



STRUCTURE OF THE ATOM

Domain: 5.7

relates properties of elements, compounds & mixtures to scientific models, theories and laws

Elements

An element is a **simple substance** which cannot be made any simpler by normal **chemical** means. All the known elements are listed in the **Periodic Table**. An element is made up of many small units called **atoms**. The atoms in an element are all the **same**.

The Structure of Atoms

Atoms are made up of three main sub-atomic particles. These particles are:

1. the proton;
2. the neutron;
3. the electron

The proton and neutron are located in the central **nucleus**. The electron(s) occupy certain regions of space (known as energy levels) around the nucleus. They are said to 'orbit' the nucleus.

Some of the particles are electrically **charged**. The proton has a positive (+) charge. The electron has negative (-) charge. This is **opposite** to the proton. The neutron has no (0) charge- it is electrically neutral.

The table below summarises this information:

Particle	Charge	Location	
protons ○	positive (+)	in nucleus	
neutrons ●	neutral (0)	in nucleus	
electrons ⊖	negative (-)	orbiting nucleus	
<p>For every proton in the nucleus of an atom, there has to be the same number of electrons orbiting the</p>			

The Atomic Number, Mass Number and Atomic Mass of an Element

Atomic Number (Z)	The atomic number is given on the Periodic Table. Elements are listed in order of their atomic number in the Periodic Table. All atoms of the same element have the same atomic number. The atomic number equals the number of protons in the nucleus and also the number of electrons orbiting nucleus. Atomic number=no. of protons=no. of electrons	Information given on common Periodic Tables:
Mass Number (A)	The mass number is the number of protons plus neutrons in an atom. Mass number=no. of protons + no. of neutrons The number of neutrons in an atom can be found by using the equation: No. of neutrons in atom= A-Z	
Atomic Mass	It is difficult to define atomic mass in simple terms. It is the relative mass of the atoms of an element compared to the mass of a special type of carbon atom. Atomic mass is given on the Periodic Table for each element. Atomic mass has special units- the atomic mass unit or amu. The amu is a very small unit- 1 amu= 0.000 000 000 000 000 000 000 001 661 grams.	



Electron Energy Levels

The atomic number is important in analysing how the electrons are arranged in an atom. This is known as the **electron configuration**.

Electrons are arranged around the nucleus in **energy levels**. Each energy level can only hold a certain number of electrons. The energy levels are numbered. The first energy level from the nucleus is known as $n=1$, the next level is $n=2$ etc.

The number of electrons each level can hold is given in the table below (for the first four levels):

Energy Level	n=1	n=2	n=3	n=4
Maximum number of electrons	2	8	18	32

Element	carbon	sodium	chlorine
Atomic Number	6	11	17
Number of Electrons	6	11	17
No. of electrons into $n=1$ (maximum is 2)	2 (full)	2 (full)	2 (full)
No. of electrons into $n=2$ (maximum is 8)	4 (left over)	8 (full)	8 (full)
No. of electrons into $n=3$ (maximum is 18)	7	1 (left over)	7 (left over)
No. of electrons into $n=4$ (maximum is 32)	7	7	7
Electron configuration	2, 4	2, 8, 1	2, 8, 7



STRUCTURE OF THE ATOM

You have to be able to indicate the electron configuration for the first twenty elements in the Periodic Table (the atomic number will be given).

Potassium ($Z=19$) and calcium ($Z=20$) have electron configurations slightly different to what you would expect. This is because electrons start filling the $n=4$ energy level before they have finished filling the $n=3$ level. The electron configurations for potassium and calcium are given below:

Potassium ($Z=19$) 2,8,8,1

Calcium ($Z=20$) 2,8,8,2

For the next element, scandium ($Z=21$), the electron configuration is:

Scandium ($Z=21$) 2,8,9,2

Note:
The next electron has returned to filling the $n=3$ level.

Questions:

- What is an element?
- What are elements made up of?
- What are the three main sub-atomic particles in an atom?
- Which particle(s):
 - has a positive charge?;
 - has a negative charge?;
 - has no charge?;
 - orbits the nucleus?;
 - is found in the nucleus?
- What does the atomic number of an element equal?
- What does the mass number of an element equal?
 - An atom has 11 protons and 12 neutrons in its nucleus. What is its mass number?
 - An element has a mass number of 238 and an atomic number of 92. How many neutrons are in the elements' atoms?
- What is the arrangement of electrons around an atom's nucleus known as?
 - How are electrons arranged around an atom's nucleus?
 - What is the maximum number of electrons each of the first four energy levels can hold?
 - Give the electron configuration for the first 18 elements in the Periodic Table.
- What is the electron configuration for potassium and calcium?
 - Why are these different to what you would expect them to be?
- The maximum number of electrons in each energy level is given by the equation: $2n^2$ where 'n' is the number of the energy level. How many electrons would be in the:
 - 5th level ($n=5$);
 - 6th level ($n=6$)?
- Read through the information on the Periodic Table on the following page.

Notation for mass number and atomic number:

mass number ... \rightarrow $\left(\begin{array}{c} 238 \\ \text{U} \end{array} \right)$
atomic number ... \rightarrow $\left(\begin{array}{c} 92 \\ \text{U} \end{array} \right)$



The Periodic Table

On the Periodic Table-

P Vertical columns are called **GROUPS**.

P Each row across is a **PERIOD**.

P Each group tends to have a common valency (indicated at bottom of group).

P Metals are located on the left-hand side of the stepped line.

P Non metals are located on the right-hand side of the stepped line (shaded).

P Transition metals have variable valencies.

P Some of the groups are named:

- ☀ Group ① = Alkali Metals
- ☀ Group ② = Alkaline Earth Metals
- ☀ Group ⑦ = Halogens
- ☀ Group ⑧ = Noble Gases

P The boundary between the metals and non metals is not clearly defined. Along the boundary is a set of elements which cannot be easily classified as metals or non-metals. They are called *metalloids*. They are marked with an asterisk *.

metals		non-metals				Group 8		
Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	
1 Li	2 Be	3 B*	4 C	5 N	6 O	7 F	8 Ne	
11 Na	12 Mg	13 Al	14 Si*	15 P	16 S	17 Cl	18 Ar	
19 K	20 Ca	31 Ga	32 Ge*	33 As*	34 Se	35 Br	36 Kr	
37 Rb	38 Sr	49 In	50 Sn	51 Sb	52 Te*	53 I	54 Xe	
55 Cs	56 Ba	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
+ 1 ions	+ 2 ions	Variable valencies	+ 1 or + 3 ions		- 3 ions	- 2 ions	- 1 ions	Do not form ions

Atomic number & atomic mass increase across → table and down ↓ table.