FACTFILE: GCSE CHEMISTRY: UNIT 1.6

Rewarding Learning

Periodic Table

1.6.1 describe how Mendeleev arranged the elements in the Periodic Table and left gaps for elements that had not been discovered at that time, and how this enabled him to predict properties of undiscovered elements;

1.6.2 demonstrate knowledge and understanding of how scientific ideas have changed over time in terms of the differences and similarities between Mendeleev's Periodic Table and the modern Periodic Table;

1.6.3 describe an element as a substance that consists of only one type of atom and demonstrate understanding that elements cannot be broken down into simpler substances by chemical means;

1.6.4 demonstrate knowledge and understanding that a group is a vertical column in the Periodic Table and a period is a horizontal row;

1.6.5 identify and recall the position of metals and non-metals in the Periodic Table and distinguish between them according to their properties including conduction of heat and electricity, ductility, malleability, melting point and sonority;

1.6.6 identify elements as solids, liquids and gases (at room temperature and pressure) in the Periodic Table;

1.6.7 demonstrate knowledge and understanding that elements in the same group in the Periodic Table have the same number of electrons in their outer shell and this gives them similar chemical properties;

1.6.8 recall that elements with similar properties appear in the same group (for example Group 1 (I) and Group 2 (II) are groups of reactive metals, Group 7 (VII) is a group of reactive non-metals and Group 0 is a group of non-reactive non-metals) locate these groups in the Periodic Table and recall the names of the groups;

1.6.9 demonstrate knowledge and understanding that the alkali metals have low density and the first three are less dense than water;

1.6.10 assess and manage risks associated with storage and use of alkali metals and recall that alkali metals are easily cut, are shiny when freshly cut and tarnish rapidly in air;

1.6.11 demonstrate knowledge and understanding that Group 1 (I) metals react with water to produce hydrogen and a metal hydroxide, and give observations for the reactions;

1.6.12 demonstrate knowledge and understanding that alkali metals have similar chemical properties because when they react an atom loses an electron to form a positive ion with a stable electronic configuration;

1.6.13 **write half equations for the formation of a Group 1 (I) ion from its atom;**

1.6.14 demonstrate knowledge and understanding of how the trend in reactivity down the group depends on the outer shell electrons of the atoms;

1.6.15 demonstrate knowledge and understanding that most Group 1 (I) compounds are white and dissolve in water to give colourless solutions;

1.6.16 recall data about the colour, physical state at room temperature and pressure, diatomicity and toxicity of the elements in Group 7 (VII), interpret given data to establish trends within the group and make predictions based on these trends;

1.6.17 recall the observations when solid iodine sublimes on heating and demonstrate understanding of the term sublimation;

1.6.18 describe how to test for chlorine gas (damp universal indicator paper changes to red and then bleaches white);

1.6.19 investigate the displacement reactions of Group 7 (VII) elements with solutions of other halides to establish the trend in reactivity within the group and make predictions based on this trend;

1.6.20 demonstrate knowledge and understanding of how the reactivity down the group depends on the outer shell electrons of the atoms;

1.6.21 demonstrate knowledge and understanding that the halogens have similar chemical properties because when they react an atom gains an electron to form a negative ion with a stable electronic configuration;

1.6.22 **write half equations for the formation of a halide ion from a halogen molecule or atom;**

1.6.23 use the concept of electronic configuration to explain the lack of reactivity and the stability of the noble gases;

1.6.24 recall that the noble gases are colourless gases;

1.6.25 demonstrate knowledge and understanding of the trend in boiling points of the noble gases going down the group;

1.6.26 compare the physical properties of the transition metals with Group 1 (I) elements including melting point and density and demonstrate understanding that the transition metals are much less reactive with water;

1.6.27 demonstrate knowledge that transition elements form ions with different charges (for example iron(II) and iron(III)) and form coloured compounds: copper(II) oxide is black; copper(II) carbonate is green; hydrated copper(II) sulfate is blue; and copper(II) salts are usually blue in solution.

The Periodic Table

The Periodic Table is the organisation of all known elements, which are the building blocks of all materials and life itself. There are over 100 known elements, most of which are naturally occurring and are metals. The Periodic Table as we know it today has undergone significant development since scientists began grouping elements together.

The Russian scientist Dmitri Mendeleev has received most of the credit for arranging elements in the Periodic Table; the work he published in 1869 is the basis of the modern Periodic Table today.

There were a number of important features of the Periodic Table proposed by Mendeleev:

- He listed the elements in order of increasing atomic mass (or weight as it was known then) but he was prepared to slightly alter the order of the elements if he felt the properties of the element fitted a different position;
- He left gaps for undiscovered elements and predicted the properties of these elements; for example, the properties of germanium, when it was discovered, were very similar to what he had predicted.

Today's Periodic Table has a number of other important differences compared to Mendeleev's table:

- Elements are arranged in order of atomic number, rather than atomic mass;
- Noble gases are present;
- There are no gaps and there are more elements;
- There is a block of transition metals;
- There is a block of actinides and lathanides.

An element is a substance which consists of only one type of atom. Elements cannot be broken down into simpler substances by chemical means.

Elements can be classified as metals and non-metals. Metals are to the left of the staircase line on the Periodic Table and are malleable (can be hammered into shape), ductile (can be drawn into wires), sonorous (make a ringing sound when struck), good conductors of heat and electricity and have high melting points. Non–metals are found to the right of the staircase line and have the opposite properties.

Two elements in the Periodic Table are liquids at room temperature and pressure (mercury and bromine), there are 11 gases including the six noble gases, fluorine, chlorine, hydrogen, oxygen and nitrogen, and the rest of the elements are solid at room temperature and pressure.

A period is a horizontal row in the Periodic Table.

A group is a vertical column in the Periodic Table.

Elements that are in the same group in the Periodic Table have similar chemical properties as each element in the group has the same number of electrons in its outer shell.

- Group 1 (I) is a group of reactive metals and the group is known as the alkali metals.
- Group 2 (II) is a group of reactive metals and the group is known as the alkaline-earth metals.
- Group 7 (VII) is a group of reactive non-metals and the group is known as the halogens.
- Group 0 is a group of unreactive non-metals and the group is known as the noble gases.

Group 1 (I) – The Alkali Metals

These are very reactive metals and are stored **under oil** to prevent them reacting with air or water vapour in the air. The alkali metals:

- are **soft** and are easily cut with a knife;
- are **shiny** when freshly cut but tarnish (go dull) rapidly when exposed to air;
- have **low density** and the first three – lithium, sodium and potassium are less dense than water, and float on the surface of water;
- are **grey solids** which have relatively low melting points. The melting points decrease as the atoms get bigger going down the group.

Reactivity of Group 1

Reactivity increases down the group. All of the atoms of Group 1 elements have one electron in their outer shell which they lose when the elements react to form a positive ion with full electron shells; as the outer electron is further from the nucleus as Group 1 is descended the elements become more reactive as the outer electron is lost more readily. The half equation for the formation of a sodium ion from a sodium atom is:

$$Na \longrightarrow Na^{+} + e^{-}$$

Reactions of Group 1 metal with water

Group 1 metal + water ⟶ metal hydroxide + hydrogen

For example

Word equation: potassium + water ⟶ potassium hydroxide + hydrogen

Symbol equation: $2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$

In this experiment use small pieces of metal and a large trough of water, wear safety glasses, use tweezers and a safety screen.

The observations are the metal floats, fizzing occurs, heat is released, a lilac flame is observed, the potassium moves on the surface of the water and disappears with a crackle/explosion at the end.

For sodium, the observations are similar but there is no flame or crackle/explosion.

To test for the **hydrogen** gas produced apply a lighted splint and a pop is heard.

Group 7 (VII) – The Halogens

The halogens are a group of reactive non-metals. They are toxic.

Halogen	Formula	Colour	State at room temperature and pressure
fluorine	F_2	yellow	gas
chlorine	Cl_2	yellow-green	gas
bromine	Br_2	red-brown	liquid
iodine	I_2	grey-black	solid
astatine	At_2	——	——

Iodine sublimes (change from solid to gas) when heated and changes from a grey-black solid to a purple vapour.

To **test for chlorine** add some damp universal indicator: it changes to red and then bleaches white.

Reactivity of Group 7

Reactivity decreases down the group. All of the atoms of Group 7 (VII) elements have seven electrons in their outer shell and so they gain one electron when the elements react to form a negative ion with a full outer shell.

For example:

$$Cl + e^- \longrightarrow Cl^-$$

or for a molecule of chlorine reacting

$$Cl_2 + 2e^- \longrightarrow 2Cl^-$$

Further down the group, the atoms have more shells of electrons, so the outermost shell containing electrons is further from the positive attraction of the nucleus. This means the force of attraction between the positive nucleus and an incoming electron decreases and they are less reactive. Also there are more electron shells between the outer electron and the nucleus and these inner electrons shield the outer electron from the attractive power of the nucleus.

Displacement reactions

A more reactive halogen displaces a less reactive halogen from solution. Chlorine is more reactive than iodine so chlorine can displace it from potassium iodide solution forming iodine and potassium chloride.

Word equation: chlorine + potassium iodide ⟶ iodine + potassium chloride

Symbol equation: $Cl_2 + 2KI \longrightarrow I_2 + 2KCl$

Ionic equation: $Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$

Observation: Colourless solution of potassium iodide changes to brown solution of iodine.

Group 0 – The noble gases

The noble gases are a group of unreactive non-metals. Their lack of reactivity is due to the atoms of each element in the group having a full outer shell of electrons.

All of the elements in the group are colourless gases at room temperature and exist as individual atoms. As the group is descended the boiling points of the elements increase due to the increased strength of the van der Waals' forces between the atoms.

The Transition Metals

The transition metals are different from Alkali Metals in Group 1 in the following ways:

- they have higher melting points;
- they have higher density;
- they are less reactive with water;
- they react and form ions with different charges, but Group 1 metals only form 1^+ ions.

Revision Questions

1.

The table below shows part of **Mendeleev's** Periodic Table.

I	II	III	IV	V	VI	VII			
H									
Li	Be	B	C	N	O	F			
Na	Mg	Al	Si	P	S	Cl			
K	Ca		Ti	V	Cr	Mn	Fe	Co	Ni
Cu	Zn			As	Se	Br			

(a) In what order did Mendeleev set out the elements?

_____ [1]

(b) **(i)** Name the Group of elements known today which is not in Mendeleev's table.

_____ [1]

(ii) Suggest a reason why this Group was not in Mendeleev's table.

_____ [1]

(c) Using the Data Leaflet and your knowledge, name one element that Mendeleev placed in the wrong position.

_____ [1]

(d) In what order are the elements set out in the modern Periodic Table?

_____ [1]

2.

Chemists have collected a vast amount of information about the atoms of elements and have displayed it on a table called the Periodic Table.

The table below gives information about the atomic number, group number and electronic configuration of the atoms of elements A, B, C and D.

Elements	Atomic Number	Electronic configuration	Group Number
A	12	2,8,2	
B	6		4
C		2,7	7
D	15		5

(a) Complete the table above. [4]

(b) How many electrons would you expect an atom of strontium to have in its outer shell?

_____ [1]

(c) Name the element in Group 6 and Period 3 of the Periodic Table.

_____ [1]

3.

Describe how potassium is stored in the laboratory and the steps that need to be taken before adding it to water. Include in your answer its appearance at each stage and any safety precautions that need to be taken.

[6]

4.

The elements of Group 7 of the Periodic Table, the halogens, all react in a similar way.

(a) Explain, in terms of electrons, why the halogens all react in a similar way.

[1]

(b) In an experiment to compare the reactivity of the halogens, a solution of a halogen is added to a solution of a compound containing a different halogen. The more reactive halogen will displace a less reactive halogen from its compound.

The results of the experiment are shown in the table below.

Solution of potassium halide	Solution of halogen		
	chlorine	**bromine**	**iodine**
potassium chloride		no reaction	no reaction
potassium bromide	colourless solution darkens to orange		no reaction
potassium iodide	colourless solution darkens to brown	colourless solution darkens to brown	

(i) Using the information in the table write a reactivity series of the halogens beginning with the most reactive.

Most Reactive: _____

_____

Least Reactive: _____ [2]

(ii) Explain why a colour change occurs when chlorine is added to a solution of potassium bromide.

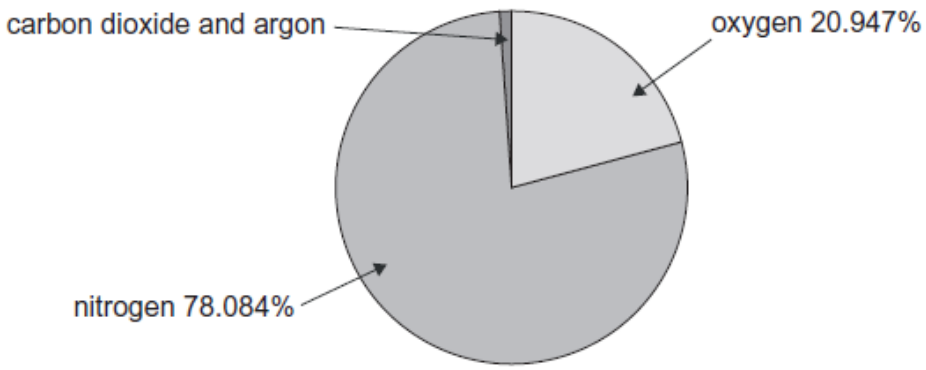
_____ [1]

(iii) Write a balanced chemical equation for the reaction between potassium bromide and chlorine.

_____ [3]

5.

The pie chart below shows the percentage (%) of the different gases in a sample of dry air.



(a) Calculate the percentage (%) of carbon dioxide and argon in this sample of dry air.

_____% [2]

(b) Carbon dioxide, oxygen and nitrogen are present as **diatomic** molecules with multiple bonds. Argon is present as an atom.

(i) What is meant by the term diatomic?

_____

_____ [1]

(ii) Explain, in terms of electrons, why argon is present as an atom.

_____

_____

_____ [2]

6.

A small piece of sodium metal was added, using tongs, to a trough of water to which a few drops of universal indicator had been added.

(a) How is sodium stored in the laboratory?

_____ [1]

(b) Why was a **small** piece of sodium added to the water?

_____ [1]

(c) Why was the sodium handled with tongs instead of using fingers to lift it?

_____

_____

_____ [2]

(d) Choose **three** statements which describe what happens when sodium is placed into the water.

Put a tick (✓) in the three correct boxes.

bubbles of carbon dioxide gas form	☐	melts into a silvery ball	☐
burns with a lilac flame	☐	sinks to the bottom then floats to the top	☐
moves quickly across the surface of the water	☐	eventually disappears	☐

[3]

At the end of this reaction the universal indicator had turned purple.

(e) What does this tell you about the product of the reaction?

_____

_____ [1]

Sodium is a Group 1 metal.

(f) Explain, in terms of electrons, why all Group 1 metals react in a similar way.

_____

_____ [1]

(g) Suggest why rubidium is **not** used in the school laboratory instead of sodium to demonstrate the reaction of Group 1 metals with water.

_____

_____

_____ [1]