

12.12: The History of the Periodic Table

The periodic law was developed independently by Dmitri Mendeleev and Lothar Meyer in 1869. Mendeleev created the first periodic table and was shortly followed by Meyer. They both arranged the elements by their mass and proposed that certain properties periodically reoccur. Meyer formed his periodic law based on the atomic volume or molar volume, which is the atomic mass divided by the density in solid form. Mendeleev's table is noteworthy because it exhibits mostly accurate values for atomic mass and it also contains blank spaces for unknown elements.

Introduction

In 1804 physicist John Dalton advanced [the atomic theory of matter](#), helping scientists determine the mass of the known elements. Around the same time, two chemists Sir Humphry Davy and Michael Faraday developed electrochemistry which aided in the discovery of new elements. By 1829, chemist Johann Wolfgang Doberiner observed that certain elements with similar properties occur in group of three such as; chlorine, bromine, iodine; calcium, strontium, and barium; sulfur, selenium, tellurium; iron, cobalt, manganese. However, at the time of this discovery too few elements had been discovered and there was confusion between molecular weight and atomic weights; therefore, chemists never really understood the significance of Doberiner's triad.

In 1859 two physicists Robert Willhem Bunsen and Gustav Robert Kirchoff discovered spectroscopy which allowed for discovery of many new elements. This gave scientists the tools to reveal the relationships between elements. Thus in 1864, chemist John A. R Newland arranged the elements in increasing of atomic weights. Explaining that a given set of properties reoccurs every eight place, he named it the law of Octaves.

The Periodic Law

In 1869, **Dmitri Mendeleev** and **Lothar Meyer** individually came up with their own periodic law "when the elements are arranged in order of increasing atomic mass, certain sets of properties recur periodically." Meyer based his laws on the atomic volume (the atomic mass of an element divided by the density of its solid form), this property is called **Molar volume**.

$$\text{Atomic (molar) volume (cm}^3/\text{mol)} = \frac{\text{molar mass (g/mol)}}{\rho \text{ (cm}^3/\text{g)}}$$

Mendeleev's Periodic Table

Mendeleev's periodic table is an arrangement of the elements that group similar elements together. He left blank spaces for the undiscovered elements (atomic masses, element: 44, scandium; 68, gallium; 72, germanium; & 100, technetium) so that certain elements can be grouped together. However, Mendeleev had not predicted the noble gases, so no spots were left for them.

ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ИХЪ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

		Ti = 50	Zr = 90	? = 180.	
		V = 51	Nb = 94	Ta = 182.	
		Cr = 52	Mo = 96	W = 186.	
		Mn = 55	Rh = 104,4	Pt = 197,4.	
		Fe = 56	Ru = 104,4	Ir = 198.	
		Ni = Co = 59	Pd = 106,4	Os = 199.	
H = 1		Cu = 63,4	Ag = 108	Hg = 200.	
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112	
	B = 11	Al = 27,1	? = 68	U = 116	Au = 197?
	C = 12	Si = 28	? = 70	Sn = 118	
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?
	O = 16	S = 32	Se = 79,4	Te = 128?	
	F = 19	Cl = 35,4	Br = 80	I = 127	
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204.
		Ca = 40	Sr = 87,4	Ba = 137	Pb = 207.
		? = 45	Ce = 92		
		?Er = 56	La = 94		
		?Yt = 60	Di = 95		
		?In = 75,4	Th = 118?		

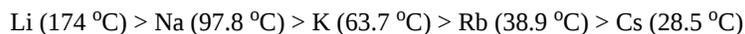
Д. Менделѣевъ

Figure 1: Mendeleev's original periodic table⁴

In Mendeleev's table, elements with similar characteristics fall in vertical columns, called groups. Molar volume *increases* from top to bottom of a group³

✓ Example

The **alkali metals** (Mendeleev's group I) have high molar volumes and they also have low melting points which decrease in the order:



Atomic Number as the Basis for the Periodic Law

Assuming there were errors in atomic masses, Mendeleev placed certain elements not in order of increasing atomic mass so that they could fit into the proper groups (similar elements have similar properties) of his periodic table. An example of this was with argon (atomic mass 39.9), which was put in front of potassium (atomic mass 39.1). Elements were placed into groups that expressed similar chemical behavior.

In 1913 Henry G.J. Moseley did research on the X-Ray spectra of the elements and suggested that the energies of electron orbitals depend on the nuclear charge and the nuclear charges of atoms in the target, which is also known as anode, dictate the frequencies of emitted X-Rays. Moseley was able to tie the X-Ray frequencies to numbers equal to the nuclear charges, therefore showing the placement of the elements in Mendeleev's periodic table. The equation he used:

$$\nu = A(Z - b)^2$$

with

- ν : X-Ray frequency
- Z : Atomic Number
- A and b : constants

With Moseley's contribution the Periodic Law can be restated:

Similar properties recur periodically when elements are arranged according to increasing atomic number."

Atomic numbers, not weights, determine the factor of chemical properties. As mentioned before, argon weighs more than potassium (39.9 vs. 39.1, respectively), yet argon is in front of potassium. Thus, we can see that elements are arranged based on their atomic number. The periodic law is found to help determine many patterns of many different properties of elements; melting and boiling points, densities, electrical conductivity, reactivity, acidic, basic, valance, polarity, and solubility.

The table below shows that elements increase from left to right accordingly to their atomic number. The vertical columns have similar properties within their group for example Lithium is similar to sodium, beryllium is similar to magnesium, and so on.

Group	1	2	13	14	15	16	17	18
Element	Li	Be	B	C	N	O	F	Ne
Atomic Number	3	4	5	6	7	8	9	10
Atomic Mass	6.94	9.01	10.81	12.01	14.01	15.99	18.99	20.18
Element	Na	Mg	Al	Si	P	S	Cl	Ar
Atomic Number	11	12	13	14	15	16	17	18
Atomic Mass	22.99	24.31	26.98	20.09	30.97	32.07	35.45	39.95

Elements in Group 1 (periodic table) have similar chemical properties and are called **alkali metals**. Elements in Group 2 have similar chemical properties, they are called the **alkaline earth metals**.

Short form periodic table

The short form periodic table is a table where elements are arranged in 7 rows, periods, with increasing atomic numbers from left to right. There are 18 vertical columns known as groups. This table is based on Mendeleev's periodic table and the periodic law.

Long form Periodic Table

In the long form, each period correlates to the building up of electronic shell; the first two groups (1-2) (s-block) and the last 6 groups (13-18) (p-block) make up the main-group elements and the groups (3-12) in between the s and p blocks are called the transition metals. Group 18 elements are called noble gases, and group 17 are called halogens. The f-block elements, called inner transition metals, which are at the bottom of the periodic table (periods 8 and 9); the 15 elements after barium (atomic number 56) are called **lanthanides** and the 14 elements after radium (atomic number 88) are called **actinides**.

References

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Problems

1) The periodic law states that

- a. similar properties recur periodically when elements are arranged according to increasing atomic number
- b. similar properties recur periodically when elements are arranged according to increasing atomic weight
- c. similar properties are everywhere on the periodic table
- d. elements in the same period have same characteristics

2) Which element is most similar to Sodium

- a. Potassium
- b. Aluminum
- c. Oxygen
- d. Calcium

3) According to the periodic law, would argon be in front of potassium or after? Explain why.

4) Which element is most similar to Calcium?

- a. Carbon
- b. Oxygen
- c. Strontium
- d. Iodine

5) Who were the two chemists that came up with the periodic law?

- a. John Dalton and Michael Faraday
- b. Dmitri Mendeleev and Lothar Meyer
- c. Michael Faraday and Lothar Meyer
- d. John Dalton and Dmitri Mendeleev

Answers

1. A
2. A

3. Argon would in front of potassium because the periodic law states that the periodic table increases from left to right based on atomic number not atomic weights
4. C
5. B

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