جامعة المستقبل
AL MUSTAQBAL UNIVERSITY
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Analytical Chemistry

1st stage

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Lecture 1: Atoms & Electronic Structure

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1.1 Atomic Model (Atomic Chemistry)

1.1. 1Dalton's Atomic Theory

Assumption

1. Every substance is made up of very small particles called atoms.
2. Atoms cannot be destroyed, created, divided, or transformed.
3. Atoms of the same element have the same size, mass, and properties, and differ from the atoms of other elements.

Limitation of Dalton's theory

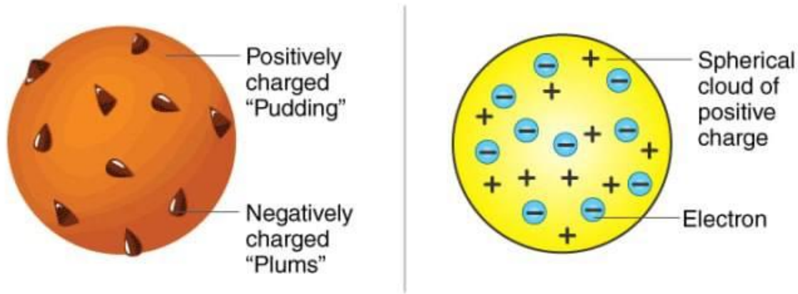
1. Atoms exist in the form of groups, not just as individual units.
2. The discovery of the electron, proton, and neutron made the concept that the atom is indivisible incorrect.

1.1.2 Thomson Model of Atom

1. It was suggested that the atom is circular in shape and electrically neutral.
2. The atom is made up of positive and negative particles.
3. The electron and proton were discovered in relation to this concept.

Limitation of Thomson's theory

1. It did not explain how the positive and negative charges are connected within a single atom.
2. It also did not provide an explanation for the stability of the atom.



Thomson's model of an atom

1.1.3 Rutherford Model of Atom

1.The atom's mass is concentrated in the center, called the nucleus.

2. The nucleus is made up of positive charges.
3. Electrons move around the positive nucleus in circular orbits.
4. The nucleus is very small compared to the size of the atom.

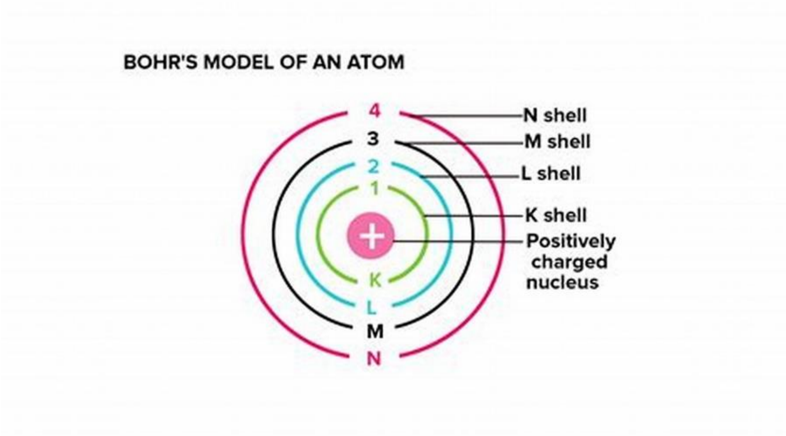
The theory suggests electrons lose energy continuously, spiraling into the nucleus, which contradicts quantum theory. Quantum theory states energy is emitted in discrete packets, not continuously.

1.1.4 Bohr's Model of Atom

Postulates of Bohr's model are:

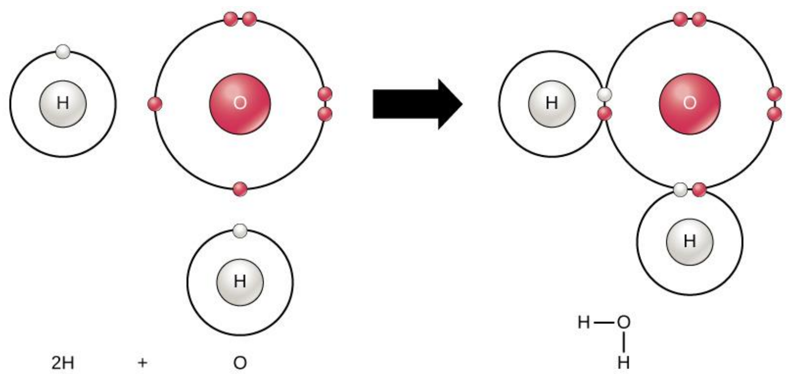
1. Electrons revolve around the nucleus in a specific circular path known as orbital, energy of each orbital is constant.
2. Energy absorbed or emitted during the transition is given by $\Delta E = h\nu$

1. Its fails to explain the effect of magnetic field on the spectra of atoms. **2.**It also failed to explain the Stark effect and Heisenberg Uncertainty Principle



1.2 The Structure of the Atom

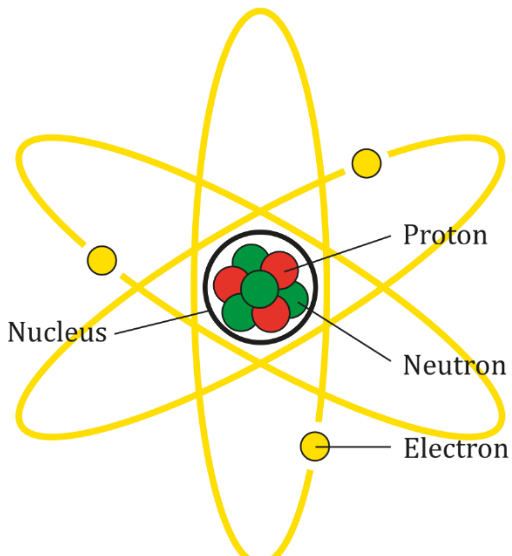
An atom is the smallest unit of matter that retains all of the chemical properties of an element. Atoms combine to form molecules, which then interact to form solids, gases, or liquids. For example, water is composed of hydrogen and oxygen atoms that have combined to form water molecules. Many biological processes are devoted to breaking down molecules into their component atoms so they can be reassembled into a more useful molecule.



1.3 Atomic Particles

Atoms consist of three basic particles: protons, electrons, and neutrons.

- **Protons** positively charged particles, make up part of the nucleus, which is in the center of the atom.
- **Neutron** uncharged particles, make up the other part of the nucleus
- **Electrons** negatively charged particles, orbit around the nucleus like the planets orbit the sun in our solar system.



1.4 Atomic Mass

Protons and neutrons have approximately the same mass, about 1.67×10^{-24} grams. Scientists define this amount of mass as one atomic mass unit (amu) or one Dalton. Although similar in mass, protons are positively charged, while neutrons have no charge. Therefore, the number of neutrons in an atom contributes significantly to its mass, but not to its charge.

Electrons are much smaller in mass than protons, weighing only 9.11×10^{-28} grams, or about 1/1800 of an atomic mass unit. Therefore, they do not contribute much to an element's overall atomic mass. When considering atomic mass, it is customary to ignore the mass of any electrons and calculate the atom's mass based on the number of protons and neutrons alone.

Protons, Neutrons, and Electrons			
	Charge	**Mass (amu)**	**Location**
Proton	+1	1	nucleus
Neutron	0	1	nucleus
Electron	–1	0	orbitals

1.5 Atomic Number and Mass Number

1.5.1 Atomic number

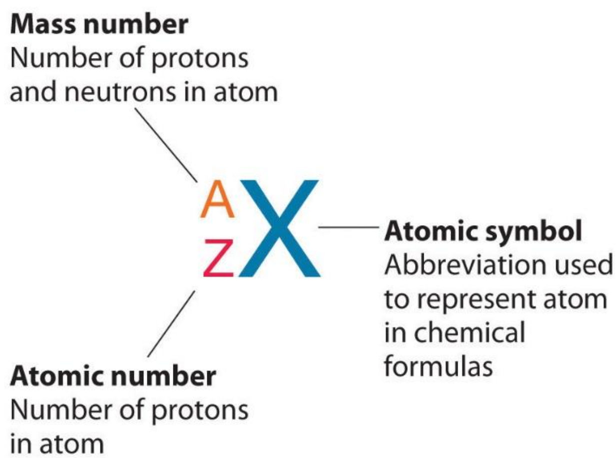
- The number of protons determines an element's atomic number (Z) and distinguishes one element from another. For example, carbon's atomic number (Z) is 6 because it has 6 protons. The number of neutrons can vary to produce isotopes, which are atoms of the same element that have different numbers of neutrons. The number of electrons can also be different in atoms of the same element, thus producing ions (charged atoms). For instance, iron, Fe, can exist in its neutral state, or in the +2 and +3 ionic states.

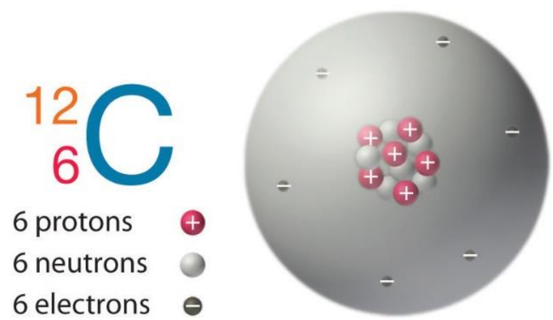
1.5.2 Mass Number

- An element's mass number (A) is the sum of the number of protons and the number of neutrons. The small contribution of mass from electrons is disregarded in calculating the mass number. This approximation of mass can be used to easily calculate how many neutrons an element has by simply subtracting the number of protons from the mass number. Protons and neutrons both weigh about one atomic mass unit or amu. Isotopes of the same element will have the same atomic number but different mass numbers.
  - **Mass Number (A) = Number of Protons + Number of Neutrons**

  Or

  - **A =Z+N**


Mass number
Number of protons and neutrons in atom
A
Z
X
Atomic symbol
Abbreviation used to represent atom in chemical formulas
Atomic number
Number of protons in atom


12
6
C
6 protons
6 neutrons
6 electrons

Problem 1: Find the element mass number whose atomic number is 18 and the neutron number is 20.

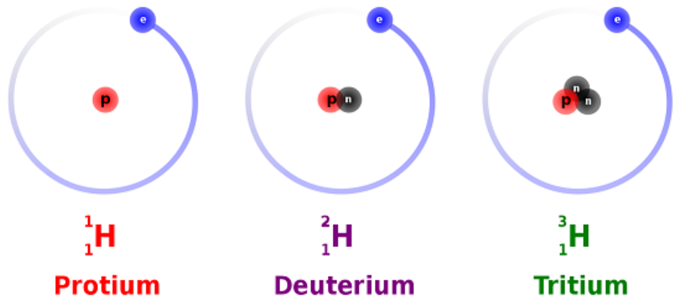
Solution:
Number of protons = 18
Number of Neutrons = 20
Atomic mass Number = Number of protons + number of neutrons
A = 20 + 18
Mass number (A) = 38

Problem 2:
Atoms of the element chromium (Cr) have an atomic number of 24 and a mass number of 52. How many neutrons are in the nucleus of a chromium atom?

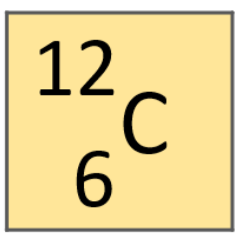
Solution
To determine this, you subtract the atomic number from the mass number, as shown above:
52−24=28 neutrons in a chromium atom

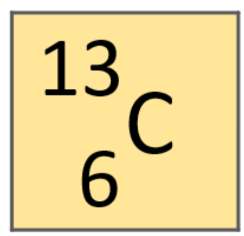
1.6 Isotopes

Atoms that have the same atomic number (number of protons), but different mass numbers (number of protons and neutrons) are called isotopes. There are naturally occurring isotopes and isotopes that are artificially produced.for example Most hydrogen atoms have one proton, one electron, and do not contain any neutrons, but less common isotopes of hydrogen can contain either one or two neutrons.



Another example, there are two common isotopes of carbon: carbon-12 and carbon-13:





Problem3:
Find the number of protons and neutrons in the following isotopes: ^{20}Ne, ^{21}Ne, ^{22}Ne
Solution:
^{20}Ne has 10 p and 10 n; ^{21}Ne has 10 p and 11 n; ^{22}Nehas 10 p and 12 n