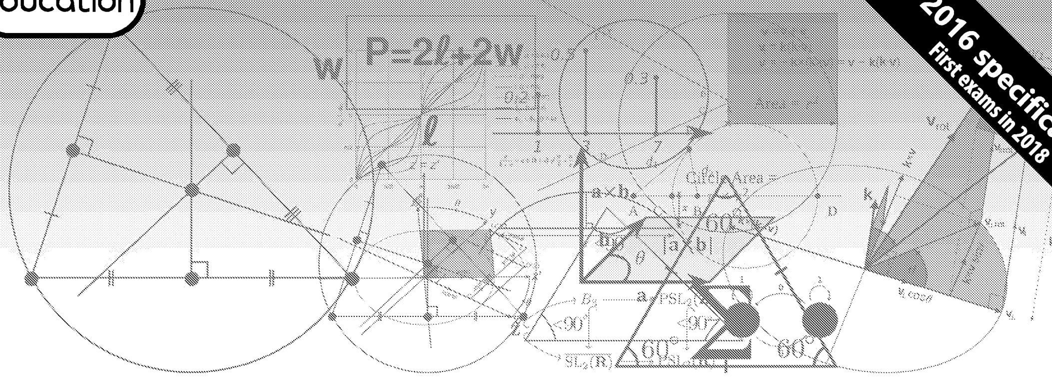
Chemistry

GCSE | WJEC | 3410



2016 specificaion
First exams in 2018

Maths Skills

for GCSE WJEC Chemistry

zigzageducation.co.uk

POD 12401

Contents

Teacher's Introduction

This GCSE Maths Skills pack will help students to develop the key mathematical skills needed in studying GCSE Chemistry. The pack has been written to cover mathematical skills required by the WJEC specification.

Mathematical skills pose a challenge for many students, with some finding it difficult to see how a skill learned in a Maths lesson is applied in a Chemistry lesson. This resource has been designed to support students in making this connection. It gives a gentle, conversational review of the skill, with worked examples, and offers students the opportunity to practise the skill in isolation and then also in the context of an examination-style question.

By using this resource, students can ensure they have the skills they need for each section of the Chemistry course. They can work through the chapters proactively, or they can be directed to them as support for skills identified in class as in need of some improvement.

There are five chapters covering all the key maths skills needed for GCSE Chemistry. Each chapter contains the following elements:

- **Specification overview** – this provides an overview of the skills and explains what the exam board requires students to demonstrate in the exam with the skills.
- **Theoretical overview** – a brief summary recapping the skills and demonstrating how to apply the skills.
- **Worked examples** – shows one or more fully worked questions which use the relevant skill, to demonstrate how students should approach them.
- **Practice questions** – each skill is concluded with practice questions that increase in difficulty. All the chemistry knowledge needed to complete the question will be provided, and the question focuses on testing students' understanding of the maths skill itself.

The chapters cover:

1. Arithmetic and numerical computation
2. Handling data
3. Algebra
4. Graphs
5. Geometry and trigonometry

There are two diagnostic tests for each chapter. The first is designed to be used before you work through each chapter and is provided at the start of the resource. The second is designed to be used after reviewing the chapter's content and is provided after the main content of the resource, just before the answers. The tests will allow you to identify areas for particular focus before undertaking the work, and then afterwards, should further focus on particular areas be necessary.

Graph paper is required for Diagnostic Tests for D2.

July 2024

Students' Introduction

Mathematical skills pose a challenge for many students, with some finding it diffic
a Maths lesson is applied in a Chemistry lesson. This resource has been designed
connection. It gives a gentle, conversational review of the skill, with worked exam
opportunity to practise the skill in isolation and then also in the context of an exa

By using these resources, you can ensure you have the skills you need for each se
course. You can work through the chapters proactively, or your teacher will direc
skills that you need to improve.

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these are linked to the relevant chapters. Within each chapter, there are four ele

- **Specification overview** – this provides an overview of the skills and explains
  you to demonstrate in the exam with the skills.
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particular areas be necessary.

DIAGNOSTIC TEST

A1 Arithmetic and numerical computation

1. Write the fraction $\frac{3}{8}$ as a decimal.

....

2. Write the fraction $\frac{4}{9}$ as a decimal to three decimal places.

....

3. Which of the following is the correct way to write the number 21 368 in stand

   A. 21.368×10^{3} ☐
   B. 2.1368×10^{4} ☐
   C. 21.368×10^{-3} ☐
   D. 2.1368×10^{-4} ☐

4. 12 moles of iron react with 18 moles of oxygen. Express the ratio 12:18 in its whole numbers).

....

....

5. Two gases are mixed in the ratio 3:1. If the total volume of gases is 8 dm^3, w the two gases.

....

....

6. Convert the decimal 0.25 to the following:

   a. a percentage: ....

   b. a fraction in its simplest terms ....

7. A chemical weighing 1.20 g is heated, which causes its mass to reduce to 0.84

   a. How much mass has been lost?

   ....

   b. Express the mass lost as a percentage of the original mass.

   ....

8. The term '$PM_{2.5}$' refers to particles that have a maximum diameter of 2.5 µm. particle with a maximum diameter of 0.1 µm. Use this information to estimate is than a nanoparticle.

....

9. Every time the pH of a solution increases by one unit, the concentration of H^+ ic Estimate how many times the concentration of H^+ ions decreases when a soluti

....

....

DIAGNOSTIC TEST

B1 Handling data

1. How many significant figures are in the following numbers?

   a. 234.202 ....

   b. 0.001304 ....

   c. 0.070050 ....

2. Give the answers to these calculations. Make sure that you give the answer to places, rounding if necessary.

   a. 1.479 + 0.3421 ....

   b. 12.323 – 0.85 ....

   c. 0.003 + 0.012 ....

3. Give the answers to these calculations. Make sure that you give the answer to figures, rounding if necessary.

   a. $14.9 \div 3.0$ ....

   b. 147×0.025 ....

   c. 3.87×1.575 ....

4. The pH of a buffer solution was measured three times. The results were: 8.4, 8 What is the mean average pH?

   ....

   ....

5. A class is asked to measure the rate of a reaction by counting the number of b minute period. Twenty-five students each measured the number of bubbles, a order) are shown below.

   Put this data into a frequency table and from that calculate the arithmetic mea number of bubbles.

   98, 98, 98, 99, 99, 99, 99, 100, 100, 100, 100, 100, 100, 101, 101, 101, 1 102, 103, 103

   ....

   ....

   ....

DIAGNOSTIC TEST

C1 Algebra

1. The rate of a chemical reaction can be defined as: rate $= \frac{\text{mass of product formed}}{\text{time}}$

   The rate of a reaction is found to be **0.85 g/s**. Use this value and the equatio grams of product would be formed in **15 s.**

   ....

   ....

   ....

   ....

2. Rearrange the equation $y = 4x + 7$ to make x the subject.

   ....

3. The concentration of a solution can be calculated using the formula:

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{number of moles of substanc}}{\text{volume of solution (dm}^3}$$

   Calculate the concentration of a solution with a volume of 250 cm^3 that contai

   You will need to pay careful attention to the units.

DIAGNOSTIC TEST

D1 Graphs

1. Plot the data shown in the table below on graph paper. Draw a line of best fi gradient of that line.

x	y
1	6.8
2	13.4
5	30.8
8	53.0
10	61.6

2. Use the graph that you drew in question 1 to work out the following:

   a. what the y value would be when $x = 6.5$ ....

   b. what the x value would be when $y = 55$ ....

   c. what the value for y would be when $x = 0$ (you may need to extend your

   ....

3. Use your answers to question 1 and question 2 part c to write an equation for form $y = mx + c$

   ....

4. A reaction is monitored by weighing the mass of the reaction flask every 2 min graph below. Use this to find the gradient (which represents the rate of reacti

   a. 1 minute

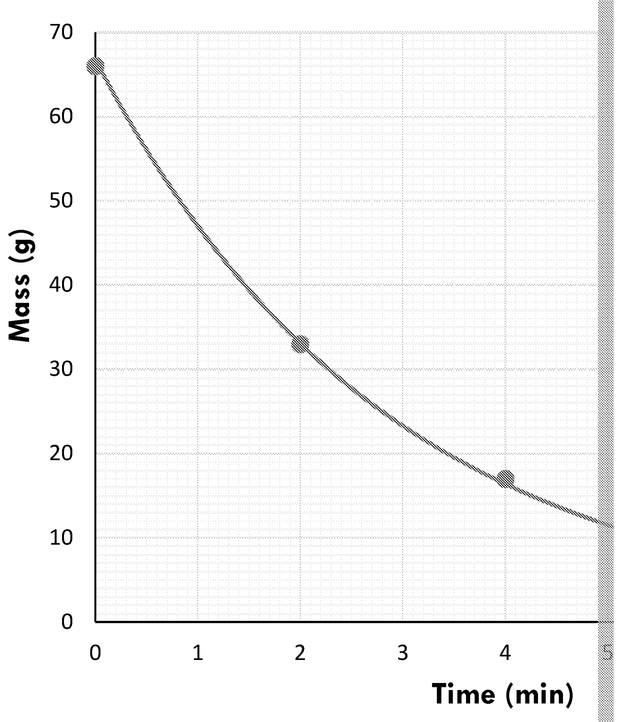
   ....

   b. 3 minutes

   ....

   c. 7 minutes

   ....



DIAGNOSTIC TEST

E1 Geometry and trigonometry

1. A cube has six faces. If all the sides of the cube are 15 mm long, calculate:

   a. The volume of the cube ....

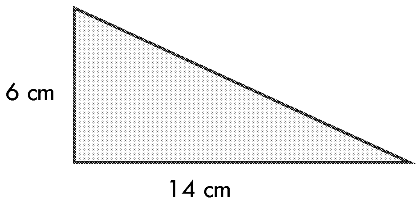
   ....

   b. The surface area of the cube ....

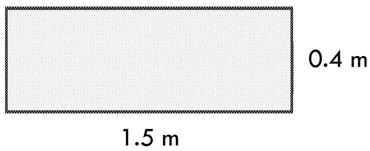
   ....

2. Calculate the area of the following shapes.

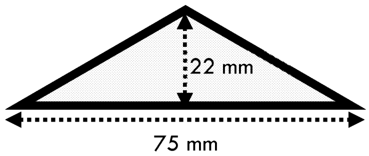
   a.



   b.



   c.



1 ARITHMETIC AND NU COMPUTATIO

SPECIFICATION OVERVIEW

Recognise and use expressions in decimal form
Recognise and use expressions in standard form
Use ratios, fractions and percentages
Make estimates of the results of simple calculations

THEORETICAL OVERVIEW

In this section you will learn how to perform some calculations that are important in c fractions, ratios and percentages. You will also learn how to work with numbers tha

Fractions and decimals

A fraction is written as one number on top of the other. The value of a fraction is t divided by the bottom number (the *denominator*). For example: $\frac{2}{4}$ is equal to 2 divi written as a **decimal**: 0.5.

Some common fractions and decimals			
Fraction	**Decimal (to 3 decimal places)**	**Fraction**	**Deci**
$\frac{4}{5}$	0.800 (0.8 exactly)	$\frac{1}{3}$	0.33
$\frac{3}{4}$	0.750 (0.75 exactly)	$\frac{1}{4}$	
$\frac{2}{3}$	0.667 (the ‘6’ repeats infinitely)	$\frac{1}{5}$	
$\frac{1}{2}$	0.500 (0.5 exactly)	$\frac{1}{6}$	0.16
$\frac{2}{5}$	0.400 (0.4 exactly)	$\frac{1}{8}$	

Not all fractions have exact values. If you try to write $\frac{1}{3}$ as a decimal (you could tr calculator) you get a string of ‘3’s after the decimal point that only ends because t a decimal like this you will have to decide how many digits to include after the dec **places** to write the number to. For example, $\frac{1}{3}$ = 0.33 to two decimal places or 0.3

WORKED EXAMPLE 1

Write the fraction $\frac{4}{7}$ as a decimal. Give the answer to three decimal places.

Solution

4 ÷ 7 = 0.571 (you should work this out using a calculator)
More digits are possible in the answer, but the question specifies that only three d should be given. You should look at the fourth decimal place (one more than aske this number. In this case the number is 0.5714. Because 4 is less than 5 you do n

WORKED EXAMPLE 2

Write the fraction $\frac{7}{11}$ as a decimal. Give the answer to two decimal places.

Solution

$7 \div 11 = 0.64$

In this case, you have been asked to give the number to two decimal places, so yo decimal place to decide how to round. The number is 0.636. You must round the 3 to 4 (always round up when the digit after the one you are rounding is 5 or bi

Fractions can sometimes be simplified, i.e. written using smaller numbers. You do thi the denominator by the same number. This only works if you get whole numbers wh the denominator by this number.

WORKED EXAMPLE 3

The number of moles of atoms in an element is calculated using the formula: number of moles = mass/A_r

How many moles of beryllium are there in 6 g? (A_r for beryllium = 9)
Give the answer as a fraction in its simplest form.

Solution

Number of moles = $\frac{6}{9}$. This fraction can be simplified because both the numerato divided by 3: number of moles = $\frac{\not{6}\,2}{\not{9}\,3}$.

Standard form

Sometimes the numbers used in chemistry can be very large (e.g. the number of ato small (e.g. the length of the bond between two atoms in a molecule). When studyi to write such numbers without using very long strings of digits – many of which woul

This is where **standard form** is helpful. Numbers are written in standard form as a to a power. For example:

9.8×10^x

Decimal must be at least 1 but less than 10 → 9.8; x can be positive

For very large numbers, a positive value of x is used. For example, in a strip of ma (0.001 g) there are about 24.8 billion billion atoms. You could write this as 24 80 shorter way is to write it as 2.48×10^{19}. The power to which 10 is raised (+19) te need to move the decimal point to the **right** (adding zeros if necessary) to convert f

For very small numbers, a negative value of x is used. The distance between the C 0.000000000097 m. You could write this as 9.7×10^{-11} m. The power to which 1 many places you need to move the decimal point to the **left** (adding zeros if necess form to a decimal.

WORKED EXAMPLE 1

Write 2437.8 in standard form.

Solution

Move the decimal point until you get a number that is at least 1 but less than 1
the decimal point moves. Multiply this decimal by 10^x where x is how many tim
moved. The sign of x is positive since the original number is bigger than 10 (and
point to the left).

$$2437.8 \quad = \quad 2.4378 \times 10^3$$

WORKED EXAMPLE 2

Write 0.0631 in standard form.

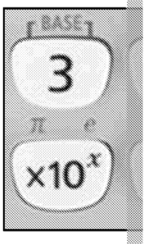
Solution

Move the decimal point until you get a number that is at least 1 but less than 1
the decimal point moves. Multiply this decimal by 10^x where x is how many tim
moved. The sign of x is negative since the original number is less than 10 (and y
point to the right).

$$0.0631 \quad = \quad 6.31 \times 10^{-2}$$

Using standard form with a calculator

When you enter a number in standard form into a calculator you do not use the normal multiply button and the '1' and '0' buttons to enter '$\times 10^x$'. There is a special button that enters '$\times 10^x$' in one go. On some calculators it is written as '$\times 10^x$'; on others (usually older models) it is written as 'exp'. Look at the bottom of your calculator on the right-hand side.



Ratio

A ratio tells you how big a set of numbers are relative to one another, but not the

For example, if a box of pens contains black and blue pens in the ratio 2:1 this tel
black pens as blue pens. It does not tell us how many pens there are of either colo

If we knew the total number of pens, we could work out how many of each there w
given ratio. One way of doing this is to convert the ratio number into fractions by
and using this total as the denominator, with each ratio number as the numerator.
thirds because 2 + 1 = 3).

If there are 45 pens in the box, the number of black pens is $\frac{2}{3} \times 45 = 30$ and the nu

Ratios can sometimes be simplified – you divide all the numbers in the ratio by the
6 moles of hydrogen react with **3** moles of oxygen to produce **6** moles of water, th
6:3:6. Since 3 can be divided into all of these numbers, the ratio can be simplifie

A **balanced chemical equation** is written using the simplest reacting ratio of react
of hydrogen and oxygen is written as $2H_2 + O_2 \longrightarrow 2H_2O$ (the number '1' is never

WORKED EXAMPLE 1

A dilute acid is prepared by mixing concentrated acid and water in the ratio 1

To prepare a total volume of 100 ml of the diluted acid, what volume of conc water should be used?

Solution

Since 1 + 9 = 10, the ratio can be written as fractions. Ratio acid:water = $\frac{1}{10}$: $\frac{9}{10}$

The volume of acid required is $\frac{1}{10} \times 100 = 10$ *ml*

The volume of water required is $\frac{9}{10} \times 100 = 90$ *ml*

(You can check the answer by making sure the two volumes add up to the total:

WORKED EXAMPLE 2

The balanced equation for the reaction of nitrogen (N_2) and hydrogen (H_2) to

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

To produce 0.6 moles of NH_3, how many moles of N_2 and H_2 should be react

Solution

The balanced equation gives you the reacting ratio N_2:H_2:NH_3 *= 1:3:2*

It may be easier to think of these in two pairs. Firstly, N_2:NH_3 *= 1:2, so to make 0.3 moles of* N_2 *(since 0.3:0.6 = 1:2).*

Then, N_2:H_2 *= 1:3. We now know that 0.3 moles of* N_2 *is needed, so we can work needed (because 0.3:0.9 = 1:3).*

Finally, check all three amounts are in the right ratio. N_2:H_2:NH_3 *= 0.3:0.9:0.6 =*

Percentages

A percentage can be thought of as a fraction where the denominator is always 10 fractions with 100 on the bottom though. Instead, the symbol '%' is written after the be the numerator, the top number, if it was written as a fraction).

Thinking about percentages as fractions can sometimes help to simplify them.

For example, 25% is the same as $\frac{25}{100}$. Since we know how to simply fractions by di thing (in this case they can both be divided by 25) we can say $25\% = \frac{1}{4}$.

If you need to express a fraction as a percentage, you simply multiply it by 100. same as $\frac{7}{20} \times 100 = 35\%$.

WORKED EXAMPLE 1

A mixture of H_2, I_2 and HI has a total volume of 15 ml. If the mixture contains (by volume), what is the volume of each of the three components of the mix

Solution

If 20% of the mixture is H_2 *and 20% of the mixture is* I_2*, then 60% must be HI (*

These can be written as fractions and simplified: 20% = $\frac{20}{100} = \frac{1}{5}$ *and* $\frac{60}{100} = \frac{3}{5}$

So the volume of H_2 *in the mixture is* $\frac{1}{5} \times 15$ *ml = 3 ml*

The volume of I_2 *in the mixture is also* $\frac{1}{5} \times 15$ *ml = 3 ml*

The volume of HI_2 *in the mixture is also* $\frac{3}{5} \times 15$ *ml = 9 ml*

WORKED EXAMPLE 2

The theoretical yield (the maximum possible mass) of a reaction is 0.45 g. A reaction and gets 0.33 g of product.

What is the percentage yield? Give your answer to one decimal place.

Solution

The question is asking what the amount of product that was actually made (0.3 theoretical yield (0.45 g).

You can write these numbers as a fraction and multiply by 100 (you will need t 0.45 on a calculator and then multiply this by 100): $\frac{0.33}{0.45} \times 100 = 73.33\%$*, whic decimal place to give 73.3%.*

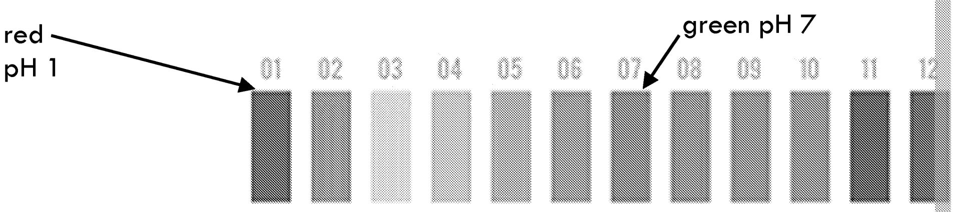
Estimating answers

It is not always possible or necessary to calculate exact answers. It may be that yo the data that you are using in a calculation, or it may be that you do not need to k so can estimate the answer to make the calculation easier and faster.

For example, when you are trying to understand the structure of atoms it is useful t sizes of the proton, neutron and electron, but you do not need to know the actual s a proton, a neutron and an electron is thought to be about 0.84, 0.80 and 0.001 f

You could get your calculator out and work out exactly how much bigger one partic you need to know this? If you are just trying to get a feel for what an atom is like, recognise that protons and neutrons are about the same size (and electrons are ab

An example of where we do not have very precise data is working out the concent using universal indicator. The indicator colour tells you the pH – but only to the nea need to get your calculator out and use the inverse log function to work out the con – you can make an estimate like this: pH 1 is a concentration of 0.1 M, pH 2 is 0.01 estimate because you do not know the pH value exactly.



WORKED EXAMPLE 1

A carbon atom has a radius of 77 pm, a nitrogen atom has a radius of 74 pm has a radius of 153 pm. Estimate the ratio of sizes of the atoms.

Solution

Because we only need to estimate an approximate answer, we can say that carbo and 74 pm) are almost the same size. The gallium atom (153 pm) is close to dou So, the ratio of the sizes of the atoms can be written as: ***carbon:nitrogen:gallium***

WORKED EXAMPLE 2

The rate of a reaction is estimated by timing how long it takes for a colour ch reaction is set up, it takes 84 s for the colour to change. The reaction is repea twice as much of one of the chemicals in the solution. This time it takes 20 s.

Estimate how many times faster the reaction becomes when the amount of th

Solution

Since 20 is approximately one quarter of 84, we can say that the reaction was f performed the second time (with twice as much chemical in the solution).

PRACTICE QUESTIONS

1. Write the number 0.4 as a fraction in its simplest terms.

2. In a sample of 0.40 moles of a mixture of gases there are 0.15 moles of hydr
   The rest of the mixture is oxygen.

   a. What is the ratio of hydrogen to oxygen in this mixture? Give the answer

   b. What fraction of the total number of moles of gas is hydrogen? Write thi

   c. Convert the answer to part b to a decimal. Round the answer to 2 decim

3. Write these numbers in standard form.

   a. 0.006423

   b. 970854

   c. 0.0000582

4. The number of atoms or molecules in one mole is called the Avogadro number
   Use a calculator to work out how many atoms are in 1.275×10^{-5} moles.
   (**HINT**: You need to multiply these two numbers together and give the final ans

5. A solution is made by dissolving 41 g of solid in 1.9 dm^3 of water. Estimate th
   solution in g/dm^3. Give your answer to the nearest 10 g/dm^3. Do **not** use a c

6. The theoretical yield for a reaction is 3.6 g. If a student produces 2.9 g, what
   percentage of the theoretical yield?

7. A sample of an organic compound is analysed and found to contain 0.15 mole
   and 0.35 moles of hydrogen atoms.

   a. Give the ratio of moles of carbon atoms to moles of hydrogen atoms in th

   b. What fraction of the total number of atoms are carbon atoms? Give the fra

   c. Express the answer to part b as a percentage.

8. When the concentration of a strong acid increases ten times, the pH decreases
   solution of a strong acid is made by dissolving 5.1 g of acid in 1 dm^3 of solutio
   indicator paper, the pH is approximately 3. Estimate the mass of strong acid t
   use to make 1 dm^3 of solution with a pH of approximately 2.

9. 21% of the volume of air is oxygen. Estimate the volume of oxygen in 250 cm
   Do **not** use a calculator.

10. In an equilibrium mixture of gases, there are 0.84 moles of NO_2 and 0.28 mol

    a. What is the ratio of moles of NO_2 to moles of N_2O_4 in its simplest terms?

    b. What fraction of the total number of moles is N_2O_4?

    c. Write the fraction from part b as a decimal.

2 HANDLING DAT

SPECIFICATION OVERVIEW

Use an appropriate number of significant figures
Find arithmetic means
Construct and interpret frequency tables and diagrams, bar charts and histogra
Make order of magnitude calculations

THEORETICAL OVERVIEW

In this section you will learn some important statistical processes such as how to wor display data in graphical forms (such as bar charts or histograms). You will also le calculations to the correct number of decimal places or significant figures.

Significant figures and decimal places

The number of decimal places is how many digits (including zeros) are after the de out how many significant figures are in a number, count all the digits *except* any ze number (as soon as you count the first non-zero digit, count any zeros after that, inc

e.g. The number 0.02030 has five decimal places (five digits after the decimal poi final '0'). It has four significant figures because you do not count the first two '0's (do count the '0' in the middle of the number (a **contained** or **trapped zero**) and at

When you are **adding** or **subtracting** numbers, you should give the answer to the s as the numbers you are adding or subtracting. If the numbers do not all have the s them, give your answer to the same number of decimal places as the one with the f

When you are multiplying or dividing, you should give the answer to the same num numbers you are multiplying or dividing. If the numbers do not all have the same n them, give your answer to the same number of significant figures as the one with th

If the answer that you work out has more significant figures or decimal places than then you need to **round** your answer. Decide how many significant figures or deci then look at the next digit to the right of the last one that you are going to include then you need to 'round up' – increase the last digit by 1. If it is less than 5, do no

WORKED EXAMPLE 1

Give the answer to this calculation: 1.457 + 3.92
Be careful to give your answer to the correct number of decimal places.

Solution

1.457 + 3.92 = 5.377 (if you put it into the calculator this is what you will see)
However, you should give the answer as ***5.38*** *because the number '3.92' has onl must give your answer to two decimal places. Since the digit in the third decim you must round up.*

WORKED EXAMPLE 2

Give the answer to this calculation: 10.9 × 1.105
Be careful to give your answer to the correct number of significant figures.

Solution

10.9 × 1.105 = 12.0445 (if you put it into the calculator this is what you will s
However, you should give the answer as ***12.0*** *because the number '10.9' has only must give your answer to three significant figures. Since the fourth significant dig round up – but you must include the last zero (because '12' is only two significan*

The arithmetic mean

The arithmetic mean (sometimes just called 'the mean') is a type of **average** that yo values. You do this by adding the numbers together and dividing by how many nu

For example, if you take the temperature in your house four times during the day, y temperature for that day by adding the four temperatures together and dividing b

Say the temperatures that you recorded were 18 °C, 19 °C, 22 °C and 21 °C. The would be calculated like this:

$$\text{average temperature} = \frac{18 + 19 + 22 + 21}{4} = \frac{80}{4} = 2$$

The rules about how many decimal places or significant figures to give in an arithm depend on the data that you are working out the mean for. However, a useful gui the above example there was no question of how many significant figures to includ 20) then you should give the arithmetic mean to one more significant figure than is i

Imagine you measure the temperature three times and get these values: 19 °C, 20 temperature would be calculated like this:

$$\text{average temperature} = \frac{19 + 20 + 19}{3} = \frac{58}{3} = 19.33333$$

There is no justification (or need) for all those '3's in the answer, so applying the ru figure than the data, you should give the answer as **19.3 °C.**

WORKED EXAMPLE 1

A titration is repeated until 3 concordant titres (volumes added from the bure 0.1 cm³ of one another) are obtained. These are:

Titre 1 (cm^3)	Titre 2 (cm^3)	Titre 3 (cm^3)
12.40	12.45	12.40

Calculate the average titre. Give your answer to 2 decimal places.

Solution:

$$\text{average titre} = \frac{12.40 + 12.45 + 12.40}{3} = \frac{37.25}{3} = 12.4166666$$

Since the question specifies that the answer must be given to 2 decimal places yo

WORKED EXAMPLE 2

A group of five students each measures the volume of gas produced by a ch first 30 seconds. Their results are shown below. Work out the average volum

Student 1 (cm^3)	Student 2 (cm^3)	Student 3 (cm^3)	Student 4 (c
43.4	40.5	39.8	42.9

Solution:

$$\text{average volume} = \frac{43.4 + 40.5 + 39.8 + 42.9 + 41.1}{5} = \frac{207.7}{5} =$$

Applying the rule of using one more significant figure than the data, you should (and not round it to 41.5 cm³).

Frequency tables and diagrams

A frequency table lists measurements and tells you how often each one occurs in a s neater way of displaying the data, but it can also make the process of calculating c example demonstrates how to make a frequency table from a set of data.

WORKED EXAMPLE 1

You are investigating the masses of 100 cm³ beakers in a laboratory. There a beakers and you weigh all of them and record the masses. You write out the from smallest to largest, like this:

33.4 g; 33.4 g; 33.4 g; 33.4 g; 33.4 g; 33.5 g; 33.5 g; 33.6 g; 33.6 g; 33.6 g; 33.6 g; 33.6 g; 33.6 g; 33.6 g; 33.7 g; 33.7 g; 33.7 g; 33.7 g; 33.7 g; 33.7 g; 33.7 g; 33.8 g; 33.8 g; 33.8 g; 33.8 g; 33.8 g; 33.8 g; 33.9 g; 33.9 g; 33.9 g

Display this data in a frequency table.

Solution:

To produce a frequency table, list all the values for the masses in one column and set of data in the next column.

Mass (g)	Frequency
33.4	5
33.5	2
33.6	7
33.7	7
33.8	6
33.9	3

A frequency diagram (also called a 'frequency polygon' or 'line chart') is another w To produce a frequency diagram, plot a graph with the data values on the x-axis a y-axis. You then join the points with a line.

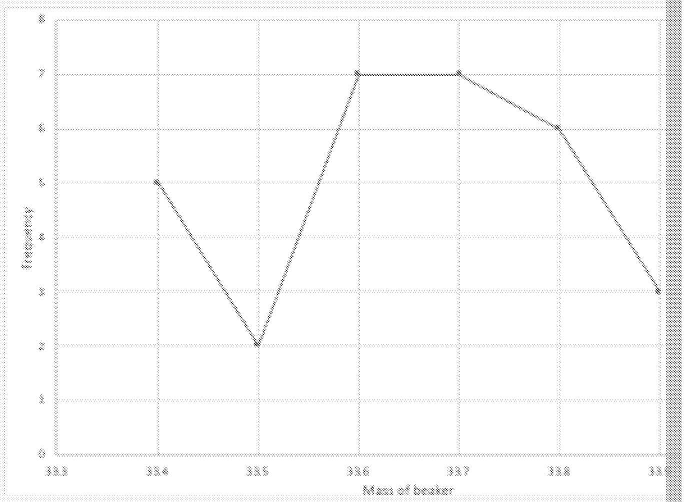
(**NOTE:** this is not the same as a trend line or line of best fit – it is a line that 'joins th

WORKED EXAMPLE 2

Display this data from WORKED EXAMPLE 1 as a frequency diagram.

Solution:

Plot the data from the frequency table with mass values on the x-axis and the fr join the points with a series of straight lines.



Calculating averages from frequency tables

There are three different averages that you can work out for sets of many number (see p. 15) there is also the **mode**, which is the value in a set of data that occurs m is the middle value when they are all lined up in order. If there is an even number will be two middle values. In this case you add them together and divide by two.

The mode can be found from the frequency table or diagram by looking for the va frequency. If there is more than one value with the highest frequency, then you sho

The median can also be found using the frequency table. To make it easier to see you should add an extra column with a running total of the frequency numbers (cal

WORKED EXAMPLE 1

Using the frequency table (masses of 100 cm³ beakers) from the previous se mode (or modes) and the median average mass.

Solution:

To find the mode, look for the masses with the highest frequency or frequencies. modes: ***33.6 g*** *and* ***33.7 g****.*

To find the median, add a cumulative frequency column to the table and work o be the middle. For a total of ***n*** *numbers, the middle one would be at position (****n*** *is 31 / 2 = 15.5. This means that the median number would be between the 15 sequence. Since these are both 33.7 g, the median is (33.7 + 33.7) / 2 =* ***33.7*** *g*

Mass (g)	Frequency	Cumulative frequency
33.4	5	5
33.5	2	7
33.6	7	14
33.7	7	21
33.8	6	27
33.9	3	30

To calculate the mean, add an extra column that shows the mass multiplied by its fr the numbers in this column. The mean is this total divided by the number of values i

WORKED EXAMPLE 2

Using the frequency table (masses of 100 cm³ beakers) from the previous sec mean average mass.

Solution:

Add the mass × frequency column to the table and work out the total of the num total mass of all 30 beakers (and you avoided having to add up all 30 numbers!) beakers (30) to get the mean.

Mass (g)	Frequency	Mass × frequency (g)
33.4	5	167
33.5	2	67
33.6	7	235.2
33.7	7	235.9
33.8	6	202.8
33.9	3	101.7
	Total	1009.6

1009.6 / 30 = 33.653333333

Applying the rule of using one more significant figure than the data, you should g

Bar charts and histograms

Both bar charts and histograms represent frequency data using a set of bars along of the bars represents the frequency.

Bar charts are only used to represent **discrete data** (numbers that do not have inte **data** (names of things, such as colours or chemical elements). The bars in a bar cha any neighbouring bars to show that values between the bars are not possible.

Histograms are used when the data is **continuous** (where there can be any value, temperature of a liquid could be 20 °C or 21 °C – or any value in between). The another to show this.

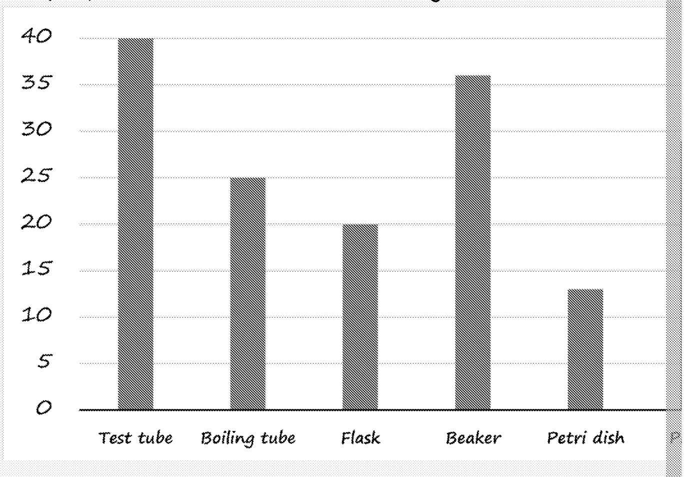
WORKED EXAMPLE 1

The table below shows how many of each item of laboratory equipment is lab. Display this data using either a bar chart or a histogram, whichever is the type of data.

Item	Number
Test tube	40
Boiling tube	25
Flask	20
Beaker	36
Petri dish	13
Pipette	29

Solution:

The data is categorical and so the most appropriate way to display it is using a items can be in any order along the horizontal axis. The vertical axis needs to be fit in the highest number (40) and the bars drawn to a height that matches the



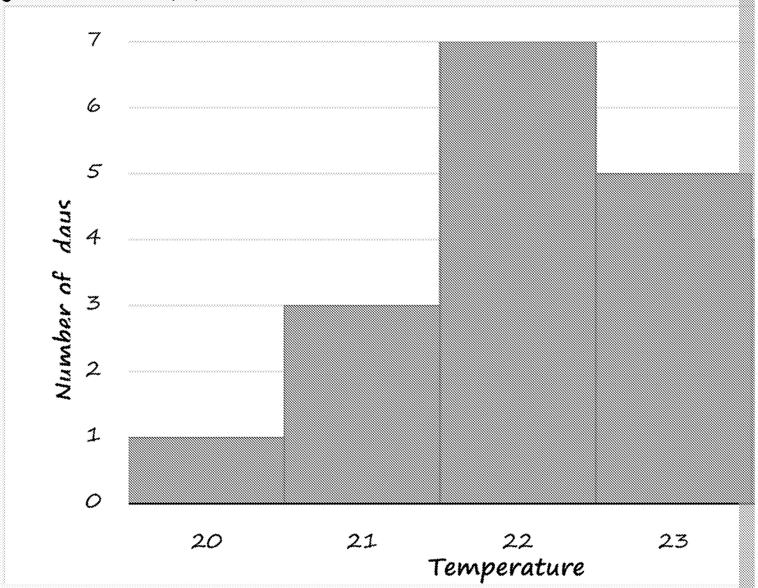
WORKED EXAMPLE 2

A student records the temperature of a classroom every day for one month. T shows how many days the room was at each temperature. Display this data chart or a histogram, whichever is most appropriate for the type of data.

Temperature °C	Number of days
20	1
21	3
22	7
23	5
24	4

Solution:

The data is continuous and so the most appropriate way to display it is using a h should be displayed on a scale along the horizontal axis. The vertical axis needs to can fit in the highest number (7) and the bars drawn like this:



Calculating orders of magnitude

An order of magnitude calculation is a special type of estimation where you are try nearest multiple of ten, i.e., 1, 10, 100, 1000, etc. You could also write these numb 10^2, 10^3, etc.

WORKED EXAMPLE

The mass of a proton is 1.67×10^{-27} kg. The mass of an electron is 9.11×10 orders of magnitude bigger is the mass of the proton compared to the electro

Solution:

Since we are only working with orders of magnitude, we can round both numbers

$1.67 \times 10^{-27} \approx 10^{-27}$ *and* $9.11 \times 10^{-31} \approx 10^{-30}$

Divide the mass of the proton by that of the electron using just the orders of mag

$10^{-27}/10^{-30} = 10^3$ *(1000 or 'three orders of magnitude')*

PRACTICE QUESTIONS

1. Calculate 119.4 ÷ 3.21, giving your answer to the appropriate number of si

2. The mass of a solid was recorded using four different balances.
   The results were: 12.423 g; 12.5 g; 12.46 g and 12.4 g.
   a. Calculate the total of these masses. Give your answer to an appropriate n
   b. What is the arithmetic mean of these masses? Give your answer to two d

3. Five students measure the time taken for a colour change in a chemical reactio table below.

Student	1	2	3	4	
Time taken (s)	97	89	92	99	[illegible]

   What is the arithmetic mean average time for the reaction?

4. A class of 25 students each drops a lump of limestone into some dilute acid an of gas produced over a period of 30 seconds. Their results are shown below.
   Number of bubbles =
   25; 26; 26; 27; 27; 27; 27; 28; 28; 28; 28; 29; 29; 29; 29; 29; 29; 30; 30;
   a. Produce a frequency table from this data including a column of **cumulati** column with **number of bubbles × frequency** in.
   b. Display this data in a frequency diagram.
   c. Use the frequency table to calculate the mode, median and arithmetic me bubbles produced in 30 seconds.

5. Which would be the correct way of displaying the data from question 4: a ba

6. A survey is done of the chemicals in the laboratory stock cupboard to investiga compounds contain the elements sodium, potassium, magnesium, calcium and b the frequency table below.

Element	sodium	potassium	magnesium	calci
No. compounds	12	9	6	8

   a. Display this information in a bar chart.
   b. Why is a bar chart, and not a histogram, the correct way of displaying th

7. The pH of saliva samples from a group of people was measured. The results a
   pH = 6.5; 7.0; 6.9; 6.8; 7.1; 6.6; 7.3; 7.0; 6.9; 7.2; 6.4; 6.3; 6.9; 6.2; 7.0; 7.
   a. Produce a frequency table from this data and use it to calculate the medi pH values.
   b. Display this information in a histogram.

8. One indicator of air quality is the amount of '$PM_{2.5}$' particles in the air. These of no more than 2.5×10^{-6} m. These particles often get into the air as soot fr mainly carbon. A carbon atom has a diameter of approximately 1.5×10^{-10} magnitude bigger is a '$PM_{2.5}$' particle compared to a single carbon atom?

3 ALGEBRA

SPECIFICATION OVERVIEW

Change the subject of an equation
Substitute numerical values into algebraic equations using appropriate units for p

THEORETICAL OVERVIEW

In this section you will learn how to use equations in calculations, including how to re used to calculate different things.

Rearranging equations

Many equations are used in chemistry to work out quantities. For example, you can number of moles of a substance using the equation: mass = number of moles × M_r. calculate mass you need to multiply the number of moles by M_r (the relative formul What if you know the mass and want to calculate the number of moles? To do this equation to make the number of moles the **subject** of the equation (the variable th the '=' sign).

To rearrange an equation, you perform an operation on **both** sides of the equation function involved with a term (a part of the equation) that you want to move (it mus

In simple terms, if a term is being **multiplied** in an equation you can move it by **div** by that term (because dividing is the inverse of multiplying). If a term is being **add** by **subtracting** it from both sides of the equation (because subtracting is the inverse

WORKED EXAMPLE 1

Rearrange the equation mass = number of moles × M_r so that it could be use number of moles from mass and M_r.

Solution:

The equation has mass as its subject, so it needs rearranging to make number of what we want to find).

We need to get the term 'number of moles' on its own. We can move the term ' equation by it like this:

$$\frac{\text{mass}}{M_r} = \frac{\text{number of moles} \times \cancel{M_r}}{\cancel{M_r}}$$

The term 'M_r' on the right side of the equation vanishes since it is divided by itse

$$\frac{\text{mass}}{M_r} = \text{number of moles} \quad \text{or:} \quad \text{number of moles} = \frac{\text{mass}}{M_r}$$

WORKED EXAMPLE 2

Rearrange the equation mass number = number of protons + number of neu be used to calculate number of protons when the mass number and number o

Solution:

The equation has mass number as its subject, so it needs rearranging to make nu (since this is what we want to find).

We need to get the term 'number of protons' on its own. We can move the term ***subtracting*** *it from both sides of the equation by it like this:*

$$\text{mass number} - \text{number of neutrons} = \text{number of protons} + \cancel{\text{number of neut}}$$

The term 'number of neutrons' on the right side of the equation vanishes since it i

$$\text{mass number} - \text{number of neutrons} = \text{number of pro}$$

$$\text{or:} \quad \text{number of protons} = \text{mass number} - \text{number of}$$

Solving equations by substitution

'Solving an equation by substitution' simply means replacing all but one of the vari values, and then working out the value of the remaining variable.

For example, if $y = 2x$ and you are told that $x = 7$, then substituting 7 for x gives y

If the variable that you want to find a value for is not the subject of the equation th equation first, then make the substitutions.

WORKED EXAMPLE 1

A solution is made by dissolving 0.095 moles of substance in 0.50 dm³ of so equation concentration = $\frac{\text{number of moles}}{\text{volume}}$ to work out the concentration of the so

Solution:

Since number of moles = 0.095 and volume = 0.5 dm³, we can substitute these v calculate the concentration: **concentration** = $\frac{0.095}{0.50}$ = *0.19 mol/dm³*

WORKED EXAMPLE 2

Use the equation concentration = $\frac{\text{number of moles}}{\text{volume}}$ to work out how many moles be needed to make 0.25 dm³ of solution with a concentration of 1.5 mol/dm³.

Solution:

First, we need to rearrange the equation to make the number of moles the subjec volume you get: ***number of moles = concentration × volume.***

Then you can substitute in the values: ***number of moles*** *= 1.5 × 0.25 = 0.375 (sinc places in the values of number of moles and volume, we could round the answer t*

Dealing with units in equations

When you work out a value by substituting numbers into an equation, you need to th with the value. These should match the units in the numbers you have used in the eq units after the numbers as you substitute them into an equation.

For example, the density of a substance can be calculated from the formula density

If you are told a substance has a mass of 142 g and a volume of 200 cm³, you wo

$$\text{density} = \frac{142\ \text{g}}{200\ \text{cm}^3} = 0.710\ \text{g/cm}^3$$

WORKED EXAMPLE 1

1.26 g of a solid is dissolved in water and made up to a total volume of 30 c the equation concentration = $\frac{\text{mass}}{\text{volume}}$ to work out the concentration of the soluti

Solution:

concentration = $\frac{1.26\ g}{30\ cm^3}$ = *0.042 g/cm³. The units for the answer must be g/cm³ (a mol/dm³) because the units in the numbers that were substituted into the equati*

When you are substituting numbers into equations, you need to be careful about the for different variables do not match, you will not get the correct answer. Sometime some numbers to make sure that they all match before carrying out the calculation.

Here are a few unit conversions that are common in chemistry:

Quantity	Units	Ho
Mass	1 kg = 1000 g	Divide by 1000 to go f Multiply by 1000 to go
Volume	1 dm^3 = 1000 cm^3	Divide by 1000 to go f Multiply by 1000 to go
Concentration	1 mol/cm^3 = 1000 mol/dm^3 1 g/cm^3 = 1000 g/dm^3	Divide by 1000 to go f Multiply by 1000 to go (do the same for g/cm^3
Energy	1 kJ = 1000 J	Divide by 1000 to go f Multiply by 1000 to go

WORKED EXAMPLE 2

Use the equation number of moles = concentration × volume to work out ho substance would be needed to make 50 cm^3 of solution with a concentration

Solution:

First, we need to do a unit converstion because the concentration is in a differen

50 cm^3 = 50 / 1000 dm^3 = 0.050 dm^3

Then we can make the substitutions: number of moles = 0.25 mol/dm^3 × 0.050 d

PRACTICE QUESTIONS

1. In a chemical reaction, the percentage yield can be calculated using this equat

$$\text{percentage yield} = \frac{\text{actual mass of product}}{\text{theoretical mass of product}} \times 1($$

   a. Rearrange the equation to make actual mass of product the subject.

   b. In a reaction where the theoretical mass of product is **2.5 g** and the perce what would the actual yield be?

2. The relative formula mass of a metal chloride salt (where the metal is from gro table) is calculated by adding together the relative atomic masses of the meta shown by this equation:

$$M_r = A_r(\text{metal}) + A_r(\text{chlorine})$$

   a. Rearrange the equation to make A_r(metal) the subject.

   b. The relative formula mass of the compound, M_r, is **74.5**, and the relative a A_r (chlorine), is **35.5.** Use this information and your answer to part a to ca atomic mass of the group 1 metal. Which metal is it?

3. The number of moles of a gas can be calculated from this equation:

$$\text{moles} = \frac{\text{volume (dm}^3)}{24\ \text{dm}^3/\text{mol}}$$

   A reaction produces 420 cm^3 of gas.

   a. Convert the volume (420 cm^3) into dm^3. (**HINT:** there are 1000 cm^3 in 1 d

   b. How many moles of gas were produced?

4. In a titration, 24.55 cm^3 of a solution with a concentration of 0.150 mol/dm^3 w a burette. How many moles of chemical were dispensed?

$$\text{moles} = \text{concentration (mol/dm}^3) \times \text{volume (dm}^3$$

4 GRAPHS

SPECIFICATION OVERVIEW

Translate information between graphical and numeric form
Plot two variables from experimental or other data
Determine the slope and intercept of a linear graph
Draw and use the slope of a tangent to a curve as a measure of rate of change

THEORETICAL OVERVIEW

In this section you will learn how to create graphs from data by plotting two variab graph). Graphs will be used to see data in a visual form but also to analyse data You will learn to deal with graphs that consist of straight lines as well as those with graph is related to whether the variables plotted on the graph are directly proport By learning to measure features of graphs, such as their gradients, you will be able data that they represent.

Plotting and reading graphs

A graph consists of a set of points that are plotted in specific positions described by axes of the graph. Often the horizontal axis is referred to as the *x*-axis and the ver numbers on the *x*-axis are values of an *independent* variable, i.e. something that has the person collecting the data (or allowed to change naturally, e.g. time progressing values that have been measured in the experiment – these are called the *dependent*

A **line of best fit** (sometimes called a trend line) is a straight line or a curve that pa how the two variables are related. It does not have to touch all (or even any) of th line running between the points and not a 'dot-to-dot' series of lines joining them up

WORKED EXAMPLE 1

The data shown was collected by measuring the rate of a series of reactions, a different concentration of sodium hydroxide. Plot these on a graph with a l

Concentration of sodium hydroxide (mol/dm^3)	Rate of reacti
0.010	0
0.020	0
0.050	0
0.080	0
0.100	0

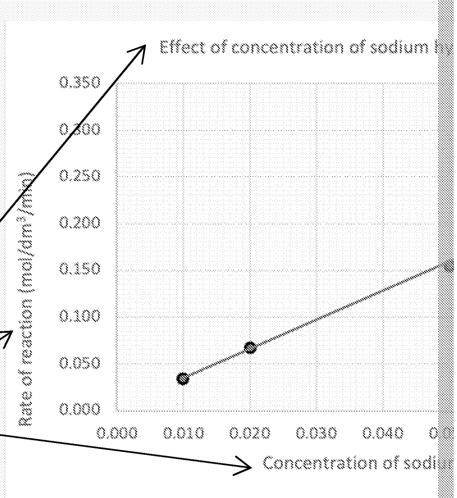
Solution:

The independent variable is the concentration of sodium hydroxide (since this is what has been deliberately changed), so these numbers go on the x-axis with the rate of reaction on the y-axis

Title describes what the graph is showing

Both axes are labelled with the name of the variable ***and*** *the units*

Line of best fit is through the middle of the points (some are above and some below the line)



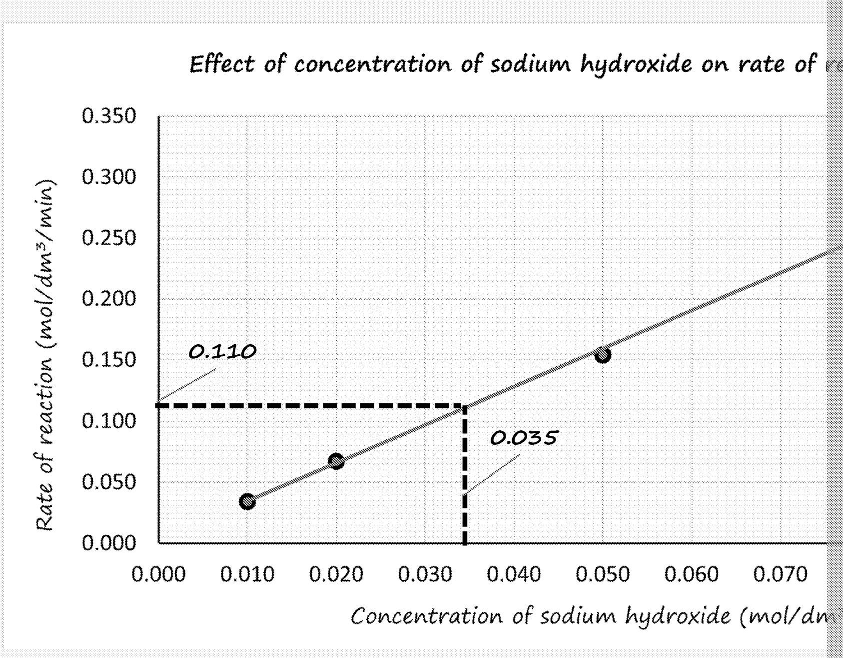
Graphs with a line of best fit can be used to convert the value of one of the variabl
finding the value that you know on the axis and drawing a straight line (horizontally
from the x-axis) until it meets the line of best fit. Then draw another line from this p
the value.

WORKED EXAMPLE 2

Using the graph from WORKED EXAMPLE 1, find out what the rate of reactio concentration of sodium hydroxide was 0.035 mol/dm³.

Solution:

Find 0.035 on the x-axis, draw a vertical line from this to the line of best fit, th the y-axis and read the rate of reaction: 0.110 mol/dm³.



Straight line graphs

The slope (gradient) of a line can be found by dividing the change in *y* by the cha line (longer sections tend to give more accurate measurements). The *y*-intercept is f on the *y*-axis where the line of best fit crosses it (i.e. the value of *y* when *x* = 0).

It is important to understand what the gradient of a line means. It is a measure of h *y*-axis is affected by changes in the variable on the *x*-axis. In the worked example of best fit was steeper (had a larger gradient), it would mean that changing the co hydroxide solution had a bigger effect on the rate of reaction.

When the variable on the *x*-axis is **time**, the gradient of the line of best fit tells you is changing. Steep lines mean a rapid change while lines with a lower gradient ind

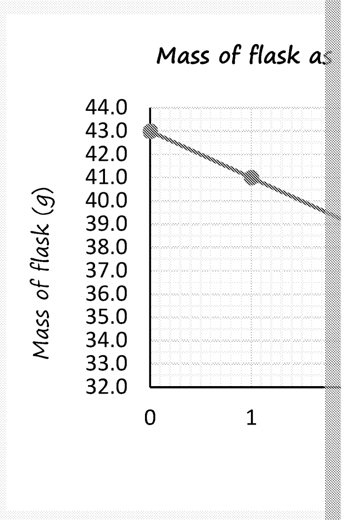
WORKED EXAMPLE

A reaction that releases carbon dioxide gas was set up in an open flask and every minute. Plot the data in the table below and work out the slope and th

Time (min)	0	1	2	3
Mass of flask (g)	43	41	39	37

Solution:

Plot the graph and find the y-intercept: 43.0.
Work out the gradient by dividing the change in y over the whole line
(33.0 g – 43.0 g = -10.0 g – it's a negative number because the mass is ***decreasing****) by the change in x over the whole line*
(5 min – 0 min = 5 min):
Gradient = -10.0 g/5 min = -2 g/min



Non-linear graphs

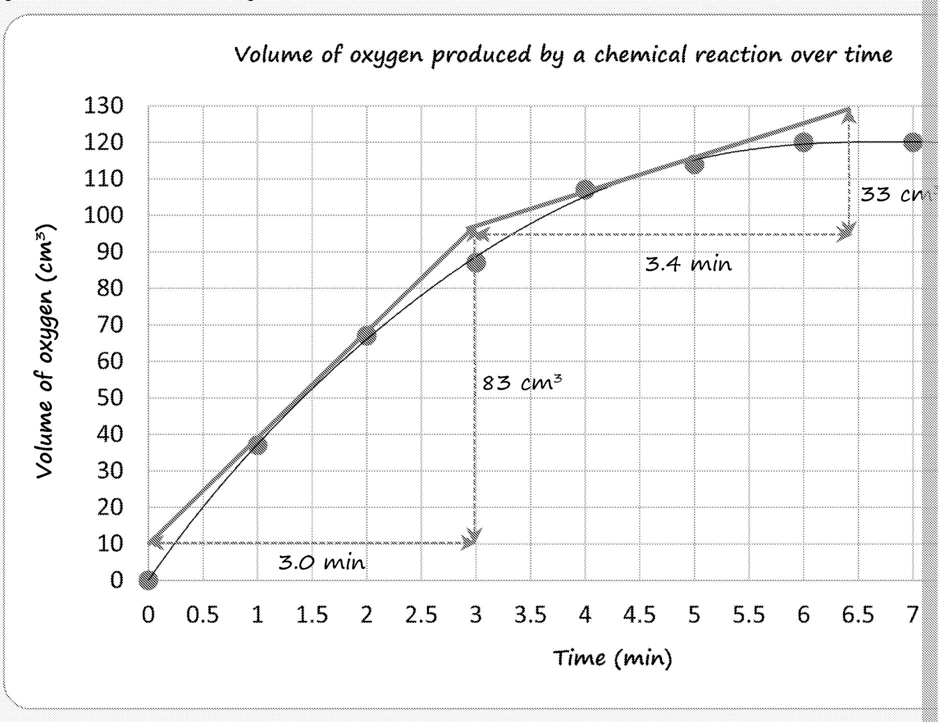
The line of best fit in a graph is not always a straight line. For some data, the trenc a curve. This means that the gradient of the line changes from point to point, and sc same way as you can for a straight line. You can measure the gradient *at one poin* **tangent** to that point. A tangent is a straight line that touches only one point on a c tangent is the gradient of the curve *at that point only*.

WORKED EXAMPLE

A reaction that produces oxygen gas was set, and the volume of gas produc every minute. A graph of this data is shown below. Use the graph to work o reaction (the rate of change of volume of gas) at 1.5 minutes and at 4.5 min

Solution:

Since the line of best fit is a curve, you need to draw tangents to the curve at th gradient of these tangents.



At 1.5 minutes: rate of reaction = gradient = 83 cm³/3.0 min = 28 cm³/min (t

At 4.5 minutes: rate of reaction = gradient = 33 cm³/3.4 min = 9.7 cm³/min

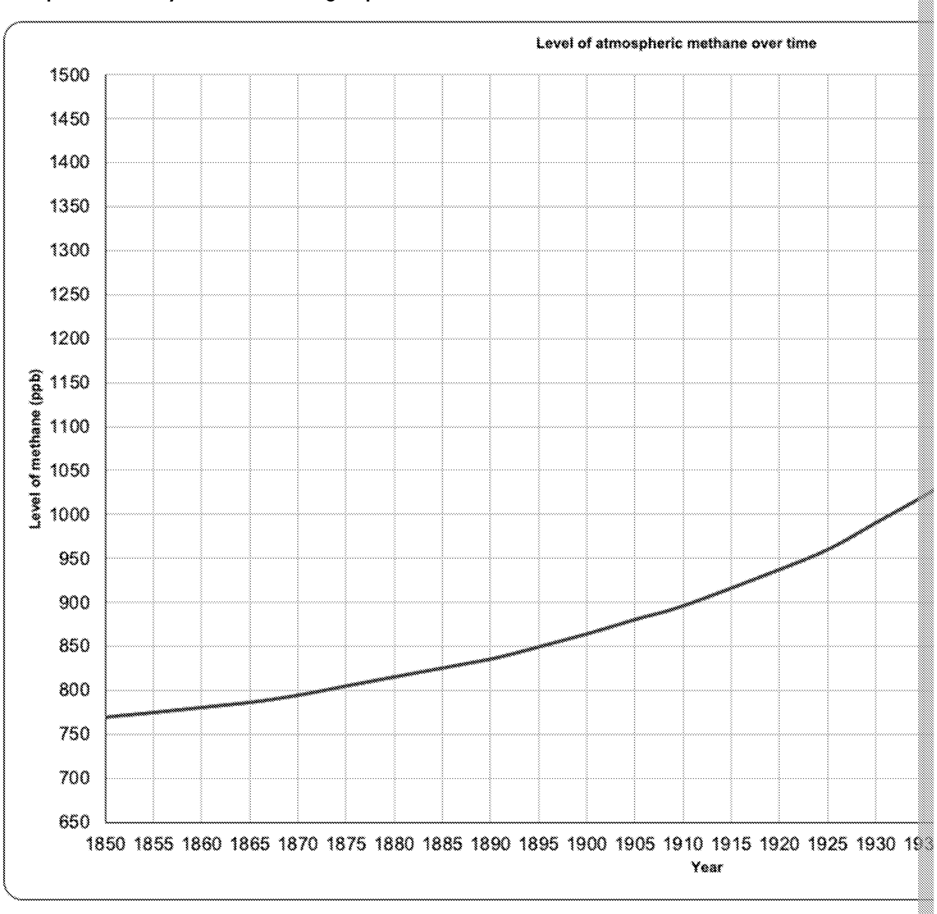
PRACTICE QUESTIONS

1. The rate of a chemical reaction between two gases is measured at different p
The results are shown in the table below.

Pressure (atms)	1.0	1.5	2.0	2.5
Rate of reaction (mol/min)	0.63	0.94	1.25	1.61

Plot the data on a graph and add a trend line. Extend the trend line back to (
read off the intercept on the *y*-axis (the rate of reaction when pressure = 0).

2. The graph below shows how the level of methane in the atmosphere changed b
Describe what happens to the **rate of change** of methane levels over this time
Explain how you used the graph to work this out.



3. By drawing a tangent on the graph above, measure the rate of change of me
Each division on the y-axis represents 40 ppb (parts per billion, the units of co

5 GEOMETRY AND TRIGO

SPECIFICATION OVERVIEW

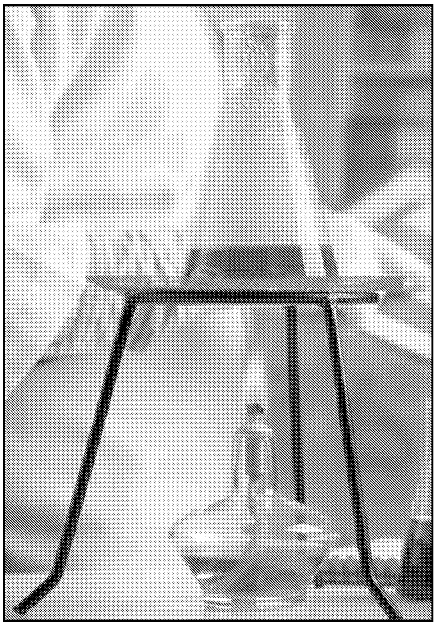
Visualise and represent 2D and 3D forms, including two-dimensional representat
Calculate areas of triangles and rectangles, surface areas and volumes of cubes

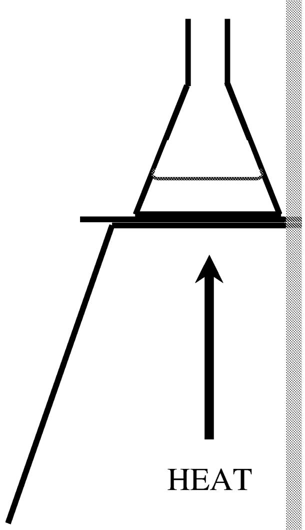
THEORETICAL OVERVIEW

Being able to draw and interpret diagrams that represent objects is an important s
you will explore some ways in which objects (including very tiny objects such as mol
2D and 3D form. You will also learn how to perform some calculations to work out
and 3D shapes such as triangles, rectangles and cubes.

Representing objects in both 2D and 3D

'Real' objects are three-dimensional (3D), but a sheet of paper in a book, or your ow
sketch a representation of a 3D object, but sometimes it is better to draw a 2D versio
representation is less realistic, it can be much clearer and easier to draw and to unde
objects. A good example is the equipment used to heat a solution, shown below. The
diagram is much simpler than the realistic image and it is easier to use this to show ho





WORKED EXAMPLE 1

A 3D image of a molecule of methane (CH_4) is shown.
Sketch out a 2D representation with all of the bond angles at 90°.

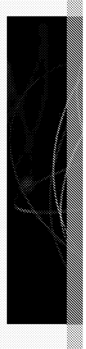
Solution:

Organic molecules are often drawn in 2D with bond angles of 90° for simplicity

WORKED EXAMPLE 2

A 3D image of a carbon atom is shown.

Sketch out a simple 2D version, showing where the electrons are in the shells using concentric circles.

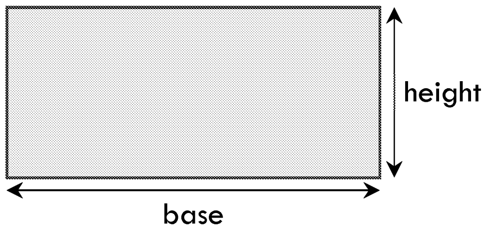


Solution:

There are two electrons orbiting closest to the nucleus and another four orbiting further out. This can be shown as:

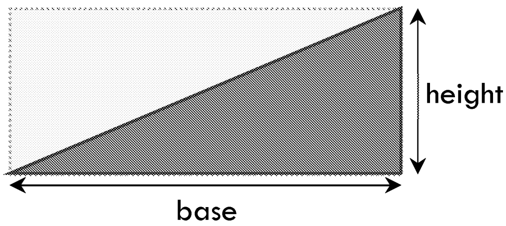
Calculating areas of triangles and rectangles

The area of a rectangle is calculated by multiplying the length of its base by its he



$$\text{area} = \text{base} \times \text{height}$$

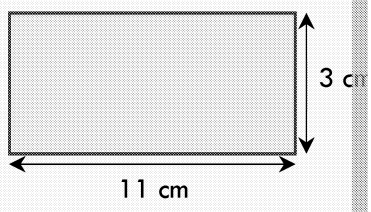
A triangle can be formed by dividing a rectangle in half and so the area of a trian of a rectangle. Note: the height must be measured at 90° to the base of the triang



$$\text{area} = \frac{1}{2} \times \text{base} \times \text{heigh}$$

WORKED EXAMPLE 1

Calculate the area of the rectangle shown.

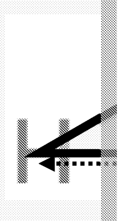


Solution: *area = base × height = 11 cm × 3 cm = 33 cm²*

Note that because you are multiplying cm by cm, the answer is in units of cm².

WORKED EXAMPLE 2

The atoms of a water molecule lie at the corners of a traingle as shown in the diagram. What is the area of this triangle?



Solution:

area = $\frac{1}{2}$ *base × height* = $\frac{1}{2}$ × 160 *pm* × 60 *pm* = 4800 *pm*^{2}

(pm is the unit ***picometre*** *– it is very small but works exactly like a centimetre o area are pm*^{2}*)*

Calculating the surface area and volume of a cube

The volume of a cube is calculated by multiplying the length, height and width of th cube together. A cube has all sides the same length, so volume of cube= l^3, where l is the length of all sides.

To work out the surface area of a cube, think about each of the six faces as a squa with sides of length l. The area is found by squaring l.
Since there are six faces, surface area of cube = $6l^2$.

WORKED EXAMPLE 1

Calculate the volume and surface area of a cube which has sides of length 5

Solution:

volume of cube = l^3 = (5 *mm*)^3 = 5 *mm* × 5 *mm* × 5 *mm* = 125 *mm*^{3}.

Note the units of volume are whichever units of length were used, but ***cubed****.*

surface area of cube = $6l^2$ = 6 × (5 *mm*)^2 = 6 × 5 *mm* × 5 *mm* = 150 *mm*^{2}

Note the units of surface area are whichever units of length were used, but ***squa***

WORKED EXAMPLE 2

The cube in WORKED EXAMPLE 1 is cut in half along every side producing eight smaller cubes, each with sides of 2.5 mm.

What is the total volume and total surface area of these eight cubes?

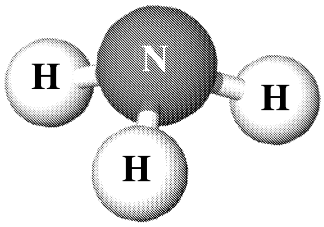
Solution:

The volume of each cube is **(2.5 mm)^3 = 15.625 mm^3**, *so the total volume of a* **15.625 mm^3 × 8 = 125 mm^3**. *This is exactly the same as the volume before th should be since none of the cube is lost and no new material is gained.*

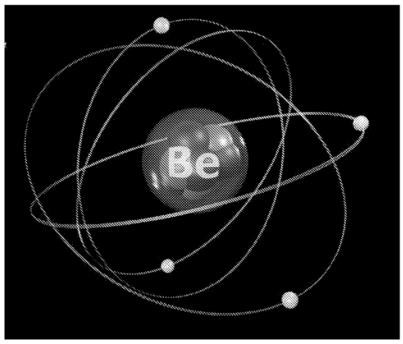
The surface area of each cube is 6 × 2.5 *mm* × 2.5 *mm* = 37.5 *mm*^{2} *so the total su* 37.5 *mm*^{2} × 8 = 300 *mm*^{2}. *This is* ***double*** *the surface area of the single cube – but cutting it, you have exposed new surfaces. It is* ***always*** *true that when a piece of s pieces, the total volume remains the same but the total surface area increases.*

PRACTICE QUESTIONS

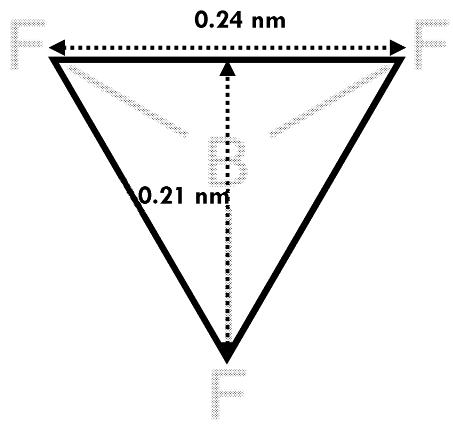
1. Sketch out a 2D representation of a molecule of ammonia (NH_3). The bond a same as each other but do **not** have to be the same as in the 3D model, which



2. A 3D image of a beryllium atom is shown. Sketch out a simple 2D version, sho electrons are in the shells using concentric circles.



3. The F atoms in the molecule BF_3 are at the corners of a triangle (with the B ato shown in the diagram. Calculate the area of this triangle.



4. A microscope slide is a rectangle with length = 75 mm and width = 26 mm. Calc

5. A cube measuring 2 cm on all sides is cut into eight smaller cubes, each measu
   a. What is the total volume of the eight small cubes?
   b. What is the surface are of the original, larger cube?
   c. What is the **total** surface area of all eight smaller cubes?

DIAGNOSTIC TEST

A2 Arithmetic and numerical computation

1. Write the fraction $\frac{1}{6}$ as a decimal to three decimal places.

   ....

2. Write the fraction $\frac{3}{4}$ as a decimal.

   ....

3. Which of the following is the correct way to write the number 0.007849 in sta
   - **A.** 7.849×10^{3} ☐
   - **B.** 7.849×10^{2} ☐
   - **C.** 7.849×10^{-3} ☐
   - **D.** 7.849×10^{-2} ☐

4. 1.8 moles of calcium react with 3.6 moles of water. Express this molar reactin

   ....

5. Two gases are mixed in the ratio 7:2. If the total volume of gases is 45 cm^3, w
   the two gases.

   ....

   ....

6. Convert the decimal 0.125 to the following:
   - a. a percentage ....
   - b. a fraction ....

7. A chemical weighing 0.821 g is heated in air until its mass becomes 1.270 g.
   - a. How much mass has been gained?

     ....

   - b. Express the mass gained as a percentage of the original mass.

     ....

8. A human hair is approximately 7.0×10^{-5} m wide, and a carbon atom is abo
   Estimate, to the nearest one hundred thousand, how many carbon atoms could
   the width of a human hair.

   ....

DIAGNOSTIC TEST

B2 Handling data

1. How many significant figures are in the following numbers?

   a. 0.475 ....

   b. 12.0089 ....

   c. 0.004030 ....

2. Give the answers to these calculations. Make sure that you give the answer to places, rounding if necessary.

   a. 17.925 + 0.1837 ....

   b. 1.608 – 0.24 ....

   c. 0.032 + 0.0073 ....

3. Give the answers to these calculations. Make sure that you give the answer to figures, rounding if necessary.

   a. 9.39 ÷ 3.0 ....

   b. 401 × 0.125 ....

   c. 0.264 × 12.69 ....

4. The temperature of a liquid was measured three times. The results were: 28.9, mean average temperature?

   ....

   ....

5. A class is asked to measure the rate of a reaction by timing how long it takes a Twenty students each measured the time in seconds, and their measurements (p Put this data into a frequency table and from that calculate the arithmetic mea time for the colour change.

   Time (seconds): 66, 66, 67, 67, 67, 67, 68, 68, 68, 68, 69, 69, 69, 69, 69, 69

   ....

   ....

   ....

DIAGNOSTIC TEST

C2 Algebra

1. The concentration of a solution can be calculated using the formula: concentrati

   Use this equation to calculate how many moles of solute would be needed to m a concentration of **2.50 mol/dm³**.

   ....

   ....

   ....

2. Rearrange the equation $4p + 2q = 2x + 6$ to make x the subject.

   ....

3. The number of moles of a substance can be calculated using the formula:

$$\text{number of moles (mol)} = \frac{\text{mass of substance (g)}}{M_r \text{ (g/mol)}}$$

   Calculate the M_r of a substance if 24.0 moles of that substance has a mass of 4

   You will need to pay careful attention to the units.

DIAGNOSTIC TEST

D2 Graphs

1. A wet compound is dried by heating it in a warm oven. The compound is take and weighed. The mass of the compound (plus any remaining water) and the are shown below.

Time (min)	Mass (g)
0	92.4
5	46.2
10	23.8
15	11.2
20	5.6

Plot the data shown in the table below on graph paper and draw a line of be drying by measuring the gradient at these times:

a. 2 minutes ....

....

b. 8 minutes ....

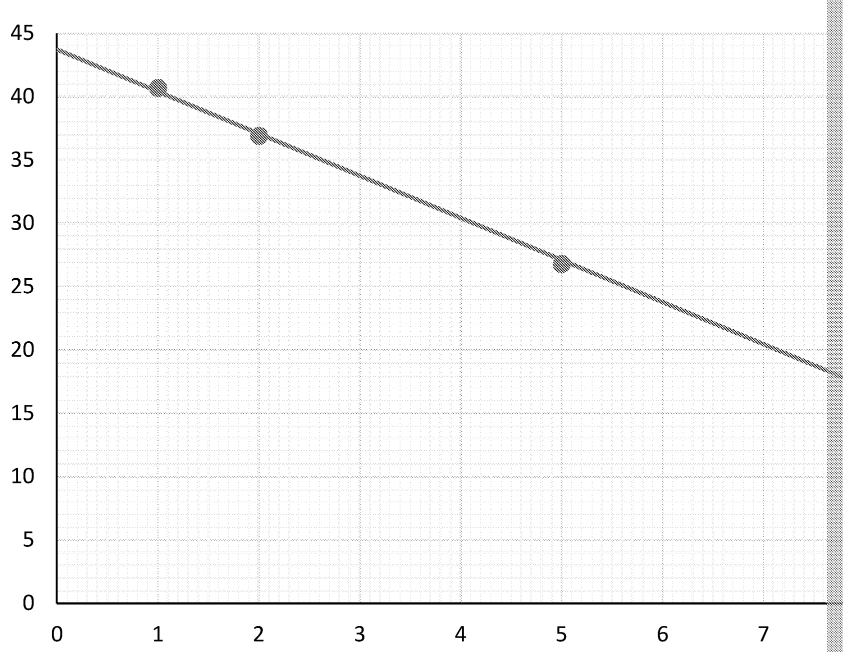
....

c. 16 minutes..

....

2. Use the graph shown to write an equation for the line of best fit in the form y

....

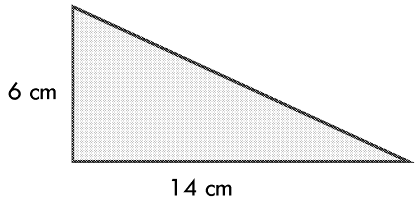


DIAGNOSTIC TEST

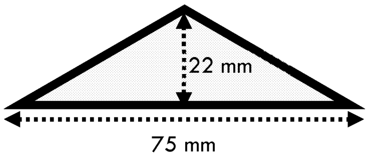
E2 Geometry and trigonometry

1. What is the area of the following shapes?

   a.



   b.



2. a. What is the volume and total surface area of a cube with sides that are 2

      i) volume..

      ii) surface area...

   b. If the cube was cut into eight cubes by cutting each of the three sides in h
      volume and total surface area of the eight cubes?

      i) total volume..

      ii) total surface area ....

SOLUTIONS TO QUES

DIAGNOSTIC TEST 1

A1 Arithmetic and numerical computation

1. 0.375
2. 0.444
3. B. 2.1368×10^4
4. 2:3
5. 3 + 1 = 4
   8 dm^3 / 4 = 2 dm^3
   3×2 dm^3 = **6 dm^3** and 1×2 dm^3 = **2 dm^3**
6. a. 25%
   b. $\frac{1}{4}$
7. a. 1.20 g – 0.84 g = 0.36 g
   b. (0.36 g / 1.20 g) $\times$ 100 = 30%
8. Approximately 2.5 µm / 0.1 µm = 25 times bigger
9. The difference between 3.2 and 6.1 is close to 3, so the concentration of H^+ i
   $10 \times 10 \times 10$ = 1000 times

B1 Handling data

1. a. Six
   b. Four
   c. Five
2. a. 1.821 (three decimal places)
   b. 11.47 (two decimal places)
   c. 0.015 (three decimal places)
3. a. 5.0 (4.966… rounded to two significant figures)
   b. 3.7 (3.675 rounded to two significant figures)
   c. 6.10 (6.09525 rounded to three significant figures)
4. (8.4 + 8.5 + 8.3) / 3 = 8.4
5.

Rate (no. bubbles)	Frequency	Cumulative frequency	Rate × fr
98	3	3	
99	4	7	
100	6	13	
101	7	20	
102	3	23	
103	2	25	
		Total	

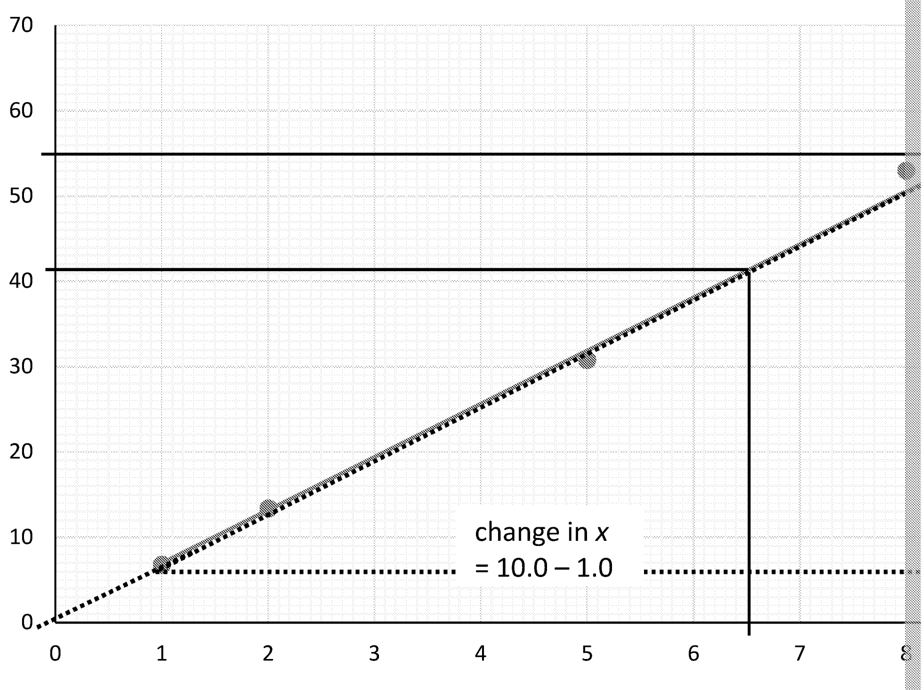
Mean = 2509 / 25 = 100.36 (100.4 would be acceptable)
Mode = 101 (has the highest frequency)
Median = 100 (the (25 + 1) / 2 = 13th value)

C1 Algebra

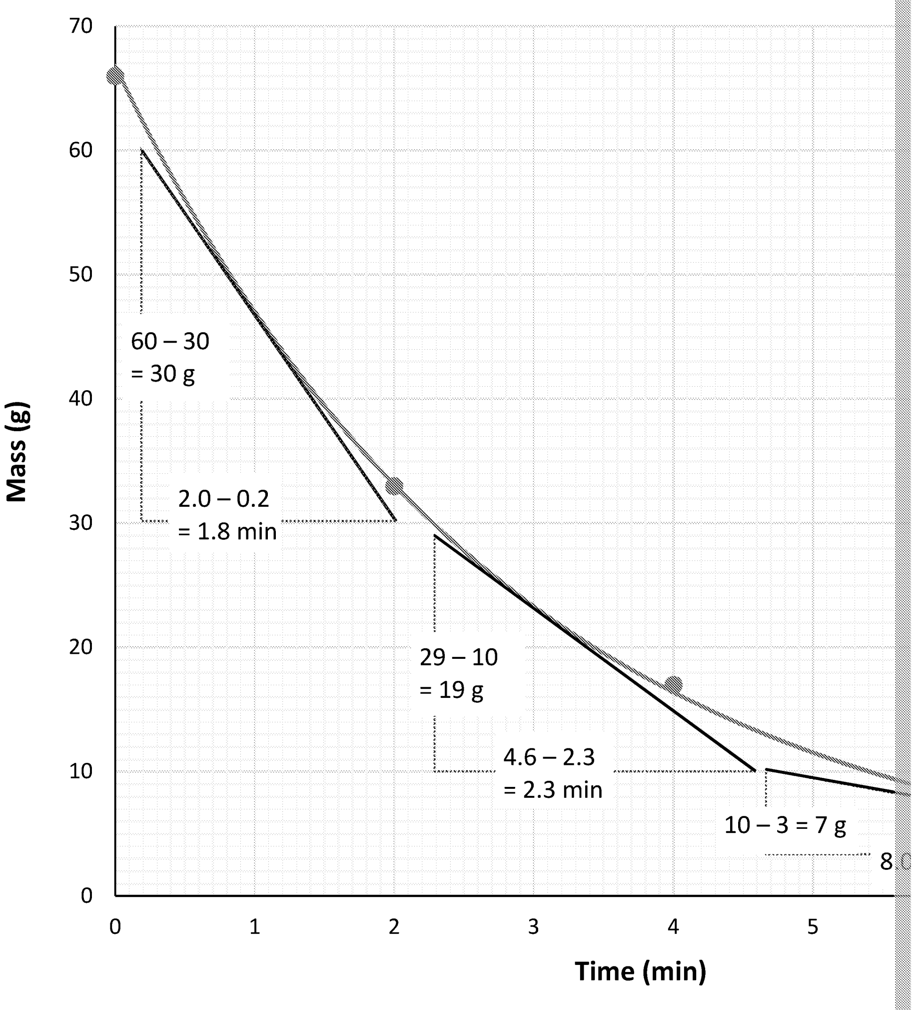
1. Mass of product formed = rate $\times$ time
   Mass of product formed = 0.85 g/s $\times$ 15 s
   = 12.75 g (13 g to two significant figures)
2. $x = \frac{y-7}{4}$
3. 250 cm^3 = 0.250 dm^3
   concentration (mol/dm^3) = $\frac{0.445 \text{ mol}}{0.250 \text{ dm}^3}$ = 1.78 mol/dm^3

D1 Graphs

1. Gradient = 56 / 9.0 = 6.2 (two significant figures) – allow any gradient betwe



2. a. *y* = 41 (allow 41 to 42) b. *x* = 8.7 (allow 8.5 to 8.7) c. *y* = 0.
3. *y* = 6.2*x* + 0.7 (must use the exact values given in question 1 and question 2 p
4. a. gradient (rate) = 30 g/1.8 min = 17 g/min (two significant figures, allow 1
   b. gradient (rate) = 19 g/2.3 min = 8.3 g/min (two significant figures, allow
   c. gradient (rate) = 7.0 g/3.3 min = 2.1 g/min (two significant figures, allow



E1 Geometry and trigonometry

1. a. Volume of cube = $(15\ mm)^3 = 3375\ mm^3$
   b. Surface area of cube = $6 \times 15\ mm \times 15\ mm = 1350\ mm^2$
2. a. $½ \times 6\ cm \times 14\ cm = 42\ cm^2$
   b. $1.5\ m \times 0.4\ m = 0.6\ m^2$
   c. $½ \times 75\ mm \times 22\ m = 825\ mm^2$

PRACTICE QUESTIONS

Arithmetic and numerical computation

1. $0.4 = \frac{4}{10} = \frac{2}{5}$ (1)
2. a. Moles of oxygen = 0.40 – 0.15 = 0.25; ratio hydrogen:oxygen = 0.15:0.25
   b. $\frac{0.15}{0.40} = \frac{3}{8}$ (1)
   c. $\frac{3}{8} = 0.375 = 0.38$ (two decimal places) (1)
3. a. 6.423×10^{-3} (1)
   b. 9.70854×10^{5} (1)
   c. 5.82×10^{-5} (1)
4. $6.022 \times 10^{23} \times 1.275 \times 10^{-5} = 7.67805 \times 10^{18}$ (7.678×10^{18} is an acceptable an
5. This is approximately $40\ g/2\ dm^3 = 20\ g/dm^3$ (1)
6. $\frac{2.9\ g}{3.6\ g} \times 100 = 80.55\% = 81\%$ (to two significant figures) (1)
7. a. C:H = 0.15:0.35 = 3:7 (1)
   b. $\frac{0.15\ moles}{(0.15 + 0.35)\ moles} = \frac{0.15\ moles}{0.50\ moles} = \frac{3}{10}$ (1)
   c. $\frac{3}{10} \times 100 = 30\%$ (1)
8. To decrease the pH by about one unit, you need approximately ten times as of solution. Since just over 5 g in 1 dm^3 makes a solution with pH = 3, about 1 dm^3 solution with a pH of 2. (1)
9. This is easiest to do using fractions. Since the percentage is very nearly 20%, of the volume of air is oxygen. $\frac{1}{5}$ of 250 cm^3 = **50 cm^3**. (1)
10. a. $NO_2:N_2O_4 = 0.84:0.28 = 3:1$ (1)
    b. You could work it out without the ratio like this: $\frac{0.28}{(0.84 + 0.28)} = \frac{0.28}{1.12} = \frac{1}{4}$ but it ratio: 3 + 1 = 4 so $\frac{1}{4}$ of the total number of moles is N_2O_4 (1)
    c. $\frac{1}{4} = 0.25$ (1)

Handling data

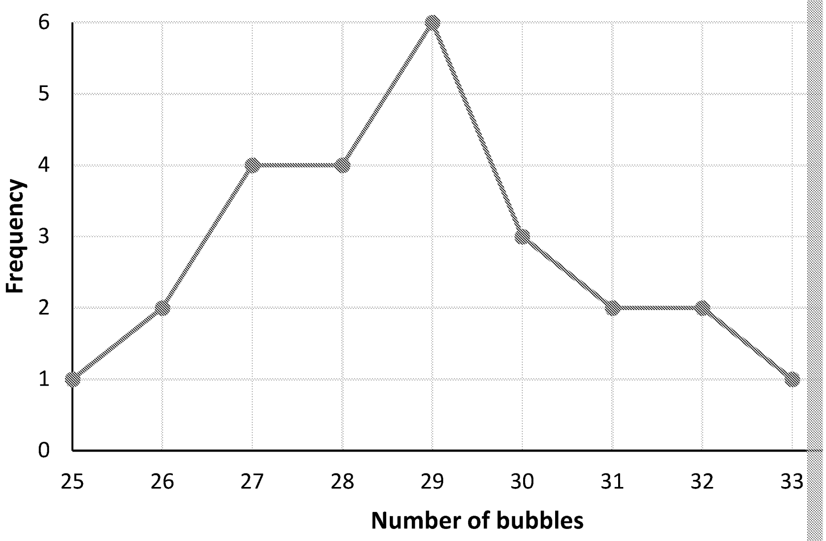
1. **37.2** (37.196… rounded to three significant figures) (1)
2. a. 12.423 + 12.5 + 12.46 + 12.4 = **49.8 g** (49.783 rounded to one decimal pl
   b. $\frac{49.783}{4} = 12.44575$ = **12.45** to two decimal places (1)
3. $\frac{(97 + 89 + 92 + 99 + 95)}{5} = 94.4$ seconds (1)

4. a.

Number of bubbles	Frequency	Cumulative frequency
25	1	1
26	2	3
27	4	7
28	4	11
29	6	17
30	3	20
31	2	22
32	2	24
33	1	25
		Total

(3 – 1 fo

b.



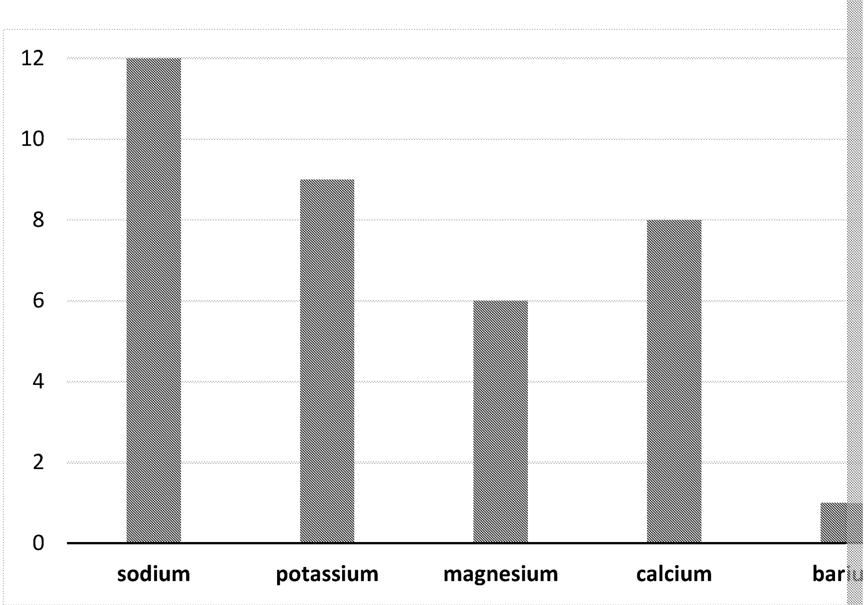
c. Mode = 29 (highest frequency) (1)

Median = 29 (the $\frac{(25+1)}{2}$ =13th number) (1)

Arithmetic mean = $\frac{720}{25}$ = 28.8 (1)

5. Bar chart (the data is discrete, not continuous, since you cannot have a fracti

6. a.



b. Because the data is **categorical** (names of elements) not continuous nu

7. a.

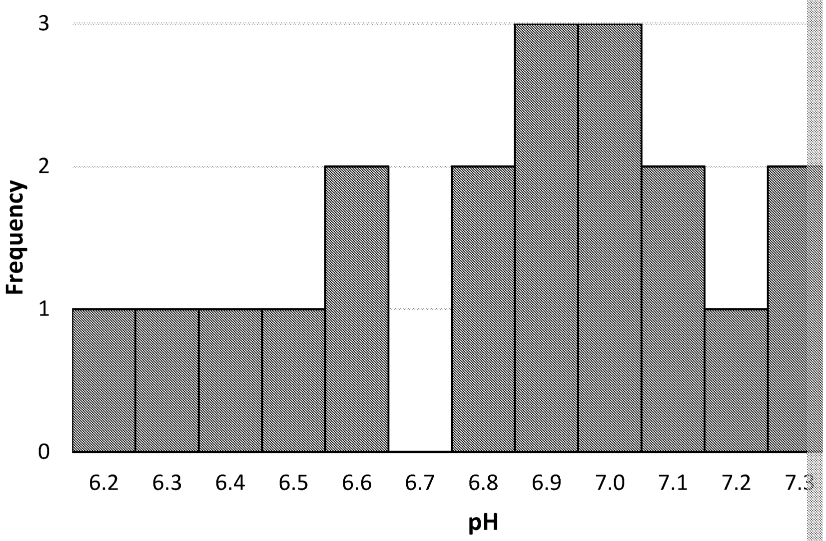
pH	Frequency	Cumulative frequency	pH	Frequency
6.2	1	1	6.9	3
6.3	1	2	7.0	3
6.4	1	3	7.1	2
6.5	1	4	7.2	1
6.6	2	6	7.3	2
6.7	0	6	7.4	1
6.8	2	8		

(2 – 1 for each of frequency

Median = **6.9** (since there is an even number of pH values, the median is both of which are 6.9) (1)

There are two modes: **6.9 and 7.0** (1)

b.



8. $\frac{10^{-6}}{10^{-10}} = 10^4$ (10 000) (1)

Algebra

1. a. actual mass of product = $\frac{\text{percentage yield} \times \text{theoretical mass of product}}{100}$ (1)

   b. actual mass of product= $\frac{59 \times 2.5\text{ g}}{100}$ = 1.475 g (1.5 g to two significant figures

2. a. A_r(metal) = M_r – A_r(chlorine) (1)

   b. A_r(metal) = 74.5 – 35.5 = 39 (1) The metal is **potassium** (1)

3. a. 420 cm^3 = 0.420 dm^3 (1)

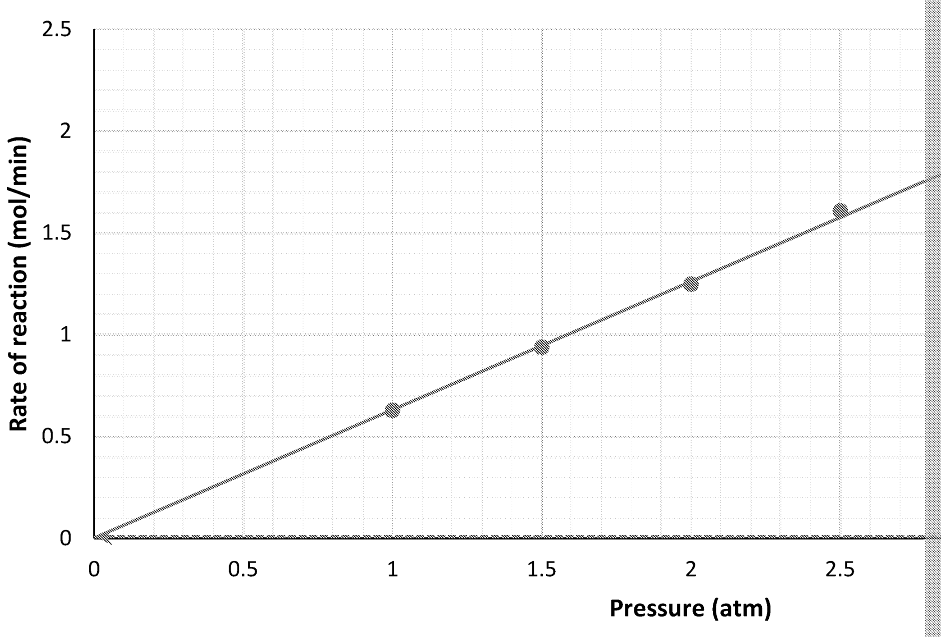
   b. moles = $\frac{0.420}{24}$ = 0.0175 (1)

4. 24.55 cm^3 = 0.02455 dm^3 (1)

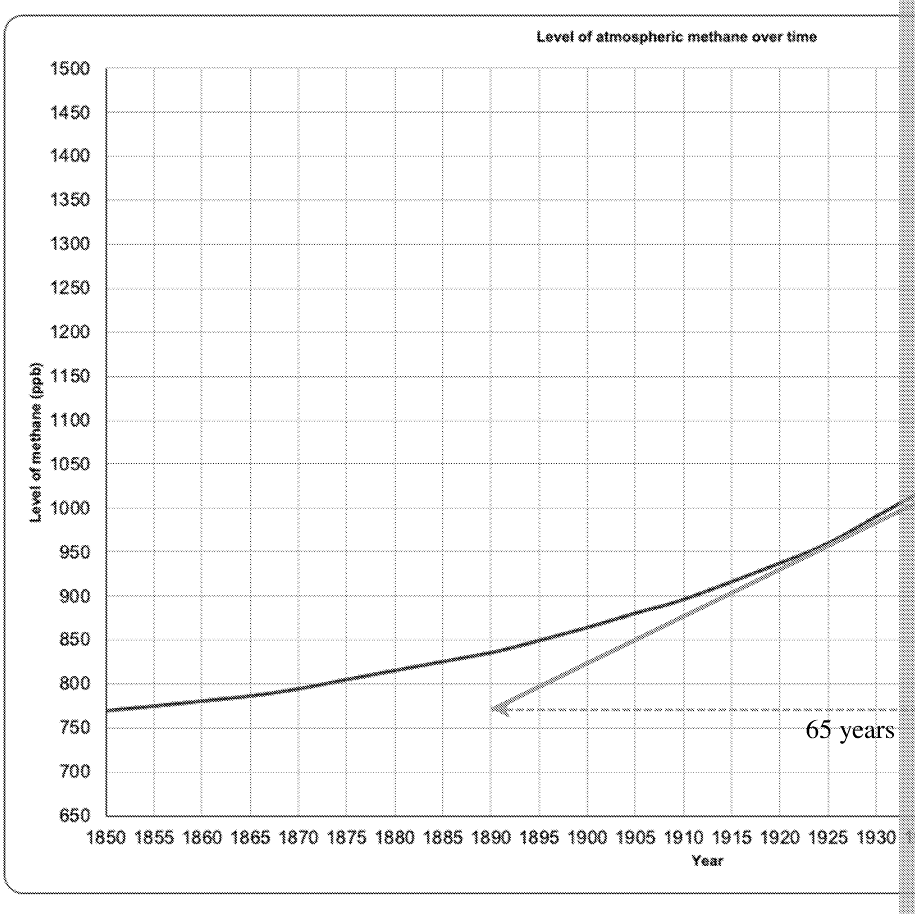
   moles = 0.150 × 0.02455 = 0.0036825 = 3.68×10^{-3} (three significant figures)

Graphs

1. Correct plotting (1), trend line drawn correctly (1) Intercept at y-axis = 0



2. The rate of change of methane increases over the years. (1) This is shown on gets steeper over time. (1)
3. 1 mark for drawing the tangent as a straight line that only touches the curve
   1 mark for calculating the rate of increase in methane in 1925 to be between 4.0
   The rate of increase of methane = 350 ppb/65 years = 5.38 ppb/year (5.4 to t

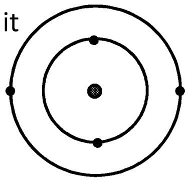


Geometry and trigonometry

1. (1) for a 2D model with three H atoms attached to a central N atom
   (1) for the H–N–H bond angles being approximately 120° (by eye)

H

2. (1) for each concentric circle with two dots (electrons) on it



3. area = $\frac{1}{2}$ × 0.24 nm × 0.21 nm = 0.0252 nm^2 (1) (allow rounding to two signifi
4. area = 75 mm × 26 mm = 1950 mm^2 (1) (allow rounding to two significant fig
5. a. You can calculate the volume of the original, larger cube since the volu
   cube is divided into smaller cubes. volume of cube = $(2\ cm)^3$ = 8 cm^3 (1)
   (It could also be done as total volume = 8 × $(1\ cm)^3$= 8 cm^3)
   b. surface area of cube = 6 × 2 cm × 2 cm = 24 cm^2 (1)
   c. surface area of eight cubes = 8 × 6 × 1 cm × 1 cm = 48 cm^2

DIAGNOSTIC TEST 2

A2 Arithmetic and numerical computation

1. 0.167
2. 0.75
3. C. 7.849×10^{-3}
4. 1:2
5. 35 cm^3 and 10 cm^3
6. a. 12.5%
   b. $\frac{1}{8}$
7. a. 0.449 g
   b. 54.7% (to three significant figures)
8. 200 000

B2 Handling data

1. a. Three
   b. Six
   c. Four
2. a. 18.109
   b. 1.37
   c. 0.039
3. a. 3.1
   b. 50.1
   c. 3.35
4. 28.93 (to four significant figures)
5.

Time (s)	Frequency	Cumulative frequency	
66	2	2	
67	4	6	
68	4	10	
69	6	16	
70	3	19	
71	1	20	
		Total	

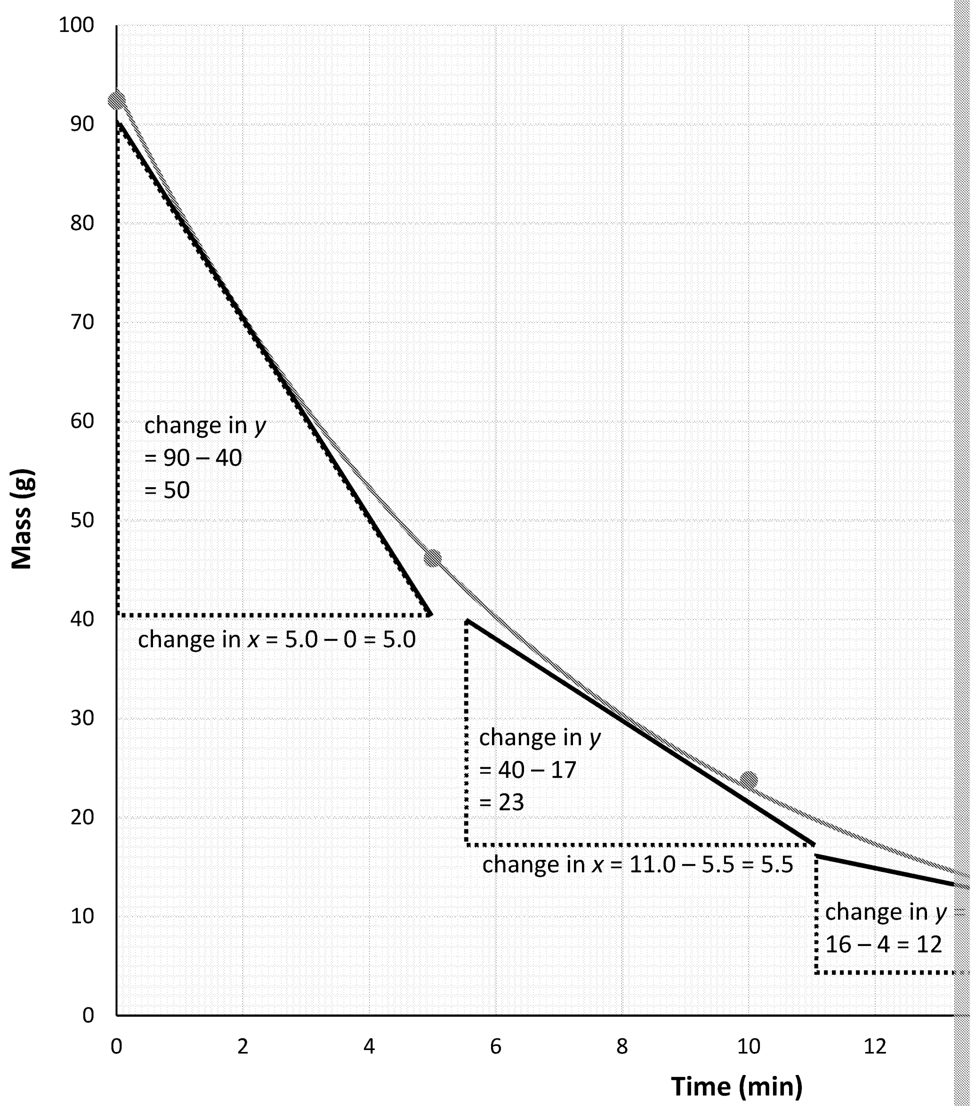
Mean = 1367 / 20 = 68.35
Mode = 69
Median (between 10^{th} and 11^{th} number in order) = (68 + 69) / 2 = 68.5

C2 Algebra

1. 1.25 moles
2. $x = 2p + q - 3$
3. 180 g/mol (or 0.180 kg/mol)

D2 Graphs

1.

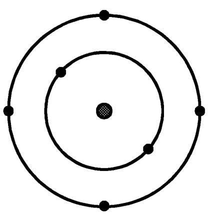


a. 50 g / 5.0 s = 10 g/s
b. 23 g / 5.5 s = 4.2 g/s
c. 12 g / 9.0 s = 1.3 g/s

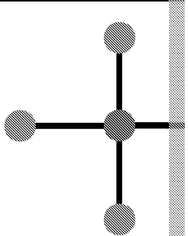
2. $y = -3.3x + 44$

E2 Geometry and trigonometry

1. a.



b.



2. a. $0.5 \times 14\text{ cm} \times 6\text{ cm} = 42\text{ cm}^2$
   b. $0.5 \times 75\text{ mm} \times 22\text{ mm} = 825\text{ mm}^2$
3. a. i) volume = $2.40\text{ cm} \times 2.40\text{ cm} \times 2.40\text{ cm} = 13.8\text{ cm}^3$ (13.824 to three s
   ii) surface area = $6 \times 2.40\text{ cm} \times 2.40\text{ cm} = 34.6\text{ cm}^2$ (three significant fi
   b. i) volume = 13.8 cm^3 (unchanged)
   ii) surface area = $8 \times 6 \times 1.20\text{ cm} \times 1.20\text{ cm} = 69.1\text{ cm}^2$ (two significant