



Inspiring Excellence

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. Awakened, 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

—The properties 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	Gruppe I. — R ⁰	Gruppe II. — R ⁰	Gruppe III. — R ⁰	Gruppe IV. RH ⁴ R ⁰	Gruppe V. RH ⁵ R ⁰	Gruppe VI. RH ⁶ R ⁰	Gruppe VII. RH ⁷ R ⁰	Gruppe VIII. — R ⁰
1	II=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=86	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	—	—

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period ↓	1 1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	* 104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				* 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	71 Lu	
				* 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	103 Lr	

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Period ↓																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	* 104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
				* 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	71 Lu	
				* 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	103 Lr	

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

1 H HYDROGEN 1.0079																	2 He HELIUM 4.0026						
3 Li LITHIUM 6.941	4 Be BERYLLIUM 9.0122																	5 B BORON 10.811	6 C CARBON 12.011	7 N NITROGEN 14.007	8 O OXYGEN 15.999	9 F FLUORINE 18.998	10 Ne NEON 20.1797
11 Na SODIUM 22.989	12 Mg MAGNESIUM 24.305																	13 Al ALUMINUM 26.981	14 Si SILICON 28.085	15 P PHOSPHORUS 30.974	16 S SULFUR 32.066	17 Cl CHLORINE 35.453	18 Ar ARGON 39.948
19 K POTASSIUM 39.098	20 Ca CALCIUM 40.078	21 Sc SCANDIUM 44.955	22 Ti TITANIUM 47.867	23 V VANADIUM 50.9415	24 Cr CHROMIUM 51.9961	25 Mn MANGANESE 54.938	26 Fe IRON 55.845	27 Co COBALT 58.933	28 Ni NICKEL 58.6934	29 Cu COPPER 63.546	30 Zn ZINC 65.38	31 Ga GALLIUM 69.723	32 Ge GERMANIUM 72.63	33 As ARSENIC 74.921	34 Se SELENIUM 78.971	35 Br BROMINE 79.904	36 Kr KRYPTON 83.798						
37 Rb RUBIDIUM 85.467	38 Sr STRONTIUM 87.62	39 Y YTTORIUM 88.9058	40 Zr ZIRCONIUM 91.224	41 Nb NIOBIUM 92.9063	42 Mo MOLYBDENUM 95.95	43 Tc TECHNETIUM (98)	44 Ru RUTHENIUM 101.07	45 Rh RHODIUM 102.90	46 Pd PALLADIUM 106.42	47 Ag SILVER 107.8682	48 Cd CADMIUM 112.414	49 In INDIUM 114.818	50 Sn TIN 118.710	51 Sb ANTIMONY 121.760	52 Te TELLURIUM 127.60	53 I IODINE 126.90	54 Xe XENON 131.293						
55 Cs CAESIUM 132.905	56 Ba BARIUM 137.327	57-71*	72 Hf HAFNIUM 178.49	73 Ta TANTALUM 180.94	74 W TUNGSTEN 183.84	75 Re RHENIUM 186.207	76 Os OSMIUM 190.23	77 Ir IRIDIUM 192.217	78 Pt PLATINUM 195.084	79 Au GOLD 196.96	80 Hg MERCURY 200.59	81 Tl THALLIUM 204.38	82 Pb LEAD 207.2	83 Bi BISMUTH 208.98	84 Po POLONIUM (209)	85 At ASTATINE (210)	86 Rn RADON (222)						
87 Fr FRANCIUM (223)	88 Ra RADIUM (226)	89-103**	104 Rf RUTHERFORDIUM (261)	105 Db DUBNIUM (268)	106 Sg SEABORGIUM (271)	107 Bh BOHRHIUM (272)	108 Hs HASSIUM (278)	109 Mt MEITNERIUM (276)	110 Ds DARMSTADIUM (281)	111 Rg ROENTGENIUM (288)	112 Cn COPERNICIUM (285)	113 Uut UNUNTRIUM (286)	114 Fl FLEROVIUM (289)	115 Uup UNUNPENTIUM (288)	116 Lv LIVERMORIUM (293)	117 Uus UNUNSEPTIUM (294)	118 Uuo UNUNOCTIUM (294)						

Non-metal

Alkali metal

Alkaline earth metal

Transition metal

Metal


Metalloid

Halogen

Noble gas

Lanthanide

Actinide



57 La LANTHANUM 138.90	58 Ce CERIUM 140.116	59 Pr PRASEODYMIUM 140.90	60 Nd NEODYMIUM 144.242	61 Pm PROMETHIUM (143)	62 Sm SAMARIUM 150.36	63 Eu EUROPIUM 151.964	64 Gd GADOLINIUM 157.25	65 Tb TERBIUM 158.92	66 Dy DYSPROSIUM 162.500	67 Ho HOLMIUM 164.93	68 Er ERBIUM 167.259	69 Tm THULIUM 168.93	70 Yb YTTERIUM 173.054	71 Lu LUTETIUM 174.9668
89 Ac ACTINIUM (227)	90 Th THORIUM 232.0377	91 Pa PROTACTINIUM 231.04	92 U URANIUM 238.02	93 Np NEPTUNIUM (237)	94 Pu PLUTONIUM (244)	95 Am AMERICIUM (243)	96 Cm CURIUM (247)	97 Bk BERKELIUM (247)	98 Cf CALIFORNIUM (251)	99 Es EINSTEINIUM (252)	100 Fm FERMIUM (257)	101 Md MENDELEVIUM (258)	102 No NOBELIUM (259)	103 Lr LAWRENCIUM (262)

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**.

PERIODIC TABLE

Representative Elements s-block												Representative Elements p-block						Noble gases
1	2											13	14	15	16	17	18	
1	H											B	C	N	O	F	He	
2	Li	Be	Transition Elements d-block														Ne	
3	Na	Mg	3	4	5	6	7	8	9	10	11	12	Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt									
			Inner Transition Elements f-block															
			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

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 $ns1$ outermost configuration. They are called alkali metals since they react with water to form strong bases.



- ❖ **Group 2** elements are called **alkaline earth metals** with $ns2$ 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 $ns2np5$ configuration are called **halogens group**.
- ❖ Elements of group 11 are called **coinage metals**.

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																			57 La LANTHANUM 138.90	58 Ce CELIUM 140.12	59 Pr PRASEODYMIUM 140.90	60 Nd NEODYMIUM 144.24	61 Pm PROMETHIUM (145)	62 Sm SAMARIUM 150.36	63 Eu EUROPIUM 151.964	64 Gd GADOLINIUM 157.25	65 Tb TERBIUM 158.92	66 Dy DYSPROSIUM 162.50	67 Ho HOLMIUM 164.93	68 Er ERBIUM 167.259	69 Tm THULIUM 168.93	70 Yb YTERBIUM 173.054	71 Lu LUTETIUM 174.967
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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:

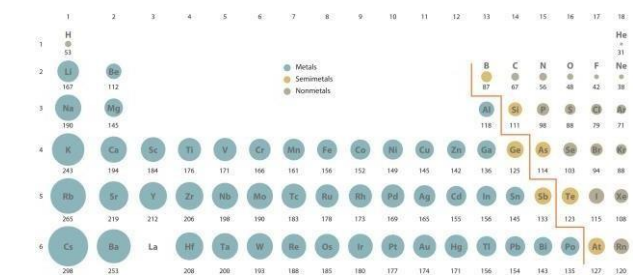
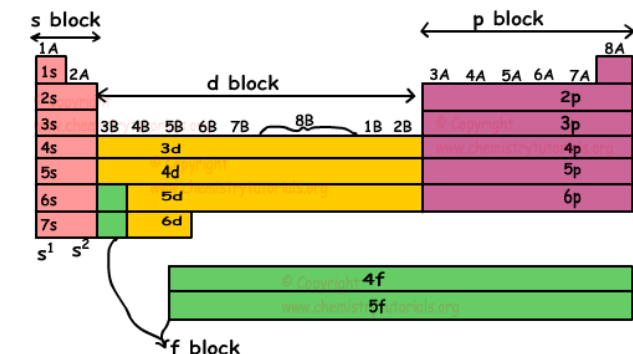
The metallic character of elements **increases on moving downward in a group**. This is particularly apparent in groups IVA, VA, and VIA, which begin with nonmetals (namely C, N and O respectively) and end with metals (namely Pb, Bi and Po respectively).

5. Number of Electron Shells:

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

Valence Electrons in Each

Group																		2
1	2																	8
1	2																	8
1	2																	8
1	2																	8
1	2																	8
1	2																	8
1	2																	8



IA	IIA	Transition Elements						IIIA	IVA	VA	VIA	VIIA	Zero
H	He							B	C	N	O	F	Ne
Li	Be							Al	Si	P	S	Cl	Ar
Na	Mg							Ga	Ge	As	Se	Br	Kr
K	Ca							In	Sn	Sb	Te	I	Xe
Rb	Sr							Tl	Pb	Bi	Po	At	Rn
Cs	Ba												
Fr	Ra												

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 larger than the previous elements of the same period.

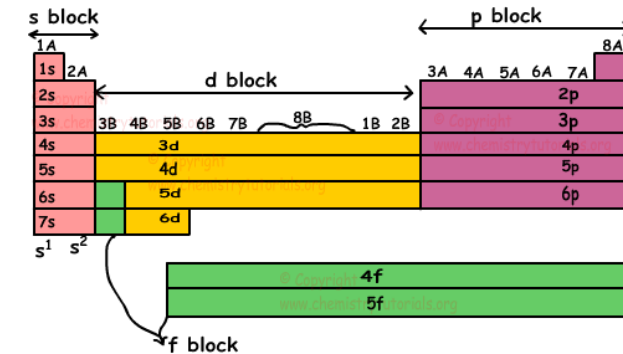
4. Metallic Character:

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.

Valence Electrons in Each Group																	
1																2	
1	2															3	4
1	2															3	4
1	2															3	4
1	2															3	4
1	2															3	4
1	2															3	4
1	2															3	4



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H	He																
Li	Be	B	C	N	O	F	Ne										
Na	Mg	Al	Si	P	S	Cl	Ar										
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

IA	IIA	Transition Elements						IIIA	IVA	VA	VIA	VIIA	Zero
H	He							B	C	N	O	F	Ne
Li	Be							Al	Si	P	S	Cl	Ar
Na	Mg							Ga	Ge	As	Se	Br	Kr
K	Ca							In	Sn	Sb	Te	I	Xe
Rb	Sr							Tl	Pb	Bi	Po	At	Rn
Cs	Ba												
Fr	Ra												

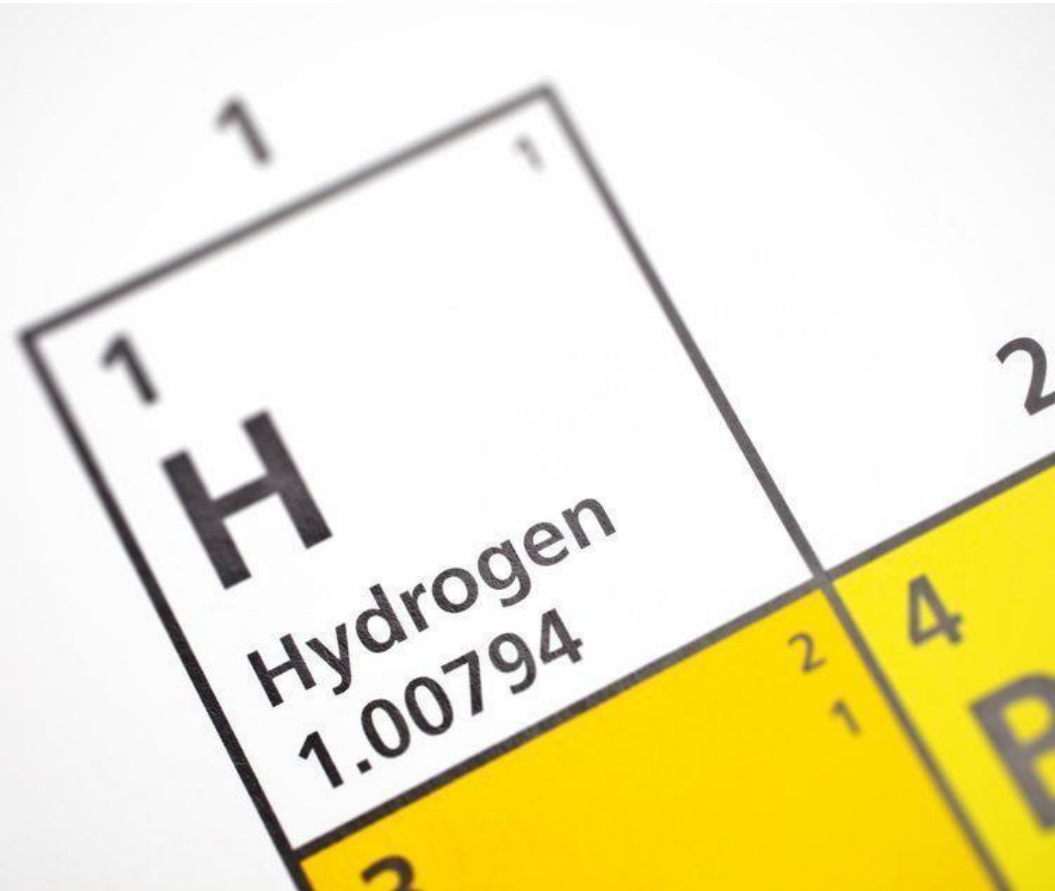
Application of Periodic Table

- ❖ **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 can 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.

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

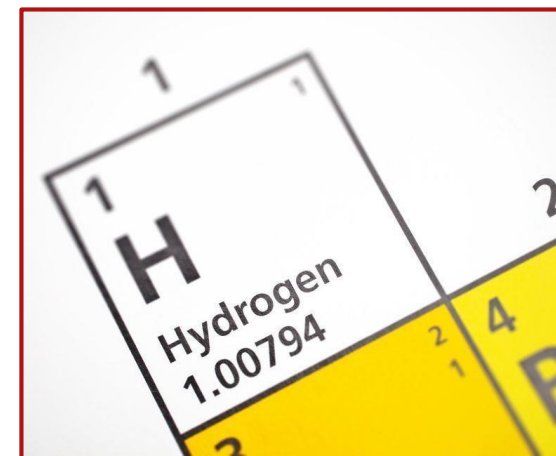
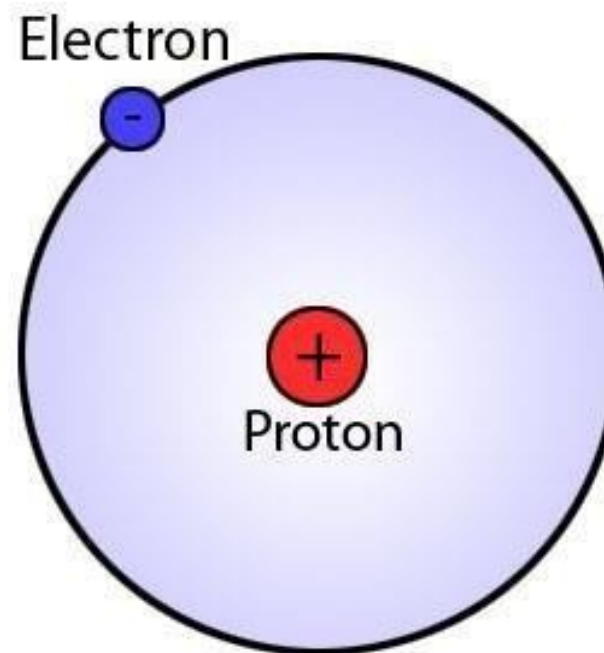
Hydrogen, having just one s electron, is chemically analogous to group 1 alkali metals, which possess a single valence electron in their outermost s orbital. However, the hydrogen showed pronounced structural differences under ambient conditions. This is clearly shown by **hydrogen being a gas** and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



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 unique 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 same 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



Inspiring Excellence

