3.3 Unit 1: Chemistry 1

Throughout this unit candidates will be expected to write word equations for reactions specified. **Higher Tier candidates will also be expected to write and balance symbol equations for reactions specified throughout the unit.**

C1.1 The fundamental ideas in chemistry

Atoms and elements are the building blocks of chemistry. Atoms contain protons, neutrons and electrons. When elements react they produce compounds.

C1.1.1 Atoms

a) 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.

Additional guidance:

Candidates should understand where metals and non-metals appear in the periodic table.

b) Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen, and Na represents an atom of sodium.

Additional guidance:

Knowledge of the chemical symbols for elements other than those named in the specification is **not** required.

c) Atoms have a small central nucleus, which is made up of protons and neutrons and around which there are electrons.

d) The relative electrical charges are as shown:

Name of particle	Charge
Proton	+1
Neutron	0
Electron	–1

e) In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.

f) All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons.

g) The number of protons in an atom of an element is its atomic number. The sum of the protons and neutrons in an atom is its mass number.

Additional guidance:

Candidates will be expected to calculate the number of each sub-atomic particle in an atom from its atomic number and mass number.

h) 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). Candidates may answer questions in terms of either energy levels or shells.

Additional guidance:

Candidates should be able to represent the electronic structure of the first 20 elements of the periodic table in the following forms:

sodium
2,8,1

C1.1.2 The periodic table

a) Elements in the same group in the periodic table have the same number of electrons in their highest energy level (outer electrons) and this gives them similar chemical properties.

Additional guidance:

Knowledge is limited to the reactions of Group 1 elements with water and oxygen.

Candidates are **not** required to know of trends within each group in the periodic table, but should be aware of similarities between the elements within a group.

b) The elements in Group 0 of the periodic table are called the noble gases. They are unreactive because their atoms have stable arrangements of electrons.

Candidates should know that the noble gases have eight electrons in their outer energy level, except for helium, which has only two electrons.

C1.1.3 Chemical reactions

a) When elements react, their atoms join with other atoms to form compounds. This involves giving, taking or sharing electrons to form ions or molecules. Compounds formed from metals and non-metals consist of ions. Compounds formed from non-metals consist of molecules. In molecules the atoms are held together by covalent bonds.

Additional guidance:

Further details of the types of bonding are **not** required.

Candidates should know that metals lose electrons to form positive ions, whereas non-metals gain electrons to form negative ions. Knowledge of such transfers is limited to single electrons.

b) Chemical reactions can be represented by word equations or by symbol equations.

Candidates should be able to write word equations for reactions in the specification. The ability to interpret given symbol equations in terms of numbers of atoms is required.

Higher Tier candidates should be able to balance symbol equations.

c) No atoms are lost or made during a chemical reaction so the mass of the products equals the mass of the reactants.

Knowledge and understanding of masses in chemical reactions is limited to conservation of mass. Calculations based on relative atomic masses are **not** required but candidates should be able to calculate the mass of a reactant or product from information about the masses of the other reactants and products in the reaction.

Suggested ideas for practical work to develop skills and understanding include the following:

- modelling of atoms (using physical models or computer simulations) to illustrate chemical reactions at the atomic level
- precipitation reactions, such as lead nitrate with potassium iodide, to show conservation of mass.

C1.2 Limestone and building materials

Rocks provide essential building materials. Limestone is a naturally occurring resource that provides a starting point for the manufacture of cement and concrete.

Candidates should use their skills, knowledge and understanding to:	Additional guidance:
■ consider and evaluate the environmental, social and economic effects of exploiting limestone and producing building materials from it	Candidates should know that limestone is needed for buildings and that the positive benefits of using this material should be considered against the negative aspects of quarrying. Knowledge of building materials is limited to limestone, cement and concrete.
■ evaluate the developments in using limestone, cement and concrete as building materials, and their advantages and disadvantages over other materials.	Knowledge of particular developments is **not** required, but information may be supplied in examination questions for candidates to evaluate. Knowledge of the properties of other building materials is **not** required, but candidates may be provided with information about materials such as timber, stone, glass and steels in the examination so that they can make comparisons about their uses.

C1.2.1 Calcium carbonate

	Additional guidance:
a) Limestone, mainly composed of the compound calcium carbonate ($CaCO_3$), is quarried and can be used as a building material.	
b) Calcium carbonate can be decomposed by heating (thermal decomposition) to make calcium oxide and carbon dioxide.	
c) The carbonates of magnesium, copper, zinc, calcium and sodium decompose on heating in a similar way.	Knowledge and understanding of metal carbonates is limited to metal carbonates decomposing on heating to give carbon dioxide and the metal oxide. Candidates should be aware that not all carbonates of metals in Group 1 of the periodic table decompose at the temperatures reached by a Bunsen burner.
d) Calcium oxide reacts with water to produce calcium hydroxide, which is an alkali that can be used in the neutralisation of acids.	Knowledge of the common names quicklime and slaked lime is **not** required.

	Additional guidance:
e) A solution of calcium hydroxide in water (limewater) reacts with carbon dioxide to produce calcium carbonate. Limewater is used as a test for carbon dioxide. Carbon dioxide turns limewater cloudy.	Candidates should be familiar with using limewater to test for carbon dioxide gas.
f) Carbonates react with acids to produce carbon dioxide, a salt and water. Limestone is damaged by acid rain.	The reaction of carbonates with acids is limited to the reactions of magnesium, copper, zinc, calcium and sodium.
g) Limestone is heated with clay to make cement. Cement is mixed with sand to make mortar and with sand and aggregate to make concrete.	

Suggested ideas for practical work to develop skills and understanding include the following:

- investigation of the limestone cycle: decomposition of $CaCO_3$ to give CaO, reaction with water to give $Ca(OH)_2$, addition of more water and filtering to give limewater and use of limewater to test for CO_2
- thermal decomposition of $CaCO_3$ to show limelight
- honeycomb demonstration: heat sugar syrup mixture to 150 °C and add sodium bicarbonate
- making concrete blocks in moulds, investigation of variation of content and carrying out strength tests
- design and carry out an investigation of trends in the thermal decomposition of metal carbonates
- investigation of the reaction of carbonates with acids.

C1.3 Metals and their uses

Metals are very useful in our everyday lives. Ores are naturally occurring rocks that provide an economic starting point for the manufacture of metals. Iron ore is used to make iron and steel. Copper can be easily extracted but copper-rich ores are becoming scarce so new methods of extracting copper are being developed. Aluminium and titanium are useful metals but are expensive to produce. Metals can be mixed together to make alloys.

Candidates should use their skills, knowledge and understanding to:	Additional guidance:
■ consider and evaluate the social, economic and environmental impacts of exploiting metal ores, of using metals and of recycling metals	Candidates should know that metal ores are obtained by mining and that this may involve digging up and processing large amounts of rock. Knowledge and understanding of obtaining, using and recycling metals is limited to the metals named in the subject content.
■ evaluate the benefits, drawbacks and risks of using metals as structural materials.	Knowledge and understanding of the uses and properties of metals and alloys is limited to those specified in the subject content. Information may be given in examination questions so that candidates can evaluate their uses.

C1.3.1 Extracting metals

	Additional guidance:
a) Ores contain enough metal to make it economical to extract the metal. The economics of extraction may change over time.	Knowledge of specific examples is **not** required. Data may be provided in examination questions for candidates to analyse.
b) Ores are mined and may be concentrated before the metal is extracted and purified.	Knowledge of specific examples other than those given below is **not** required.
c) 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.	

	Additional guidance:
d) 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.	Knowledge and understanding is limited to the reduction of oxides using carbon. Knowledge of reduction is limited to the removal of oxygen. Knowledge of the details of the extraction of other metals is **not** required. Examination questions may provide further information about specific processes for candidates to interpret or evaluate. Details of the blast furnace are **not** required.
e) Metals that are more reactive than carbon, such as aluminium, are extracted by electrolysis of molten compounds. The use of large amounts of energy in the extraction of these metals makes them expensive.	Knowledge of the details of industrial methods of electrolysis is **not** required.
f) Copper can be extracted from copper-rich ores by heating the ores in a furnace (smelting). The copper can be purified by electrolysis. The supply of copper-rich ores is limited.	Details of industrial smelting processes are **not** required. ■ copper is extracted from its ores by chemical processes that involve heat or electricity ■ copper-rich ores are being depleted and traditional mining and extraction have major environmental impacts.

g) New ways of extracting copper from low-grade ores are being researched to limit the environmental impact of traditional mining.

Copper can be extracted by phytomining, or by bioleaching.

Additional guidance:

Candidates should know and understand that:

- phytomining uses plants to absorb metal compounds and that the plants are burned to produce ash that contains the metal compounds
- bioleaching uses bacteria to produce leachate solutions that contain metal compounds.

Further specific details of these processes are **not** required.

h) Copper can be obtained from solutions of copper salts by electrolysis or by displacement using scrap iron.

Candidates should know that during electrolysis positive ions move towards the negative electrode. They do **not** need to describe this in terms of oxidation and reduction, or to understand half equations.

i) Aluminium and titanium cannot be extracted from their oxides by reduction with carbon. Current methods of extraction are expensive because:

- there are many stages in the processes
- large amounts of energy are needed.

Candidates do **not** need to know the details of methods used to extract these metals, but should be able to comment on and evaluate information that is given about the chemical processes that can be used.

j) We should recycle metals because extracting them uses limited resources and is expensive in terms of energy and effects on the environment.

Candidates are **not** required to know details of specific examples of recycling, but should understand the benefits of recycling in the general terms specified here.

C1.3.2 Alloys

a) Iron from the blast furnace contains about 96% iron. The impurities make it brittle and so it has limited uses.

Additional guidance:

Knowledge of uses of blast furnace iron is limited to blast furnace iron being used as cast iron because of its strength in compression.

b) Most iron is converted into steels. Steels are alloys since they are mixtures of iron with carbon. Some steels contain other metals. 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.

Knowledge and understanding of the types of steel and their properties is limited to those specified in the subject content. Information about the composition of specific types of steel may be given in examination questions so that candidates can evaluate their uses.

c) Most metals in everyday use are alloys. Pure copper, gold, iron and aluminium are too soft for many uses and so are mixed with small amounts of similar metals to make them harder for everyday use.

Candidates should be familiar with these specified examples but examination questions may contain information about alloys other than those named in the subject content to enable candidates to make comparisons.

C1.3.3 Properties and uses of metals

	Additional guidance:
a) 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.	Knowledge of the properties of specific transition metals other than those named in this unit is **not** required.
b) Copper has properties that make it useful for electrical wiring and plumbing.	Candidates should know and understand that copper: ■ is a good conductor of electricity and heat ■ can be bent but is hard enough to be used to make pipes or tanks ■ does not react with water.
c) Low density and resistance to corrosion make aluminium and titanium useful metals.	

Suggested ideas for practical work to develop skills and understanding include the following:

- comparing less reactive metals (gold, silver, copper) with more reactive metals, eg in acid
- heating metal oxides with carbon to compare reactivity, eg CuO, PbO, Fe_2O_3
- heating copper carbonate with charcoal to produce copper
- displacement reactions, eg $CuSO_4$(aq) + Fe (using temperature sensors to investigate differences in metal reactivity)
- investigation of the physical properties of metals and alloys, eg density / thermal and electrical conductivity
- electrolysis of copper sulfate solution using copper electrodes
- ignition tube demonstration of blast furnace – potassium permanganate, mineral wool plug, iron oxide mixed with carbon
- investigation of phytomining: growing brassica plants in compost with added copper sulfate or spraying brassica plants (eg cabbage leaves) with copper sulfate solution, ashing the plants (fume cupboard), adding sulfuric acid to the ash, filtering and obtaining the metal from the solution by displacement or electrolysis.

C1.4 Crude oil and fuels

Crude oil is derived from an ancient biomass found in rocks. Many useful materials can be produced from crude oil. Crude oil can be fractionally distilled. Some of the fractions can be used as fuels. Biofuels are produced from plant material. There are advantages and disadvantages to their use as fuels. Fuels can come from renewable or non-renewable resources.

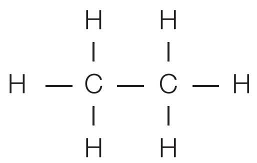
Candidates should use their skills, knowledge and understanding to:	**Additional guidance:**
■ evaluate the impact on the environment of burning hydrocarbon fuels	Knowledge and understanding of the products of burning hydrocarbon fuels and the effects of these products is limited to those named in the subject content for this section.
■ consider and evaluate the social, economic and environmental impacts of the uses of fuels	Candidates may be given information and data about other fuels and their products of combustion for comparison and evaluation in the examinations.
■ evaluate developments in the production and uses of better fuels, for example ethanol and hydrogen	Candidates should know and understand the benefits and disadvantages of ethanol and hydrogen as fuels in terms of: ■ use of renewable resources ■ storage and use of the fuels ■ their products of combustion.
■ evaluate the benefits, drawbacks and risks of using plant materials to produce fuels.	

C1.4.1 Crude oil

	Additional guidance:
a) Crude oil is a mixture of a very large number of compounds.	
b) A mixture consists of two or more elements or compounds not chemically combined together. The chemical properties of each substance in the mixture are unchanged. It is possible to separate the substances in a mixture by physical methods including distillation.	
c) 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}.	Candidates are **not** expected to know the names of specific alkanes other than methane, ethane and propane.

C1.4.2 Hydrocarbons

a) Alkane molecules can be represented in the following forms:

- C_2H_6
- 

Additional guidance:

Candidates should be able to recognise alkanes from their formulae in any of the forms but do not need to know the names of individual alkanes other than methane, ethane, propane and butane.

Candidates should know that in displayed structures — represents a covalent bond.

b) 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.

Candidates should know and understand the main processes in continuous fractional distillation in a fractionating column.

Knowledge of the names of specific fractions or fuels is **not** required.

c) Some properties of hydrocarbons depend on the size of their molecules. These properties influence how hydrocarbons are used as fuels.

Knowledge of trends in properties of hydrocarbons is limited to:

- boiling points
- viscosity
- flammability.

C1.4.3 Hydrocarbon fuels

a) Most fuels, including coal, 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, sulfur dioxide and oxides of nitrogen. Solid particles (particulates) may also be released.

Additional guidance:

Candidates should be able to relate products of combustion to the elements present in compounds in the fuel and to the extent of combustion (whether complete or partial).

No details of how the oxides of nitrogen are formed are required, other than the fact that they are formed at high temperatures.

Solid particles may contain soot (carbon) and unburnt fuels.

b) The combustion of hydrocarbon fuels releases energy. During combustion the carbon and hydrogen in the fuels are oxidised.

	Additional guidance:
c) Sulfur dioxide and oxides of nitrogen cause acid rain, carbon dioxide causes global warming, and solid particles cause global dimming.	Candidates are not required to know details of any other causes of acid rain or global warming.
d) 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.	Knowledge of the methods of removing sulfur is **not** required.
e) Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use.	Knowledge of the methods of biofuel production is **not** required but candidates may be given information from which a range of questions may be asked.

Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of fractional distillation of crude oil using CLEAPSS mixture (take care to avoid confusion with the continuous process in a fractionating column)
- design an investigation on viscosity, ease of ignition or sootiness of flame of oils or fuels
- comparison of the energy content of different fuels, for example by heating a fixed volume of water
- demonstration of the production of solid particles by incomplete combustion using a Bunsen burner yellow flame or a candle flame to heat a boiling tube of cold water
- collecting and testing the products of combustion of candle wax and methane
- demonstration of burning sulfur or coal in oxygen and then testing the pH of the gas produced
- design an investigation on growing cress from seeds in various concentrations of sodium metabisulfite solution to show how acid rain affects plants.

C1.5 Other useful substances from crude oil

Fractions from the distillation of crude oil can be broken down (cracked) to make smaller molecules including unsaturated hydrocarbons such as ethene. Unsaturated hydrocarbons can be used to make polymers and ethene can be used to make ethanol. Ethanol can also be made by fermentation.

Candidates should use their skills, knowledge and understanding to:

- evaluate the social and economic advantages and disadvantages of using products from crude oil as fuels or as raw materials for plastics and other chemicals

Additional guidance:

Candidates should be aware that crude oil is used to produce fuels and chemicals, and that it is a limited resource.

Candidates should be able to evaluate information about the ways in which crude oil and its products are used. Although candidates will probably know the names of some common polymers, these are **not** required knowledge, unless they are included in the subject content for this section.

- evaluate the social, economic and environmental impacts of the uses, disposal and recycling of polymers

- evaluate the advantages and disadvantages of making ethanol from renewable and non-renewable sources.

Additional guidance:

Candidates should be able to compare the environmental impact of producing ethanol from renewable and non-renewable sources.

C1.5.1 Obtaining useful substances from crude oil

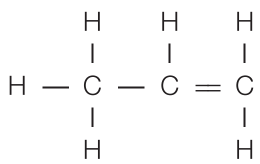
a) Hydrocarbons can be cracked to produce smaller, more useful molecules. This process involves heating the hydrocarbons to vaporise them. The vapours are either passed over a hot catalyst or mixed with steam and heated to a very high temperature so that thermal decomposition reactions then occur.

b) The products of cracking include alkanes and unsaturated hydrocarbons called alkenes. Alkenes have the general formula C_nH_{2n}.

Additional guidance:

Candidates should be able to recognise alkenes from their names or formulae, but do **not** need to know the names of individual alkenes, other than ethene and propene.

c) Unsaturated hydrocarbon molecules can be represented in the following forms:

- C_3H_6
- 

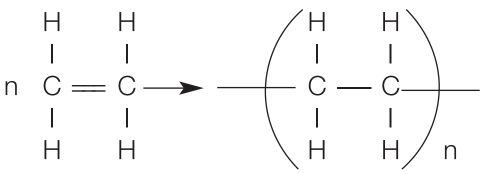
Candidates should know that in displayed structures ═ represents a double bond.

d) Alkenes react with bromine water, turning it from orange to colourless.

e) Some of the products of cracking are useful as fuels.

C1.5.2 Polymers

a) 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).
For example:



ethene poly(ethene)

Additional guidance:

Candidates should be able to recognise the molecules involved in these reactions in the forms shown in the subject content. They should be able to represent the formation of a polymer from a given alkene monomer.

Further details of polymerisation are **not** required.

b) 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).

Candidates should consider the ways in which new materials are being developed and used, but will **not** need to recall the names of specific examples.

c) Many polymers are not biodegradable, so they are not broken down by microbes and this can lead to problems with waste disposal.

Knowledge of specific named examples is **not** required, but candidates should be aware of the problems that are caused by landfill sites and by litter.

d) Plastic bags are being made from polymers and cornstarch so that they break down more easily. Biodegradable plastics made from cornstarch have been developed.

C1.5.3 Ethanol

a) Ethanol can be produced by hydration of ethene with steam in the presence of a catalyst.

Additional guidance:

No further details of these processes are required.

b) Ethanol can also be produced by fermentation with yeast, using renewable resources. This can be represented by:

sugar → carbon dioxide + ethanol

Suggested ideas for practical work to develop skills and understanding include the following:

- demonstration of the cracking of liquid paraffin using broken pottery as the catalyst
- testing for unsaturation in the alkenes using bromine water
- making a polymer from cornstarch
- demonstration of making Perspex
- molecular modelling of polymers
- design an investigation of a property of different plastics, eg strength, flexibility, biodegradability
- investigate the amount of water that can be absorbed by a hydrogel (eg those used as additives to garden composts)
- testing coated fabrics for water penetration.

C1.6 Plant oils and their uses

Many plants produce useful oils that can be converted into consumer products including processed foods. Emulsions can be made and have a number of uses. Vegetable oils can be hardened to make margarine. Biodiesel fuel can be produced from vegetable oils.

Candidates should use their skills, knowledge and understanding to:	Additional guidance:
evaluate the effects of using vegetable oils in foods and the impacts on diet and health	Knowledge is limited to the high-energy content of vegetable oils, the possible health benefits of unsaturated fats compared with saturated fats, and the effects of cooking foods in oil. Information may be provided in examinations for candidates to evaluate.
evaluate the use, benefits, drawbacks and risks of emulsifiers in foods.	Candidates do **not** need to recall the names of specific additives. Further information will be provided in questions for evaluation and comparison.

C1.6.1 Vegetable oils

	Additional guidance:
a) 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. Water and other impurities are removed.	Candidates should study the general principles of the extraction of vegetable oils, such as olive oil, rapeseed oil or lavender oil. Knowledge of specific examples or processes is **not** required.
b) Vegetable oils are important foods and fuels as they provide a lot of energy. They also provide us with nutrients.	Knowledge of the details of the production of biodiesel is **not** required. Knowledge of specific nutrients is **not** required.

c) Vegetable oils have higher boiling points than water and so can be used to cook foods at higher temperatures than by boiling. This produces quicker cooking and different flavours but increases the energy that the food releases when it is eaten.

C1.6.2 Emulsions

a) 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, ice creams, cosmetics and paints.

Additional guidance:

Candidates should study how emulsions are made and should understand the role of emulsifiers in producing emulsions that are more stable. Knowledge of specific names of ingredients in proprietary products is **not** required.

b) **Emulsifiers have hydrophilic and hydrophobic properties.**

HT only

Knowledge is limited to a simple model of the structure of emulsifier molecules.

C1.6.3 Saturated and unsaturated oils

a) Vegetable oils that are unsaturated contain double carbon–carbon bonds. These can be detected by reacting with bromine water.

Additional guidance:

Candidates should be familiar with a test for unsaturation using bromine water.

b) **Vegetable oils that are unsaturated can be hardened by reacting them with hydrogen in the presence of a nickel catalyst at about 60 °C. Hydrogen adds to the carbon–carbon double bonds. The hydrogenated oils have higher melting points so they are solids at room temperature, making them useful as spreads and in cakes and pastries.**

HT only

Candidates should know how and why vegetable oils are hardened for use in foods. Knowledge of trans fats is not required.

Examination questions may provide further information from which candidates may be asked to make comparisons.

Suggested ideas for practical work to develop skills and understanding include the following:

- pressing nuts (eg walnuts) between paper towels and studying the grease marks
- steam distillation of lavender oil, orange oil, lemon oil, olive oil, rapeseed oil or vegetable oil
- simple calorimetery investigations using small spirit burners or bottle tops to measure the energy released from various oils (weigh before and after, and measure the temperature change for a known mass of water)
- making emulsions, eg oil/water, oil/vinegar
- design and carry out an investigation into the effect of emulsifiers on the stability of emulsions
- using bromine water to test fats and oils for unsaturation, eg testing sunflower oil against butter (using colorimeter to measure level of unsaturation).

C1.7 Changes in the Earth and its atmosphere

The Earth and its atmosphere provide everything we need. The Earth has a layered structure. The surface of the Earth and its atmosphere have changed since the Earth was formed and are still changing. The atmosphere has been much the same for the last 200 million years and provides the conditions needed for life on Earth. Recently human activities have resulted in further changes in the atmosphere. There is more than one theory about how life was formed.

Candidates should use their skills, knowledge and understanding to:

- recognise that the Earth's crust, the atmosphere and the oceans are the only source of minerals and other resources that humans need

	Additional guidance:
■ explain why Wegener's theory of crustal movement (continental drift) was not generally accepted for many years	Candidates should have studied accounts of Wegener's work. Knowledge is limited to the theories relating to mountain building and continental drift. Candidates should know that 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.
■ explain why scientists cannot accurately predict when earthquakes and volcanic eruptions will occur	Candidates may be given information which they will be expected to interpret.
■ explain and evaluate theories of the changes that have occurred and are occurring in the Earth's atmosphere	Candidates should be able to compare and evaluate different theories when given suitable information.
■ explain and evaluate the effects of human activities on the atmosphere	Knowledge of the effects of human activities is limited to those in the subject content.
■ **describe why we do not know how life was first formed.**	**HT only**

C1.7.1 The Earth's crust

	Additional guidance:
a) The Earth consists of a core, mantle and crust, and is surrounded by the atmosphere.	Knowledge is limited to the names of the three major parts, and an awareness of the relative sizes of these features.
b) The Earth's crust and the upper part of the mantle are cracked into a number of large pieces (tectonic plates).	Knowledge of the names, shapes or locations of specific plates is **not** required.
c) 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.	Candidates should know that the mantle is mostly solid, but that it is able to move slowly.

d) The movements can be sudden and disastrous. Earthquakes and / or volcanic eruptions occur at the boundaries between tectonic plates.

Additional guidance:

Knowledge of the changes that occur at plate boundaries is limited to earthquakes and volcanic eruptions.

Knowledge of the mechanism of these changes is **not** required.

C1.7.2 The Earth's atmosphere

a) 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.

b) 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.

c) There are several theories about how the atmosphere was formed.

One theory suggests 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.

Additional guidance:

No knowledge of other theories is required. Information may be given in questions which candidates will be expected to interpret.

d) There are many theories as to how life was formed billions of years ago.

e) One theory as to how life was formed involves the interaction between hydrocarbons, ammonia and lightning.

Additional guidance:

HT only

Candidates should be aware of the Miller-Urey experiment and the 'primordial soup' theory, but they should know that this is not the only theory.

f) Plants and algae produced the oxygen that is now in the atmosphere.

Candidates should be aware that plants and algae produce oxygen by a process called photosynthesis and that this process uses carbon dioxide from the atmosphere.

Knowledge of the process of photosynthesis is **not** required.

g) Most of the carbon from the carbon dioxide in the air gradually became locked up in sedimentary rocks as carbonates and fossil fuels.

Additional guidance:

Candidates should know that carbon dioxide dissolves in the oceans and that limestone was formed from the shells and skeletons of marine organisms. Fossil fuels contain carbon and hydrocarbons that are the remains of plants and animals.

h) The oceans also act as a reservoir for carbon dioxide but increased amounts of carbon dioxide absorbed by the oceans has an impact on the marine environment.

i) Nowadays the release of carbon dioxide by burning fossil fuels increases the level of carbon dioxide in the atmosphere.

Additional guidance:

Candidates should be aware that this increase in carbon dioxide is thought to be causing global warming but, for this unit, candidates do **not** need to know how CO_2 causes this effect.

j) **Air is a mixture of gases with different boiling points and can be fractionally distilled to provide a source of raw materials used in a variety of industrial processes.**

HT only

Knowledge of the boiling points of the different gases is not required.

Suggested ideas for practical work to develop skills and understanding include the following:

- investigating the composition of air by passing air over heated copper using gas syringes and measuring the percentage of oxygen. Then burning magnesium in the nitrogen to form Mg_3N_2. Add water to produce ammonia (nitrogen must have come from the air)
- collecting gas produced by aquatic plants and testing for oxygen (using dissolved oxygen sensor)
- measuring the amount of carbon dioxide in inhaled and exhaled air (using carbon dioxide sensor)
- testing the products of combustion of fuels to show that carbon dioxide is produced
- design an investigation to compare the amount of carbon dioxide released by reacting crushed shells (eg cockle, oyster) with dilute hydrochloric acid.