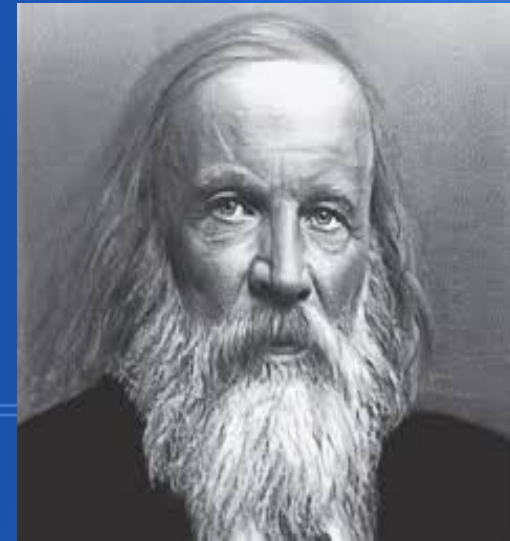
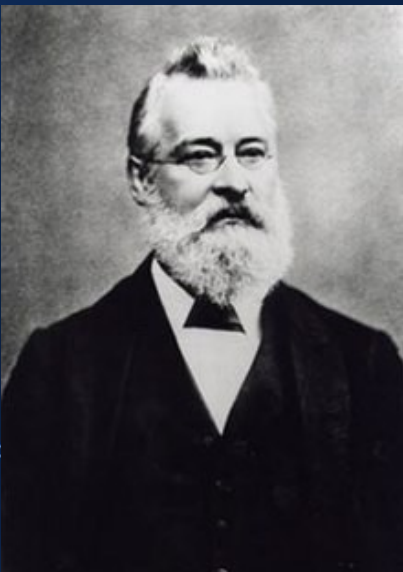




PERIODIC CLASSIFICATION OF ELEMENTS



NEED FOR CLASSIFICATION

During the year 1800 when only 30 elements were known and all of them were of different properties.

Problem faced during the year 1800:- Scientists had difficulty in organising all the elements that were known at that time, so they started looking for the pattern in their properties so that their study becomes easy .

So the concept of making an order out of chaos (classification) was of the utmost need during that time.

SIGNIFICANCE OF CLASSIFICATION

Classification helps in systematic observations, drawing meaningful patterns in terms of similarities and dissimilarities for the **better and meaningful understanding of the properties of elements** (as metals, non metals).

EARLY ATTEMPTS OF CLASSIFICATION – **Based on ATOMIC MASS**

DOBEREINER'S LAW OF TRIADS - In 1817, Johann Wolfgang Dobereiner tried to arrange the known elements during that time.

NEWLAND'S LAW OF OCTAVES – In 1866, John Newlands arranged the then known 56 elements.

MENDELEEV'S PERIODIC TABLE - In 1872, Dmitri Ivanovich Mendeleev arranged 63 elements into a table.

DOBEREINER'S LAW OF TRIADS



He identified elements with similar properties and grouped them into groups of three, hence the name 'triads'.

He realized when we arrange these three elements according to their increasing atomic mass, the atomic mass of the second element was roughly the average of the atomic masses of the first and third element as Dobereiner's Law of Triads.

TRIAD 1	TRIAD 2	TRIAD 3	TRIAD 4
Li (6.9u)	Ca (40.1u)	Cl (35.5u)	N (14u)
Na (22.9u)	Sr (87.6u)	Br (79.9u)	P (30.9u)
K (39.1u)	Ba (137.3u)	I (126.9u)	As (74.9u)

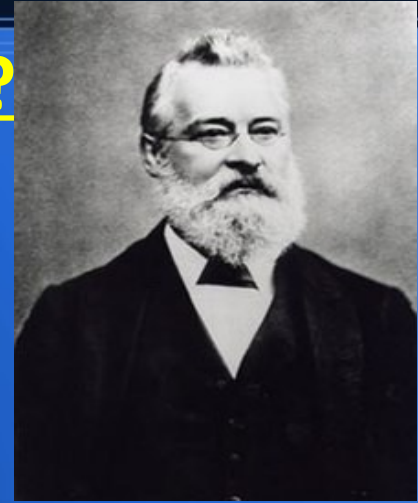
VALIDITY OF DOBEREINER'S LAW – CALCULATING AVERAGE OF ATOMIC MASS

TRIAD 1	Li (6.9u)	Na (22.9u)	K (39.1u)	$(6.9\text{u} + 39.1\text{u}) / 2$ $= (46.0\text{u}) / 2$ $= 23.0\text{u}$	SUCCESSFUL TRIAD
TRIAD 2	Ca (40.1u)	Sr (87.6u)	Ba (137.3u)	$(40.1\text{u} + 137.3\text{u}) / 2$ $= (177.4\text{u}) / 2$ $= 88.7\text{u}$	SUCCESSFUL TRIAD
TRIAD 3	Cl (35.5u)	Br (79.9u)	I (126.9u)	$(35.5\text{u} + 126.9\text{u}) / 2$ $= (162.4\text{u}) / 2$ $= 81.2\text{u}$	SUCCESSFUL TRIAD
TRIAD 4	N (14.0u)	P (30.9u)	As (74.9u)	$(14.0\text{u} + 74.9\text{u}) / 2$ $= (88.9\text{u}) / 2$ $= 44.5\text{u}$	UNSUCCESSFUL TRIAD

LIMITATIONS OF DOBEREINER'S LAW OF TRIADS:-However, Dobereiner soon found out that this was not uniform across all elements, and so this system had very short-lived and limited success. **The Law was therefore discarded.**

NEWLAND'S LAW OF OCTAVES

Do Chemistry and music have a connection?
That's right.



In 1866, Newland arranged the then known 56 elements in increasing order of their **atomic masses** (Hydrogen being the lightest was obviously first and the last one being thorium) and realised that **every eighth element had properties similar to that of the first element just like eight musical notes (do, re, mi, fa, sol, la, ti) as Newland's Law of Octaves.**

NEWLAND'S LAW OF OCTAVES

Sa (indian) (do (western))	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	-----	-----

Li, Na and K (similar properties) as Dobereiner's Triad in Newland's Law of Octaves. If Li is first element then Na is eighth element. If Na is first element then K is eighth element thus obeying Newland's Law of Octaves also.

LIMITATIONS OF NEWLAND'S LAW OF OCTAVES

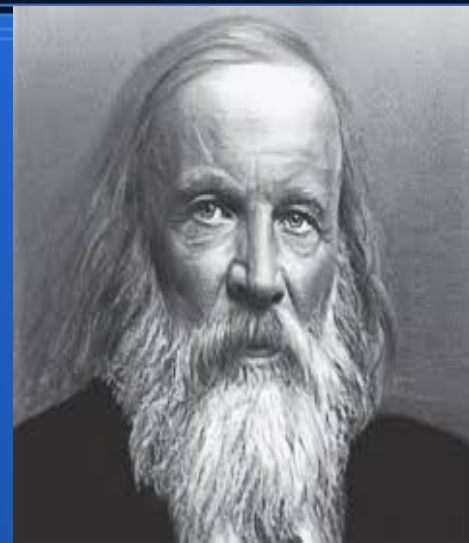
However, there were a number of faults with the classification.

1. The law was only applicable ONLY upto Calcium. After calcium, every eighth element did not possess similar properties to the first one. It **worked well with lighter elements only**.
2. Also as **new elements were discovered** and the number expanded from 56, their properties **did not fit into the law**.
3. Newland had also adjusted **two elements in the same slot** and paired together some very unlike elements **in order to make the classification work**. Like - Co and Ni are in the same slot and are placed with F, Cl and Br which have different properties. Fe that resembles Co and Ni has been placed far at the extreme end.

Ultimately this classification also failed to leave a lasting impression as it did not have any scientific intervention.

MENDELEEV'S PERIODIC TABLE

In 1872, Dmitri Ivanovich Mendeleev did the extensive research of the elements (apart from physical properties) wherein he reacted the known 63 elements known at that time with hydrogen and oxygen.



The elements with similar formulae of hydrides and oxides were arranged in the same vertical columns called groups and the elements with dissimilar formula were arranged in horizontal rows as periods in the increasing order of their atomic masses which led to the formation of table.

MENDELEEV'S PERIODIC LAW

Now, this was **the most successful attempt among all the earlier attempts at classification of Elements** due to meticulous and systematic observations associated with scientific intervention.

He had noticed a **relation between atomic masses of elements and their chemical and also physical properties.** He observed that there was a periodic re-occurrence of elements with similar properties.

Mendeleev stated that '**the properties of elements are the periodic function of their atomic masses**' and this came to be known as Periodic Law.

MEDELEEV'S PERIODIC TABLE

Table 5.4 Mendelée'v's Periodic Table

Group	I		II		III		IV		V		VI		VII		VIII		
Oxide Hydride	R_2O RH		RO RH ₂		R_2O_3 RH ₃		RO ₂ RH ₄		R_2O_5 RH ₃		RO ₃ RH ₂		R_2O_7 RH		RO ₄		
Periods ↓	A	B	A	B	A	B	A	B	A	B	A	B	A	B	Transition series		
1	H 1.008																
2	Li 6.939		Be 9.012		B 10.81		C 12.011		N 14.007		O 15.999		F 18.998				
3	Na 22.99		Mg 24.31		Al 29.98		Si 28.09		P 30.974		S 32.06		Cl 35.453				
4 First series: Second series:	K 39.102 Cu 63.54		Ca 40.08 Zn 65.37		Sc 44.96 Ga 69.72		Ti 47.90 Ge 72.59		V 50.94 As 74.92		Cr 50.20 Se 78.96		Mn 54.94 Br 79.909		Fe 55.85	Co 58.93	Ni 58.71
5 First series: Second series:	Rb 85.47 Ag 107.87		Sr 87.62 Cd 112.40		Y 88.91 In 114.82		Zr 91.22 Sn 118.69		Nb 92.91 Sb 121.75		Mo 95.94 Te 127.60		Tc 99 I 126.90		Ru 101.07	Rh 102.91	Pd 106.4
6 First series: Second series:	Cs 132.90 Au 196.97		Ba 137.34 Hg 200.59		La 138.91 Tl 204.37		Hf 178.49 Pb 207.19		Ta 180.95 Bi 208.98		W 183.85				Os 190.2	Ir 192.2	Pt 195.09

ACHIEVEMENTS OF MEDELEEV'S PERIODIC TABLE

1. He could place almost all the 63 elements with similar properties in the same group (A and B having same chemical formula of hydrides and oxides).
2. He had left gaps for the elements which were yet to be discovered. After careful study of the atomic masses of elements, Mendeleev could actually predict the existence of some elements for which he had placed Sanskrit numeral 'eka' to the name of the preceding element in the same group.
(BIG ACHIEVEMENT)
3. The discovery of noble gases after his table was formed could not affect the existing Periodic table. They were given a separate slot.

Predicted element	Element discovered
Eka - aluminum	Gallium
Eka - boron	Scandium
Eka - silicon	Germanium

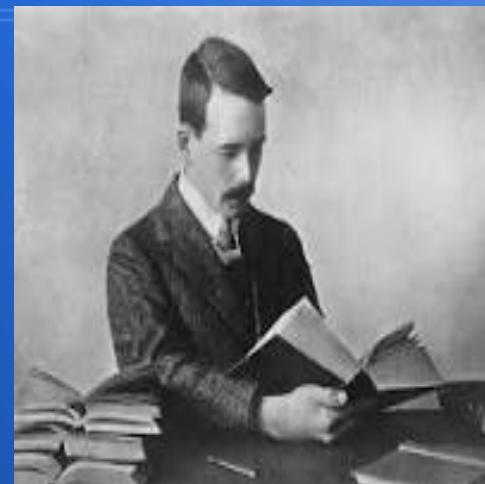
LIMITATIONS/ ANOMALIES OF MENDELEEV'S PERIODIC TABLE

Despite its huge success, there were still some shortfalls in Mendeleev's Periodic Table.:-

1. He **could not assign fixed position to Hydrogen** in his Periodic table as Hydrogen exhibits properties of both alkali metals as well as those of halogens.
2. **Isotopes posed a challenge** as they were discovered long after when Mendeleev proposed his periodic classification of elements .
3. The elements with similar properties were being grouped together but the **order of atomic masses was being violated at some places**. For e.g:- Cobalt (atomic mass – 58.9u) appeared before Nickel (atomic mass –58.7u) , Tellurium (atomic mass – 127.6u) placed before Iodine (atomic mass – 126.9u)

MODERN PERIODIC LAW

It was due to **Mendeleev** - The pioneer in the early development of a Periodic Table, we have our current/ Modern periodic table in which **Henry Moseley** , Father of Modern Periodic table , in 1913, changed the fundamental property of classification of elements from **ATOMIC MASS TO ATOMIC NUMBER.**



By doing so the **anomalies of Mendeleev's periodic table** (position of isotopes, wrong order of atomic masses) could be easily overcome.

Modern Periodic Law states '**the properties of elements are the periodic function of their atomic number.**'

MODERN PERIODIC TABLE

Table 5.6 Modern Periodic Table

References

Metalloids

Non-metals

The zigzag line separates the metals from the non-metals.

GROUP NUMBER

GROUP NUMBER

18

		GROUP NUMBER																GROUP NUMBER	
PERIODS	1	1 H Hydrogen 1.0																	2 He Helium 4.0
	2	3 Li Lithium 6.9	4 Be Beryllium 9.0											13 B Boron 10.8	14 C Carbon 12.0	15 N Nitrogen 14.0	16 O Oxygen 16.0	17 F Fluorine 19.0	18 Ne Neon 20.2
	3	11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminum 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
	4	19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 44.9	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.8	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.5	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
	5	37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yttrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium 98.0	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
	6	55 Cs Cesium 132.9	56 Ba Barium 137.3	57 La* Lanthanum 138.9	72 Hf Hafnium 178.4	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 208.9	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222
	7	87 Fr Francium 223	88 Ra Radium 226	89 Ac** Actinium 227	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Uub Ununbium	114 Uuq Ununquadium	—	116 Uuh Ununhexium	—	—	—

* Lanthanoides

Actinoides

58 Ce Cerium (140.12)	59 Pr Praseodymium (140.91)	60 Nd Niobium (144.24)	61 Pm Promethium (144.91)	62 Sm Samarium (150.36)	63 Eu Europium (151.96)	64 Gd Gadolinium (157.25)	65 Tb Terbium (158.93)	66 Dy Dysprosium (162.50)	67 Ho Holmium (164.93)	68 Er Erbium (167.26)	69 Tm Thulium (168.93)	70 Yb Ytterbium (173.05)	71 Lu Lutetium (174.97)
90 Th Thorium (232.04)	91 Pa Protactinium (231.04)	92 U Uranium (238.03)	93 Np Neptunium (237.05)	94 Pu Plutonium (244.06)	95 Am Americium (243.06)	96 Cm Curium (247.07)	97 Bk Berkelium (247.07)	98 Cf Californium (251.08)	99 Es Einsteinium (252.08)	100 Fm Fermium (257.10)	101 Md Mendelevium (258.11)	102 No Nobelium (259.10)	103 Lr Lr (262.11)

POSITION OF AN ELEMENT IN MODERN PERIODIC TABLE

TO FIND GROUP:- Look for **valence electrons** (electrons in the outermost shell).

If valence electrons are 1 or 2 , then group number is 1 or 2 respectively.

If valence electrons are 3,4,5,6,7 or 8 , then add number 10 to get the group number.

Element Symbol Atomic Number	Sodium Na 11
Electronic Configuration	2,8, 1
Valence electron	1
Group number	1
Element Symbol Atomic Number	Chlorine Cl 17
Electronic Configuration	2,8, 7
Valence electron	7
Group Number	$7 + 10 = 17$

POSITION OF AN ELEMENT IN MODERN PERIODIC TABLE

TO FIND PERIOD:- Count
the **total number of shells**
In which all electrons are
being filled up.

Element Symbol Atomic Number	Magnesium Mg 12
Electronic configuration	2,8,2
Period Number	3 (as there are three shells in total)
Element Symbol Atomic Number	Carbon C 6
Electronic Configuration	2,4
Period Number	2 (as there are two shells in total)

TRENDS IN MODERN PERIODIC TABLE – IN A GROUP (TOP TO BOTTOM)

Group 2	Electronic Configuration
Be	2, 2
Mg	2,8, 2
Ca	2,8,8, 2
Group 13	Electronic Configuration
B	2, 3
Al	2,8, 3

VALENCY:- The tendency to combine either by losing , gaining or sharing electrons.

Valency depends upon number of electrons in the outermost shell
(valence electrons).

The number of valence electrons are same as we go from top to bottom, thus **valency remains the same.**

TRENDS IN MODERN PERIODIC TABLE – IN A GROUP (TOP TO BOTTOM)

Group 1 Elements	Electronic Configuration Atomic Radius pm (picometer)
Li	2, ¹ 152 pm
Na	2,8, ¹ 186pm
K	2,8,8, ¹ 231pm
Rb	244pm
Cs	262pm

ATOMIC SIZE / radius of an atom:-

The distance between the centre of the nucleus and the valence shell of an isolated atom.

As we go from top to bottom, the **valence electrons are being added to new shell**, which increases the distance between the valence electrons and the nucleus so that atomic size increases much more in spite of the increase in Nuclear charge. Thus, **atomic size increases down the group.**

TRENDS IN MODERN PERIODIC TABLE – ALONG A PERIOD (LEFT TO RIGHT)

	Group 1	Group 2	Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
Period 2	Li	Be	B	C	N	O	F	Ne
Electronic Configuration	2, 1	2, 2	2, 3	2, 4	2, 5	2, 6	2, 7	2, 8
Period 3	Na	Mg	Al	Si	P	S	Cl	Ar
Electronic Configuration	2,8, 1	2,8, 2	2,8, 3	2,8, 4	2,8, 5	2,8, 6	2,8, 7	2,8, 8

VALENCY:-The number of valence electrons change as we go from left to right, thus valency first increases from 1 to 4 and then decreases from 3 to 0 (for e.g:- In N :- valency :- $8-5=3$).

Thus valency changes as we move along a period.

TRENDS IN MODERN PERIODIC TABLE – ALONG A PERIOD (LEFT TO RIGHT)

	Group 1	Group 2	Group 13	Group 14	Group 15	Group 16
Period 2	Li	Be	B	C	N	O
Electronic Configuration	2, 1	2, 2	2, 3	2, 4	2, 5	2, 6
Atomic size -pm(picometer)	152pm	111pm	88pm	77pm	74pm	66pm

ATOMIC SIZE:-The valence electrons are being added to the **same shell** on going from left to right, thus the nuclear charge increases much more and tends to pull the valence electrons closer to the nucleus, thus the atomic size decreases.

TRENDS IN MODERN PERIODIC TABLE – IN A GROUP

1. Metallic (Electropositive character – tendency to lose electrons) increases down the group , due to increase in atomic size , valence electrons can be easily removed out of the bound of nucleus. For eg:-K is more metallic than Na
2. Thus cation (positive ion) formation tendency also increases down the group. For eg:-K loses its one valence electron more readily than Na. K is more reactive than Na.
3. Basic oxide / Metal oxide formation tendency also increases down the group. Potassium oxide forms a stronger base in water i.e. Potassium Hydroxide than Sodium Oxide forming Sodium Hydroxide in water and thus turn red litmus blue.

TRENDS IN MODERN PERIODIC TABLE – ALONG A PERIOD

1. Non - Metallic (Electronegative character – tendency to gain/share electrons) increases as we go from left to right along a period, due to decrease in atomic size, valence electrons cannot be easily removed out of the bound of nucleus and nucleus is positively charged, it attracts the incoming of electrons. For ex:- Na is metallic but Cl is non-metallic.
2. Thus anion (negative ion) formation tendency also increases along the period. Na forms Na ion readily and Cl forms Chloride ion readily.
3. Acidic oxide / Non - Metallic oxide formation tendency also increases along the period. Oxides of carbon, nitrogen, sulphur and phosphorus are acidic in nature and thus turn blue litmus red in water.