4. Understand the importance of purity in substances in everyday life, e.g. foodstuffs and drugs.

Importance of Purity:

- It is essential to make sure some substances are pure.
  - For example, substances used as food additives, and in medical drugs and vaccines.
- **Foodstuff**: Purity in foodstuff and drugs can be very important to make sure that what we are consuming is what we are expecting to consume. Allergies might become an issue.
- **Medicine**: If there are different things in it than what is intended, the patient may not get better and may even get much worse.

5. Identify substances and assess their purity from melting point and boiling point information.

A Pure Substance:

- Has no particles of any other substance mixed with it.
- Melts and boils at temperatures that are unique to it.
  - Ex: ice melts at 0°C and water boils at 100°C – no other substance has those melting and boiling points.
- Melts sharply at its melting point.

An Impure Substance:

- Has particles of another substance mixed with it.
- Melts over a range of temperature, not sharply.
  - Melts at a lower temperature than the pure substance.
  - Boils at a higher temperature than the pure substance.

Conclusion:

- By measuring the melting and boiling point of a substance, you can tell if it is pure.
- Identify an unknown pure substance, by measuring its melting and boiling points, and then looking these up in tables.

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6. Suggest suitable purification techniques, given information about the substances involved.

To purify a substance, you have to separate the unwanted substances from it.

Terminology:

- Mixture – 2 or more substances that are not chemically combined.
- Solution – a mixture made by dissolving a substance in a solvent.
- Solute – the substance that you dissolve.
- Solvent – the liquid in which you dissolve the substance.

Separation Methods:

- **Filtration**: To separate an insoluble solid from a liquid.
- **Crystallization**: To separate the solute from a solution.
- **Simple Distillation**: To separate the solvent from a solution.
- **Fractional Distillation**: To separate 2 or more miscible liquids (liquids that mix completely)

C3. Atoms, elements and compounds

3.1 Physical & chemical changes

1. Identify physical and chemical changes, and understand the differences between them.

Chemical Changes:

- These occur when a substance combines with another to form a new substance.
- Examples:
  - Rotting fruit
  - Mixing chemicals
  - Tarnishing silver

Distribution:

- The first shell can hold **2** electrons.
  - It fills up first – is at the lowest energy level.
- The second shell can hold **8** electrons.
  - It fills up next.
- The third shell can hold 18 electrons, but it fills up to **8**.
  - The next **2** go into the fourth shell – after that the rest of the third shell fills.

Electron Configuration:

- The distribution of the electrons in their shells, is: 2, 8, 8.

3. State the relative charges and approximate relative masses of protons, neutrons and electrons.

Particle	Mass – in relative atomic mass units	Charge
Proton (p)	1	1+ (positive)
Neutron (n)	1	No charge
Electron (e)	1/1840 (almost nothing – 0)	1- (negative)

4. Define proton number and nucleon number.

Proton Number:

- The **atomic number** (also called the proton number) is the number of protons in an atom.

Nucleon Number:

- The **mass number** (also called the nucleon number) is the total number of protons and neutrons in an atom.

5. Use proton number and the simple structure of atoms to explain the basis of the Periodic Table (see C9), with special reference to the elements with proton numbers 1 to 20.

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Explanation:

- Elements are arranged in order of their proton number, row by row.
- The rows are called **periods**, and the columns are called **groups**.
- The period number shows how many shells there are.
- The group number for Groups I to VII is the same as the number of outer-shell electrons.
  - The outer-shell electrons are often called the **valency electrons**.
- The outer-shell electrons dictate how the element reacts.
  - All the elements in Group I have similar reactions, because their atoms all have one outer-shell electron.
- The atoms of the Group VIII elements (the noble gases) have 8 electrons in their outer shells - except for helium, which has 2.
- This arrangement makes these atoms stable - Group VIII elements are unreactive.

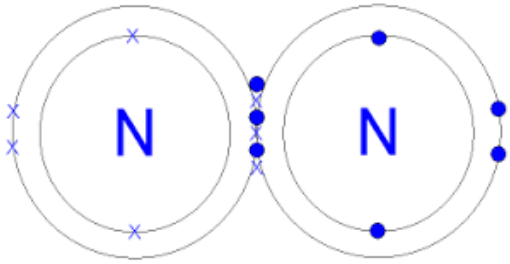
The Elements after Calcium:

- After calcium, the shells fill in a more complex order.

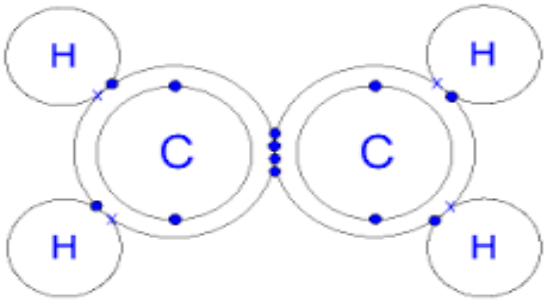
		Where the element is in the Period Table		
Element	**Proton Number** (= number of electrons)	**Period** (how many shells its atoms have)	**Group** (how many outer-shell electrons there are; Group VIII has a full outer shell)	**Electron Distribution**
Bromine, Br	35	**4**	**VII**	**2 + 8 + 18 + 7**
Krypton, Kr	36	**4**	**VIII**	**2 + 8 + 18 + 8**
Rubidium, Rb	37	**5**	**I**	**2 + 8 + 18 + 8 + 1**
Strontium, Sr	38	**5**	**II**	**2 + 8 + 18 + 8 + 2**

4. Draw dot-and-cross diagrams to represent the multiple bonding in N_2, C_2H_4 and CO_2.

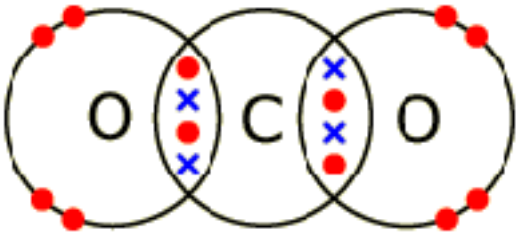
N_2:



C_2H_4:

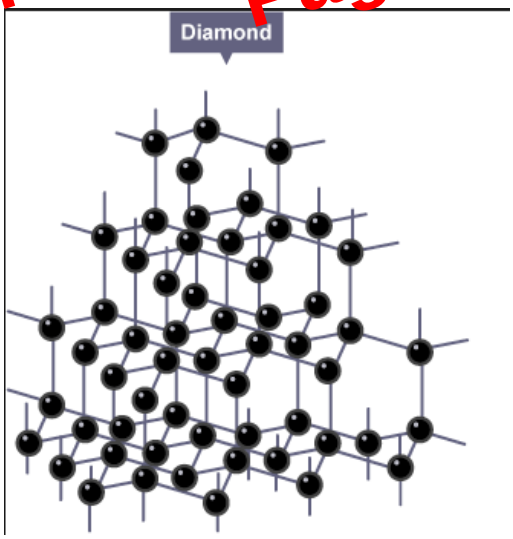
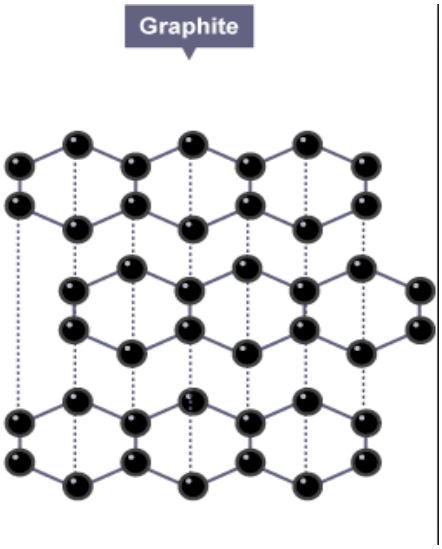


CO_2:



3.6 Giant structures

1. Describe the giant covalent structures of graphite and diamond.

Form	Diamond	Graphite
Bonding	A carbon atom shares all 4 of its outer electrons with other carbon atoms, to form a 3D lattice.	A carbon atom shares 3 of its outer electrons with other carbon atoms, to form a layer structure. The 4th electron exists between the layers and is free to move.
Giant Structure	Each carbon atom forms a **tetrahedron** with 4 other carbon atoms. 	Each carbon atoms becomes part of a **flat hexagonal ring.** 
Forces	All the covalent bonds are identical, and strong. There are no weak forces.	The covalent bonds **within** the layers are strong. But the layers are held together by weak forces.
Properties	**-** Very high melting point, because all the bonds are strong.	**-** Very high melting point, because the covalent bonds are strong.

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- Aluminium ore is called **bauxite**.
- The bauxite is purified to yield a white powder, aluminium oxide, from which aluminium can be extracted.
- The extraction is done by electrolysis.
- First, the aluminium oxide must be made molten so that electricity can pass through it.

- Aluminium oxide has a very high melting point (over 2,000°C), so it would be expensive to melt it.
- Instead, it is dissolved in **molten cryolite**, an aluminium compound with a lower melting point than aluminium oxide.
- The use of **cryolite** reduces some of the energy costs involved in extracting aluminium.

- Both the negative electrode (cathode) and positive electrode (anode) are made of **graphite**, a form of carbon.
- **Aluminium metal forms at the negative electrode** and sinks to the bottom of the tank, where it is tapped off.
- **Oxygen forms at the positive electrodes**.
    - This oxygen reacts with the carbon of the positive electrodes, forming carbon dioxide, and they gradually burn away.

<u>Chlorine, hydrogen and sodium hydroxide from concentrated aqueous sodium chloride:</u>

- If an electric current is passed through concentrated sodium chloride solution, **hydrogen gas forms at the negative electrode** and **chlorine gas forms at the positive electrode**.
- A solution of sodium hydroxide forms.
- Sodium is too reactive for sodium metal to be deposited at the negative electrode, to happen, so hydrogen is given off instead.
- During electrolysis:
    - Hydrogen ions H^+ (from the water) are discharged at the negative electrode as hydrogen gas, H_2
    - Chloride ions Cl^- are discharged at the positive electrode as chlorine gas, Cl_2
    - Sodium ions Na^+ and hydroxide ions OH^- (from the water) stay behind - they form sodium hydroxide solution, NaOH

The 3 Product of Electrolysis:

- Hydrogen is used as a fuel and for making ammonia
- Chlorine is used to kill bacteria in water, and to make bleach and plastics
- Sodium hydroxide is used to make soap and bleach

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C6. Energy changes in chemical reactions

6.1 Energetics of a reaction

1. Relate the terms exothermic and endothermic to the temperature changes observed during chemical reactions.

<u>Exothermic & Endothermic Reactions:</u>

- Chemical reactions transfer energy to, or from, the surroundings.
- They often cause a temperature change.
- Example:
    - When a bonfire burns, it transfers heat energy to the surroundings.
    - Objects near a bonfire become warmer.
    - The temperature rise can be measured with a thermometer.
- Bond making and breaking provides the energy change for endothermic and exothermic reactions.

<u>Exothermic Reactions:</u>

- Exothermic reactions transfer energy to the surroundings.
- The energy is usually transferred as heat energy, causing the reaction mixture and its surroundings to become hotter.
    - The release of heat means that an exothermic reaction **increases temperature of the surroundings**.
- The temperature increase can be detected using a thermometer.

2. Describe a practical method for investigating the speed of a reaction involving gas evolution.

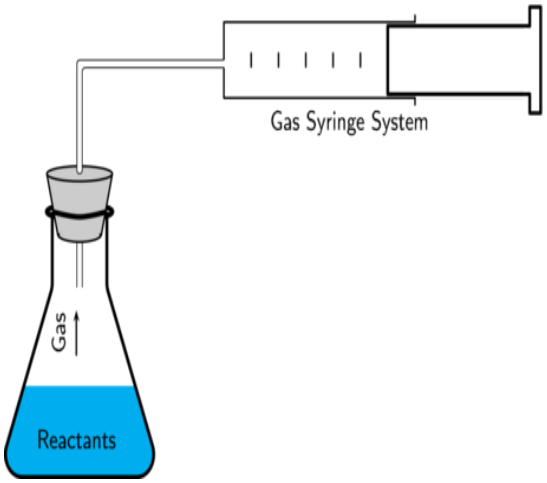
Apparatus:

- Gas syringe
- 2x Reactants
- Stopwatch
- Conical Flask

Procedure:

1. Add the reactant into the flask.
2. Simultaneously, add the stopper + gas syringe.
3. Start stopwatch.
4. Volume of the gas is obtained at regular intervals.
   (6. Measure the volume moved by the plunger every minute.)

As more gas is produced, the plunger is pushed out and the volume of the gas in the syringe can be recorded.



3. Devise a suitable method for investigating the effect of a given variable on the speed of a reaction.

Concentration:

- Repeat the experiment above, however, this time use two different types of concentrations of HCl .
  - For one experiment use, "x" concentration of HCl.
  - For the second experiment, use "2x" concentration of HCl.

Temperature:

- Repeat the experiment above, but this time with **2 different types of temperatures of HCl**, and compare the differences of **volume of gas** produced.
- As you use a higher temperature, we see a steeper graph.
  - Higher temperature leads to a higher rate of reaction.

Surface Area:

- Repeat the experiment again, but this time use **two different sizes of reactant (ex. magnesium)**.
- The reactants (ex. magnesiums) you should use are:
  1. Normal magnesium chips.
  2. Magnesium chips of same mass, but smaller pieces.

Catalysts:

- Again, repeat the experiment two times again.
  - Once with a catalyst.
  - Once without a catalyst.

4. Interpret data obtained from experiments concerned with speed of reaction.

Calculation:

- Rate of Reaction = Volume of Gas Produced / Time
- Average Rate of Reaction = Total Volume of Hydrogen / Total Time

Interpretation:

- Steepness of graph:
  - The graph is steepest in the beginning - the rate of reaction is fastest at the beginning.

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Carbonates:

- When acids react with carbonates, such as calcium carbonate (found in chalk, limestone and marble), a salt, water and carbon dioxide are made.
- In general:

1. **acid + metal carbonate → salt + water + carbon dioxide**

- Notice that an extra product - carbon dioxide - is made.
- It causes bubbling during the reaction, and can be detected using limewater.
- Characteristics:
  - Metal carbonate starts to disappear
  - Temperature rises (exothermic reaction)
  - Color change

Reactive Metals:

- Acids will react with reactive metals, such as magnesium and zinc, to make a salt and hydrogen.
- In general:

1. **acid + metal → salt + hydrogen**

- The **hydrogen** causes bubbling during the reaction, and can be detected using a **lighted splint**.

3. Describe and explain the importance of controlling acidity in the environment (air, water and soil).

Explanation:

- Most crops grow best when the pH of the soil is near 7.
- If soil is too acidic or too alkaline, crops grow badly or not at all.
- Usually acidity is the problem.
- Because of a lot of vegetation rotting in it or because too much fertilizer was used in the past.

Solutions:

- To reduce the acidity, the soil is treated with a base like **limestone** or **quicklime** or **slaked lime.**

Effects of lower pH:

- Lack of nutrients
- Poor growth of crops
- May pass on to rivers, damaging the ecosystem within it.

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8.2 Types of oxides

1. Classify oxides as either acidic or basic, related to the metallic and non-metallic character of the other element in the oxide.

Classification:

- Oxides are compounds composed of oxygen and another element.

Basic Oxides:

- Generally, metals react with oxygen to form basic oxides.

- Copper (II) oxide is called a basic oxide, since it can neutralize an acid:
  - Acid + Base → Salt + Water
  - $CuO\ (s) + 2HCl\ (aq) \longrightarrow CuCl_2\ (aq) + H_2O\ (l)$
- Iron (III) oxide and magnesium also behaves in a similar way - they also **neutralize acids**, and therefore they are basic oxides.

Acidic Oxides:

- Generally, non-metals react with oxygen to form acidic oxides.

- Carbon dioxide is slightly soluble in water as the solution will turn litmus paper red, which makes carbon dioxide acidic.

- $CO_2 + H_2O \rightarrow H_2CO_3$
- Sulfur dioxide and phosphorus pent-oxide also **dissolve in water to form acids** - they are also acidic oxides.

2. Further classify some other oxides as neutral, given relevant information.

Classification:

- Some oxides of non-metals are neither acidic nor basic.
- These are called neutral oxides.
- Neutral oxides neither react with acids or bases.
- Examples Include:
  - Carbon Monoxide
  - Di-nitrogen Oxide

8.3 Preparation of salts

1. Describe the preparation, separation and purification of salts using techniques selected from section C2.1 and the reactions specified in section C8.1.

Preparation:
Take the acid and:

- Heat it.
- Add the base.
- Let the acid and the base react.
- Filter out solution.
- Evaporate water from produced during reaction.
- Retrieve salt.

Separation:

- Separating a mixture is quite easy, as they are not chemically fused together.
- For example, we can easily separate salt and sand as they are not chemically combined together.
- The procedure to separating them are as follows:
  - Add water.
  - Stir.
  - Wait for the salt to dissolve.
  - Filter the mixture. Most of the sand will be trapped in the filter, but the salt will pass through.
  - Rinse the sand in water.
  - Dry it in an oven.
  - Evaporate water from salt solution to produce dry salt.

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Purification:

- If salt is soluble, distillation.
- If salt is insoluble, filtration.
- The steps in distillation:
  - Gently heat the solution in the flask.
  - As the temperature increases, the liquids will eventually boil, allowing the water vapour the slowly rise to the condenser, leaving the salt behind.
  - Vapour condenses to water in the condenser, and the water falls into a beaker through the condenser.

2. Suggest a method of making a given salt from suitable starting materials, given appropriate information.

Substances:
There are three types of substances an acid can react with to produce a salt. These are:

- Metals
- Insoluble Bases
- Alkalis
- Carbonates

Metals:

- The weaker attraction means that less energy is required to break these bonds apart from each other.
- Less heat energy is needed to change the elements into their molten states.
- **As you go down the elements in Group 1, you generally see a decline in melting points.**

Reaction with Water:

- Alkali metals react with water to produce hydrogen and hydroxide.
  - Lithium floats and then fizzes
  - Sodium shoots across the water.
  - The potassium melts with the heat of the reaction, and then the hydrogen catches fire.

2. Predict the properties of other elements in Group I, given data where appropriate.

Properties:

- Melting points decrease as you go down the group.
- Reaction with water increases as you go down the group.

3. Describe the trends in properties of chlorine, bromine and iodine in Group VII including colour, physical state and reactions with other halide ions.

Group VII:

- Group VII consists mainly of non-metals.
- The elements in group VII are:
  - Fluorine
  - Chlorine
  - Bromine
  - Iodine
- Typical characteristics of **halogens**:
  - **Form colored gases**: This is quite evident as fluorine is a pale yellow gas and chlorine is a green gas.
  - **Poisonous**: Chlorine was typically used in World War I as a poison to kill the enemies. Inhaling chlorine gas is a one-way ticket to the graveyard.
  - **Form Diatomic Molecules**: This is basically a molecule that contains two atoms.

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Characteristics:

Halogen	At Room Temperature:	Boiling Points / Degrees:
Fluorine	Yellow gas	-188
Chlorine	Green gas	-35
Bromine	Red liquid	59
Iodine	Black solid	184

Trends:

- Reactivity decreases as you go down the group.
- The Halogens often react with metals to form compounds called Halides.

Notes:

- Boiling point increases as we go down the group.
- Color gets deeper.
- Density increases.

Reactions with Other Halides:

- The more reactive halogen will take the place of the less reactive halogen, as we clearly saw in the example just now.

4. Predict the properties of other elements in Group VII, given data where appropriate.

Properties:

- As you go down the group:
  - Melting and boiling points will continue to increase.