Unit 2: Origin and Level of Organization of Life

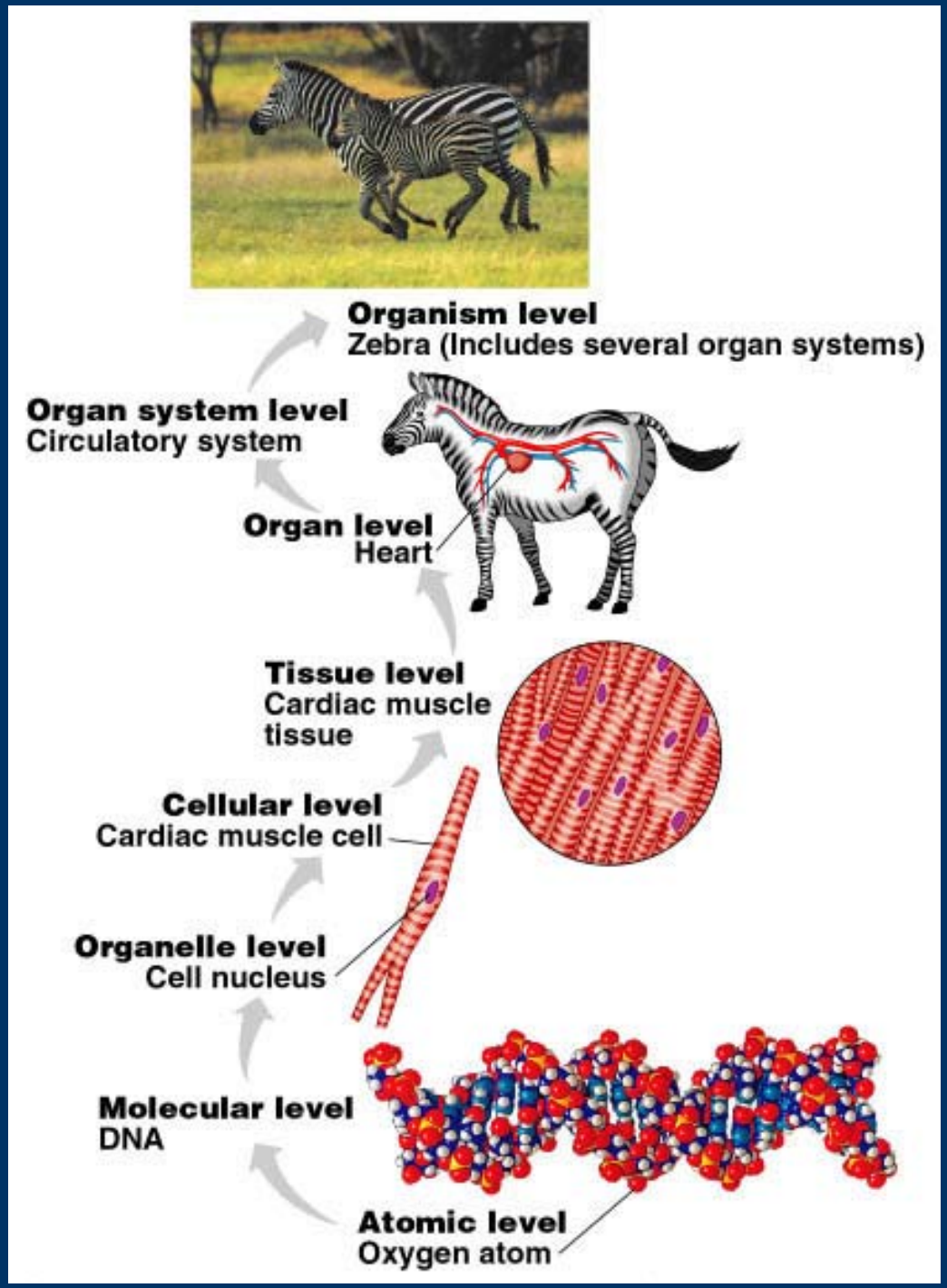
7 hrs

อ.ดร.จุฑาพันธุ์ พิณสวัสดิ์
Rm 226 ตึกชีววิทยา 1
02-218-5265
Fax 02-218-5256

Reference:

Campbell, N.A. and Reece, J.B. *Biology* 6th edition. Benjamin/Cummings, 2002

The hierarchy of biological order: from atom to organism.



Chemical Basis of Life

Element (ธาตุ) = substance that cannot be broken down to other substances by chemical reaction.

92 elements in nature: Au, Cu, C, O

Compound (สารประกอบ) = a substance consisting of 2 or more elements combined in a fixed ratio.

Sodium + Chlorine = salt (Sodium chloride) NaCl

1:1 ratio of Na:Cl

Among 92 nature elements, only 25 elements are essential to life.

Only 4 elements: C, H, O, N make up 96% of living matter.

Table 2.1 Naturally Occurring Elements in the Human Body

Symbol	Element	Atomic Number (See p. 29)	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).

Trace elements
= elements that are required by an organism in only minute quantities.

Fe = required by all organisms
I = an ingredient of thyroid hormone (need 0.15mg/day)

Goiter due to iodine deficiency

Atomic Structure

Atom = smallest unit of matter that still retains the properties of an element.

3 types of subatomic structure: proton, neutron and electron

Proton:

positive charge

mass ~1.7×10^{-24} gm

($1.67262171 \times 10^{-24}$ gm)

Electron:

negative charge

mass = 1/2,000 of proton mass

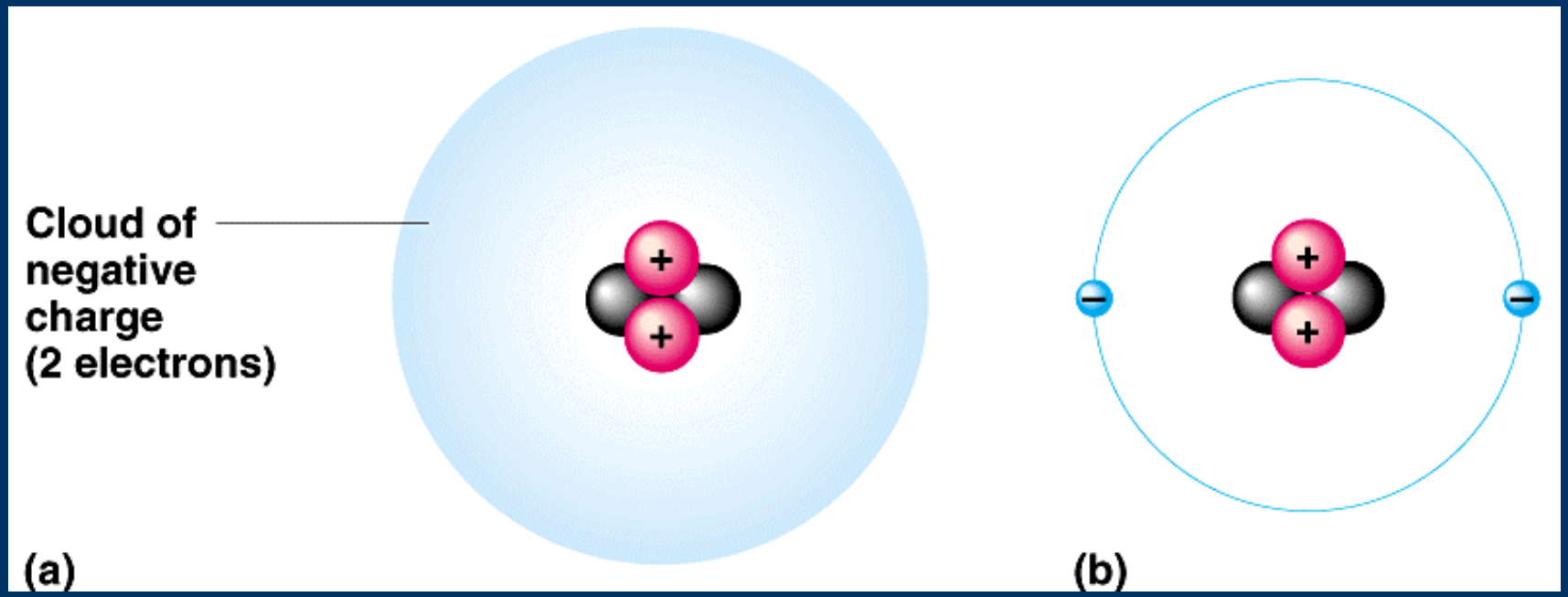
Neutron:

no charge

mass ~1.7×10^{-24} gm

($1.67492728 \times 10^{-24}$ gm)

Helium atom



Protons and neutrons are packed together to form atomic nucleus.

Electrons (moving at nearly the speed of light) form a cloud around the nucleus = หมอกอิเล็กตรอน

Atomic number (Z) and Mass number (A)

Atomic number (Z) เลขอะตอม = the number of protons, identity of an element

Mass number (A) เลขมวล = the sum of proton and neutrons in the nucleus.

$$^{A}_{Z}E \qquad ^{23}_{11}Na$$

= 11 protons = 11 electrons
23-11 =12 neutrons

Atomic mass or Atomic weight (มวลอะตอม)

Atomic mass = mass of the nucleus (protons + neutrons)

mass of electron = 1/2,000 of proton
thus mass of electron can be ignored.

atomic mass unit (amu) = dalton

1 amu or 1 Da = 1.66053873 X 10^{-24} gm)

1 proton, 1 neutron = 1 Da

$^{12}_{6}C$ = 6 protons, 6 neutrons = 12 Da

Atomic mass ~ Mass number

Molecular weight = sum of atomic weight of every atoms in a molecule

molecular weight of NaCl

= 23 + 35 = 58 daltons(1 molecule)

= 58 x 1.66×10^{-24} gm

(1 dalton = 1.66×10^{-24} gm)

1 mol of NaCl = 58 grams = 6.02×10^{23} molecules

6.02×10^{23} = Avogadro's number

($6.02214199 \times 10^{-23}$)

Isotopes

=The different atomic form of an element:

-the same number of protons (same element)

-different number of neutron

In nature, an elements occurs as a mixture of its isotopes:

$^{12}_{6}C$ C with 6 neutron, 99% of the carbon in nature, stable isotopes

$^{13}_{6}C$ C with 7 neutrons, stable isotopes

$^{14}_{6}C$ C with 8 neutrons, unstable isotopes

Unstable isotopes have tendency to lose particles and energy =radioactive isotopes (สารกัมมันตรังสี)

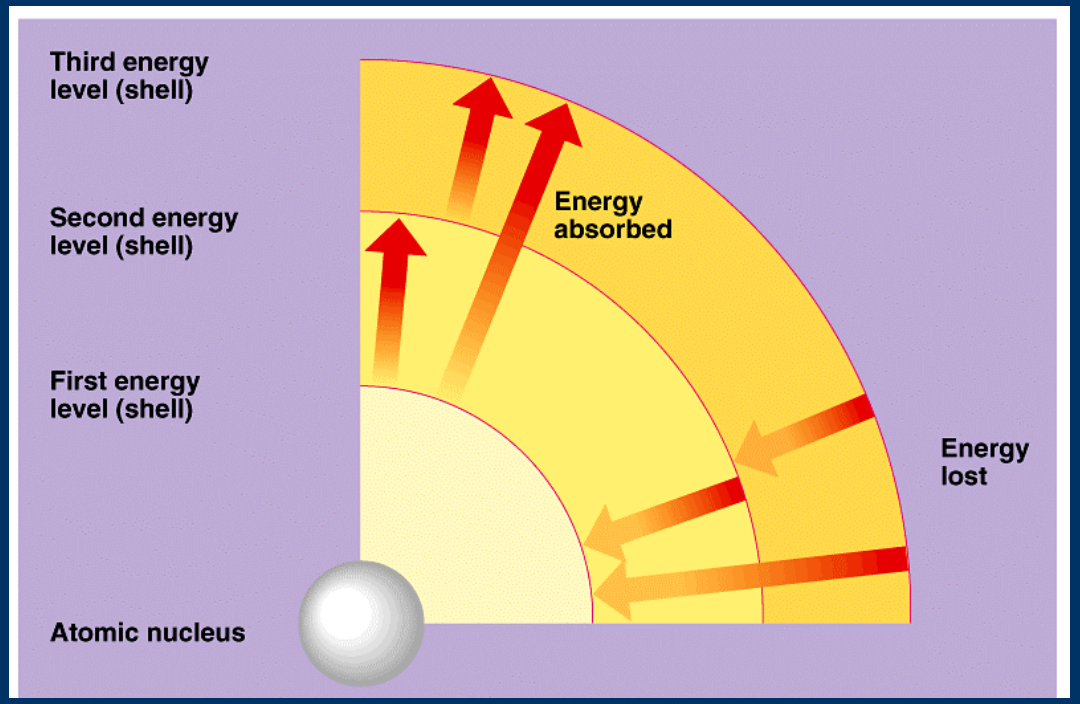
-leads to the change in number of protons = transform to a different elements

-e.g. radioactive carbon decays to form nitrogen

Half life of C^{14} = 5,730 years

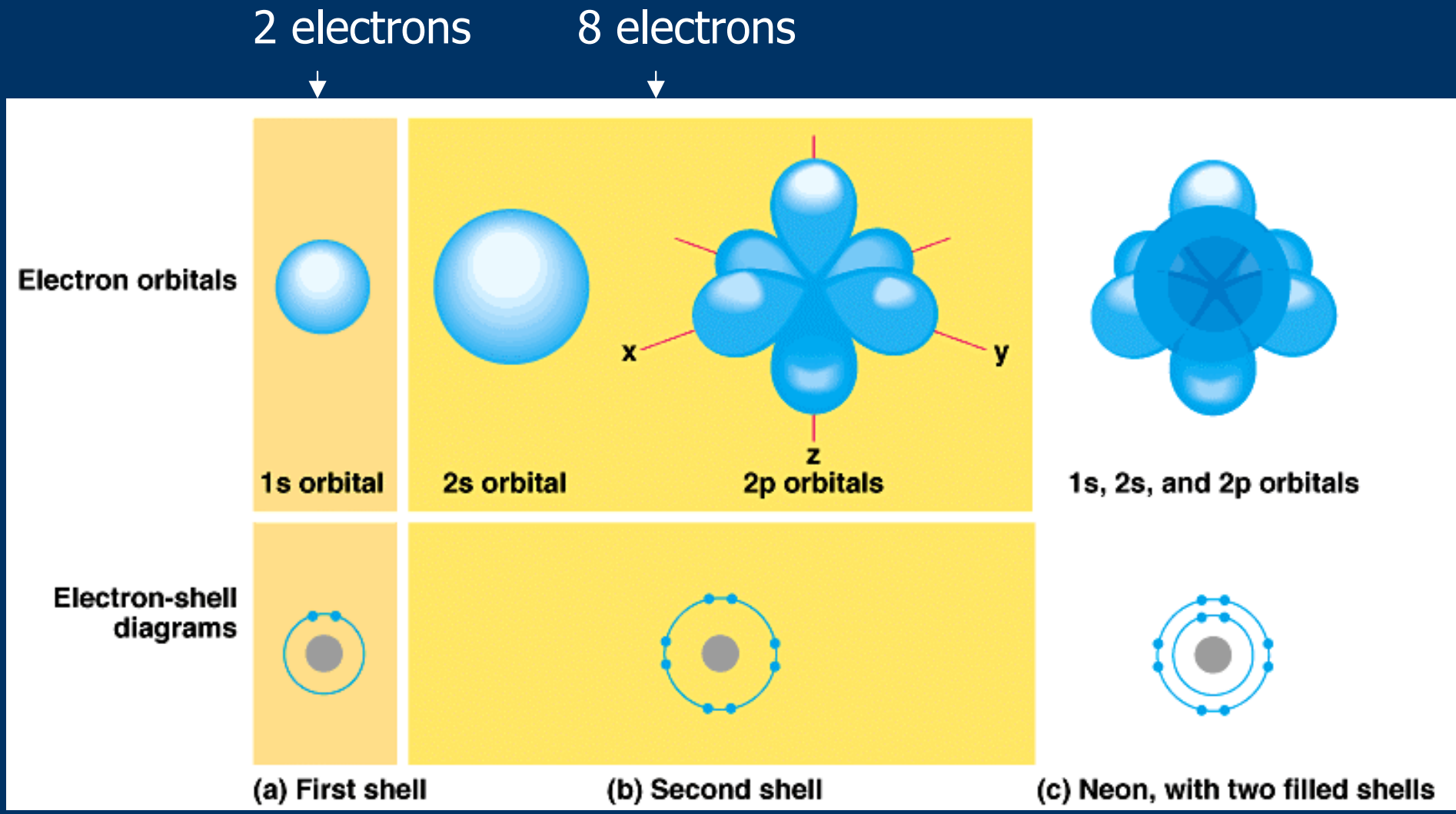
The Energy Levels of Electrons

-Electrons exist only at fixed level of potential energy = electron shells.
-Electrons in the first shell (closed to nucleus) have the lowest energy level.

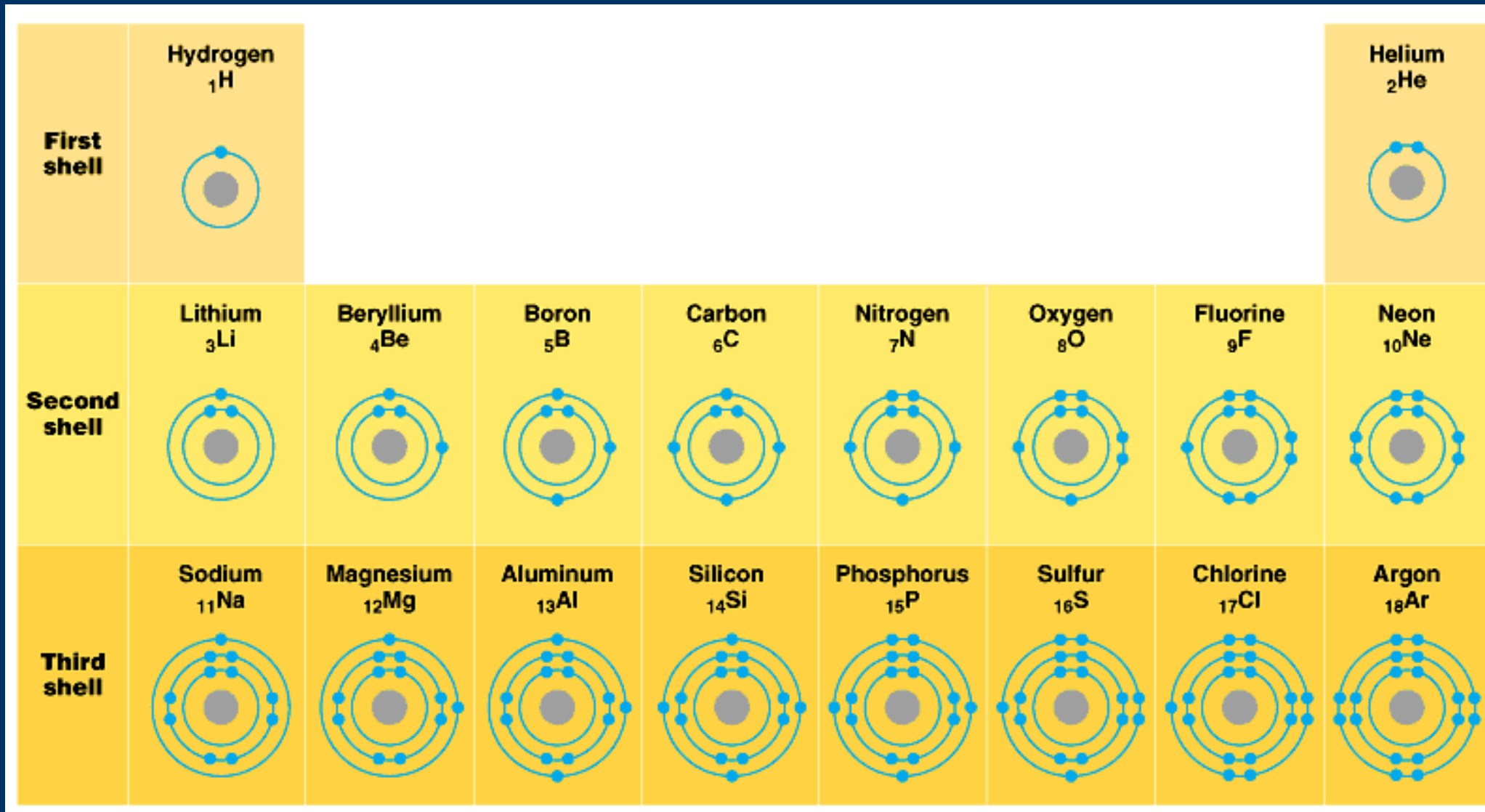


-Electrons can change its shell, by absorbing or losing energy equal to the difference in potential between the old and new shell.

Electron orbitals = the three dimensional space where electrons of an atoms were most likely to be found (90% of the time).



Valence electrons = electrons with the highest energy level, exist at the outermost shell.



Chemical Bonds

Atoms with incomplete valence shells (2 or 8) can interact with certain other atoms (to complete valence shell) forming a molecule.

Interaction can be either sharing or transferring valence electrons

-Covalent bond -Ionic bond

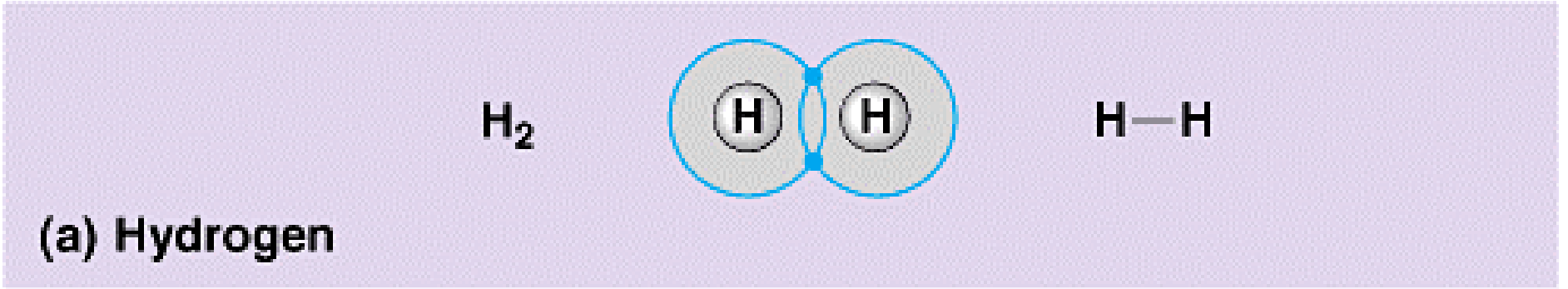
-Hydrogen bond

-Van der Waals interactions

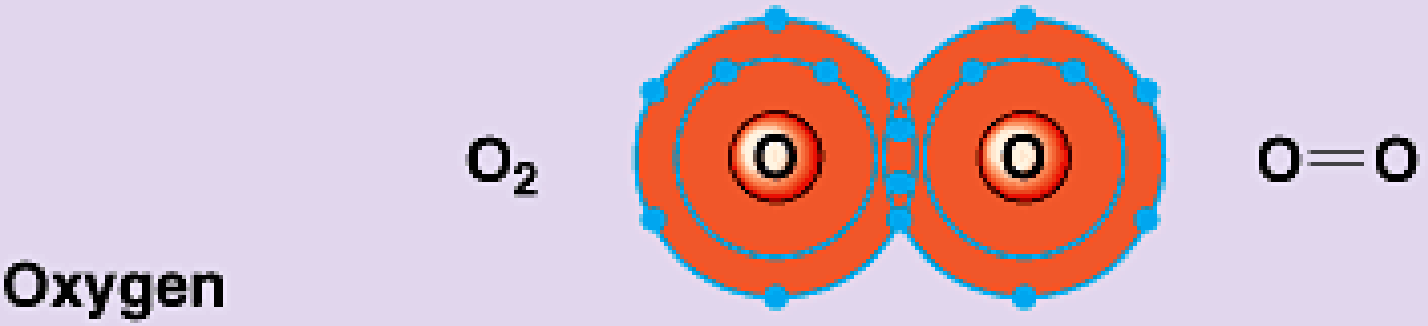
-Hydrophobic interaction

Covalent bonds

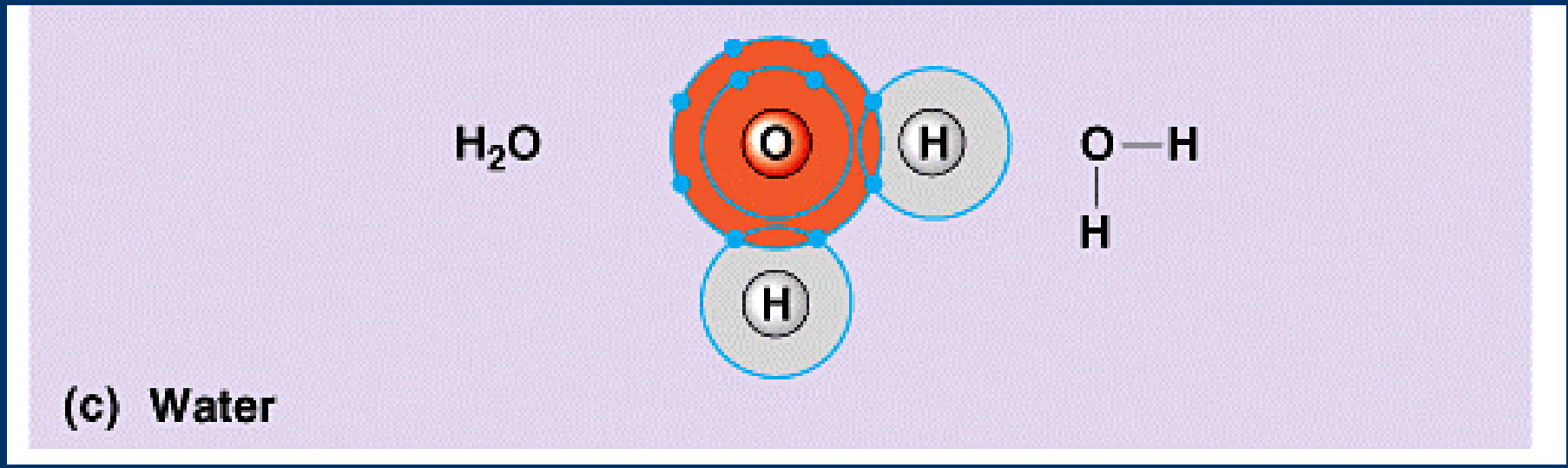
A covalent bond is the result of the sharing of a pair of valence electrons by 2 atoms.



2 hydrogen atoms (valence electron = 1) share 1 pair of electron = a single covalent bond.

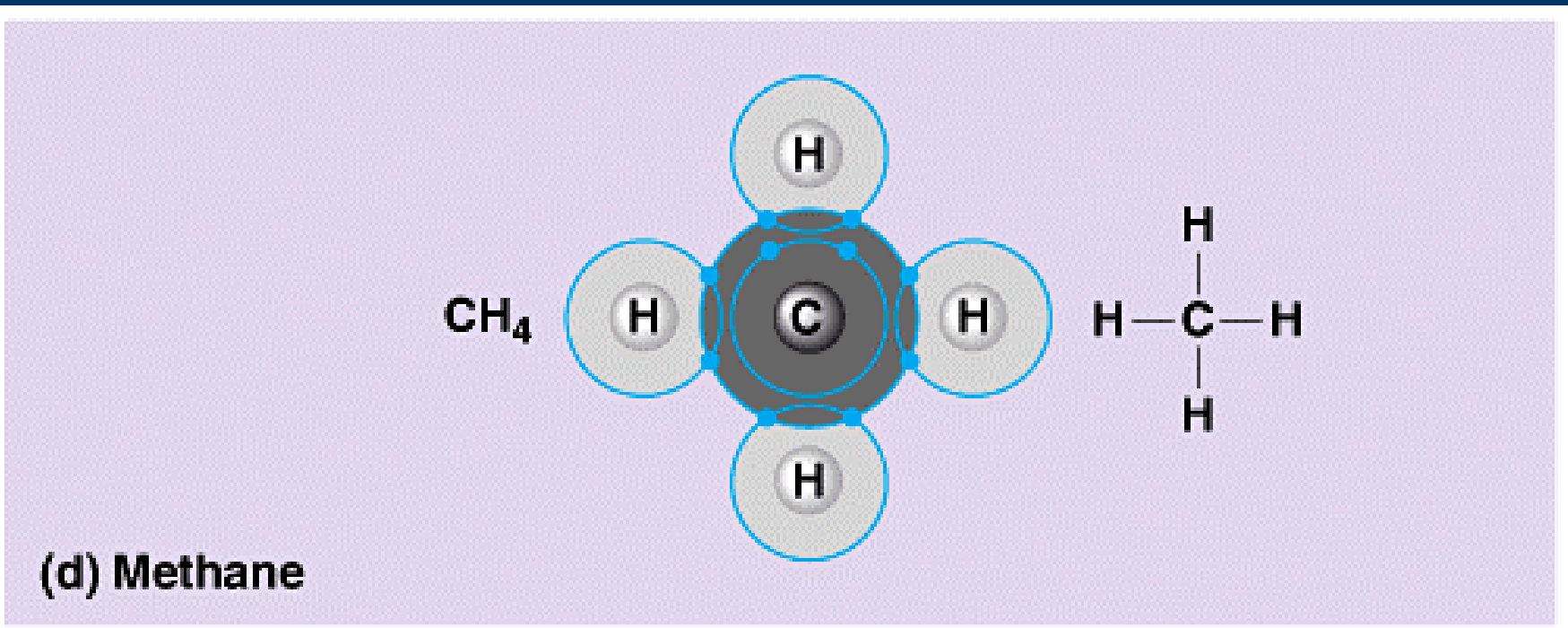


2 oxygen atoms (valence electrons = 6) form an oxygen molecule by sharing 2 pairs of valence electrons = double covalent bond.



Water consists of 2 hydrogen atoms (valence electron = 1) and 1 oxygen atom (valence electron = 6).

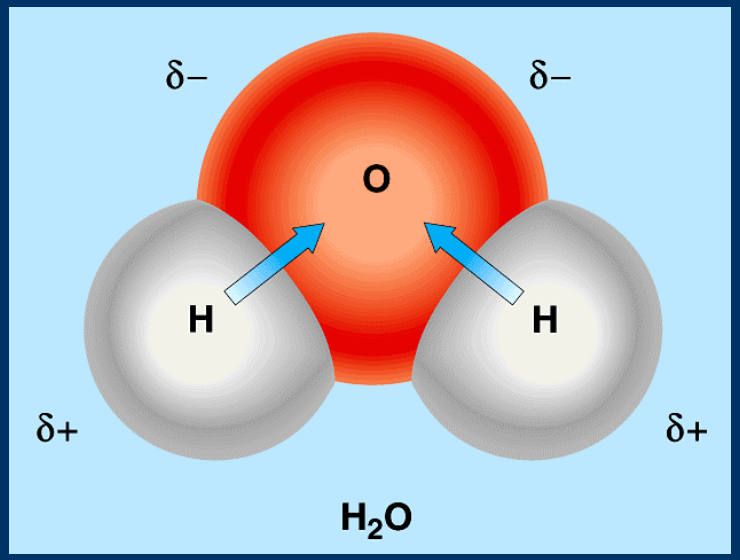
Each hydrogen atom shares 1 pair of electron or form a covalent bond with oxygen atom.



In methane molecule, each hydrogen atom (valence electron = 1) share 1 pair of electron with carbon atom (valence electron = 4).

Polar and Nonpolar Covalent Bond

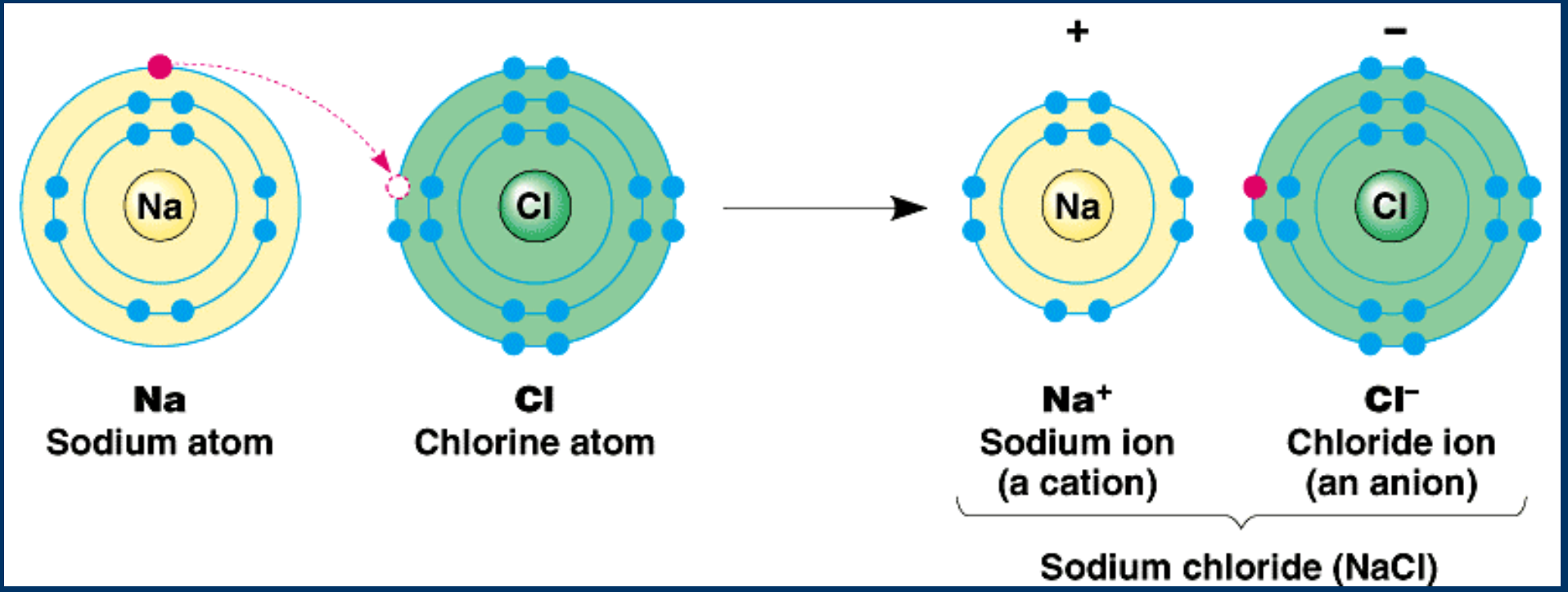
-Electronegativity = attraction of atom for the electrons of a covalent bond.
-Nonpolar covalent bond

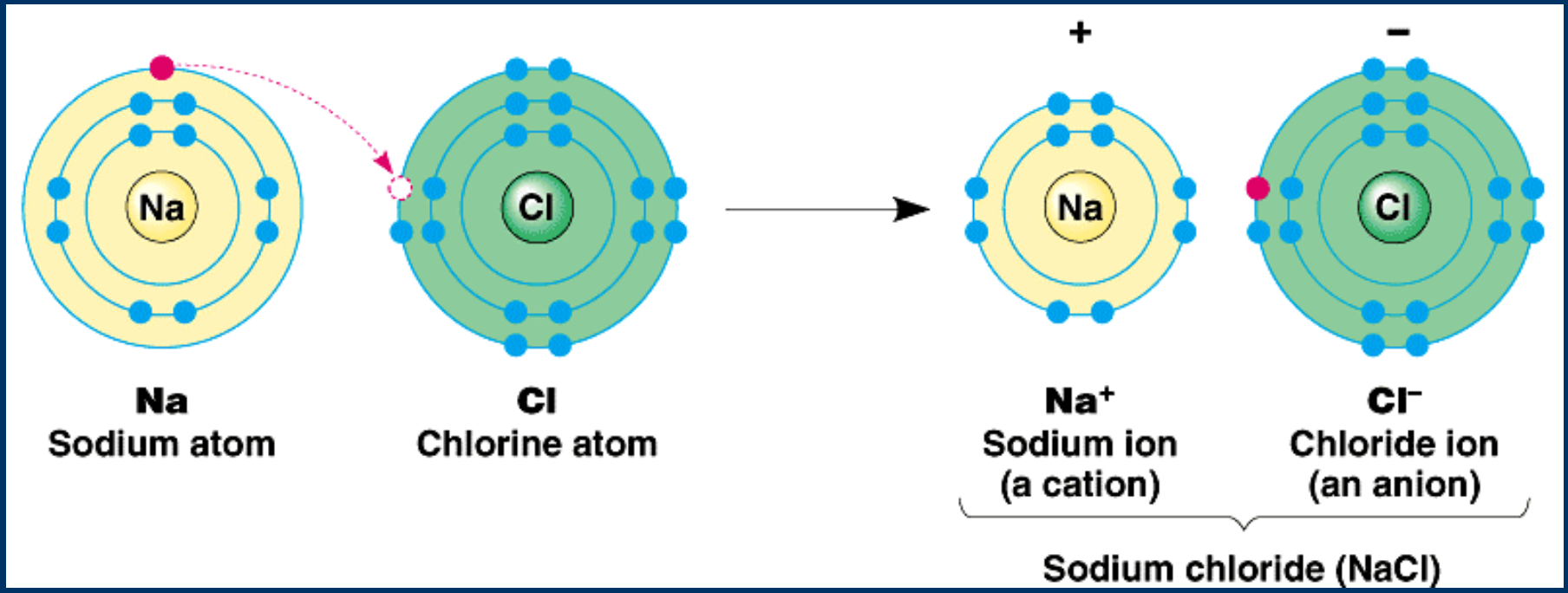


= covalent bond between atoms with the same electronegativity e.g. H_2, O_2
-Polar covalent bond = covalent bond between atoms with different electronegativity e.g. H_2O

Ionic Bonds

Formed by transferring of an electron between atoms in a molecule.





Chlorine atom is a more electronegative atom than sodium atoms. An electron of sodium atom is transferred to chlorine atom creating a sodium ion (cation) and a chloride ion (anion).

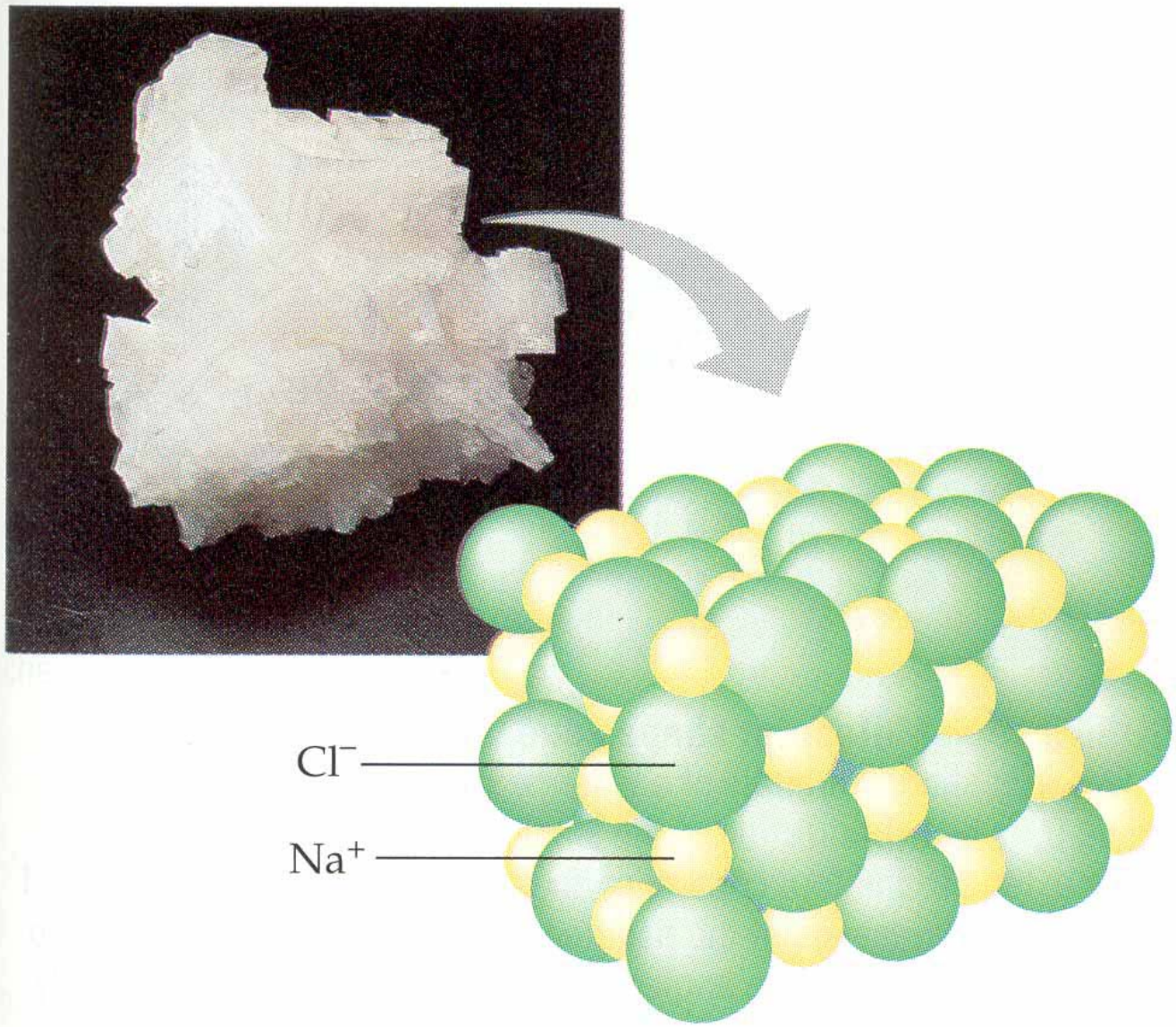
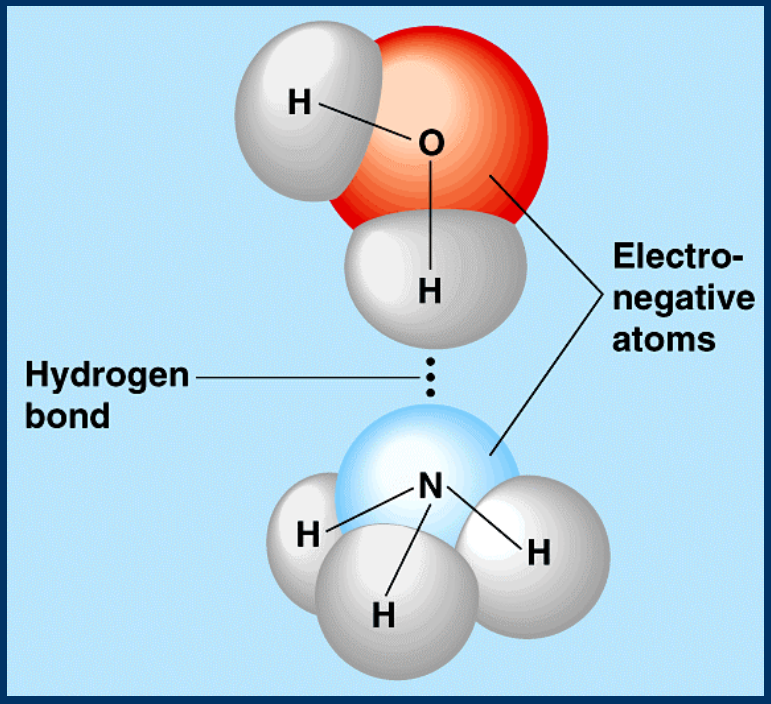


FIGURE 2.13 ▪ A sodium chloride crystal. The sodium ions (Na^+) and chloride ions (Cl^-) are held together by ionic bonds.

Hydrogen bond

A hydrogen bond forms when a hydrogen atom covalently bonded to one electronegative atom is also attracted to another electronegative atom.

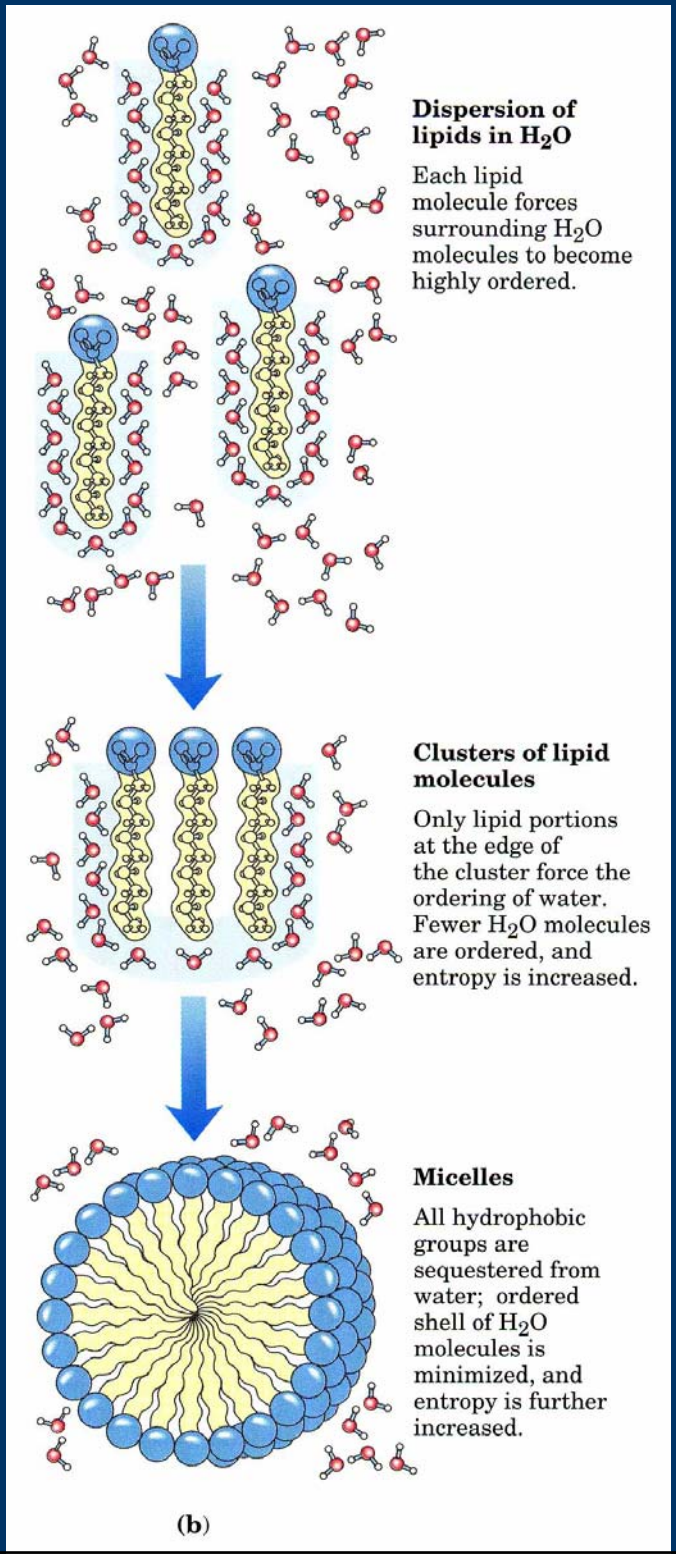


Hydrogen atom of H_2O is $\delta+$ while nitrogen atom of NH_3 is $\delta-$.

Hydrophobic interaction

-In a suspension of nonpolar molecule, hydrogen bonding are formed between water molecules.

-Thus the nonpolar molecules are forced to aggregate together with hydrophobic interaction avoiding any contact with water.



Van der Waals Interaction

-occurs when atoms and molecules are very close together

-due to unsymmetrically distribution of electrons in atoms or molecules

Ionic bond, Hydrogen bond, Hydrophobic interaction, Van der Waals interaction = weak interactions