Edexcel GCSE Chemistry

Your notes

The Periodic Table

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Mendeleev´s Periodic Table

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Mendeleev's Arrangement

- Before the discovery of the subatomic particles, scientists struggled to find ways of ordering the growing knowledge of elements and their chemistry
- When the elements that were known at that time were sorted by mass into a table, patterns emerged at **regular periods** along the table, giving rise to the term periodic
- The earlier tables were incomplete as some elements were forced into a position to fill **gaps** which appeared during the sorting process
- Other elements were placed in the wrong group as they were sorted strictly on their mass and had their chemical properties ignored
- There were many early versions of the tables as scientists in different countries grappled with the ordering of the elements
- In 1869 the Russian chemist Dmitri Mendeleev created his first draft of the periodic table
- He organised the elements into **vertical columns** based on their properties and the properties of their compounds
- He then started to arrange them **horizontally** in order of **increasing atomic mass** and as he worked, he found that a **pattern** began to appear in which chemically similar elements fell naturally into the same columns

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ROW	GROUPS							
	I	II	III	IV	V	VI	VII	VIII
1	H	—	—	—	—	—	—	—
2	Li	Be	B	C	N	O	F	—
3	Na	Mg	Al	Si	P	S	Cl	—
4	K	Ca	?	Ti	V	Cr	Mn	Fe, Co, Ni, Cu
5	(Cu)	Zn	?	?	As	So	Br	—
6	Rb	Sr	Yt	Zr	Nb	Mo	?	Ru, Rh, Pd, Ag

Mendeleev's Periodic Table showing gaps

- There were exceptions though as some elements didn't fit the pattern when arranged by atomic mass
- Mendeleev worked to include all the elements, but he didn't force an element to fit the pattern, rather he left **gaps** in the table that he thought would best be filled by elements that had not yet been discovered
- He also switched the order of the elements to maintain consistency down the columns

Mendeleev's Predictions

- Mendeleev quickly realised that elements with the **same properties** should be placed in the **same column**

- He realised that gaps in the table must correspond to elements that had not yet been discovered or isolated
- He used the properties and trends of other elements in the group with the gap to **predict** the properties of these undiscovered elements
- Mendeleev left a gap between silicon and tin and used his knowledge of the properties of those two elements to make predictions about the physical and chemical properties of the undiscovered element
- He called this element 'eka-silicon' which comes from the Greek 'like silicon' and when the element germanium was discovered in 1887 it was found to almost exactly match the properties Mendeleev had predicted
- No one doubted that Mendeleev had got the right idea about ordering the elements
- Strangely enough, Mendeleev always denied the existence of an eighth group of elements, even after the discovery of the noble gases in Mendeleev's final years

Examiner Tips and Tricks

Mendeleev’s table had gaps into which he didn’t force an element, rather he left them empty to be filled at a later date when the correct element was isolated. In this way his version of the table allowed him to predict the existence and properties of then-unknown elements.

Problems with Mendeleev's Table

- Once he was finished, Mendeleev thought he had organised the elements systematically but there were still some elements which didn't quite fit in as neatly as he wanted.
- This is because **isotopes** were not known in Mendeleev's time, and he made no provisions for them in his table
- This meant that there was always going to be some level of inaccuracy in Mendeleev ́s work even though he did also consider the elements chemical properties as well as their atomic mass when sorting them
- Mendeleev switched the order of tellurium and iodine is his table, because even though tellurium was heavier than iodine, the chemistry of iodine fitted better with the other halogen elements; it was a nagging problem that was not solved in his lifetime
- The discovery of the proton lead to the determination of **atomic number** for each element
- This number is used to arrange the elements in the modern-day periodic table which fits with Mendeleev 's patterns

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The Modern Periodic Table

The Modern Periodic Table

- There are over 100 chemical elements which have been isolated and identified
- Elements are arranged on the periodic table in order of **increasing atomic number**
  - Each element has one proton **more** than the element preceding it
  - This is done so that elements end up in columns with other elements which have similar properties
- The table is arranged in vertical columns called **groups** and in rows called **periods**
  - **Period:** These are the horizontal rows that show the number of shells of electrons an atom has and are numbered from 1 - 7
  - E.g. elements in period 2 have two electron shells, elements in period 3 have three electron shells
- **Group:** These are the vertical columns that show how many outer electrons each atom has and are numbered from 1 – 7, with a final group called group 0 (instead of group 8)
  - E.g. group 4 elements have atoms with 4 electrons in the outermost shell, group 6 elements have atoms with 6 electrons in the outermost shell and so on

The Periodic Table

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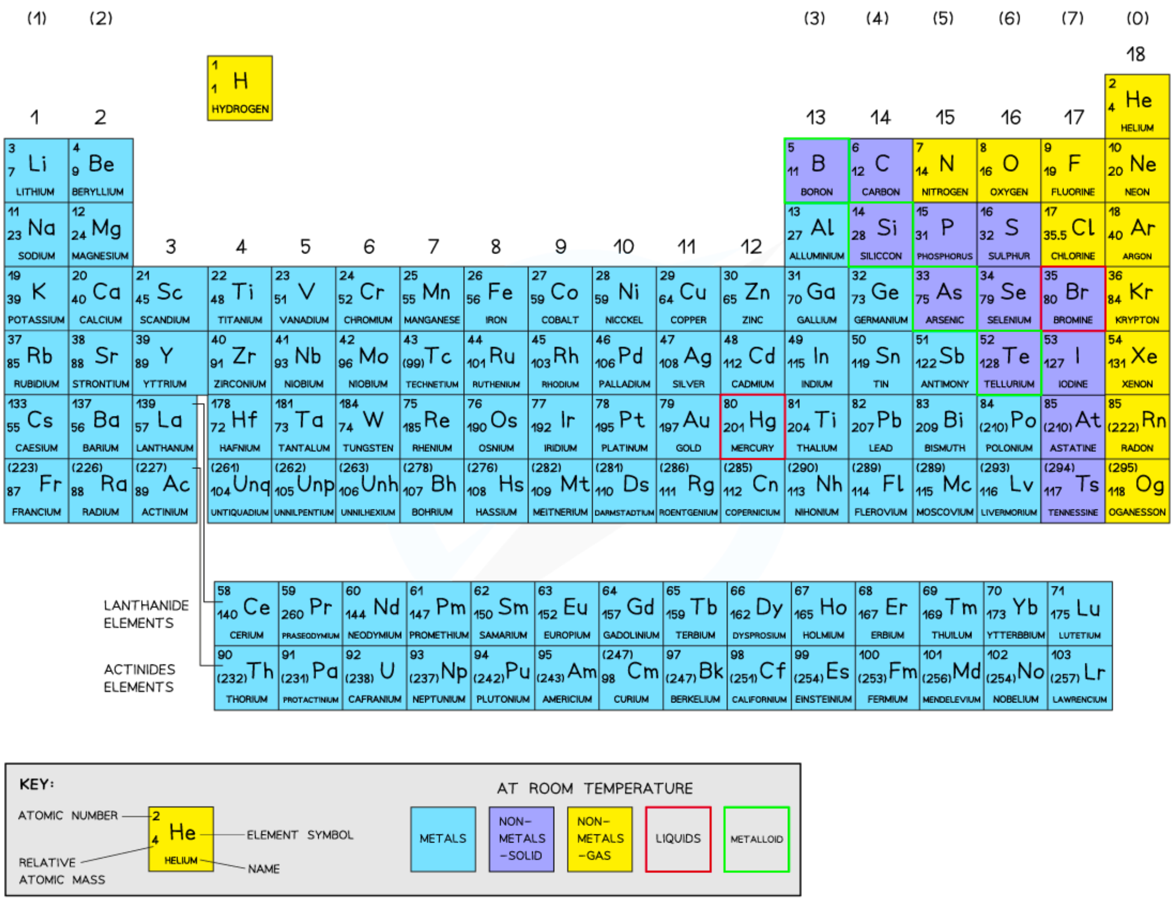

The Periodic Table of the Elements

Examiner Tips and Tricks

The atomic number is unique to each element and could be considered as an element's "fingerprint".

The number of electrons changes during chemical reactions, but the atomic number does not change.

Metals and Non-Metals in the Periodic Table

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- The metals that are further to the left on the periodic table do not have many electrons to remove from their outer shells
- As you descend the groups, the outer shell electrons become **further away** from the nucleus due to increasing atomic size
  - This **weakens their attraction** to the nucleus
- The further down the group an element is, the more easily it can react and lose its outer electron(s)
- For the non-metals which are placed on the right-hand side, the opposite is the case
- These elements have a lot of outer electrons, and it is more feasible for them to gain (or share electrons) to obtain a full outer shell
  - This is a key difference between metals and non-metals and influences their chemical behaviour
- It also clearly illustrates the important link between an element's atomic number and how it reacts as well as its position on the periodic table
- The general properties of most metals and non-metals are summarised below:

A summary of the General Properties of Metals & Non-metals

Property	Metals	Non-metals
Electron arrangement	1 – 3 outer shell electrons	4 – 7 outer shell electrons
Bonding	Metallic bonding due to loss of outer shell electrons	Covalent by sharing of outer shell electrons
Electrical conductivity	Good conductors of electricity	Poor conductors of electricity
Type of oxide	Basic oxides (a few are amphoteric)	Acidic oxides (some are neutral)
Reaction with acids	Many react with acids	Usually do not react with acids
Physical characteristics	• Usually lustrous (shiny) • Solid at room temperature (excluding mercury) • Malleable, can be bent and shaped • High melting and boiling points	• Dull, non-reflective • Different states at room temperature • Flaky, brittle • Low melting and boiling points

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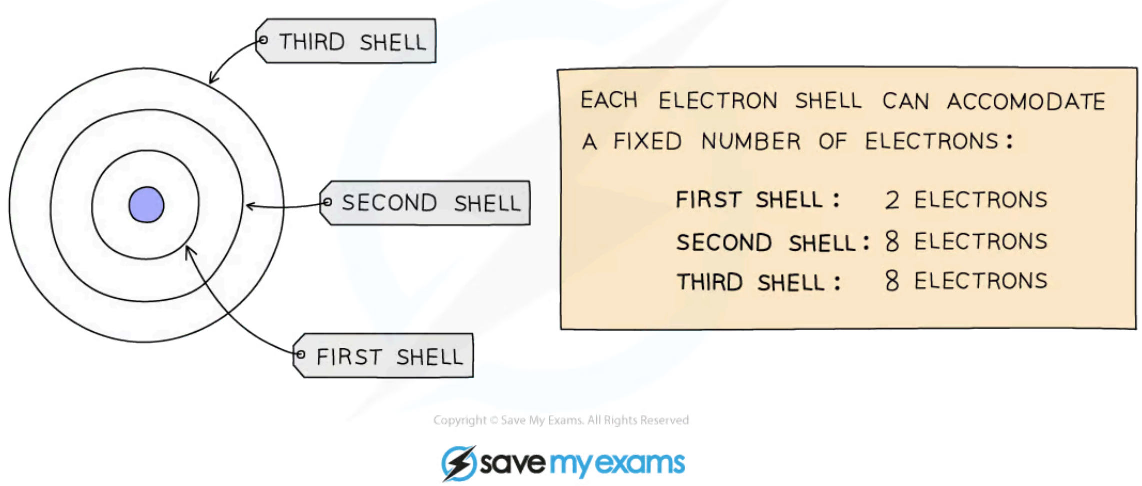
Electronic Configurations

Electronic Configurations

- We can represent the electronic structure of atoms using electron **shell diagrams**
- Electrons orbit the nucleus in shells and each shell has a different amount of energy associated with it
- The further away from the nucleus, the more energy a shell has
- Electrons first occupy the shell closest to the nucleus which can hold a maximum of **2 electrons**
- When a shell becomes full of electrons, additional electrons have to be added to the next shell
- The second shell and third shell can hold **8 electrons** each
- The outermost shell of an atom is called the **valence shell** and an atom is much more stable if it can manage to completely fill this shell with electrons
- In most atoms, the outermost shell is not full and therefore these atoms react with other atoms in order to achieve a full outer shell of electrons (which would make them more stable)
- In some cases, atoms lose electrons to entirely empty this shell so that the next shell below becomes a (full) outer shell



Deducing electron configuration

- The arrangement of electrons in shells can also be explained using numbers

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- Instead of drawing electron shell diagrams, the number of electrons in each electron shell can be written down, separated by full stops
- This notation is called the electronic configuration (or electronic structure)
  - E.g. Carbon has 6 electrons, 2 in the 1st shell and 4 in the 2nd shell
    - Its electronic configuration is 2.4
- Electronic configurations can also be written for ions
  - E.g. A sodium atom has 11 electrons, a sodium ion has lost one electron, therefore has 10 electrons; 2 in the first shell and 8 in the 2nd shell
    - Its electronic configuration is 2.8
- There is a clear **relationship** between the electronic configuration and how the Periodic Table is designed
- The number of notations in the electronic configuration will show the number of occupied shells of electrons the atom has, showing the **period** in which that element is in
- The last notation shows the number of outer electrons the atom has, showing the **group** that element is in (for elements in groups 1 to 7)
- The electron configuration of the first twenty elements is shown below:

Electronic Configuration of the First 20 Elements Table

Element	Atomic number	Electronic configuration
Hydrogen	1	1
Helium	2	2
Lithium	3	2.1
Beryllium	4	2.2
Boron	5	2.3
Carbon	6	2.4
Nitrogen	7	2.5
Oxygen	8	2.6
Fluorine	9	2.7
Neon	10	2.8
Soidum	11	2.8.1
Magnesium	12	2.8.2
Aluminium	13	2.8.3
Silicon	14	2.8.4
Phosphorus	15	2.8.5
Sulfur	16	2.8.6
Chlorine	17	2.8.7
Argon	18	2.8.8

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Potassium	19	2.8.8.1
Calcium	20	2.8.8.2

Note: Although the third shell can hold up to 18 electrons, the filling of the shells follows a more complicated pattern after potassium and calcium. For these two elements, the third shell holds 8 and the remaining electrons (for reasons of stability) occupy the fourth shell first before filling the third shell

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Examiner Tips and Tricks

You should be able to represent the first 20 elements using either electron shell diagrams or written electronic configuration.