The Periodic Table Notes

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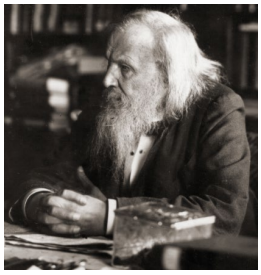
Before the discovery of subatomic particles, such as protons, early chemists organised the element's that they knew about and worked with. They arranged them in order of their atomic weights. What was once called atomic weight is now known as an element's relative atomic mass.

The big issue with arranging the elements like this was that a lot of elements had not yet been discovered. So, there wasn't much order and lots of empty spaces in early tables.

The Russian chemist **Dmitri Mendeleev** arranged the elements in order of increasing relative atomic mass, but this was not always true as isotopes messed up his calculations a bit.



Mendeleev rocking a beard

Mendeleev noticed that the chemical properties of the elements and their compounds showed a periodic trend. He then arranged the elements by putting those with similar properties below each other into groups.

To make his classification work Mendeleev made a few changes to his order:

1. He left gaps for elements that had not been discovered yet.
2. He switched the order of a few elements to keep the groups consistent.

Why were the "gaps" important? By looking at the chemical properties and physical properties of the elements next to a gap, Mendeleev and other chemists could also predict the properties of the undiscovered elements. This realisation led to the modern periodic table.

We could see a question asking us why Mendeleev swapped the order of some elements, like Iodine, breaking his own order of atomic mass? This is a good one 😊 So, that their properties matched the rest of the group.

The Modern Periodic Table

Unlike Mendeleev's table, the modern periodic table is arranged in order of increasing atomic number (the number of protons). **The horizontal rows are called Periods and the vertical columns are called Groups**. The shape of the periodic table matches the patterns of the electrons in their shells.

Group Number: tells us the number of outer shell electrons of an atom.

Period Number: tells us the number of electron shells for a given atom.

Elements in the same group react in similar ways because they have the same number of electrons in their outer shell.

Let's start by looking at Group 1, the alkali metals 😊

Group 1 – The Alkali Metals

All alkali metals have one electron on their out shell. They all lose one electron from their outer shells to from 1+ ions.

Why are they called alkali metals? Group 1 are called the alkali metals because when they react with water, they form alkali solutions. For example, see the following reaction:

$$\text{sodium} + \text{water} \rightarrow \text{sodium hydroxide} + \text{hydrogen}$$

$$2Na\ (s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2\ (g)$$

Reactivity: **Increases** as we move **DOWN** the group.

Why do the elements become more reactive as you move down the group? This is a very popular exam question!

1. The outer electron is further from the nucleus as you go down the group. Atomic radius increases.
2. Shielding increases.
3. The attraction between the nucleus and outer electron decreases as you go down the group - so the outer electron is more easily lost.

What is shielding? Think of shielding as mini eclipses 😊 Electrons on the inner shells block the attraction between the outer electrons and the nucleus. The more shells there are the more electrons there are, the more shielding occurs. Just like how the moon gets in the way of the sun and blocks the sunlight from reaching some of the surface.

Reactions with water: all alkali metals react vigorously with water. The intensity of the reaction increases as you go down the group for the reasons mentioned above. All alkali metals also react with oxygen forming metal oxides.

What will we observe when we react alkali metals with water? This is a very popular exam question!
We need to know that they all float, move around, and fizz or effervesce. We also specifically need to know that Potassium burns with a lilac flame.

Transition Metals

At GCSE we don't have to know an awful lot about transition metals. There is much more that must be known for A level. We have included the key points that could form questions that we may see.

Why are they called transition metals? All elements in the transition metals have variable oxidative states. That means that ions of elements can be different. For example we could have Fe^{2+} and Fe^{3+}. So, simply, the charges can vary.

Most metals are transition metals. They include elements such as iron, silver, gold, copper and chromium. The transition elements are in the central part of the periodic table. The figure below shows the transition metals.

Some properties of transition elements are different from those of the metals in group 1 and group 2. Transition metals have the following characteristics.

Similarities between transition metals and group 1 & group 2 metals
1. Ability to conduct electricity. Due to the capacity of their delocalised electrons to move and carry charge.
2. Are shiny when they are first cut.
3. All are solids at room temperature (except Mercury, which is a liquid).

Differences between transition metals and group 1 & group 2 metals
1. **Melting and boiling points** – transition metals have higher melting and boiling points.
2. **Density** – transition metals have higher densities.
3. **Less reactive with water** – transition metals are less reactive with water.
4. **Coloured compounds** – transition metals can form coloured compounds. What we mean by that is… When iron reacts with oxygen it goes brown. When copper reacts with oxygen it goes green. **Note**: when all the metals in group 1 and group 2 react with oxygen they produce white compounds.
5. **Can be used as catalysts** – transition metals can be used as catalysts.

Group 7 – The Halogens

Name: Halogens.

Why are they called that? The term "Halogen" means "salt-former" in Greek, because these elements will readily react with alkali metals and alkaline earth metals to form halide salts. Take the following reaction as an example,

$$\text{sodium} + \text{fluorine} \rightarrow \text{sodium fluoride}$$

Diatomic molecules: halogens exist as diatomic molecules these are pairs of atoms joined by a covalent bond, for example F_2, Cl_2 or Br_2.

Reactivity: Decreases as we move **DOWN** the group.

Why do the elements become **less reactive** as you move down the group?

1. The outer electrons is further from the nucleus as you go down the group. Atomic radius increases.
2. Shielding increases.
3. The attraction between the nucleus and outer electron decreases as you go down the group - so the atom is less able to capture an electron from another species.

Group 7 – Displacement Reactions

You could be asked for the products of the displacement reactions of halogens.

The rule is: a more reactive halogen will displace a less reactive Halogen from its compound.

Halogen	F^-	Cl^-	Br^-	I^-
F_2	No reaction	**Displacement**	**Displacement**	**Displacement**
Cl_2	No reaction	No reaction	**Displacement**	**Displacement**
Br_2	No reaction	No reaction	No reaction	**Displacement**
I_2	No reaction	No reaction	No reaction	No reaction

We can see, from the table above, that a more reactive halogen is able to displace a less reactive halogen. Fluorine is the most reactive halogen so it is capable of displacing chlorine, bromine and iodine. Chlorine is less reactive than fluorine, so it can't displace fluorine but it can displace bromine and iodine and so on 😊

We also need to know the physical state and colour of the main halogens at room temperature. These are…

Chlorine (Cl_2): pale green gas Bromine (Br_2): red-brown liquid

Iodine (I_2): dark grey solid (Note: when heated, it sublimes into a purple vapour)

Group 0 – The Noble Gases

Name: The Noble Gases.

Why are they called that? The English term "Noble Gas" comes from the translation of the German word Edelgas. Noble gases have had their own special name since as early as 1898.

Reactivity: They are unreactive.

Why are elements in group 0 unreactive? Each element has a full outer shell of electrons so each element is stable. This means that they don't lose or gain any electrons.

Uses of noble gases:

1. Helium is used as an industrial coolant.
2. Helium is also used in balloons 😊 and they will of course accept this correct use.
3. Argon is used in filament light bulbs to provide an inert atmosphere, which stops the hot filament from reacting with oxygen and burning out.

Boiling Point and Melting Point Trends

Before we look at the trends in the periodic table, let's quickly define what these terms actually mean, boiling point melting point and trend while we're at it!

A trend: a predictable pattern in which something changes. I know that sounds vague but it needs to be.

Boiling point: the specific temperature at which a substance changes state from a liquid to a gas.

Melting point: the specific temperature at which a substance changes state from a solid to a liquid.

The trend of Group 1: melting and boiling points **decrease** as you move **down** the group.

Why does this happen? As the atoms get larger, the attractive forces holding the metal atoms together get weaker. Therefore, less heat energy is needed to break them apart.

The trend of Group 7: melting and boiling points **increase** as you move **down** the group.

Why does this happen? As you go down the group, the molecules get larger. Larger molecules have stronger intermolecular forces between them. This means more heat energy is needed to overcome these forces.

The trend of Group 0: boiling points **increase** as you move **down** the group.

Why does this happen? Just like the halogens, as the atoms get larger going down the group, the intermolecular forces between the atoms become stronger, requiring more energy to overcome.