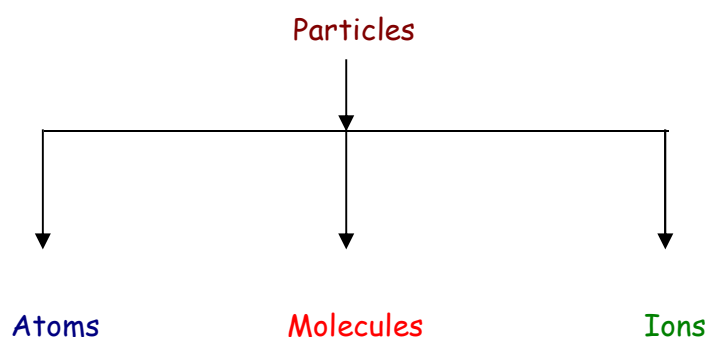


Structure of matter

Chapter-3:

All matter is made of very tiny particles. The particles may be atoms, molecules or ions.



An atom is the neutral smallest particle that (still) represents an element.

An atom is electrically **neutral** and cannot exist on its own [except 6 inert gases]

Video Link:

A molecule is a group of atoms held together chemically, electrically neutral and can exist on its own.

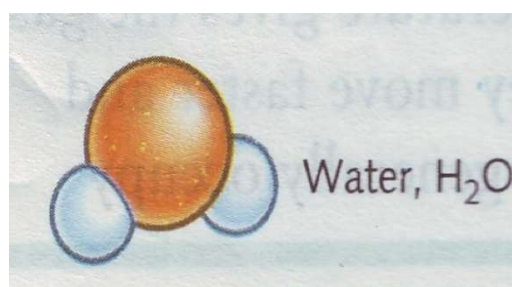
A molecule can, simply, be considered a family of atoms.

A molecule, maybe, consists of atoms of one element or more than one elements.

When a molecule or a substance consists of only one type of atoms, it is called an element.

When a molecule or a substance consists of more than one types of atoms, it is called a **compound**.

So, we get more than one element when we split a compound.



1. **Rutherford Atomic Model: Video link:** https://www.youtube.com/watch?v=B-k_kMwB1zM
2. **Neil Boh'r Atomic Model: Video Link:** <https://www.youtube.com/watch?v=fm2C0ovz-3M>

Ions:

An ion is a single particle or a group of particles carrying an electric charge.

Ions, maybe, either cations or anions.

Cations are the positively charged ions formed by loss of electrons.

For example: NH_4^+ , Na^+ , Ca^{2+} etc are cations.

Anions are the negatively charged ions formed by gain of electrons.

For example: Cl^- , O^{2-} , CO_3^{2-} etc are anions.

Formulae of the particles:

You need to know these definitions by heart, but you also need to be able to recognize the formulae of atoms and molecules when you see them. O , O_2 , O^{2-} , H_2O are all formulae which consist of the element, oxygen.

- O is single, without any charge represents oxygen atom; cannot exist on its own.
- O_2 is a group of two oxygen atoms, without any charge represents oxygen molecule; can exist on its own; Maximum gaseous molecules, like oxygen, are diatomic molecules and do not exist as atoms on their own. (e.g. H_2 , N_2 , Cl_2 etc)
- O^{2-} is single, with negative charge represents an anion of oxygen; cannot exist on its own.
- H_2O is a group of atoms, without any charge represent a molecule of water; cannot exist on its own; As it consists of two different elements (hydrogen and oxygen), it is also called compound.

Problems:

Classify the type of particles represented by the following formulae.

HCl	Cl	H_2	H_3O^+	Br^-	He	Mg
SO_3^{2-}	NH_3	N	N^{3-}	Ca^{2+}	Na	Cl_2

Atoms

Elementary Molecules

Compound molecules

Cations

ANSWER:

The sub-atomic particles

Atoms are too tiny to see with open eyes. An atom consists of a nucleus and an area outside the nucleus. A nucleus is much smaller in size than an atom and it contains two sub-atomic particles, they are- proton and neutron. Another sub-atomic particle, named electron, occurs in the area outside the nucleus of an atom, but most of the space of an atom is empty.

The following Table shows relative properties of the sub-atomic particles:

Particle	Symbol	Position in atom	Relative charge	Relative mass
Proton	<i>p</i>	Nucleus	+1	1
Neutron	<i>n</i>	Nucleus	0	1
Electron	<i>e</i>	Orbits/shells	-1	1/1836

Here, the mass of a proton is equal to the mass of a

However, an electron's mass is onlyth of either a proton or neutron.

The electron's mass is regarded as so, it can be ignored.

Note: An atom consists of equal number of protons and electrons.

So the amount of positive charge and negative charge are also equal, which cancel each other causing the atom to be neutral.

Comprehensive Questions: This question is about the sub-atomic particle of an atom.

- (a) Name the three subatomic particle of atoms.
- (b) State the name of an element which may not have one of the sub-atomic particles.
- (c) Which of the sub-atomic particles has almost no mass?
- (d) Which two of the sub-atomic particles have equal amount of electric charge?

- (e) Which of the subatomic particles is neutral?
- (f) Which two of the sub-atomic particles have equal mass?
- (g) If the mass of an electron is 1 gram, what would be the mass of a proton?
- (h) An atom carries charged particles, but why it is neutral? []

The identity of an element:

The main identity of an element is its atomic number (Z) and mass number (A).

Atomic number: The atomic number of an element is the number of protons in the nucleus of its atom. (which is equal to the number of electrons).

It is represented by Z.

Atomic number, Z, is the main identity of an element as every element has its individual proton number.

Mass number: The mass number of an element is the total number of protons and neutrons in its atom.

Mass Number = the number of protons + the number of neutrons = (nucleon number)

It is represented by A.

Notation:

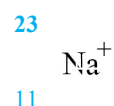
Consider an atom, X, mass number is A and the proton number (atomic number) is Z.

To represent these numbers, we write:

$$\begin{matrix} A \\ Z \end{matrix} X$$

We obtain the number of neutrons present in the atom by subtracting atomic number from its mass number. eg. Neutron number = A-Z

Examples:



(i) With the formula, we can deduce that a sodium atom has

- Mass number, A = proton + neutron = 23
- Atomic number, Z = Proton number, = 11
- Electron = 10
- Neutron = (A-Z) = 23-11= 12

-which tell us the atomic number and mass number of sodium are 11 and 23 respectively.

Complete the table:

Formula	${}^{40}_{20}\text{Ca}^{2+}$	${}^{16}_8\text{O}^{2-}$	${}^7_3\text{Li}^+$
Mass number (A)			
Atomic number (Z)			
No of proton (p)			
No of electron (e ⁻)			
No of neutron (n)			

Name of the student:

1. The following table is about the properties of three fundamental sub-atomic particles in atoms. Complete the missing information.

Particle	Symbol	Position in atom	Relative charge	Relative mass
Proton	p	.....	.....	1
Neutron	n	Nucleus	0	.....
Electron	.....	Shells	-1	.....

2. (a) Define the terms “atomic number” and “mass number”

atomic number:

.....

mass number:

.....

(b) Complete the following table for the number of the subatomic particles.

Formula	Number of protons	Number of electron	Number of neutron
${}^1_1\text{H}$	1	1	.....
${}^7_3\text{Li}^+$	.....	2	4
.....	11	10	12
${}^{16}_8\text{O}^{2-}$	8	.....	8

(c) An atom consists of both positive sub-atomic particles, protons, and negative sub-atomic particles, electrons, the atom carries no overall electric charge. Explain why?

.....

.....

.....

[1.5]

3. Identify the atoms, molecules, and ions (cations & anions) represented by the following formulae.

HCl Cl H₂ H₃O⁺ Br⁻ He

CO₃²⁻ NH₃ N N³⁻ Ca²⁺ Na

Atoms

Molecules

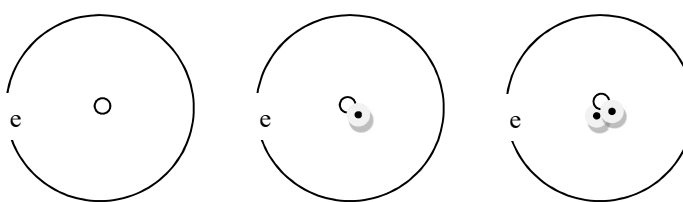
Cations

Anions

Total 10 marks for the test

Isotopes:

Three different atoms of hydrogen are:



No.	Properties	${}^1_1\text{H}$	${}^2_1\text{H}$	${}^3_1\text{H}$
1	Atomic number	1	1	1
2	Electron number	1	1	1
3	Mass number	1	2	3
4	Neutron number	0	1	2

These three atoms are the isotopes of hydrogen.

So we **define**-

'Isotopes are the atoms of an element which differ in their mass numbers.Or,

'The atoms with same proton number but different neutron numbers are called isotopes of an element.'

NOTE: Isotopes of an element are chemically identical, as they contain the same number

[you may be asked to distinguish the composition of the nuclei of two isotopes]

Comprehensive Questions:

${}^6_{12}\text{C}$ and ${}^6_{13}\text{C}$ are two atoms of carbon.

(a) What name is given to the different atoms of an element? [1]

(b) Explain, in terms of subatomic particles, how the composition of their nuclei.

(i) are different :

(ii) are the same :

[2]

(c) Explain why both ${}_6^{12}\text{C}$ and ${}_6^{13}\text{C}$ have the same chemical properties.

.....

[1]

(d) Give the symbol of an atom that has 1 less proton than in ${}_6\text{C}$.

.....

[1]

Total 5 marks

Arrangement of electrons in atoms:

Several groups of electrons may occur in an atom and each group is known as an electron shell or orbit. Shells are numbered as 1, 2, 3, etc. outwards the nucleus.

- Electrons in a given shell have approximately equal amount of energy. This energy increases in successive shells outwards the nucleus.

- The maximum possible number of electrons in a shell is $2n^2$, i.e. in successive shells, 2, 8, 18, 32, electrons.

- Outermost shell of an atom can accommodate maximum 8 electrons.

The atoms having 8 electrons in their outermost shell are stable and unreactive.

The electrons in the outermost shell of atoms are known as valence electrons and the outermost shells are known as valence shells.

These have great significance in determining type of bonding they form and chemical properties of their compounds.

The electrons in the outermost shell of an atom are called valence electrons.

These have great significance in determining the chemical properties of an atom and, as we shall see in bonding, determine how atoms join together.

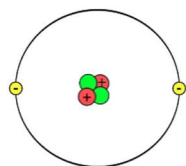
Electron number and Electron configurations of some elements:

Formula/ Name	Number of electron	Electron Arrangement
${}_1^1\text{H}$	1	1
${}_2^4\text{He}$	2	2
${}_3^7\text{Li}$	3	2, 1
${}_4^9\text{Be}$	4	2, 2
${}_5^{11}\text{B}$	5	2, 3

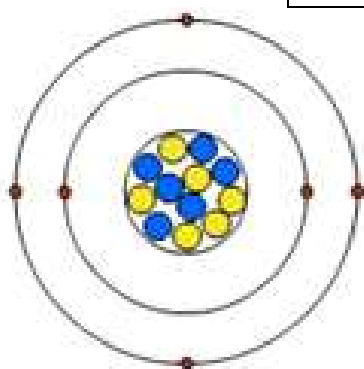
$^{12}_6\text{C}$	6	2, 4
$^{14}_7\text{N}$		
$^{14}_7\text{N}^{3-}$		
$^{16}_8\text{O}$		
$^{16}_8\text{O}^{2-}$	10	2, 8
$^{18}_9\text{F}$		
$^{19}_9\text{F}^-$		
$^{20}_{10}\text{Ne}$		
$^{23}_{11}\text{Na}$	11	2, 8, 1
$^{23}_{11}\text{Na}^+$	10	2, 8
$^{24}_{12}\text{Mg}$		
$^{24}_{12}\text{Mg}^{2+}$		
$^{27}_{13}\text{Al}$		
$^{27}_{13}\text{Al}^{3+}$		
$^{28}_{14}\text{Si}$		
$^{31}_{15}\text{P}$		
$^{31}_{15}\text{P}^{3-}$		
$^{32}_{16}\text{S}$		
$^{32}_{16}\text{S}^{2-}$		
$^{35}_{17}\text{Cl}$		
$^{35}_{17}\text{Cl}^-$		
$^{40}_{18}\text{Ar}$		
$^{39}_{19}\text{K}$		
$^{39}_{19}\text{K}^+$		
$^{40}_{20}\text{Ca}$		
$^{40}_{20}\text{Ca}^{2+}$		

Atomic and ionic models:

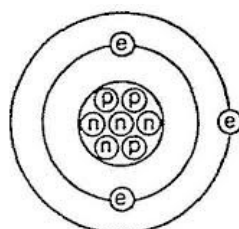
(i) ^4_2He



(ii) $^{12}_6\text{C}$



(iii)



key
 (p) proton
 (n) neutron
 (e) electron

Name of the student:

Comprehensive Question:

1. Fill in the blanks with suitable number, word or formula.

(i) The maximum number of electrons can be accommodated in 3rd shell of an atom is

(ii) Outermost shell of any atom can accommodate maximum electrons.

(iii) The electrons in the outermost shell of an atom is known as electrons.

(iv) The electron configuration of ${}_{19}\text{K}^+$ is

Total 4 marks for the question 1

2. ${}^{12}_6\text{C}$ and ${}^{13}_6\text{C}$ are two atoms of carbon.

(a) Draw the full atomic model for the ${}^{12}_6\text{C}$ indicating

- as an electron,
- as a proton and
- as a neutron.

[2]

(b) (i) What name is given to describe the occurrence of different atoms of the same element?

.....
.....

[1]

(ii) State the similarity and dissimilarity between the nuclei of the atoms.

.....
.....
.....

[2]

(d) Explain why both atoms react in the same way.

.....

[1]

Total 6 marks for the question 2

3. Bromine is an element in Group 7 of the Periodic Table.

(a) What is the name given to the Group 7 elements? (1)

(b) The symbols of two isotopes of bromine are $^{79}\text{Br}_{35}$ and $^{81}\text{Br}_{35}$.

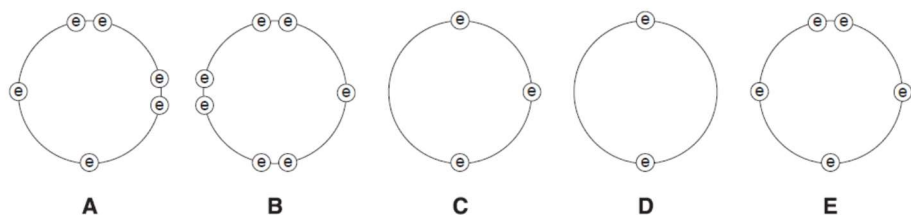
(i) State what is meant by the term isotopes. (2)

(ii) Complete the table to show the number of protons, neutrons and electrons in one atom of $^{79}\text{Br}_{35}$ and $^{81}\text{Br}_{35}$. (3)

Isotope	Number of protons	Number of neutrons	Number of electrons
$^{79}\text{Br}_{35}$
$^{81}\text{Br}_{35}$

4. These diagrams show the electron arrangement in the outer shells of five elements, A to E.

All elements are from Period 3 of the Periodic Table.



(a) Which element is most likely to be in Group VI?

(b) Which element will form an ion of the type X^{2+} ?

(c) Which element has an atomic number of 15?

(d) Which two elements will form an ionic compound with a formula of the type YZ_2 ?

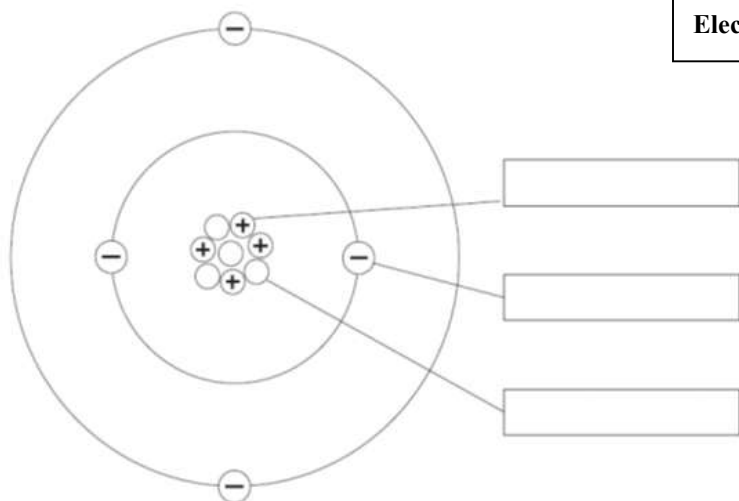
(e) Put the letters A to E in the table to show which elements are metals and which are nonmetals.

Metals	Non-metals

5. This question is about atoms.

(a) (i) Choose words from the table below to label the diagram.

Electron	Proton	Neutron
----------	--------	---------



(ii) State the mass number of this atom.

(ii) State the name of the element.