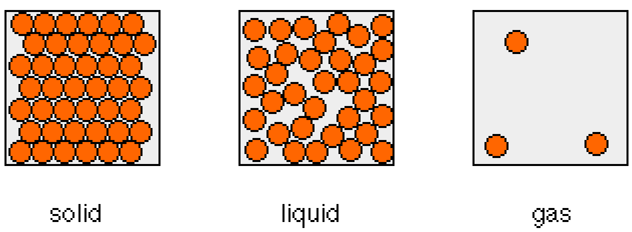
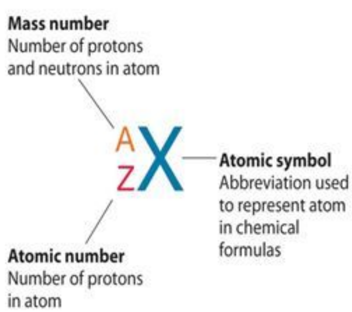
Topics on both papers

Working scientifically

A **hypothesis** is a possible explanation for what has been observed.
A **control variable** is something that remains constant throughout the experiment e.g. experiments done in the same test tubes.
A **dependant variable** is the value in the expiriment we are measuring e.g. volume of gas produced.
An **Independent variable** is what is being changed in the experiment e.g. the effect of temperature on a reaction

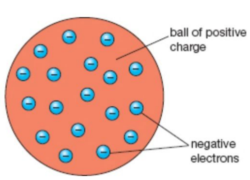
Chemical fundamentals
Solids- fixed positions, regular arrangement in lattice, very strong forces of attraction.
Liquids-weak forces of attraction, random arrangement, no fixed position.
Gases- little forces of attraction, free to move, random motion, move in straight lines.





Limitations to particles theory- forces of attraction not shown.distances between particles not shown to scale.
If a substance only contains one type of atom it is an element
A molecule is a group of atoms bonded together.
A compound is a molecule that is made up of two or more different elements.

Atomic structure
The history of the atomic model
First was Thomson's plum pudding model that said that an atom was a sphere of positive charge with negatively charged electrons scattered throughout the sphere.



Thomson's 'plum-pudding' model of the atom

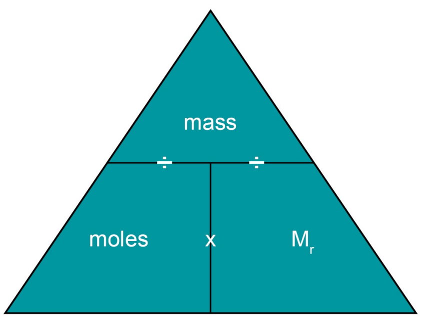
Next was the Nuclear model from Rutherford that said that disproved the plum pudding model through the alpha scattering experiment where the fired positively alpha particles at a thin gold sheet.
Some alpha particles were reflected, this meant that there must be a positively charged nucleus at the core of the atom where most of the mass is concentrated. A "cloud" of negative electrons must surround the nucleus.

At last, Bohr created a model of the atom that included shells of electrons surrounding the nucleus of the atom

Protons have a positive charge and a mass of 1, Neutrons have a mass of 1 and no charge, electrons have a charge of -1 and no mass.
The nucleus of an atom is very small compared to the rest of the atom. About 1/10,000
Isotopes are different forms of the same atom with varying numbers of neutrons.

Relative atomic mass = sum of (isotope abundance percentage x isotope mass number) / 100

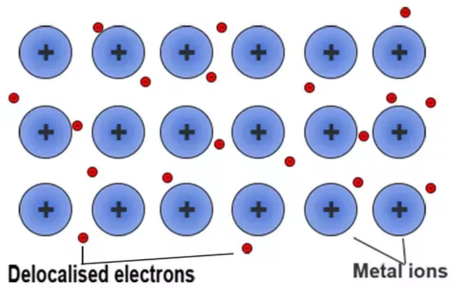
Chemical measurements



Mass must always be the same on either side of a reaction
If mass increases then some mass must have come from somewhere like the air.
If mass decreases then some mass may have been given off as a gas.

Bonding and structure
Metals form positive ions when they react
Non-metals form negative ions when they react in ionic bonds or they bond covalently with other non-metals.
Metals are: Strong, Malleable, good conductors, high melting and boiling points
Non-metals are: Dull, Brittle, have lower melting and boiling points, usually don't conduct electricity, less dense than metals.

In metals, the electrons in the outer shell are delocalized.



There are strong forces of electrostatic attraction between the positive metal ions and delocalized electrons.
Normally metals have atoms in a regular structure that are the same size. This means that the ions can slide over each other and make the metal malleable.
Alloys enhance the strength of metals by adding different sizes of atoms so that layers can not slide over each other as easily.
Examples of alloys include steel (iron and carbon or chromium), Bronze (copper and tin), Brass (copper and zinc), and Gold (zinc copper or silver added) 24 carat is pure.
Metal atoms form positive atoms (cations)
Non-metal atoms form negative ions (anions)

In ionic bonds, there are strong electrostatic forces of attraction between the positive and negatively charged ions.
Ways of representing ionic compounds.

1. Dot and cross diagrams - useful for showing how they are formed, don't show the structure of the compound, relative sizes, or arrangement.
2. 3D models- show relative sizes and patterns of arrangement, however only let you see the outer layer
3. Ball and stick- show pattern and arrangement, sometimes not to scale, they suggest there are gaps between the ions when in reality there aren't.

Properties of ionic compounds:
High melting and boiling points due to strong electrostatic attraction, good solubility in water, conduct electricity in water, and when melted because the ions are free to move and carry electrical current.

Covalent bonds are formed when a pair of electrons is shared between two atoms. These occur in Non-metals.
There are various ways of representing covalent bonding:

1. Dot and cross- good for showing origins of electrons but don't show relative sizes of the atoms or arrangements
2. Displayed formulas (E.g. O=O) - good for showing the connections between atoms
3. 3D and ball and stick models - can get confusing in large models, don't show origins of electrons.

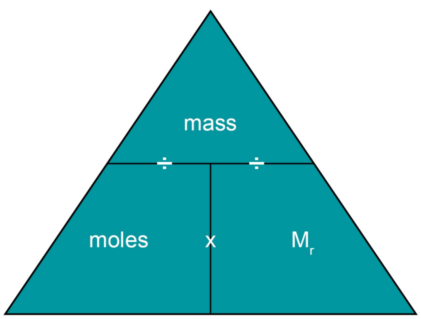
H_2 and Cl_2 are both examples of covalent simple molecules. They have low melting and boiling points as they have weak intermolecular forces of attraction. They don't conduct electricity.

Larger Covalent structures such as polymers. All atoms are joined by strong electrostatic bonds.
The molecular formula of a poly(ethene) is $(C_2H_4)_n$
Giant covalent structures (macromolecules) are similar to giant ionic structures (lattices) but there are no charged ions. An example of this is carbon in diamonds.
Allotropes of carbon include: diamond, graphite, and graphene
Fullerenes are hollow molecules of carbon that are used in medicines and electronics.

Nanoparticles are between 1nm and 100nm they have very high volume to surface area ratios.
They are used as catalysts, in electronics, deodorants, and sun cream.

Quantitative chemistry.

+-Uncertainty= range/2
Percentage mass of an element in a compound = Ar x number of atoms / Mr of compound
A mole = 6.02×10^{23}



1 mole of something weighs its Mr in grams
To balance equations using reacting masses:

1. Work out the Mr (or Ar) for each substance in the reaction
2. Divide the mass by Mr to find No of moles
3. Divide the moles by the smallest No of moles
4. Balance

Volume of gas (dm^3) = (mass of gas (g) / Mr of gas) x 24

Atom economy =(relative formula mass of desired products / relative formula mass of all reactants) x100
Percentage yield = (mass of product actually made (g) / maximum theoretical mass of product (g)) x 100

Topics on paper 1 only
The periodic table

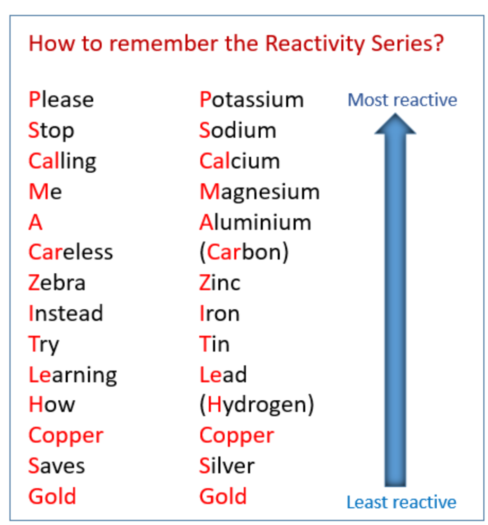
Firstly Dobereiner noticed that elements with similar chemical properties often occurred in threes and he called these triads. An example of these was Sodium lithium and potassium. After this discovery scientists become to wonder if the elements could be arranged into some sort of logical order.
Later Newland found that when he arranged the elements in order of atomic mass every 8th element reacted in a similar way.
Mendeleev developed the earliest real periodic table by ordering the elements by atomic mass, switching around some elements to match the properties of the groups, and leaving gaps for undiscovered elements. He could look at the properties of elements in the same group of undiscovered elements and predict their properties.
The modern period table orders in atomic number and not in atomic mass which Mendeleev's was. Also, the modern periodic table has group 0 which Mendeleev had not discovered

Group 0 - Noble gases that exist as single atoms
Properties:
- Low boiling points - boiling point increases going down the group
- Low densities - density increases going down the group
- They are inert (unreactive)

Group 1 - The alkali metals
Properties:
- Very reactive - must be stored under oil to keep air and water away from them
- form alkaline solutions when they react with water and hydrogen gas is given off
- reactivity increases as you go down the group because the outer electron is further from the nucleus
- Soft and have low densities

Group 7 - The halogens
Properties
- The halogens have low melting points and low boiling points.
- The melting and boiling points then increase as you go down the group.
- state from gas to liquid to solid as you go down the group.
- darker in color as you go down the group
- less reactive as you go down the group
- A more reactive halogen displaces a less reactive halogen from a solution of one of its salts.

Properties
- Hard and strong
- High melting points
- High density



- Less reactive than group 1 elements
- Form colored compounds
- They can be used as catalysts

Reactivity of metals

Production of salts
Acid + metal → acid+metal + Hydrogen
E.g
Hydrochloric acid + iron → iron chloride + hydrogen
Sulfuric acid + zinc → zinc sulfate + hydrogen

Displacement reactions - A more reactive metal will displace a less reactive one from its compound.
E.g. Iron + copper sulfate → iron sulfate + copper

Extractions - many metals found in the earth are found as compounds and need to be extracted from their metal ore.
Oxidation is the gain of oxygen
E.g. $2Mg + O_2 \rightarrow 2MgO$
Reduction is the loss of oxygen from a compound
E.g $2CuO + C \rightarrow 2Cu + CO_2$
Anything below Carbon can be extracted using carbon. Anything above has to be extracted using electrolysis.
Redox reactions occur when electrons are transferred between substances.
OIL RIG – Oxidation Is Loss of electrons, Reduction Is Gain of electrons.
Transition elements are all metals

An example of a redox reaction is:
Zinc + copper sulfate → zinc sulfate + copper
Zinc is oxidized, Copper is reduced
In a redox reaction metals and oxidized.

Corrosion is when a metal is gradually destroyed by reacting with substances in the environment.
In order for rusting to occur, it must be in contact with water and oxygen.

The demand for copper is increasing and the supply of copper-rich ores is decreasing.
Plants absorb mineral ions through their roots.
Phytoextraction makes use of this:

1. plants are grown in soil that contains low-grade ore
2. the plants absorb metal ions through their roots and concentrate these ions in their cells
3. the plants are harvested and burnt

4. the ash left behind contains metal compounds

Bioleaching

Certain bacteria can break down low-grade ores to produce an acidic solution containing copper ions. The solution is called leachate. Iron can be used to displace copper from the leachate

Ad Phytomining: Reduces rock waste, conserves supplies of copper, no mining needed
Ad Bioleaching: High temperatures not needed,
Dis Phytomining: very slow process
Dis Bioleaching: produces toxic substances

Acids, pH, salts and titrations
Acid + metal → salt + hydrogen
E.g Hydrochloric acid + iron → iron chloride + hydrogen
Metal + water → metal hydroxide + hydrogen
E.g. calcium + water → calcium hydroxide + hydrogen

Reaction with metal oxides and metal hydroxides
All-metal (oxides or hydroxides) and bases can react with acids to neutralize.
Acid + metal (oxide or hydroxide) → salt + water
E.g. hydrochloric acid + copper oxide → copper chloride + water

The reaction of metal carbonates and acids
Metal carbonate + acid → metal salt + carbon dioxide + water
E.g. calcium carbonate + sulfuric acid → calcium sulfate + carbon dioxide + water

You can test pH using an indicator (a dye that changes color) Universal indicator changes from purple when alkali to red when acidic.
Whether a substance is an acid or alkali depends on what type of ions are released when the substance is dissolved in water. Acids form hydrogen ions (H+) whereas alkalis form hydroxide ions (OH-)
Neutralization reactions
Acid + alkali → salt + water
H+ + OH- → H2O

Dissociation of acid - When acids are added to an aqueous solution they ionize to produce H+ ions. E.g hydrogen chloride dissolves in water like this:
HCL → H+ + Cl-

The strength of an acid tells you about the proportion of acids particles that will dissociate to produce H+ ions
Strong acids fully dissociate in water E.g. Hydrogen chloride
E.g. H2SO4 → 2H+ + SO4)2-
Weaker acids will only partially dissociate E.g. Ethanoic acid

E.g. $CH_3COOH = H^+ + CH_3COO^-$
Reactions of acids involve H^+ ions reacting with other substances therefore strong acids will react faster at the same concentration.

Concentration (g/dm^3) = mass of solute (g) / volume of solution (dm^3)
$1000cm^3 = 1dm^3$

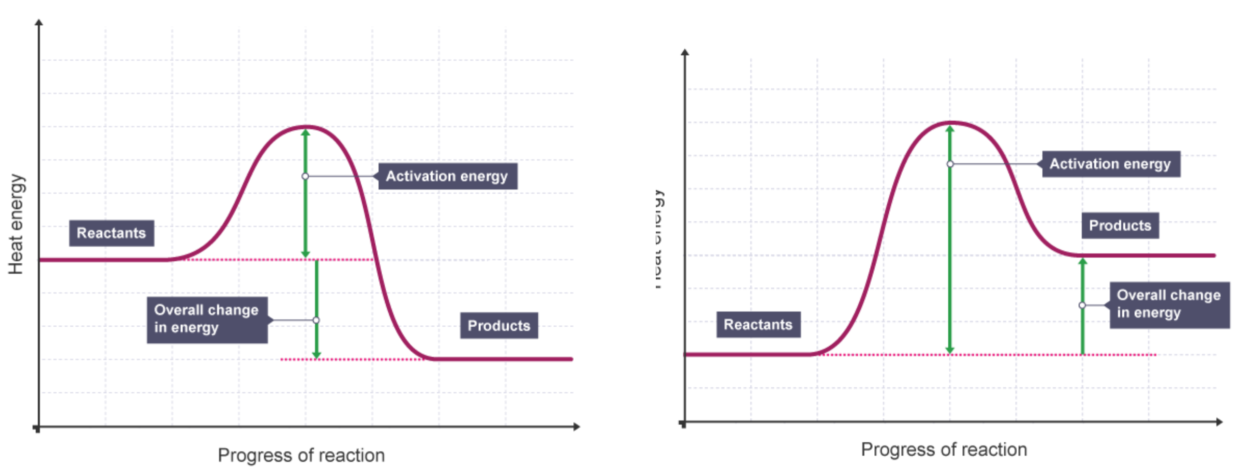
$$Concentration\ in\ mol/dm^3 = \frac{amount\ of\ solute\ in\ mol}{volume\ in\ dm^3}$$

Titrations are experiments that let you see what volume of a reactant is needed to react completely with a certain volume of another reactant. For example, you could use titration to figure out how much acid is needed to neutralize an alkali.

Carrying out a titration (how much acid is needed to neutralize an alkali):

1. Use the pipette and pipette filler to add a measured volume of alkali to a clean conical flask.
2. Add a few drops of indicator (methyl red) and put the conical flask on a white tile.
3. Fill the burette with the acid of a known concentration and note the starting volume. Run a small amount through the tap and then turn the tap off and place the conical flask under the tap.
4. Slowly add the acid from the burette to the alkali in the conical flask, swirling to mix.
5. Stop adding the acid when the end-point is reached (when the indicator first permanently changes color). Note the final volume reading.
6. Repeat steps 1 to 5 until concordant titers are obtained. More accurate results are obtained if acid is added drop by drop near the end-point.
7. Calculate the mean volume of acid that was needed to neutralize the alkali

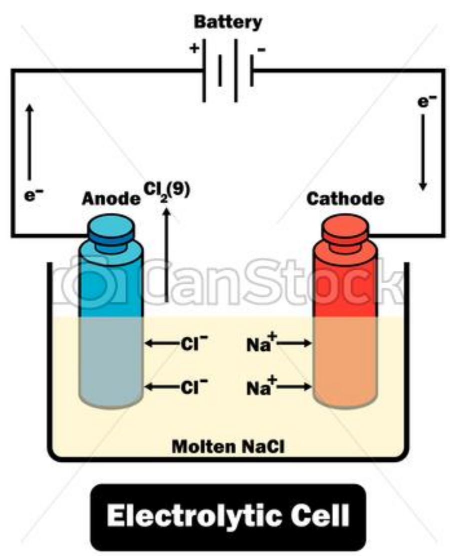
An exothermic reaction transfers energy to its surroundings E.g. Hand warmers and self-heating cans
An endothermic reaction takes in energy from its surroundings E.g. a cold pack for sports injuries.
The diagram shows a reaction profile for an exothermic reaction (left) and an endothermic reaction on the right.



Energy is measured in joules
Energy is needed to make bonds and energy is released when bonds are broken.
If at the end of a reaction to overall energy change is positive an exothermic reaction has occurred if it is negative then an endothermic reaction has occurred.

Electrolysis is a method of decomposing an ionic compound/ substance.
Electrolysis requires a liquid to conduct the electricity, called the electrolyte
Electrolysis is based on an electrical circuit that includes an electrolyte and two electrodes- an electrode is a solid that conducts electricity and is submerged in the electrolyte.
In electrolysis, th ions move from one electrode to another, this allows the conduction of electricity through the circuit.
The positive ions move to the negative electrode (cathode) in order to gain electrons.
The negative ions move to the positive electrode (anode) in order to lose electrons.
As electrons are gained/lost elements and molecules are released
OIL RIG
Oxidation is losing reduction is gaining
You can write half equations as:
Negative:
Pb2+ +2e- → Pb
Positive:
2Br- -2e- → Br2

A cell is a system that contains chemicals that react and produce electricity. A cell contains two electrodes in contact with an electrolyte. Chemical reactions between the electrodes and the electrolyte set up a charge difference between the electrodes. Connecting the electrodes to a wire allows charge to flow and electricity to be produced.



You have to use different metals in the electrodes so that there is a difference in charge. The bigger difference in the reactivity of the electrodes, the larger the Voltage.

The higher the concentration of ions in the electrolyte the larger the voltage.

A battery is two or more cells together in series.

A fuel cell is an electrical cell that's supplied with fuel and oxygen (or air) and efficiently transfers the energy released by the reaction between them as electricity.
An example of a fuel cell is a hydrogen-oxygen fuel cell that uses hydrogen as a fuel that is oxidized to form water and releases energy.

The potential difference is what powers the vehicle

Two separate reactions happen, one on each side of the fuel cell.
1. On one side, hydrogen molecules lose electrons and form hydrogen ions:
$2H_2 \rightarrow 4H^+ + 4e^-$
The two products reach the other side of the cell, hydrogen ions through a membrane and electrons through the electrical circuit.
2. On the other side, hydrogen ions react with oxygen molecules and electrons to form water:
$4H^+ + O_2 + 4e^- \rightarrow 2H_2O$
The overall reaction in a hydrogen-oxygen fuel cell is (redox):
hydrogen + oxygen → water
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

- Fuel cells don't produce pollutants
- Batteries in electric vehicles can be recharged. (but not forever and are expensive to make)
- Batteries store less energy than fuel cells.
- Hydrogen needs a lot more space to be stored
- Hydrogen is explosive
- Energy still has to be put in to make hydrogen