

Historical Development of the Periodic Table

Periodic Table of the Elements

- is an arrangement of the elements according to their properties.
- It enables chemists to classify the elements *so* that it is possible to identify patterns and trends in their properties.
- Many scientists have made significant contributions to the development of the modern Periodic Table,

Historical contributions to Development of Periodic Table

- Greek philosophers 400 B. C.
 - Aristotle discussed the existence of four 'basic elements' earth, air, fire and water
- Alchemists 1600s
 - Tried to convert known common metals (especially lead) into gold
- Robert Boyle 1661
 - First defined an element as a simple substance.

Historical contributions to Development of Periodic Table

- Joseph Priestley 1774
 - Isolated oxygen gas
- Antoine Lavoisier 1774
 - Explained combustion as reaction with oxygen from the air.
 - Developed the Law of Conservation of Mass. Produced a table of '33 elements'.

Historical contributions to Development of Periodic Table

- Humphrey Davy 1807
 - Isolated sodium, potassium, barium, calcium strontium, magnesium and boron. Identified iodine and aluminium as elements
- John Dalton 1808
 - Re-introduced idea of atoms. Estimated relative atomic masses.

Historical contributions to Development of Periodic Table

- Johann Dobereiner 1817
 - Identified 'triads' of elements based on their properties and relative atomic masses.
- Jons Berzelius 1828
 - Calculated accurate values for relative atomic masses for many elements. Introduced letters as symbols for the elements.

Historical contributions to Development of Periodic Table

- **Stanislao Cannizzaro** 1860
 - At the Karlsruhe Congress, distinguished between atoms and molecules and defined valence.
 - Errors in relative atomic mass calculations were remedied.
- **John Newlands** 1864
 - Arranged known elements in whole number order. Proposed 'Law of Octaves' - periodic variation of properties with relative atomic mass.

Historical contributions to Development of Periodic Table

- **Lothar Meyer** 1868
 - Classified the elements in a systematic table which demonstrated the periodic nature of their properties
- **Dimitri Mendeleev** 1869
 - Put forward the periodic law.
 - Arranged known elements according to relative atomic mass and properties into vertical 4 groups' and horizontal 'periods'.
 - Left gaps and predicted properties of undiscovered elements.

Historical contributions to Development of Periodic Table

- **William Ramsay** 1892
 - Discovered the noble gases.
 - Recognised them as a new group of elements for the Periodic Table with zero valency.
- **Marie Curie** 1898
 - Investigated radioactivity of uranium.
 - Isolated polonium and radium

Historical contributions to Development of Periodic Table

- **Henry Moseley** 1913
 - Using X-rays discovered the correct order of the elements in the Periodic Table, later called the atomic number.
- **James Chadwick** 1932
 - Discovered the neutron. Led to explanation for the existence of isotopes and idea of mass number and relative atomic mass.

Historical contributions to Development of Periodic Table

- **Glenn Seaborg** 1941 onwards
 - Artificially produced most of the transuranium elements up to atomic number 109.

Discovery of the Elements

- *(particularly the first 36 elements and the halogens; includes period 3 and the first transition series)*
- **Ancient Civilisations**
 - 9 elements were known: C S Fe Cu Ag Sn Au Hg Pb
- **Alchemists 1400-1600s**
 - Another 5 elements were discovered: P Zn As Bi Sb

Discovery of the Elements

- **1700s**
 - 17 new elements including: H Be N O Cl Ti Cr Mn Co Ni U
- **1800's**
 - 51 new elements including: He Li B F Ne Na Mg Al Si Ar K Ca Sc V Ga Ge Se Br Kr I

Discovery of the Elements

- 1900s
 - The rest of the naturally occurring elements (10) up to number 92 and the 17 artificially produced elements up to number 109.

Discovery of the Elements

- At the beginning of the nineteenth century, only about 30 elements were known.
- Several scientists, namely John Dobereiner (1817), John Newlands (1864) and Lothar Meyer (1868) attempted to classify the known elements during the 1900s.

Discovery of the Elements

- When Dimitri Mendeleev compiled the first Periodic Table in 1869, it contained 63 elements.
- The accuracy of his predictions is illustrated by the subsequent discovery of elements to fill the gaps he left in his table and by the subsequent discovery of the noble gases by William Ramsay.

Dimitri Mendeleev (1834-1907)

- **The First Periodic Table**
- Mendeleev, a Russian chemist, spent several years collecting, collating and summarising detailed information about the sixty or so known elements.
- In 1869, he eventually arranged his cards into the first Periodic Table which had the following features:

Features of the Periodic Table

- the elements were arranged in order of **increasing relative atomic mass**
- elements with similar chemical properties were put into vertical **groups**
- horizontal rows were called **periods**
- gaps were left in the table for **undiscovered elements**.

Dimitri Mendeleev (1834-1907)

- Mendeleev had realised that the chemical properties of the elements vary periodically with increasing atomic mass.
- This is known as his Periodic Law. Nevertheless he placed greater importance on properties than on atomic mass values.
- He was able to predict, with great accuracy, the properties of the elements that should fit into the gaps he had left.

Dimitri Mendeleev (1834-1907)

- In particular, germanium, scandium and gallium were later shown to have very similar properties to those forecast by Mendeleev.
- Subsequently in 1914, Henry Moseley's X-ray data led to the concept of atomic number, which is the number of protons in the nucleus of an atom.
- It was soon shown to be a more fundamental property of atoms than relative atomic mass.

Dimitri Mendeleev (1834-1907)

- It also proved that Mendeleev had been correct to place tellurium (atomic number 52) before iodine (atomic number 53) in spite of iodine's lower relative atomic mass.
- The modern Periodic Table shows the elements organised in order of increasing atomic number.

Dimitri Mendeleev (1834-1907)

- The ideas Mendeleev used in the preparation of his Periodic Table were
 - Convinced the chemical properties of the elements changed in a regular, repeating manner.
 - Arranged the known elements in order of increasing atomic mass so that horizontal rows (periods) were formed.
 - Elements with similar chemical properties were put into vertical columns called groups.
 - Left gaps in his table if an element with the appropriate chemical properties was not known at the time.

William Ramsay (1852-1916)

- Discoverer of the noble gases

William Ramsay (1852-1916)

Atomic No.	Symbol	Name	Interpretation
2	He	Helium	Sun
10	Ne	Neon	New
18	Ar	Argon	Idle
36	Kr	Krypton	Hidden
54	Xe	Xenon	Stranger
86	Ra	Radon	

William Ramsay (1852-1916)

- In 1892, a British physicist, Lord Rayleigh, compared the density of nitrogen gas obtained from chemical reactions.
- He was surprised to find that the nitrogen from air was denser than the nitrogen from chemical reactions.
- One of his assistants, William Ramsay, investigated the matter further.

William Ramsay (1852-1916)

- After the careful removal of carbon dioxide, oxygen, water vapour, dust and finally nitrogen,
- Ramsay examined the emission spectrum of the residual gas.
- This spectrum, consisted of groups of red and green lines, had not been seen before and was therefore a new element.

William Ramsay (1852-1916)

- Ramsay realised that he had discovered one of a new group of elements that were not reactive.
- The new element was given the name **argon** (from the Greek, meaning 'idle')
- He was later able to isolate and identify the other noble gases krypton, neon and xenon by the fractional distillation of liquid argon obtained from air.

William Ramsay (1852-1916)

- Helium had previously been detected as a bright yellow line in the emission spectrum of light from the sun during a solar eclipse in 1868.
- Ramsay demonstrated its existence on Earth by examining the spectrum of gas obtained from uranium ore.
- Radon, formed by the radioactive decay of radium, was discovered by Friedrich Dorn in 1900.
- Ramsay determined its relative atomic mass.

Significance of Ramsay's Work

- Argon, first of the noble gases to be discovered, appeared to be totally unreactive
- Its identification led Ramsay to suggest this new gas was part of a new group of elements with zero valency coming after Group VII
- Other members of the new group VIII were subsequently isolated and identified.

Historical Development of Modern Atomic Theory

- Mendeleev's work inspired others not only to search for undiscovered elements but also to investigate the nature of matter itself
- Mendeleev arranged the elements in order of increasing atomic mass.
- The values he used for relative atomic masses were based on those estimated by John Dalton in the early part of the eighteenth century.

Historical Development of Modern Atomic Theory

- Dalton had also revived the ancient Greek idea concerning the particulate or atomic nature of matter in 1808.
- The discovery of the electron by John Joseph Thomson in 1897 and his plum pudding model of the atom led the way to further investigations by Ernest Rutherford during the years from 1902 to 1920.

Historical Development of Modern Atomic Theory

- Other discoveries enabled the nuclear atom model proposed by Rutherford to be further modified and refined into the shell model of Niels Bohr and eventually into the modern day quantum mechanical model of Erwin Schrodinger and Werner Heisenberg.
- A time-line of these ideas and discoveries is shown below.

Historical development of theories of atomic structure

- **Greek Philosophers 300-400 BC**
 - Democritus and Epicurus first explored the idea that matter was made up of atoms.
 - Aristotle disagreed. He argued that matter is continuous and made up of the four basic elements 'earth, air, fire and water'.
- **John Dalton 1808**
 - Re-introduced idea of indivisible atoms in his 'atomic theory'.

Historical development of theories of atomic structure

- **John J. Thomson** Identified the electron as a negative particle. Concluded that all **1897-1899** atoms contain electrons. Proposed the 'plum pudding' model.
- **Ernest Rutherford** Proposed model of atom with central positively charged nucleus **1902-1920** surrounded by negative electrons. Proposed existence of proton and predicted existence of neutron.

Historical development of theories of atomic structure

- **Henry Moseley 1913**
 - Introduced concept of atomic number based on the positive charge of the nucleus.
 - Later shown to equal the number of protons.
- **Niels Bohr 1913**
 - Proposed existence of electron orbits (shells or energy levels) around the nucleus of the atom.

Historical development of theories of atomic structure

- **Frederick Soddy 1914**
 - Investigated origin and nature of isotopes
- **Francis Aston 1919**
 - Proved that several common stable elements consist of isotopes using his invention - the mass spectrometer.
- **Wolfgang Pauli 1925**
 - Proposed his 'Exclusion Principle' to explain the distribution of electrons in energy levels around the nucleus.

Historical development of theories of atomic structure

- **Erwin Schrodinger 1926**
 - Considered the electron as a wave and worked out a mathematical description of its motion called quantum mechanics.
- **Werner Heisenberg 1932**
 - Produced a mathematical description of energy levels for electrons.
 - Put forward his 'Uncertainty Principle' - it is impossible to know *both* the position and the velocity of an electron in an atom simultaneously.

Historical development of theories of atomic structure

- **James Chadwick 1932**
 - Discovered the neutron - led to explanation for the existence of isotopes
- **Lise Meitner**
 - First to suggest the idea of nuclear fission (previously observed by Marie Curie in 1898).
- **Glenn Seaborg 1941**
 - Produced most of the transuranium elements

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