GCSE Science – Schemes of Work

Chemistry

Unit 2: Chemistry 2

*The suggested timings relate to the learning outcomes rather than to the activities.

Spec Reference	Summary of the Specification Content	Learning Outcomes *What most candidates should be able to do*	Suggested timing (hours)	*Opportunities to develop Scientific Communication skills* *Possible activities*	Opportunities to apply Practical and Enquiry skills	Self/Peer assessment Opportunities & resources *reference to past questions that indicate success* *Candidates should:*
C2.1 and C2.2 Structure and bonding and how structure influences the properties and uses of substances Simple particle theory is developed in this unit to include atomic structure and bonding. The arrangement of electrons in atoms can be used to explain what happens when elements react and how atoms join together to form different types of substances. Substances that have simple molecular, giant ionic and giant covalent structures have very different properties. Ionic, covalent and metallic bonds are strong. However, the forces between molecules are weaker, eg in carbon dioxide and iodine. Metals have many uses, when different metals are combined alloys are formed. Shape memory alloys have a range of uses. There are different types of polymers with different uses. Nanomaterials have new properties because of their very small size. The unit opens with an investigation into properties of covalent and ionic compounds, so that candidates develop the ideas about structure and bonding from a perspective of properties and seeking hypotheses and theories to explain known facts.						

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C2.2.1 Molecules						
a	Substances that consist of simple molecules are gases, liquids or solids that have relatively low melting points and boiling points.	Recognise that compounds with low melting and boiling points are likely to be simple molecules. Classify compounds according to their properties. Know that covalent bonds are not broken during changes of state.	1	**Presenting and writing descriptions and explanations** **Describe** the two groups that the substances can be put into. **Explain** how the properties of the substances place them within this group. **Communication for audience and purpose** **Role play** Students work in groups to model water molecules in three states of matter. Students represent an atom of hydrogen or oxygen and join together by holding hands (representing the covalent bond) . The important LO being that they model the fact that covalent bonds do not break as they	**Obtaining and presenting evidence** Investigate the melting point, conductivity, solubility and use of hand lens to study crystal structure of both ionic and covalent compounds such as NaCl, $MgSO_4$, Al_2O_3, wax and ethanol. **Working critically with primary evidence** Are there any patterns emerging from your measurements and observations? **Planning an approach** Develop an hypothesis to explain these patterns	

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				change state. Discuss: Can you change the boiling point of a liquid?		

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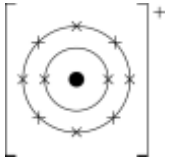
C2.1.1 Structure and bonding						
b c	Chemical bonding involves either transferring or sharing electrons in the highest occupied energy levels (shells) of atoms in order to achieve the electronic structure of a noble gas. When atoms form chemical bonds by transferring electrons, they form ions. Atoms that lose electrons become positively charged ions. Atoms that gain electrons become negatively charged ions. Ions	Describe the electronic structure of the ions in sodium chloride, magnesium oxide and calcium chloride in the following form: for sodium ion (Na+)  Recognise that the noble gas structure is unreactive.	1	**Ionic bonding** **Communication for audience and purpose** How can you show what is happening to the electrons in the reaction between sodium and chlorine using annotated diagrams? **Explain:** Why is the reaction between sodium and chlorine likely to happen? **Explain:** how ionic substances, when dissolved in water, can conduct electricity (and why as solids they cannot).. **Presenting and writing descriptions and explanations**	**Assessing risk and working safely** Show video of sodium reacting with chlorine gas to form sodium chloride. What are the risks associated with carrying out this reaction? How can you reduce these identified risks? **Developing explanations using ideas and models** Use the video about ionic bonding and periodic table to consolidate learning.	Use data sheet to give charge on ions http://www.bbc.co.uk/learningzone/clips/ionic-bonding-and-the-periodic-table/10666.html

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	have the electronic structure of a noble gas (Group 0).			Explain in terms of electron transfer other simple ionic compounds		
d	The elements in Group 1 of the periodic table, the alkali metals, all react with non-metal elements to form ionic compounds in which the metal ion has a single positive charge.					
e	The elements in Group 7 of the periodic table, the halogens, all react with the alkali metals to form ionic compounds in which the halide ions have a					

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	single negative charge.					

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C2.2.2 Ionic compounds						
b	When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and carry the current.	Explain why ionic substances are electrical conductors		**Presenting and writing descriptions and explanations** **Describe** the electrical conductivity of ionic substances. **Explain:** how ionic substances, when dissolved in water, can conduct electricity (and why as solids they cannot).	**Planning an approach** **Assessing risk and working safely** **Obtaining and presenting evidence.** Do ionic substances conduct electricity? Investigate both solutions of the ionic compound and in its solid form **Applications, Implications and cultural understanding** What use are ionic substances? Research the uses of an ionic compound e.g. sodium chloride, ammonium nitrate, barium sulfate, iron sulfate, sodium fluoride etc.	
		Use the data sheet to write correct formulae for ionic compounds		**Developing explanations using ideas and models** Write the correct formula for the		

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				following compounds: Lithium bromide, magnesium chloride, calcium oxide and sodium oxide?		
f a	An ionic compound is a giant structure of ions. Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions. These forces act in all directions in the lattice and this is called ionic bonding. Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces in all directions	Describe the form of the sodium chloride crystal lattice and explain why: • it doesn't conduct electricity • It is hard to melt.	1	**Presenting and writing descriptions and explanations** **Modelling** Use marshmallows and spaghetti (or similar) to make a model of sodium chloride lattice. **Discuss:** Why are ionic compounds hard to melt? Relate this to the regular structure of sodium chloride and its crystal structure **Describe and explain** the properties of ionic substances with a discussion of their structure and bonding .	**Developing explanations using ideas and models** Why does a solution of sodium chloride conduct electricity? Draw and annotate a diagram which models what happens when sodium chloride is added to water. **Explain** why the solution will conduct electricity **Applications, Implications and cultural understanding** Why is mixing wet hands and electricity a bad idea? Explain using examples highlighting electrical safety e.g in the home, garden and from	PPT C2 2.2.2 Foundation tier only

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	between oppositely charged ions. These compounds have high melting points and high boiling points because of the large amounts of energy needed to break the many strong bonds.				hobbies.	

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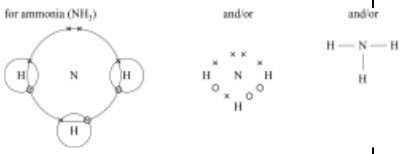
C2.1.1 Structure and bonding						
b g	Chemical bonding involves either transferring or sharing electrons in the highest occupied energy levels (shells) of atoms in order to achieve the electronic structure of a noble gas. When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong. Some covalently bonded substances consist of	Represent the covalent bonds in molecules such as water, ammonia, hydrogen, hydrogen chloride methane and oxygen, and in giant structures such as diamond and silicon dioxide in the following forms: 	1	**Presenting and writing descriptions and explanations** Draw structures of, H_2, Cl_2, O_2, HCl, H_2O, NH_3 and CH_4. Explain the covalent bonding in these molecules.	**Developing explanations using ideas and models** **Discuss:** Bonding in non-metal compounds relating properties of non-metal compounds to the electronic arrangements of non-metals and that electron shells are nearly full.	http://www.bbc.co.uk/learningzone/clips/covalent-bonding-and-the-periodic-table/10667.html PPT C2 1.1 Foundation tier only

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	simple molecules such as H_2, Cl_2, O_2, HCl, H_2O, NH_3 and CH_4.					

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C2.2.1 Molecules						
a b	Substances that consist of simple molecules are gases, liquids or solids that have relatively low melting points and boiling points. HT only **Substances that consist of simple molecules have only weak forces between the molecules (intermolecular forces). It is these intermolecular forces that are overcome, not the covalent bonds, when the**	Explain: • why covalent molecules have low melting and boiling points • **HT only that there are weak forces of attraction between the molecules that need overcoming at melting and boiling.** • why covalent molecules are unable to conduct electricity	1	**Presenting and writing descriptions and explanations** Represent the following molecules as a formula (using symbols), structural formula, dot and cross diagram and showing the full outer shells. Water, ammonia, chlorine and methane Why are molecular elements such as oxygen and nitrogen gases at room temperature? Explain why molecular substances have low melting point, and are non-conductors of electricity. Discuss: Can chemical bonds set your hair?	**Working critically with secondary evidence** **Through group discussion** Describe a covalent bond as a shared pair of electrons Explain: • why covalent bonds are poor conductors of electricity; • why covalent compounds have low melting and boiling points, • **(HT only) that there are very weak forces between molecules, not strong bonds as in ionic compounds.**	Exampro Extra Online Chemistry Activity: Structure and bonding. Exampro Extra Online Chemistry Activity: Bonding snap.

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	substance melts or boils.					
c	Substances that consist of simple molecules do not conduct electricity because the molecules do not have an overall electric charge.	Use the pattern of a substance's properties to suggest the type of structure it will have.				

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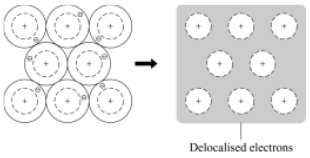
C2.1.1 Structure and bonding						
g h i	Others (covalently bonded substances) have giant covalent structures (macromolecules), such as diamond and silicon dioxide. Metals consist of giant structures of atoms arranged in a regular pattern. HT only The electrons in the highest occupied energy levels (outer shell) of metal atoms are delocalised and so free to move through	Recognise giant covalent structures and name substances that have them Describe the structure of metals, and explain why they conduct electricity. HT only Represent the bonding in metals in the following form:  Explain the flow of an electric current in terms of delocalised electrons.	1	Presenting and writing descriptions and explanations Explain through diagrams, why in terms of their structure, giant covalent structures are hard, have high melting points and cannot conduct electricity. HT only Research and discuss in a group the structure of metals and use this to explain why metals conduct electricity.	Developing explanations using ideas and models Make models of diamond and silicon dioxide using molymod kits Model metal structure with balls to show the effect of introducing different atom size to the structure. Applications, Implications and cultural understanding What are memory wires? Why are they useful?	

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	the whole structure. This corresponds to a structure of positive ions with electrons between the ions holding them together by strong electrostatic attractions.					

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C2.2.4 Metals						
a b c	HT only **Metals conduct electricity and heat because of the delocalised electrons in their structures.** The layers of atoms in metals are able to slide over each other and so metals can be bent and shaped. Alloys are usually made from two or more metals. The different sized atoms of the metals distort the layers in the structure, making it	 Use the structure of metals to explain their ability to bend and be shaped. Describe what alloys are, why they can be more useful than pure metals, and how the metal structure is altered by the insertion of different sized atoms	1	**Presenting and writing descriptions and explanations** Use annotated diagrams to explain metal and alloy structure and properties. Are alloys designer metals? What are memory alloys- how do they work? Explain why memory alloys are useful. Discuss: Is there an unusual bonding pattern in smart materials?	**Developing explanations using ideas and models** Show a model of a metal lattice structure and demonstrate how atoms can slide over each other Use this idea to explain that metals are malleable and ductile. **Obtaining and presenting evidence,** **Working critically with primary evidence** Compare samples of pure metals with alloys, eg copper and brass, iron and steel. What are the differences between the metals and the alloys **Applications, Implications and cultural understanding**	Structure of metals http://www.bbc.co.uk/learningzone/clips/the-structure-of-metals/13758.html Structure of alloys http://www.bbc.co.uk/learningzone/clips/bronze-the-first-alloy/13749.html Uses of alloys http://www.bbc.co.uk/learningzone/clips/super-alloys-and-the-jet-engine/13759.html

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	more difficult for them to slide over each other and so make alloys harder than pure metals.				What would a world without alloys be like?	
d	Shape memory alloys can return to their original shape after being deformed, eg Nitinol used in dental braces.	Define a memory alloy, and be able to give an example.				

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C2.2.3 Covalent structures						
a	Atoms that share electrons can also form giant structures or macromolecules. Diamond and graphite (forms of carbon) and silicon dioxide (silica) are examples of giant covalent structures (lattices) of atoms. All the atoms in these structures are linked to other atoms by strong covalent bonds and so they have very high melting points.	Recognise diamond and graphite from their structures. Recognise other examples of giant covalent structures from diagrams. Explain the differences in the properties of diamond and graphite. Describe diamond and graphite as being constructed from the same element, carbon.	1	**Presenting and writing descriptions and explanations** Annotate diagrams to explain the structures and properties of diamond and graphite.	**Planning an approach** Compare and contrast the structure and properties of diamond and graphite **Obtaining and presenting evidence** Test graphite and silica to demonstrate their properties as giant covalent structures.	Properties and uses of diamond http://www.bbc.co.uk/learningzone/clips/properties-and-uses-of-diamond/1863.htm Properties and uses of graphite http://www.bbc.co.uk/learningzone/clips/properties-and-uses-of-graphite/1864.html PPT C2 2.3 Foundation only
b	In diamond, each carbon atom forms four covalent bonds	Describe the covalent bonding in diamond.		**Presenting and writing descriptions and explanations**		

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c	with other carbon atoms in a giant covalent structure, so diamond is very hard. In graphite, each carbon atom bonds to three others, forming layers. The layers are free to slide over each other because there are no covalent bonds between the layers and so graphite is soft and slippery. HT only **Be able to explain the properties of graphite in terms of weak intermolecular forces between the layers.**	Describe the covalent bonding in graphite. Explain why graphite is soft and slippery. Make connections between the properties of substances and their uses. HT only **Explain how, in graphite, the other outer electron is delocalised between the sheets of covalently bonded atoms.**		Work as a group to role play the structures of diamond and graphite. Each student represents a carbon atom. Extend to show why layers make graphite soft. Can you show why diamond and graphite have very high melting points? Produce a concept map to show the links between giant covalent and simple molecular structures HT only **Describe and explain the structure and bonding in graphite**		

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d e	In graphite, one electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct electricity and heat. Carbon can also form fullerenes with different numbers of carbon atoms. Fullerenes can be used for drug delivery into the body, in lubricants, as catalysts, and in nanotubes for reinforcing materials, eg in tennis rackets.	Apply knowledge of fullerenes to explain the use of nanotubes		HT only Research fullerenes, models of fullerenes and their uses.		

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C2.2.5 Polymers						
a	The properties of polymers depend on what they are made from and the conditions under which they are made. For example, low density (LD) and high density (HD) poly(ethene) are produced using different catalysts and reaction conditions.	Explain how ▪ LD polythene and HD poly(ethene) are made ▪ the differences in polymers' properties depend on the monomer used and also the conditions under which they are made, as these influence the type of structure produced.	1	**Presenting and writing descriptions and explanations** **Discuss:** a variety of possible monomers, draw and annotate diagrams to show how different monomers polymerise. **Developing explanations using ideas and models** Use molymod kits to show how polymerisation happens. **Presenting and writing arguments** Plastics can have an adverse effect on the environment. Should all polymerisation be stopped? Consider and present your views.	**Working critically with primary evidence** Selection of polymers with different properties including LD and HD poly(ethene). What differences do you notice between the polymers? Can you explain these differences? **Activity:** Identifying LD and HD poly(ethene) using 50 parts ethanol and 50 parts water mix. **Applications, Implications and cultural understanding** What use is made of polymers?	See Exampro Extra Online Practical Guide: Making slime.
b	Thermosoftening polymers consist of individual, tangled	**HT only** **Explain how intermolecular forces. Determine the**		**Developing explanations using ideas and models** Using only string and scissors, make a	**Planning an approach** How could you test a polymer to see if it is thermosetting or	A video on the properties of plastics can be

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	polymer chains. Thermosetting polymers consist of polymer chains with cross-links between them so that they do not melt when they are heated.	**properties of thermosoftening and thermosetting polymers**		model that can show the differences between thermosetting and thermosoftening polymers.	thermosoftening? **Applications, Implications and cultural understanding** Describe the uses of some thermosetting and thermosoftening polymers.	found on the BBC website at www.bbc.co.uk/learningzone/clips by searching for clip '903'. More information on poly(ethene) can be found on the RSC Alchemy website www.rsc.org/Education/Teachers/Resources/Alchemy/index2.htm PPT C2 2.2.5 Higher tier only

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C2.2.6 Nanoscience						
a	Nanoscience refers to structures that are 1-100nm in size, of the order of a few hundred atoms. Nanoparticles show different properties to the same materials in bulk and have a high surface area to volume ratio, which may lead to the development of new computers, new catalysts, new coatings, highly selective sensors, stronger and lighter construction materials, and new	Describe the size of nano particles. Explain the use of a given nano particles application, eg in sunscreen.	1	**Presenting and writing descriptions and explanations** Use the internet and other resources to find out about nanoscience, and nanoparticles, and their current applications. **Either** In groups produce mini project/ poster. or groups givea presentation on one use of nanoparticles they have researched. **Communication for audience and purpose** Are nanoparticles safe? Should we ban nanoparticles? Research this question and list the	**Applications, Implications and cultural understanding** What are fullerenes? How do nanoparticles help keep windows clean? Can nanoparticles help fight the MRSA bacterium?	PPT C2 2.6 Foundation and Higher tiers

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	cosmetics such as sun tan creams and deodorants.			good and bad aspects of nanoscience. Debate the question in small groups		

<table>
<tr><th>Spec Reference</th><th>Summary of the Specification Content</th><th>Learning Outcomes

What most candidates should be able to do</th><th>Suggested timing (hours)</th><th>Opportunities to develop Scientific Communication skills
Possible activities</th><th>Opportunities to apply Practical and Enquiry skills</th><th>Self/Peer assessment
Opportunities & resources
reference to past questions that indicate success Candidates should:</th></tr>
<tr><td colspan="7">C2.3 Atomic structure, analysis and quantitative chemistry The relative masses of atoms can be used to calculate how much to react and how much we can produce, because no atoms are gained or lost in chemical reactions. There are various methods used to analyse these substances.</td></tr>
<tr><td colspan="7">C2.3.1 Atomic structure</td></tr>
<tr><td>a

b

c</td><td>Atoms can be represented as shown in the specification.

The relative masses of protons, neutrons and electrons are:
<table><tr><td>Name of particle</td><td>Mass</td></tr><tr><td>Proton</td><td>1</td></tr><tr><td>Neutron</td><td>1</td></tr><tr><td>Electron</td><td>Very small</td></tr></table>The total number of protons and neutrons in an atom is called</td><td>Use representation of different atoms to show atomic number and mass number.

Explain how isotopes of the same atom differ.

Calculate the atomic structure of an atom from the data on a Periodic Table.</td><td>1</td><td>Communication for audience and purpose
Use the periodic table to represent elements 1-20 as their chemical symbol, mass number and proton number e.g.

40
K
19

Can you calculate the number of protons, neutrons and electrons in elements 1-20?

Model Carbon 12 and carbon 14 using students to role play the sub-atomic particles</td><td>Developing explanations using ideas and models
Build a 3D model of an atom
There are two forms of bromine- one with a mass number of 79 the other with a mass number of 81.
Explain the difference between these two forms?
State the name given to these two forms of bromine</td><td>PPT C2 2.3.1
Foundation Tier only</td></tr>
</table>

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d e	its mass number. Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element. HT only **The relative atomic mass of an element (A_r) compares the mass of atoms of the element with the ^{12}C isotope. It is an average value for the isotopes of the element.**	HT only **Calculate A_r from provided data.** Explain that atomic masses are relative to ^{12}C isotope.		Presenting and writing descriptions and explanations HT only Explain why the mass number of an atom is a whole number but relative atomic mass is not Define relative atomic mass (A_r) Explain the connection of the ^{12}C isotope to relative atomic mass Discuss: If positive and negative things attract each other, why aren't electrons found in the nucleus of the atom?		
f	The relative formula	Calculate the relative formula		Presenting and writing descriptions and explanations	Developing explanations using ideas and models	

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g	mass (M_r) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula. The relative formula mass of a substance, in grams, is known as one mole of that substance.	mass (M_r) of a compound from its formula. Define one mole in terms of M_r and A_r		What have moles got to do with chemistry?	Chemists need to be sure of the amount of a compound present in terms of the number of molecules or atoms. Can you **calculate** relative formula mass (M_r) of some common molecules? **Obtaining and presenting evidence** Given some samples of chemical compounds, calculate the number of moles present.	

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C2.3.3 Quantitative chemistry						
a	The percentage of an element in a compound can be calculated from the relative mass of the element in the formula and the relative formula mass of the compound.	Calculate percentage mass of a named element in a formula.	1	.	**Working critically with secondary evidence** **Discuss:** how to calculate relative formula mass **Explain:** how to calculate percentage by mass of one element in a given formula eg Oxygen in water.	Exampro Extra Online chemistry activity: moles dominoes

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C2.3.2 Analysing substances						
b	Chemical analysis can be used to identify additives in foods. Artificial colours can be detected and identified by paper chromatography.	Explain how, when travelling in a solvent, substances move at different speeds and so can be identified.	1	**Presenting and writing descriptions and explanations** Describe the outcomes from the chromatograms Explain why some dyes travel further than others. Analyse given chromatograms Evaluate the use of paper chromatography in gathering evidence at crime scenes	**Obtaining and presenting evidence (KS3 revision)** Produce paper chromatograms of food dyes or inks	
a	Elements and compounds can be detected and identified using instrumental methods. Instrumental methods are accurate,	Explain how: ▪ Gas chromatography ▪ Mass spectrometer enables the analysis of substances		**Presenting and writing descriptions and explanations** **Explain** how gas chromatography separates substances in a mixture? **Describe** what a molecular ion is. What is instrumental analysis- what is	**Applications, Implications and cultural understanding** Prepare a flow chart of how gas chromatography and mass spectroscopy can help substances to be identified quickly and easily, even with	PPT C2 2.3.3 Foundation and higher tier PPT C2 2.3.3 (ii) higher only

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c	sensitive and rapid and are particularly useful when the amount of a sample is very small. Gas chromatography linked to mass spectroscopy (GC-MS) is an example of an instrumental method: ▪ Gas chromatography allows the separation of a mixture of compounds. ▪ The time taken for a substance to travel through the column can be used to help identify the			it used for and why is it useful? How would these techniques have been used in the Olympics?	small samples **HT only** Demo: Demonstration of modelmass spectrometer. Use ball bearings of different sizes rolling down a slope past a powerful magnet. Show deflection according to mass size of ball bearing. Ball bearings represent molecular ions. **Describe a mass spectrometer. Explain how it can measure the mass of a molecular ion.**	

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	substance. ▪ The output from the gas chromatography column can be linked to a mass spectrometer, which can be used to identify the substances leaving the end of the column. **HT only** **The mass spectrometer can also give the relative molecular mass of each of the substances separated in the column.**					

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C2.3.3 Quantitative chemistry						
b	HT only The empirical formula of a compound can be calculated from the masses or percentages of the elements in a compound.	HT only Calculate the empirical formulae either from a graph or from mass data.		Presenting and writing descriptions and explanations Use either a graphical method where each group plots their result on a graph to establish best fit line to get answer from, or calculate mean for the class to process using atomic masses. If time permits use both methods to see which gives result closest to the true value.	Planning an approach Selecting and managing variables Assessing risk and working safely, Obtaining and presenting evidence, Working critically with evidence Calculate the formula of either magnesium oxide or copper oxide. practically	See Exampro Extra Online Practical Activity for other details.
d	Even though no atoms are gained or lost in a chemical reaction, it is not always possible to	Explain why: • a reaction may not go to completion • some of the product may be lost when it is		How Science Works: Describe the errors in the practical? Explain how errors could be reduced. Developing models: Use the ingredients for baking a cake as	Working critically with primary evidence Class discussion about result of the experiment from last lessons.	

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e c	obtain the calculated amount of a product The amount of a product obtained is known as the yield. When compared with the maximum theoretical amount as a percentage, it is called the percentage yield. HT only The masses of reactants and products can be calculated from balanced symbol equations.	separated from the reaction mixture • some of the reactants may react in ways different from the expected reaction. Calculate the percentage of an element in a compound, given its formula. HT only Calculate empirical formulae. Calculate the masses of individual products from a given mass of a reactant and the balanced symbol equation. Calculate the necessary number of moles to balance symbol		an analogy for why yield is not what is expected – not 100%. Suggest why losses happen and link to percentage yield in chemical reactions Discuss: Class discussion on development issues relating to starting materials, yield, and energy, • How long will the reactants be available? • How much of the product do we get? • how much does it cost? HT only Calculations masses of reactants and products from balanced symbol equations. Can you calculate your own expected yield for the copper oxide/magnesium oxide experiment, and hence the percentage yield?	Suggest why results are not always correct. Understand and use the terms yield, and percentage yield correctly Applications, Implications and cultural understanding Is it a good idea to extract gold from seawater? Is it ethical to use mercury to extract metals?	

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		equations. **Calculate percentage yields of reactions.**				
f	In some chemical reactions, the products of the reaction can react to produce the original reactants. Such reactions are called reversible reactions and are represented: A + B ⇌ C + D	Explain what is meant by a reversible reaction, describe its symbol and be able to give an example	1	**Presenting and writing descriptions and explanations** Describe reversible reactions in equations by using a two single headed arrows- one going in each direction. .	**Obtaining and presenting evidence** Observe the following reversible reactions: ▪ Copper sulfate hydration/ dehydration ▪ Heating ammonium chloride in a test tube. ▪ Adding alkali and acid alternately to bromine water or to potassium chromate solution. ▪ 'blue bottle' reaction (RSC Classic Chemistry Experiments no. 83) ▪ Oscillating reaction (RSC Classic Chemistry Experiments no.140.	

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C2.4 Rates of Reaction Being able to speed up or slow down chemical reactions is important in everyday life and in industry. Changes in temperature, concentration of solution, gas pressure, surface area of solids and the presence of catalysts all affect the rates of reaction. Catalysts can help to reduce the cost of some industrial processes. This unit is very much practical led, seeking to develop the collision theory as a hypothesis, through observations, and using evidence to confirm it as a theory. **C2.4.1 Rates of reaction**						
a	The rate of a chemical reaction can be found by measuring the amount of a reactant used or the amount of product formed over time: Rate of reaction = $\frac{\text{amount of reactant used}}{\text{time}}$	Interpret graphs showing the amount of product formed (or reactant used up) with time, in terms of the rate of the reaction. Calculate rate of reaction from given data.	1	**Presenting and writing descriptions and explanations** How many different types of chemical reaction can you think of? Which of these are relatively fast and which are relatively slow? Which type of product would manufacturers want in order to make lots of product? **Presenting and writing descriptions and explanations** Calculate the rate of reaction at three times to show change in rate over the experiment.	**Obtaining and presenting evidence** React marble chips with dilute hydrochloric acid and measure the volume of carbon dioxide evolved against time taken. **How Science Works** Record results in a chart and plot a graph of results of volume of gas produced against time. **Working critically with primary evidence** Analyse the graph to obtain rate of reaction at one time. Explain clearly what the graph shows at each part: • Initially rate is fast	Exampro Extra Online Chemistry Activity: Rates of reactions.

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	Rate of reaction = amount of product used time			.	• Slows down • Reaction is complete. **Planning an approach** **Selecting and managing variables- two approaches.** **Plan one but share outcomes of both in class discussion time** 1 Plan an investigation which will follow the rate of reaction between marble chips and hydrochloric acid by measuring the mass of carbon dioxide produced and 'lost' over time Explain how you would calculate the rate of reaction in this investigation. 2. Plan an investigation into how concentration	

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					of the acid would affect the rate of reaction Describe what you think will happen and explain why you think this.	
c b	Increasing the temperature increases the speed of the reacting particles so that they collide more frequently and more energetically. This increases the rate of reaction. Chemical reactions can only occur when reacting particles collide with each other and with sufficient energy.	Explain how temperature affects rate of reaction. Explain how particles have to collide for a reaction to happen Use collision theory to explain the change in rate in terms of particle behaviour. Explain how a hypothesis may become accepted scientific knowledge.	1	**Presenting and writing descriptions and explanations** Why might increasing temperature make the reaction faster? Use this idea to develop a hypothesis based on collision theory Explain the difference between a guess, hypothesis, and theory.	**Obtaining and presenting evidence** Investigate the effect of temperature on the same reaction as last lesson.. **How Science Works:** You can get different groups to do the experiment using different instruments to measure gas volume, eg gas syringe, burette, measuring cylinder etc to develop ideas of precision. Candidates plot graph of results **Working critically with primary evidence** Compare results between groups.	

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b f	The minimum amount of energy particles must have to react is called the activation energy. Increasing the surface area of solid reactants increases the frequency of collisions and so increases the rate of reaction.	Use the idea of particle size to explain effect on rate of reaction. Explain how particles have to collide with sufficient energy for a reaction to take place Define activation energy. Use collision theory to explain the change in rate in terms of particle behaviour.	1	**Presenting and writing descriptions and explanations** Describe what activation energy is. Explain why every particle doesn't react at once?	**Obtaining and presenting evidence** Use decreasing mass method to investigate reacting equal masses of large chips and small chips of marble with dilute hydrochloric acid. **Working critically with primary evidence** Plot a graph of the results. explain the results using collision theory	
e	Increasing the concentration of reactants in solutions increases the frequency of collisions and so increases the	Explain how concentration affects rate of reaction. Use collision theory to explain the change in rate in terms of particle behaviour.	1	**Presenting and writing descriptions and explanations** Describe how changing the concentration of a reactant affects the rate of reaction Explain using collision theory why this	**Obtaining and presenting evidence** Disappearing cross method. Investigate sodium thiosulfate solution and different concentrations of dilute hydrochloric acid.	

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	rate of reaction.	.		happens	Measurements can be taken by either data logging or by eye.	
d	Increasing the pressure of reacting gases increases the frequency of collisions and so increases the rate of reaction.	Use the collision theory to explain how the change in conditions affects the rate of any reaction, in terms of particle behaviour. Explain how gas pressure affects rate of reaction.		**Presenting and writing descriptions and explanations** Draw particle diagrams to show how each change in conditions affects the particle mixture in the reaction and how this relates to the theory.	**How Science Works:** Make a prediction on the effect of altering the pressure in a gas reaction. Use collision theory to explain this prediction	
g	Catalysts change the rate of chemical reactions but are not used up during the reaction. Different reactions need different catalysts.	Describe how catalysts change the rate of a chemical reaction. Explain why this is important in industry to reduce costs. Evaluate the benefits of using a catalyst for a given process to the industry involved.	1	**Presenting and writing descriptions and explanations** **Explain:** Develop idea of catalysts helping the reaction to take place. You may wish to mention how catalysts work, active sites, forming intermediates etc.	**Obtaining and presenting evidence** Investigating the effect of catalysts. Use one of these catalysts on hydrogen peroxide: liver, potato, manganese(IV) oxide **Applications, Implications and cultural understanding**	PPT C2 2.4 Foundation tier only

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h	Catalysts are important in increasing the rates of chemical reactions used in industrial processes to reduce costs.			**Explain:** the value to industry of using catalysts in terms of reducing costs etc. Make links between how catalysts work and the need for them to have a large surface area.	Why do cars have catalysts in their exhaust system? What do they do?	

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C2.5 Exothermic and endothermic reactions Chemical reactions involve energy transfers. Many chemical reactions involve the release of energy. For other chemical reactions to occur, energy must be supplied.						
C2.5.1 Energy transfer in chemical reactions						
a b c	When chemical reactions occur, energy is transferred to or from the surroundings. An exothermic reaction is one that transfers energy to the surroundings. An endothermic reaction is one that takes in energy from the surroundings.	Describe the differences between exothermic and endothermic reactions and give examples	1	Describe the differences between exothermic and endothermic reactions and give examples Use the terms exothermic and endothermic correctly.	**Selecting and managing variables** **Obtaining and presenting evidence** What happens to the temperature in each reaction? ▪ sodium hydroxide solution and hydrochloric acid ▪ mixture of equal masses of sodium hydrogencarbonate, citric acid and ammonium nitrate dissolved in water ▪ zinc in copper sulfate solution.	Exothermic and endothermic reactions http://www.bbc.co.uk/learningzone/clips/endothermic-exothermic/13509.html
b	Examples of	Apply the idea of exothermic	1	**Presenting and writing descriptions and explanations**	**Obtaining and presenting evidence**	PPT C2 2.5

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c	exothermic reactions include combustion, many oxidation reactions and neutralisation. Everyday uses of exothermic reactions include self-heating cans (eg for coffee) and hand warmers. Endothermic reactions include thermal decompositions. Some sports injury packs are based upon endothermic reactions.	and endothermic reactions to describe uses of these types of reaction. Explain self-heating cans/ hand warmers, and sports injury packs in general terms. (no need to recall chemicals or equations for processes). Evaluate everyday uses of exothermic and endothermic reactions.		How do cold packs work? Hand warmers can be a life saver. Explain why. Discuss: Are endothermic reactions energy thieves?	Observe the heat changes in chemical reactions. **Exothermic:** ▪ burning fuel (Bunsen burner) ▪ concentrated sulfuric acid and sugar ▪ a thermite reaction ▪ hand warmer (if available) **Endothermic** ▪ ammonium nitrate and barium hydroxide Sports injury pack Investigate the temperature changes for the reversible reaction **Applications, Implications and cultural understanding** Can you devise a drink which	Foundation tier only

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d	If a reversible reaction is exothermic in one direction, it is endothermic in the opposite direction. The same amount of energy is transferred in each case.	Define a reversible reaction as one where the same energy change takes place in either direction.			cools itself? hydrated copper sulfate (blue) ⇌ (endothermic / exothermic) anhydrous copper sulfate (white) + water	

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C2. 6 Acids, bases and salts Soluble salts can be made from acids and insoluble salts can be made from solutions of ions. When acids and alkalis react the result is a neutralisation reaction.						
C.2.6.1 Making salts						
b c a	Soluble salts can be made from acids by reacting them with: metals. not all metals are suitable; some are too reactive and others are not reactive enough Salt solutions can be crystallised to produce solid salt. The state symbols in equations are (s), (l), (g) and (aq).	Explain how to make a salt from a metal + acid and that this releases hydrogen gas. Write a word equation for the reaction **HT only** **Write symbol equation for the reaction.** Interpret a symbol equation containing state symbols.	1	**Presenting and writing descriptions and explanations** **Discuss the** suitability of metals for this reaction, in terms of reactivity series. Refer to data sheet. Draw a flow chart of the steps needed to make a salt starting with a metal or metal oxide Discuss: Doe the amount of acid affect the pH?	**Obtaining and presenting evidence** Make a salt by reacting a metal with sulfuric acid. Crystallise the salt and write a symbol equation, using state symbols	

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C2.6.2 Acids and bases						
a d e	Metal oxides and hydroxides are bases. Soluble hydroxides are called alkalis. Hydrogen ions, H^+ (aq), make solutions acidic, and hydroxide ions, OH^-(aq), make solutions alkaline. The pH scale is a measure of the acidity or alkalinity of a solution. In neutralisation reactions, hydrogen ions react with hydroxide ions to	Explain how alkalis are different to bases. Describe the reaction between an acid and an alkali. Describe the ions that make substances either acid or alkali.	1	Revise pH scale from KS3. **Presenting and writing descriptions and explanations** What does pH stand for and mean? **Discuss:** What makes an acid and an alkali in terms of ions. List and produce formulae for acids and alkalis. Is there a pattern in the ions present in acids and alkalis? Describe and explain the reaction between an acid and an alkali	**Obtaining and presenting evidence** What is best for measuring pH- universal indictor solution or a pH meter?	

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	produce water. This reaction can be represented by the equation: $H^+ (aq) + OH^- (aq) \longrightarrow H_2O (l)$					

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C2.6.1 Making Salts						
b	Soluble salts can be made from acids by reacting them with alkalis. An indicator can be used to show when the acid and alkali have completely reacted to produce a salt solution.	Describe the pH scale. Describe neutralisation in terms of hydrogen ions reacting with hydroxide ions to form water.	1	**Presenting and writing descriptions and explanations** Draw annotated diagrams to explain how the salt was formed. write symbol equation, using state symbols to explain the chemical	**Obtaining and presenting evidence:** Make a salt by neutralisation of an alkali. eg NaCl (pH sensors could be used here instead of indicator paper or solution to be able to crystallise the salt without the need for boiling with carbon).	
b	Soluble salts can be made from acids by reacting them with insoluble bases.	Describe how to make a soluble salt from an insoluble base.		**Presenting and writing descriptions and explanations** Draw annotated diagrams to explain how the salt was formed.	**Obtaining and presenting evidence** Make a salt by neutralisation of an insoluble base such as copper oxide to make copper	PPT C2 2.6.1 Question matched to Foundation and Higher Tier

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	The base is added to the acid until no more will react and the excess solid is filtered off			write symbol equation, using state symbols to explain the chemical reactions involved	sulfate. Crystallise the salt.	Opportunity for assessing QWC

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C2.6.2 Acids and bases						
b c	The particular salt produced in any reaction between an acid and a base or alkali depends on: ▪ the acid used (hydrochloric acid produces chlorides, nitric acid produces nitrates, sulfuric acid produces sulfates) ▪ the metal in the base or alkali. Ammonia dissolves in water to produce an alkaline solution. It is	Predict which acid makes which salt, and which metal makes which salt. Formulate methods and starting substances to make a named soluble salt.	1	**Presenting and writing descriptions and explanations** Describe all reactions to make salts so far, include writing word and symbol equation for each one, along with the state symbols. Construct some rules for making soluble salts, eg nitric acid makes nitrates etc..	**Applications, Implications and cultural understanding** Making a salt. From a list of salts to make, state the chemicals needed and the method to use to make each one. How does growing food depend on salts?	

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	used to produce ammonium salts. Ammonium salts are important as fertilisers.					

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C2.6.1 Making salts						
d	Insoluble salts can be made by mixing appropriate solutions of ions so that a precipitate is formed. Precipitation can be used to remove unwanted ions from solutions, for example in treating water for drinking or in treating effluent.	Explain what precipitation is, and how it can be used to make insoluble salts. Explain how making insoluble salts can be useful in the water industry as a cheap and effective way of removing unwanted ions from water. Deduce the names of substances needed to make a named insoluble salt.	1	**Presenting and writing descriptions and explanations** Research and then describe and explain Minamata disease- a condition caused by contaminated fish.	**Obtaining and presenting evidence** Prepare an insoluble salt, eg lead iodide and/or barium sulfate. **Applications, Implications and cultural understanding** How can you easily remove unwanted ions from drinking water and effluents?	

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C2.7 Electrolysis Ionic compounds have many uses and can provide other substances. Electrolysis is used to produce alkalis and elements such as aluminium, chlorine and hydrogen. Oxidation-reduction reactions do not just involve oxygen.						
C2.7.1 Electrolysis						
b a	Passing an electric current through ionic substances that are molten, for example lead bromide, or in solution breaks them down into elements. This process is called electrolysis. When an ionic substance is melted or dissolved in water, the ions are free to move about within the liquid or solution.	Describe and explain how compounds can be broken down into their elements by using electricity. Know that this process is called electrolysis and explain how it works . Link the charge on the electrode to the type of ion which will move towards it	1	**Presenting and writing descriptions and explanations** **Describe** the products of electrolysis in each of the experiments or demonstrations seen. **Explain** how these product are formed Complete and balance half equations for each of the reactions Research the work of Sir Humphry Davy. Present a short presentation about his work to the group	**Obtaining and presenting evidence** Electrolysis of copper chloride solution, using carbon electrodes to obtain copper on the cathode and chlorine at the anode. Demonstrate: Electrolysis of molten lead bromide. The movement of ions, eg the electrolysis of a crystal of $KMnO_4$ on filter paper dampened with sodium chloride solution. What happens when an electric current is passed through a	You can find a variety of resources including video clips on the RSC website at www.rsc.org/education/teachers/resources/alchemy/index.htm Exampro Extra Online Chemistry Activity: Electrolysis – human model

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c	During electrolysis, positively charged ions move to the negative electrode, and negatively charged ions move to the positive electrode.	Predict the products of electrolysing solutions of ions.			solution of a salt?	
d e	Electrolysis is used to electroplate objects. This may be for a variety of reasons and includes copper plating and silver plating. At the negative electrode, positively	Explain how electroplating works. Explain in terms of oxidation and reduction the changes to ions when touching the electrodes.	1	**Presenting and writing descriptions and explanations** What is a suitable solution for electroplating a copper object with nickel? Which electrodes should be used? Explain your choice	**Obtaining and presenting evidence** electroplating copper foil with nickel (using nickel sulfate solution) **Applications, Implications and cultural understanding** What are the uses of electroplating including silver and copper? Explore what is happening in terms of electrons	

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g	charged ions gain electrons (reduction) and at the positive electrode, negatively charged ions lose electrons (oxidation). **HT only** **Reactions at electrodes can be represented by half equations, for example:** $2Cl^- \rightarrow Cl_2 + 2e^-$ **or** $2Cl^- - 2e^- \rightarrow Cl_2$	**HT only** **Interpret and/or complete half equations.**			at both electrodes.	
h	Aluminium is manufactured by the	Know the ore of aluminium.	1	**Presenting and writing descriptions and**	**Applications, Implications and cultural understanding**	Visit the RSC Alchemy for more

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	electrolysis of a molten mixture of aluminium oxide and cryolite. Aluminium forms at the negative electrode and oxygen at the positive electrode. The positive electrode is made of carbon, which reacts with the oxygen to produce carbon dioxide.	Describe how aluminium is extracted by electrolysis. Explain why cryolite is added during the process		**explanations** Through a **presentation** explore how aluminium is extracted from its ore.	Describe and explain the variation in the price of aluminium from the 1850s until the present day.	information on Aluminium at www.rsc.org/Education/Teachers/Resources/Alchemy/index.htm PPT C2 2.7 Foundation and Higher Tier question
i	The electrolysis of sodium chloride solution produces hydrogen and chlorine. Sodium hydroxide solution is also produced. These are important	Evaluate the importance of salt as an important raw material. Explain how we get other raw materials from salt Describe the uses of these	1	**Presenting and writing descriptions and explanations** Describe the products from the electrolysis of salt solution and explain how they were formed. Why hydrogen is formed?	**Obtaining and presenting evidence** Electrolysis of NaCl solution in Petri dish with universal indicator. To establish split into chlorine (bleaches indicator), an alkali (turns indicator blue/purple	RSC Alchemy video on Chemicals from Salt can be found at www.rsc.org/Education/Teachers/Resources/Alchemy/index.htm

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	reagents for the chemical industry, eg sodium hydroxide for the production of soap and chlorine for the production of bleach and plastics.	materials			**Demo:** of Hoffman voltameter to show products clearly and also to enable hydrogen gas to be collected and tested (use acidified NaCl and litmus solution to make demo spectacular and easier to understand the electrode processes).	
f	If there is a mixture of ions, the products formed depend on the reactivity of the elements involved.	Use the idea of reactivity to determine which element is formed at the negative electrode.			**Applications, Implications and cultural understanding** What is the connection between salt and margarine? What products are obtained from salt on an industrial scale?	