	Chemistry Unit 1				
		Syllabus point (text abridged)	**Boardworks Presentations**		
			GCSE Science	**Additional Science**	**Separate Sciences**
Chemistry 1a: Products from Rocks	**11.1 How do rocks provide building materials?**	To consider and evaluate the environmental, social and economic effects of exploiting limestone and producing building materials from it.	**Building Materials and Rocks**		
		To evaluate the developments in using limestone, cement, concrete and glass as building materials, and their advantages and disadvantages over other materials.	**Building Materials and Rocks**		
		All substances are made of atoms. A substance that is made of only one sort of atom is called an element. There are about 100 different elements. Elements are shown in the periodic table. The groups contain elements with similar properties.		**Atomic Structure** **Patterns in the Periodic Table**	
		Atoms of each element are represented by a chemical symbol, e.g. O represents an atom of oxygen, Na represents an atom of sodium.		**Patterns in the Periodic Table**	
		Atoms have a small central nucleus around which there are electrons.		**Atomic Structure** **Patterns in the Periodic Table**	
		When elements react, their atoms join with other atoms to form compounds. This involves giving, taking or sharing electrons and the atoms are held together by chemical bonds. (No further knowledge of ions, ionic and covalent bonding is required in this unit.)		**Ionic Bonding** **Covalent Bonding** **Chemical Reactions**	
		Atoms and symbols are used to represent and explain what is happening to the substances in chemical reactions.		**Chemical Reactions**	
		The formula of a compound shows the number and type of atoms that are joined together to make the compound.		**Ionic Bonding** **Quantitative Chemistry**	
		No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants and we can write balanced equations showing the atoms involved.		**Chemical Reactions** **Quantitative Chemistry**	
		Limestone, containing the compound calcium carbonate ($CaCO_3$), is quarried and can be used as a building material.	**Building Materials and Rocks**		
		Calcium carbonate can be decomposed by heating (thermal decomposition) to make calcium oxide (quicklime) and carbon dioxide.	**Building Materials and Rocks**		
		Carbonates of other metals decompose on heating in a similar way.	**Building Materials and Rocks**	**Chemical Reactions** **The Transition Metals**	

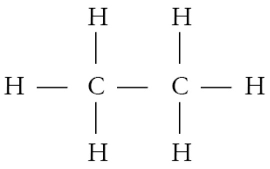
🟧		Quicklime (calcium oxide) reacts with water to produce slaked lime (calcium hydroxide).	**Building Materials and Rocks**		
		Limestone and its products have many uses, including slaked lime, mortar, cement, concrete and glass.	**Building Materials and Rocks**		

Chemistry Unit 1

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 1a: Products from Rocks	11.2 How do rocks provide metals and how are metals used?	To consider and evaluate the social, economic and environmental impacts of exploiting metal ores, using metals and recycling metals.	**Metals and Alloys** **Extracting Metals**		
		To evaluate the benefits, drawbacks and risks of using metals as structural materials and smart materials.	**Metals and Alloys** **Extracting Metals** **Designer Materials**		
		To explain how the properties of alloys (but not smart alloys) are related to models of their structures.	**Metals and Alloys**		
		Ores contain enough metal to make it economical to extract the metal. This changes over time.	**Metals and Alloys** **Extracting Metals**		
		Unreactive metals such as gold are found in the Earth as the metal itself but most metals are found as compounds that require chemical reactions to extract the metal.	**Metals and Alloys** **Extracting Metals**		
		Metals that are less reactive than carbon can be extracted from their oxides by reduction with carbon, for example, iron oxide is reduced in the blast furnace to make iron. (Details of the blast furnace are not required.)	**Extracting Metals**		
		Iron from the blast furnace contains about 96% iron. The impurities make it brittle and so it has limited uses.	**Extracting Metals**		
		Removing all of the impurities would produce pure iron. Pure iron has a regular arrangement of atoms, with layers that can slide over each other, and so is soft and easily shaped, but too soft for many uses.	**Metals and Alloys**		
		Most iron is converted into steels. Steels are alloys since they are mixtures of iron with carbon and other metals. The different sized atoms added distort the layers in the structure of the pure metal, making it more difficult for them to slide over each other, and so alloys are harder. Alloys can be designed to have properties for specific uses. Low carbon steels are easily shaped, high carbon steels are hard and stainless steels are resistant to corrosion.	**Metals and Alloys**		**Further Electro-chemistry**
		Many metals in everyday use are alloys. Pure copper, gold, and aluminium are too soft for many uses and so are mixed with small amounts of similar metals to make them harder.	**Metals and Alloys**		

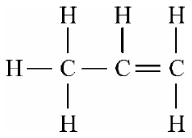
		Smart alloys can return to their original shape after being deformed.	**Metals and Alloys Designer Materials**		
		The elements in the central block of the periodic table are known as transition metals. Like other metals they are good conductors of heat and electricity and can be bent or hammered into shape. They are useful as structural materials and for making things that must allow heat or electricity to pass through them easily.		**The Transition Metals**	
		Copper has properties that make it useful for electrical wiring and plumbing. Copper is usually extracted by electrolysis. (No details are required of the extraction process.) The supply of copper-rich ores is limited. New ways of extracting copper from low-grade ores are being researched to limit the environmental impact of traditional mining.	**Extracting Metals**		
		Low density and resistance to corrosion make aluminium and titanium useful metals. These metals cannot be extracted from their oxides by reduction with carbon. Current methods of extraction are expensive because: – there are many stages in the processes – much energy is needed.	**Metals and Alloys Extracting Metals**		
		We should recycle metals because extracting them uses limited resources and is expensive in terms of energy and effects on the environment.	**Metals and Alloys Extracting Metals**		

Chemistry Unit 1

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 1a: Products from Rocks	11.3 How do we get fuels from crude oil?	To evaluate the impact on the environment of burning hydrocarbon fuels.	Earth's Atmosphere Climate Change		
		To consider and evaluate the social, economic and environmental impacts of the uses of fuels.	Earth's Atmosphere Climate Change Combustion and Alternative Fuels		
		To evaluate developments in the production and use of better fuels, for example, ethanol and hydrogen.	Combustion and Alternative Fuels		Food and Fuels
		Crude oil is a mixture of a very large number of compounds.	Making Oil Useful Fractions from Oil		
		A mixture consists of two or more elements or compounds not chemically combined together. It is possible to separate the substances in a mixture by physical methods including distillation.			CFCs and Alcohols
		Most of the compounds in crude oil consist of molecules made up of hydrogen and carbon atoms only (hydrocarbons). Most of these are saturated hydrocarbons called alkanes, which have the general formula C_nH_{2n+2}.	Making Oil Useful Fractions from Oil		
		Alkane molecules can be represented in the following forms: – C_2H_6 –  $\begin{array}{ccccccc} & & H & & H & & \\ & & \vert & & \vert & & \\ H & — & C & — & C & — & H \\ & & \vert & & \vert & & \\ & & H & & H & & \end{array}$	Making Oil Useful Fractions from Oil		
		The many hydrocarbons in crude oil may be separated into fractions, each of which contains molecules with a similar number of carbon atoms, by evaporating the oil and allowing it to condense at a number of different temperatures. This process is fractional distillation.	Making Oil Useful		

		Some properties of hydrocarbons depend on the size of their molecules. These properties influence how hydrocarbons are used as fuels.	**Making Oil Useful** **Fractions from Oil** **Combustion and Alternative Fuels**		
		Most fuels contain carbon and/or hydrogen and may also contain some sulfur. The gases released into the atmosphere when a fuel burns may include carbon dioxide, water (vapour), carbon monoxide and sulfur dioxide. Particles may also be released.	**Combustion and Alternative Fuels** **Earth's Atmosphere** **Climate Change**		
		Sulfur dioxide causes acid rain, carbon dioxide causes global warming, and particles cause global dimming.	**Earth's Atmosphere** **Climate Change**		
		Sulfur can be removed from fuels before they are burned, for example, in vehicles. Sulfur dioxide can be removed from the waste gases after combustion, for example, in power stations.	**Earth's Atmosphere** **Climate Change**		

Chemistry Unit 1

		Syllabus point (text abridged)	**Boardworks Presentations**		
			GCSE Science	**Additional Science**	**Separate Sciences**
Chemistry 1b: Oils, Earth and Atmosphere	**11.4 How are polymers and ethanol made from oil?**	To evaluate the social and economic advantages and disadvantages of using products from crude oil as fuels or raw materials for plastic and other chemicals.	**Making Oil Useful** **Fractions from Oil** **Making Polymers** **Combustion and Alternative Fuels** **Earth's Atmosphere** **Climate Change**		
		To evaluate the social, economic and environmental impacts of the use, disposal and recycling of polymers.	**Earth's Atmosphere** **Climate Change** **Making Polymers**		
		To evaluate the advantages and disadvantages of making ethanol from renewable and non-renewable sources.	**Combustion and Alternative Fuels** **Earth's Atmosphere** **Climate Change**		**CFCs and Alcohols**
		Hydrocarbons can be broken down (cracked) to produce smaller, more useful molecules. This process involves heating the hydrocarbons to vaporise them and passing the vapours over a hot catalyst. A thermal decomposition reaction then occurs.	**Making Oil Useful**		
		The products of cracking include alkanes and unsaturated hydrocarbons called alkenes. Alkenes have the general formula C_nH_{2n}.	**Making Oil Useful**		
		Unsaturated hydrocarbon molecules can be represented in the following forms: - C_3H_6 - 	**Making Polymers**		
		Some of the products of cracking are useful as fuels.	**Making Oil Useful** **Fractions from Oil**		

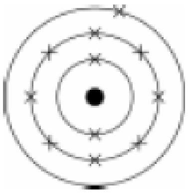
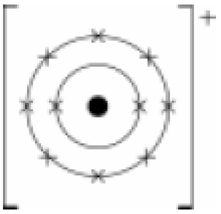
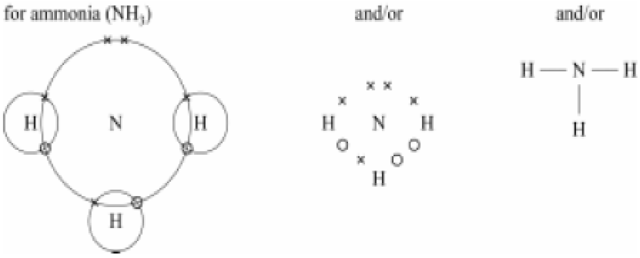
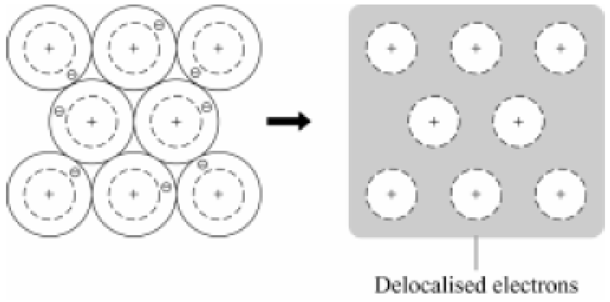
		Ethene can be reacted with steam in the presence of a catalyst to produce ethanol.			**CFCs and Alcohols**
		Alkenes can be used to make polymers such as poly(ethene) and poly(propene). In these reactions, many small molecules (monomers) join together to form very large molecules (polymers).	**Making Polymers**		
		Polymers have properties that depend on what they are made from and the conditions under which they are made. For example, slime with different viscosities can be made from poly(ethenol).	**Designer Materials** **Making Polymers**		
		Polymers have many useful applications and new uses are being developed, for example: new packaging materials, waterproof coatings for fabrics, dental polymers, wound dressings, hydrogels, smart materials, including shape memory polymers.	**Making Polymers** **Designer Materials**		
		Many polymers are not biodegradable, so they are not broken down by micro-organisms and this can lead to problems with waste disposal.	**Making Polymers** **Designer Materials**		

Chemistry Unit 1					
		Syllabus point (text abridged)	**Boardworks Presentations**		
			GCSE Science	**Additional Science**	**Separate Sciences**
Chemistry 1b: Oils, Earth and Atmosphere	**11.5 How can plant oils be used?**	To evaluate the effects of using vegetable oils in foods and the impact on diet and health.			
		To evaluate the benefits, drawbacks and risks of using vegetable oils to produce fuels.	**Combustion and Alternative Fuels**		
		To evaluate the use, benefits, drawbacks and risks of ingredients and additives in foods.	**Food Chemistry**		
		Some fruits, seeds and nuts are rich in oils that can be extracted. The plant material is crushed and the oil removed by pressing or in some cases by distillation.	**Food Chemistry**		
		Vegetable oils are important foods and fuels as they provide a lot of energy. They also provide us with nutrients.	**Food Chemistry**		
		Oils do not dissolve in water. They can be used to produce emulsions. Emulsions are thicker than oil or water and have many uses that depend on their special properties. They provide better texture, coating ability and appearance, for example, in salad dressings and ice creams.	**Food Chemistry**		
		Vegetable oils that are unsaturated contain double carbon-carbon bonds. These can be detected by reacting with bromine or iodine.	**Food Chemistry**		
		Vegetable oils that are unsaturated can be hardened by reacting them with hydrogen in the presence of a nickel catalyst at about 60 °C.			
		Processed foods may contain additives to improve appearance, taste and shelf-life. These additives must be listed in the ingredients and some permitted additives are given E-numbers.	**Food Chemistry**		
		Chemical analysis can be used to identify additives in food. Artificial colours can be detected and identified by chromatography.	**Food Chemistry**		**Chemical Analysis – Instrumental Techniques**

		Chemistry Unit 1			
		Syllabus point (text abridged)	**Boardworks Presentations**		
			GCSE Science	**Additional Science**	**Separate Sciences**
Chemistry 1b: Oils, Earth and Atmosphere	**11. 6 What are the changes in the Earth and its atmosphere?**	To explain why the theory of crustal movement (continental drift) was not generally accepted for many years after it was proposed.	**Earth's Structure**		
		To explain why scientists cannot accurately predict when earthquakes and volcanic eruptions will occur.	**Earth's Structure**		
		To explain and evaluate theories of the changes that have occurred, and are occurring, in the Earth's atmosphere.	**Earth's Structure** **Earth's Atmosphere**		
		To explain and evaluate the effects of human activities on the atmosphere.	**Earth's Atmosphere**		**CFCs and Alcohols**
		The Earth consists of a core, mantle and crust.	**Earth's Structure**		
		Scientists once thought that the features of the Earth's surface were the result of the shrinking of the crust as the Earth cooled down following its formation.			
		The Earth's crust and the upper part of the mantle are cracked into a number of large pieces (tectonic plates). Convection currents within the Earth's mantle, driven by heat released by natural radioactive processes, cause the plates to move at relative speeds of a few centimetres per year.	**Earth's Structure**		
		The movements can be sudden and disastrous. Earthquakes and/or volcanic eruptions occur at the boundaries between tectonic plates.	**Earth's Structure**		
		For 200 million years, the proportions of different gases in the atmosphere have been much the same as they are today: – about four-fifths (80%) nitrogen – about one-fifth (20%) oxygen – small proportions of various other gases, including carbon dioxide, water vapour and noble gases.	**Earth's Atmosphere**		
		The noble gases are in Group 0 of the periodic table. They are all chemically unreactive gases and are used in filament lamps and electric discharge tubes. Helium is much less dense than air and is used in balloons.		**The Noble Gases**	
		During the first billion years of the Earth's existence there was intense volcanic activity. This activity released the gases that formed the early atmosphere and water vapour that condensed to form the oceans.	**Earth's Atmosphere**		

		Some theories suggest that during this period, the Earth's atmosphere was mainly carbon dioxide and there would have been little or no oxygen gas (like the atmospheres of Mars and Venus today). There may also have been water vapour, and small proportions of methane and ammonia.	**Earth's Atmosphere**		
		Plants produced the oxygen that is now in the atmosphere.	**Earth's Atmosphere**		
		Most of the carbon from the carbon dioxide in the air gradually became locked up in sedimentary rocks as carbonates and fossil fuels.	**Earth's Atmosphere**		
		Nowadays the release of carbon dioxide by burning fossil fuels increases the level of carbon dioxide in the atmosphere.	**Earth's Atmosphere** **Climate Change**		

Chemistry Unit 2

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 2	12. 1 How do sub-atomic particles help us to understand the structure of substances?	To represent the electronic structure of the first twenty elements of the periodic table in the following forms for sodium: or 2,8,1. 		Atomic Structure Patterns in the Periodic Table	
		To represent the electronic structure of the ions in sodium chloride, magnesium oxide and calcium chloride in the following forms for sodium ion (Na+): and [2,8]+. 		Ionic Bonding	
		To represent the covalent bonds in molecules such as water, ammonia, hydrogen, hydrogen chloride, chlorine, methane and oxygen and in giant structures such as diamond and silicon dioxide, in the following forms: 		Covalent Bonding	
		HT To represent the bonding in metals in the following form: 	Metals and Alloys		
		HT To write balanced chemical equations for reactions.		Quantitative Chemistry	
		Atoms have a small central nucleus made up of protons and neutrons around which there are electrons.		Atomic Structure	

<table>
<tr><td></td><td></td><td>The relative electrical charges are as shown:<table><tr><th>Name of particle</th><th>Charge</th></tr><tr><td>Proton</td><td>+1</td></tr><tr><td>Neutron</td><td>0</td></tr><tr><td>Electron</td><td>-1</td></tr></table></td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td></td><td></td><td>In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.</td><td></td><td>Atomic Structure
Patterns in the Periodic Table</td><td></td></tr>
<tr><td></td><td></td><td>All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons.</td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td></td><td></td><td>The number of protons in an atom is called its atomic number (proton number). Atoms are arranged in the modern periodic table in order of their atomic number (proton number).</td><td></td><td>Atomic Structure
Patterns in the Periodic Table</td><td></td></tr>
<tr><td></td><td></td><td>Electrons occupy particular energy levels. Each electron in an atom is at a particular energy level (in a particular shell). The electrons in an atom occupy the lowest available energy levels (innermost available shells). (Though only energy levels are referred to throughout this specification, candidates may answer in terms of shells if they prefer.)</td><td></td><td>Atomic Structure
Patterns in the Periodic Table</td><td></td></tr>
<tr><td></td><td></td><td>Elements in the same group in the periodic table have the same number of electrons in the highest energy levels (outer electrons).</td><td></td><td>Patterns in the Periodic Table</td><td></td></tr>
<tr><td></td><td></td><td>Compounds are substances in which atoms of two or more elements are not just mixed together but chemically combined.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Chemical bonding involves either transferring or sharing electrons in the highest occupied energy levels (shells) of atoms.</td><td></td><td>Covalent Bonding</td><td></td></tr>
<tr><td></td><td></td><td>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 have the electronic structure of a noble gas (Group 0).</td><td></td><td>Ionic Bonding</td><td></td></tr>
<tr><td></td><td></td><td>The elements in Group 1 of the periodic table, the alkali metals, have similar chemical properties. They all react with non-metal elements to form ionic compounds in which the metal ion has a single positive charge.</td><td></td><td>The Alkali Metals</td><td></td></tr>
<tr><td></td><td></td><td>The elements in Group 7 of the periodic table, the halogens, have similar chemical properties. They react with the alkali metals to form ionic compounds in which the halide ions have a single negative charge.</td><td></td><td>The Halogens</td><td></td></tr>
<tr><td></td><td></td><td>An ionic compound is a giant structure of ions. Ionic compounds are held together by strong forces of attraction between oppositely charged ions. These forces act in all directions in the lattice and this is called ionic bonding.</td><td></td><td>Ionic Bonding</td><td></td></tr>
</table>

		When atoms share pairs of electrons, they form covalent bonds. These bonds between atoms are strong. Some covalently bonded substances consist of simple molecules such as H_2, Cl_2, O_2, HCl, H_2O and CH_4. Others have giant covalent structures (macromolecules), such as diamond and silicon dioxide.		**Covalent Bonding**	
		HT Metals consist of giant structures of atoms arranged in a regular pattern. The electrons in the highest occupied energy levels (outer shell) of metal atoms are delocalised and so free to move through the whole structure. This corresponds to a structure of positive ions with electrons between the ions holding them together by strong electrostatic attractions.	**Metals and Alloys**		

Chemistry Unit 2

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 2	12.2 How do structures influence the properties and uses of substances?	To relate the properties of substances to their uses.	Fractions from Oil Metals and Alloys	The Alkali Metals The Halogens The Noble Gases The Transition Metals	
		To suggest the type of structure of a substance given its properties.		Ionic Bonding Covalent Bonding	
		To evaluate developments and applications of new materials, e.g. nanomaterials, smart materials.	Designer Materials	Nano-technology	
		HT Substances that consist of simple molecules are gases, liquids or solids that have relatively low melting points and boiling points. This is because there are only weak forces between the molecules (intermolecular forces). It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.		Covalent Bonding	
		Substances that consist of simple molecules do not conduct electricity because the molecules do not have an overall electric charge.		Covalent Bonding	
		Ionic compounds have regular structures (giant ionic lattices) in which there are strong electrostatic forces in all directions between oppositely charged ions. These compounds have high melting and boiling points.		Ionic Bonding	
		When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and carry the current.		Ionic Bonding Electro-chemistry	
		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.		Covalent Bonding	
		In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure, so diamond is very hard.		Covalent Bonding	
		HT In graphite, each carbon atom bonds to three others, forming layers. The layers are free to slide over each other and so graphite is soft and slippery. One electron from each carbon atom is delocalised. These delocalised electrons allow graphite to conduct heat and electricity.		Covalent Bonding	

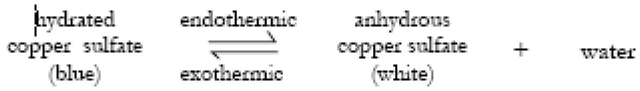
		HT Metals conduct heat and electricity because of the delocalised electrons in their structures.		**Covalent Bonding**	
		The layers of atoms in metals are able to slide over each other and so metals can be bent and shaped.	**Metals and Alloys**		
		Nanoscience refers to structures that are 1 – 100 nm 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 and stronger and lighter construction materials.	**Designer Materials**	**Nano-technology**	

<table>
<tr><th rowspan="3"></th><th colspan="5">Chemistry Unit 2</th></tr>
<tr><th rowspan="2"></th><th rowspan="2">Syllabus point (text abridged)</th><th colspan="3">Boardworks Presentations</th></tr>
<tr><th>GCSE Science</th><th>Additional Science</th><th>Separate Sciences</th></tr>
<tr><td rowspan="11">Chemistry 2</td><td rowspan="11">12.3 How much can we make and how much do we need to use?</td><td>To calculate chemical quantities involving formula mass (Mr), percentages of elements in compounds, empirical formulae, reacting masses and percentage yield.</td><td></td><td>Quantitative Chemistry</td><td>Further Quantitative Chemistry
The Chemical Industry</td></tr>
<tr><td>HT To calculate the atom economy for industrial processes and be able to evaluate sustainable development issues related to this economy.</td><td></td><td></td><td>The Chemical Industry</td></tr>
<tr><td>HT Atoms can be represented as shown:
Mass number 23
Na
Atomic number 11</td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td>The relative masses of protons, neutrons and electrons are:<table><tr><th>Name of particle</th><th>Mass</th></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></td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td>The total number of protons and neutrons in an atom is called its mass number.</td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td>Atoms of the same element can have different numbers of neutrons: these atoms are called isotopes of that element.</td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td>HT The relative atomic mass of an element (Ar) compares the mass of atoms of the element with the 12C isotope. It is an average value for the isotopes of the element.</td><td></td><td>Atomic Structure</td><td></td></tr>
<tr><td>The relative formula mass (Mr) of a compound is the sum of the relative atomic masses of the atoms in the numbers shown in the formula.</td><td></td><td>Quantitative Chemistry</td><td></td></tr>
<tr><td>The relative formula mass of a substance, in grams, is known as one mole of that substance.</td><td></td><td>Quantitative Chemistry</td><td></td></tr>
<tr><td>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.</td><td></td><td>Quantitative Chemistry</td><td></td></tr>
<tr><td>HT The masses of reactants and products can be calculated from balanced symbol equations.</td><td></td><td>Quantitative Chemistry</td><td></td></tr>
</table>

		Even though no atoms are gained or lost in a chemical reaction, it is not always possible to obtain the calculated amount of a product because: – the reaction may not go to completion because it is reversible – some of the product may be lost when it is separated from the reaction mixture – some of the reactants may react in ways different to the expected reaction.		Quantitative Chemistry	
		HT 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.		Quantitative Chemistry	The Chemical Industry
		The atom economy (atom utilisation) is a measure of the amount of starting materials that end up as useful products. It is important for sustainable development and for economical reasons to use reactions with high atom economy.		Quantitative Chemistry	The Chemical Industry
		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 $\rightleftharpoons$ C+ D ammonium chloride $\rightleftharpoons$ ammonia + hydrogen chloride		Reversible Reactions	
		HT When a reversible reaction occurs in a closed system, equilibrium is reached when the reactions occur at exactly the same rate in each direction.		Reversible Reactions	
		HT The relative amounts of all the reacting substances at equilibrium depend on the conditions of the reaction.		Reversible Reactions	
		Although reversible reactions may not go to completion, they can still be used efficiently in continuous industrial processes, such as the Haber process that is used to manufacture ammonia.		Reversible Reactions	
		The raw materials for the Haber process are nitrogen and hydrogen. Nitrogen is obtained from the air and hydrogen may be obtained from natural gas or other sources.		Reversible Reactions	
		The purified gases are passed over a catalyst of iron at a high temperature (about 450 °C) and a high pressure (about 200 atmospheres). Some of the hydrogen and nitrogen reacts to form ammonia. The reaction is reversible so ammonia breaks down again into nitrogen and hydrogen: nitrogen + hydrogen $\rightleftharpoons$ ammonia		Reversible Reactions	
		On cooling, the ammonia liquefies and is removed. The remaining hydrogen and nitrogen is recycled.		Reversible Reactions	
		HT The reaction conditions are chosen to produce a reasonable yield of ammonia quickly.		Reversible Reactions	

	Chemistry Unit 2				
		Syllabus point (text abridged)	**Boardworks Presentations**		
			GCSE Science	**Additional Science**	**Separate Sciences**
Chemistry 2	**12.4 How can we control the rates of chemical reactions?**	To interpret graphs showing the amount of product formed (or reactant used up) with time, in terms of the rate of the reaction.		**Reversible Reactions** **Rates of Reaction**	
		To explain and evaluate the development, advantages and disadvantages of using catalysts in industrial processes.		**Reversible Reactions** **Rates of Reaction**	**The Chemical Industry**
		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: $\text{Rate of reaction} = \frac{\text{amount of reactant used/amount of product formed}}{\text{time}}$		**Reversible Reactions** **Rates of Reaction**	
		The rate of a chemical reaction increases: – if the temperature increases – if the concentration of dissolved reactants or the pressure of gases increases – if solid reactants are in smaller pieces (greater surface area) – if a catalyst is used.		**Rates of Reaction**	
		Chemical reactions can only occur when reacting particles collide with each other and with sufficient energy. The minimum amount of energy particles must have to react is called the activation energy.		**Rates of Reaction** **Energy Transfer**	
		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.		**Rates of Reaction**	
		Increasing the concentration of reactants in solutions and increasing the pressure of reacting gases also increases the frequency of collisions and so increases the rate of reaction.		**Rates of Reaction**	
		HT Concentrations of solutions are given in moles per cubic decimetre (mol/dm^3). Equal volumes of solutions of the same molar concentration contain the same number of moles of solute, i.e. the same number of particles.			**Soap and Water** **Titrations**
		HT Equal volumes of gases at the same temperature and pressure contain the same number of molecules. (Candidates will not be expected to find concentrations of solutions or volumes of gases in this unit.)		**Rates of Reaction**	**Further Quantitative Chemistry**
		Catalysts change the rate of chemical reactions but are not used up during the reaction. Different reactions need different catalysts.		**Rates of Reaction**	
		Catalysts are important in increasing the rates of chemical reactions used in industrial processes to reduce costs.			**The Chemical Industry**

Chemistry Unit 2

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 2	12.5 Do chemical reactions always release energy?	To describe the effects of changing the conditions of temperature and pressure on a given reaction or process.		**Rates of Reaction**	
		To evaluate the conditions used in industrial processes in terms of energy requirements.		**Rates of Reaction**	
		When chemical reactions occur, energy is transferred to or from the surroundings.		**Energy Transfer**	
		An exothermic reaction is one that transfers energy, often as heat, to the surroundings. Examples of exothermic reactions include combustion, many oxidation reactions and neutralization.		**Energy Transfer**	
		An endothermic reaction is one that takes in energy, often as heat, from the surroundings. Endothermic reactions include thermal decomposition.		**Energy Transfer**	
		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. For example:  $\text{hydrated copper sulfate (blue)} \underset{\text{exothermic}}{\overset{\text{endothermic}}{\rightleftharpoons}} \text{anhydrous copper sulfate (white)} + \text{water}$		**Energy Transfer** **Reversible Reactions**	
		HT When a reversible reaction occurs in a closed system, equilibrium is reached when the reactions occur at exactly the same rate in each direction.			**Understand-ing Acids and Alkalis**
		HT The relative amounts of all the reacting substances at equilibrium depend on the conditions of the reaction.		**Reversible Reactions**	**Understand-ing Acids and Alkalis**
		HT If the temperature is raised, the yield from the endothermic reaction increases and the yield from the exothermic reaction decreases.		**Reversible Reactions**	**Understand-ing Acids and Alkalis**
		HT If the temperature is lowered, the yield from the endothermic reaction decreases and the yield from the exothermic reaction increases.		**Reversible Reactions**	**Understand-ing Acids and Alkalis**
		HT In gaseous reactions, an increase in pressure will favour the reaction that produces the least number of molecules, as shown by the symbol equation.			**Understand-ing Acids and Alkalis**
		HT These factors, together with reaction rates, are important when determining the optimum conditions in industrial processes, including the Haber process.		**Reversible Reactions**	**Understand-ing Acids and Alkalis**
		It is important for sustainable development as well as economic reasons to minimise energy requirements and energy wasted in industrial processes. Non-vigorous conditions mean less energy is used and less is released into the environment.		**Reversible Reactions**	**The Chemical Industry**

	Chemistry Unit 2				
		Syllabus point (text abridged)	**Boardworks Presentations**		
			GCSE Science	**Additional Science**	**Separate Sciences**
Chemistry 2	**12. 6 How can we use ions in solutions?**	To predict the products of electrolysing solutions of ions.		**Electro-chemistry**	**Further Electro-chemistry**
		To suggest methods to make a named salt.		**Chemical Reactions**	
		To explain and evaluate processes that use the principles described in this unit.			
		HT To complete and balance supplied half equations for the reactions occurring at the electrodes during electrolysis.			**Further Electro-chemistry**
		The state symbols in equations are (s), (l), (g) and (aq).		**Chemical Reactions**	
		When an ionic substance is melted or dissolved in water, the ions are free to move about within the liquid or solution.		**Electro-chemistry**	
		Passing an electric current through ionic substances that are molten or in solution breaks them down into elements. This process is called electrolysis.		**Electro-chemistry**	
		During electrolysis, positively charged ions move to the negative electrode, and negatively charged ions move to the positive electrode.		**Electro-chemistry**	
		At the negative electrode, positively charged ions gain electrons reduction) and at the positive electrode, negatively charged ions lose electrons (oxidation).		**Electro-chemistry**	
		If there is a mixture of ions, the products formed depend on the reactivity of the elements involved.		**Electro-chemistry**	
		HT Reactions at electrodes can be represented by half equations, for example: $2Cl^- \rightarrow Cl_2 + 2e^-$		**Electro-chemistry**	
		The electrolysis of sodium chloride solution produces hydrogen and chlorine. Sodium hydroxide solution is also produced. These are important reagents for the chemical industry.		**Electro-chemistry**	
		Copper can be purified by electrolysis using a positive electrode made of the impure copper and a negative electrode of pure copper in a solution containing copper ions.	**Extracting Metals**	**Electro-chemistry**	

		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.		**Chemical Reactions**	**Chemical Analysis – Chemical Techniques, Soap and Water**
		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) – insoluble bases (the base is added to the acid until no more will react and the excess solid is filtered off) – alkalis (an indicator can be used to show when the acid and alkali have completely reacted to produce a salt solution).		**Chemical Reactions**	
		Salt solutions can be crystallised to produce solid salt.		**Chemical Reactions**	**Soap and Water**
		Metal oxides and hydroxides are bases. Soluble hydroxides are called alkalis.		**Chemical Reactions**	**Understanding Acids and Alkalis**
		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.		**Chemical Reactions**	**Understanding Acids and Alkalis**
		Ammonia dissolves in water to produce an alkaline solution. It is used to produce ammonium salts. Ammonium salts are important as fertilisers.		**Reversible Reactions**	**Understanding Acids and 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.		**Chemical Reactions**	**Understanding Acids and Alkalis**
		In neutralization reactions, hydrogen ions react with hydroxide ions to produce water. This reaction can be represented by the equation: $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$		**Chemical Reactions**	**Understanding Acids and Alkalis**

Chemistry Unit 3

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 3	13.1 How was the periodic table developed and how can it help us understand the reactions of elements?	To explain how attempts to classify elements in a systematic way, including those of Newlands and Mendeleev, have led through the growth of chemical knowledge to the modern periodic table.		Patterns in the Periodic Table	
		To explain why scientists regarded a periodic table of the elements first as a curiosity, then as a useful tool and finally as an important summary of the structure of atoms.			
		Newlands, and then Mendeleev, attempted to classify the elements by arranging them in order of their atomic weights. The list can be arranged in a table so that elements with similar properties are in columns, known as Groups. The table is called a periodic table because similar properties occur at regular intervals.		Patterns in the Periodic Table	
		The early periodic tables were incomplete and some elements were placed in inappropriate Groups if the strict order of atomic weights was followed. Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered.		Patterns in the Periodic Table	
		When electrons, protons and neutrons were discovered early in the 20th century, the periodic table was arranged in order of atomic (proton) numbers. When this was done, all elements were placed in appropriate groups.		Patterns in the Periodic Table	
		The modern periodic table can be seen as an arrangement of the elements in terms of their electronic structures. Elements in the same Group have the same number of electrons in their highest occupied energy level.		Atomic Structure Patterns in the Periodic Table	
		HT The trends in reactivity within Groups in the periodic table can be explained because the higher the energy level: – the more easily electrons are lost – the less easily electrons are gained.		The Alkali Metals	
		The elements in Group 1 of the periodic table (known as the alkali metals): – are metals with low density (the first three elements in the Group are less dense than water) – react with non-metals to form ionic compounds in which the metal ion carries a charge of +1. The compounds are white solids which dissolve in water to form colourless solutions – react with water releasing hydrogen – form hydroxides which dissolve in water to give alkaline solutions.		The Alkali Metals	
		In Group 1, the further down the group an element is: – the more reactive the element – the lower its melting point and boiling point.		The Alkali Metals	

		The elements in Group 7 of the periodic table (known as halogens): – have coloured vapours – consist of molecules which are made up of pairs of atoms – form ionic salts with metals in which the chloride, bromide or iodide ion (halide ion) carries a charge of –1 – form molecular compounds with other non-metallic elements.		**The Halogens**	
		In Group 7, the further down the group an element is: – the less reactive the element – the higher its melting point and boiling point.		**The Halogens**	
		A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.		**The Halogens**	
		In the periodic table between Groups 2 and 3 is a block of elements known as the transition elements. These elements are all metals.		**The Transition Metals**	
		HT The transition elements have similar properties and some special properties because a lower energy level (inner shell) is being filled in the atoms of the elements between Groups 2 and 3. This is because the third energy level can hold up to 18 electrons, once two electrons have occupied the fourth level.		**The Transition Metals**	
		Compared with the elements in Group 1, transition elements: – have higher melting points (except for mercury) and higher densities – are stronger and harder – are much less reactive and so do not react as vigorously with water or oxygen.		**The Transition Metals**	
		Many transition elements have ions with different charges, form coloured compounds and are useful as catalysts.		**The Transition Metals**	

Chemistry Unit 3

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 3	13.2 What are strong and weak acids and alkalis? How can we find the amounts of acids and alkalis in solutions?	**HT** To evaluate the contributions of Arrhenius, Lowry and Brønsted to our understanding of acid-base behaviour.			Understanding Acids and Alkalis
		HT To suggest why the work of some scientists, for example, Arrhenius, took much longer to be accepted than the work of others, for example, Lowry and Brønsted.			Understanding Acids and Alkalis
		HT To calculate the chemical quantities in titrations involving concentrations (in moles or mass per unit volume) and masses.			Titrations
		HT An acid can be defined as a proton donor. A base can be defined as a proton acceptor.			Understanding Acids and Alkalis
		Water must normally be present for a substance to act as an acid or as a base.			Understanding Acids and Alkalis
		Acids produce hydrogen ions in aqueous solution. The H+ ion is a proton. In water this proton is hydrated and is represented as H^+ (aq).		Chemical Reactions	Understanding Acids and Alkalis
		Alkalis produce hydroxide ions, OH^- (aq), in aqueous solutions.		Chemical Reactions	Understanding Acids and Alkalis
		Acids and alkalis are classified by the extent of their ionisation in water. – A strong acid or alkali is one that is completely ionised in water. Examples of strong acids are hydrochloric, sulfuric and nitric acids. Examples of strong alkalis are sodium and potassium hydroxide. – A weak acid or alkali is only partially ionised in water. Examples of weak acids are ethanoic, citric and carbonic acids. An example of a weak alkali is ammonia solution.			Understanding Acids and Alkalis
		The volumes of acid and alkali solutions that react with each other can be measured by titration using a suitable indicator: – strong acid + strong alkali – any acid-base indicator **– HT** strong acid + weak alkali – methyl orange indicator **– HT** weak acid + strong alkali – phenolphthalein indicator.			Titrations
		HT If the concentration of one of the reactants is known, the results of a titration can be used to find the concentration of the other reactant.			Titrations

Chemistry Unit 3

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 3	13.3 What is in the water we drink?	To interpret solubility curves and explain when crystallization may occur.			**Soap and Water**
		To consider and evaluate the environmental, social and economic aspects of water quality and hardness.			**Soap and Water**
		Water in rivers, lakes and the oceans is evaporated by the heat of the Sun. This forms water vapour that rises in the atmosphere and cools so that it condenses to form clouds. The water droplets in the clouds join together to produce rain. This is known as the water cycle.			**Soap and Water**
		Many substances dissolve in water. Most ionic compounds are soluble in water. Some molecular substances are soluble but many covalent compounds are insoluble in water.		**Ionic Bonding** **Covalent Bonding**	
		The solubility of a solute in water, or any other solvent, is usually given in grams of solute per 100 grams of water (or solvent) at that temperature.			**Soap and Water**
		The solubility of most solutes that are solids increases as the temperature increases.			**Soap and Water**
		A saturated solution is one in which no more solute will dissolve at that temperature. When a hot saturated solution cools, some of the solute will separate from the solution.			**Soap and Water**
		Many gases are soluble in water. Their solubility increases as the temperature decreases and as the pressure increases. – Dissolving carbon dioxide in water under high pressure makes carbonated water. When the pressure is released, the gas bubbles out of the solution. Carbonated water is used to make fizzy drinks. – Dissolved oxygen is essential for aquatic life. If the temperature of the water increases, the amount of oxygen that is dissolved decreases.			**Soap and Water**
		Soft water readily forms lather with soap. Hard water reacts with soap to form scum and so more soap is needed to form lather.			**Soap and Water**
		Hard water contains dissolved compounds, usually of calcium or magnesium. The compounds are dissolved when water comes into contact with rocks.			**Soap and Water**
		Using hard water can increase costs because more soap is needed. When hard water is heated it can produce scale that reduces the efficiency of heating systems and kettles.			**Soap and Water**

		Hard water has some benefits because calcium compounds are good for health.			**Soap and Water**
		Hard water can be made soft by removing the dissolved calcium and magnesium ions. This can be done by: – adding sodium carbonate which reacts with the calcium and magnesium ions forming a precipitate of calcium carbonate and magnesium carbonate – using an ion exchange column containing hydrogen ions or sodium ions which replace the calcium and magnesium ions when hard water passes through the column.		**Chemical Reactions**	**Soap and Water**
		Water of the correct quality is essential for life. For humans, drinking water should have sufficiently low levels of dissolved salts and microorganisms. This is achieved by choosing an appropriate source, passing the water through filter beds to remove any solids and then sterilising with chlorine.			**Soap and Water**
		Water filters containing carbon, silver and ion exchange resins can remove some dissolved substances from tap water to improve the taste and quality.			**Soap and Water**
		Pure water can be produced by distillation.			**Soap and Water**

Chemistry Unit 3

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 3	13.4 How much energy is involved in chemical reactions?	To compare the energy produced by different fuels and foods.			**Food and Fuels**
		To consider the social, economic and environmental consequences of using fuels.	**Earth's Atmosphere** **Climate Change** **Combustion and Alternative Fuels**		**Food and Fuels**
		To interpret simple energy level diagrams in terms of bond breaking and bond formation (including the idea of activation energy and the effect on this of catalysts).		**Energy Transfer**	
		HT To calculate the energy transferred in reactions, using simple energy level diagrams or supplied bond energies.		**Energy Transfer**	
		The relative amounts of energy released when substances burn can be measured by simple calorimetry, e.g. by heating water in a glass or metal container. This method can be used to compare the amount of energy produced by fuels and foods.			**Food and Fuels**
		Energy is normally measured in joules (J). Some dietary information is given in calories, which are equal to 4.2 joules.			**Food and Fuels**
		Different foods produce different amounts of energy. Foods with high proportions of carbohydrates, fats and oils produce relatively large amounts of energy.			**Food and Fuels**
		Eating food that provides more energy than the body needs can lead to obesity.			**Food and Fuels**
		The amount of energy produced by a chemical reaction in solution can be found by mixing the reagents in an insulated container and measuring the temperature change of the solution. This method can be used for reactions of solids with water or for neutralization reactions.			**Food and Fuels**
		During a chemical reaction: – energy must be supplied to break bonds – energy is released when bonds are formed. These changes can be represented on an energy level diagram.		**Energy Transfer**	
		In an exothermic reaction, the energy released from forming new bonds is greater than the energy needed to break existing bonds.		**Energy Transfer**	
		In an endothermic reaction, the energy needed to break existing bonds is greater than the energy released from forming new bonds.		**Energy Transfer**	

Chemistry Unit 3

		Syllabus point (text abridged)	Boardworks Presentations		
			GCSE Science	Additional Science	Separate Sciences
Chemistry 3	13.5 How do we identify and analyse substances?	To interpret results of the chemical tests in this specification.			Chemical Analysis – Chemical Techniques
		To evaluate the advantages and disadvantages of instrumental methods of analysis and the features that influence that development.			Chemical Analysis – Instrumental Techniques
		To interpret and evaluate the results of instrumental analyses carried out to identify elements and compounds for forensic, health or environmental purposes.			Chemical Analysis – Instrumental Techniques
		Flame tests can be used to identify metal ions. Lithium, sodium, potassium, calcium and barium compounds produce distinctive colours in flame tests.		The Alkali Metals	Chemical Analysis – Chemical Techniques
		Carbonates react with dilute acids to form carbon dioxide. Carbon dioxide turns limewater milky.		Chemical Reactions	Chemical Analysis – Chemical Techniques
		Copper carbonate and zinc carbonate decompose on heating and can be identified by the distinctive colour changes.		Chemical Reactions	
		Aluminium, calcium and magnesium ions form white precipitates with sodium hydroxide solution but only the aluminium hydroxide precipitate dissolves in excess sodium hydroxide solution. Copper(II), iron(II) and iron(III) ions form coloured precipitates with sodium hydroxide solution.		Chemical Reactions	Chemical Analysis – Chemical Techniques
		Halide ions in solution produce precipitates with silver nitrate solution in the presence of dilute nitric acid. Silver chloride is white, silver bromide is cream and silver iodide is yellow.			Chemical Analysis – Chemical Techniques
		Sulfate ions in solution produce a white precipitate with barium chloride solution in the presence of dilute hydrochloric acid.			Chemical Analysis – Chemical Techniques
		Ammonium ions react with sodium hydroxide solution to form ammonia. Ammonia gas turns damp litmus paper blue.			Chemical Analysis – Chemical Techniques
		Nitrate ions are reduced by aluminium powder in the presence of sodium hydroxide solution to form ammonia.			Chemical Analysis – Chemical Techniques

		Organic compounds burn or char when heated in air.			
		HT The empirical formula of an organic compound can be found from the masses of the products formed when a known mass of the compound is burned.			**Further Quantitative Chemistry**
		Unsaturated organic compounds containing double carbon-carbon bonds decolourize bromine water.	**Food Chemistry**		
		The development of modern instrumental methods has been aided by the rapid progress in technologies such as electronics and computing.			**Chemical Analysis – Instrumental Techniques**
		Elements and compounds can be detected and identified using a variety of instrumental methods. Instrumental methods are accurate, sensitive and rapid and are particularly useful when the amount of a sample is very small.			**Chemical Analysis – Instrumental Techniques**
		HT Some instrumental methods are suited to identifying elements, such as atomic absorption spectroscopy used in the steel industry. Other instrumental methods are suited to identifying compounds, such as infrared spectrometry, ultraviolet spectroscopy, nuclear magnetic resonance spectroscopy, and gas-liquid chromatography. Some methods can be adapted for elements or compounds, such as mass spectrometry. (Details of how the instruments work are not required.)			**Chemical Analysis – Instrumental Techniques**