HANDOUT-1
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UNIT 5: Classification of Elements and Periodicity in Properties

This HANDOUT intends to cover following topics:

1.Dobereiners Traids.

2.Newlands Law of Octaves.

3.Mendeleev Periodic Table.

4.Merits and Limitations of above .

MAKING ORDER OUT OF CHAOS — EARLY ATTEMPTS AT THE AT THE CLASSIFICATION OF OF ELEMENTS :

We have been learning how various things or living beings can be classified on the basis of their properties. Even in other situations, we come across instances of organisation based on some properties. For example, in a shop, soaps are kept together at one place while biscuits are kept together elsewhere. Even among soaps, bathing soaps are stacked separately from washing soaps. Similarly, scientists made several attempts to classify elements according to their properties and obtain an orderly arrangement out of chaos. The earliest attempt to classify the elements resulted in grouping the then known elements as metals and non-metals. Later further classifications were tried out as our knowledge of elements and their properties increased.

Classification of Elements was necessary since many elements were being discovered in the 19th century and the study of these elements individually was proving difficult.

There were many attempts at classifying elements including *'Dobereiner's Triads' and 'Newland's Octaves'.*

Set I		Set II		Set-III	
Element	Atomic mass	Element	Atomic mass	Element	Atomic mass
Calcium	40	Lithium	7	Chlorine	35.5
Strontium	87.5	Sodium	23	Bromine	80
Barium	137	Potassium	39	Iodine	127
Average of the atomic masses of calcium and barium $= \frac{40+137}{2} = 88.5$		Average of the atomic masses of lithium and potassium $= \frac{7+39}{2} = 23$		Average of the atomic masses of chlorine and iodine $= \frac{35.5+127}{2} = 81.2$	
Atomic mass of strontium = 87.5		Atomic mass of sodium = 23		Atomic mass of bromine = 80	

Dobereiner's Triads

German chemist Johann Wolfgang Dobereiner attempted to classify elements with similar properties into groups of three elements each. These groups were called 'triads'. Dobereiner suggested that in these triads, the atomic mass of the element in the middle would be more or less equal to the mean of the atomic masses of the other two elements in the triad.

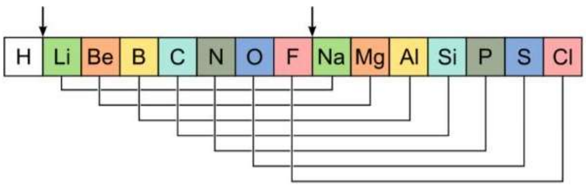
An example of such a triad would be one containing lithium, sodium, and potassium. The atomic mass of lithium 6.94 and that of potassium is 39.10. The element in the middle of this triad, sodium, has an atomic mass of 22.99 which is more or less equal to the mean of the atomic masses of lithium and potassium (which is 23.02).

The *Limitations of Dobereiner's Triads* are :

- All the elements known at that time couldn't be classified into triads.
- Only four triads were mentioned – (Li,Na,K + Ca,Sr,Ba + Cl,Br,I + S,Se,Te).

Newland's Octaves

English scientist John Newlands arranged the 56 known elements in increasing order of atomic mass in the year 1866. He observed a trend wherein every eighth element exhibited properties similar to the first. This similarity in the properties of every eighth element can be illustrated as follows.



Classification of Elements and Periodicity in Properties – Newland's Octaves

Newland's Law of Octaves states that when the elements are arranged in increasing order of atomic mass, the periodicity in properties of two elements which have an interval of seven elements in between them would be similar.

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	—	—

Limitations of Newland's octaves are:

- It was only up till calcium that the classification of elements is done via Newland's Octaves.
- The discovery of noble gases added to the limitations of this method since they couldn't be included in this arrangement without disturbing it completely.

Mendeleev’s Periodic Table

Russian chemist Dmitri Ivanovich Mendeleev put forth his periodic table in 1869. He observed that the properties of elements, both physical and chemical, were periodically related to the atomic mass of the elements.

The **Periodic Law** (also referred to as Mendeleev’s Law), states that the chemical properties of elements are a periodic function of their atomic weights.

The *advantages of Mendeleev’s Periodic table* are:

The *limitations of Mendeleev’s Periodic table* are:

- Hydrogen’s position was in the group of alkali metals but hydrogen also exhibited halogen like qualities.
- Isotopes were positioned differently since this type of classification of elements was done by considering the atomic weight of the element. Therefore – protium, deuterium, and tritium would occupy varying positions in Mendeleev’s table.
- An anomalous positioning of a few elements showed that the atomic masses did not increase regularly from one element to the next. An example of this would be the placement of cobalt (atomic mass of 58.9) before nickel (atomic mass of 58.7).

These methods were the foundation on which the modern periodic table was built. However, the greatest contributor to the modern periodic table was Dmitri Mendeleev. Mendeleev is also known as the Father of the Modern Periodic Table..

Group	I	II	III	IV	V	VI	VII	VIII
Oxide : Hydride:	R_2O RH	RO RH_4	R_2O_3 RH_4	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 22.99	Al 24.31	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 65.54	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 Co Ni 55.85 58.93 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 121.60	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru Rh Pd 101.07 102.91 106.4
6 First series Second series	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.40 Pb 207.19	Ta 180.95 Bi 208.98	W 183.85		Ru Rh Pd 190.2 192.2 195.09

Introduction to Mendeleev Periodic Table

Dmitri Ivanovich Mendeléev, a Russian chemist, was the most important contributor to the early development of the periodic table. Many periodic tables were made but the most important one was the Mendeleev periodic table.

In 1869, after the rejection of Newlands Octave Law, Mendeleev Periodic table came into the picture. In Mendeleev's periodic table, elements were arranged on the basis of the fundamental property, atomic mass, and chemical properties. During Mendeleev's work, only 63 elements were known. After studying the properties of every element, Mendeleev found that the properties of elements were related to atomic mass in a periodic way. He arranged the elements such that elements with similar properties fell into the same vertical columns of the periodic table.

Among chemical properties, Mendeleev treated formulae of hydrides and oxides as one of the basic criteria for categorization. He took 63 cards and on each card, he wrote the properties of one element. He grouped the elements with similar properties and pinned it on the wall. He observed that elements were arranged in the increasing order of atomic mass and there was the periodic occurrence of elements with similar properties.

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:	K 39.102	Ca 40.08	Sc 44.96	Ti 47.90	V 50.94	Cr 50.20	Mn 54.94	Fe 55.85 Co 58.93 Ni 58.71
Second series:	Cu 63.54	Zn 65.37	Ga 69.72	Ge 72.59	As 74.92	Se 78.96	Br 79.909	
5 First series:	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 99	Ru 101.07 Rh 102.91 Pd 106.4
Second series:	Ag 107.87	Cd 112.40	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.90	
6 First series:	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.85		Os 190.2 Ir 192.2 Pt 195.09
Second series:	Au 196.97	Hg 200.59	Tl 204.37	Pb 207.19	Bi 208.98			

According to this observation, he formulated a periodic law which states:

"*the properties of elements are the* periodic *function of their atomic masses."*

In Mendeleev periodic table, vertical columns in the periodic table and horizontal row in the periodic table were named as groups and period respectively.

Characteristics of Mendeleevs periodic Table:

1.Systematic study of the elements:

Mendeleev for the first time arranged a very large of elements into groups and periods.This made their study quite systematic in the sense that if the properties of one element is known ,those of the other can be predicted.

2.Prediction of new elements and their properties:

Mendeleev laid more stress on similarity in properties rather on increasing atomic masses of the elements.so whenever a particular element did not fit in the arrangement ,he left gaps in the periodic table.He even predicted the properties of the undiscovered elements and called them as eka boron ,eke aluminium and eka silicon which later came to be known as scandium,Gallium and germanium.

3.Correction of doubtful atomic masses:

Mendeleev also corrected the atomic masses of certain elements with the help of their expected positions nad properties.For example ,the element Be had been assigned atomic mass 13.5 by multiplying its equilivalent weight(4.5) with the valency (wrongly calculated as 3).As such it should have been placed between carbon (atomic mass =12) and Nitrogen (atomic mass 14),But the properties of the elements suggested that it should be the company of the elements Mg and Ca which were assigned positions in the group IIA. Therefore he corrected the valence as 2 and the corrected atomic mass of Be came out to be 9.In a similar way the atomic masses of many other elements were corrected.

Demerits of Mendeleev Periodic Table

Mendeleev's periodic table was a good attempt to classify sixty elements known at this time. There some noteworthy aberrations in the periodic table and no explanations were, given for the deviations.

i) Elements not obeying increasing atomic mass

Elements like, Argon-potassium, cobalt-nickel, tellurium-iodine and thorium and protactinium, are arranged in the decreasing mass order than increasing mass order.

ii) Properties and uneven grouping.

The periodic table contains elements of dissimilar properties together and separates elements of same properties. For example, copper resemble mercury and so of silver & thallium, barium& lead. But they are, placed in different column. Copper is in first column

while mercury is in second grouping. Silver is, present in first group while thallium is in third group. Similarly barium and lead are, separated in second and fourth groups. Coinage metals copper, silver, and gold elements are, grouped together with alkali metals. Manganese metal is, grouped with totally different halogens in the seventh group.

iii) Position of hydrogen

Hydrogen resembles both alkali metals in some respect and halogens in some other respects. But it is placed, along with alkali metals only.

iv) Position of isotopes

All elements, more or less have isotopes. The isotopes cannot be accommodated in the table.

v) Position of Lanthanides and actinides

Elements of Lanthanides and actinides, which were, discovered later, cannot be, arranged in the table without disturbing it.

vi) Eighth group elements

4th, 5th and 6th periods have three elements in their eighth group. Reasons for such triad in eight column was not given.

vii) Source of periodicity

The relationship between the properties and atomic weight is a fact. But no explanation was, given for this relationship.

viii) Mendeleev's periodic table may be better for the sixty-three elements known at his time. But it cannot accommodate the presently known 118 elements.