approx$ 35.5

Exam practice 6

1. From the periodic table, find the relative atomic masses of the following elements:
   a. Nitrogen
   b. Magnesium
   c. Argon
   d. Copper
   e. Platinum
   f. Barium
   g. Bismuth
2. Copper has two isotopes, ^{63}Cu and ^{65}Cu. The percentage abundances are 69% and 31%. Calculate the mean relative atomic mass of copper.

Key Knowledge Relative formula mass

- Relative formula mass is the sum of the relative atomic masses of all the atoms shown in a chemical formula of a substance.
- The symbol for relative formula mass is M_r.
- When dealing with molecular substances it can also be referred to as the relative molecular mass.
- You can calculate the percentage by mass of an element in a compound using the atomic masses of the elements and the formula mass of the compound:
  - % by mass(element) = $\frac{A_r(element)\times number\ of\ atoms}{M_r(compound)} \times 100\%$

Worked example, relative formula mass:
Calculate the formula mass of sulfuric acid.
The formula is H_2SO_4. The A_r(H)=1, A_r(S)=32, A_r(O)=16.
M_r = (1x2) + 32 + (16x4) = 2 + 32 + 64 = 98

Worked example, percentage by mass:
Calculate the percentage by mass of hydrogen in water.
A_r(H)=1
A_r(O)=16
M_r(H_2O) = (1x2) + 16 = 18
% by mass(H) = $\frac{1\times2}{18} \times 100\%$ = 11%

Exam practice 7

1. Calculate the relative formula mass for the following compounds:

   a. Nitric acid
   b. Hydrochloric acid
   c. Water
   d. $CaCO_3$
   e. NaOH

2. Calculate the % by mass of oxygen in the following compounds:

   a. H_2O

   b. NaOH

   c. $CaCO_3$

Exam practice 8

Q1.

(ii) Calculate the relative formula mass of ammonium chloride, NH_4Cl.

(Relative atomic masses: H = 1, N = 14, Cl = 35.5)

....

....

Relative formula mass = ...

(2)

Q2. Iron is an essential part of the human diet. Iron(II) sulfate is sometimes added to white bread flour to provide some of the iron in a person's diet.

(a) The formula of iron(II) sulfate is $FeSO_4$

Calculate the relative formula mass (M_r) of $FeSO_4$

Relative atomic masses: O = 16; S = 32; Fe = 56.

....

....

The relative formula mass (M_r) = ...

(2)

Q3. Toothpastes often contain fluoride ions to help protect teeth from attack by bacteria.

Some toothpastes contain tin(II) fluoride.

This compound has the formula SnF_2 .

(a) Calculate the relative formula mass (M_r) of SnF_2.

Relative atomic masses: F = 19; Sn = 119

....

....

....

Relative formula mass (M_r) = ...

(2)

Key knowledge for % of an element in a compound

1. Write down the formula of the compound
2. Use the relative atomic mass (A_r) of the elements to calculate the relative formula mass (M_r).
3. Write the mass of the element you are investigating as a fraction of the total M_r.
4. Find the percentage by multiplying the fraction by 100.

Example

What percentage of carbon dioxide is actually carbon?

Formula of carbon dioxide = CO_2

1. Ar of carbon = 12

   Ar of oxygen = 16

   Therefore Mr = 12 + (16 x 2) = 44

2. $\frac{\text{Mass of carbon}}{\text{total mass of compound}} = \frac{12}{44}$

4. The percentage of carbon in the compound is:

$$\frac{12}{44} \times 100 = 27.3\ \%$$

Exam practice 9

Q1.

(a) The percentage by mass of oxygen in carbon dioxide (CO_2) is calculated by the equation:

$$\text{percentage by mass} = \frac{\text{number of atoms of O} \times \text{Relative atomic mass of oxygen (O)}}{\text{relative molecular mass of carbon dioxide } (CO_2)} \times 100$$

Relative atomic masses (A_r): C = 12 O = 16

Calculate the percentage by mass of oxygen in carbon dioxide (CO_2).

____

____

____

____

Percentage by mass of oxygen = ____________________ %

(3)

Q2.

Some students investigated magnesium oxide.

(a) Magnesium oxide has the formula MgO.

Calculate the percentage by mass of magnesium in magnesium oxide.

____

____

Percentage by mass of magnesium in magnesium oxide = _______%

(2)

Q3.

(a) Molecular formula of copper oxide is CuO.

Calculate the percentage of copper in copper oxide.

____

____

____

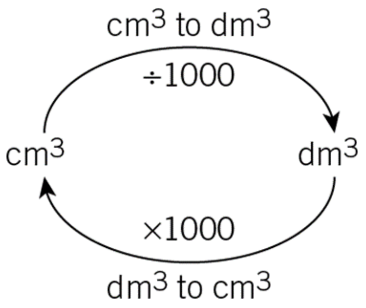
Percentage of copper = __________________ %

(2)

Expressing concentrations

Key Knowledge Volume

- Volume is the amount of space a substance or object occupies.
- There are many units that can be used to measure volume:
  - Millilitres – ml
  - Litres – l
  - Cubic metres – m^3
  - Cubic centimetres – cm^3
  - **Cubic decimetres – dm^3 ← THIS IS THE UNIT CHEMISTS USE MOST**
- 1 litre is the same as 1 dm^3
- 1 ml is the same as 1 cm^3
- Just as there are 1000 millilitres in a litre, there are **1000 cm^3 in 1 dm^3**



Worked examples:

Q1. A solution has a volume of 500cm^3, what is its volume in dm^3?

- 1 dm^3 = 1000 cm^3
- So to convert cm^3 into dm^3 you just have to divide by 1000!

$$\frac{500\ cm^3}{1000} = 0.5\ \text{dm}^3$$

Q2. A solution has a volume of 0.432 dm^3, what is its volume in cm^3?

- 1 dm^3 = 1000 cm^3
- So to convert dm^3 into cm^3 you just have to multiply by 1000!

$$0.432\ \text{dm}^3 \times 1000 = 432\ \text{cm}^3$$

Exam practice 10

1. What is 0.025 dm^3 in cm^3?
2. What is 270 cm^3 in dm^3?
3. How many cm^3 are in 0.052 dm^3?
4. A solution has a total volume of 986 cm^3, what is this in cubic decimetres?
5. 25 cm^3 is taken from a solution of total volume 0.45 dm^3 what volume of the solution remains?

Key Knowledge Concentration

- Solute – the substance that is dissolved in a liquid.
- Solvent – a liquid in which a substance is dissolved.
- Solution – a mixture of the dissolved solute and solvent.
- Concentration – the amount of substance in a certain amount of solution.
- Calculating concentration:
    - $concentration, c\ (g/dm^3) = \frac{amount\ of\ solute, m\ (g)}{volume\ of\ solution, V\ (dm^3)}$
- If the concentration is high, we call the solution concentrated.
- If the concentration if low, we call the solution dilute.
- Increasing the volume (adding more solvent), decreases the concentration.
- Decreasing the volume (evaporating some of the solvent), increases the concentration.
- By rearranging the concentration equation, you can calculate how much solute is in the solution, if you know the concentration and the volume of the solution.

Worked examples:

Q1. If 4g of sodium is dissolved in 2 dm^3 what is the concentration?

$$c\ (g/dm^3) = \frac{m\ (g)}{V\ (dm^3)}$$

c = 4/ 2= 2 g/dm^3

Q2. If 5.5g of sodium hydroxide is dissolved in 3 dm^3 what is the concentration?

c = 5.5/3= 1.83 g/dm^3

Q3. A solution of potassium hydroxide has a concentration of 10 g/dm^3, what mass of potassium hydroxide is dissolved in 0.5 dm^3 of it?

$m\ (g) = c\ (g/dm^3) \times V\ (dm^3)$ m = 10 x 0.5 = 5 g

Exam practice 11

1. If 5 g of sodium is dissolved in 1 dm^3 what is the concentration?

2. If 8 g of sodium hydroxide is dissolved in 2 dm^3 what is the concentration?

3. What is the concentration of a solution when 50 g of hydrogen chloride is dissolved in 5 dm^3 of water?

4. How concentrated is a 500 cm^3 solution that contains 6 g of potassium hydroxide?

5. What mass of lithium is dissolved in 0.4 dm^3 of a 15 g/dm^3 solution?

6. How many grams of hydrogen chloride are dissolved in 4 dm^3 of a 1.4 g/dm^3 solution?

7. A flask contains 400 cm^3 of a 5 g/dm^3 solution of potassium hydroxide. If all the water was evaporated, what mass of potassium hydroxide would remain?

8. A student took 25 cm^3 of 0.1 g/dm^3 sodium thiosulfate solution. What mass of sodium thiosulfate does it contain

Exam practice 12

1. Calculate the concentrations of each of the following solutions in units of g/dm3:
   a) 10.0 g of sodium chloride dissolved in 2.00 dm^3 of water

   ....

   ....

   (1 mark)

   b) 2.5 g of glucose dissolved in 0.5 dm^3 of water

   ....

   ....

   (1 mark)

   c) 3.8 g of copper sulfate dissolved in 250 cm^3 of water

   ....

   ....

   (2 marks)

   d) 25.6 g of potassium chloride dissolved in 1500 cm3 of water.

   ....

……

(2 marks)

2. Calculate the mass of solute dissolved in each of the following solutions in g:
   a) 2 dm^3 copper sulphate solution of concentration 3 g/dm^3.

      ……

      ……

      (1 mark)

   b) 5 dm^3 sodium carbonate solution of concentration 2.5 g/dm^3.

      ……

      ……

      (1 marks)

   c) 250 cm3 copper sulfate solution of concentration 1.2 g/dm^3.

      ……

      ……

      (2 marks)