



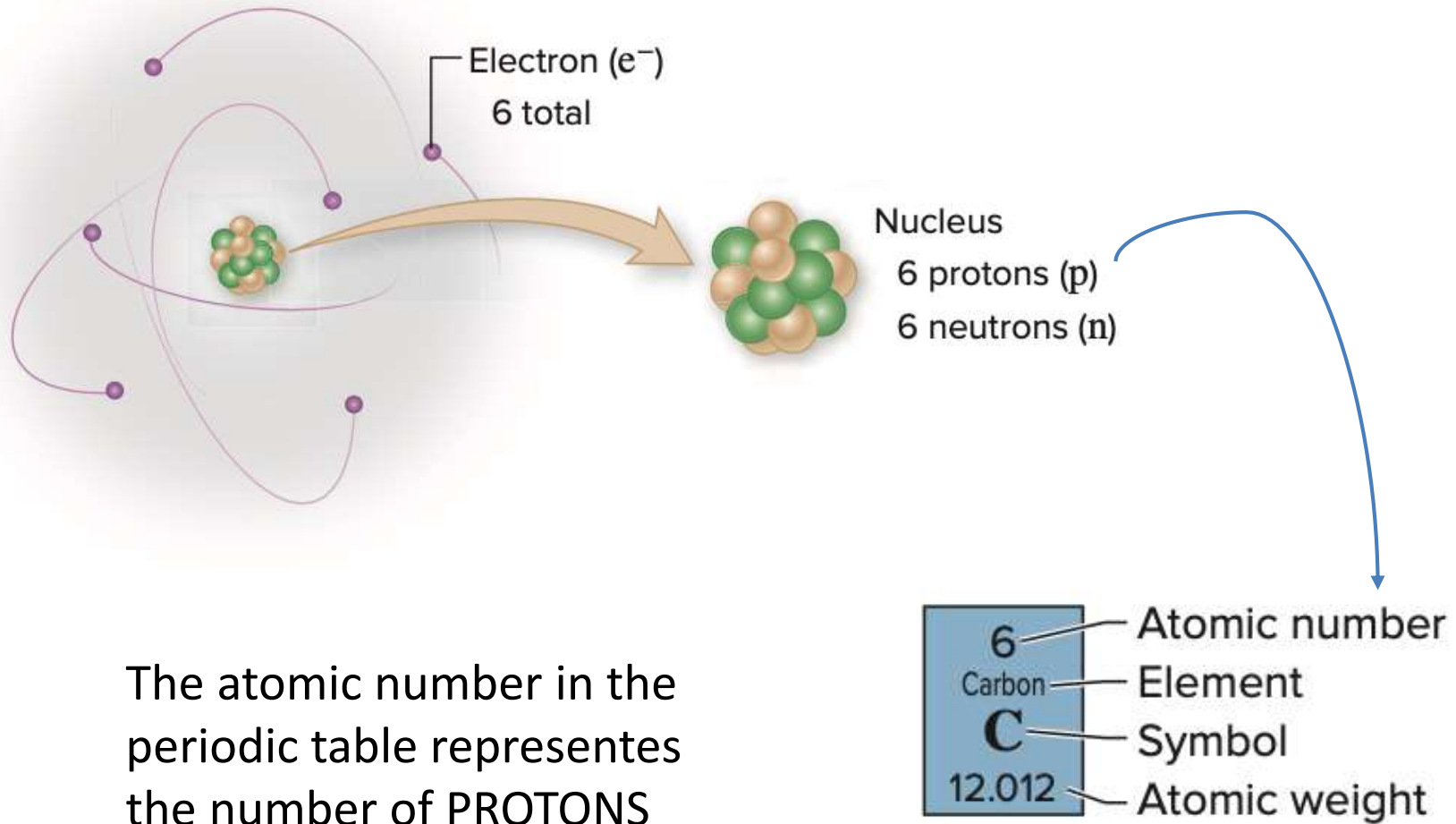
Chemistry of Life

Prof. Dr. Chiara Valsecchi

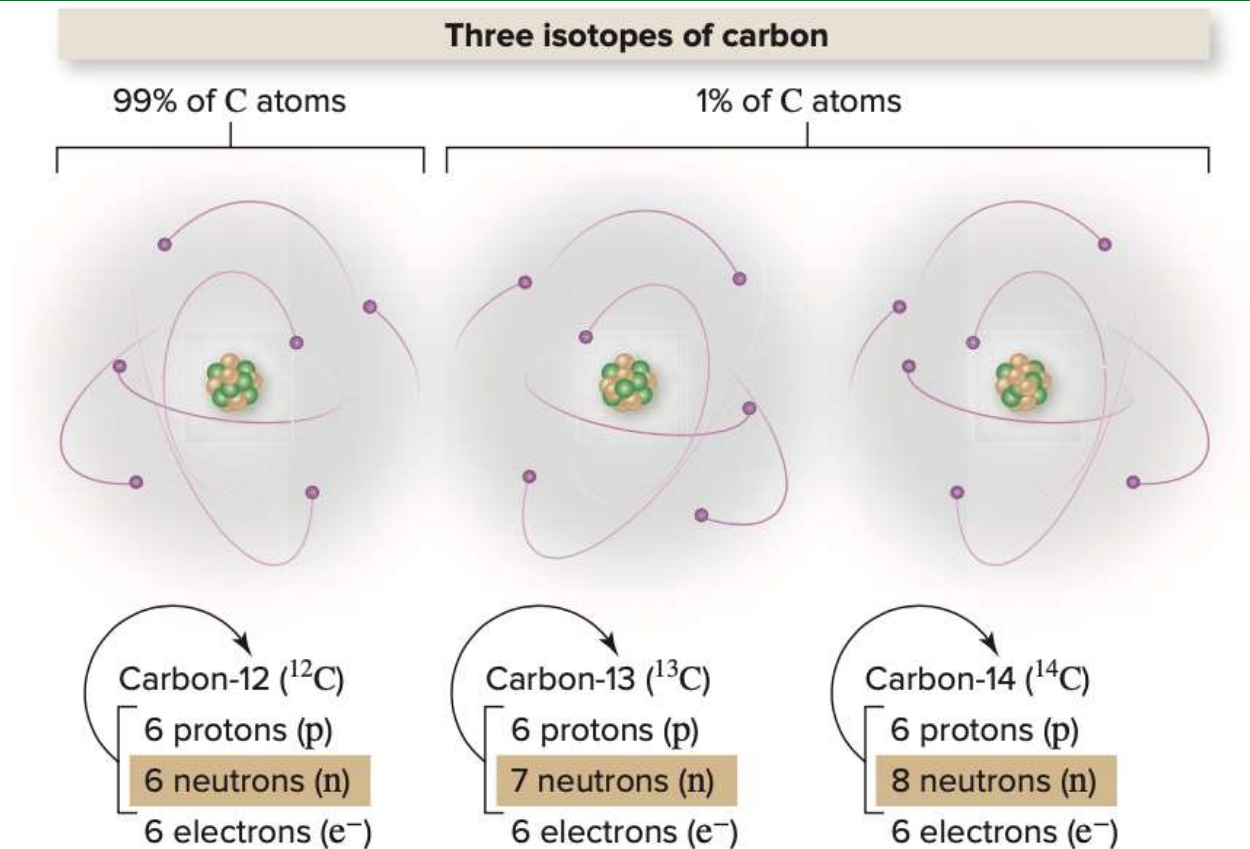
Class Goals

- Understand how the **atoms** are organize
- Understand the basics of **chemical bond** theory
- Explore the main classes of **biological molecules**

Atomic Structure



Atomic Isotopes

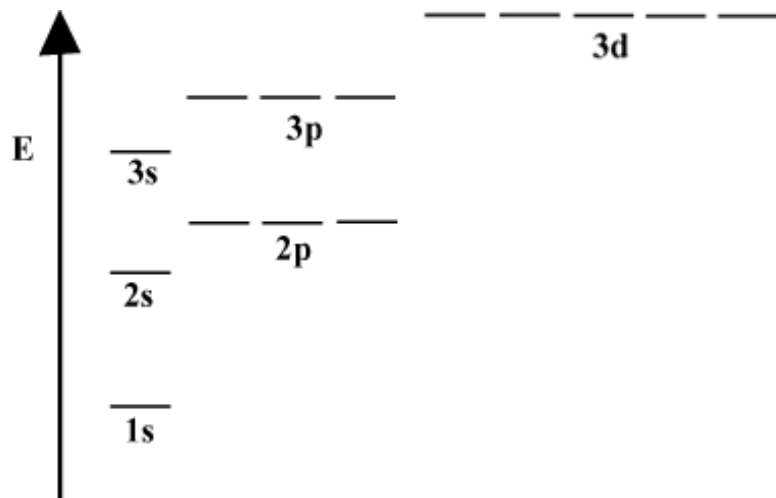


Isotopes changes the number of NEUTRON.

Isotope ^{14}C is used to obtain the date of ancient or historical artifacts

Atomic Orbitals

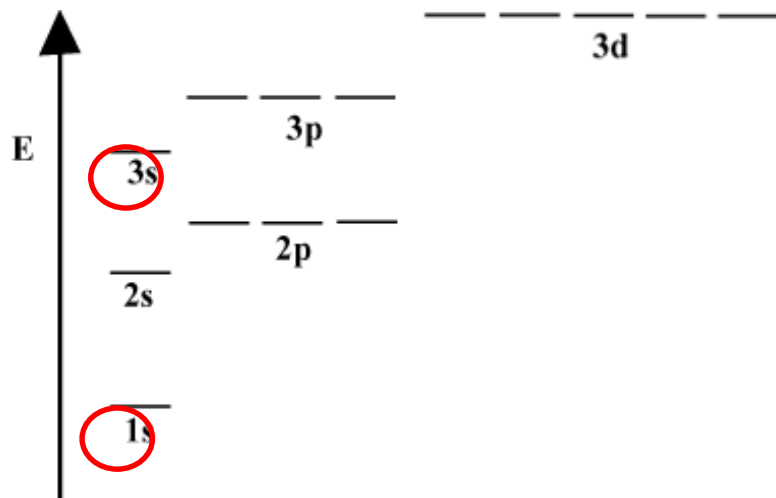
Orbitals have different energy levels, which are associated to a number, called **quantic number n**



Multielectronic Atoms

Atomic Orbitals

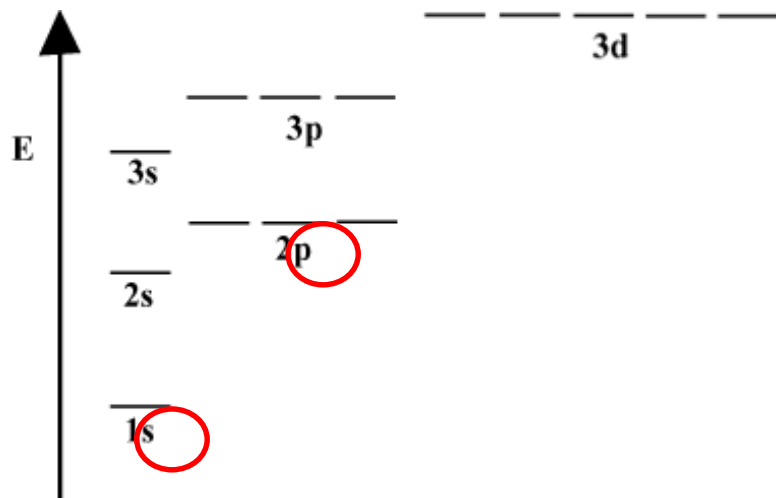
Orbitals have different energy levels, which are associated to a number, called **quantic number n**



Multielectronic Atoms

Atomic Orbitals

The letter indicates the type of orbital, and most important, how many electrons it can contain



Multielectronic Atoms

s = 2 electrons

p = 6 electrons

d = 10 electrons

Therefore:

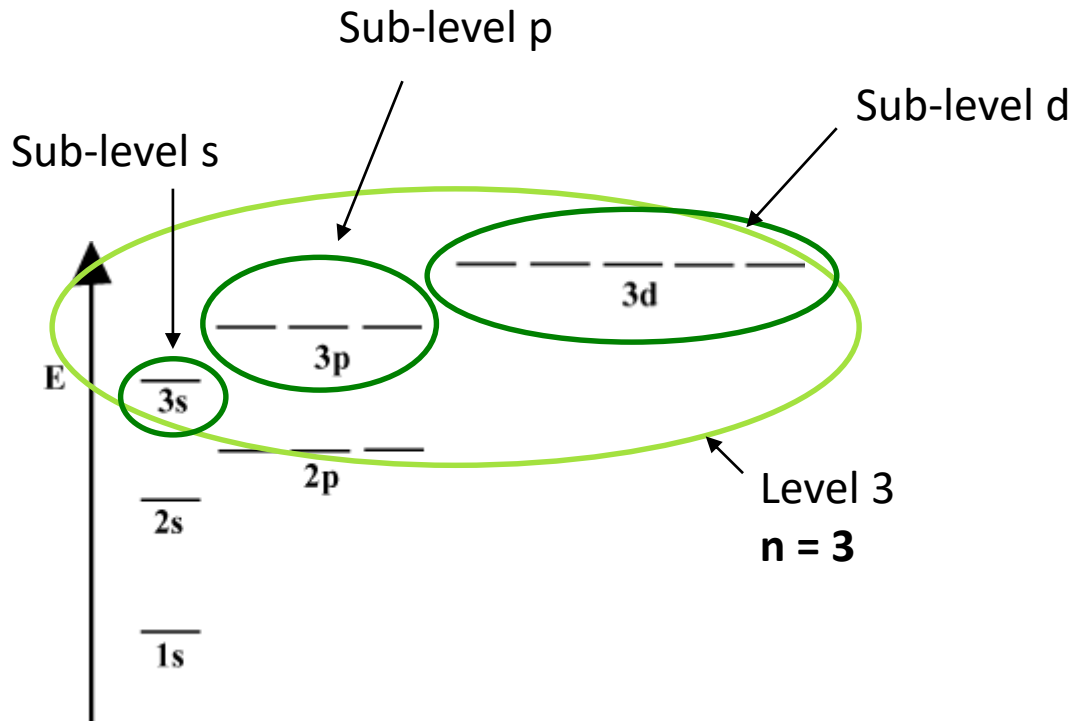
1st level (**n = 1**) can have 2 electrons

2nd level (**n = 2**) can have 8 electr.

3rd level (**n = 3**) can have 18 electr.

....

Atomic Orbitals Levels

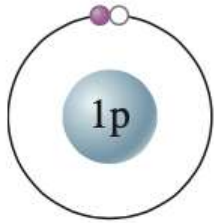
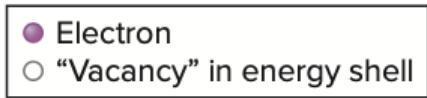


Each level can have sub-levels

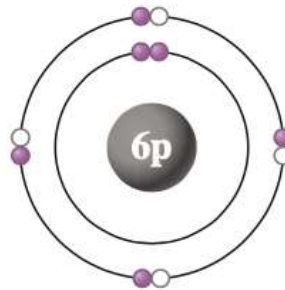
The outmost atomic orbital level is the one that will affect the capacity of the atoms to create bonds

VALENCE SHELL

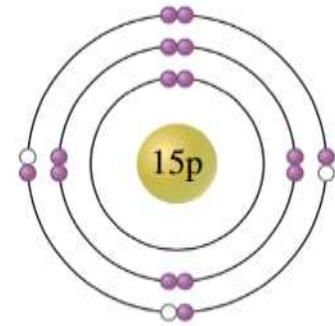
Valence Shell



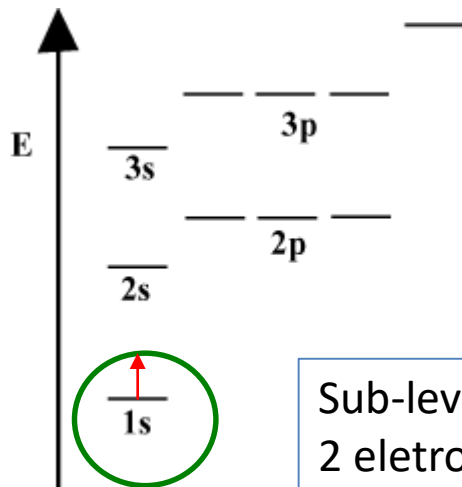
Hydrogen



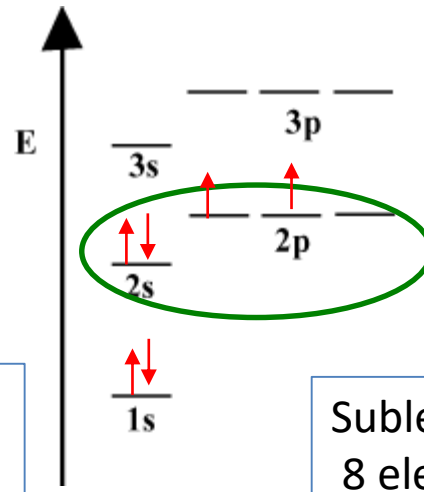
Carbon



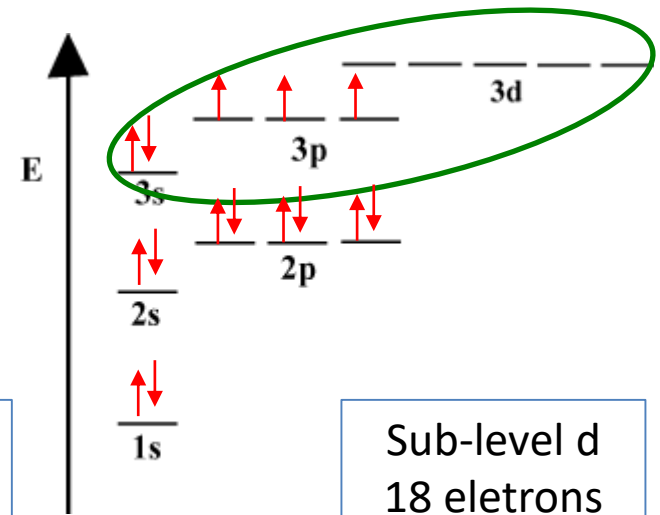
Phosphorus



Sub-level s
2 eletrons



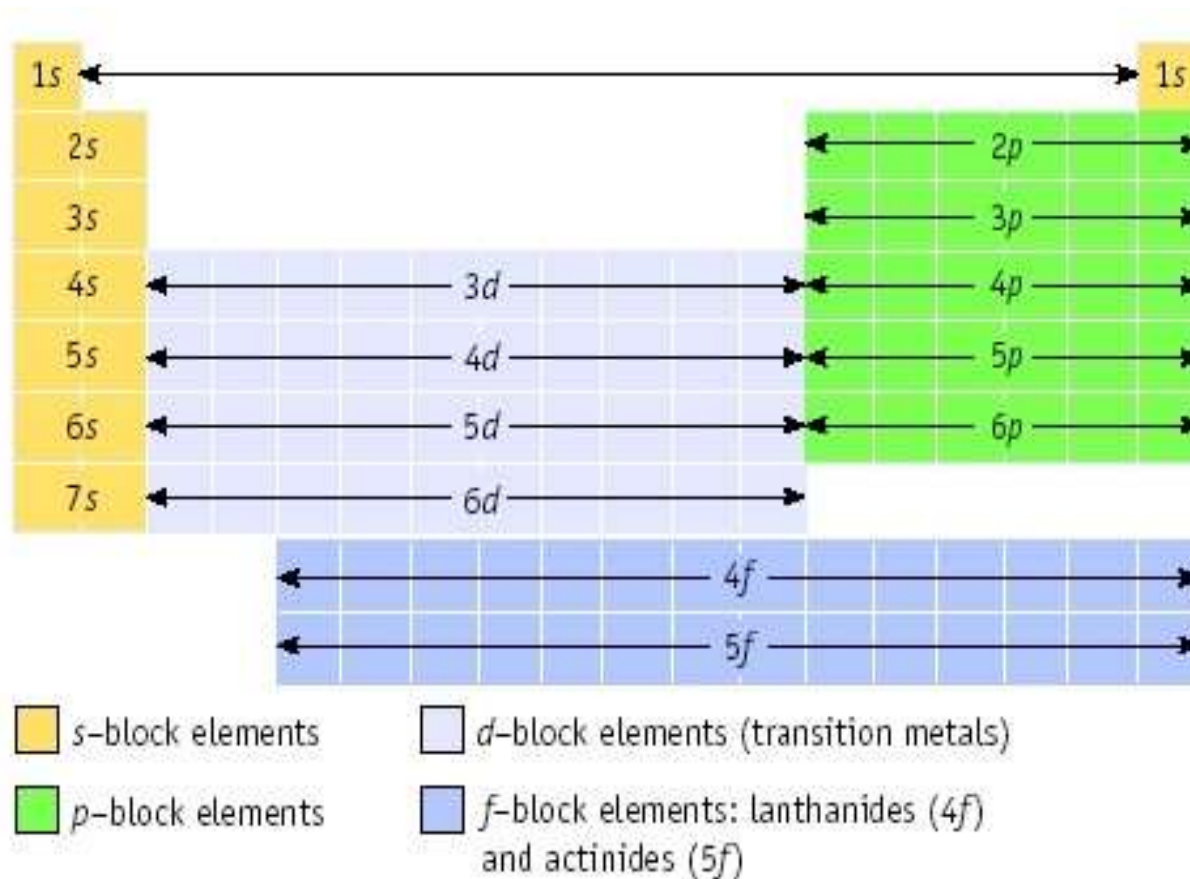
Sublevel p
8 eletrons



Sub-level d
18 eletrons

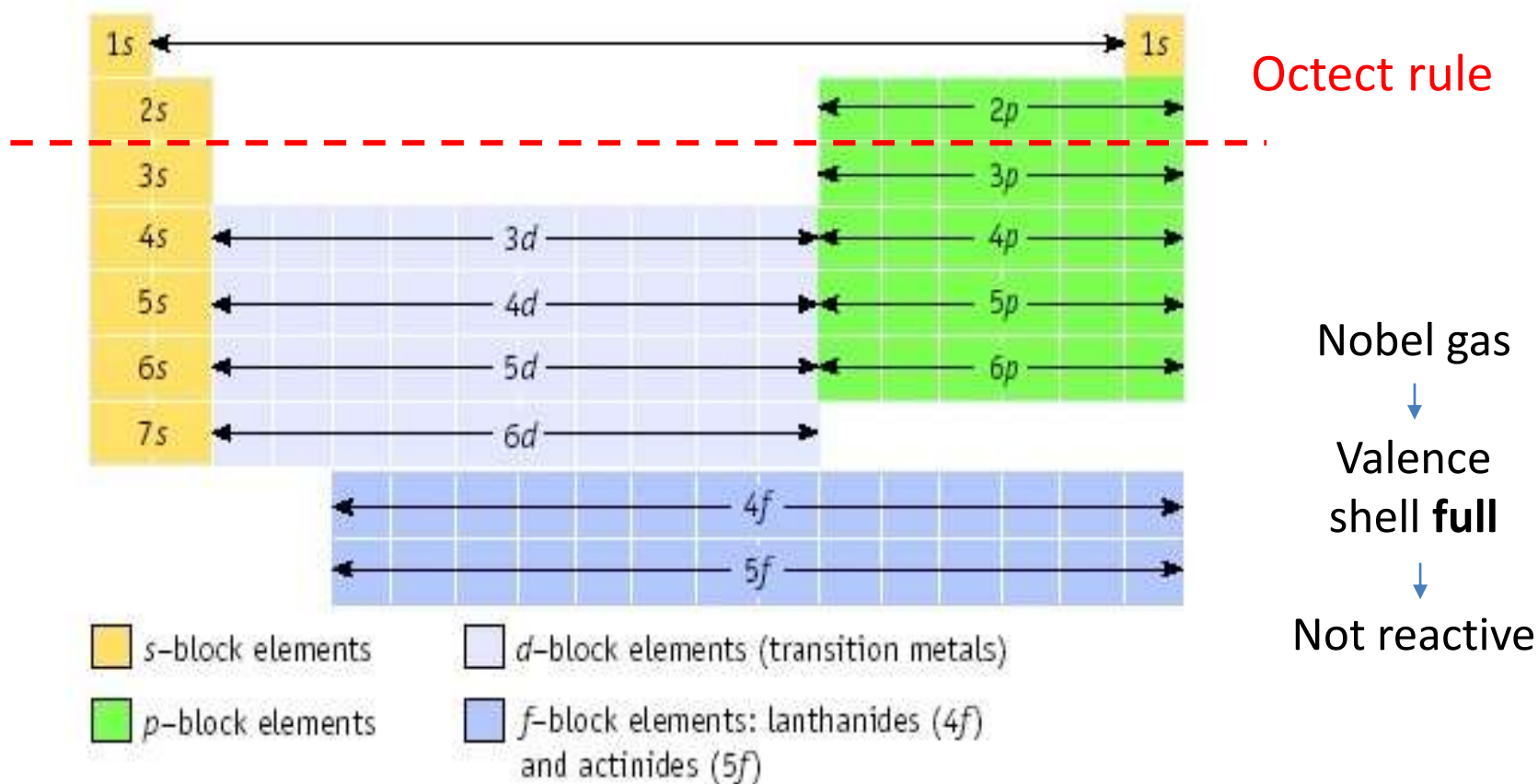
Valence Shell

The valence shell can be easily found in the periodic table

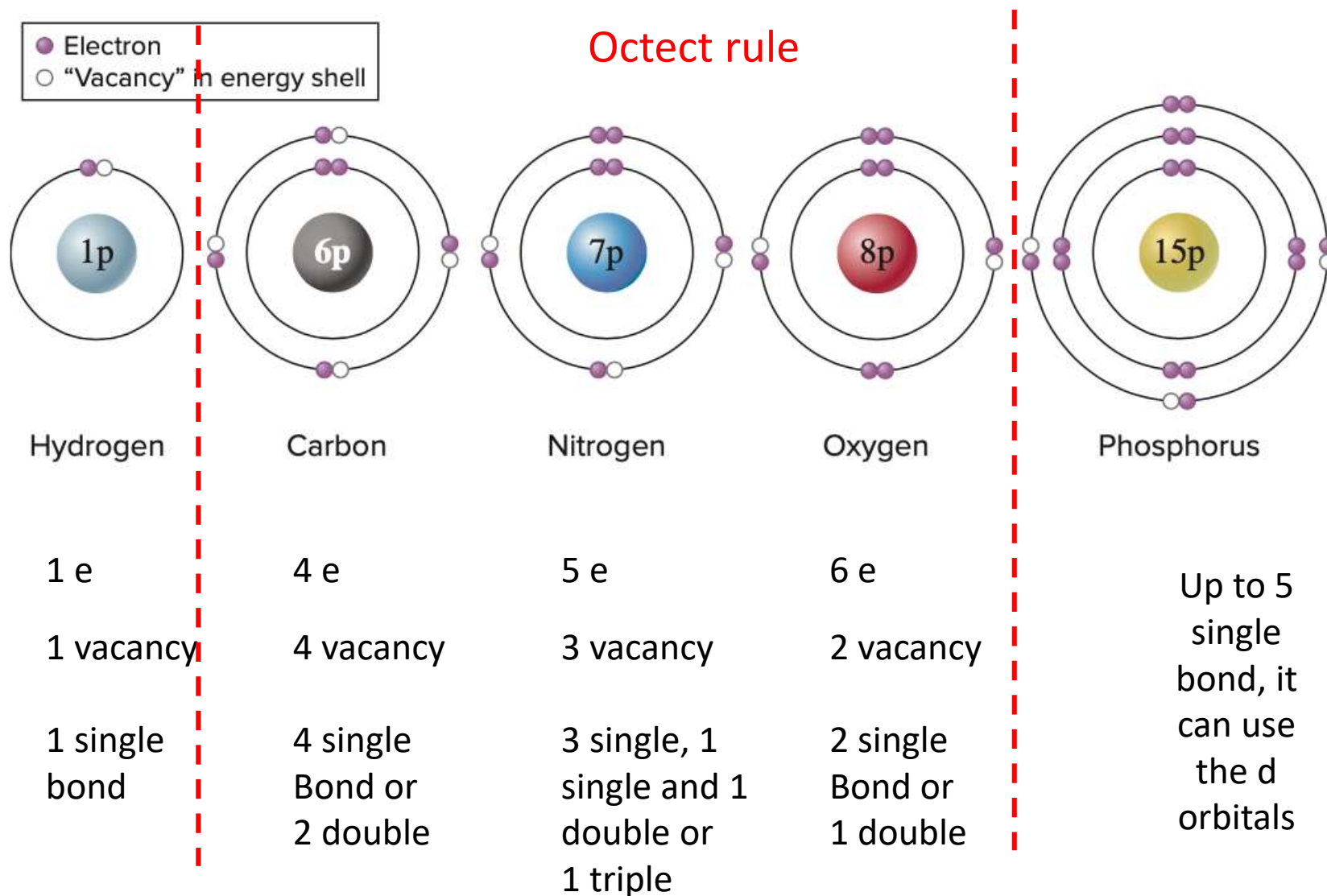


Valence Shell

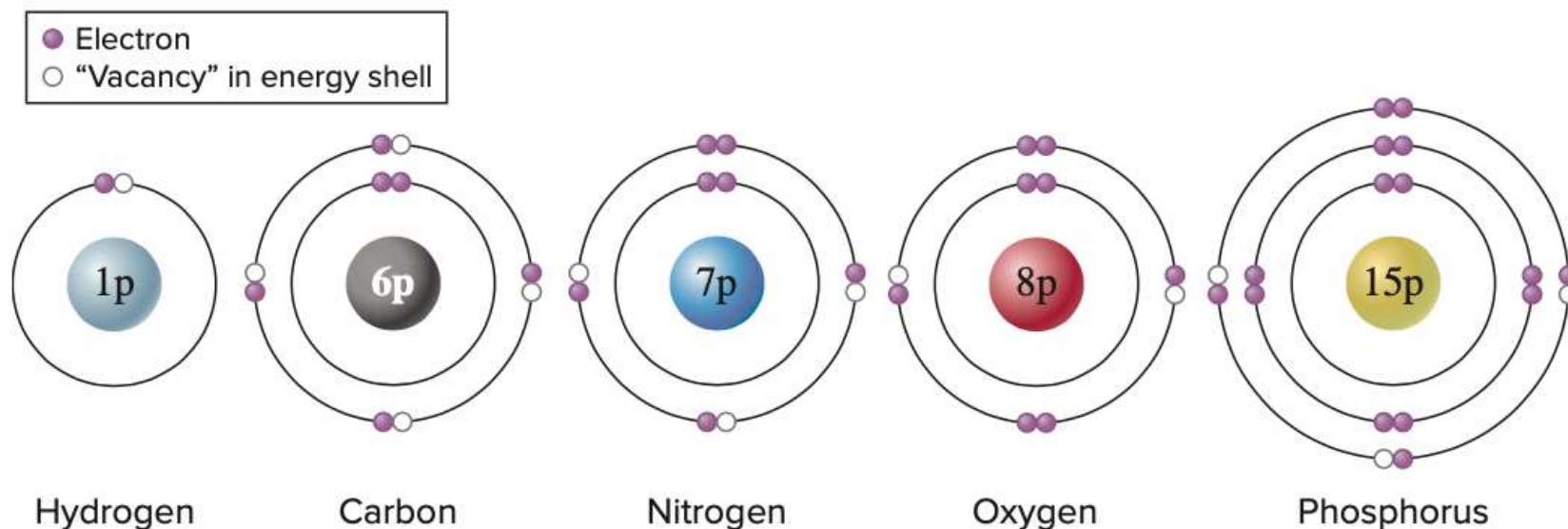
The valence shell can be easily found in the periodic table



Valence Shell



Valence Shell



1 e⁻

1 vacancy

1 single
bond

4 e⁻

4 vacancy

4 single
Bond or
2 double

5 e⁻

3 vacancy

3 single, 1
single and 1
double or
1 triple

6 e⁻

2 vacancy

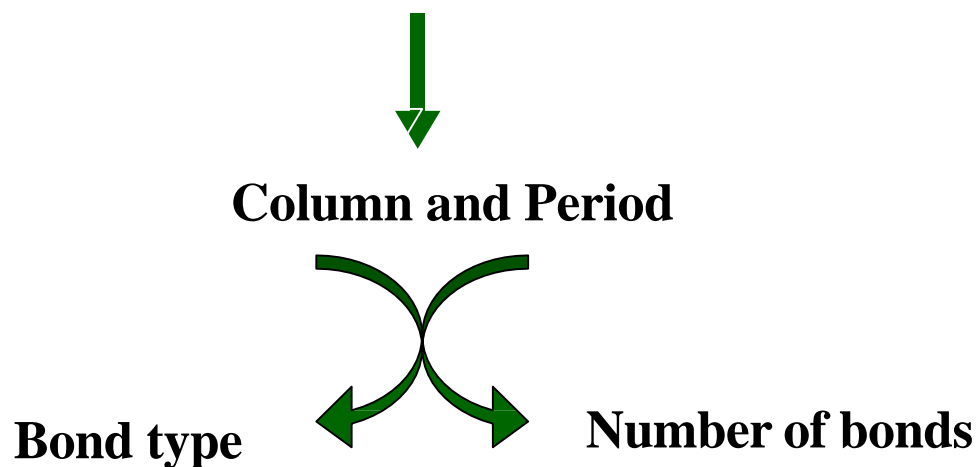
2 single
Bond or
1 double

Up to 5
single
bond, it
can use
the d
orbitals

Concepts of chemical bonds

The electronic structure of the element determines the bond type: only the electrons in the valence shell are involved.

Where the element is in the *Periodic Table*



Concepts of chemical bonds

Ionic



Metal + Non-metal

Electron transfer

Covalent



Non-Metal + Non-Metal

Electron sharing

Hydrogen 1																	Helium 2
Lithium 3	Beryllium 4											Boron 5	Carbon 6	Nitrogen 7	Oxygen 8	Fluorine 9	Neon 10
Sodium 11	Magnesium 12											Aluminium 13	Silicon 14	Phosphorus 15	Sulfur 16	Chlorine 17	Argon 18
Potassium 19	Calcium 20	Scandium 21	Titanium 22	Vanadium 23	Chromium 24	Manganese 25	Iron 26	Cobalt 27	Nickel 28	Copper 29	Zinc 30	Gallium 31	Germanium 32	Arsenic 33	Selenium 34	Bromine 35	Krypton 36
Rubidium 37	Strontium 38	Yttrium 39	Zirconium 40	Niobium 41	Molybdenum 42	Technetium 43	Ruthenium 44	Rhodium 45	Palladium 46	Silver 47	Cadmium 48	Indium 49	Tin 50	Antimony 51	Tellurium 52	Iodine 53	Xenon 54
Caesium 55	Barium 56	Lanthanides (Below)	Hafnium 72	Tantalum 73	Tungsten 74	Rhenium 75	Osmium 76	Iridium 77	Platinum 78	Gold 79	Mercury 80	Thallium 81	Lead 82	Bismuth 83	Polonium 84	Astatine 85	Radon 86
Francium 87	Radium 88	Actinides (Below)	Rutherfordium 104	Dubnium 105	Seaborgium 106	Bohrium 107	Hassium 108	Meitnerium 109	Darmstadtium 110	Roentgenium 111	Copernicium 112	Nihonium 113	Flerovium 114	Moscovium 115	Livermorium 116	Tennesse 117	Oganesson 118
			Lanthanum 57	Cerium 58	Praseodymium 59	Neodymium 60	Promethium 61	Samarium 62	Europium 63	Gadolinium 64	Terbium 65	Dysprosium 66	Holmium 67	Erbium 68	Thulium 69	Ytterbium 70	Lutetium 71
			Actinium 89	Thorium 90	Protactinium 91	Uranium 92	Neptunium 93	Plutonium 94	Americium 95	Curium 96	Berkelium 97	Californium 98	Einsteinium 99	Fermium 100	Mendelevium 101	Nobelium 102	Lawrencium 103

Ionic bond

Metal, column 1A, 2A and 3A → **lose** electrons = CATION (+)

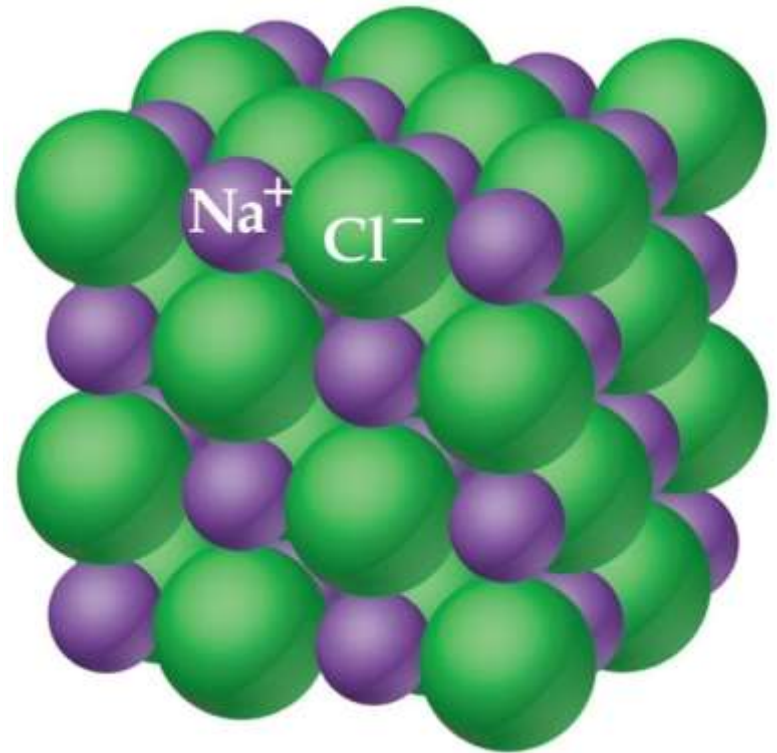
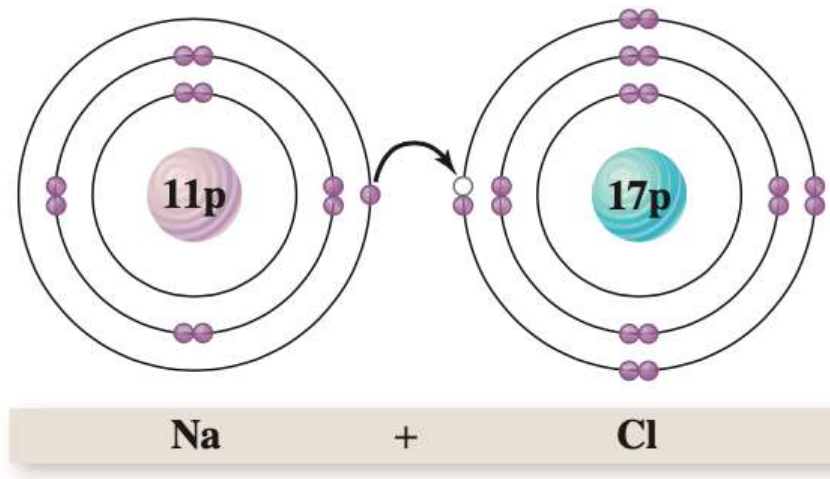
Non-metal, column 5A, 6A and 7A → **gain** electrons = ANION (-)

Metals										Non-metals					
1A	2A									3A	4A	5A	6A	7A	8A
H ⁺														H ⁻	He
Li ⁺												N ³⁻	O ²⁻	F ⁻	Ne
Na ⁺	Mg ²⁺	Metais de transição								Al ³⁺			S ²⁻	Cl ⁻	Ar
K ⁺	Ca ²⁺											Se ²⁻	Br ⁻	Kr	
Rb ⁺	Sr ²⁺											Te ²⁻	I ⁻	Xe	
Cs ⁺	Ba ²⁺													Rn	

Noble gas

Ionic bond

Ordered solids = ionic compounds or SALTS or Crystals

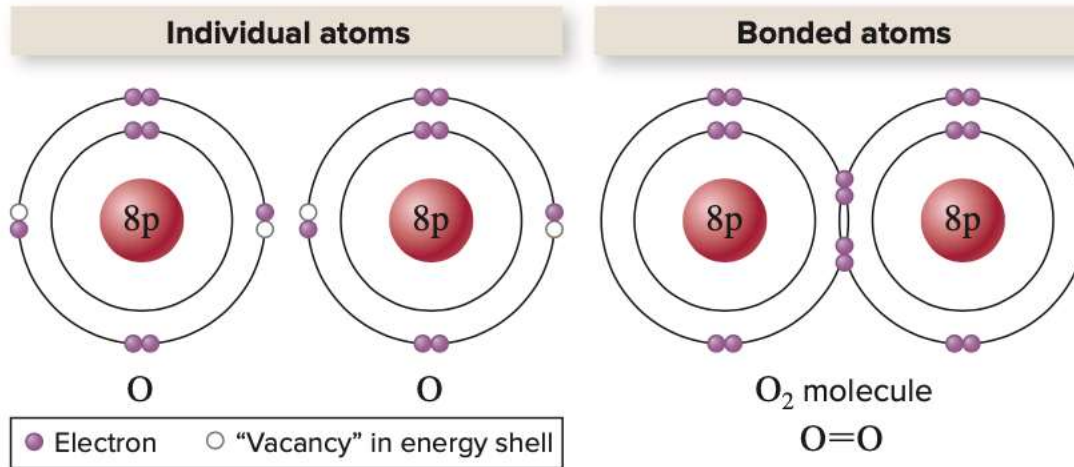


Ionic bond

Ionic solids typically have high melting temperature,
but they are fragile



Covalent bond



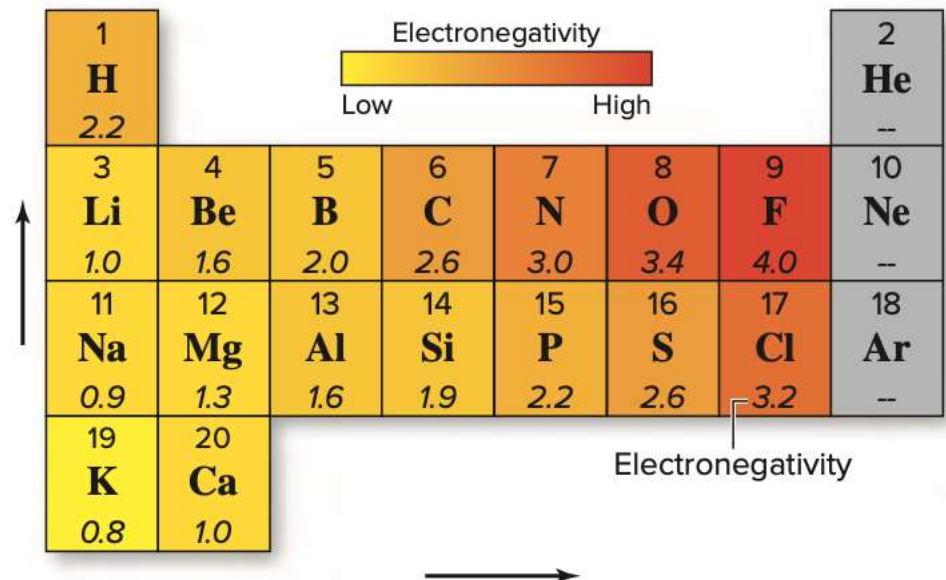
Electrons are shared

However, this is NOT
an equal sharing

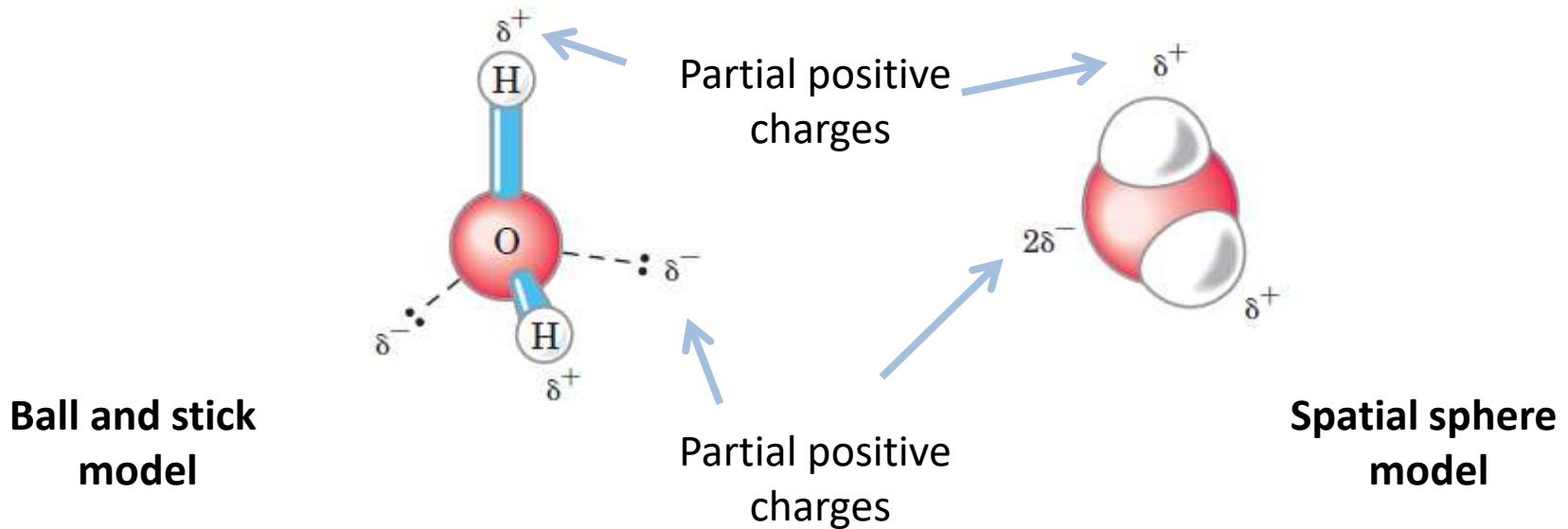
Atoms that are more
electronegative (like O, F and Cl)
keep the electron more close

They have a partial negative
charge

The others, a partial positive
charge



Water Molecule Structure

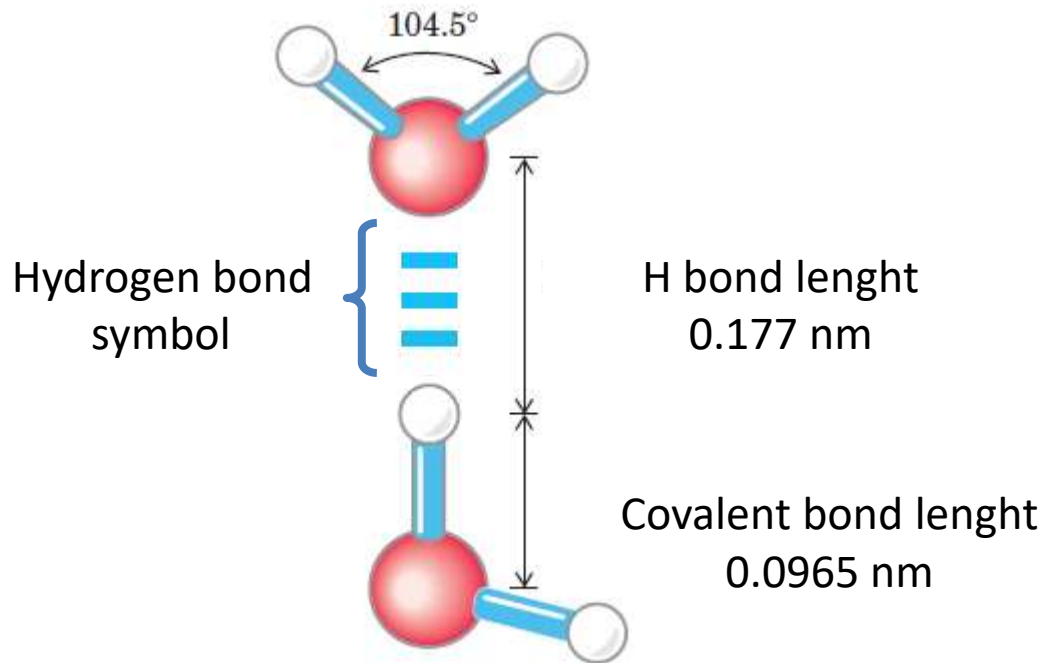


Oxygen is more electronegative than hydrogen and attracts more the shared electrons to itself. This uneven distribution creates partial charges



The molecule is **POLAR**

Hydrogen Bond



Atoms are further apart than in a covalent bond, so hydrogen bond is weaker.

However, the hydrogen bond allows all the special properties of water.

Water Properties

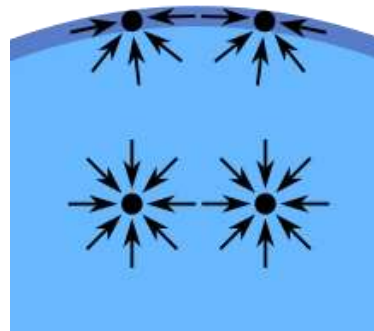
1. Cohesive force
2. Adhesive force
3. High boiling point
4. Lower solid density
5. Solvation power

Water Properties

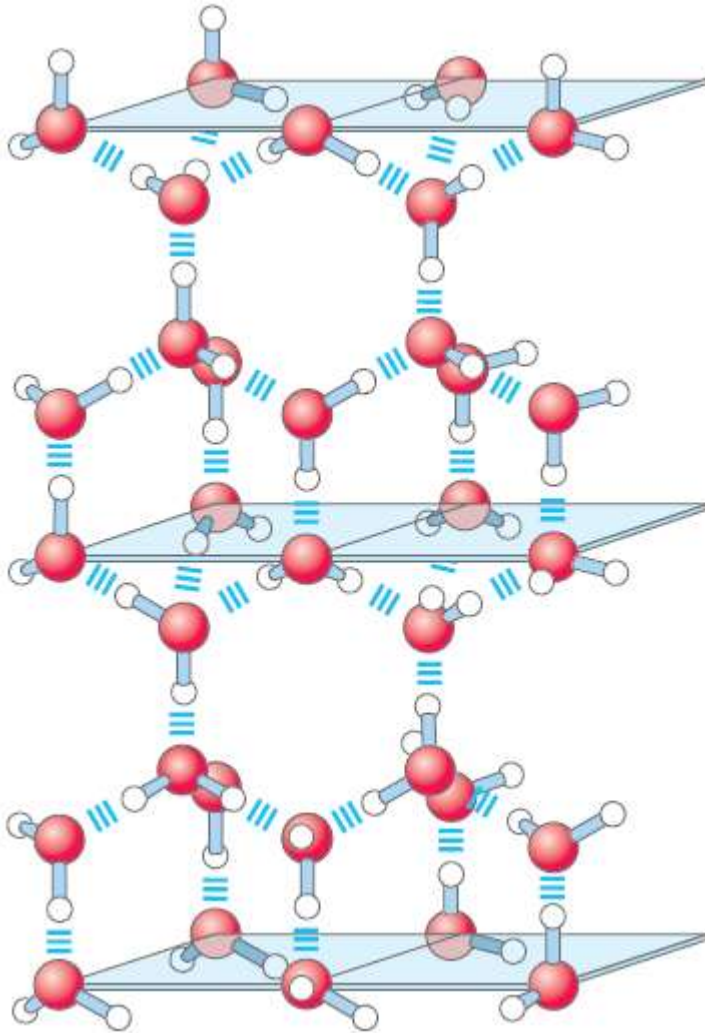
1. Cohesive force
2. Adhesive force

Outside molecules stick together, give higher surface resistance

↓
Surface Tension



Water Properties

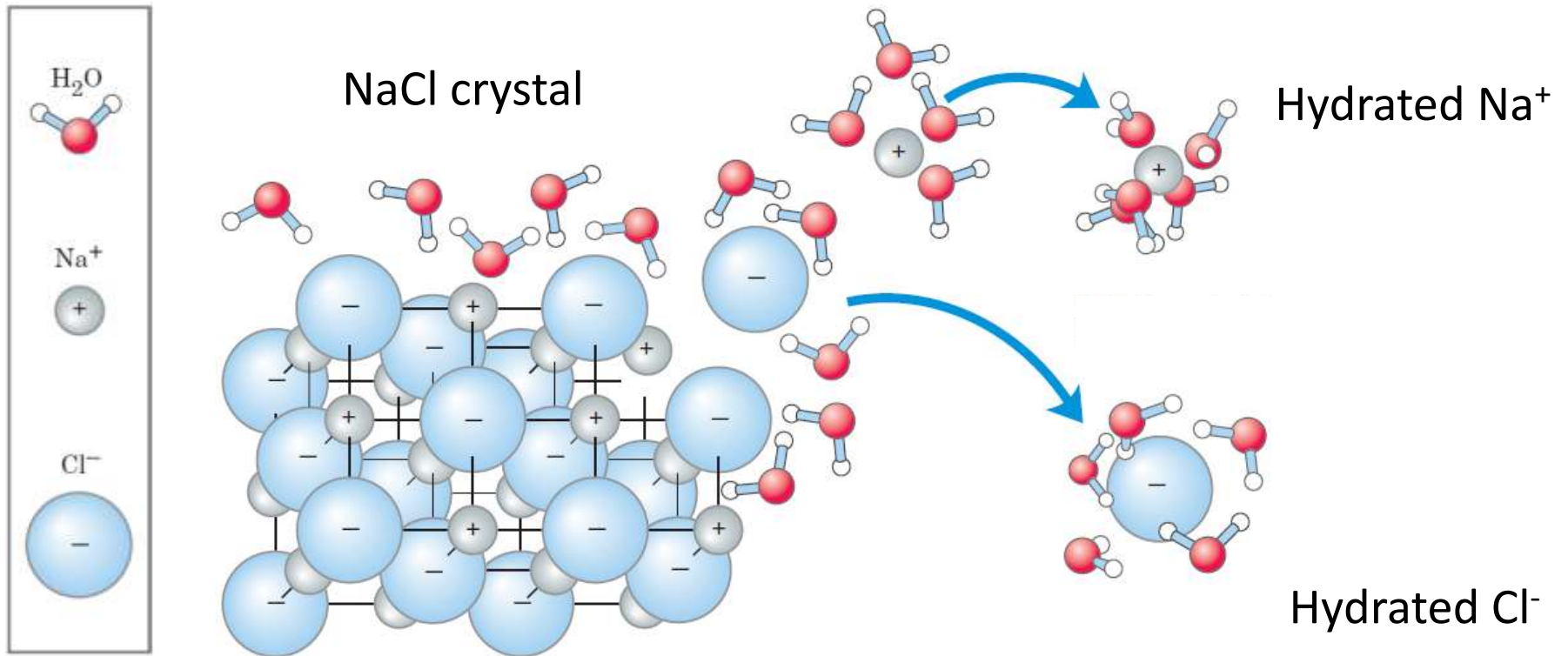


3. Lower solid density

Water molecules in ICE have 4 hydrogen bonds, organized in a tetrahedral formation

Ice expands → less dense than liquid water

Water Properties



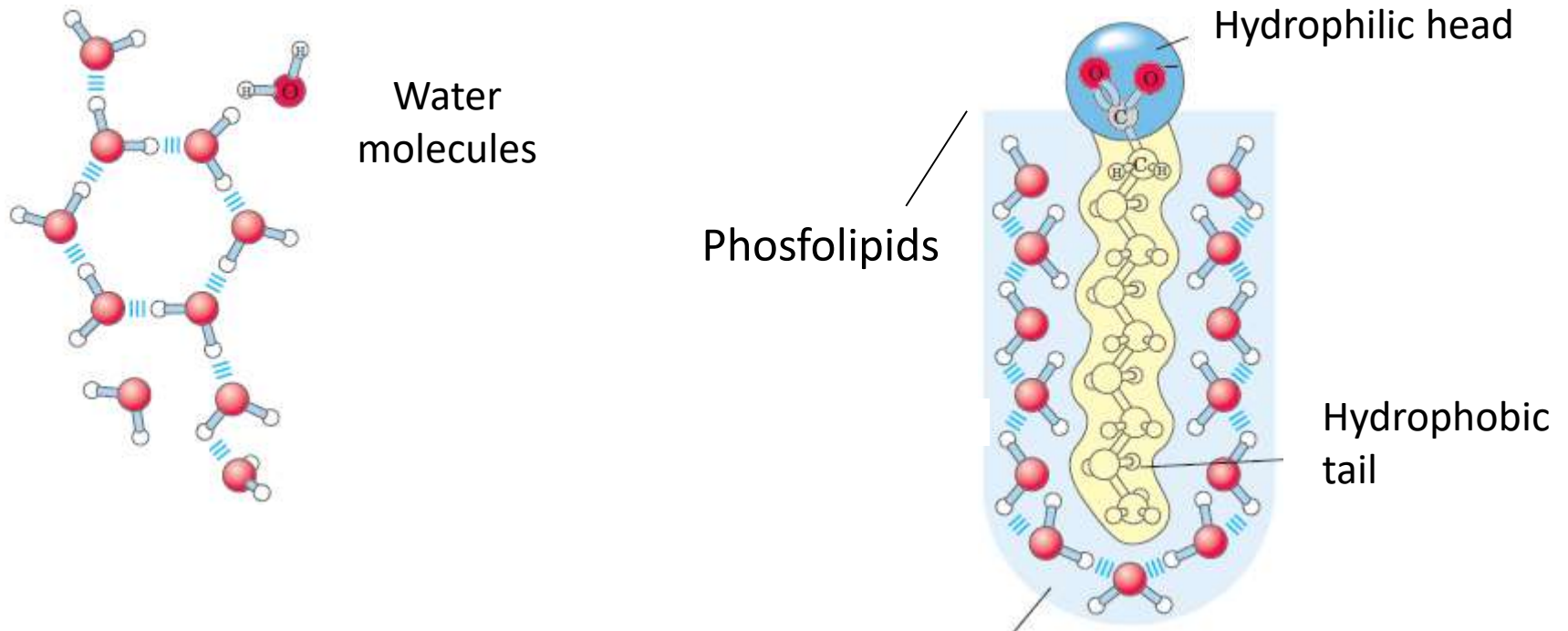
5. Solvation power:

A lot of water molecules can overcome the ionic bond and dissolve salts

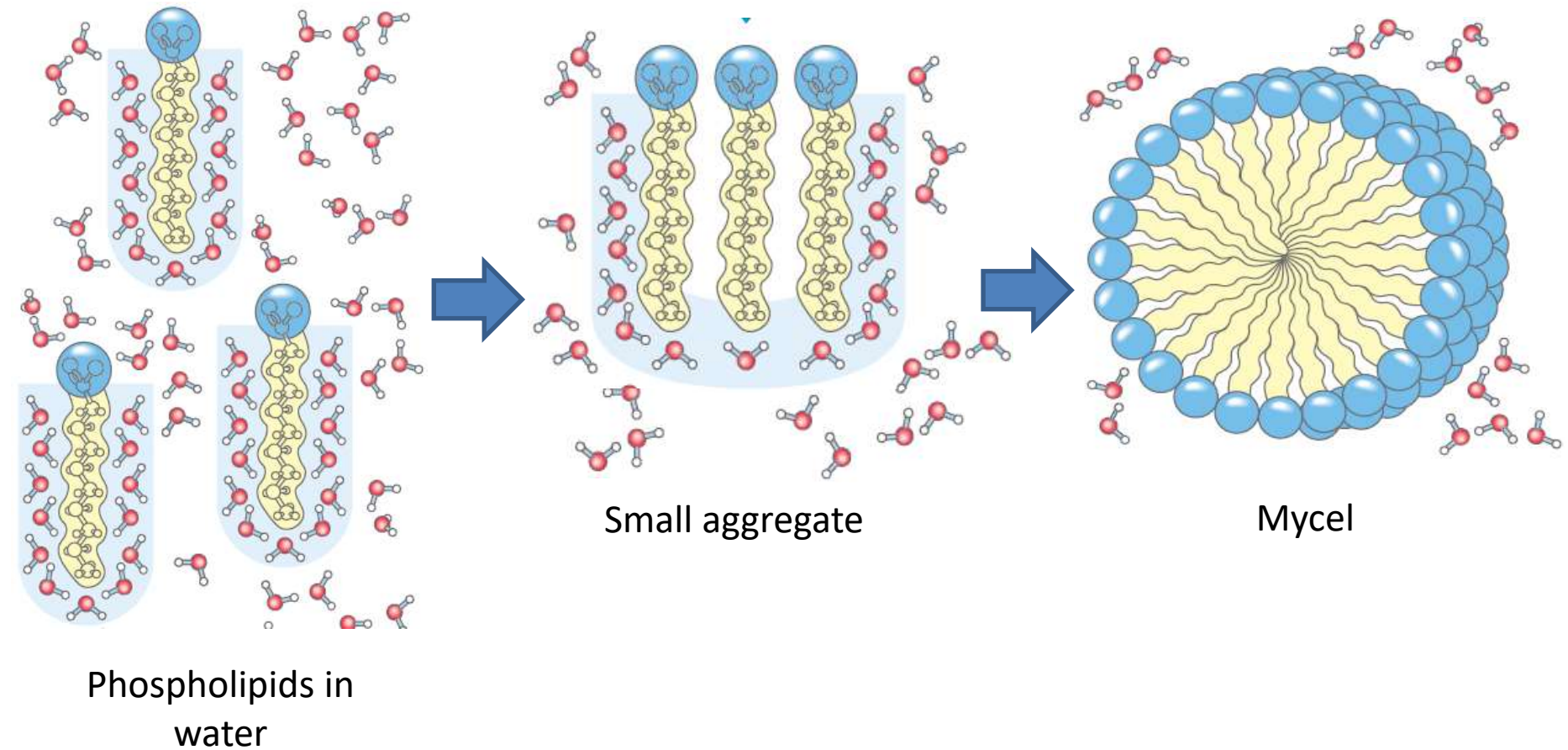
Polar or Apolar ?

Polar molecules interact between themselves and with water. They are called **HYDROPHILIC**.

Apolar molecules tend to separate from water (like oil): they are called **HYDROPHOBIC**.



Polar or Apolar ?



Phospholipids tends to aggregate in order to "escape" from water → membranes and mycelles are formed

pH Scale

Concentration of H^+ ions in water

To avoid scientific notation, due to small number, the pH Scale is actually a logarithmic scale

p : means: “minus logarithm of...”

Ex.:

$$[H^+] = 1,0 \times 10^{-5}$$

$$\text{pH} = -\log [H^+] = -\log [10^{-5}] = +5$$

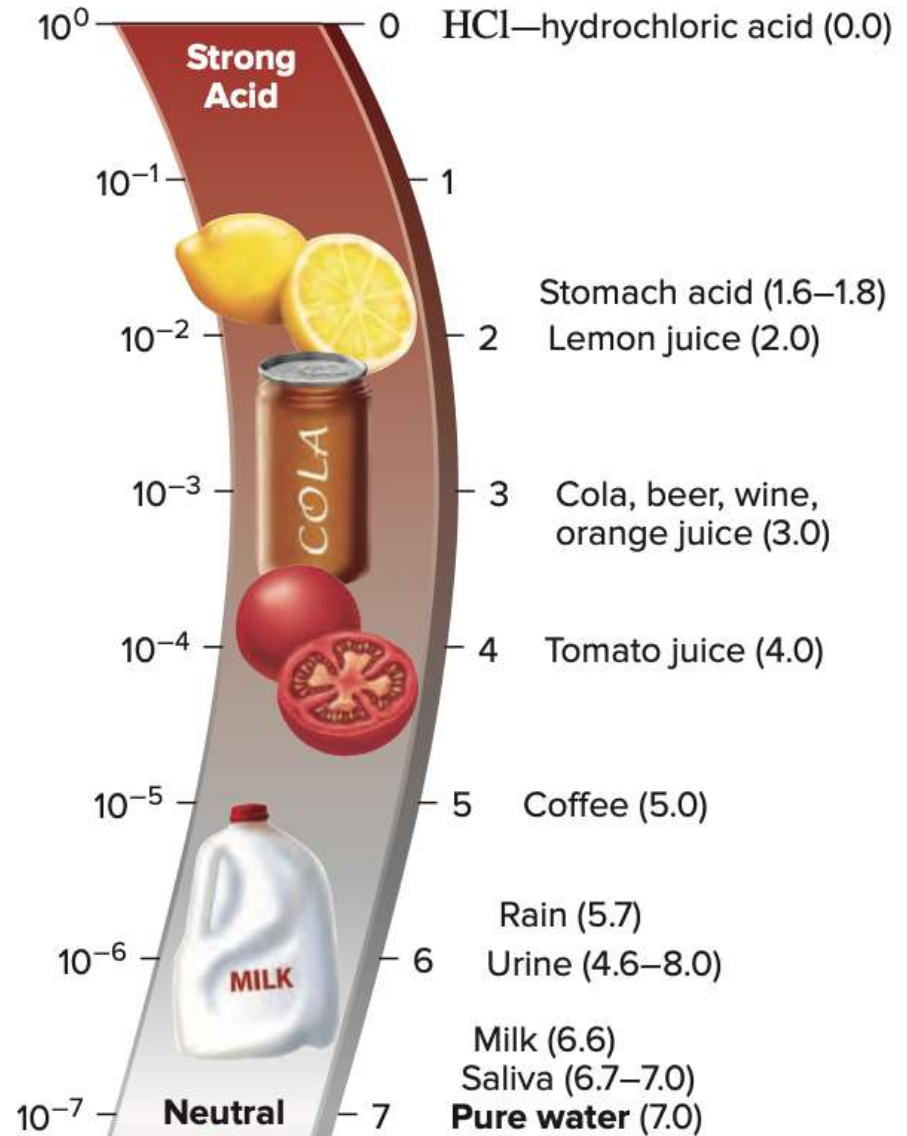
pH is negative logarithm of H^+ concentration

pH Scale

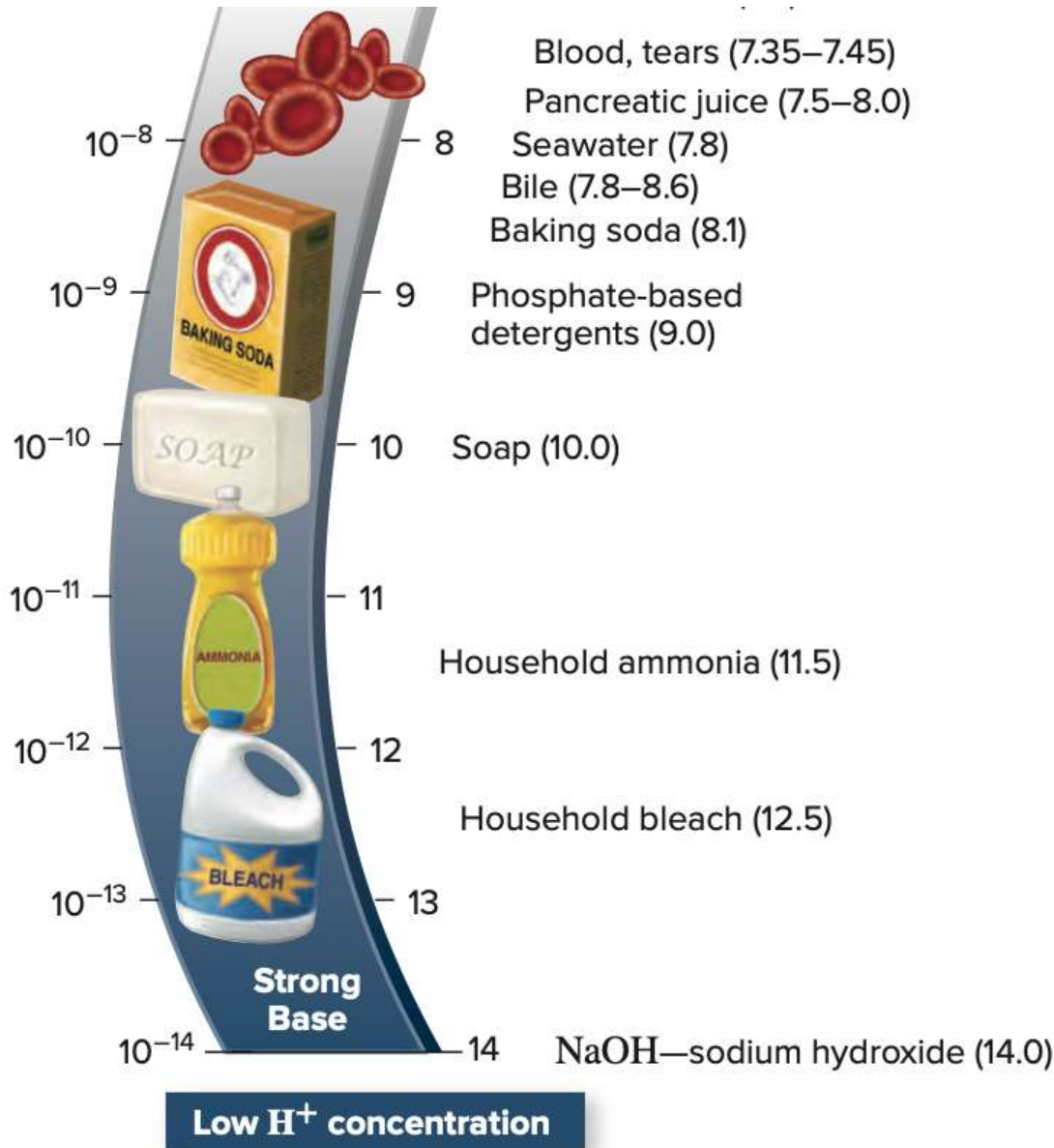
Acidic solution:

$$0 < \text{pH} < 7$$

An acid molecule
generate H^+ ions, like HCl



pH Scale



Basic solution:

$$7 < \text{pH} < 14$$

A basic molecule
generate OH⁻ ions, like
NaOH



pH Scale

Neutral solution: $\text{pH} = 7$

Pure water is neutral

$$[\text{H}^+] = [\text{OH}^-]$$

pH Scale

Neutral solution:

$$\text{pH} = 7$$

Pure water is neutral

$$[\text{H}^+] = [\text{OH}^-]$$

OBSERVATIONS

✓ $[\text{H}^+] \times [\text{OH}^-]$ is always
equal to 10^{-14}

✓ **pH + pOH is always equal
to 14**