C1 Chemistry Revision Checklist

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.

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

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.

h) Electrons occupy particular energy levels or shells and be able to represent the electronic structure of the first twenty 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.
Knowledge of reactions of Group 1 elements with water and oxygen. elements in Group 0 of the periodic table are called the noble gases

C1.1.3 Chemical reactions

a) When elements react, their atoms join with other atoms to form compounds. 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.
Metals lose electrons to form positive ions, whereas non-metals gain electrons to form negative ions.

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

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.

C1.2.1 Calcium carbonate

a) Limestone, mainly composed of the compound calcium carbonate (CaCO3), 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.
You 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.

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. Limewater to test for carbon dioxide gas.

f) Magnesium, copper, zinc, calcium and sodium carbonates react with acids to produce carbon dioxide, a salt and water. Limestone is damaged by acid rain.

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.

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.

C1.3.1 Extracting metals

a) Ores contain enough metal to make it economical to extract the metal.

b) Ores are mined and may be concentrated before the metal is extracted and purified.

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.

d) Metals that are less reactive than carbon can be extracted from their oxides by reduction with carbon.

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.

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.

• 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.

• 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.

h) Copper can be obtained from solutions of copper salts by electrolysis or by displacement using scrap iron. During electrolysis positive ions move towards the negative electrode

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.

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

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.

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.

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.

C1.3.3 Properties and uses of metals

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.

b) Copper has properties that make it useful for electrical wiring and plumbing.
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.

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.

C1.4.1 Crude oil

a) Crude oil is a mixture of a very large number of compounds.

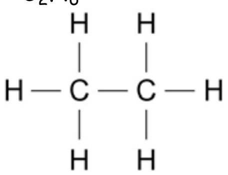
b) A mixture consists of two or more elements or compounds not chemically combined together. The chemical properties of each substance in the mixture are unchanged.

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}.

C1.4.2 Hydrocarbons

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

• C_2H_6



Know the names of individual alkanes - methane, ethane, propane and butane.

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.

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.

Larger hydrocarbons have higher boiling points, viscosities and are less flammable because they have stronger intermolecular forces of attraction between the molecules.

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.

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

c) Sulfur dioxide and oxides of nitrogen cause acid rain, carbon dioxide causes global warming, and solid particles cause global dimming.

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.

e) Biofuels, including biodiesel and ethanol, are produced from plant material. There are economic, ethical and environmental issues surrounding their use.

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.

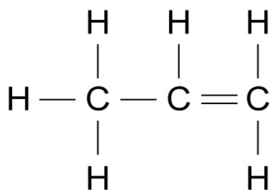
C1.5.1 Obtaining useful substances from crude oil

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 double bonds and have the general formula C_nH_{2n}.

c) Unsaturated hydrocarbon molecules have double bonds = and can be represented in the following forms:

- C_3H_6

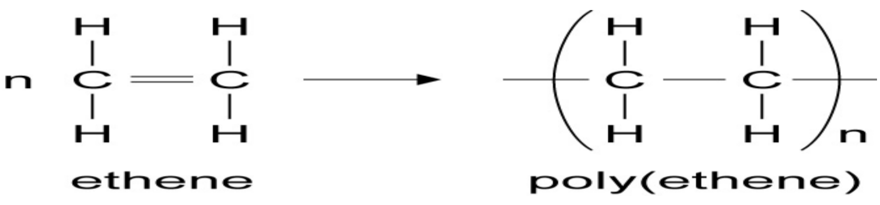


d) Alkenes react with bromine water, turning it from orange to colourless.

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:



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).

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

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.

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

sugar → carbon dioxide + ethanol

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.

C1.6.1 Vegetable oils

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.

b) Vegetable oils are important foods and fuels as they provide a lot of energy. They also provide us with nutrients.

c) Vegetable oils have higher boiling points than water because they have stronger intermolecular forces of attraction 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.

b) **Emulsifiers have hydrophilic and hydrophobic properties (Higher Tier only)**

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. The bromine water goes from orange to colourless.

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 (Higher Tier only)**

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.		
C1.7.1 The Earth's crust		
a) The Earth consists of a core, mantle and crust, and is surrounded by the atmosphere. b) The Earth's crust and the upper part of the mantle are cracked into a number of large pieces (tectonic plates). Where plates move apart magma can rise to the surface and cool to form new rock e.g. mid–atlantic ridge. Where plates collide volcanoes and fold mountains can be formed. 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. The mantle is mostly solid but is able to move slowly like a liquid. d) The movements can be sudden and disastrous. Earthquakes and/or volcanic eruptions occur at the boundaries between tectonic plates. Scientists cannot accurately predict where these will occur because they do not know exactly what is happening in the mantle or where forces/pressure are building up. e) Scientists once thought that the features of the Earth's surface e.g. mountains were the result of the shrinking of the crust as the Earth cooled down following its formation. Wegener's theory of crustal movement (continental drift) was not generally accepted for many years.		
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. 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 based on the Miller-Urey experiment and the 'primordial soup' theory (Higher Tier Only)**. f) Plants and algae produced the oxygen that is now in the atmosphere through photosynthesis. g) Most of the carbon from the carbon dioxide in the air gradually became locked up in sedimentary rocks as carbonates and fossil fuels. Carbon dioxide dissolves in the oceans and		

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 that is thought to be causing global warming. 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 (Higher Tier Only).**		