Hydrogen:

Hydrogen is the most abundant element in universe and third most abundant element on the surface of earth. It is the simplest element with only one electron in its orbit around the nucleus congaing only one proton. It exist as a diatomic molecule i.e. H2 in its elemental form. The global concern related to clean energy makes it so important to study hydrogen separately from the other elements. This concern can be overcome to a greater extent by the use of hydrogen as a source of energy.

- **Position of Hydrogen in Periodic Table**

Hydrogen is the first element of periodic table but its position in the periodic table has been a subject of discussion for the past few years due to its similarities with both halogens and alkali metals. A proper position could not be assigned to hydrogen either in the Mendeleev's periodic table or Modern periodic table because of the following reason: In some properties, it resembles alkali metals and in some properties it resembles halogens. So hydrogen can be placed both in group 1 and group 17 with alkali metals and halogen respectively.

- **Isotopes of Hydrogen?**

?Hydrogen has three isotopes: **Protium** $^{1}H_{1}$, or H , **Deuterium** $^{2}H_{1}$ or D & **Tritium** $^{3}H_{1}$ or T. These all differ from each other in respect of number of neutrons present in the nucleus. Protium does not contain any neutron, Deutrium (also known as heavy hydrogen) contains one neutron while the number of neutrons in the nucleus of tritium is 2. Tritium is radioactive and emits low energy β-particles.

Name of Isotope	Symbol	Atomic Number	Mass Number	Relative Abundance
Protium	$^{1}H_{1}$ or H	1	1	99.99%
Deuterium	$^{2}H_{1}$ or D	1	2	0.015%
Tritium	$^{3}H_{1}$	1	3	10^{-18} %

- **Resemblance With Alkali Metals**

1. **Electronic configuration**: Hydrogen contains one electron in the valence shell like alkali metals

Element	Electronic Configuration
H	$1s^{1}$

Li	[He]2s^1
Na	[Ne]3s^1
K	[Ar]4s^1
Rb	[Kr]5s^1

2. Electropositive Character: Like alkali metal, hydrogen also loses its only electron to form hydrogen ion, i.e, H^-

3. Oxidation state :Like alkali metals, hydrogen exhibits an oxidation state of +1 in its compounds.

4. Reducing agent : Alkali metals act as reducing agents because of their tendency to lose valence electron. Hydrogen is also a very good reducing agent as evident from the following reactions:

$$Fe_3O_4 + 4H_2 \xrightarrow{\Delta} 3Fe + 4H_2O$$

$$CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$$

5. Combination with electronegative elements : Just like alkali metals hydrogen combines with electronegative elements such as halogen, oxygen, sulphur, etc to form compounds with similar formulae

- **Difference from Alkali Metals**

1. Ionization enthalpy : Ionization enthalpy of hydrogen (1312 kJ mol-1) is very high in comparison with the ionization enthalpy of alkali metals.

2. Existence of H^- : It has been established that H- ion does not exist freely in a aqueous solution. This is because of the fact that has a very small size as compared to normal atomic and ionic size (which range from 50 to 220 pm). Thus it exists in aqueous solution in the form of hydrated proton with a formula,$H_9O_4^+$. However, for the sake of simplicity hydrated proton is represented by hydronium ion,H_3O^+.
On the other hand, the alkali metal ions mostly exist as hexahydrated ions.

3. Difference in halides: Hydrogen halides are different from the halides of alkali metals although they have similar molecular formulae. For example

(i) Pure HCl is a covalent compound while NaCl is an ionic compound.

(ii) HCl is a gaseous compound while NaCl is a solid at ordinary temperature.

- **Resemblance With Halogens**
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1. Electronic configuration.

Just like halogens, hydrogen needs one electron to attain the configuration of nearest noble gas.

2. Atomicity. Like halogens, hydrogen also exists in a diatomic state. The atomicity of hydrogen as well as halogens is two.

3. Electrochemical nature.

During electrolysis of LiH, CaH_2, etc, in molten state hydrogen is evolved at the anode indicating its electronegative nature. In this respect, hydrogen shows resemblance with halogens which are also liberated at the anode during electrolysis.

4. Oxidation state.

Just like halogens, hydrogen also exhibit state of -1 in some of its compounds such as metal hydrides.

5. Combination with alkali metals.

Just like halogen, hydrogen also combines with alkali metals to form salts with similar formulae.

NaH	LiH	CaH_2
NaCl	LiCl	$CaCl_2$

6. Combination with non-metals: Just like halogens hydrogen also react with non-metals such as carbon, silicon, germanium, etc, to form covalent compounds.

Halides :	CCl_4	$SiCl_4$	$GeCl_4$
Hydrides :	CH_4	SiH_4	GeH_4

7. Ionization energy

Ionization energy of hydrogen is comparable to the ionization energies of halogens as shown below:

Element	H	F	Cl	Br
Ionization energies (Kj mol^{-1})	1312	1681	1255	1121

Difference from Halogens

1. Less tendency of hydride – formation.

Although hydrogen forms hydride ion (H^-) like halogens, yet its tendency to form hydride ion is very less in comparison with the halogens. It is quite clear from the fact that halogens form halides with very large number of metals but hydrogen form hydrides with only a small number metals like sodium and calcium, etc.

2. Absence of unshared electrons: There is no unshared pair of electron in hydrogen molecule whereas halogen molecules have six unshared electron pairs as shown below:

3. Nature of oxides.: The oxides of halogen are acidic in nature whereas oxide of hydrogen is neutral

4. Nature of compounds: The compounds of hydrogen with halogens, i.e. hydrogen halides (HF, HCl, HBr, HI) are low boiling covalent compounds whereas alkali metal halides (LiF, NaCl, KBr, CsI) are high melting ionic solids.