AQA Chemistry Atomic Structure and the Periodic Table Journey of Knowledge

Context and introduction to the unit:
The periodic table provides chemists with a structured organisation of the known chemical elements from which they can make sense of their physical and chemical properties. The historical development of the periodic table and models of atomic structure provide good examples of how scientific ideas and explanations develop over time as new evidence emerges. The arrangement of elements in the modern periodic table can be explained in terms of atomic structure which provides evidence for the model of a nuclear atom with electrons in energy levels.
KS3: Atoms elements and compounds and Particles & Separating Mixtures units – Pupils explore atoms, elements, compounds and mixtures. They also learn about purity and various separating techniques, including chromatography. Periodic Table and metals – pupils learn about the basic features of the Periodic table and the difference between metals and non-metals.

CORE KNOWLEDGE

5.1.1.1 Atoms, elements and compounds All substances are made of atoms. An atom is the smallest part of an element that can exist. Atoms of each element are represented by a chemical symbol, eg O represents an atom of oxygen, Na represents an atom of sodium. There are about 100 different elements. Elements are shown in the periodic table. Compounds are formed from elements by chemical reactions. Chemical reactions always involve the formation of one or more new substances, and often involve a detectable energy change. Compounds contain two or more elements chemically combined in fixed proportions and can be represented by formulae using the symbols of the atoms from which they were formed. Compounds can only be separated into elements by chemical reactions.

5.1.1.2 Mixtures-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. Mixtures can be separated by physical processes such as filtration, crystallisation, simple distillation, fractional distillation and chromatography. These physical processes do not involve chemical reactions and no new substances are made. Filtration – filter sandy water. Liquid passes through filter paper; solid residue remains on the paper; liquid (filtrate) passes through. Evaporation/crystallisation - evaporate salt from water. Heat solution until solvent evaporates, leaving solid behind (e.g., salt from saltwater). Distillation – distill water from ink. Water from ink → water boils, turns to vapour, condenses in condenser, and is collected; the solute (dyes/ink) remains in the flask. Chromatography – use felt-tip pens to separate dyes. A spot of mixture is placed on the baseline; solvent moves up the paper, carrying different substances at different rates.

5.1.1.3 The development of the model of the atom-New experimental evidence may lead to a scientific model being changed or replaced. Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided. The discovery of the electron led to the plum pudding model of the atom. The plum pudding model suggested that the atom is a ball of positive charge with negative electrons embedded in it. The results from the alpha particle scattering experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged. This nuclear model replaced the plum pudding model. Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observations. Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name proton was given to these particles. The experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus. This was about 20 years after the nucleus became an accepted scientific idea.

5.1.1.4 Relative electrical charges of subatomic particles In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge. The number of protons in an atom of an element is its atomic number. All atoms of a particular element have the same number of protons. Atoms of different elements have different numbers of protons

Name of particle	Relative charge
Proton	+1
Neutron	0
Electron	–1

Disciplinary knowledge
WS 2.2, 2.3
Safe use of a range of equipment to separate chemical mixtures.

WS 1.1, 1.6 This historical context provides an opportunity for students to show an understanding of why and describe how scientific methods and theories develop over time. WS 1.2

Vocabulary
Atom, Element, compound, mixture, electron, proton, neutron, nucleus, relative charge

Reading is Power
The History of the Atom

Where next?
5.2 Bonding, structure, and the properties of matter

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CORE KNOWLEDGE

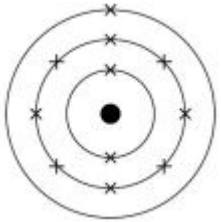
5.1.1.5 Size and mass of atoms Atoms are very small, having a radius of about 0.1 nm (1 x 10-10 m).The radius of a nucleus is less than 1/10 000 of that of the atom(about 1 x 10-14 m).Almost all of the mass of an atom is in the nucleus. The sum of the protons and neutrons in an atom is its mass number. Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.

Name of particle	Relative mass
Proton	1
Neutron	1
Electron	Very small

Atoms can be represented as shown in this example:

(Mass number) 23
(Atomic number) 11 Na

5.1.1.6 Relative atomic mass The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element.



5.1.1.7 Electronic structure The electrons in an atom occupy the lowest available energy levels (innermost available shells).
The electronic structure of an atom can be represented by numbers or by a diagram. For example, the electronic structure of sodium is 2,8,1 or:
showing two electrons in the lowest energy level, eight in the second energy level and one in the third energy level.

5.1.2.1 The periodic table The elements in the periodic table are arranged in order of atomic (proton) number and so that elements with similar properties are in columns, known as groups. The table is called a periodic table because similar properties occur at regular intervals. Elements in the same group in the periodic table have the same number of electrons in their outer shell (outer electrons) and this gives them similar chemical properties.

5.1.2.2 Development of the periodic table Before the discovery of protons, neutrons and electrons, scientists attempted to classify the elements by arranging them in order of their atomic weights. The early periodic tables were incomplete and some elements were placed in inappropriate groups if the strict order of atomic weights was followed. Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered and in some places changed the order based on atomic weights. Elements with properties predicted by Mendeleev were discovered and filled the gaps. Knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct.

Disciplinary knowledge
WS 4.3, 4 Use SI units and the prefix nano. MS 1b Recognise expressions in standard form.
WS 1.2
Students should be able to represent the electronic structures of the first twenty elements of the periodic table in both forms.
Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects.

Vocabulary
Relative mass, radius, nano, isotopes, energy levels, Periodic table, groups, properties

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CORE KNOWLEDGE

5.1.2.3 Metals and non-metals Elements that react to form positive ions are metals. Elements that do not form positive ions are non-metals. The majority of elements are metals. Metals are found to the left and towards the bottom of the periodic table. Non-metals are found towards the right and top of the periodic table.

5.1.2.4 Group 0 The elements in Group 0 of the periodic table are called the noble gases. They are unreactive and do not easily form molecules because their atoms have stable arrangements of electrons. The noble gases have eight electrons in their outer shell, except for helium, which has only two electrons. The boiling points of the noble gases increase with increasing relative atomic mass (going down the group).

5.1.2.5 Group 1 The elements in Group 1 of the periodic table are known as the alkali metals and have characteristic properties because of the single electron in their outer shell. Students should be able to describe the reactions of the first three alkali metals with oxygen, chlorine and water. In Group 1, the reactivity of the elements increases going down the group. Students should be able to: explain how properties of the elements in Group 1 depend on the outer shell of electrons of the atoms, predict properties from given trends down the group.

5.1.2.6 Group 7 The elements in Group 7 of the periodic table are known as the halogens and have similar reactions because they all have seven electrons in their outer shell. The halogens are non-metals and consist of molecules made of pairs of atoms. Students should be able to describe the nature of the compounds formed when chlorine, bromine and iodine react with metals and non-metals. In Group 7, the further down the group an element is the higher its relative molecular mass, melting point and boiling point. In Group 7, the reactivity of the elements decreases going down the group. A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.
Students should be able to: explain how properties of the elements in Group 7 depend on the outer shell of electrons of the atoms • predict properties from given trends down the group.

Disciplinary knowledge
WS 1.1, 1.6 Explain how testing a prediction can support or refute a new scientific idea.

Vocabulary
Metal, non metal, noble gases, ions, unreactive, molecules, alkali, reactivity, trends, halogens, melting, boiling, displace.

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