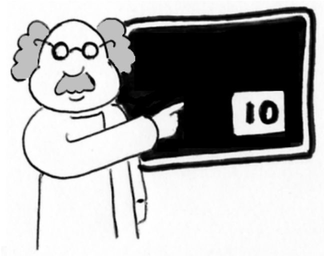


STARTER FOR 10...

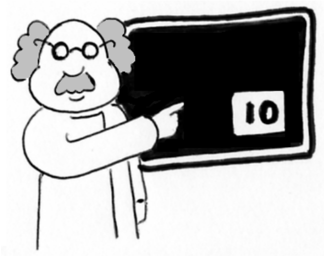
0. TRANSITION SKILLS

A selection of resources to support the transition to A-level and equivalent with the skills required at that level, using simple quizzing and lesson starters which teachers can easily incorporate into lesson plans

Kristy Turner and Catherine Smith

RSC School Teacher Fellows 2011–12

ROYAL SOCIETY OF CHEMISTRY



STARTER FOR 10...

0. TRANSITION SKILLS

Biographies

Kristy trained as a teacher following a PhD in synthetic chemistry at the University of Glasgow and has been teaching chemistry in state and independent schools in Greater Manchester since 2006. Since 2015 she has combined teaching in school with teaching in higher education, teaching foundation and undergraduate chemistry students at the University of Manchester and carrying out chemistry education research.

Catherine graduated from the University of Sheffield in 1998 with an MChem degree before moving to the University of Cambridge to undertake PhD studies in organic synthesis. Following postdoctoral work as a Junior Research Fellow at Girton College, Cambridge, Catherine moved into secondary teaching through the Graduate Teacher Programme. She has been teaching at Hinckley Academy and John Cleveland Sixth Form Centre, Leicestershire, since 2006, where she now holds the position of Lead Practitioner for Teaching and Learning. In 2011–12 Catherine had a year's sabbatical from school to take up a position as an RSC School Teacher Fellow based at the University of Leicester looking at the transition from school to university.

STARTER FOR 10...

0. TRANSITION SKILLS

Contents

ROYAL SOCIETY OF CHEMISTRY

STARTER FOR 10...

0.1.1. Balancing equations

Balance the equations below.

1. $.....C + ...O_2 \longrightarrow .....CO$

2. $.....Ba + ...H_2O \longrightarrow .....Ba(OH)_2 + ...H_2$

3. $.....C_2H_6 + ...O_2 \longrightarrow .....CO_2 + ...H_2O$

4. $.....HCl + ...Mg(OH)_2 \longrightarrow .....MgCl_2 + H_2O$

5. $.....N_2 + ...O_2 \longrightarrow .....NO$

6. $.....Fe_2O_3 + ...C \longrightarrow .....Fe + ...CO_2$

7. $.....CH_3CH_2OH + ...[O] \longrightarrow .....CH_3COOH + ...H_2O$

8. $.....HNO_3 + ...CuO \longrightarrow .....Cu(NO_3)_2 + H_2O$

9. $.....Al^{3+} + ...e^{-} \longrightarrow .....Al$

10. $.....[Fe(H_2O)_6]^{3+} + ...CO_3^{2-} \longrightarrow .....Fe(OH)_3(H_2O)_3 + ...CO_2 + ...H_2O$

(10 marks)

STARTER FOR 10...

0.1.2. Constructing ionic formulae

1. For each of the following ionic salts, determine the cation and anion present and use these to construct the formula of the salt. (5 marks)

a. Magnesium oxide

b. Sodium sulfate

c. Calcium hydroxide

d. Aluminium oxide

e. Copper(I) oxide

2. When an acid is added to water it dissociates to form H^+ ions (which make it acidic) and an anion. These acidic hydrogen atoms can be used to determine the charge on the anion. Deduce the charge on the anions in the following acids. The acidic H atoms, H^+, have been underlined for you. (5 marks)

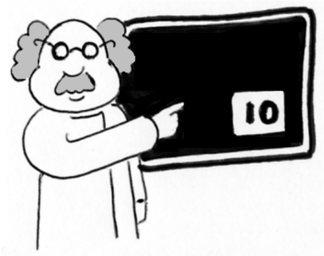
a. $\underline{H}_2SO_3$

b. $\underline{H}NO_3$

c. $\underline{H}_3PO_4$

d. $HCOO\underline{H}$

e. $\underline{H}_2CO_3$



STARTER FOR 10...

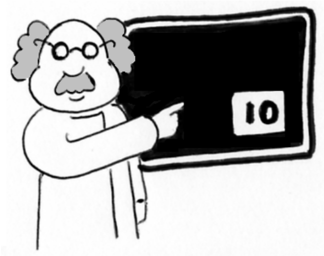
0.1.3. Writing equations from text

The following questions contain a written description of a reaction. In some cases the products may be missing as you will be expected to predict the product using your prior knowledge.

For more advanced equations you may be given some of the formulae you need.

For each one, write a balanced symbol equation for the process. (10 marks)

1. The reaction between silicon and nitrogen to form silicon nitride Si_3N_4.
2. The neutralisation of sulfuric acid with sodium hydroxide.
3. The preparation of boron trichloride from its elements.
4. The reaction of nitrogen and oxygen to form nitrogen monoxide.
5. The combustion of ethanol (C_2H_5OH) to form carbon dioxide and water only.
6. The formation of silicon tetrachloride ($SiCl_4$) from SiO_2 using chlorine gas and carbon.
7. The extraction of iron from iron(III) oxide (Fe_2O_3) using carbon monoxide.
8. The complete combustion of methane.
9. The formation of one molecule of ClF_3 from chlorine and fluorine molecules.
10. The reaction of nitrogen dioxide with water and oxygen to form nitric acid.



STARTER FOR 10...

0.2.1. Rearranging equations

1. The amount of substance in moles (n) in a solution can be calculated when the concentration given in mol/dm^3 (c) and volume (v) in cm^3 are known by using the equation:

$$n = \frac{cv}{1000}$$

a. Rearrange this equation making c the subject of the equation. (1 mark)

b. Rearrange this equation making v the subject of the equation. (1 mark)

2. The density of a substance can be calculated from its mass (m) and volume (v) using the equation:

$$d = \frac{m}{v}$$

a. Rearrange this equation so that the mass of a substance can be calculated given its density and volume. (1 mark)

Chemists most commonly work with masses expressed in grams and volumes in cm^3. However, the SI unit for density is kg/m^3.

b. Write an expression for the calculation of density in the SI unit of kg/m^3 when the mass (m) of the substance is given in g and the volume (v) of the substance is given in cm^3. (2 marks)

3. The de Broglie relationship relates the wavelength of a moving particle (λ) with its momentum (p) through Planck's constant (h):

$$\lambda = \frac{h}{p}$$

a. Rearrange this equation to make momentum (p) the subject of the formula. (1 mark)

Momentum can be calculated from mass and velocity using the following equation.

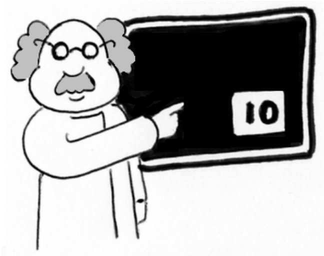
$$p = mv$$

b. Using this equation and the de Broglie relationship, deduce the equation for the velocity of the particle. (2 marks)

4. The kinetic energy (KE) of a particle in a time of flight mass spectrometer can be calculated using the following equation.

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

Rearrange this equation to make v the subject of the equation. (2 marks)



STARTER FOR 10...

0.2.2. BODMAS (order of operations)

The order of operations for a calculation is very important. If operations are carried out in the wrong order then this could lead to the wrong answer. Most modern calculators will anticipate BODMAS issues when operations are entered but human beings can override the calculator's instincts.

1. Do the following calculations in your head.

(a) 3 + 5 × 5 =

(b) 6 × 6 + 4 =

(c) 20 – 6 × 2 =

(d) 48 – 12 ÷ 4 =

(e) 4 + 4 ÷ 2 =

(f) 100 – (20 × 3) =

(6 marks)

2. The molecular formula of glucose is $C_6H_{12}O_6$. Three students entered the following into their calculators to calculate the relative formula mass of glucose. Repeat their calculations as shown.

(a) [12] [×] [6] [+] [1] [×] [12] [+] [16] [×] [6] [=]

(b) [12] [×] [6] [=] [+] [1] [=] [×] [12] [=] [+] [16] [=] [×] [6] [=]

(c) [(] [12] [×] [6] [)] [+] [(] [12] [×] [1] [)] [+] [(] [16] [×] [6] [)] [=]

(d) Write a sentence summing up why the answers differ.

(4 marks)

STARTER FOR 10...

0.2.3. Quantity calculus (unit determination)

1. Determine the units of density given that

$$density = \frac{mass(g)}{volume\ (cm^3)}$$

(1 mark)

2. Determine the units of concentration given that

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

(1 mark)

3. Pharmacists often calculate the concentration of substances for dosages. In this case the volumes are smaller, measured in cm^3, and the amount is given as a mass in grams. Determine the units of concentration when

$$concentration = \frac{mass\ (g)}{volume\ (cm^3)}$$

(1 mark)

4. Rate of reaction is defined as the *'change in concentration per unit time'*. Determine the units for rate when concentration is measured in mol dm^{-3} and time in seconds.

(1 mark)

5. Pressure is commonly quoted in pascals (Pa) and can be calculated using the formula below. The SI unit of force is newtons (N) and area is m^2.

$$pressure = \frac{force}{area}$$

Use this formula to determine the SI unit of pressure that is equivalent to the Pascal.

(1 mark)

6. Determine the units for each of the following constants (K) by substituting the units for each part of the formula into the expression and cancelling when appropriate. For this exercise you will need the following units [ ] = mol dm^{-3}, rate = mol dm^{-3} s^{-1}, p = kPa.

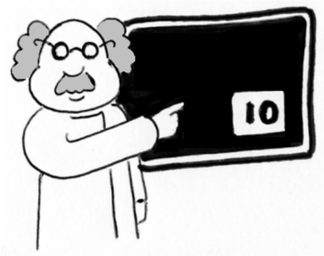
a. $K_c = \frac{[A][B]^2}{[C]}$

b. $K = \frac{rate}{[A][B]}$

c. $K_p \frac{(pA)^{0.5}}{(pB)}$

d. $K_w = [H^+][OH^-]$

e. $K_a = \frac{[H^+]\,[X^-]}{[HX]}$



STARTER FOR 10...

0.2.4. Expressing large and small numbers

Standard form and scientific form

Large and small numbers are often expressed using powers of ten to show their magnitude. This saves us from writing lots of zeros, expresses the numbers more concisely and helps us to compare them.

In standard form a number is expressed as;

$$\boldsymbol{a \times 10^{n}}$$

where ***a*** is a number between 1 and 10 and ***n*** is an integer.

Eg, 160 000 would be expressed as 1.6×10^{5}

Sometimes scientists want to express numbers using the same power of ten. This is especially useful when putting results onto a graph axis. This isn't true standard form as the number could be smaller than 1 or larger than 10. This is more correctly called **scientific form**.

Eg, 0.9×10^{-2}, 2.6×10^{-2}, 25.1×10^{-2} and 101.6×10^{-2} are all in the same scientific form.

1. Express the following numbers using standard form.

a. 1 060 000
b. 0.001 06
c. 222.2

(3 marks)

2. The following numbers were obtained in rate experiments and the students would like to express them all on the same graph axes. Adjust the numbers to a suitable scientific form.

0.1000	0.0943	0.03984	0.00163

(3 marks)

3. Calculate the following without using a calculator. Express all values in standard form.

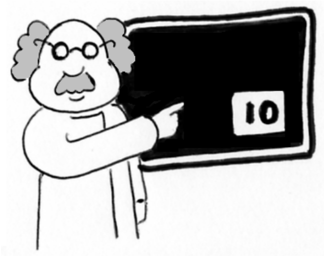
a. $\frac{10^{9}}{10^{5}}$

b. $\frac{10^{7}}{10^{-7}}$

c. $\frac{1.2 \times 10^{6}}{2.4 \times 10^{17}}$

d. $(2.0 \times 10^{7}) \times (1.2 \times 10^{-5})$

(4 marks)



STARTER FOR 10...

0.2.5. Significant figures, decimal places and rounding

For each of the numbers in questions 1–6, state the number of significant figures and the number of decimal places.

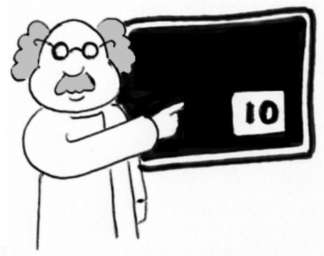
		Significant figures	Decimal places
1	3.131 88		
2	1000		
3	0.000 65		
4	1006		
5	560.0		
6	0.000 480		

(6 marks)

7. Round the following numbers to (i) 3 significant figures and (ii) 2 decimal places.

a. 0.075 84
b. 231.456

(4 marks)



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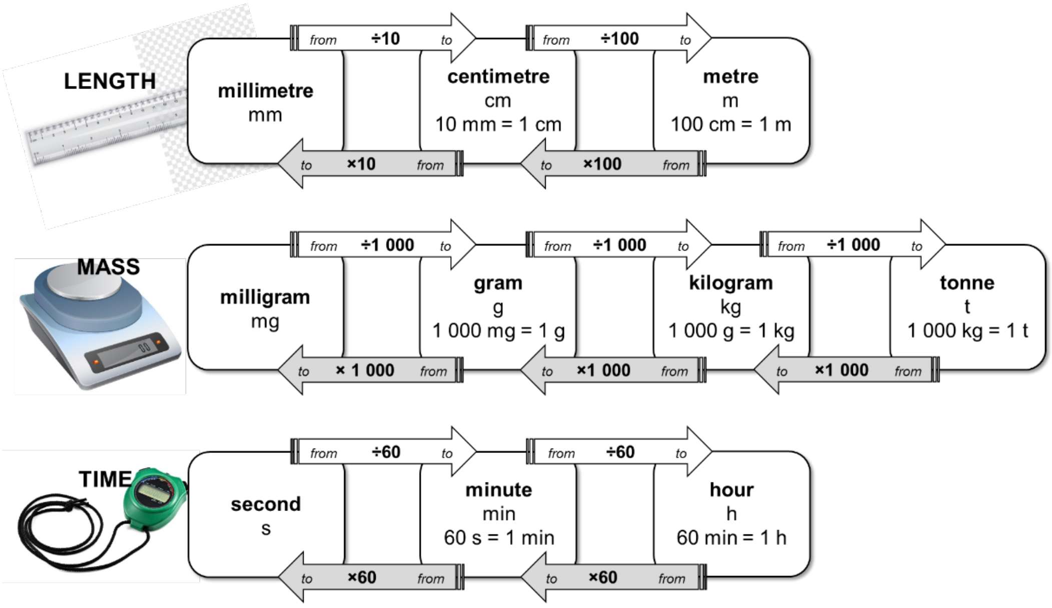
0.2.6. Unit conversions 1 – Length, mass and time

Mo's teacher has drawn a diagram on the board to help him with converting quantities from one unit into another.



For example, to convert a length in millimetres into units of centimetres, divide by 10, eg 10 mm = 1 cm.

Use the diagram to help with the following unit conversions. (10 marks)

1. A block of iron has a length of 1.2 cm. Calculate its length in millimetres.
2. The width of the classroom is 7200 cm. Calculate its length in metres.
3. A reaction reaches completion after 4½ minutes. Convert this time into seconds.
4. The stop clock reads 2 min 34 s. Convert this time into seconds.
5. A method states that a reaction needs to be heated under reflux for 145 min. Calculate this time in hours and minutes.
6. A factory produces 15 500 kg of ammonia a day. Calculate the mass of ammonia in tonnes.
7. A paper reports that 0.0265 kg of copper oxide was added to an excess of sulfuric acid. Convert this mass of copper oxide into grams.
8. A packet of aspirin tablets states that each tablet contains 75 mg of aspirin. Calculate the minimum number of tablets that contain a total of 1 g of aspirin.
9. A student measures a reaction rate to be 0.5 g/s. Convert the rate into units of g/min.
10. A factory reports that it produces fertiliser at a rate of 10.44 kg/h. Calculate the rate in units of g/s.

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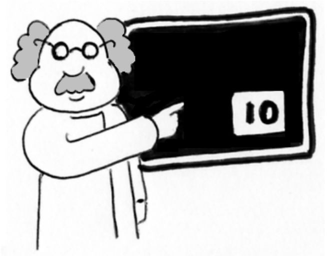

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0.2.7. Unit conversions 2 – Volume

The SI unit for volume is **metre cubed, m^3**. However as volumes in chemistry are often smaller than 1 m^3, fractions of this unit are used as an alternative.

centimetre cubed, cm^3	**decimetre cubed, dm^3**
centi- *prefix* one hundredth	**deci-** *prefix* one tenth
1 cm = $\frac{1}{100}$ m so,	1 dm = $\frac{1}{10}$ m so,
1 cm^3 = $\left(\frac{1}{100}\right)^3$ m^3 = $\left(\frac{1}{1\,000\,000}\right)$ m^3	1 dm^3 = $\left(\frac{1}{10}\right)^3$ m^3 = $\left(\frac{1}{1\,000}\right)$ m^3

1. Complete the table by choosing the approximate volume from the options in bold for each of the everyday items (images not drawn to scale). (1 mark)

1 cm^3 **1 dm^3** **1 m^3**

			
	drinks bottle	sugar cube	washing machine
Approx. volume			

2. Complete the following sentences; (1 mark)

To convert a volume in **cm^3** into a volume in **dm^3**, divide by.............................

To convert a volume in **cm^3** into a volume in **m^3**, divide by...............................

3. a. A balloon of helium has a volume of 1600 cm^3. What is its volume in units of dm^3?

b. The technician has prepared 550 cm^3 of HCl(aq). What is its volume in units of m^3?

c. An experimental method requires 1.35 dm^3 of NaOH(aq). What volume is this in cm^3?

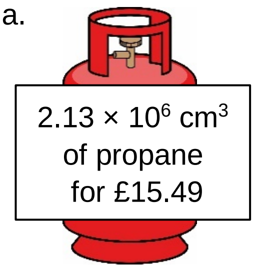
d. A swimming pool has a volume of 375 m^3. What volume is this in cm^3?

e. A 12 g cylinder of CO_2 contains 6.54 dm^3 of gas. What volume of gas is this in units of m^3?

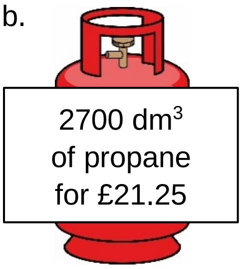
(5 marks)

4. Which cylinder of propane gas is the best value for money? (3 marks)

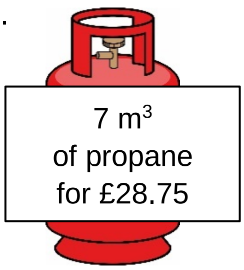
a.

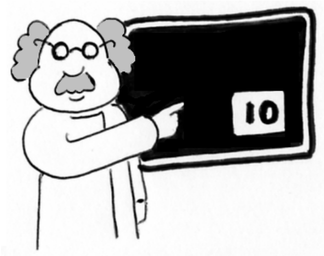


b.



c.





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0.2.8. Moles and mass

One mole of a substance is equal to **6.02×10^{23} atoms**, **ions** or **particles** of that substance. This number is called the **Avogadro constant**.

The value of the Avogadro constant was chosen so that the relative formula mass of a substance weighed out in grams is known to contain exactly 6.02×10^{23} particles. We call this mass its **molar mass**.

We can use the equation below when calculating an amount in moles:

$$\text{amount of substance (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$$

How is a mole similar to a dozen?

Stating the amount of substance in moles is just the same as describing a quantity of eggs in dozens. You could say you had 24 or 2 dozen eggs.

Use the equation above to help you answer the following questions.

1. Calculate the amount of substance, in moles, in: (3 marks)

a. 32 g of methane, CH_4 (molar mass, 16.0 g mol^{-1})

b. 175 g of calcium carbonate, $CaCO_3$

c. 200 mg of aspirin, $C_9H_8O_4$

2. Calculate the mass in grams of: (3 marks)

a. 20 moles of glucose molecules (molar mass, 180 g mol^{-1})

b. 5.00×10^{-3} moles of copper ions, Cu^{2+}

c. 42.0 moles of hydrated copper sulfate, $CuSO_4{\bullet}5H_2O$

3. a. 3.09 g of a transition metal carbonate was known to contain 0.0250 mol.

i. Determine the molar mass of the transition metal carbonate. (1 mark)

ii. Choose the most likely identity for the transition metal carbonate from the list below:

$CoCO_3$ **$CuCO_3$** **$ZnCO_3$** (1 mark)

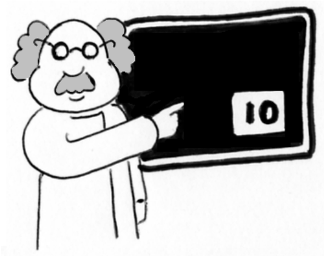
b. 4.26 g of a sample of chromium carbonate was known to contain 0.015 mol.

Which of the following is the correct formula for the chromium carbonate? (2 marks)

$CrCO_3$ **$Cr_2(CO_3)_3$** **$Cr(CO_3)_3$**

BONUS QUESTION

If you had 1 mole of pennies which you could share with every person on earth how much could you give each person? Approximate world population = 7 500 000 000.



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0.2.9. Moles and concentration

To calculate the concentration of a solution we use the equation:

$$\text{concentration (mol dm}^{-3}\text{)} = \frac{\text{amount of substance (mol)}}{\text{volume (dm}^3\text{)}}$$

Use the equation to help you complete each of the statements in the questions below.

1. a. 1.5 mol of NaCl dissolved in 0.25 dm^3 of water produces a solution with a concentration of.................................mol dm^{-3}. (1 mark)

b. 250 cm^3 of a solution of HCl(aq) with a concentration of 0.0150 mol dm^{-3} contains ....moles. (1 mark)

c. A solution with a concentration of 0.85 mol dm^{-3} that contains 0.125 mol has a volume of ....dm^3. (1 mark)

2. In this question you will need to convert between an amount in moles and a mass as well as using the equation above.

Space for working is given beneath each question.

a. 5.0 g of $NaHCO_3$ dissolved in 100 cm^3 of water produces a solution with a concentration of ....mol dm^{-3}. (2 marks)

b. 25.0 cm^3 of a solution of NaOH(aq) with a concentration of 3.8 mol dm^{-3} contains .... g of NaOH. (2 marks)

c. The volume of a solution of cobalt(II) chloride, $CoCl_2$, with a concentration of 1.3 mol dm^{-3} that contains 2.5 g of $CoCl_2$ is ....cm^3. (3 marks)

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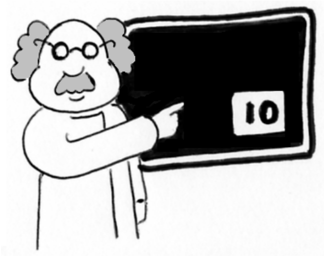

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0.3.1. Laboratory equipment

Practical work is a key aspect in the work of a chemist.

To help you plan effective practical work it is important that you are familiar with the common laboratory equipment available to you.

1. For each of the pieces of glassware shown in the images below, state their name and give a possible volume(s).

a. 

Name: ....

Possible volume(s): ....

b. 

Name: ....

Possible volume(s): ....

c. 

Name: ....

Possible volume(s): ....

d. 

Name: ....

Possible volume(s): ....

e. 

Name: ....

Possible volume(s): ....

f. 

Name: ....

Possible volume(s): ....

(6 marks)

2. Name the common laboratory equipment in the images below. (4 marks)

a. 

....

b. 

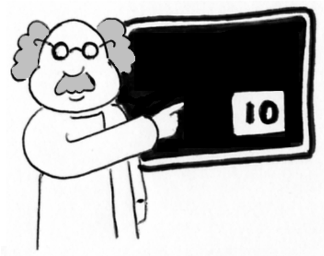
....

c. 

....

d. 

....



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0.3.2. Recording results

1. A student is looking at endothermic processes. He adds 2.0 g of ammonium nitrate to 50 cm^3 of water and measures the temperature change. He repeats the experiment three times.

His results are shown in the table below.

	Temperature at start	**Temperature at end**	**Temperature change**
Run 1	21.0	–1.1	22.1
Run 2	20	–2	22
Run 3	20.2	2	18.2
Mean			**22.05**

Annotate the table to suggest **five ways** in which the table layout and the recording and analysis of his results could be improved. (5 marks)

2. For each of the experiments described below, design a table to record the results.

Experiment 1: Simon is investigating mass changes during chemical reactions. He investigates the change in mass when magnesium ribbon is oxidised to form magnesium oxide:

magnesium + oxygen → magnesium oxide

He records the mass of an empty crucible. He places a 10 cm strip of magnesium ribbon in the crucible and records the new mass of the crucible. He heats the crucible strongly until all the magnesium ribbon has reacted to form magnesium oxide. He allows the crucible to cool before recording the mass of the crucible and magnesium oxide.

Experiment 2: Nadiya is investigating how the rate of a reaction is affected by concentration. She investigates the reaction between magnesium ribbon and hydrochloric acid.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

She places 25 cm^3 of hydrochloric acid with a concentration of 0.5 mol dm^{-3} into a conical flask and fits a gas syringe. She adds a 3.0 cm strip of magnesium ribbon and measures the volume of hydrogen gas produced every 20 s for 3 minutes.

She repeats the experiment with hydrochloric acid with concentrations of 1.0 mol dm^{-3} and then 1.5 mol dm^{-3}.

(5 marks)

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STARTER FOR 10...

0.3.3. Drawing scatter graphs

When you want to find a correlation between two variables it is helpful to draw a scatter graph.

Key points to remember when drawing scatter graphs include:

- The **independent variable** (the variable that is changed) goes on the *x*-axis and the **dependent variable** (the variable you measured) goes on the *y*-axis.
- The plotted points must cover more than half the graph paper.
- The axes scales don't need to start at zero.
- A straight **line** or smooth **curve of best fit** is drawn through the points to show any correlation.

Karina is investigating the relationship between the volume of a gas and its temperature. She injects 0.2 cm^3 of liquid pentane (b.p. 36.1 °C) into a gas syringe submerged in a water bath at 40 °C. After 5 minutes she measures the volume of gas in the syringe. She repeats the experiment three times with the water bath at 40 °C.

She then repeats the experiment for temperatures of 50, 60, 70 and 80 °C.

Her results are shown in the table below:

Temperature / °C	**Volume of gas / cm^3**			
	Run 1	**Run 2**	**Run 3**	**Mean**
40	40.8	43.1	42.7	**42.2**
50	46.1	46.2	46.9	**46.4**
60	54.7	48.1	48.3	**48.2**
70	49.1	49.6	49.5	**49.4**
80	51.0	47.3	51.0	**51.0**

1. Plot a scatter graph of the volume of the gas against the temperature. (6 marks)
2. Add error bars to show the range of readings used to calculate the mean volume of the gas at each temperature. (2 marks)
3. Draw in a line of best fit. (1 mark)
4. Describe the correlation observed. (1 mark)

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