

Engineering Chemistry I

Unit 2 LP5

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History of periodic table

Arranging known elements with similar properties

Lavoisier periodic table

- In 1789, Antoine Lavoisier classified the substances into four groups of elements namely:
 1. acid-making elements,
 2. gas-like elements,
 3. metallic elements and
 4. earthy element

Lavoisier periodic table

Table 3.1 Lavoisier table

acid-making elements	gas-like elements
sulphur	light
phosphorus	caloric (heat)
charcoal (carbon)	oxygen
	azote (nitrogen)
	hydrogen

metallic elements	earthy elements
cobalt, mercury, tin	lime (calcium oxide)
copper, nickel, iron	magnesia (magnesium oxide)
gold, lead, silver, zinc	barytes (barium sulphate)
manganese, tungsten	argilla (aluminium oxide)
platina (platinum)	silex (silicon dioxide)

Döbereiner classification

- In 1817, J. W. Döbereiner classified some elements such as chlorine, bromine and iodine *with similar chemical properties* into the group of three elements called as triads.
- In triads, *the atomic weight of the middle element nearly equal to the arithmetic mean of the atomic weights of the remaining two elements.*
- However, only a limited number of elements can be grouped as triads

Döbereiner classification

Table 3.2 Döbereiner Triads

S. No.	Elements in the Triad	Atomic weight of middle element	Average atomic weight of the remaining elements
1	Li, Na, K	23	$\frac{7+39}{2} = 23$
2	Cl, Br, I	80	$\frac{35.5+127}{2} = 81.25$
3	Ca, Sr, Ba	88	$\frac{40+137}{2} = 88.5$

- i. Properties of elements in each triad are similar.
- ii. The atomic mass of the middle element is roughly the average of the atomic masses of the other two elements.

Limitations of Dobereiner's Traids

- Dobereiner could identify only three triads. He was not able to prepare triads of all the known elements
- This concept cannot be extended to some triads which have nearly same atomic masses such as [Fe, Co, Ni], [Ru, Rh, Pd] and [Os, Ir, Pt].

Newland classification

- John Newlands, an English scientist, arranged the known elements in the order of increasing atomic masses and called it the Law of Octaves.
- Characteristics of Newlands' Law of Octaves:
 - i. It contained the elements from Hydrogen to Thorium.
 - ii. Properties of every eighth element are similar to those of the first element

Newland classification

Table showing Newlands' Octaves

sa (do)	re (re)	ga (mi)	ma (fa)	pa (so)	da (la)	ni (ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	-	-

Properties of every eighth element are similar to those of the first element

Note — frequently asked question

Limitations of Newlands' Law of Octaves

- The law was applicable to elements up to Calcium (Ca) only.
- It contained only 56 elements. Further, it was assumed by Newlands that only 56 elements existed in nature and no more elements would be discovered in the future.
- To fit elements into the table, Newlands adjusted two elements in the same slot and also put some unlike elements under the same note. For example, Iron, which resembles Cobalt and Nickel in properties, has been placed differently away from these elements.

Note – frequently asked question

Mendeleev's Classification

- **Periodic law** - “The properties of the elements are the periodic functions of their atomic weights”
- Mendeleev listed 70 elements, which were known till his time in several vertical columns in order of increasing atomic weights.
- Thus, Mendeleev constructed the first periodic table based on the periodic law.

Mendeleev's Classification

H 1.01									
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5			
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9			
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127			
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195
Au 197	Hg 201	Tl 204	Pb 207	Bi 209					
			Th 232		U 238				

Features of Mendeleev's Periodic Table

- i. In Mendeleev's Periodic table, the horizontal rows are called **periods** and vertical columns are called **groups**.
- ii. There are seven periods and eight groups in Mendeleev's periodic table. Each group from I to VII are divided into two subgroups A and B.
- iii. In each period elements are placed based on increasing atomic masses.
- iv. In any period, the properties of elements show regular gradation.

E.g. Metallic character decreases, while non-metallic character increases.

Merits of Mendeleev's Periodic Table

- The vacant places present in the periodic table correctly predicted the existence of undiscovered element. Based on their position it become possible to predict the properties of undiscovered elements before their actual discovery.
- E.g. Predicted Elements were Eka-boron, Eka-aluminium, Eka-silicon. After discovery these elements are named Scandium, Gallium and Germanium respectively.

Merits of Mendeleev's Periodic Table

Table 3.5 Properties predicted for Eka-aluminium and Eka-silicon

S.No.	Property	Eka-aluminium (Predicted)	Gallium (Observed)	Eka-silicon (Predicted)	Germanium (Observed)
1.	Atomic weight	68	70	72	72.59
2.	Density (g/cm^3)	5.9	5.94	5.5	5.36
3.	Melting point	low	29.78°C	High	947°C
4.	Formula of oxide	E_2O_3	Ga_2O_3	EO_2	GeO_2
5.	Formula of chloride	ECl_3	GaCl_3	ECl_4	GeCl_4

Merits of Mendeleev's Periodic Table

- The properties of predicted element and the discovered element were almost same. E.g. Predicted atomic weight of Eka-aluminium was 68 and the discovered element Gallium had atomic weight 69.72.
- In Mendeleev's periodic table, noble gases are placed in separate group without disturbing the position of already placed elements.

Demerits of Mendeleev's Periodic Table

- *Position of Hydrogen:* Mendeleev's periodic table failed to classify hydrogen.
- *Classification of Isotopes:* Elements having same atomic number but different Mass Number are called Isotopes. Since isotopes have different masses hence there should be dedicated position to each isotope in Mendeleev's periodic table.

Note — frequently asked question

Demerits of Mendeleev's Periodic Table

- *Arrangement on the Basis of Atomic Mass:* At some places elements with higher atomic mass was placed before the element with lower atomic mass. e.g. Cobalt with atomic mass 58.93 was placed before Nickel with atomic mass 58.71 and so the classification no longer remained orderly arrangement of atomic masses.

Note – frequently asked question

Demerits of Mendeleev's Periodic Table

- ***Properties in a Group:*** Ideally in a group the properties of element must be same but in the periodic table elements with different properties placed in the same group. e.g. Manganese is a metal which is placed in the group of nonmetals i.e. halogens

Modern Periodic Law

- **Moseley's Modern Periodic Law** - Properties of elements are a periodic function of their **atomic number**.
- Hydrogen gets a position
- Isotopes of same atoms are put in one place as the elements are arranged based on atomic number rather mass number.

Note — frequently asked question

Characteristics of Modern Periodic Law

- i. The modern periodic table consists of 18 groups and 7 periods.
- ii. All the elements in a group have the same number of valence electrons and show similar chemical properties.
- iii. Elements present in a period contain the same number of shells. The number of elements in a period is fixed by the maximum number of electrons which can be accommodated in the various shells of an atom.
- iv. Each period marks a new electronic shell getting filled.

Note — frequently asked question

Periodic table

Group ►	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period ▼																		
<i>Nonmetals</i>	1 H																	<i>Noble gases</i> 2 He
<i>Metals</i>	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
	19 K	20 Ca											31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
	37 Rb	38 Sr											49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
	55 Cs	56 Ba	La to Yb										81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
	87 Fr	88 Ra	Ac to No										113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
	s-block (incl. He)		f-block	d-block									p-block (excl. He)					
Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb				
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No				