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Periodic Properties

Course: CHE101: Introduction To Chemistry

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Periodic Table

The periodic table is a **tabular arrangement of the chemical elements, ordered by their atomic number, electron configurations, and recurring chemical properties.**

The Russian chemist **Dmitri Mendeleev** published the first widely recognized periodic table in 1869.

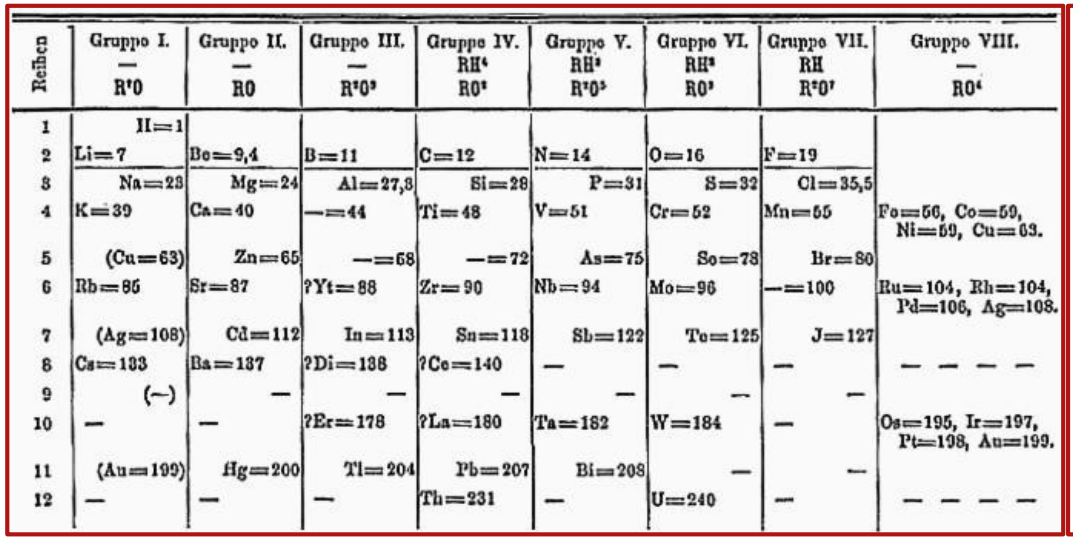
"I saw in a dream a table where all elements fell into place as required. Awakening, I immediately wrote it down on a piece of paper, only in one place did a correction later seem necessary."
— Mendeleev

Mendeleev's periodic law: 1st periodic table

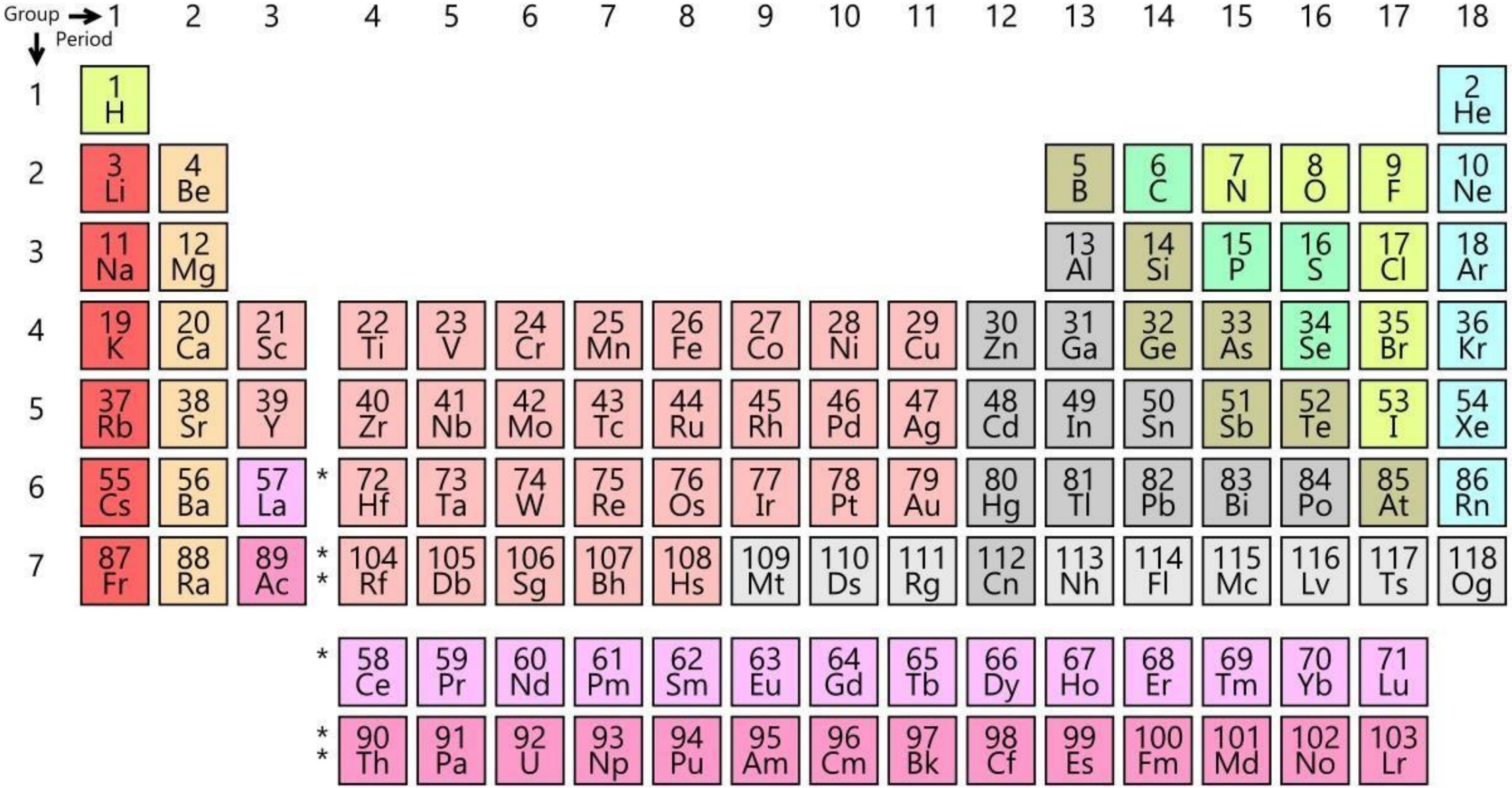
—*Theproperties of elements are the periodic function of their* ***atomic masses***‖.
Elements were arranged **horizontally in the order of their increasing atomic masses.**

Modern periodic law

The physical and chemical properties of the elements are the periodic function of their ***atomic number****.*
Elements are **arranged in order of increasing atomic numbers**



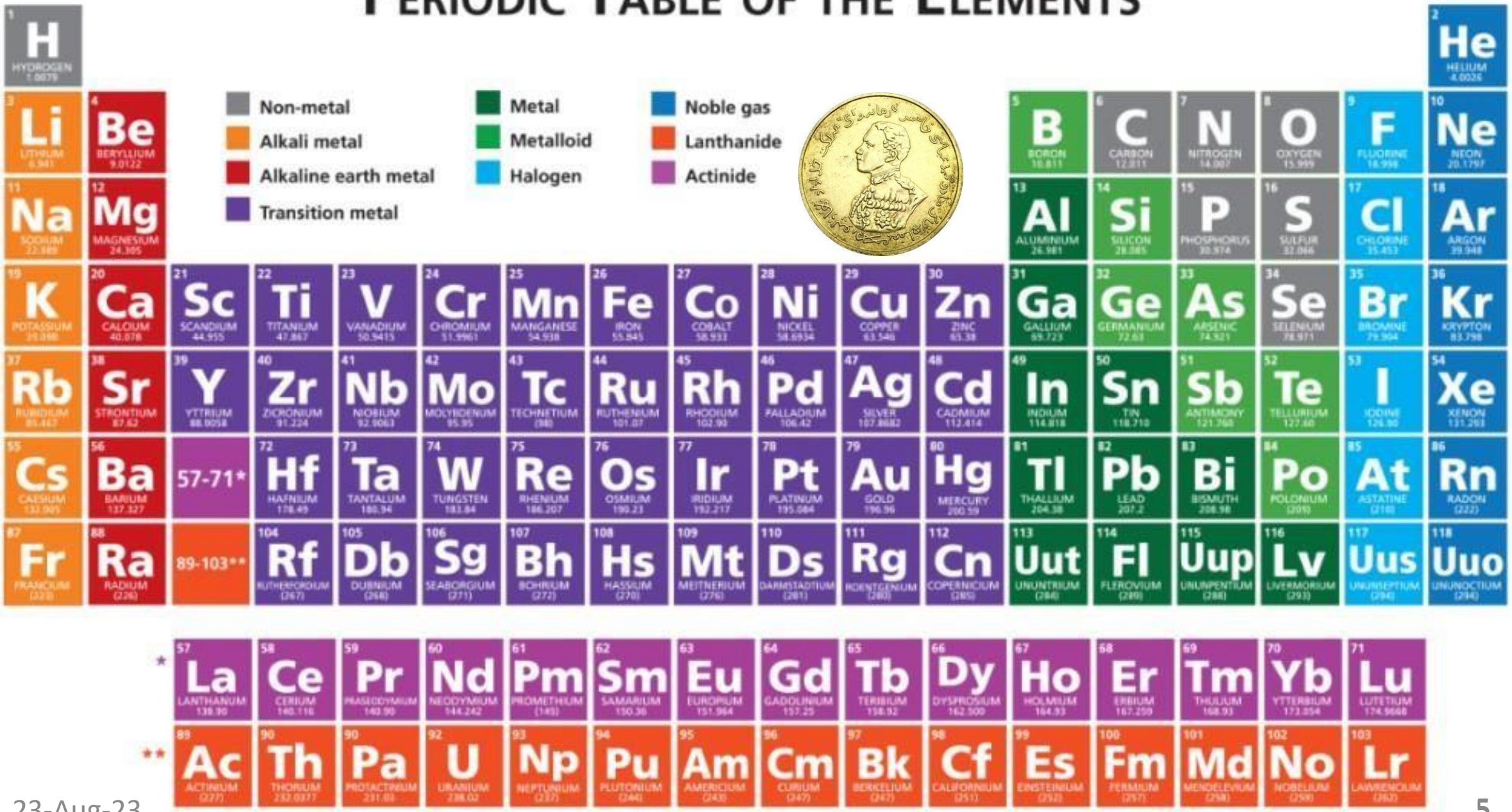
Reihen	Gruppo I. — R^1O	Gruppo II. — RO	Gruppo III. — R^2O^3	Gruppo IV. RH^4 RO^2	Gruppo V. RH^3 R^2O^5	Gruppo VI. RH^2 RO^3	Gruppo VII. RH R^2O^7	Gruppo VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —



Period: The **horizontal rows** – there are **seven periods**, each of which begins with an atom having **one valence electrons and ends with a complete outer shell structure.**

Group: The **vertical columns** are called Groups. There are **18 groups** in periodic table. The elements in a particular **Group exhibit similar properties**.

Periodic Table of the Elements



Element block

On the basis of the electronic configuration of **outer shells** (to be more specific, on the basis of the **orbital into which the last electron goes**), elements may be classified into 4 types:

- **s-block**

First two groups of the periodic table alkali metals and alkaline earths

- **p-block**

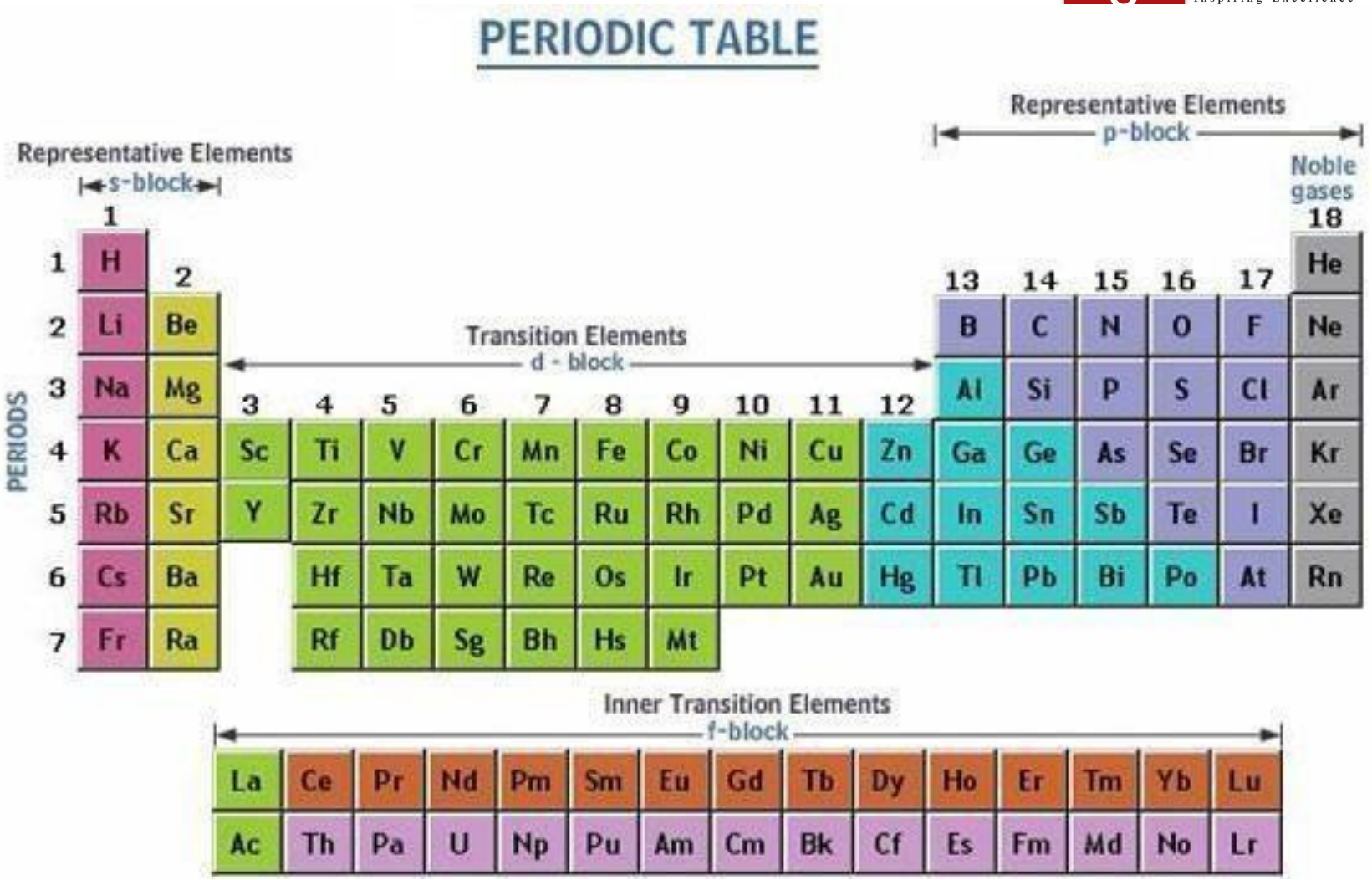
Last six element groups of the periodic table, excluding helium. The p-block elements include all of the **nonmetals** except for hydrogen and helium, the semimetals, and the post-transition metals.

- **d-block**

Transition metals of element groups 3-12.

- **f-block**

Inner transition elements, usually the lanthanide and actinide series, including lanthanum and actinium.

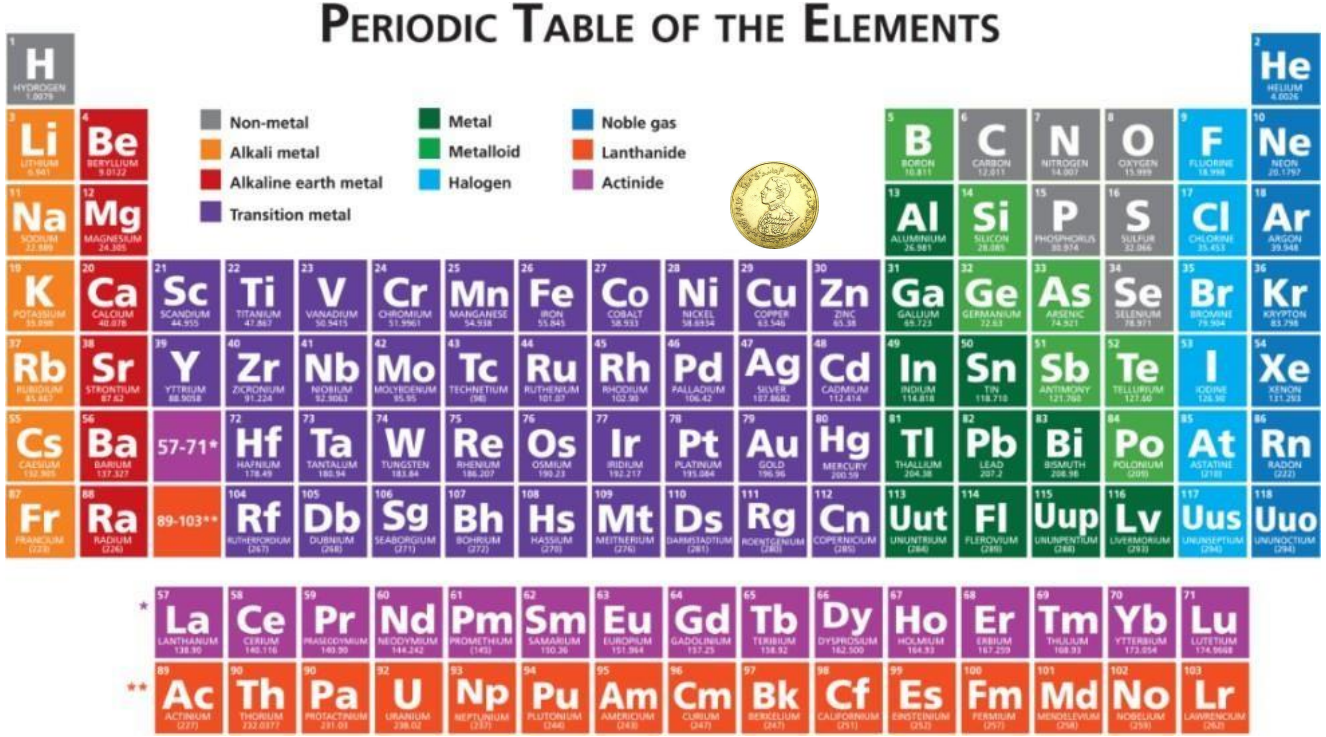


Properties related to the Periodic Table

- Elements on the left of the chart are metals with most reactive metals are in the lower left corner.
- **Non-metals** are found on the far right side with most active non-metals are in the upper right corner.
- **The noble** or inert gases are on the extreme right with ns2np6 configurations.
- **Group 1** metals are called **alkali metals** with *ns*1 outermost configuration. They are called alkali metals since they react with water to form strong bases.

$$Na\ (s) + H2O\ (l) = NaOH\ (aq) + H2\ (g)$$

- **Group 2** elements are called **alkaline earth metals** with *ns*2 outermost configurations
- As you proceed from left to right the base-forming properties decreases and acid-forming properties increases.
- The metals in the first two Groups are **light metals**
- The metals toward the center are called **heavy metals**
- The metals along the dark line in the Periodic Table are called **metalloids**, ie. B, Si, Ge, As, Sb, Te and Po.
- Group 17 elements with *ns*2*np*5 configuration are called **halogens group.**
- Elements of group 11 are called **coinage metals**.



General characteristics of groups

1. Number of Valence Electrons:

The number of valence electrons of all the elements in a **group is the same.**

2. Properties of Elements:

- All the elements of a given group possess **very similar physical & chemical properties**, but the subgroups A & B within a group also differ in many properties.
- There is a regular **gradation** in the properties of elements within a given group when we move from top to bottom.

3. Atomic Radius:

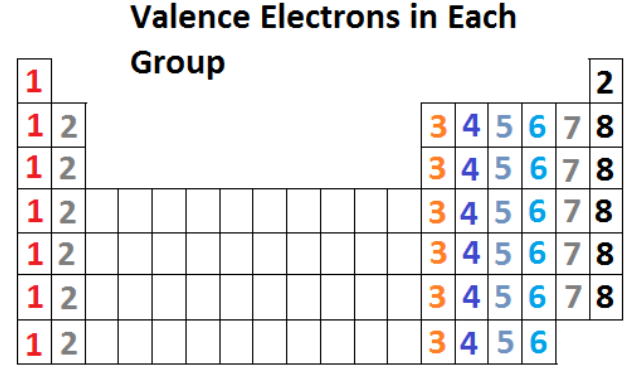
The atomic radii of elements **increase** when one moves **from top to bottom** in a group.

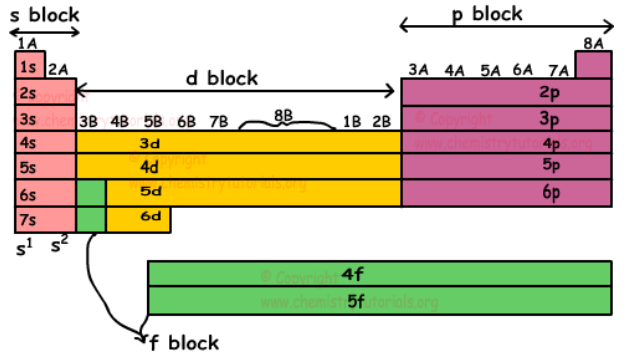
4. Metallic Character:

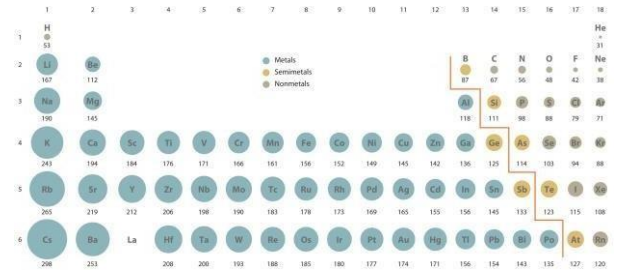
The metallic character of elements **increases on moving downward in a group**. This is particularly apparent in groups IVA, VA, and VIA, which begin with nonmetals (namely C, N and O respectively) and end with metals (namely Pb, Bi and Po respectively).

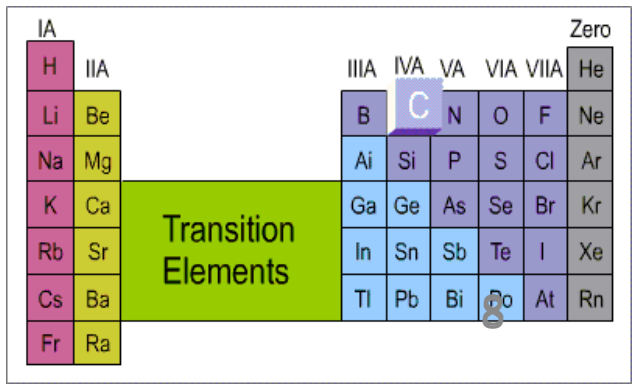
5. Number of Electron Shells:

On going down a group, the number of **electron shells increases** by one at each step









General characteristics of periods

1. Number of Valence Electrons:

The number of valence electrons **increases** from 1 to 8 when we proceed from **left to right** in a period.

2. Properties of Elements:

The properties of elements in a given period differ considerably from each other. However, the elements show a gradation of properties on moving from left to right in a period. *To illustrate*:

- *Oxidizing & Reducing Powers*: On proceeding from left to right in a period, the oxidizing power of elements progressively increases while the reducing power progressively decreases. Finally, the oxidizing and reducing power becomes zero at noble gases.
- *Electronegativity, Ionization potential and Electron affinity*: The electronegativity, ionization potential and electron affinity of elements progressively increases on moving from left to right in a period.

3. Atomic Radius:

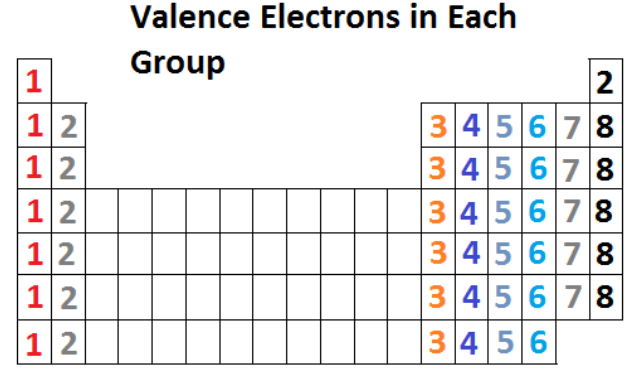
The atomic radii of elements decrease from left to right in a period, but the atomic radii of noble gases at the end of periods are lager than the previous elements of the same period.

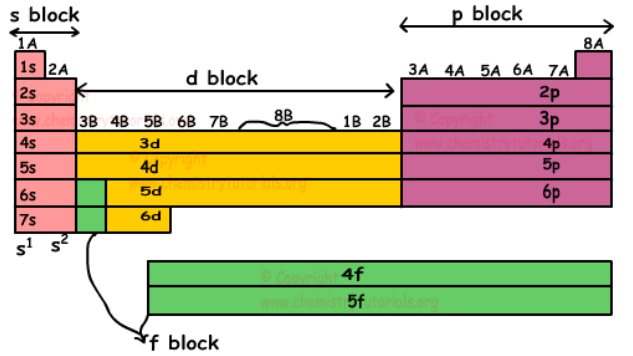
4. Metallic Character:

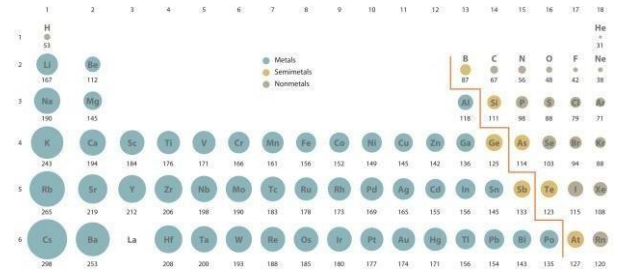
The On moving from left to right in a period, the metallic character of elements decreases.

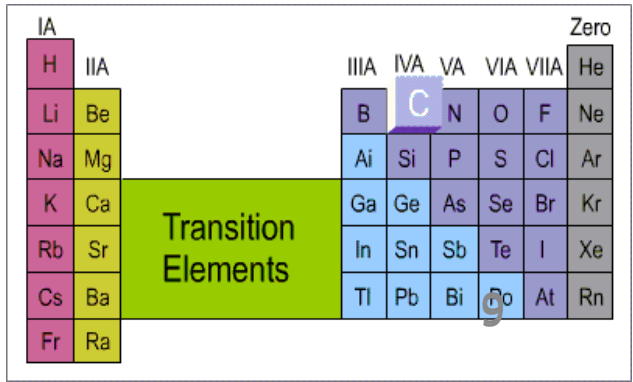
5. Number of Electron Shells:

On going from left to right in a period, the number of electron shells remains the same and the number of a period corresponds to the number of shells found in the elements of that period.









Application of Periodic Table

- **Simplification of the Study of Chemistry:** The classification of elements of similar properties into groups simplified their study. By studying any one element of a group **we can presume the properties of other elements of the same group.**

- **Prediction of Undiscovered Elements:** Arrangement of elements in increasing order of atomic weight/ number in periodic table **allows for prediction of yet undiscovered elements**. Dmitri Mendeleev kept a few places vacant in his periodic table, which were filled in later by newly discovered elements as he predicted. These elements are scandium, gallium, germanium, technetium, rhenium and polonium.

- **Finding Elements of Desired Properties for Industrial Purpose:** Appropriate elements with specific properties for industrial purposes c a n be searched out by purposeful study of the periodic table. **Several of the light metals and their alloys used in modern mechanical equipment, jet engines and aircrafts** were found by looking through the periodic table for elements having desired properties (e.g. Al alloy used in manufacturing aircrafts).

- **Correction of Atomic Weights:** Periodic table helped in correction of the **dubious atomic weights** of a number of elements e.g. In and Be. It was done by multiplying their equivalent weights by their valencies justified by their group positions in the periodic table.

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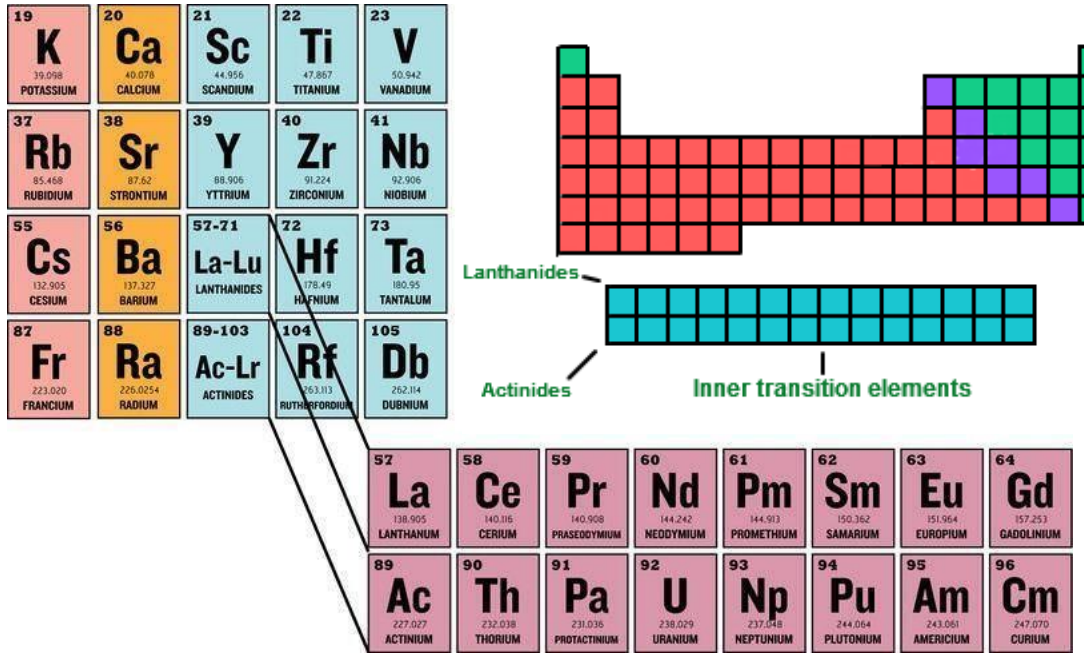
Defects of Periodic Table

- **Position of Hydrogen:** It is still debatable whether the position of hydrogen will be in **group IA** or along with alkali metals or in **group VIIA** along with halogens, because it **has similarities in properties with both alkali metals and halogens**.

- **The position of Lanthanides and Actinides:** In terms of the electronic structure of outer shell, all the 14 elements of lanthanide series need to be placed in the same position as La and similarly all the 14 elements of actinide series need to be placed in the same as position as Ac. Since such placement is practically impossible, they are placed separately as two different series beneath the main table.



Why hydrogen is not considered as an alkali metal or halogen?

Hydrogen, having just one s electron, is chemically analogous to group 1 alkali metals, which possess a single valence electron in their outermost s orbital. However, the hydrogen showed pronounced structural differences under ambient conditions. This is clearly shown by **hydrogen being a gas** and the group 1 elements being reactive **solid metals** at room temperature and pressure.

Whilst hydrogen does not exactly fit in group 1 as an "alkali metal" , it absolutely cannot be a halogen. Firstly, electronegativity decreases as you go down the periodic table, and the element becomes more and more metallic. Hydrogen would have to be more electronegative than fluorine should it be a halogen. Second, it doesn't even behave like a halogen, being mainly in the +1 oxidation state (doesn't happen to halogens, the most stable compounds of halogens have either -1 or a very high oxidation state, like +7 or +5. An oxidation state of +1 is very unstable in all halogens. It is also reactive with non-metals like oxygen, but not with metals like iron (still reacts slowly though, to form hydrides), unlike all halogens.

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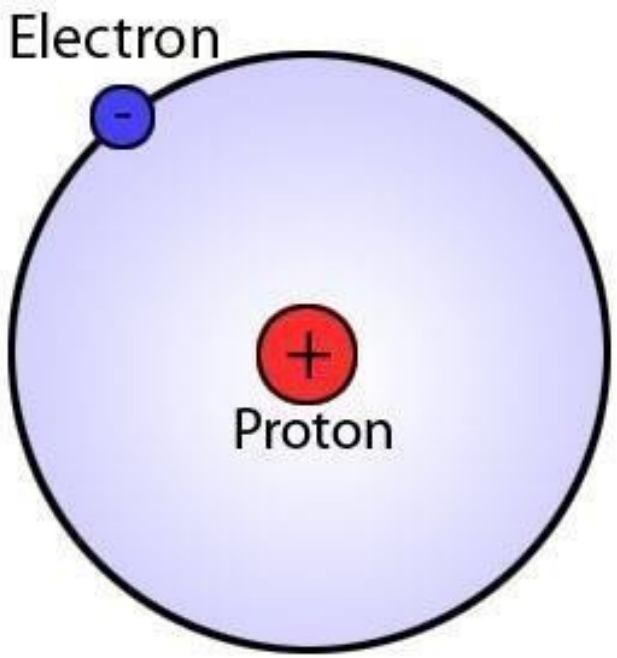
Justify the position of hydrogen in the periodic table

While hydrogen has properties similar to alkali metals and properties similar to halogens, owing to its un characteristics, hydrogen is considered neither an alkali metal nor a halogen. It is placed in group I solely because of its electronic configuration with one electron(electron configuration is the arrangement of electrons in orbital shells). It has 1 proton (the most common isotopic form) thus an atomic number of 1 (the number of protons equals the atomic number). The periodic table arranges elements according to their atomic number and electronic configuration, which are the two factors explaining the reason for position of hydrogen at the top of group I: atomic number and electronic configuration.



Elements in the some group have:

a. similar symbols
b. the same number of valence electrons
c. the same number of electrons

b. the same number of valence electrons

The elements in the present periodic table are arranged according to their:

a. atomic masses
b. atomic number
c. mass number

b. atomic number

What family of elements is in the left-most column of the Periodic Table?

a. Alkali metals
b. Halogens
c. Noble gas

a. Alkali metals

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