BTec National Extended Certificate in Applied Science

Summer Independent Learning

Y11-12

Part 1 – Compulsory Content (pages 2-15)

1. Watch the videos and complete the notes – you may consider adding flashcards / condensed notes, so you can use them to test yourself (metacognition)
2. Complete the follow up application questions
3. Correct and improve the questions where available (mark scheme at the end of the document)

This will be assessed in the initial assessment

Part 2 – Highly Recommended (pages 16-18)

This will be beneficial to you and help you succeed in your lessons.

Mark schemes (pages 19-31)

Compulsory content

Unit 1: Principles and Applications of Science I

Answer all the questions. There are links to websites which you may find helpful.
You will be given a test on these concepts at the start of the term.

This unit covers some of the key science concepts in biology, chemistry and physics.

This section looks at some of the chemistry concepts you have covered at GCSE and will cover in more depth in Unit 1.

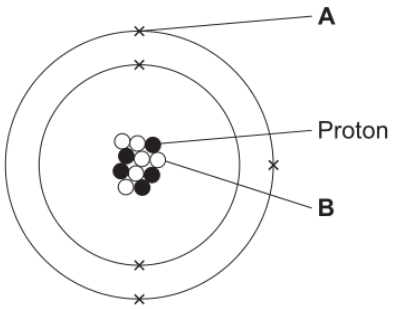
Periodicity and properties of elements

❑ Atomic Structure

https://www.bbc.co.uk/bitesize/guides/zwn8b82/revision/3 (pages 3,4 and 5)
https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html

Q1. Figure 1 shows an atom of element **G**.

Figure 1



Draw a ring around the correct answer to complete each sentence.

(a) Label **A** shows

an electron **an ion** **a nucleus** **(1)**

(b) Label **B** shows

an isotope **a molecule** **a neutron** **(1)**

(c) The atomic number of element **G** is

5 **6** **10** **11** **16** **(1)**

(d) The mass number of element **G** is

5 **6** **10** **11** **16** **(1)**

❑ Periodic Table

https://www.bbc.co.uk/bitesize/guides/ztv797h/revision/2 (pages 2-8)
https://www.rsc.org/periodic-table/

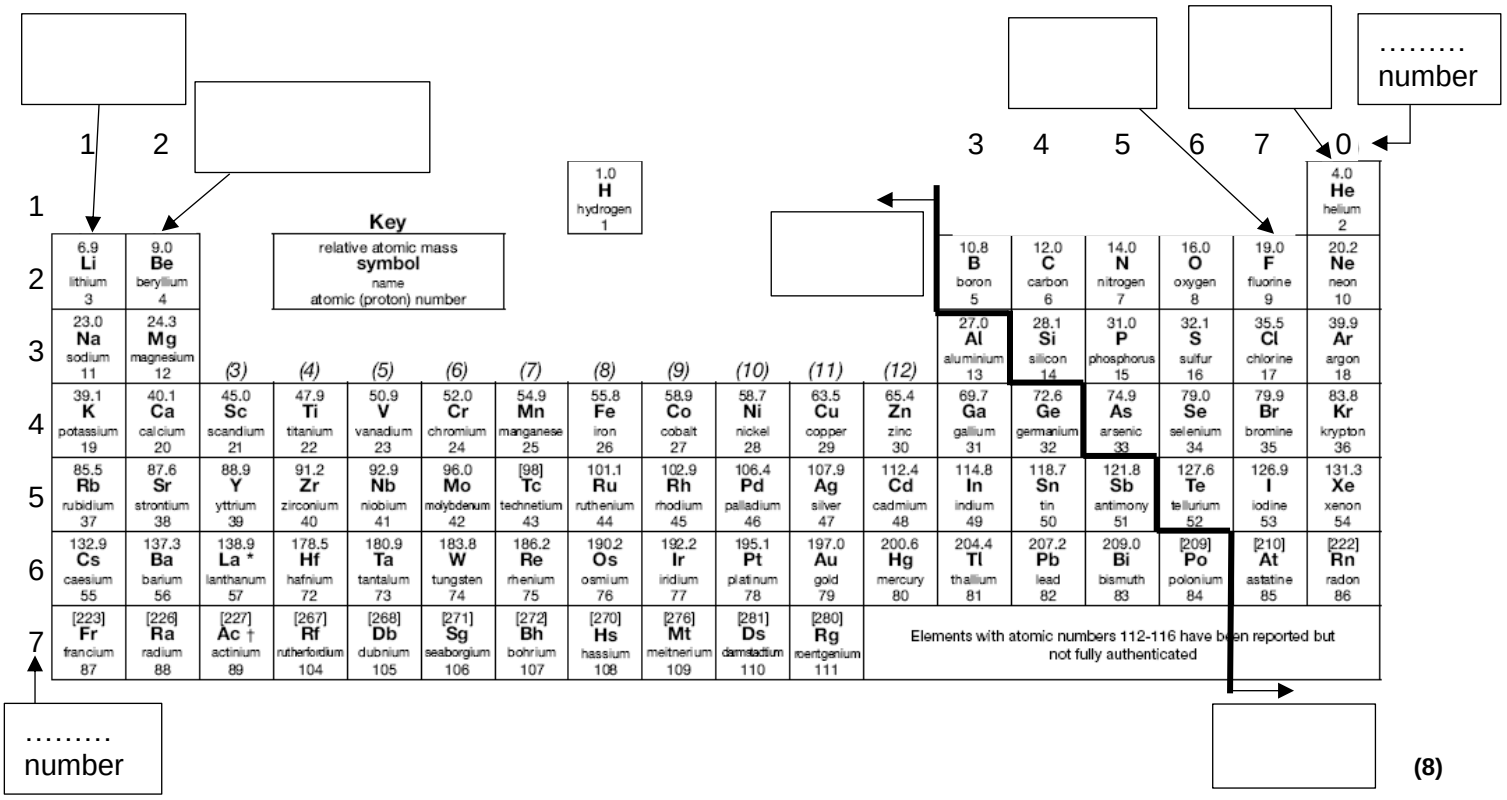
Q2. The Periodic table below contains **six** errors. Highlight these.

					H												He
Li	Be											B	C	N	O	Fl	Ne
na	Mg											Al	Si	P	S	CL	Ar
K	Ca	Sc	Ti	V	Cr	Mn	fe	CO	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	pD	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							

(6)

Q3. Complete the labels on the diagram below using the following terms:

metals	**non-metals**	**group**	**period**
Noble gases	**Alkaline-Earth metals**	**Halogens**	**Alkali metals**



(8)

Q4. Read the information below on element **X** carefully. Use this to help you answer the questions which follow.

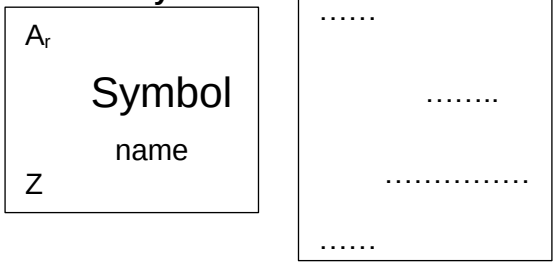
> Element **X** has two different isotopes, both of which contain 17 protons. The least abundant isotope contains 20 neutrons. The second isotope is three time more abundant and contains 2 more neutrons. All the atoms contain 2 electrons in the first shell, 8 electrons in the second shell and 7 electrons in the third.

(a) Where in the Periodic Table is element **X** found:

Group: ……. Period: …….. **(2)**

(b) Use the Periodic Table in **Q3.** the **key** and your answer to **Q4.(a)** to complete **Figure 2.** for element **X**

Key



(4)

(c) Is element **X** a metal or non-metal? …….. **(1)**

(d) Identify an element, in the same group as **X**, which has a lower boiling point than **X**.

…… **(1)**

❑ Chemical reactions and equations

https://www.bbc.co.uk/bitesize/guides/zy4pmsg/revision/1 (pages 1-6)
https://www.bbc.co.uk/bitesize/guides/z2bfxfr/revision/1 (pages 1,2)

Equations are used to show chemical reactions.
Reactants are written on the left of the arrow and products are written on the right.

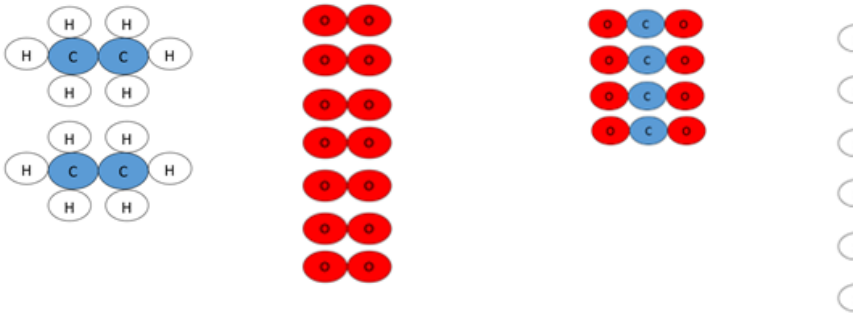
For example:

ethane + oxygen → carbon dioxide + water (word equation)

C_2H_6 O_2 CO_2 H_2O

Atoms cannot be created or destroyed. They are simply rearranged. Therefore, the equation with formulae needs balancing. (You can only add more of the same molecules. You cannot change the formula of any.)

$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$ (balanced equation)



The relative formula mass of a molecule/compound (M_r) can be calculated by adding the A_r of all the atoms it contains. The A_r value for all elements can be found in the Periodic Table.

A_r of C is 12.0, A_r of H is 1.0 and A_r of O is 16.0

M_r of C_2H_6 = (2 x 12.0) + (6 x 1.0) = 30.0

M_r of O_2 = (2 x 16.0) = 32.0

M_r of CO_2 = 12.0 + (2 x 16.0) = 44.0

M_r of H_2O = (2 x 1.0) + 16.0 = 18.0

The total mass of the reactants = the total mass of the products

Mass of reactants = (2 x M_r C_2H_6) + (7 x M_r O_2) = (2 x 30.0) + (7 x 32.0) = 284.0

Mass of products = (4 x M_r CO_2) + (6 x M_r H_2O) = (4 x 44.0) + (6 x 18.0) = 284.0

Q5. Lithium reacts with water to form lithium hydroxide and hydrogen.

(a) Balance the symbol equation for this reaction

…… Li(s) + ……. H_2O(l) → …….. LiOH(aq) + H_2(g) **(1)**

(b) (i) Complete the table below for this reaction **(8)**

	Reactant or product	State	M_r
Lithium			
Water	reactant	liquid	18.0
Lithium hydroxide			
Hydrogen			

(ii) Calculate the total mass of the reactants. Are these the same as the total mass of the products? Show your workings.

……

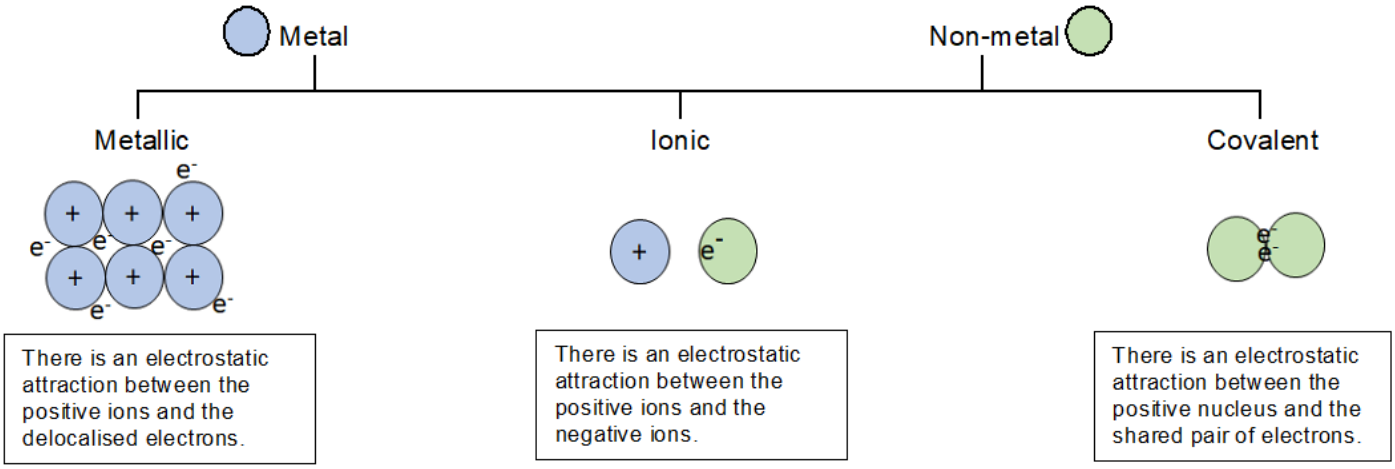
…… **(2)**

❑ Bonding

Chemical reactions involve the breaking and making of bonds. This involves electrons being transferred or shared between atoms.
The total number of electrons at the end of the reaction must be the same as at the start.
Metal atoms **lose** electrons and form **positively** charged **ions**.
Non-metal atoms **gain** electrons and form **negatively** charged ions
OR by **sharing** them (in pairs) with another non-metal atom

https://www.bbc.co.uk/bitesize/topics/z33rrwx (ionic compounds, small molecules, metals and alloys)

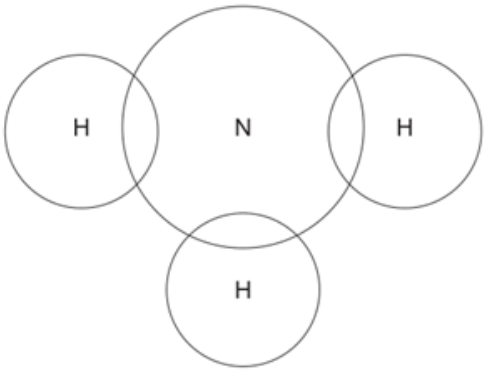
How do you know which type of bonding is present in an element or compound? Consider the type of element(s) it contains:



Q6. The electronic structure of a potassium atom is 2,8,8,1
Draw a diagram to show the electronic structure of a potassium ion. Show the charge on the ion.

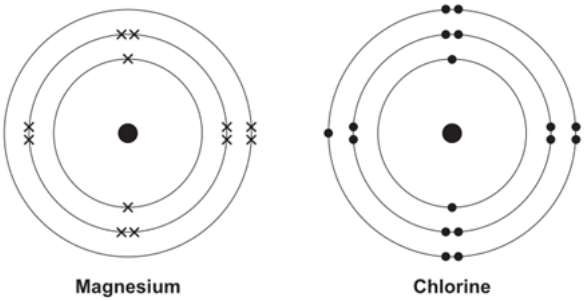
(2)

Q7. Complete the dot and cross diagram to show the electrons in the outer shells of ammonia, NH_3.
Use the periodic table to help you.



(2)

Q8. The diagrams shown an atom of magnesium and an atom of chlorine.



Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce Magnesium chloride, $MgCl_2$.
You may draw labelled diagrams.

……

……

……

……

……

……

……

…… **(4)**

Unit 2: Practical Scientific Procedures and Techniques

In this unit you will be required to complete a lot of practical procedures and so it is important that you know about laboratory safety.

❑ Laboratory Safety

- Watch the video on safety in the laboratory:
  https://www.youtube.com/watch?v=RhlOYhOvCsQ

  Use this to complete a list of safety rules to follow when completing any experiment.

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

(8)

You will be using a number of different chemicals and apparatus when completing these experiments.

- Follow the instructions provided to complete the table below on hazard symbols

i) Match the old hazard symbol to the new symbol.

ii) Match the new hazard symbol to the hazard name.
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/acs-secondary-safety-guidelines.pdf (page 22 and 23)

iii) List the precautions which should be taken (in addition to wearing a labcoat and safety glasses) when handling chemicals with these hazards to minimise the chance of an accident occurring.
https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/acs-secondary-safety-guidelines.pdf (pages 38-40)

Old	New	Name	Precautions
		**harmful / irritant**	
		oxidising agent	
		flammable	
		harmful to the environment	
		corrosive	
		toxic	

(19)

❑ Practical techniques

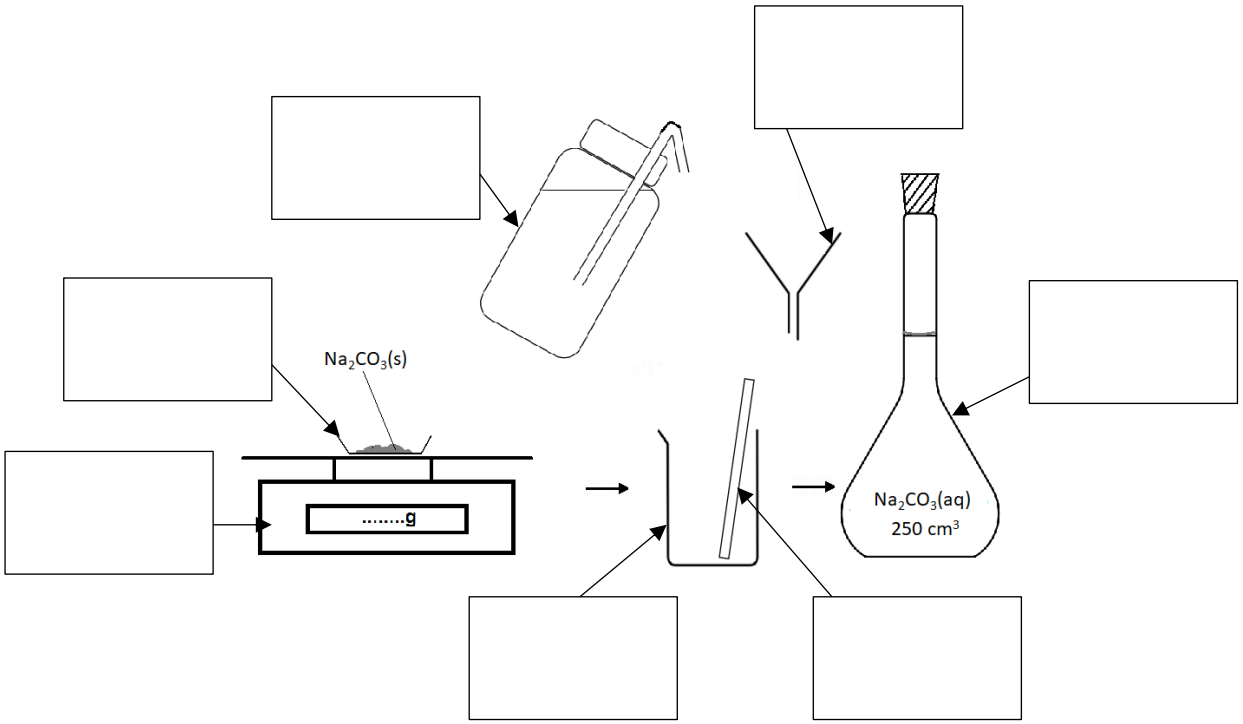
One of the practical techniques you will need to complete is the preparation of a standard solution and performing a titration to test the solution you have prepared.

- Watch these videos to help you answer the questions
  https://www.youtube.com/watch?v=xBKyjXUhJy0
  https://www.youtube.com/watch?v=rLc148UCT2w
  https://www.youtube.com/watch?v=gzvzvDv_BnA

Q1. (a) What is a standard solution? …….

…….**(1)**

(b) The diagram below shows the apparatus used to make a standard solution of sodium carbonate. Complete the labels. **(7)**



(c) The standard solution prepared can be used to find the concentration of a solution of hydrochloric acid.

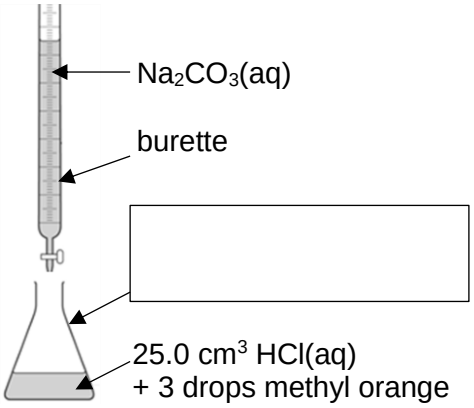
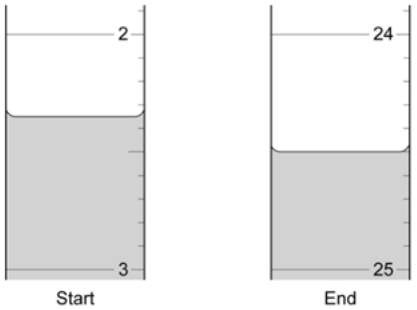


Figure 2.



(i) Complete the label to show name of the apparatus in which the acid is placed. **(1)**

(ii) What is the name given to this procedure? …… **(1)**

(iii) **Figure 2.** shows the level of the sodium carbonate solution in the burette at the start and the end of one titration. Use these to work out the volume of sodium carbonate added in the titration. Give your answer to 2 d.p.

Volume $Na_2CO_3(aq)$ added = …….. cm^3 **(1)**

Another practical technique you will need to complete is chromatography.

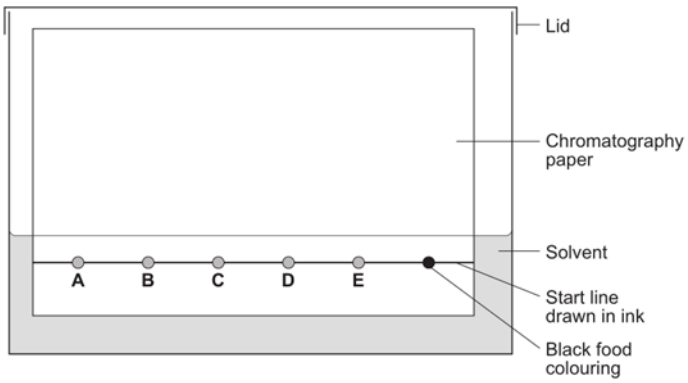
- The links below may help you to answer the questions on this technique.
  https://www.youtube.com/watch?v=lj5OWzhZSac
  https://www.bbc.co.uk/bitesize/guides/z9dfxfr/revision/4

Q2. (a) What is chromatography used for? ……

……**(1)**

(b) A student used paper chromatography to analyse a black food colouring. They placed spots of known food colours, **A**, **B**, **C**, **D** and **E** and the black food colouring on a sheet of chromatography paper. They set up the apparatus as shown in **Diagram 1.**

Diagram 1



The student made **two** errors in setting up the apparatus. Identify the **two** errors and describe the problem each error would cause.

……

……

……

……

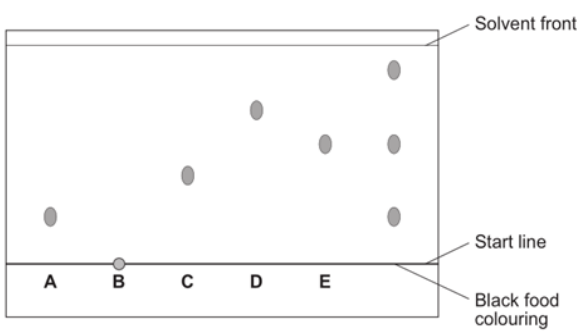
……

……

…… **(4)**

(c) A different student set up the apparatus without making any errors. The chromatogram in **Diagram 2.** shows the student's results.

Diagram 2



(i) What do the results tell you about the composition of the black food colouring?

……

……

……**(2)**

(ii) Use **Diagram 2.** to complete **Table 1.** **(2)**

Table 1.

	Distance in mm
Distance from start line to solvent front	
Distance moved by food colour **C**	

(iii) Use your answers in **(c)(ii)** to calculate the R_f value for food colour **C**. Show your workings.

R_f value = …… **(1)**

(iv) **Table 2.** gives the results of chromatography experiments that were carried out on some known food colours, using the same solvent as the students.

Table 2.

Name of food colour	**Distance from start line to solvent front in mm**	**Distance moved by food colour in mm**	**R_f value**
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

Which of the food colours in **Table 2.** could be food colour **C** from the chromatogram? Give the reason for your answer.

……

……

…….. **(2)**

❑ Obtaining and analysing results obtained in an experiment

It is important to keep a record of all data whilst carrying out practical work. It is good practice to draw a table before starting the experiment and then enter results straight into the table.

Tables should have clear headings with units.

Time / min	Temperature / °C
0	27.6
1	27.4
2	27.2

The independent variable is the left-hand column in a table, with the following columns showing the dependent variables. All measurements should be written to the same number of decimal places (matching the precision of the measuring instrument).

https://www.bbc.co.uk/bitesize/guides/zcxp6yc/revision/1
https://www.bbc.co.uk/bitesize/guides/zcxp6yc/revision/6

Q3. A student was told to complete a practical to investigate how temperature affects the rate of a reaction. The student carried out the reaction at five different temperatures and recorded the time taken for each.

The student then calculated the rate of reaction, in s^{-1} for each experiment using the equation:

$$\text{rate of reaction} = \frac{1}{\text{time}}$$

The student's results and calculations are shown below:

at 24.5 °C the experiment took 340 seconds	1/340 = 0.0029 s^{-1}
at 39.0 °C it took 256 sec	1/256 = 0.0039 s^{-1}
at 58.0 °C the experiment took 124 s	1/124 = 0.0081 s^{-1}
80.5 °C 62 s	1/62 = 0.0161
51 °C 186 s	1/186 = 0.0054

(a) What is the independent variable in this experiment? Circle the correct answer

rate of reaction **time** **temperature** **(1)**

(b) Tabulate the student's data in an appropriate manner. **(4)**

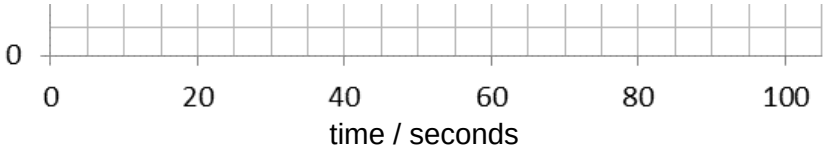
……. / …..	…….. / …….	……. / ……

https://www.bbc.co.uk/bitesize/guides/z8fq6yc/revision/8

Drawing a graph of the results obtained usually makes it easier to interpret the data and draw conclusions.

The independent variable is shown on the *x*-axis and the dependent variable is shown on the *y*-axis.

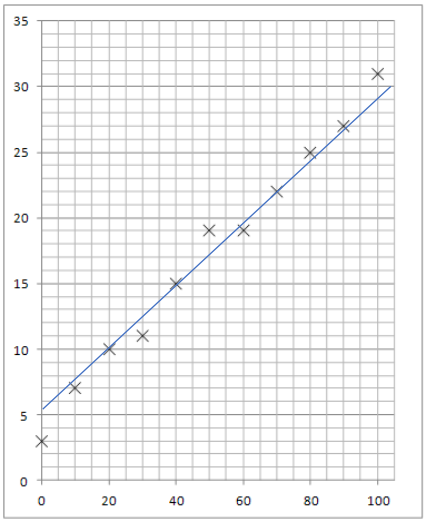
Axes should always be labelled with the quantity being measured and the units.



Data points should be marked with a cross, x.

When choosing the scales consider:

- the maximum and minimum values of each variable.
- whether 0,0 should be included as a data point.
- how to draw the axes without using difficult scale markings (e.g. multiples of 3, 7, etc)
- the data points should cover at **least half** of the grid supplied for the graph.



Consider the following when deciding where to draw a line of best fit:

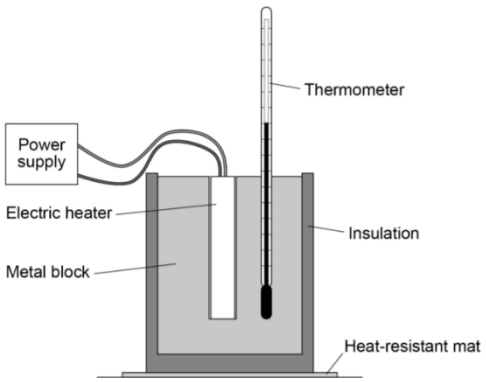
- the line can be straight or curved
- the line should pass through, or very close to, the majority of plotted points (ignoring any anomalous points)
- for points not on the line make sure that there are as many points on one side of the line as the other
- the line should be continuous and drawn with a sharp pencil (use a rule for a straight line)
- the line will go through the origin (0,0) if a value of 0 for the independent variable would produce a value of 0 for the dependent variable

Q4. A student investigated how the temperature of a metal block changed with time.

An electric heater was used to increase the temperature of the block.

The heater was place in a hole drilled in the block as shown in **Figure 1.**

Figure 9



The student measured the temperature of the metal block every 60 seconds. **Table 3.** shows the student's results.

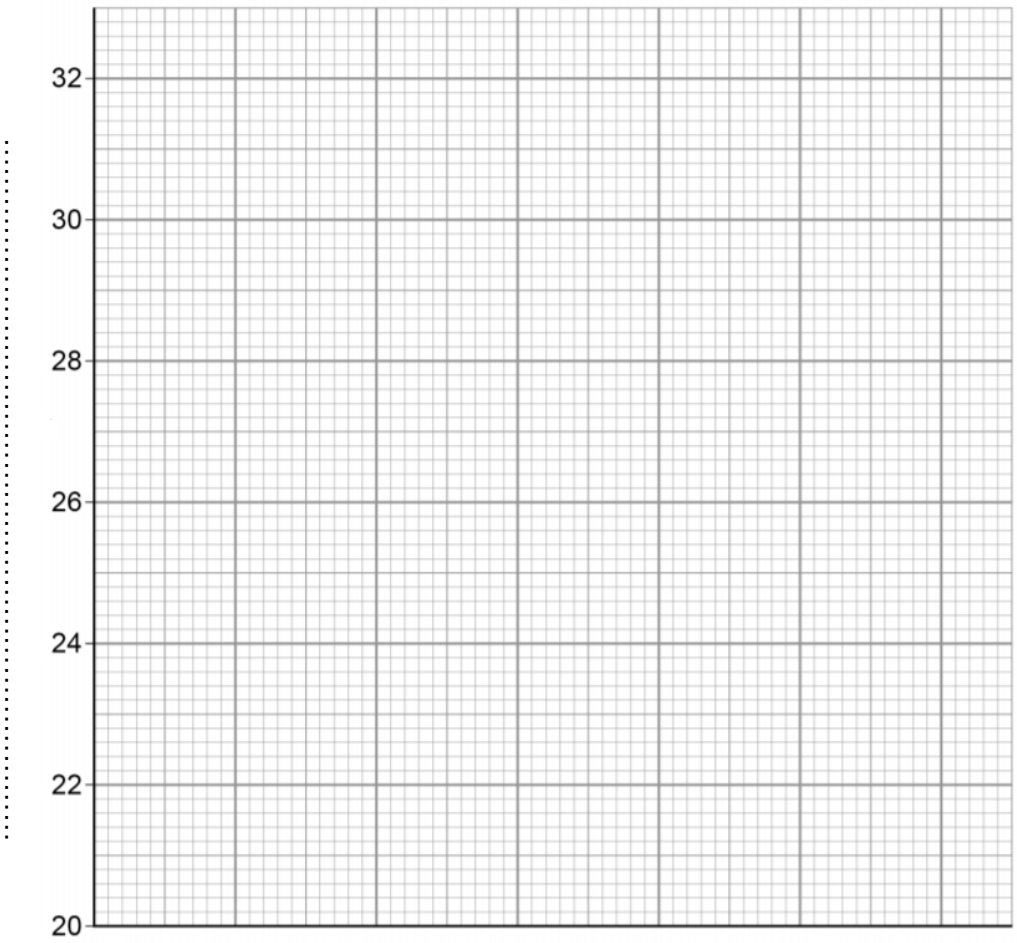
Table 3.

Time in s	Temperature in °C
0	20.0
60	24.5
120	29.0
180	31.0
240	31.5

(a) Complete the graph of the data from **Table 3.** on **Figure 2.**

- Choose a suitable scale for the x-axis.
- Label the x-axis and label the y-axis.
- Plot the student's results.
- Draw a line of best fit. **(5)**

Figure 2.



……..

(b) Use the graph to find the temperature of the metal block at time 100 s.

Temperature at 100s = …….. °C **(1)**

(c) The rate of change of temperature of the block is given by the gradient of the graph.
Determine the gradient of the graph over the first 60 seconds.

……

……

……

……

Gradient = …… °C / s **(2)**

PTO for highly recommended content

Highly recommended content

Make notes from the following resources, then have a go at completing the questions

Titrations and mole calculations

https://www.bbc.co.uk/bitesize/guides/zx98pbk/revision/3

https://www.youtube.com/watch?v=wPGVQu3UXpw

https://www.youtube.com/watch?v=ovx-Sro4NXM

Q1. This question is about acids and alkalis.

(a) Dilute hydrochloric acid is a strong acid.

Explain why an acid can be described as both strong and dilute.

_____

_____

_____

_____

(2)

A student titrated 25.0 cm^3 portions of dilute sulfuric acid with a 0.105 mol/dm^3 sodium hydroxide solution.

(c) The table below shows the student's results.

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
Volume of sodium hydroxide solution in cm^3	23.50	21.10	22.10	22.15	22.15

The equation for the reaction is:

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

Calculate the concentration of the sulfuric acid in mol/dm^3

Use only the student's concordant results.

Concordant results are those within 0.10 cm^3 of each other.

Concentration of sulfuric acid = _____ mol/dm^3

(5)

(d) Explain why the student should use a pipette to measure the dilute sulfuric acid and a burette to measure the sodium hydroxide solution.

(2)

(e) Calculate the mass of sodium hydroxide in 30.0 cm^3 of a 0.105 mol/dm^3 solution.

Relative formula mass (M_r): NaOH = 40

Mass of sodium hydroxide = _____ g

(2)

(Total 12 marks)

Q2. A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

(a) Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$$

Relative atomic masses, A_r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

_____

_____

_____

_____

Mass of copper carbonate = _____ g

(4)

(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced.

_____

_____

Actual mass of copper chloride produced = _____ g

(2)

Mark Scheme

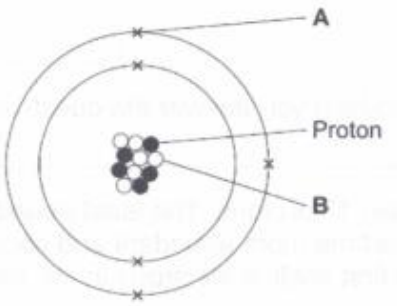
Periodicity and properties of elements

❑ Atomic Structure

https://www.bbc.co.uk/bitesize/guides/zwn8b82/revision/3 (pages 3,4 and 5)
https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html

Q1. Figure 1 shows an atom of element **G**.

Figure 1



Draw a ring around the correct answer to complete each sentence.

(a) Label **A** shows

an electron **an ion** **a nucleus** (1)

(b) Label **B** shows

an isotope **a molecule** **a neutron** (1)

(c) The atomic number of element **G** is

5 **6** **10** **11** **16** = number of protons (1)

(d) The mass number of element **G** is

5 **6** **10** **11** **16** 5 protons + 6 neutrons (1)

❑ Periodic Table

https://www.bbc.co.uk/bitesize/guides/ztv797h/revision/2 (pages 2-8)
https://www.rsc.org/periodic-table/

Q2. The Periodic table below contains **six** errors. Highlight these.

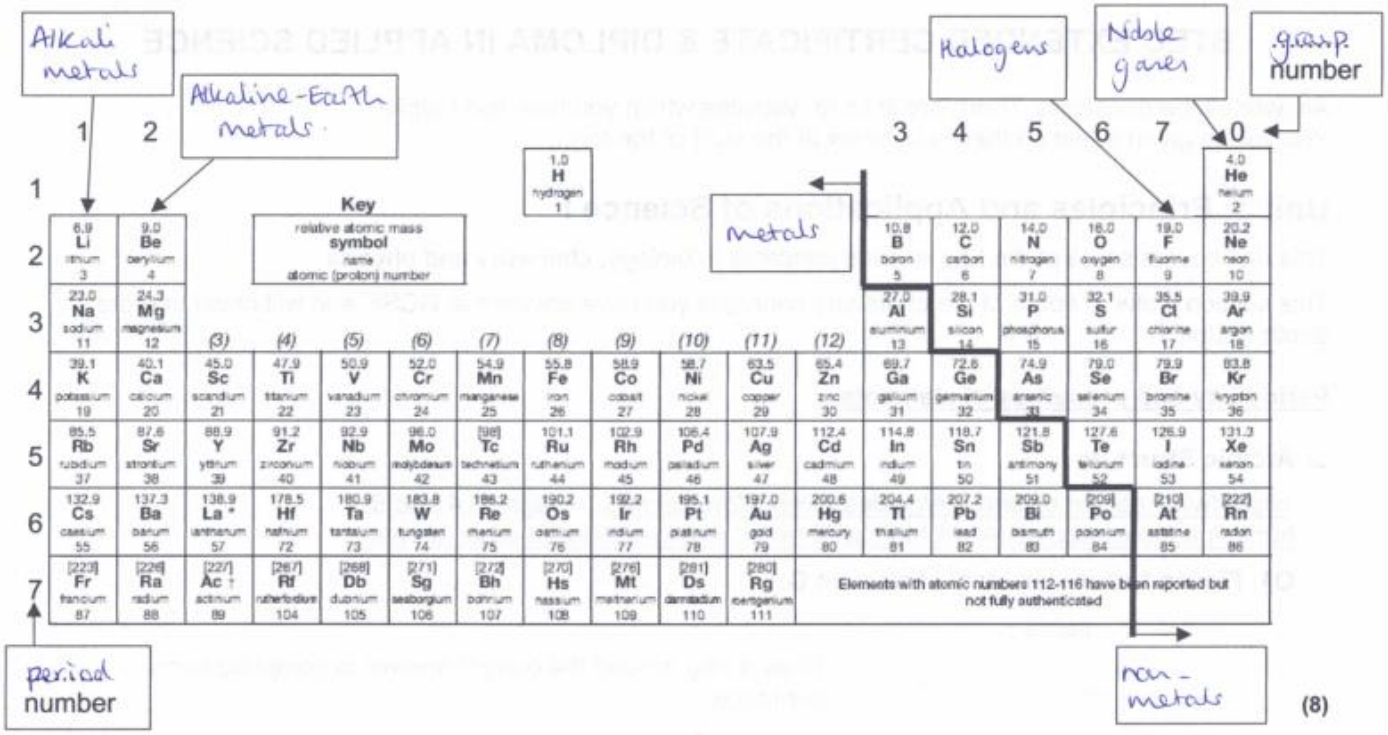
CAPITAL then lower case

							H										He
Li	Be											B	C	N	O	Fl	Ne
Na	Mg											Al	Si	P	S	CL	Ar
K	Ca	Sc	Ti	V	Cr	Mn	fe	CO	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	pD	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg							

(6)

Q3. Complete the labels on the diagram below using the following terms:

metals	**non-metals**	**group**	**period**
Noble gases	**Alkaline-Earth metals**	**Halogens**	**Alkali metals**



(8)

Q4. Read the information below on element **X** carefully. Use this to help you answer the questions which follow.

> Element **X** has two different isotopes, both of which contain 17 protons. The least abundant isotope contains 20 neutrons. The second isotope is three time more abundant and contains 2 more neutrons. All the atoms contain 2 electrons in the first shell, 8 electrons in the second shell and 7 electrons in the third.

(a) Where in the Periodic Table is element **X** found:

Group: ....7.... Period: ....3.... **(2)**

(b) Use the Periodic Table in **Q3.** the **key** and your answer to **Q4.(a)** to complete **Figure 2.** for element **X**

Figure 2

Key

A_r

Symbol

name

Z

35.5

Cl

chlorine

17

(4)

(c) Is element **X** a metal or non-metal? ....non-metal.... **(1)**

(d) Identify an element, in the same group as **X**, which has a lower boiling point.

....Fluorine.... **(1)**

Q5. Lithium reacts with water to form lithium hydroxide and hydrogen.

(a) Balance the symbol equation for this reaction

..2.. Li(s) + ...2.. H_2O(l) → ...2... LiOH(aq) + H_2(g) **(1)**

(b) (i) Complete the table below for this reaction **(8)**

	Reactant or product	State	M_r
Lithium	reactant	solid	
Water	reactant	liquid	18.0
Lithium hydroxide	product	aqueous (solution)	23.9
Hydrogen	product	gas	2.0

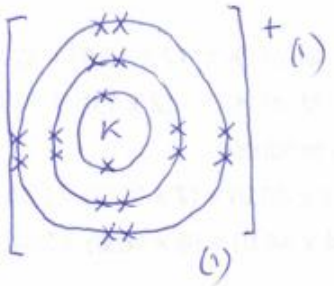
(ii) Calculate the total mass of the reactants. Are these the same as the total mass of the products? Show your workings.

...(2 x 6.9) + (2 x 18.0) = 49.8 ..total mass of reactants.....(1)..

..(2 x 23.9) + 2.0 = 49.8 ...total mass of products....is...Yes, they are the same.(1) **(2)**

Q6. The electronic structure of a potassium atom is 2,8,8,1
Draw a diagram to show the electronic structure of a potassium ion. Show the charge on the ion.

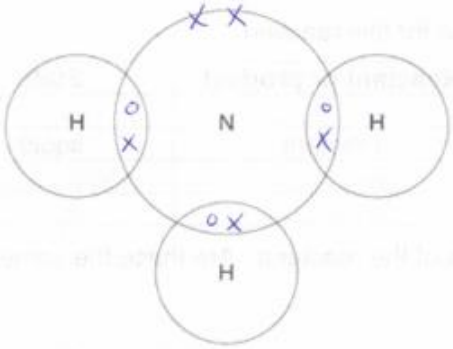
lost the 1 outer e^-



(2)

Q7. Complete the dot and cross diagram to show the electrons in the outer shells of ammonia, NH_3.
Use the periodic table to help you.

3 x (H)

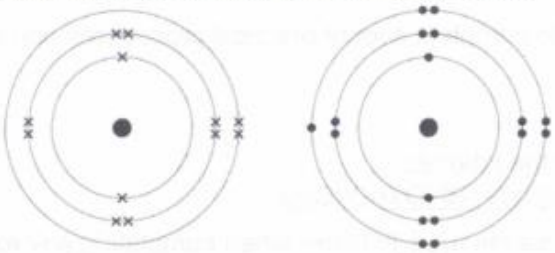


5 x (1)
3 o

sharing 3 pairs (1)

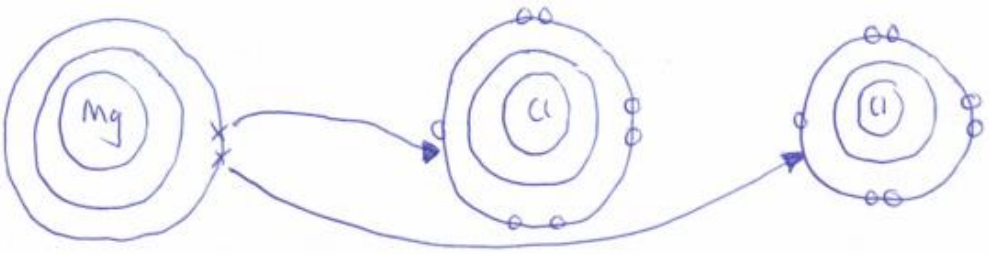
(2)

Q8. The diagrams shown an atom of magnesium and an atom of chlorine.



Magnesium Chlorine

Describe, in terms of electrons, how magnesium atoms and chlorine atoms change into ions to produce Magnesium chloride, $MgCl_2$.
You may draw labelled diagrams.



One Mg atom loses 1 e⁻ (1) to one Cl atom (1)
It loses a 2nd e⁻ (1) to a 2nd Cl atom (1)
Mg forms the Mg^{2+} ion and each Cl forms a Cl^- ion

Unit 2: Practical Scientific Procedures and Techniques

In this unit you will be required to complete a lot of practical procedures and so it is important that you know about laboratory safety.

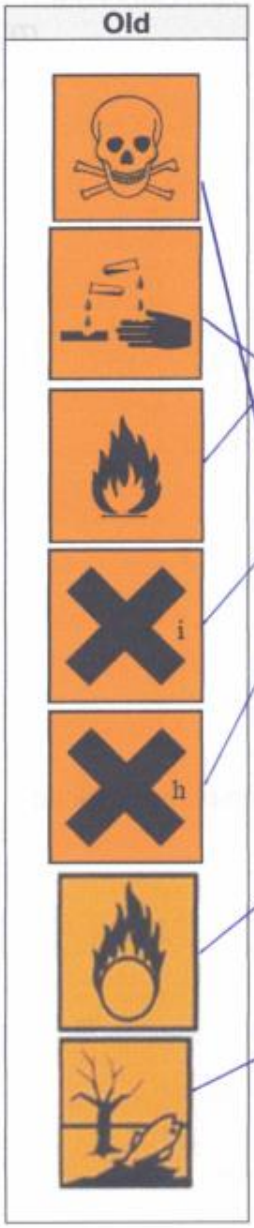
❑ Laboratory Safety

- Watch the video on safety in the laboratory:
  https://www.youtube.com/watch?v=RhlOYhOvCsQ

  Use this to complete a list of safety rules to follow when completing any experiment.

1. Wear a lab coat (buttoned up)
2. Wear safety glasses / goggles
3. Tie back long hair (particularly when using a Bunsen burner)
4. Write a risk assessment (before you complete the practical)
5. Keep the lab tidy
6. Wipe up spillages
7. Do not eat (or drink or chew gum) in the lab
8. Wash your hands (particularly before you leave the lab)

(8)



Name	Precautions
harmful / irritant	wear gloves well-ventilated laboratory
oxidising agent	No naked (open) flame or source of ignition
flammable	No naked (open) flame or source of ignition.
harmful to the environment	Don't pour down the sink
corrosive	wear gloves
toxic	wear gloves Use a fume cupboard

(19)

always wear lab coat + gloves.

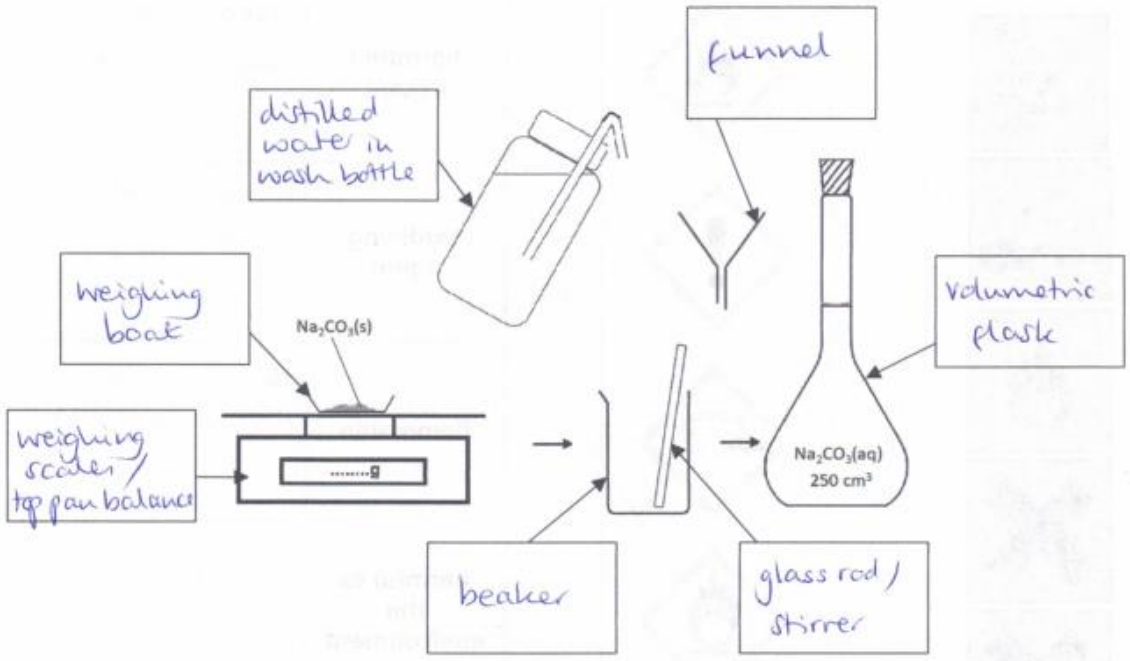
❑ Practical techniques

One of the practical techniques you will need to complete is the preparation of a standard solution and performing a titration to test the solution you have prepared.

- Watch these videos to help you answer the questions
  https://www.youtube.com/watch?v=xBKyjXUhJy0
  https://www.youtube.com/watch?v=rLc148UCT2w
  https://www.youtube.com/watch?v=gzvzvDv_BnA

Q1. (a) What is a standard solution? ....It is a solution of (accurately) known concentration..... **(1)**

(b) The diagram below shows the apparatus used to make a standard solution of sodium carbonate. Complete the labels. **(7)**



(c) The standard solution prepared can be used to find the concentration of a solution of hydrochloric acid.

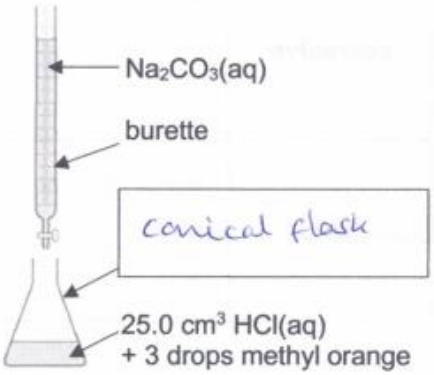
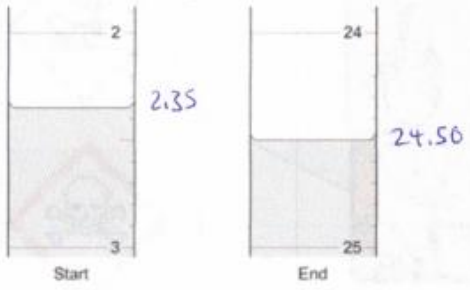


Figure 2.



(i) Complete the label to show name of the apparatus in which the acid is placed. **(1)**

(ii) What is the name given to this procedure? ....titration..... **(1)**

(iii) **Figure 2.** shows the level of the sodium carbonate solution in the burette at the start and the end of one titration. Use these to work out the volume of sodium carbonate added in the titration. Give your answer to 2 d.p.

24.50 − 2.35

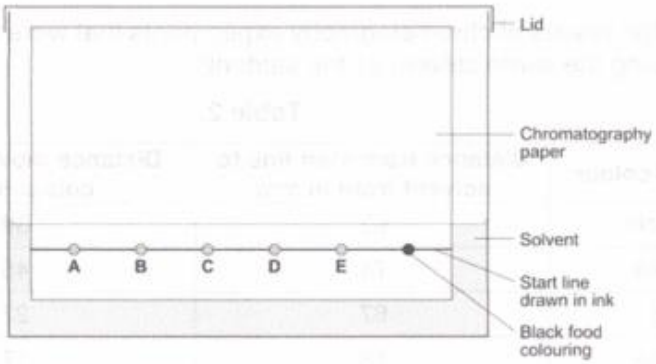
Volume $Na_2CO_3(aq)$ added = ...22.15..... cm^3 **(1)**

2 numbers after the decimal point

Q2. (a) What is chromatography used for? ....to separate (and analyse) components in a mixture.....**(1)**

(b) A student used paper chromatography to analyse a black food colouring. They placed spots of known food colours, **A**, **B**, **C**, **D** and **E** and the black food colouring on a sheet of chromatography paper. They set up the apparatus as shown in **Diagram 1.**

Diagram 1



The student made **two** errors in setting up the apparatus. Identify the **two** errors and describe the problem each error would cause.

Start line drawn in ink (1)

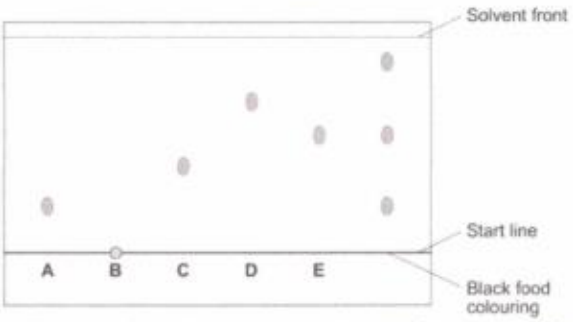
so it will run/dissolve in the solvent (1)

Solvent above the start line/spots under the solvent (1)

so they will wash off the paper/mix with the solvent (1)

(c) A different student set up the apparatus without making any errors. The chromatogram in **Diagram 2.** shows the student's results.

Diagram 2



(i) What do the results tell you about the composition of the black food colouring?

The black food colouring contains A and E (1)

and one other (unknown) substance (1) **(2)**

(ii) Use **Diagram 2.** to complete **Table 1.** (2)

Table 1.

	Distance in mm
Distance from start line to solvent front	28.5 / 29
Distance moved by food colour **C**	allow 11 – 12

(iii) Use your answers in **(c)(ii)** to calculate the R_f value for food colour **C**. Show your workings.

$$\frac{\text{distance moved by C}}{\text{distance from start line to solvent front}}$$

R_f value = 0.38 – 0.42 (1)

(iv) **Table 2.** gives the results of chromatography experiments that were carried out on some known food colours, using the same solvent as the students.

Table 2.

Name of food colour	Distance from start line to solvent front in mm	Distance moved by food colour in mm	R_f value
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

Which of the food colours in **Table 2.** could be food colour **C** from the chromatogram? Give the reason for your answer.

Fast red (1) allow more

has same / very similar Rf (1) if Rf not same as any

(2)

Q3. A student was told to complete a practical to investigate how temperature affects the rate of a reaction. The student carried out the reaction at five different temperatures and recorded the time taken for each.

The student then calculated the rate of reaction, in s^{-1} for each experiment using the equation:

$$\text{rate of reaction} = \frac{1}{\text{time}}$$

The student's results and calculations are shown below:

at 24.5 °C the experiment took 340 seconds	$1/340 = 0.0029\ s^{-1}$
at 39.0 °C it took 256 sec	$1/256 = 0.0039\ s^{-1}$
at 58.0 °C the experiment took 124 s	$1/124 = 0.0081\ s^{-1}$
80.5 °C 62 s	$1/62 = 0.0161$
51 °C 186 s	$1/186 = 0.0054$

(a) What is the independent variable in this experiment? Circle the correct answer

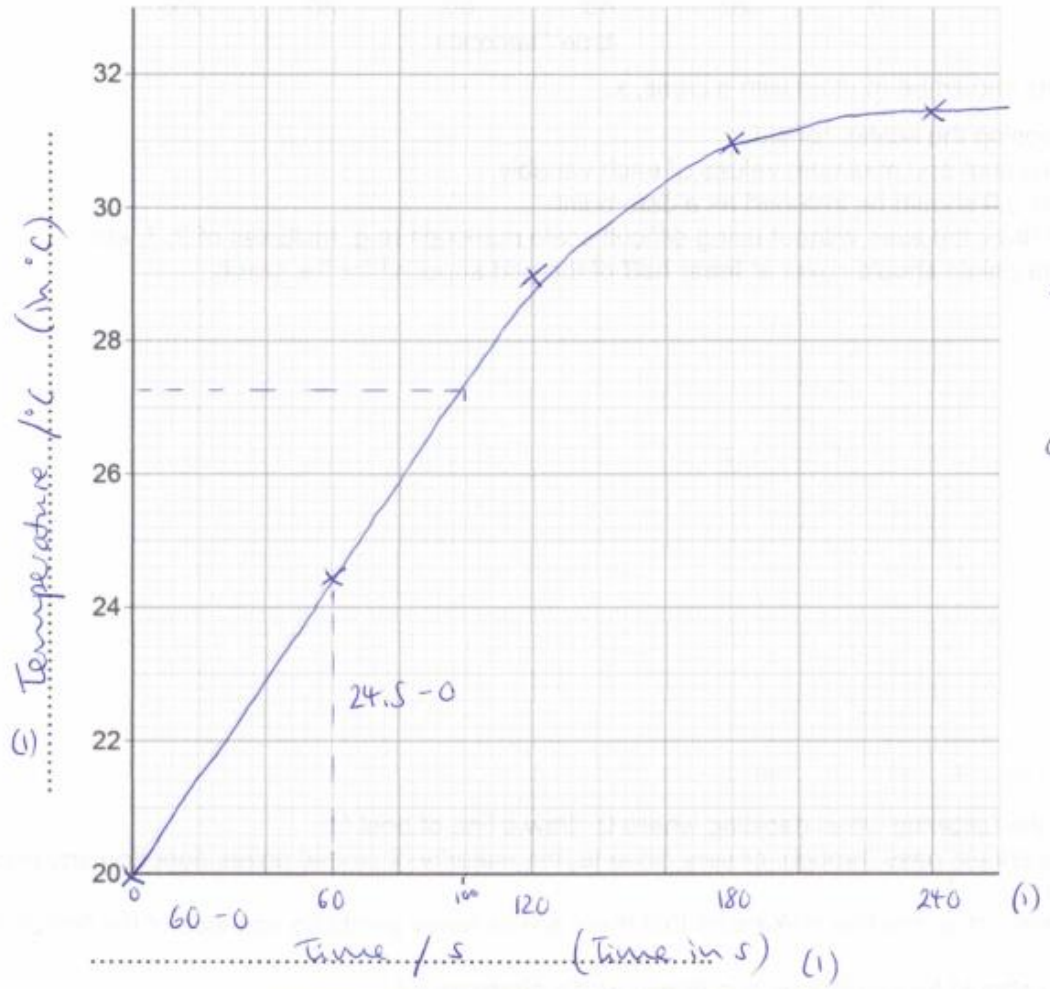
rate of reaction **time** **temperature** **(1)**

(b) Tabulate the student's data in an appropriate manner. **(4)**

temperature ..... / °C	..... time ..... / ..s..	rate of reaction ... / ..s^{-1}
24.5	340	0.0029
39.0	256	0.0039
51.0	186	0.0054
58.0	124	0.0081
80.5	62	0.0161

correct headings (1)
units with headings only (1)
all temperatures written to 1 d.p (1)
temperatures written in order of increasing size (1)

Figure 2.



all points correctly plotted (1)

curve of best fit (1)

(b) Use the graph to find the temperature of the metal block at time 100 s.

must match curve / line drawn.

Temperature at 100s = ..27.3.... °C **(1)**

write to 1dp to match precision in table

13

(c) The rate of change of temperature of the block is given by the gradient of the graph. Determine the gradient of the graph over the first 60 seconds.

24.5 - 0 = 0.41 (1)

60 - 0 (1)

Gradient = ..0.41.. °C / s **(2)**

Highly recommended content

Q1.

(a) (strong because) completely ionised (in aqueous solution)

ignore pH

allow dissociated for ionised

*do **not** accept hydrogen is ionising*
*do **not** accept H^+ are ionised*

1

(dilute because) small amount of acid per unit volume

ignore low concentration

1

(c) (titre):
chooses titrations 3, 4, 5

1

average titre = 22.13 (cm^3)

allow average titre = 22.13(3…) (cm^3)
allow a correctly calculated average from an incorrect choice of titrations

1

(calculation):
(moles NaOH =
$\frac{22.13}{1000} \times 0.105 = 0.002324$)

allow use of incorrect average titre from step 2

1

(moles H_2SO_4 =
½ × 0.002324 =) 0.001162

allow use of incorrect number of moles from step 3

1

(concentration =
$\frac{0.001162}{25} \times 1000$)
= 0.0465 (mol/dm^3)

allow use of incorrect number of moles from step 4

1

alternative approach for step 3, step 4 and step 5

$\frac{2}{1} = \frac{22.13 \times 0.105}{25.0 \times conc.\ H_2SO_4}$ *(1)*

(concentration H_2SO_4 =)
$\frac{22.13 \times 0.105}{25.0 \times 2}$

= 0.0465 (mol/dm^3) (1)

*an answer of 0.046473 **or** 0.04648 correctly rounded to at least 2 sig figs scores marking points 3, 4 and 5*

*an answer of 0.092946 **or** 0.09296 **or** 0.185892 **or** 0.18592 correctly rounded to at least 2 sig figs scores*

marking points 3 and 5
*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

(d) pipette measures a fixed volume (accurately)

1

(but) burette measures variable volume
allow can measure drop by drop

1

(e) $(\text{moles} =) \frac{30}{1000} \times 0.105$
or 0.00315 (mol)

or
(mass per dm^3 =) 0.105 × 40
or 4.2 (g)

1

$(\text{mass} = \frac{30}{1000} \times 0.105 \times 40)$

= 0.126 (g)

1

*an answer of 0.126 (g) scores **2** marks*
*an answer of 126(g) scores **1** mark*
*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[12]

Q2.

(a) add excess copper carbonate (to dilute hydrochloric acid)
accept alternatives to excess, such as 'until no more reacts'

1

filter (to remove excess copper carbonate)
reject heat until dry

1

heat filtrate to evaporate some water **or** heat to point of crystallisation
accept leave to evaporate or leave in evaporating basin

1

leave to cool (so crystals form)
until crystals form

1

*must be in correct order to gain **4** marks*

(b) M_r $CuCl_2$ = 134.5
*correct answer scores **4** marks*

1

moles copper chloride = (mass / M_r = 11 / 134.5) = 0.0817843866

1

M_r $CuCO_3$= 123.5

1

Mass $CuCO_3$ (=moles × M_2= 0.08178 × 123.5) = 10.1(00)

1

*accept 10.1 with no working shown for **4** marks*

(c) $\frac{79.1}{100} \times 11.0$

or

11.0 × 0.791

1

8.70 (g)

1

*accept 8.70(g) with no working shown for **2** marks*