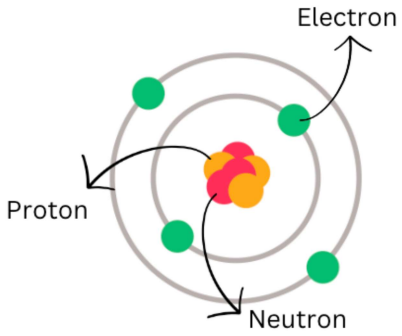
ATOM

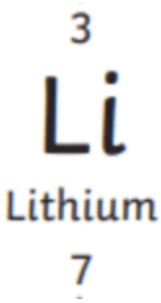


- An **atom** is the smallest particle of a substance.
- It has a **nucleus**, containing **protons and neutrons.**
    - The nucleus is a dense region at the centre of an atom
- **Electrons** are found in electron shells surrounding the nucleus

Subatomic particle	**Proton**	**Electron**	**Neutron**
Relative mass	1	1/1836	1
Relative charge	+1	-1	0 (neutral)
Location	Nucleus	Electron shell	Nucleus

What are the different parts of an atom?

- An atom has an equal number of protons and electrons
    - Hence an atom is an electrically neutral



→ **Proton (atomic) number** = total number of protons in the nucleus of an atom

→ Chemical symbol

→ **Nucleon (mass) number** = total number of protons and neutrons in the nucleus of an atom

- Nucleon number is usually greater than the proton number
    - Except for hydrogen atom where both proton number and nucleon number are 1 as hydrogen atom does not have nucleons

- Electrons are arranged in **electron shells** around the nucleus
- **Electrons must fill the lowest energy shell completely** (n=1) before filling the next energy shell (n=2) and so on (n=3,4,....)
- For each energy level, there is a maximum number of electrons that is allowed to occupy

Electron shell (n)	Maximum number of electrons
1	2
2	8
3	8

- Arrangement of electrons in an atom can be represented using **electronic configuration** or **electronic structure**
    - In an electronic structure, protons and neutrons need not be drawn

Example question:	Write down the electronic configuration of an aluminium atom
Answer:	**2,8,3**
Explanation:	• Aluminium has 13 electrons. • Electrons should fill the lowest energy shell completely first

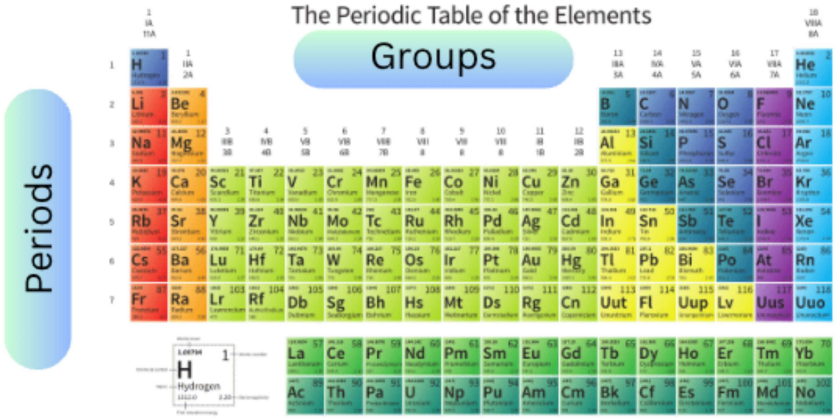
Example question: Draw the electronic structure of fluorine

Answer:

Rules:

- Electrons are drawn on electron shells
- 2 electrons on first shell
- 7 electrons on second shell
- No need to draw protons and neutrons in electronic structure

- **Valence shell** refers to the electron shell that is further away from the nucleus of the atom
    - Electrons in the valence shell are called valence electrons
    - Eg Fluorine has 5 valence electrons
- We can use valence electrons to determine metals or non-metals
    - Number of valence electrons = 1,2,3 are metals
    - Number of valence electrons = 4,5,6,7,8 are non-metals
- The group number in the Periodic Table is the same as the number of valence electrons
    - Eg lithium in Group 1 has 1 valence electrons, Neon in Group 0 has full valence shell



- **Groups** categorise elements with the **same number of valence electrons**
    - They have similar chemical properties
- **Periods** categorise elements with the **same number of electron shells**

- When an atom has the **maximum number of electrons** in the valence shell, it is stable and unreactive
    - A stable electronic configuration
    - All group 0 of the Periodic Table have stable electronic configurations, called **noble gases**
    - They are inert and exist as monoatomic elements

 An atom has a **maximum of 2** electrons at n=1 has a **duplet** electronic configuration	 An atom has a **maximum of 8** electrons at n=2 has an **octet** electronic configuration	 An atom has a **maximum of 8** electrons at n=3 has an **octet** electronic configuration

Example question:

The table below shows the electronic structures of 6 elements A, B, C, D, E and F.

Element	Electronic structure
A	1
B	2
C	2,1
D	2,6
E	2,8
F	2, 8, 2

Give the letters of

(a) Two unreactive and monatomic elements.
(b) A group 1 metal
(c) Two elements forming a water molecule.
(d) An element using three electron shells.

Answer:

A) B and E
B) A
C) A and D
D) F

Explanation:

A) They have full valence electron shells, making them chemically stable and less likely to react with other elements. B has a duplet structure as it has only 1 electron shell and E has an octet structure with 2 electron shells

B) Group I metals are also known as alkali metals and are located in the first column of the periodic table. They have one valence electron. Element A has an electronic structure of 1, which means it has one valence electron.

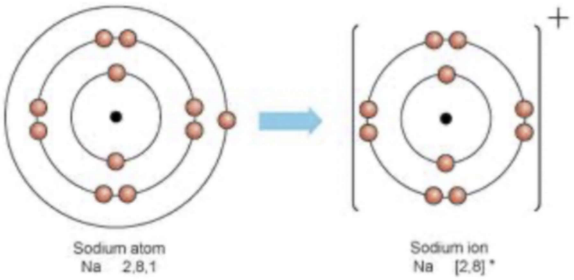
C) A water molecule (H2O) consists of two hydrogen atoms and one oxygen atom. Hydrogen typically has an electronic structure of 1, and oxygen has an electronic structure of 2,6. Elements A and D both have one valence electron (1), and element D has six valence electrons (2,6).

D) The number of electron shells an element has is determined by its period on the periodic table. The first period elements have one electron shell, the second period elements have two electron shells, and so on. Element F has an electronic structure of 2,8,2, which indicates that it has three electron shells (2 in the first shell, 8 in the

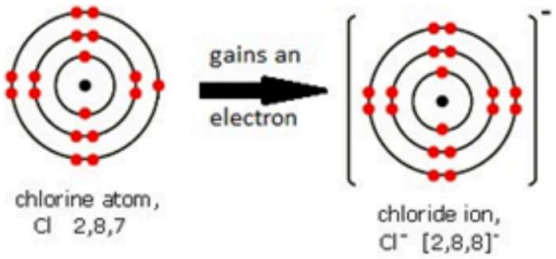
second shell, and 2 in the third shell).

IONS

- An ion is a **charged** particle formed when an atom loses or gains electrons.
    - When an atom form an ion, proton number and nucleon number does not change as protons and neutrons are not involved



- When an atom **loses** an electron, number of protons is more than number of electrons hence it will be a positively charged ion
    - The ion is called a **cation**
- The '+' indicates loss of electrons



- When an atom **gains** an electron, number of protons is less than number of electrons hence it will be a negatively charged ion
    - The ion is called an **anion**
- The '-' indicates gain of electrons

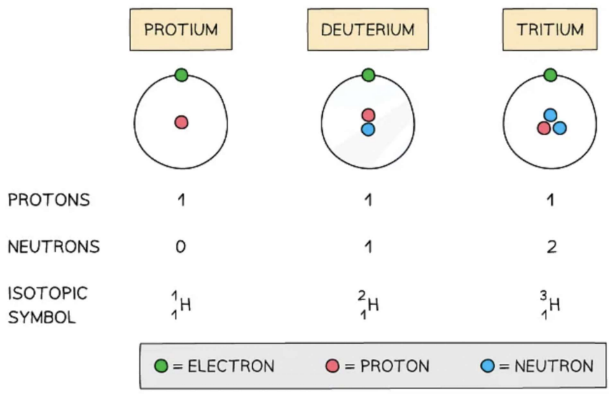
Names of non-metals change to '-ide' when they become ions

- Most atoms are not stable as their valence shell is not filled with maximum number of valence electrons
    - Atoms will lose or gain electrons so their valence shell is filled completely
    - To achieve stable electronic configuration of a noble gas

- To form ions:

Metals	Non-metals	Noble gases
Metals lose electrons to form cations • Generally found in group I, II, III • It is easier to lose 1,2 or 3 electrons to form a stable configuration • $X \rightarrow X^{n+} + ne^-$	Non-metals gains electrons to form anions • Generally found in group IV, V, VI, VII • It is easier to gain 1, 2 or 3 electrons to form a stable configuration • $Y + ne^- \rightarrow Y^{n-}$	Noble gases have full valence shells and hence do not gain or lose electrons • Found in group 0 • They do not become ions

ISOTOPES



- Isotopes are atoms of the same element with the same number of protons but different number of neutrons
- Mass numbers of many elements are not whole numbers as these elements occur as isotopes in nature

- They have similar chemical properties but slightly different physical properties
  - As chemical reactions only involve electrons but physical properties are affected by mass
  - Physical properties of isotopes like melting and boiling points are changed

Different isotopes have different mass due to difference in number of neutrons

Example question: Chlorine exists as 2 naturally occurring isotopes, Chlorine-35 and Chlorine-37. Calculate the atomic mass of chlorine if the percentage abundance of each isotope is:

Isotope	% Abundance
Chlorine-35	75.0%
Chlorine-37	25.0%

Answer: **Atomic mass of chlorine**
= 35 x 0.75 + 37 x 0.25 = 35.5

Quick summary of the notes

What Are the Different Parts of an Atom?

Subatomic particle	Proton	Electron	Neutron
Relative mass	1	1/1836	1
Relative charge	+1	-1	0 (neutral)
Location	Nucleus	Electron shell	Nucleus

Topic	Key Points
Atomic Number	• Total number of protons in the nucleus of an atom
Mass Number	• Total number of protons and neutrons in the nucleus
Electron Arrangement	• Electrons fill lower energy shells before higher energy shells • Each energy level has a maximum number of electrons.
Valence Shell and Electrons	• The outermost electron shell; electrons in the valence shell are called valence electrons. • Used to determine whether an element is a metal or nonmetal. • Metals: 1, 2, 3 valence electrons. • Non-metals: 4, 5, 6, 7, 8 valence electrons.
Stable Electronic Configuration	• When an atom has a full valence shell, it is stable and unreactive. • Noble gases have stable electronic configurations and are inert. • A maximum of 2 electrons at n=1 (duplet electronic configuration). • A maximum of 8 electrons at n=2 (octet electronic configuration).

Ion	• A charged particle formed when an atom loses or gains electrons. • Proton and nucleon numbers remain unchanged. • Cation: Positively charged ion formed when an atom loses electrons (indicated by '+'). • Anion: Negatively charged ion formed when an atom gains electrons (indicated by '-').
Isotopes	• Atoms of the same element with the same number of protons but different numbers of neutrons. • Have similar chemical properties but slightly different physical properties due to varying mass.

What are some common pitfalls?

1. Confusion about Atomic Number and Mass Number

Pitfall: Students may mix up the concepts of atomic number (number of protons) and mass number (sum of protons and neutrons).

Elaboration: Clearly explain the definitions of atomic number and mass number. Use visual aids and examples to distinguish between the two. Emphasise that the atomic number uniquely identifies an element.

Atomic proton is also be known as proton number while atomic mass is also known as nucleon number.

Atomic number = number of protons

Mass number = number of protons + number of neutrons

2. Misunderstanding Electron Configuration:

Pitfall: Students may struggle with writing electron configurations using the proper notation (e.g., 2,8,1 for sodium).

Elaboration: Electrons fill in the electron shell with the lowest energy completely first.

Example: Sodium has 11 electrons. Fill the first electron shell (n=1), which has a maximum electron count of 2. There are then 9 electrons left. Fill the next electron shell (n=2), which has a maximum electron count of 8. There are then 1 electron left. Fill the next electron shell (n=3). Hence the electronic configuration is 2,8,1.

3. Difficulty in Determining Valence Electrons:

Pitfall: Students may find it challenging to identify the number of valence electrons in an atom.

Elaboration: 2 ways to determine the number of valence electrons:

I. Find the electronic configuration: the number of electrons in the outermost electron shell is the number of valence electrons
II. Look at the group number on the periodic table. Group number is the number of valence electrons.

4. Difficulty in understanding the periodic table:

Pitfall: Students may find it challenging to understand the periodic table.

Elaboration: Elements in the Periodic Table are arranged based on their proton number. They are also placed in groups and periods based on certain characteristics.

Elements in the same period has the same number of electron shells. Example: Elements in period 1 has 1 electron shell, periodic 2 has 2 electron shells.

Elements in the same group have the same number of valence electrons. Example: Elements in group 1 have 1 valence electron, elements in group 13 have 3 valence electrons.

Studying the topic of atomic structure effectively requires a combination of strategies that cater to the conceptual understanding and application of key concepts. Here are some specific studying tips for the topic of atomic structure:

1. Master the Basics First:

Begin by understanding the basic components of an atom, including protons, neutrons, electrons, and their respective properties (charge, mass, location).

2. Study the Periodic Table:

Familiarize yourself with the periodic table, paying special attention to group numbers, periods, and the arrangement of elements based on atomic number.

3. Electron Configurations:

Focus on writing electron configurations for different elements. Practice writing configurations for elements across the periodic table to become proficient.

4. Electronic Structure:

Learn how to draw electronic structures to represent the distribution of electrons in an atom. Practice drawing these diagrams for various elements.

Practice drawing ionic structures too! These are commonly drawn wrongly by many students.

5. Isotopes:

Learn how to identify isotopes and calculate the average atomic mass of an element considering isotopic abundances.

6. Practice Problem Solving:

Solve problems related to atomic structure, including determining the number of protons, neutrons, and electrons in various elements or ions.

7. Use Visual Aids:

Utilize diagrams, charts, and models to visualize atomic structure concepts. These visual aids can help you grasp abstract ideas more easily.

8. Real-World Applications:

Connect atomic structure to real-world applications, such as the use of radioactive isotopes in medicine, electron configuration in chemical reactions, and atomic models in technology.

By following this study plan, you can confidently approach questions related to the atomic structures in your 'O' levels chemistry exams. Understanding the core concepts will set a strong foundation for your success.