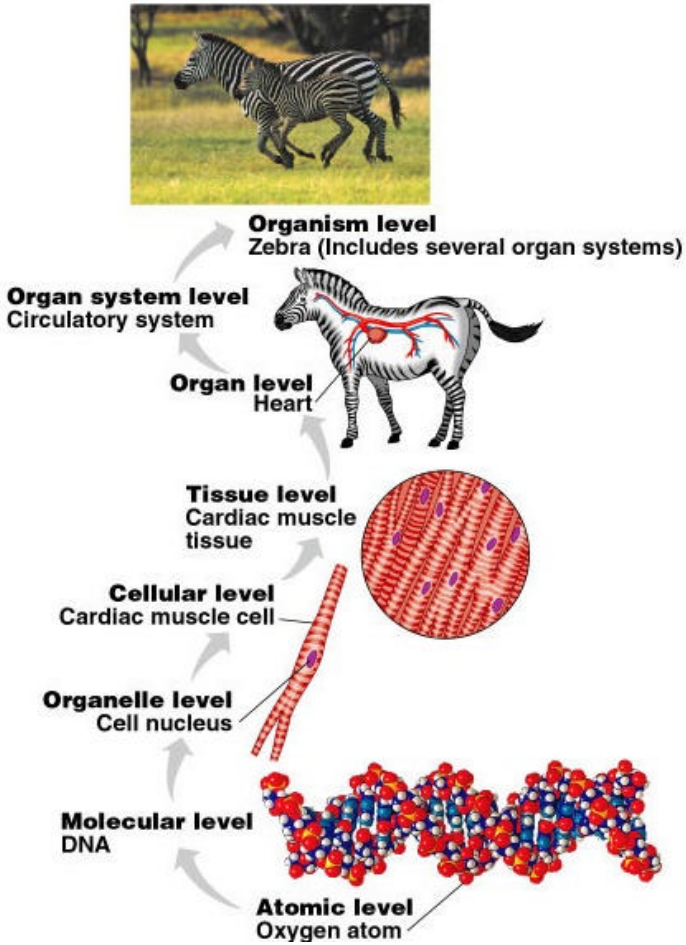
What Is Chemistry to Life?

Shared Characteristics of Life

Living organisms are organized in a certain fashion

- An organism is constituted by several organ systems
- Organ systems include several organs
- Organs are made of different tissues
- A tissue is an arrangement of cells
- Cell parts are made of macromolecules
- Macromolecules are atomic arrangements



What is an Atom?

- An atom is the smallest unit of *matter* that is unique to a particular *element*
- Matter refers to anything that occupies space and has a *mass;* it is made of the 92 naturally occurring elements
- Elements are fundamental substances that cannot be broken down to a different substance

Naturally Occurring Elements in the Human Body

Why these elements?

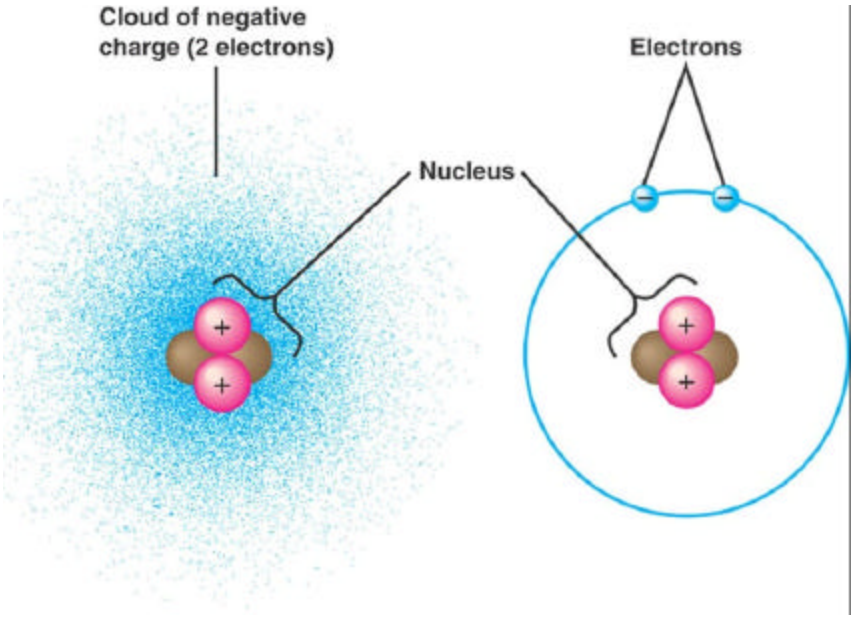
Table 2.1 Naturally Occurring Elements in the Human Body

Symbol	Element	Atomic Number (See p. 34)	Percentage of Human Body Weight
O	Oxygen	8	65.0
C	Carbon	6	18.5
H	Hydrogen	1	9.5
N	Nitrogen	7	3.3
Ca	Calcium	20	1.5
P	Phosphorus	15	1.0
K	Potassium	19	0.4
S	Sulfur	16	0.3
Na	Sodium	11	0.2
Cl	Chlorine	17	0.2
Mg	Magnesium	12	0.1

Trace elements (less than 0.01%): boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).

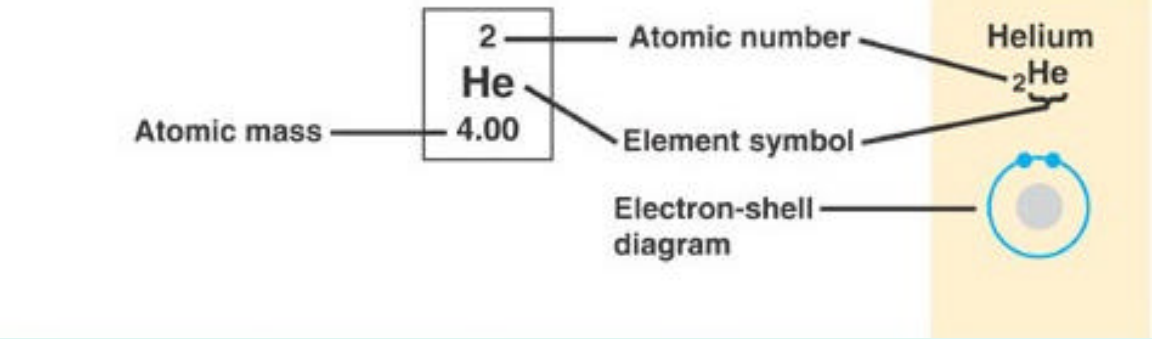
How is an Atom Structured?

- Atoms are constituted by a certain number of *subatomic particles (electrons, neutrons, and protons)*
- Electrons are negatively charged and move around the nucleus
- Protons (positively charged) and neutrons (no net charge) are located at the core region — *the atom's nucleus*
- Atoms are electrically neutral (# protons = # electrons)
- ***Atomic Number*** refers to the number of protons in the nucleus
- ***Atomic Mass*** refers to the number of protons and neutrons in the nucleus



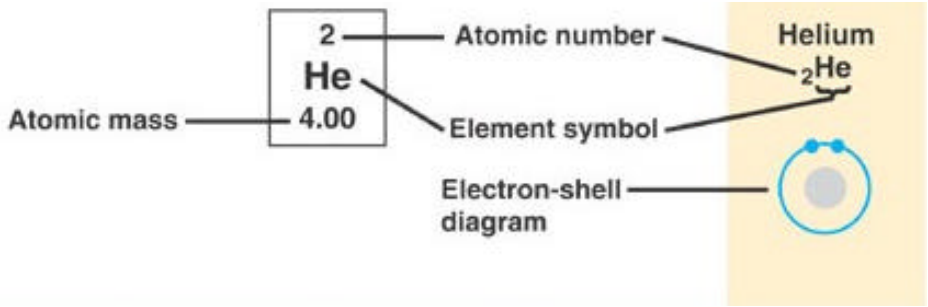
Bohr's Atomic Model

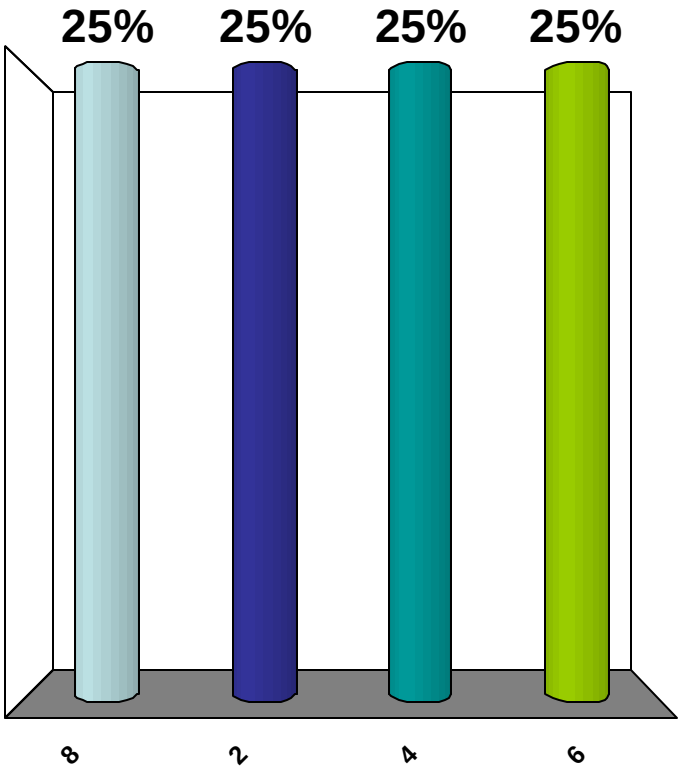
Atomic Number and Atomic Mass



Helium has __ electrons.

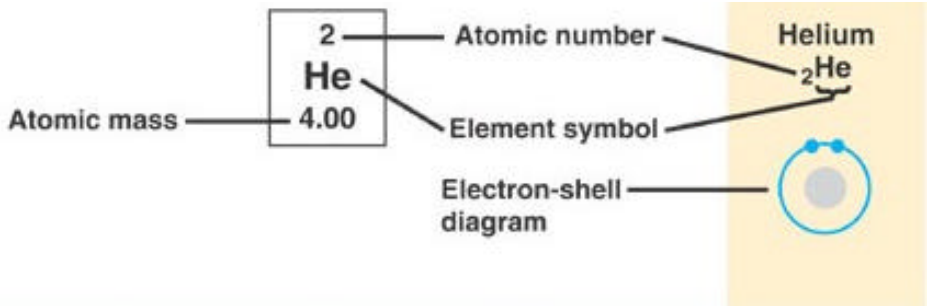
1. 8
2. 2
3. 4
4. 6

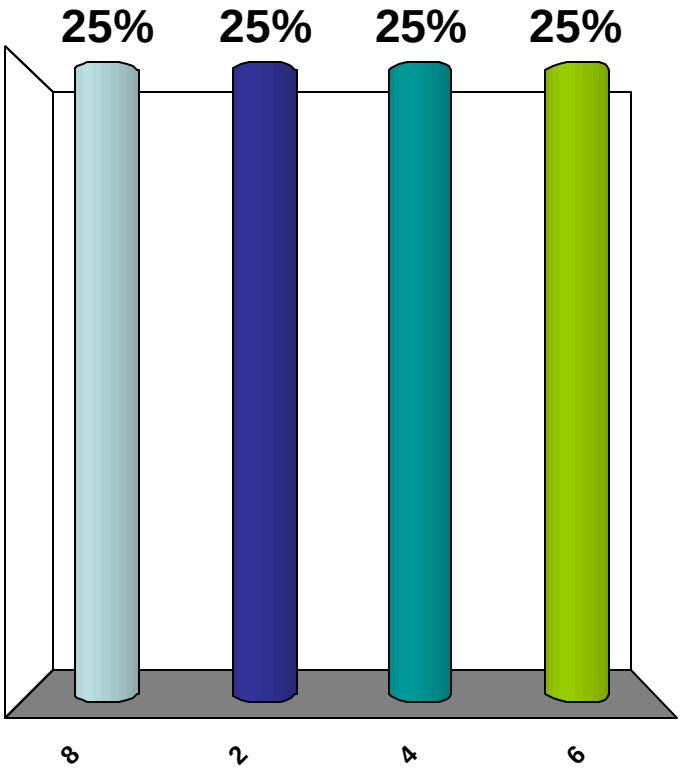




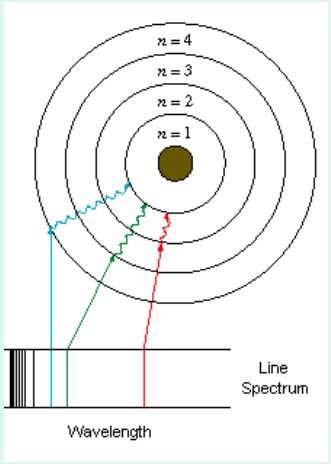
Helium has __ neutrons.

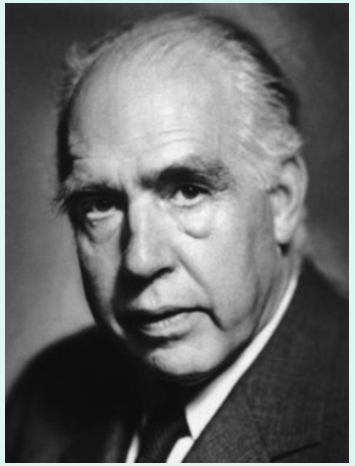
1. 8
2. 2
3. 4
4. 6





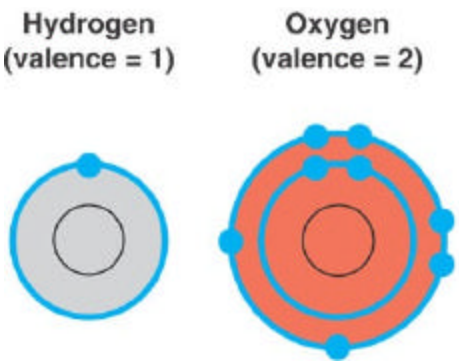
Borh's Atomic Theory



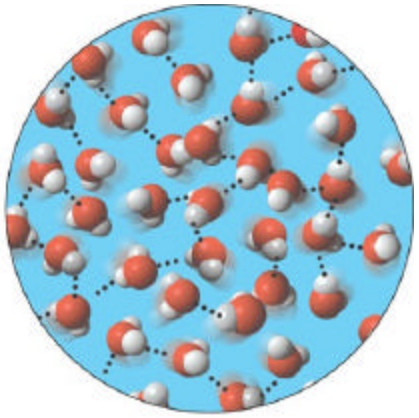


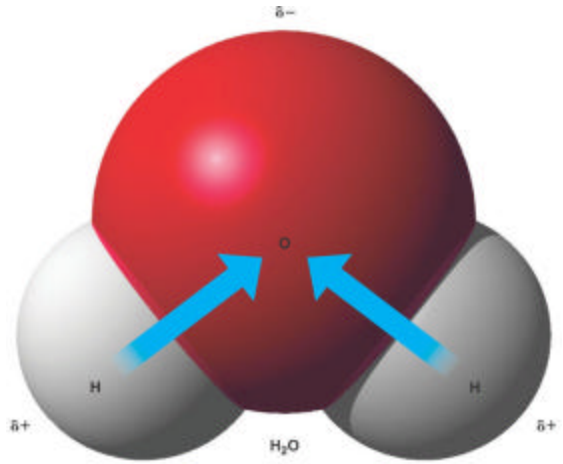
Niels Bohr

How is Matter Organized?
Atoms, Molecules, and Compounds



Atom: ***The smallest unit of matter***


Liquid water

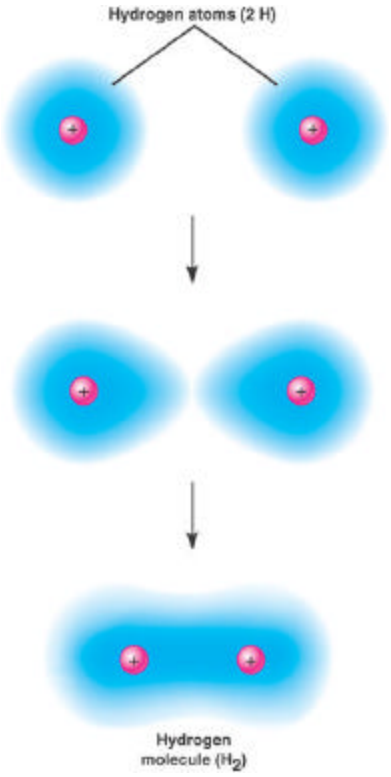


Molecule: ***A Bonded unit of two or more – same or different - atoms***

Compound: ***A substance in which the relative proportions of two or more elements never vary***

How Do Atoms Make Molecules?

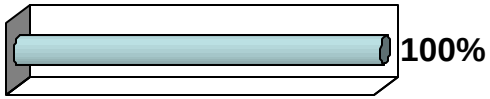
- Atoms make molecules because *chemical bonds* occur
- A chemical bond is a union between atoms that occurs when atoms give up, gain, or share electrons
- Whether an atom will bond to another atom depends upon both the number the number an arrangement of its electrons, and on the *bond distance*
- Electrons in an atom are neither uniformly distributed around the nucleus nor randomly. They are attracted to the atom's nucleus and repelled by other electrons. Why?
- Electrons move in different *orbitals*



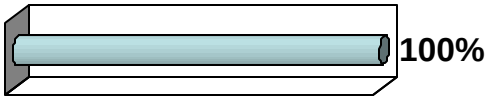
Bond Distance

Electrons in an atom are neither uniformly distributed around the nucleus nor randomly. They are attracted to the atom's nucleus and repelled by other electrons. Why?

1. Because protons and neutrons repel them, and other electrons attract them



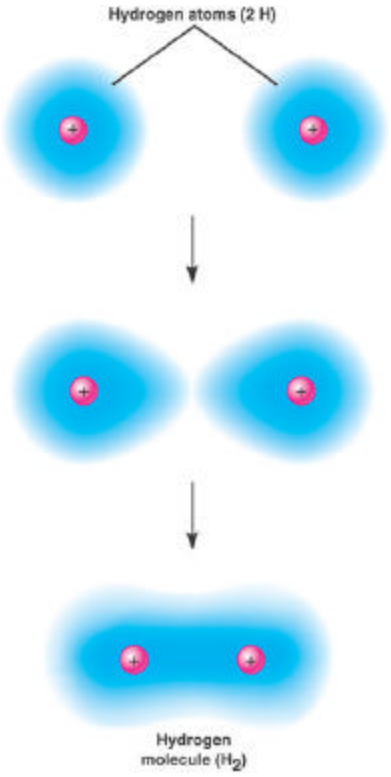
2. Because protons and neutrons attract them, and other electrons repel them



What is an Orbital?

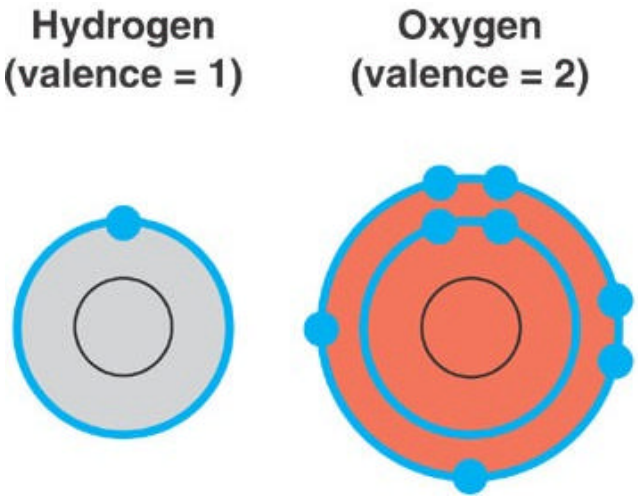
An orbital is a region of space around the atom's nucleus where electrons are likely to be found at any instant. A particular orbital allows space for ***two electrons at the most***

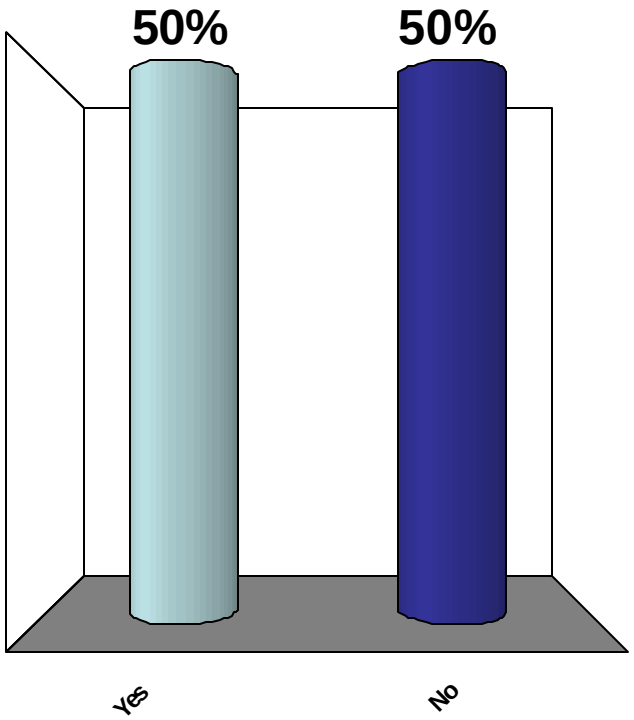
Orbitals with vacancy will be the reactive orbitals



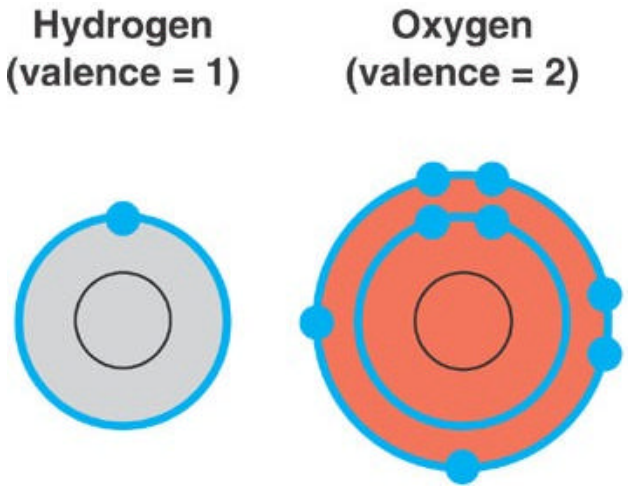
Two more electrons fit in the hydrogen's orbital. Do you agree?

1. Yes
2. No



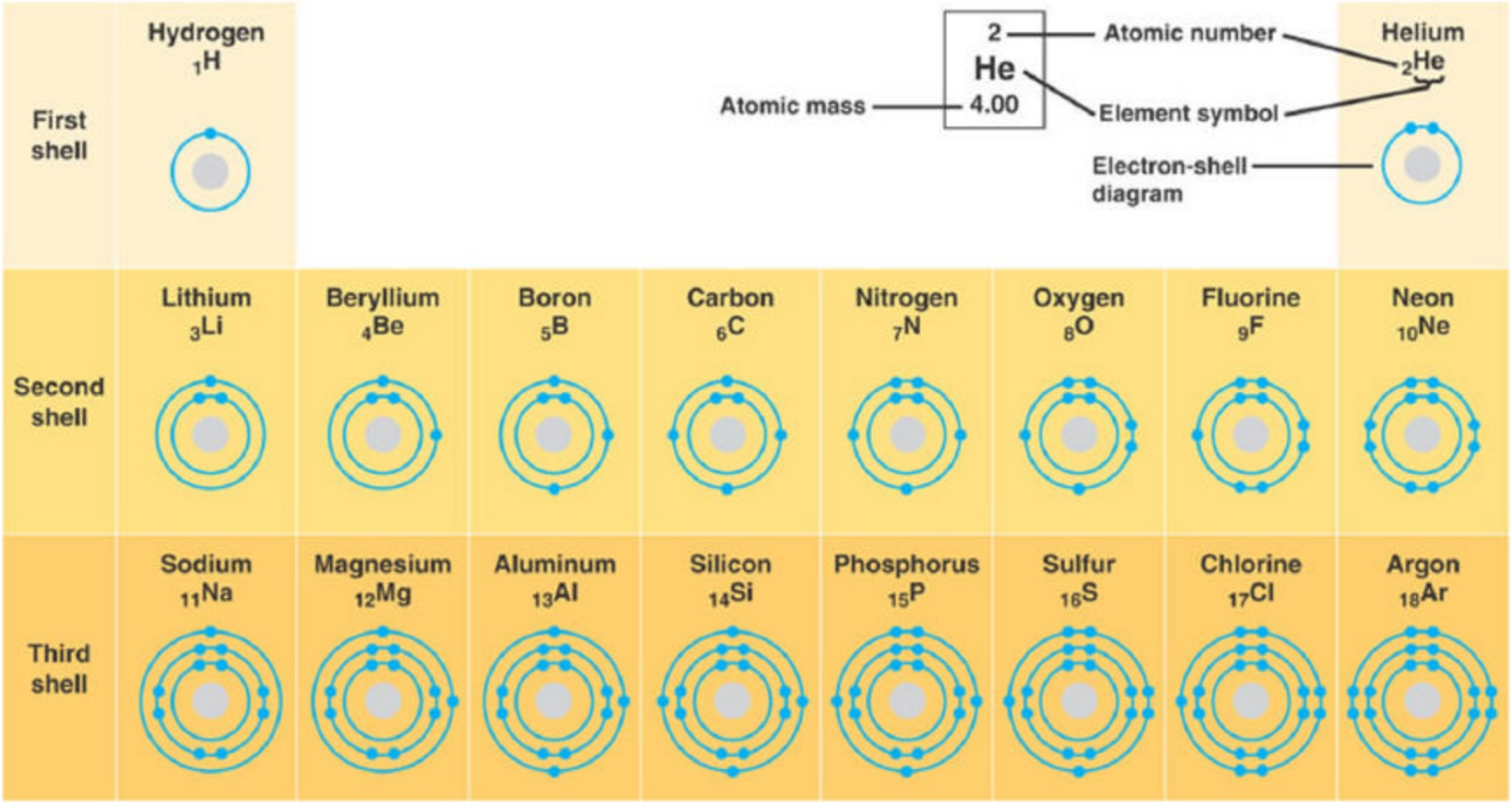


Simplified Atomic Models

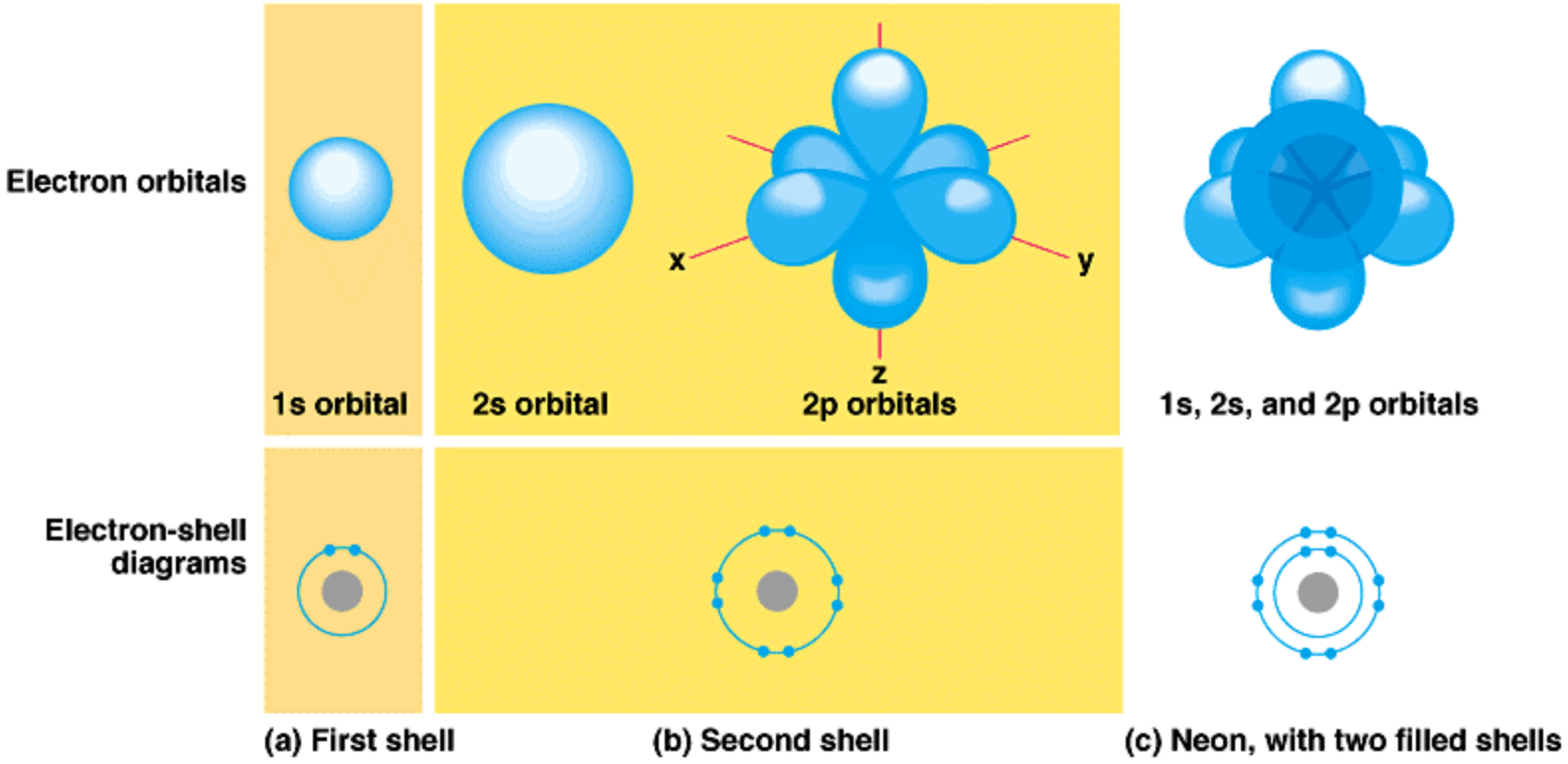


***Valence:* electron vacancy**

Simplified Atomic Model of The First 18 Elements



Orbitals and Shells



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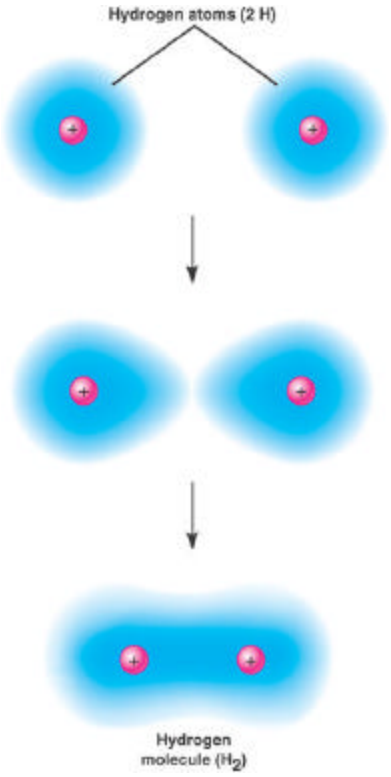
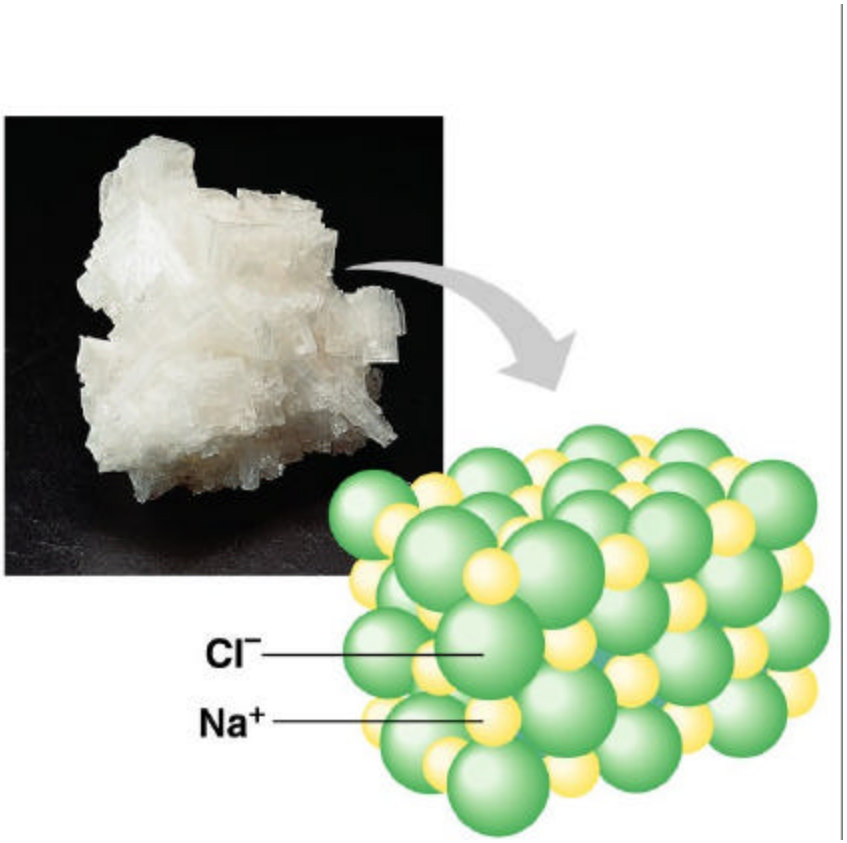
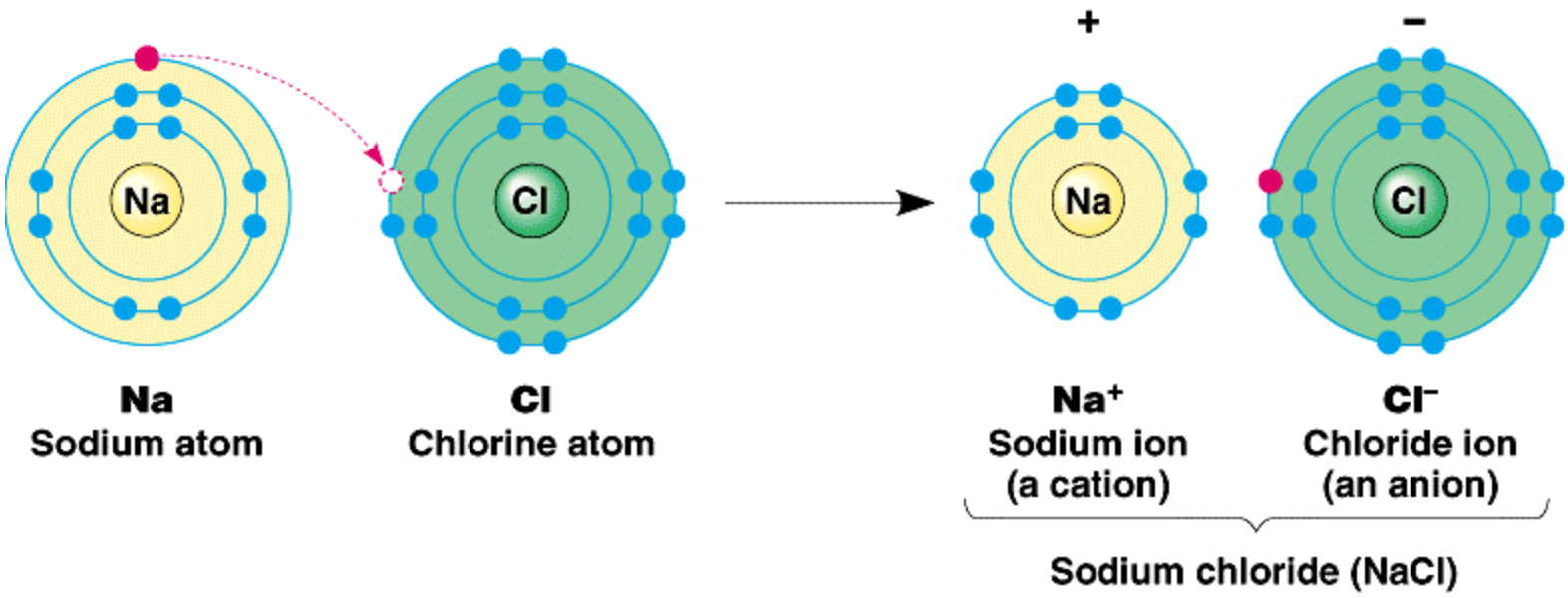


Chemical Bonds
Ionic Bonds

- An ionic bond is a chemical bond that occurs between two oppositely charged *ions*
- *Cations* are positively charged ions (i.e. Na^+)
- *Anions* are negatively charged ions (i.e. Cl^-)
- NaCl (or $Na^+ Cl^-$) represents an ionic bond
- Atoms joint by an ionic bond are referred to as *salts* or *ionic compounds*

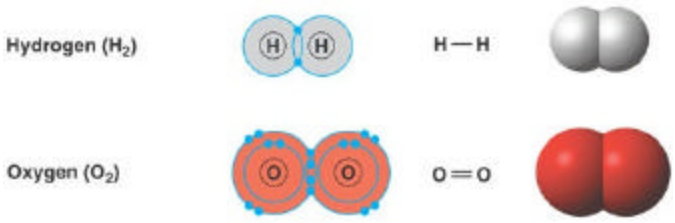


Chemical Bonds
Ionic Bonds



Chemical Bonds
Covalent Bonds

- Covalent bonds are high energy bonds. In a covalent bond, atoms share electrons
- In a *non-polar covalent bond*, shared electrons are evenly attracted to all of the atoms that constitute the bond (i.e. H_2)
- In a *polar covalent bond*, shared electrons are attracted unevenly (i.e. H_2O). Polar covalent bonds form *polar molecules*
- Atoms joint by covalent bonds are referred to as *molecules*

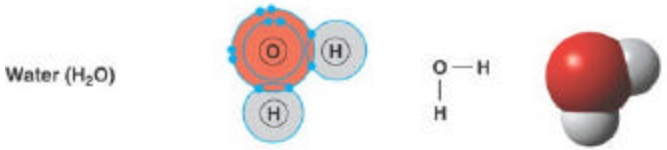


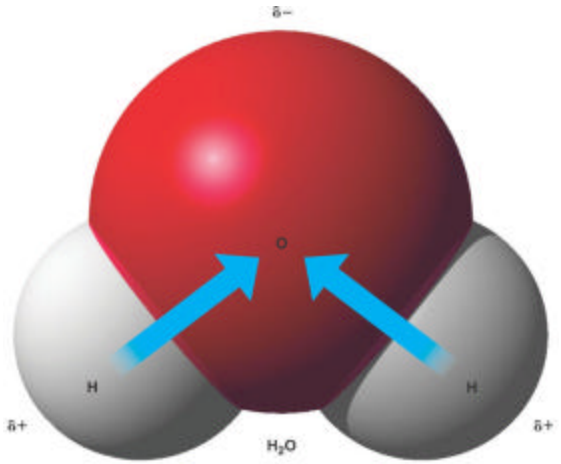
Non-polar covalent bonds

Polar covalent bond

Chemical Bonds
Polar Molecules

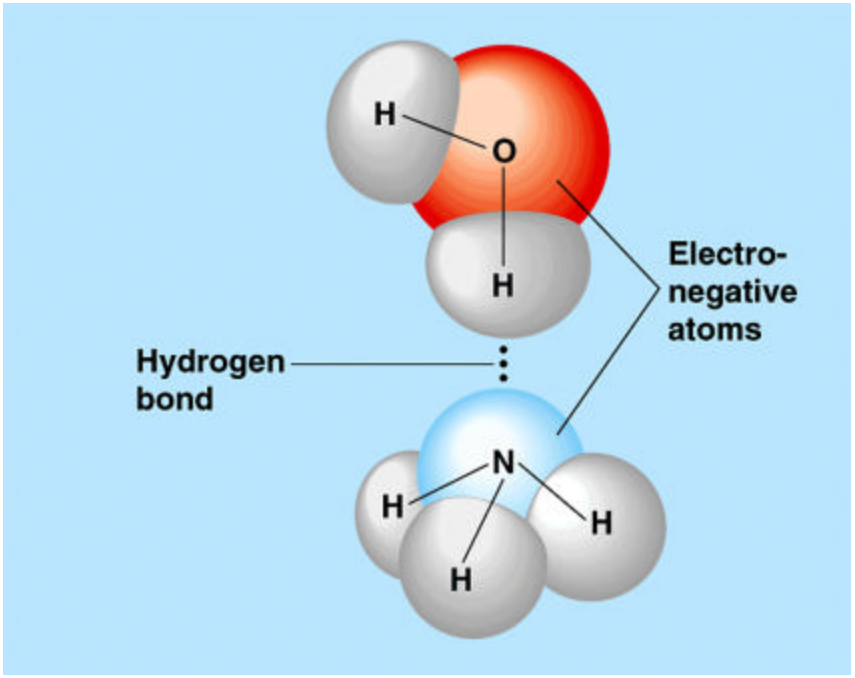
- Oxygen is more *electronegative* than hydrogen and pulls electrons more toward its nucleus
- This uneven pulling force results in a partial negative charge on the oxygen side (d^-, more electrons there for a longer time) and a partial positive charge on the hydrogen sides (d^+, less electrons there for a shorter period of time) — a polar molecule
- Electronegativity is the atom's ability to attract electrons





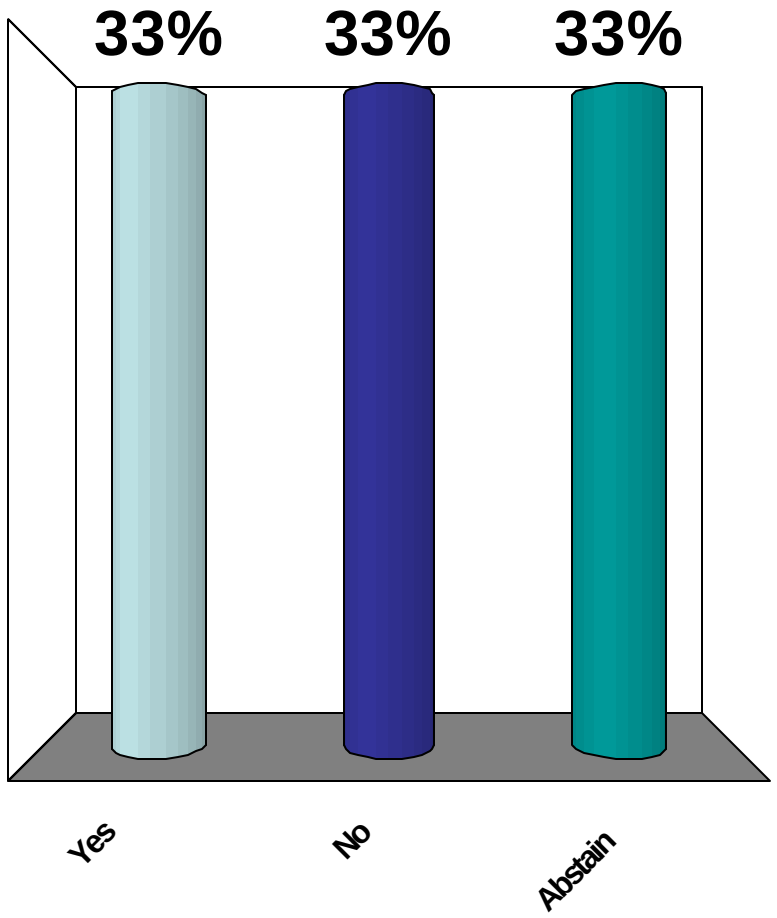
Chemical Bonds
Hydrogen Bonds

- In a hydrogen bond, an atom or molecule interacts weakly with one hydrogen atom already participating in a polar covalent bond
- Hydrogen bonds are represented by discontinuous lines
- Hydrogen bonds structure big macromolecules (i.e. DNA)



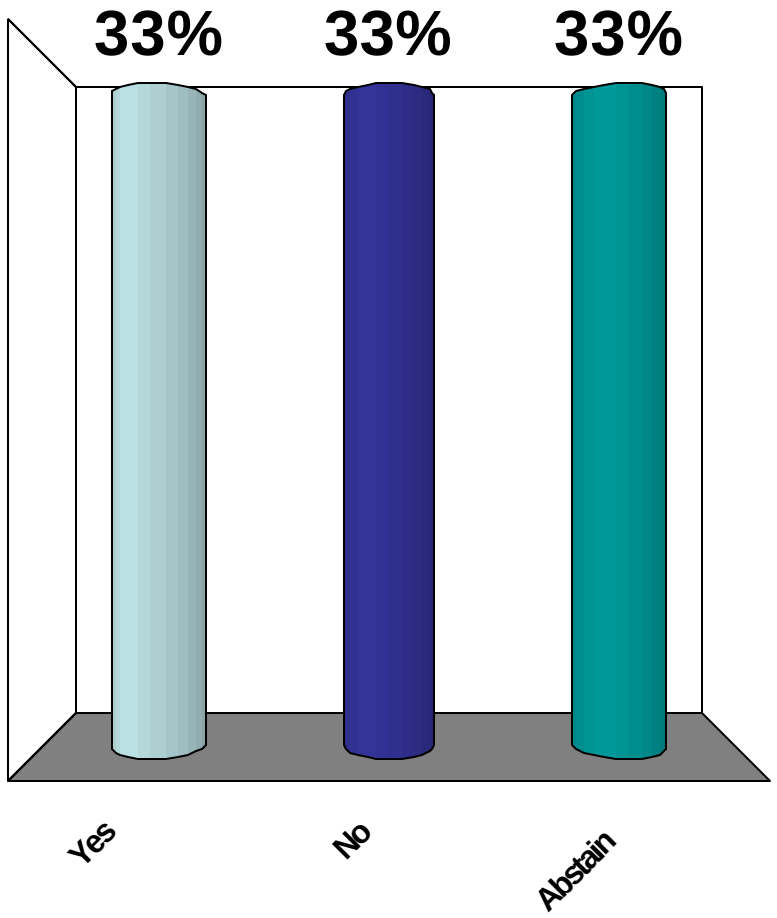
An ionic bond is a chemical bond sustained by the attraction between oppositely charged ions. Do you agree?

1. Yes
2. No
3. Abstain



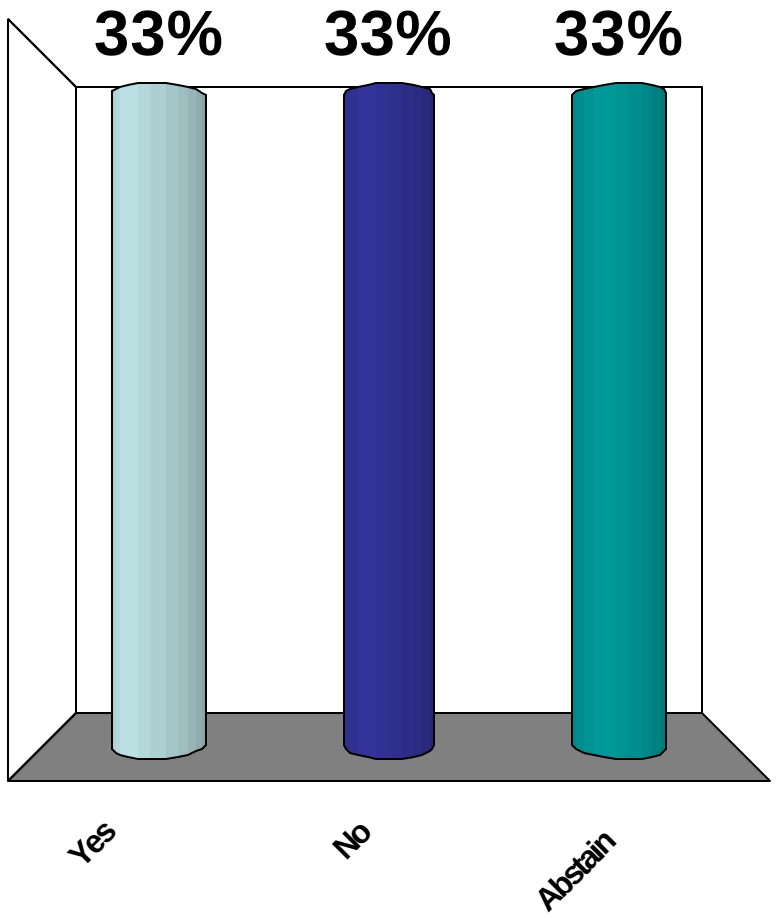
A covalent bond occurs when two or more atoms share electrons. Do you agree?

1. Yes
2. No
3. Abstain



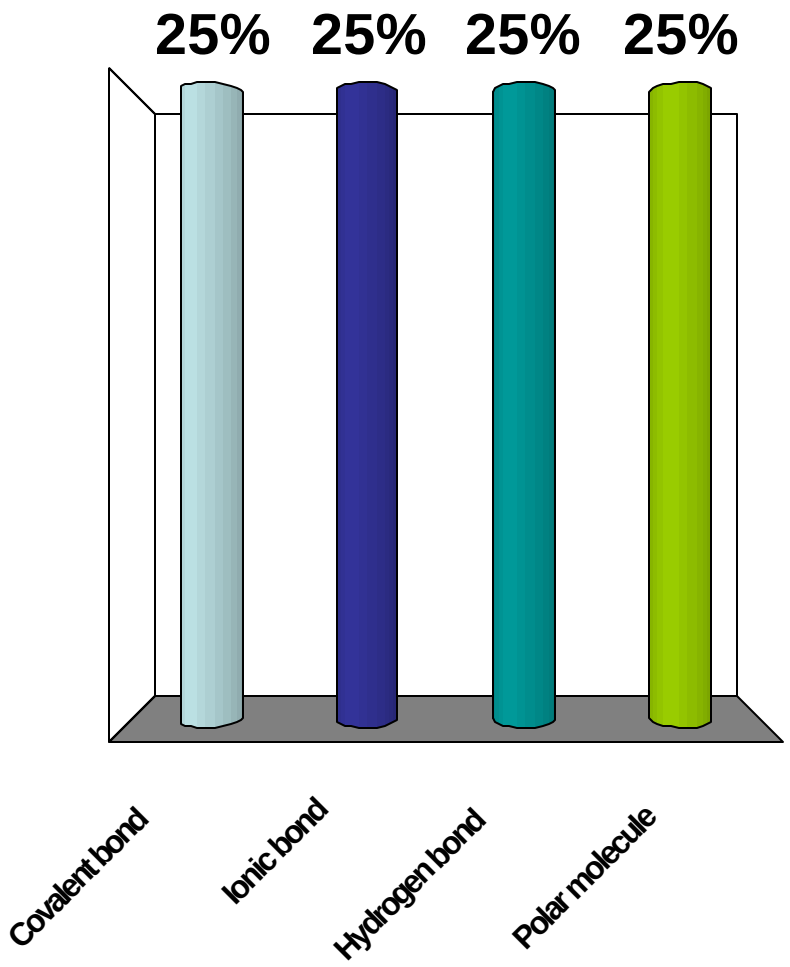
There is always an atom of hydrogen in a hydrogen bond. Do you agree?

1. Yes
2. No
3. Abstain

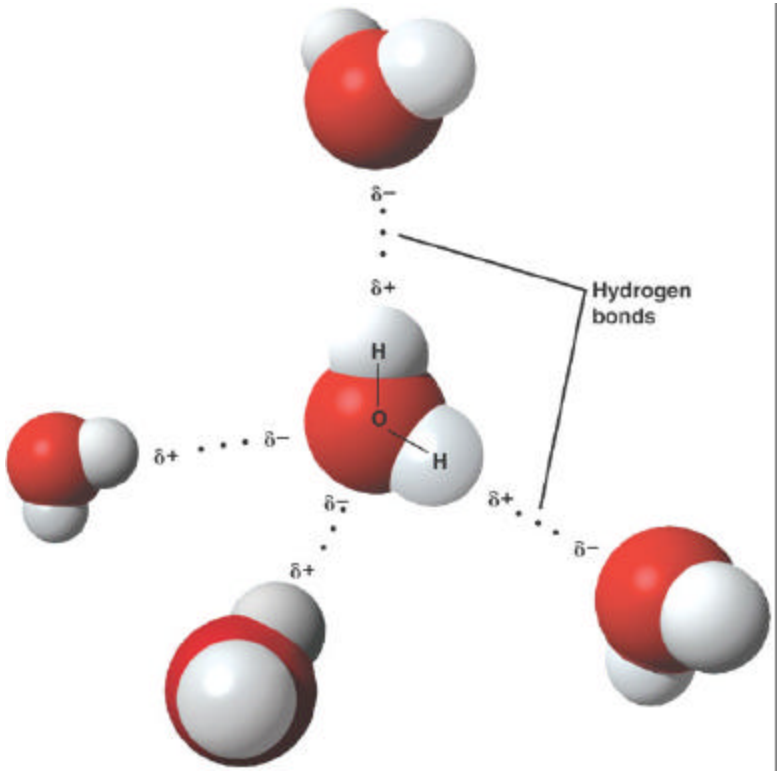


Na+ : cation :: Cl- : anion

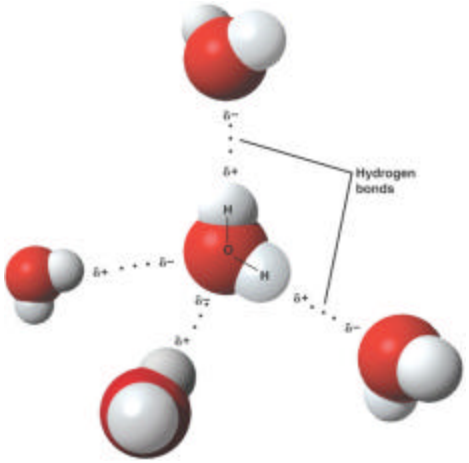
1. Covalent bond
2. Ionic bond
3. Hydrogen bond
4. Polar molecule

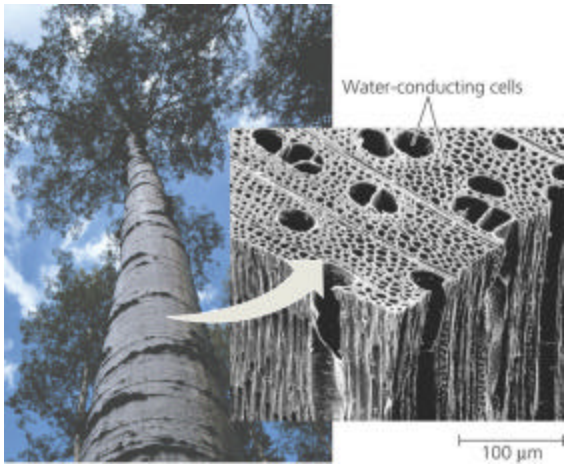


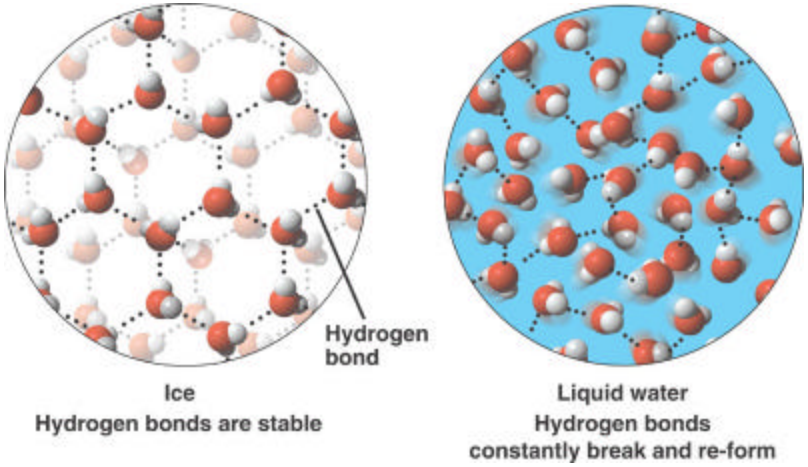
The Molecule of Water



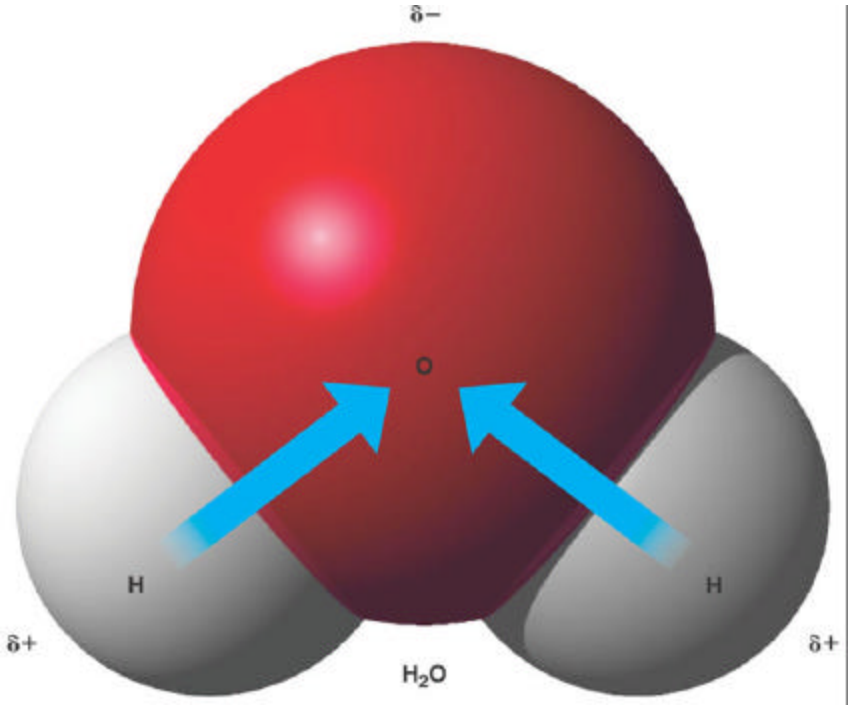
The Molecule of Water
Water is Cohesive

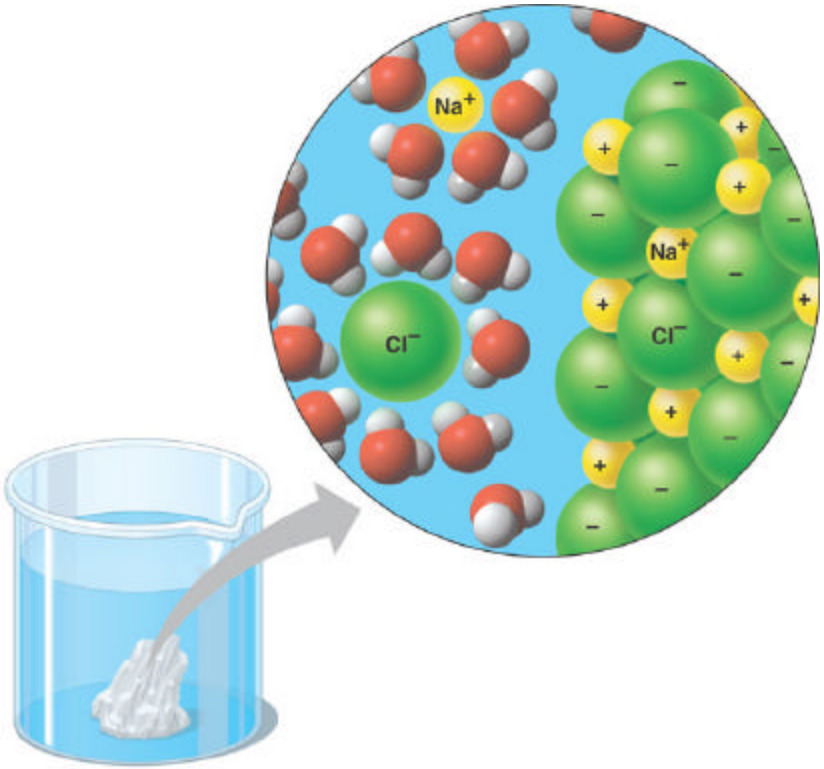






The Molecule of Water
“The Solvent of Life”

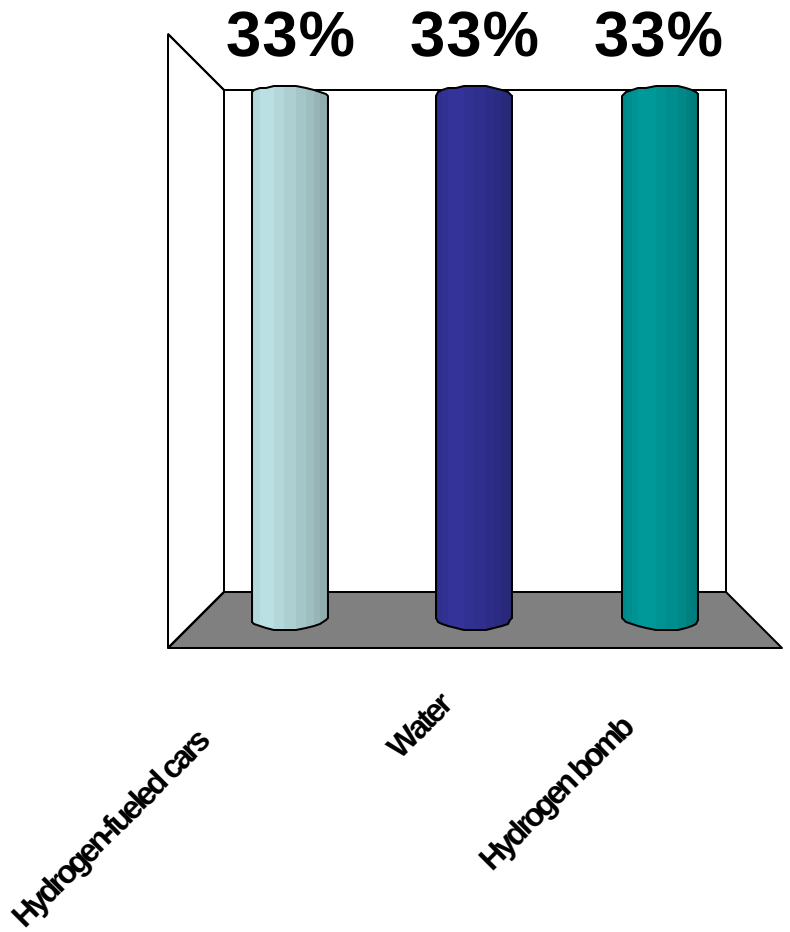




Dissociation of Salts

Hydrogen bonds : H and O :: polar molecule : universal solvent

1. Hydrogen-fueled cars
2. Water
3. Hydrogen bomb



Dissociation of Water and pH Scale