A-level Chemistry Induction Work

Welcome!

- Welcome to A level Chemistry, I hope that you are looking forward to embarking on the course, building on your understanding of chemistry from GCSE and seeing where it is found or used in the world around us every day. Chemistry is a truly fascinating subject, which was born out of the experiments of the Alchemists (the source of the word chemist). It has positively impacted mankind (e.g. through development of medicines and materials), negatively (e.g. through damage to the ozone layer) and provides an interesting tool to investigate history (e.g. in March last year it was shown that analysis of glaciers shows the rise and fall of lead extraction in England during the 12th century – it is fascinating)!

What work is being set?

Part 1

1. Complete the Microsoft Form (using the link or QR code below) about the main topics from A-Level Chemistry (identifying areas you identify as strengths and weaknesses).

   https://forms.office.com/Pages/ResponsePage.aspx?id=ALV0CGtJAkCS-T05uDMt-o72Kv-_XQJLrvg1Cl40-ZRUQlhRU0lIWDJQWVlMS0haNE4xMDY1U01ETS4u

2. Read the GCSE to A-Level key concepts document. Pay attention to reviewing any concepts that you are less confident with.
3. Check that you know and can complete the points mentioned in the A-level ready checklist. You could get someone at home to test you with these.

Part 2

1. Read through the article "Snooker balls, plum puddings and solar systems". You should produce a one-page summary of the article, showing the key details of each model of the atom and the evidence that lead to its development over time
2. Complete the worksheets dealing with dot and cross diagrams as well as the properties of different types of substance. Questions 4 and 5 for the dot and cross diagrams are meant to be challenging so given them a try, but don't worry if you can't get them completely correct – it will be interesting to see the method that you have used on them.

Part 3

1. Complete the worksheets about the Chemistry related mathematical competencies (conversion of volume, moles calculations and concentration). These are skills which we use virtually every lesson as Chemists.
2. How could we complete our induction work without having had the opportunity to write and balance symbol equations? You would have felt something was missing if I hadn't included it!

For all students, but particularly for those who completed combined science at GCSE, you have been provided with the specification statements that were covered in separate chemistry at GCSE.

While you do not need to have learned these to study A-Level Chemistry, as there will be people in the class who have completed both courses, it may help with your confidence if you know that a particular topic was covered in separate science at GCSE which is why some students may seem to 'learn' that content quicker than others.

Who should I send this work to and / or who should I contact with any questions?

- Dr Ovens (Lead Chemistry Teacher) – aco@hardenhuish.wilts.sch.uk

How and when to submit work:

- Bring your work with you to hand in during the Year 12 Induction day in September.

Part 1

Task 2 - GCSE Summary sheets

KS4 – Atomic structure

Subatomic particles: nucleus (protons and neutrons), electrons in shells.

Describe the particles in terms of their relative masses and relative charges:

- Protons – mass 1, charge +1.
- Electrons – mass = negligible ($\frac{1}{1840}$), charge –1.
- Neutrons – mass = 1, charge = 0.

Notes

- Number of protons = number of electrons (uncharged/neutral atoms).
- Proton number = atomic number.
- Mass number = protons + neutrons.

KS4 – Isotopes and calculating relative isotopic mass

Isotopes are *atoms* of the same elements which have different numbers of *neutrons* but the same number of *protons*.

$$\text{Relative isotopic mass} = \frac{\text{sum of (\% abundance} \times \text{isotopic mass)}}{100}$$

Formation of ions

Atoms of metallic elements in Groups 1,2 and 3 can form positive ions when they take part in reactions since they are readily able to lose electrons.

Atoms of Group 1 metals lose one electron and form ions with a 1+ charge, e.g. Na^{+}

Atoms of Group 2 metals lose two electrons and form ions with a 2+ charge, e.g. Mg^{2+}

Atoms of Group 3 metals lose three electrons and form ions with a 3+ charge, e.g. Al^{3+}

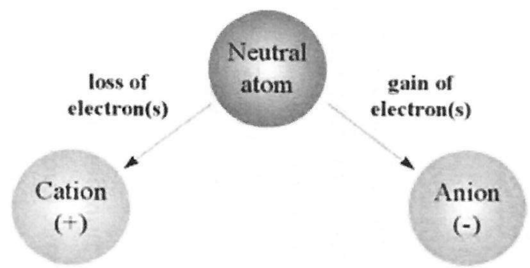
Atoms of non-metallic elements in Groups 5, 6 and 7 can form negative ions when they take part in reactions since they are able to gain electrons.

Atoms of Group 5 non-metals gain three electrons and form ions with a 3– charge, e.g. N^{3-}

Atoms of Group 6 non-metals gain two electrons and form ions with a 2– charge, e.g. O^{2-}

Atoms of Group 7 non-metals gain one electrons and form ions with a 1– charge, e.g. Cl^{-}

ANions = Negative   Ca+ions = +ive



Why are ions negative or positive?

- Find the atomic number (the smaller number with the symbol).
- This equals the number of protons, which equals the number of electrons in an uncharged/neutral atom.
- If electrons are lost from the atom, there are now more protons than electrons, so the ion is positively charged.
- If electrons are gained by the atom, there are now fewer protons than electrons, so the ion is negatively charged.

KS4 – Electron configuration

Filling electron shells

- *1st shell*, maximum = $2e^-$
- *2nd and further shells*; maximum = $8e^-$

Representing electron configurations

- Write as, e.g. 2.8.3 or 2,8,3

Using the Periodic Table

- Period number (row) = number of shells
- Group number (column) = number of electrons in the outer (last) shell

Group number	**1**		**2**		**3**				**5**		**6**		**7**	
	Li		**Be**		**B**				**N**		**O**		**F**	
	Atom	Ion	Atom	Ion	Atom	Ion			Atom	Ion	Atom	Ion	Atom	Ion
Electrons	−3	−2	−4	−2	−5	−2			−7	−10	−8	−10	−9	−10
Protons	+3	+3	+4	+4	+5	+5			+7	+7	+8	+8	+9	+9
Overall charge	0	1+	0	2+	0	3+			0	3−	0	2−	0	1−
Electron configuration	2.1	2	2.2	2	2.3	2			2.5	2.8	2.6	2.8	2.7	2.8
Name of ions	lithium		beryllium		boron				nitride		oxide		fluoride	
	Lose electrons, charge = +group number								Gain electrons, charge = group number − 8					

Hints and tips

Always …

… count the electrons!

… remember that ions should have full outer shells.

… make sure that when an ion is formed, you put square brackets round the diagram and show the charge.

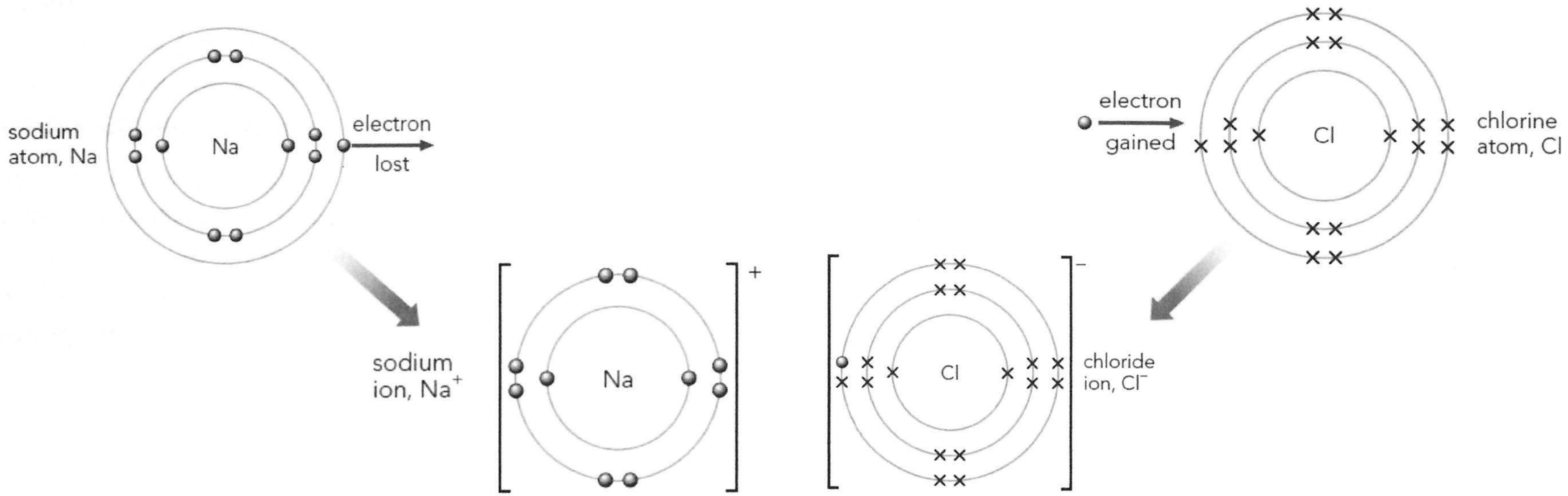
Never …

… show the electron shells overlapping.

… show electrons being shared (ions are formed by the **transfer** of electrons!).

… remove electrons from the inner shell.

… give metals a negative charge.



KS4 – Covalent compounds (simple covalent bonding)

Distinguish between:

'How a covalent bond is formed': A covalent bond is formed when a pair of electrons is shared between two atoms.

'What is a covalent bond?': Electrostatic attraction between a shared pair of electrons and the nuclei of the atoms.

Covalent bonding results in the formation of molecules.

Hints and tips

Always ...

... show the shells touching or overlapping where the covalent bond is formed.

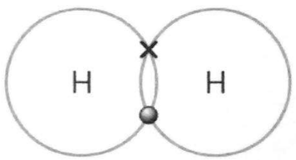
... count the final number of electrons around each atom to make sure that the outer shell is full.

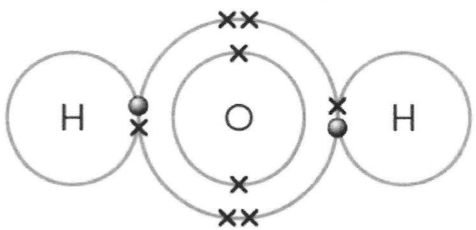
Never ...

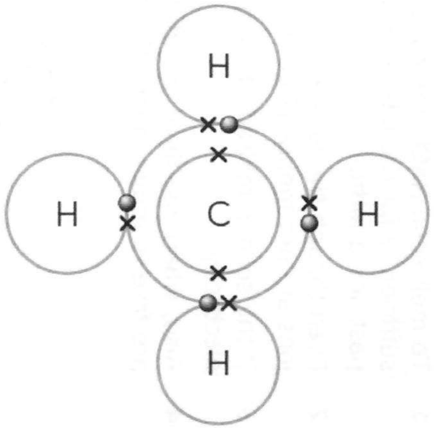
... include a charge on the atoms.

... draw the electron shells separated.

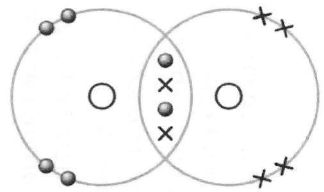
... draw unpaired electrons in the region of overlap.

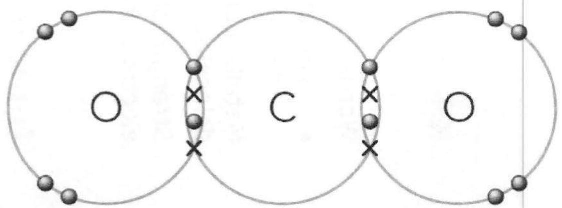






The two diagrams below only show the outer-shell electrons.





KS4 – Bonding and structure

Words used to describe structure and bonding:

- ions, atoms, molecules, intermolecular forces, electrostatic forces, delocalised electrons, cations, anions, outer electrons, shielding

Metallic bond: electrostatic attraction between the nuclei of cations (positive ions) and delocalised electrons.

Strength of the metallic bonding increases with the number of valence electrons (outer electrons in the atoms) and with decreasing size of the cation.

Ionic bonds and ionic compounds

> Explain why NaCl has a high melting point and only conducts electricity when molten or in solution. (6 marks)

An answer should cover the following points.

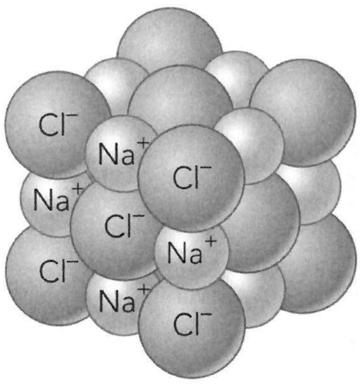
1 The Na^+ and Cl^- ions are held by strong electrostatic forces.

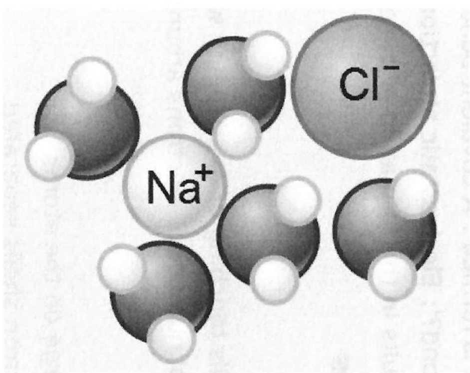
1 To melt solid NaCl, energy is needed to separate overcome the forces of attraction sufficiently for the lattice structure to break down and for the ions to be free to slide past one another.

2 Even though the ions are charged, the solid cannot conduct electricity because the ions are not mobile (free to move).

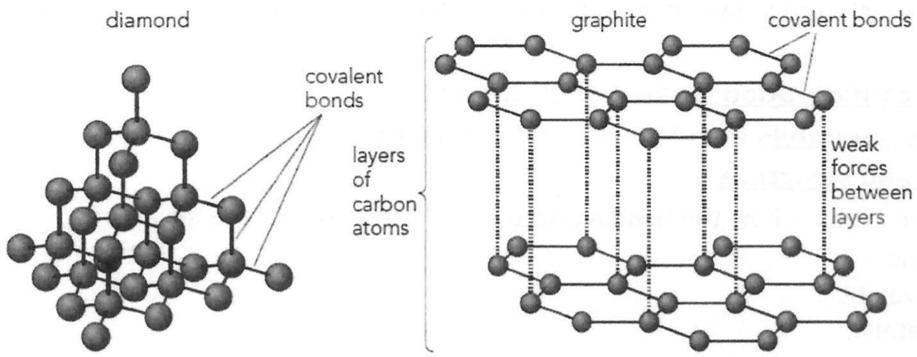
3 If the solid is melted, the ions can move freely and allow the liquid to conduct electricity.

4 Also, when dissolved in water the *ions* are separated by the water molecules and so are free to move, hence the aqueous solution can conduct electricity.





KS4 – Structure of diamond and graphite



Property	Diamond	Graphite
Melting point	High – atoms held by strong covalent bonds. Many covalent bonds must be broken to melt it. Lots of energy required. Is solid at room temp.	High – atoms held by strong covalent bonds. Many covalent bonds must be broken to melt it. Lots of energy required. Is a solid at room temp.
Electrical conductivity	Poor – no mobile electrons available. All four outer electrons of each carbon are used in bonding.	Good – each carbon only uses three of its outer electron to form covalent bonds. 4th electron form each atom contributes to a delocalised electron system. These delocalised electrons can flow when a potential difference is applied parallel to the layers.
Lubricant	Poor – structure is rigid.	Gas molecules are trapped between the layers and allow the layers to slide past one another. Same reason for its use in pencils.

Task 3 - Checklist for being A Level-ready (Chemistry)

You are expected to know/understand/be able to work out using the periodic table:

Electron configuration for the first 20 elements

Naming compounds from formulae and vice versa

Bonding and structure

Three main types – how the bonding occurs and properties of the structures

- ☐ ionic
- ☐ covalent
- ☐ metallic

Dot and cross diagrams for covalent molecules and ionic compounds to include:

- ☐ sodium chloride, magnesium oxide, sodium oxide, magnesium chloride
- ☐ chlorine (Cl_2), oxygen (O_2), nitrogen (N_2), ammonia (NH_3), carbon dioxide, methane (CH_4), water, hydrogen chloride (HCl)

Writing formulae for all of the above plus compounds with:

- ☐ ammonium ions (NH_4^+)
- ☐ carbonate ions (CO_3^{2-})
- ☐ halide ions (chloride, Cl^-; bromide, Br^- and iodide, I^-)
- ☐ hydroxide ions (OH^-)
- ☐ nitrate ions (NO_3^-)
- ☐ sulfate ions (SO_4^{2-})

Balancing equations for

- ☐ neutralisation
- ☐ metals with acids
- ☐ alkali metals with water
- ☐ redox (displacement of halogens and metals)

Calculations

- ☐ relative atomic mass, relative formula mass and empirical formulae
- ☐ Percentage yield and atom economy
- ☐ Reacting masses and limiting reagent

Energetics

- ☐ difference between exothermic and endothermic reactions
- ☐ graphs associated with these
- ☐ energies in bond making and bond breaking

Organic Chemistry

- ☐ differences between alkanes and alkenes
- ☐ naming and reactions of alkanes and alkenes
- ☐ fractional distillation
- ☐ cracking
- ☐ characteristics of good fuels
- ☐ balancing combustion equations

Part 2

MIKE
FOLLOWS

Snooker balls, plum and solar systems

GCSE key words
Atomic structure
Atomic particles

People have long wondered about what matter is made of. Snooker balls, plum puddings and solar systems have all featured in descriptive models of atoms. This article describes how people's ideas about atomic structure have changed over the years.

Before anyone knew what they were, electrons were called cathode rays because they came out of the negative terminal, the cathode.

Most ancient civilisations tried to explain the nature of matter, or substance. One explanation offered by the Greek Democritus, who lived four centuries before Christ, was that everything was made of solid particles like snooker balls, called **atoms**. Atoms are too small to see so his ideas were theoretical and not based on experimental evidence. For example, he believed that food tasted sweet because it was made of 'large' round atoms but that small, sharp atoms made things taste sour.

The word 'atom' comes from the Greek word for 'cannot be divided' and this idea was echoed by the British chemist John Dalton in 1808. Dalton proposed that matter could not be subdivided indefinitely. Each element was made up of indivisible particles — atoms — that could not be made or destroyed. All atoms of an element were exactly alike — with the same mass, volume and chemical properties.

It is almost impossible to imagine how small an atom is. Millions of carbon atoms would fit side by side on the full stop at the end of this sentence. Atoms are impossible to see with visible light but a picture of them can be built up using electrons in place of light. The photograph above right is a scanning electron micrograph of some gold and carbon atoms and they certainly look a bit like hard snooker balls.

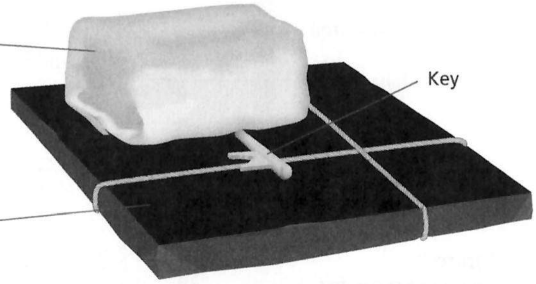
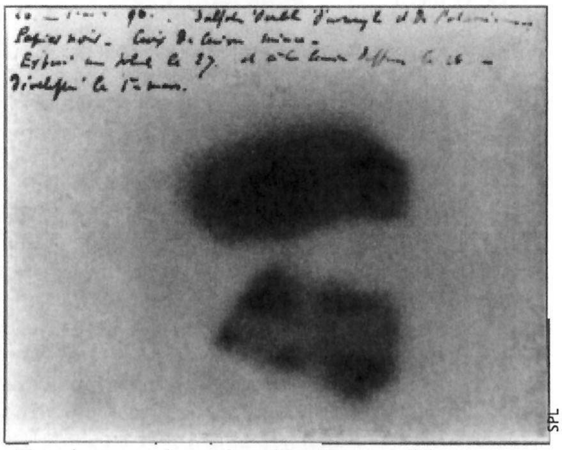


Figure 1 Becquerel's experiment with uranium salts

Fluorescent and phosphorescent materials both glow when they absorb radiation. A fluorescent material instantly re-emits the absorbed energy as light while phosphorescent materials glow for several hours.



The photograph produced by Becquerel's experiment with uranium salts

BECQUEREL TURNED THE KEY

Wilhelm Röntgen discovered X-rays in 1895 (see the September 2003 issue of CATALYST). They appeared to be produced by fluorescence. Henri Becquerel wanted to know whether **phosphorescence** would also produce X-rays. He had some potassium uranium sulphate crystals. These crystals phosphoresce (glow) after they have been exposed to sunlight. He sandwiched some coins and other metal shapes between these crystals and a photographic plate that had been double wrapped in black paper to prevent it being exposed to light (see Figure 1). As he expected, when he developed the plate, he saw the shadow made by the metal shapes just in the same way that bones cast a shadow in X-rays.

He tried repeating the experiment but the sun did not come out for several days which meant that his crystals did not phosphoresce. He decided to develop the plates anyway. To his surprise the metal shapes showed up just as well as before. He deduced that uranium was a source of invisible radiation.

puddings

THOMPSON'S PLUM PUDDING

In 1897 the British scientist J. J. Thompson discovered the **electron**, confirming that the atom was not the hard snooker ball that everyone had previously thought. Electrons could leak out of atoms.

Atoms are usually electrically neutral. This means they contain the same number of positive and negative charges. To reflect this, Thompson believed that the negatively charged electrons were contained inside a 'sphere of positive charge' — like the plums in plum pudding, which was popular at the time (see Figure 2).

In the meantime Becquerel had shown that his radiation from uranium salts was charged, and so could not be X-rays. Ernest Rutherford went on to label this radiation alpha, beta and gamma. Apparently atoms could fall apart or decay in the process called **radioactivity**.

When atoms decay, they also give off energy that ends up as heat. Radioactivity deep inside the Earth provides half the heat energy that drives the convection currents moving the tectonic plates around the Earth's surface.

FIRING ALPHA PARTICLES

Along with a couple of assistants, Ernest Rutherford decided to use alpha particles as 'bullets' and fired them at a thin gold foil 'target' (see Box 1). Why did Rutherford do this experiment? He was the world expert on alpha particles and this was a good way of providing more evidence to support the 'plum pudding' model. An alpha particle is deflected when repelled by another positive charge. If the atom was

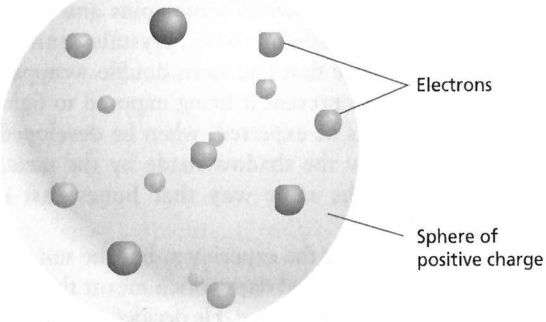
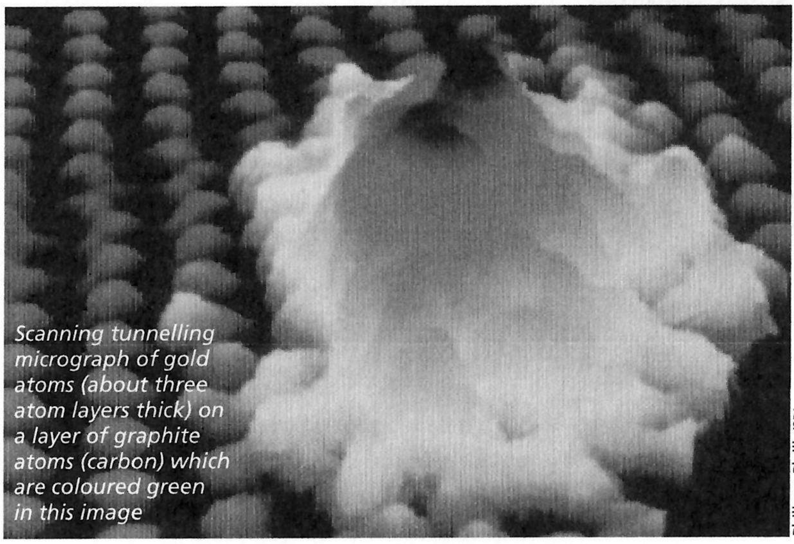


Figure 2 *J. J. Thompson's 'plum pudding' model of the atom. The electrons are like the fruit spread through a Christmas pudding*



Scanning tunnelling micrograph of gold atoms (about three atom layers thick) on a layer of graphite atoms (carbon) which are coloured green in this image

Philippe Plailly/SPL

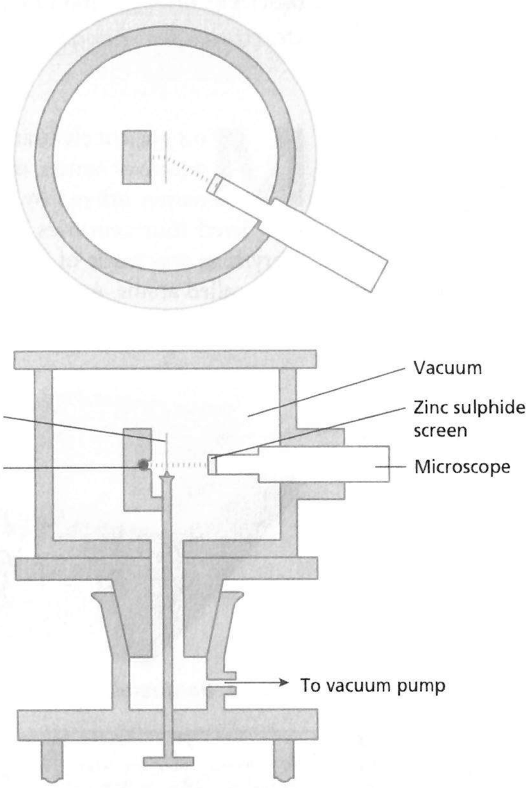


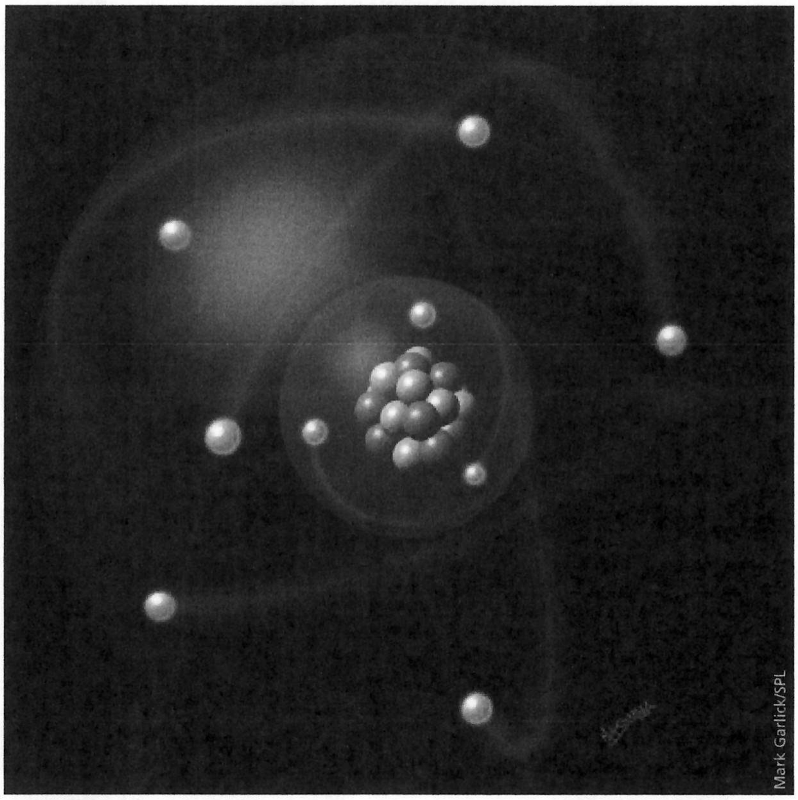
Figure 3
The apparatus for Rutherford's experiment

BOX 1 TARGET PRACTICE

The apparatus for Rutherford's experiment is shown in Figure 3. Gold was chosen because it could be beaten into a very thin leaf about 400 atoms thick. This would ensure that the alpha particles would be scattered by a single gold atom.

Had the air not been pumped out of the apparatus, the alpha particles would not have reached the foil. Their kinetic energy would have been used up ionising the air, knocking electrons out of the air molecules. It is because they are so ionising that alpha particles only travel a few centimetres in air.

A microscope was fitted to a pivoted arm in order to measure the angle through which the alpha particles were deflected. The microscope was focused on a zinc sulphide screen that would fluoresce when struck by an alpha particle.



Artist's impression of atomic structure. The central nucleus is orbited by electrons — three in an inner shell and six in an outer shell. The sizes of the particles are not to scale — they would be much smaller in an actual atom

If the electrons really did orbit the nucleus in the same way that planets orbit the Sun then they would rapidly lose energy and spiral into the nucleus. The atom would collapse in a ten billionth of a second.

really like a 'plum pudding' then the alpha particles should not have been deflected by more than 4° (see Figure 4). However, about 1 in 8000 alpha particles was deflected by more than 90°. This shocked Rutherford, 'It was quite the most incredible event that ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you.'

A 'SOLAR SYSTEM' IN THE ATOM

Rutherford developed a theory and predicted what would happen if gold was replaced by a different metal, or if the thickness of the foil was changed.

The nucleons themselves are believed to be made of even smaller particles called quarks.

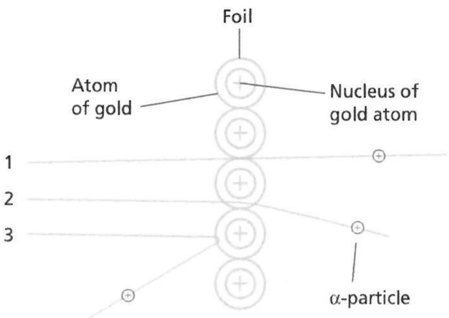


Figure 4 *What happened in Rutherford's experiment*

Table 1 *The properties of the particles inside the atom*

Sub-atomic particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0
Electron	$\frac{1}{1840}$	−1

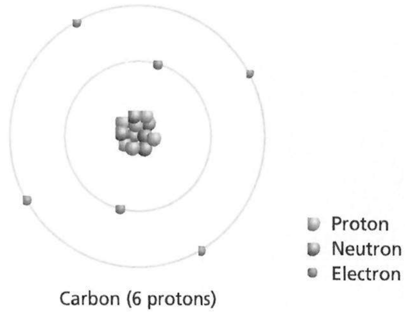


Figure 5 *The 'solar system' model for the atom*

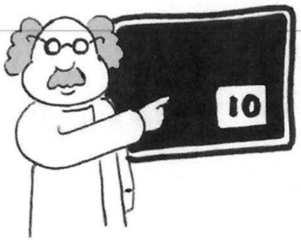
The experiments performed by his assistants confirmed his theory that most of the atom is empty space. A new model of the atom was born, with negatively charged electrons orbiting a positive **nucleus.** The nucleus contains positive **protons** and neutral **neutrons.** If an atom were the size of a football stadium then the nucleus would be roughly the size of a pea placed in the centre circle and electrons would be like crisp packets being blown by the wind around the stands.

Table 1 summarises the properties of the particles inside the atom. It shows that the protons and neutrons carry all the mass. These particles, known collectively as nucleons, live inside the nucleus. Figure 5 shows Rutherford's model of a carbon atom.

Models of the atom are useful because they help us visualise something that is too small to see. Thompson's 'plum pudding' model explained how atoms could remain neutral even though they contained negatively-charged electrons. This model is rarely used now because Rutherford's 'solar system' model explains this and much more. It also shows that the atom is mostly empty space, with electrons orbiting the tiny nucleus in shells. Because all the positive charges are concentrated in the nucleus, where they are desperately repelling each other, it also hints at why nuclei fall apart or decay.

Bohr, a Danish physicist, modified Rutherford's model of the atom to explain how atoms absorb and emit light. In order to do this he treated electrons as waves instead of particles...but that is another story.

__Mike Follows__ teaches science at Sutton Coldfield Grammar School for Girls, and is a part-time science writer.



STARTER FOR 10...

3.1.1. Covalent dot and cross

Draw dot and cross diagrams to illustrate the bonding in the following covalent compounds. If you wish you need only draw the outer shell electrons;

(2 marks for each correct diagram)

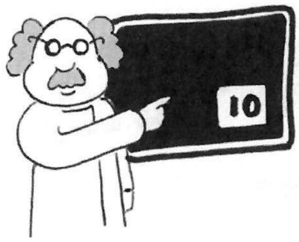
1. Water, H_2O

2. Carbon dioxide, CO_2

3. Ethyne, C_2H_2

4. Phosphoryl chloride, $POCl_3$

5. Sulfuric acid, H_2SO_4



STARTER FOR 10...

3.1.2. Ionic dot and cross

Draw dot and cross diagrams to illustrate the bonding in the following ionic compounds.

(2 marks for each correct diagram)

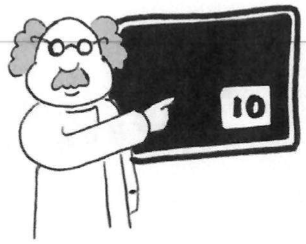
1. Lithium fluoride, LiF

2. Magnesium chloride, $MgCl_2$

3. Magnesium oxide, MgO

4. Lithium hydroxide, LiOH

5. Sodium cyanide, NaCN



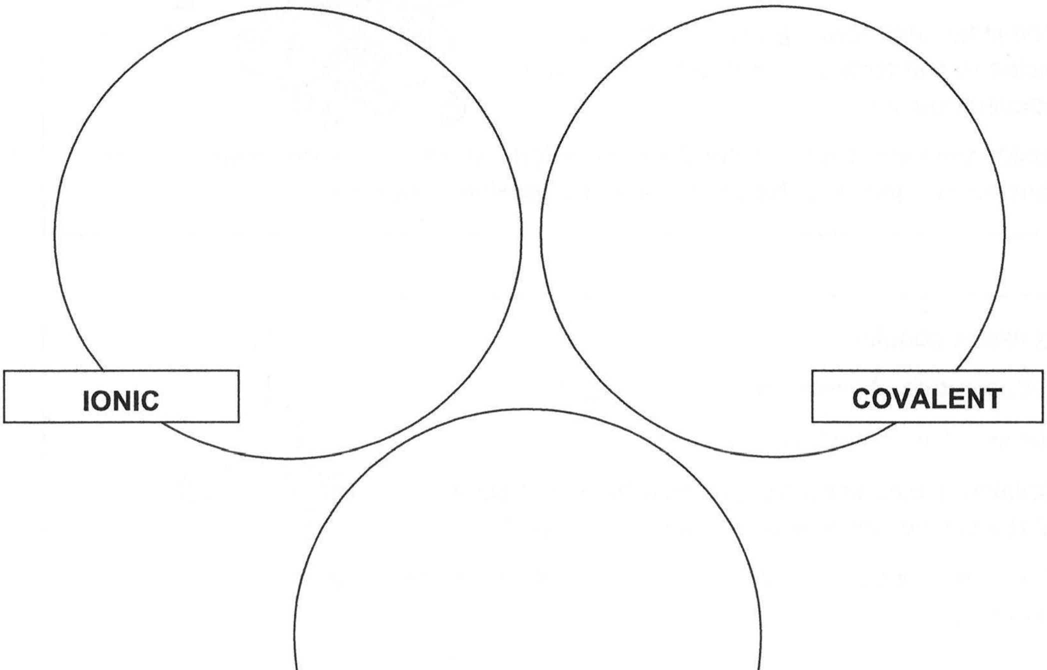
STARTER FOR 10...

3.1.3. Which type of chemical bond

There are three types of strong chemical bonds; **ionic**, **covalent** and **metallic**.

1. Sort the compounds below into groups within the circles below according to their chemical bonding;

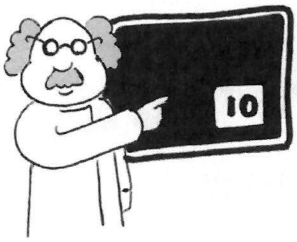
sodium chloride, NaCl	magnesium, Mg	magnesium oxide, MgO
methane, CH_4	oxygen, O_2	barium iodide, BaI_2
aluminium, Al	ammonia, NH_3	caesium, Cs



2. For each of the types of compound, indicate if you would expect them to;

(a) have a high or a low melting point

(b) conduct electricity



STARTER FOR 10...

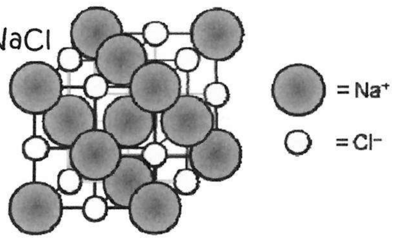
3.1.4. Bonding summary

A student has written the revision cards below to help her prepare for the exam. However she has made a number of mistakes. Can you correct her cards to make sure she has accurate information to revise from;

(1 mark for each correct correction made)

Ionic bonding

Between a metal and a non-metallic atom, e.g. NaCl



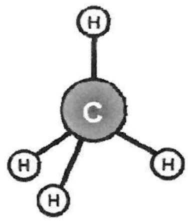
Electrons are shared between the atoms

The molecules have high melting points owing to the strong electrostatic attraction between the ions

Ionic compounds do not conduct electricity at all as the ions that carry the current are held in a fixed position in the lattice structure

Covalent bonding

Between two non-metallic atoms, e.g. CO_2



Electrons are transferred between the atoms

Covalent molecules have high melting points because of the strong covalent bonds which must be broken

Covalent compounds do not conduct electricity at all as there are no free electrons

Metallic bonding

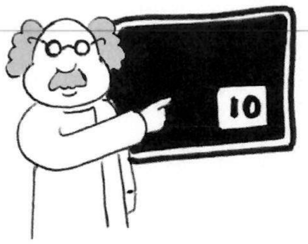
In metallic bonding, the outer electrons from the metal atoms merge to produce a lattice of negative metal ions in a sea of delocalised electrons

The strength of the metal depends on two things;
- the charge on the metal ion
- the size of the metal ion

Therefore sodium is stronger than magnesium

Metals have low melting points because of the repulsive forces between the negative electrons which need little energy to be broken

Metals conduct electricity because of the sea of delocalised electrons which can move through the structure to carry the charge



STARTER FOR 10...

3.3. Properties and bonding

Match the compound on the left to its correct structure from the middle bank of statements and one or more statements from the column on the right. Aluminium has been done for you

Compound	Structure	
aluminium	metal	Weak intermolecular forces are broken when it boils
		High melting point
diamond	simple covalent molecule	Conducts electricity when molten
		Conducts electricity when in solution
iodine	ionic compound	Conducts electricity when solid
chlorine	molecular crystal	Low melting point
		An ionic bond is broken when it melts
potassium fluoride	macromolecular crystal	A covalent bond must be broken to melt it

BONUS MARK Sketch the arrangement of molecules in a crystal of iodine

Part 3

Starters for 10 – Transition skills

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?

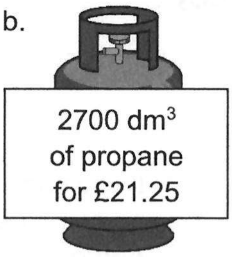
e. A 12 g cylinder of CO_2 contains 6.54 dm^3 of gas. What volume of gas is this in units of m^3?

(5 marks)

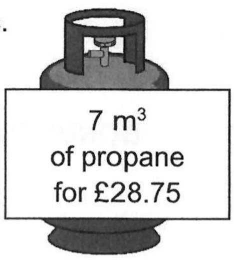
4. Which cylinder of propane gas is the best value for money? (3 marks)

a.

b.



c.



Starters for 10 – Transition skills

0.2.8 Moles and mass

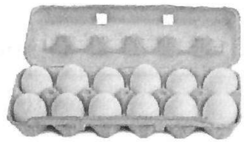
One mole of a substance is equal to **6.02×10^{23} atoms**, **ions** or **particles** of that substance. This number is called the **Avogadro constant**.

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, $CuSO_4 \cdot 5H_2O$

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)

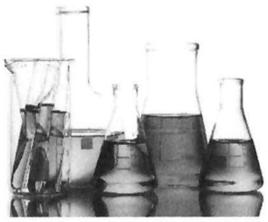
$CrCO_3$ **$Cr_2(CO_3)_3$** **$Cr(CO_3)_3$**

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.

Starters for 10 – Transition skills

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)

Starters for 10 – Transition skills

0.1.1 Balancing equations

Balance the equations below.

1. .....C + ...O_2 ⟶ .....CO

2. .....Ba + ...H_2O ⟶ .....$Ba(OH)_2$ + ...H_2

3. .....C_2H_6 + ...O_2 ⟶ .....CO_2 + ...H_2O

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

5. .....N_2 + ...O_2 ⟶ .....NO

6. .....Fe_2O_3 + ...C ⟶ .....Fe + ...CO_2

7. .....CH_3CH_2OH + ...[O] ⟶ .....CH_3COOH + ...H_2O

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

9. .....Al^{3+} + ...e^- ⟶ .....Al

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

(10 marks)

Starters for 10 – Transition skills

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.

    ....

Separate Science Specification points

Topic 5 – Separate chemistry 1

Transition metals, alloys and corrosion

Students should:		Maths skills
5.1C	Recall that most metals are transition metals and that their typical properties include: a high melting point b high density c the formation of coloured compounds d catalytic activity of the metals and their compounds as exemplified by iron	
5.2C	Recall that the oxidation of metals results in corrosion	
5.3C	Explain how rusting of iron can be prevented by: a exclusion of oxygen b exclusion of water c sacrificial protection	
5.4C	Explain how electroplating can be used to improve the appearance and/or the resistance to corrosion of metal objects	
5.5C	Explain, using models, why converting pure metals into alloys often increases the strength of the product	5b
5.6C	Explain why iron is alloyed with other metals to produce alloy steels	
5.7C	Explain how the uses of metals are related to their properties (and vice versa), including aluminium, copper and gold and their alloys including magnalium and brass	

Suggested practicals

- Carry out an activity to show that transition metal salts have a variety of colours.
- Investigate the rusting of iron.
- Electroplate a metal object.
- Make an alloy or investigate the properties of alloys.

Quantitative analysis

Students should:		Maths skills
5.8C	**Calculate the concentration of solutions in mol dm^{-3} and convert concentration in g dm^{-3} into mol dm^{-3} and vice versa**	1a, 1b, 1c, 1d 2a 3b, 3c
5.9C	*Core Practical: Carry out an accurate acid-alkali titration, using burette, pipette and a suitable indicator*	
5.10C	**Carry out simple calculations using the results of titrations to calculate an unknown concentration of a solution or an unknown volume of solution required**	1a, 1c, 1d 2a, 2b 3a, 3b, 3c
5.11C	Calculate the percentage yield of a reaction from the actual yield and the theoretical yield	1a, 1c, 1d 2a 3b, 3c
5.12C	Describe that the actual yield of a reaction is usually less than the theoretical yield and that the causes of this include: a incomplete reactions b practical losses during the experiment c competing, unwanted reactions (side reactions)	
5.13C	Recall the atom economy of a reaction forming a desired product	
5.14C	Calculate the atom economy of a reaction forming a desired product	1a, 1c, 1d 2a 3c
5.15C	**Explain why a particular reaction pathway is chosen to produce a specified product, given appropriate data such as atom economy, yield, rate, equilibrium position and usefulness of by-products**	
5.16C	**Describe the molar volume, of any gas at room temperature and pressure, as the volume occupied by one mole of molecules of any gas at room temperature and pressure** **(The molar volume will be provided as 24 dm^3 or 24000 cm^3 in calculations where it is required)**	
5.17C	**Use the molar volume and balanced equations in calculations involving the masses of solids and volumes of gases**	1a, 1c, 2a 3b, 3c
5.18C	**Use Avogadro's law to calculate volumes of gases involved in a gaseous reaction, given the relevant equation**	1a, 1c, 1d

Use of mathematics

- Arithmetic computation when calculating yields and atom economy (1a and 1c).
- Arithmetic computation, ratio, percentage and multistep calculations permeates quantitative chemistry (1a, 1c and 1d).
- Change the subject of a mathematical equation (3b and 3c).
- Provide answers to an appropriate number of significant figures (2a).
- **Convert units where appropriate particularly from mass to moles (1c).**

Suggested practicals

- Prepare a substance and calculate the percentage yield, given the theoretical yield.
- Determine the volume of one mole of hydrogen gas by using the reaction of magnesium with hydrochloric acid.

Dynamic equilibria

Students should:		Maths skills
5.19C	Describe the Haber process as a reversible reaction between nitrogen and hydrogen to form ammonia	
5.20C	**Predict how the rate of attainment of equilibrium is affected by:** **a changes in temperature** **b changes in pressure** **c changes in concentration** **d use of a catalyst**	
5.21C	**Explain how, in industrial reactions, including the Haber process, conditions used are related to:** **a the availability and cost of raw materials and energy supplies** **b the control of temperature, pressure and catalyst used produce an acceptable yield in an acceptable time**	
5.22C	Recall that fertilisers may contain nitrogen, phosphorus and potassium compounds to promote plant growth	
5.23C	Describe how ammonia reacts with nitric acid to produce a salt that is used as a fertiliser	
5.24C	Describe and compare: a the laboratory preparation of ammonium sulfate from ammonia solution and dilute sulfuric acid on a small scale b the industrial production of ammonium sulfate, used as a fertiliser, in which several stages are required to produce ammonia and sulfuric acid from their raw materials and the production is carried out on a much larger scale (details of the industrial production of sulfuric acid are not required)	

Suggested practicals

- Prepare a sample of ammonium sulfate from ammonia solution and dilute sulfuric acid.

Chemical cells and fuel cells

Students should:		Maths skills
5.25C	Recall that a chemical cell produces a voltage until one of the reactants is used up	
5.26C	Recall that in a hydrogen–oxygen fuel cell hydrogen and oxygen are used to produce a voltage and water is the only product	
5.27C	Evaluate the strengths and weaknesses of fuel cells for given uses	

Topic 9 – Separate chemistry 2

Qualitative analysis: tests for ions

Students should:		Maths skills
9.1C	Explain why the test for any ion must be unique	
9.2C	Describe flame tests to identify the following ions in solids: a lithium ion, Li^+ (red) b sodium ion, Na^+ (yellow) c potassium ion, K^+ (lilac) d calcium ion, Ca^{2+} (orange-red) e copper ion, Cu^{2+} (blue-green)	
9.3C	Describe tests to identify the following ions in solids or solutions as appropriate: a aluminium ion, Al^{3+} b calcium ion, Ca^{2+} c copper ion, Cu^{2+} d iron(II) ion, Fe^{2+} e iron(III) ion, Fe^{3+} f ammonium ion, NH_4^+ using sodium hydroxide solution	
9.4C	Describe the chemical test for ammonia	
9.5C	Describe tests to identify the following ions in solids or solutions as appropriate: a carbonate ion, CO_3^{2-}, using dilute acid and identifying the carbon dioxide evolved b sulfate ion, SO_4^{2-}, using dilute hydrochloric acid and barium chloride solution c chloride ion, Cl^-, bromide ion, Br^-, iodide ion, I^-, using dilute nitric acid and silver nitrate solution	
9.6C	*Core Practical: Identify the ions in unknown salts, using the tests for the specified cations and anions in 9.2C, 9.3C, 9.4C, 9.5C*	
9.7C	Identify the ions in unknown salts, using results of the tests above	
9.8C	Describe that instrumental methods of analysis are available and that these may improve sensitivity, accuracy and speed of tests	

Students should:	Maths skills
9.9C Evaluate data from a flame photometer: a to determine the concentration of ions in dilute solution using a calibration curve b to identify metal ions by comparing the data with reference data (no knowledge of the instrument or how it works is required)	4a

Use of mathematics

- Interpret charts, particularly in spectroscopy (4a).

Hydrocarbons

Students should:	Maths skills
9.10C Recall the formulae of molecules of the alkanes, methane, ethane, propane and butane, and draw the structures of these molecules, showing all covalent bonds	5b
9.11C Explain why the alkanes are saturated hydrocarbons	
9.12C Recall the formulae of molecules of the alkenes, ethene, propene, butene, and draw the structures of these molecules, showing all covalent bonds (but-1-ene and but-2-ene only)	5b
9.13C Explain why the alkenes are unsaturated hydrocarbons, describing that their molecules contain the functional group C=C	
9.14C Recall the addition reaction of ethene with bromine, showing the structures of reactants and products, and extend this to other alkenes	5b
9.15C Explain how bromine water is used to distinguish between alkanes and alkenes	
9.16C Describe how the complete combustion of alkanes and alkenes involves the oxidation of the hydrocarbons to produce carbon dioxide and water	

Suggested practicals

- Test for unsaturation using bromine water.

Polymers

Students should:	Maths skills
9.17C Recall that a polymer is a substance of high average relative molecular mass made up of small repeating units	
9.18C Describe: a how ethene molecules can combine together in a polymerisation reaction b that the addition polymer formed is called poly(ethene) (conditions and mechanisms not required)	5b
9.19C Describe how other addition polymers can be made by combining together other monomer molecules containing C=C, to include poly(propene), poly(chloroethene) (PVC) and poly(tetrafluoroethene) (PTFE) (conditions and mechanisms not required)	5b
9.20C Deduce the structure of a monomer from the structure of an addition polymer and vice versa	5b
9.21C Explain how the uses of polymers are related to their properties and vice versa: including poly(ethene), poly(propene), poly(chloroethene) (PVC) and poly(tetrafluoroethene) (PTFE)	
9.22C **Explain:** **a why polyesters are condensation polymers** **b how a polyester is formed when a monomer molecule containing two carboxylic acid groups is reacted with a monomer molecule containing two alcohol groups** **c how a molecule of water is formed each time an ester link is formed**	5b
9.23C Describe some problems associated with polymers including the: a availability of starting materials b persistence in landfill sites, due to non-biodegradability c gases produced during disposal by combustion d requirement to sort polymers so that they can be melted and reformed into a new product	
9.24C Evaluate the advantages and disadvantages of recycling polymers, including economic implications, availability of starting materials and environmental impact	
9.25C Recall that: a DNA is a polymer made from four different monomers called nucleotides (names of nucleotides not required) b starch is a polymer based on sugars c proteins are polymers based on amino acids	5b

Alcohols and carboxylic acids

Students should:		Maths skills
9.26C	Recall the formulae of molecules of the alcohols, methanol, ethanol, propanol (propan-1-ol only) and butanol (butan-1-ol only), and draw the structures of these molecules, showing all covalent bonds	5b
9.27C	Recall that the functional group in alcohols is –OH and that alcohols can be dehydrated to form alkenes	
9.28C	*Core Practical: Investigate the temperature rise produced in a known mass of water by the combustion of the alcohols ethanol, propanol, butanol and pentanol*	1a, 1c 2c
9.29C	Recall the formulae of molecules of the carboxylic acids, methanoic, ethanoic, propanoic and butanoic acids, and draw the structures of these molecules, showing all covalent bonds	5b
9.30C	Recall that the functional group in carboxylic acids is –COOH and that solutions of carboxylic acids have typical acidic properties	
9.31C	Recall that ethanol can be oxidised to produce ethanoic acid and extend this to other alcohols (reagents not required)	
9.32C	Recall members of a given homologous series have similar reactions because their molecules contain the same functional group and use this to predict the products of other members of these series	
9.33C	Describe the production of ethanol by fermentation of carbohydrates in aqueous solution, using yeast to provide enzymes	
9.34C	Explain how to obtain a concentrated solution of ethanol by fractional distillation of the fermentation mixture	

Suggested practicals

- Prepare a solution of ethanol by fermentation.

Bulk and surface properties of matter including nanoparticles

Students should:		Maths skills
9.35C	Compare the size of nanoparticles with the sizes of atoms and molecules	1b, 1d 2h
9.36C	Describe how the properties of nanoparticulate materials are related to their uses including surface area to volume ratio of the particles they contain, including sunscreens	1c 5c
9.37C	Explain the possible risks associated with some nanoparticulate materials	
9.38C	Compare, using data, the physical properties of glass and clay ceramics, polymers, composites and metals	2c

Students should:		Maths skills
9.39C	Explain why the properties of a material make it suitable for a given use and use data to select materials appropriate for specific uses	2c

Use of mathematics

- Estimate size and scale of atoms and nanoparticles (1d).
- Interpret, order and calculate with numbers written in standard form when dealing with nanoparticles (1b).
- Use ratios when considering relative sizes and surface area to volume comparisons (1c).
- Calculate surface areas and volumes of cubes (5c).