General Inorganic Chemistry

Pre DP Chemistry Period 1

- Teacher: Annika Nyberg
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  - Urgent messages via Wilma!

Klicka här för att ändra format på underrubrik i bakgrunden

- Course book:
  - CliffsNotes: Chemistry Quick Review

http://www.chem1.com/acad/webtext/virtualtextbook.html

Content

- Introduction
- The Structure of Matter *(Chapter 1)*
- The Atom *(Chapter 2 and 3)*
- Chemical bonding *(Chapter 5)*

- The Mole *(Chapter 2)*
- Solutions *(Chapter 9)*
- Acids and bases *(Chapter 10)*
- ***Quiz***
- ***Revision***

- **EXAM 9.00-11.45**

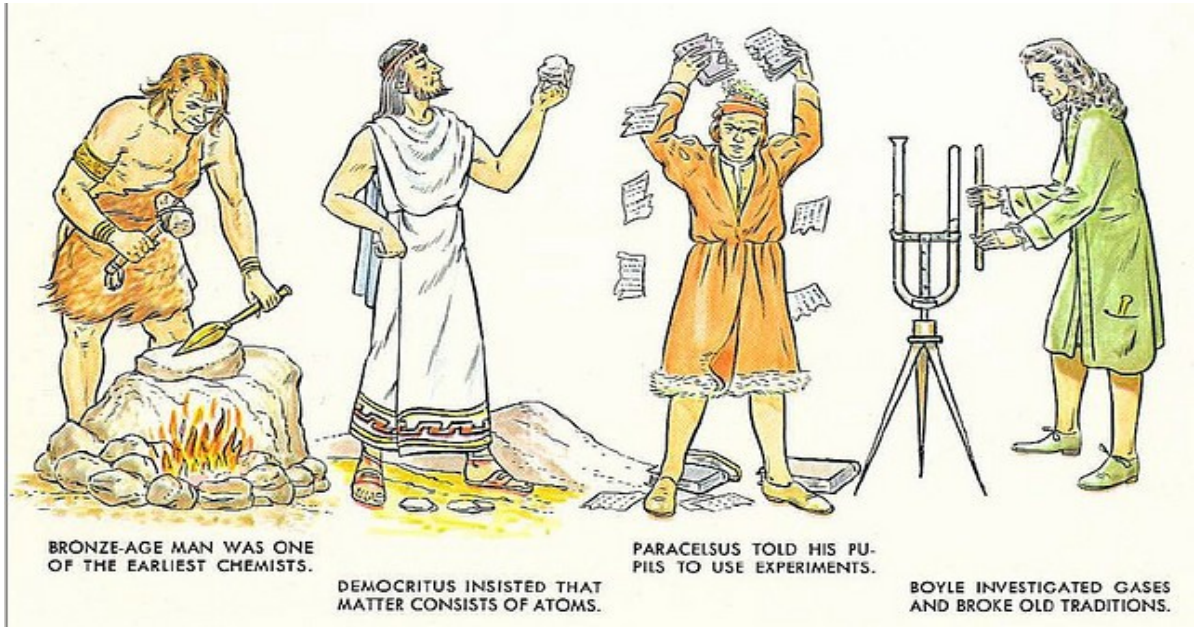
Assessment

Exam: 80 %
Quiz: 20%

+ practical work, activity and absences

1. Chemistry: a Science for the twenty-first century

- Chemistry has ancient roots, but is now a modern and active, evolving science.



- Chemistry is often called the central science, because a basic knowledge of chemistry is essential for students in biology, physics, geology and many other subjects.

https://www.youtube.com/watch?v=tTlnrhiadnI

- Chemical research and development has provided us with new substances with specific properties. These substances have improved the quality of our lives.

Health and medicine

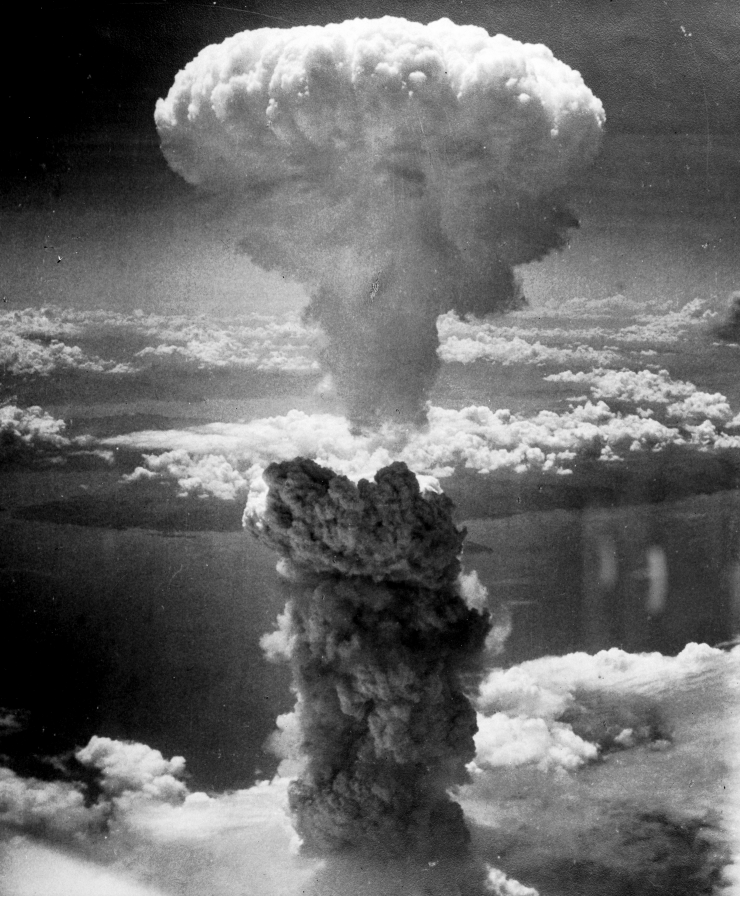
sanitation systems

vaccines

antibiotics

anesthesia

and all other drugs



Energy

new alternative energy sources (e.g. solar energy to electric energy, nuclear fission)

electric cars with long lasting batteries

Environment

greenhouse gases

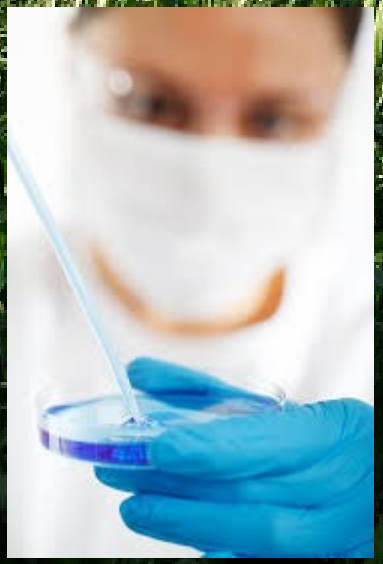
acid rain and smog

Materials and Technology

- polymers (rubber and nylon), ceramics (cookware), liquid crystals (electronic displays), adhesives (Post-It notes), coatings (latex-paint), silicon chips (computers)

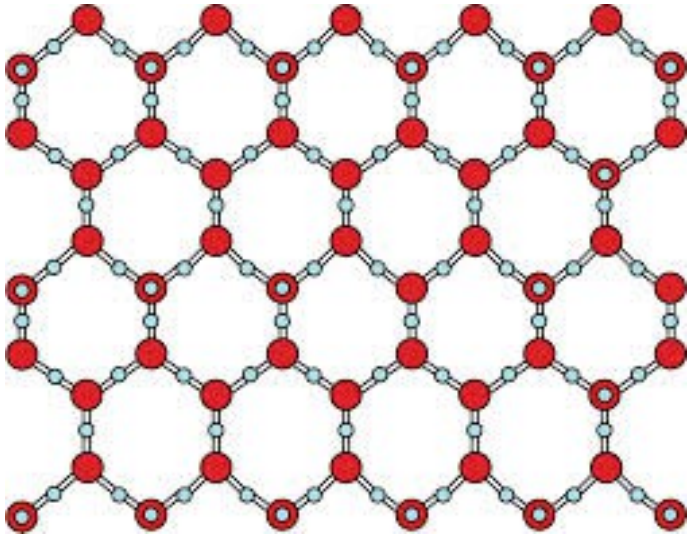
Food and Agriculture

substances for biotechnology



- The purpose of this course is to make you understand how chemists see the world.

- In other words, if you *see* one thing (in the macroscopic world) you *think* another (visualize the particles and events in the microscopic world).



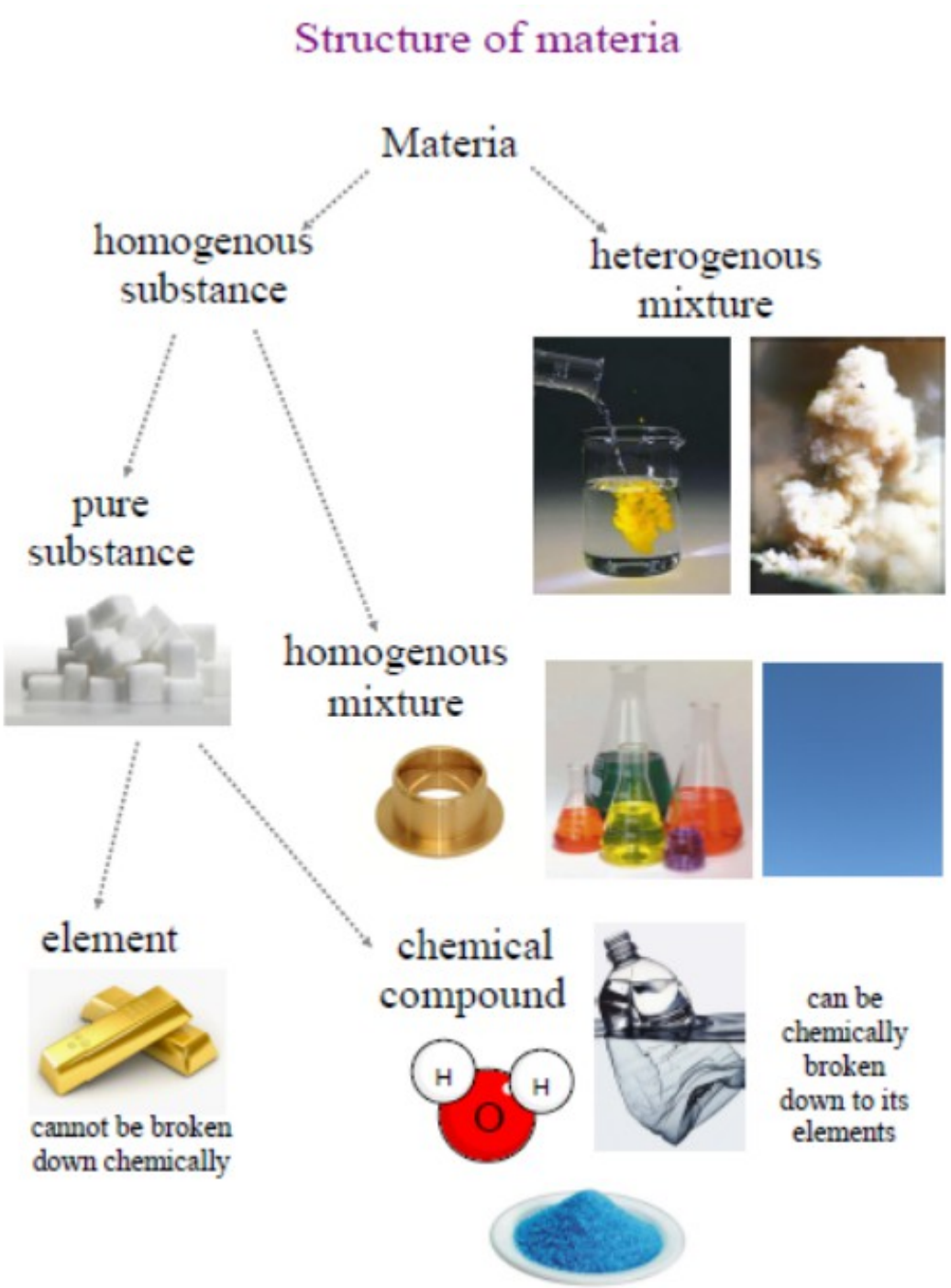
2. The Structure of Matter

- Chemistry is a study of matter and the changes it undergoes.

The Chinese characters for chemistry mean "The study of change."

https://www.youtube.com/watch?v=NJxv2FzfUDQ&list=PLB44391AC467143BA&index=2

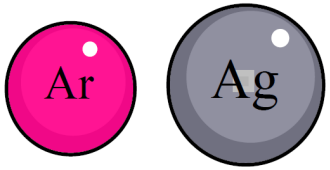
- Matter is defined as anything that takes up space and has a mass.



2.1 Elements

- An element is the simplest form of matter that cannot be broken down by chemical means.

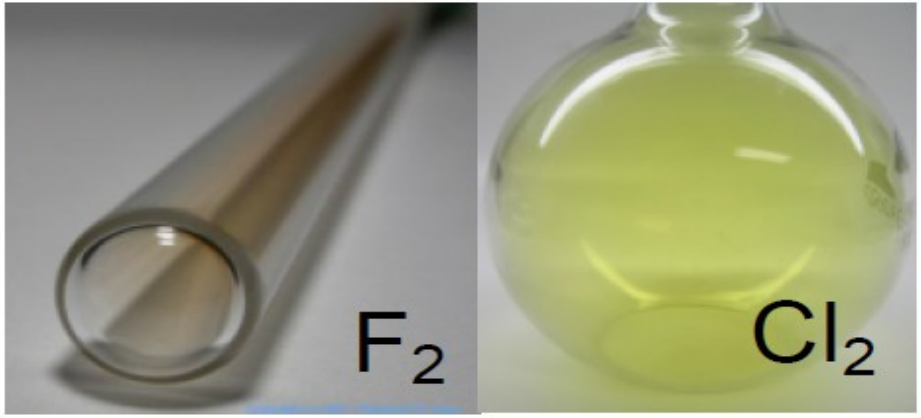
- Each element is assigned a chemical symbol.



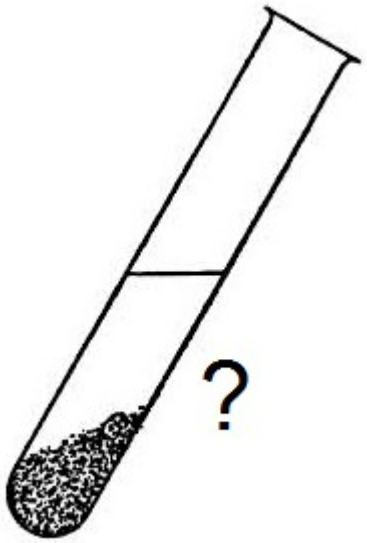
- The smallest unit of an element is an atom.




- There are 98 naturally occuring elements.
- 118 elements have been identified (nov 2011).



- Most elements are solids in room temperature, for example:
- Those that are liquids are:
- Gaseous elements in room temperature are:



- aluminium (Al)
- antimon (Sb)
- carbon (C)
- copper (Cu)
- iodine (I)
- iron (Fe)
- magnesium (Mg)
- phosphorus (P)
- sodium (Na)
- sulfur (S)
- tin (Sn)
- zinc (Zn)

Correct answers

A = iodine (I)

B = tin (Sn)

C = magnesium (Mg)

D = iron (Fe)

E = carbon (C)

F = sodium (Na)

G = sulfur (S)

H = zinc (Zn)

I = copper (Cu)

J = phosphorus (P)

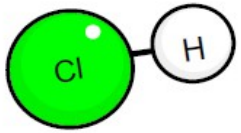
K = antimon (Sb)

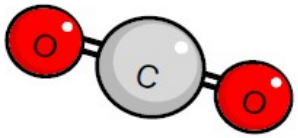
L = aluminium (Al)

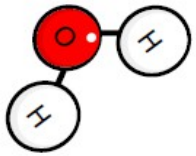
2.2 Compounds

- Elements combine with other elements to form thousands of compounds.

- A compound is made up of two or more elements that are chemically bonded together.

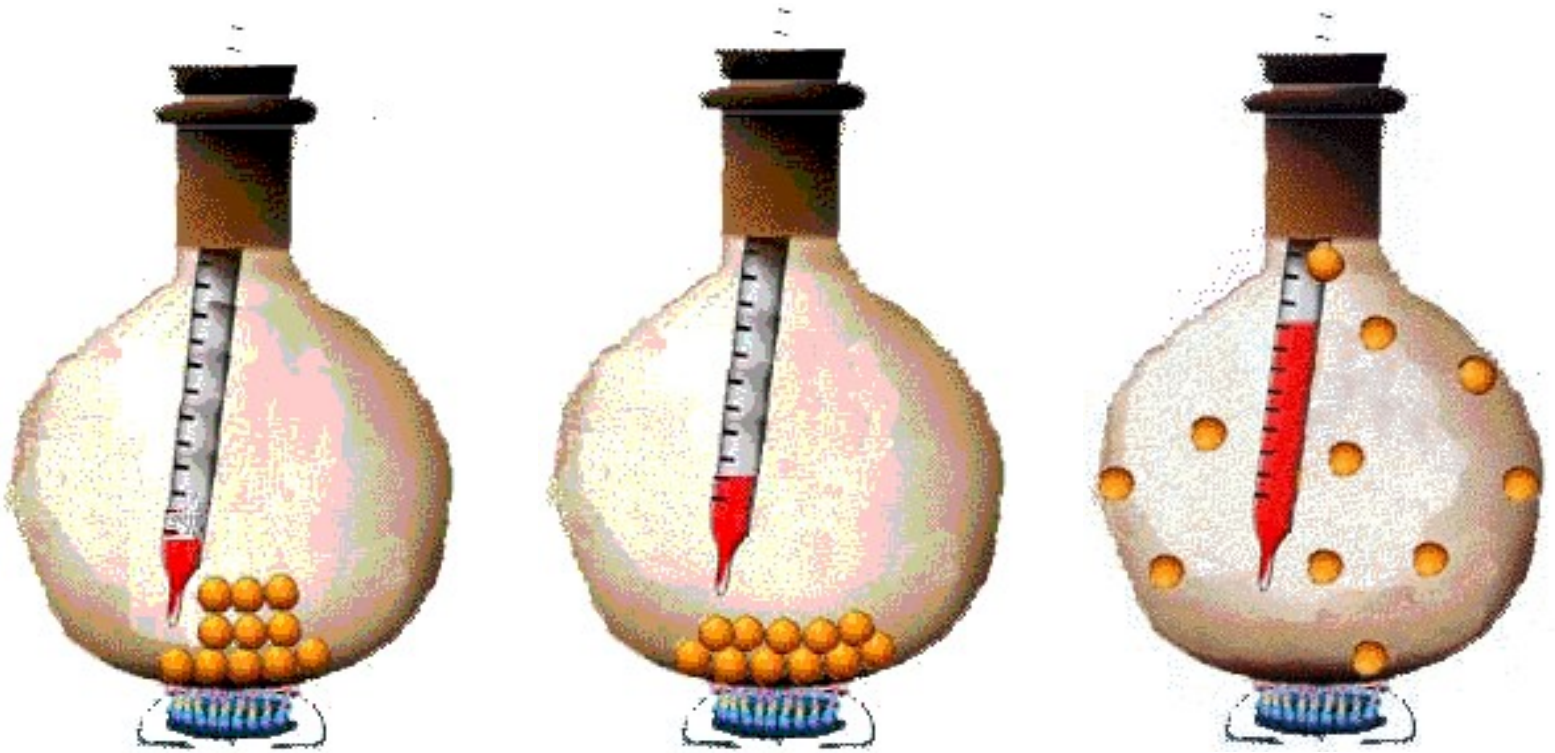






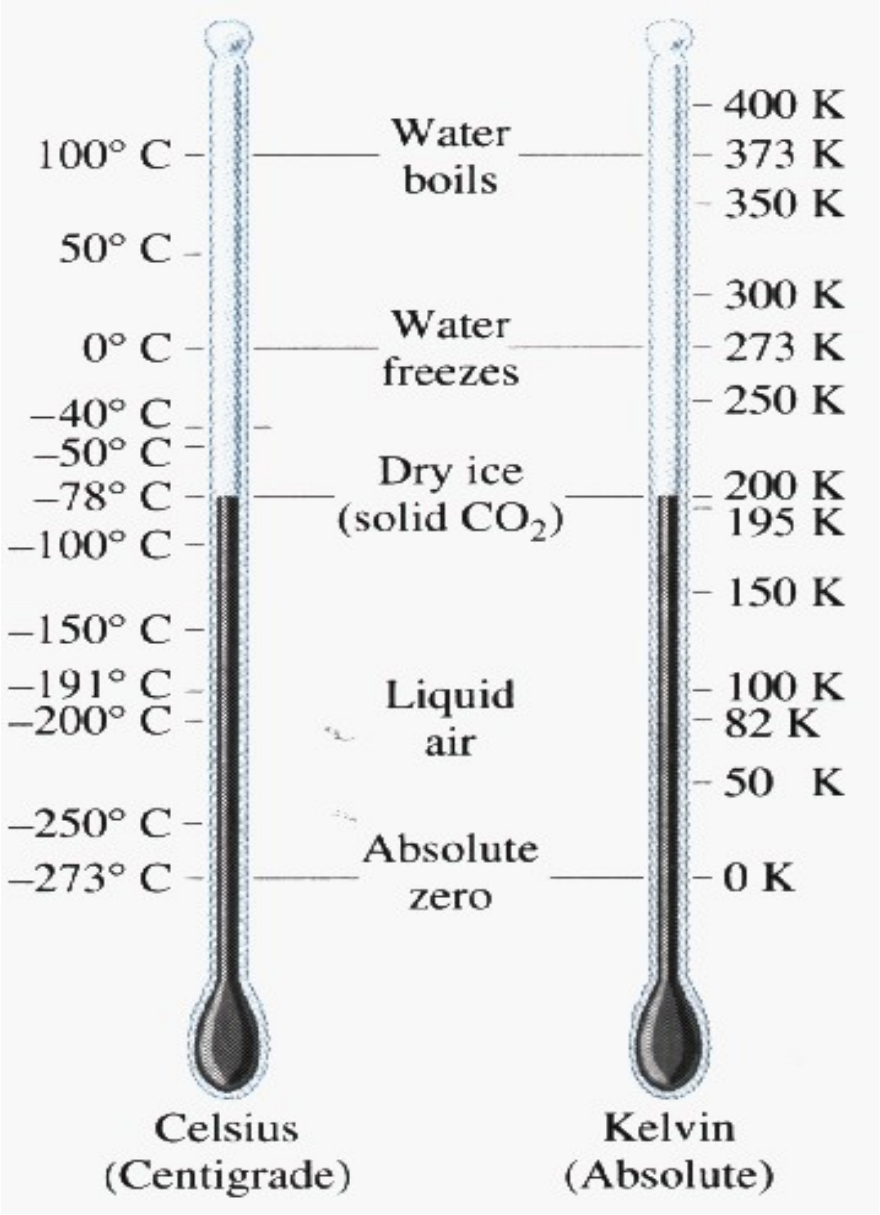
2.3 The States of Matter

- Substances have different appearances and physical properties in different states of matter.

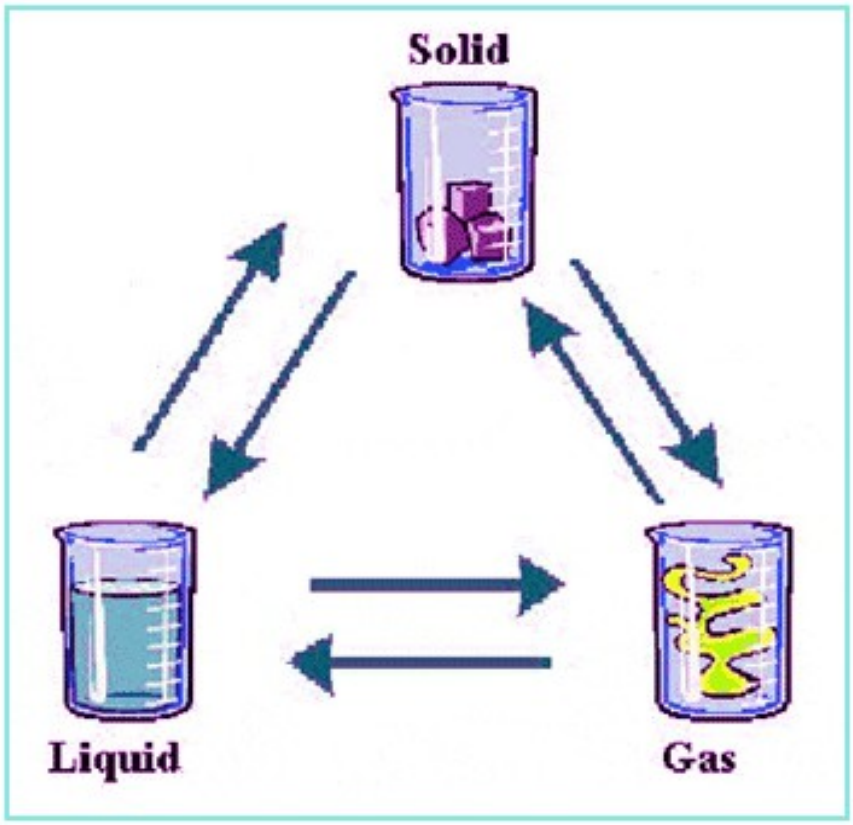


http://www.youtube.com/watch?v=s-KvoVzukHo&feature=related

2.4 Temperature scales

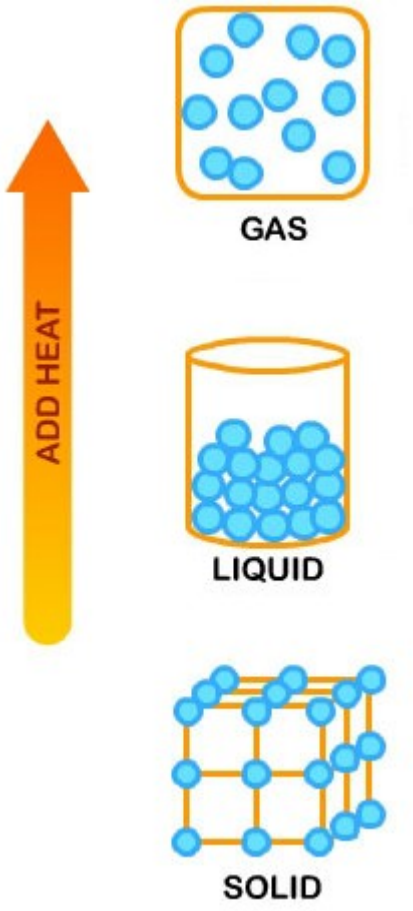


2.5 Changes of state

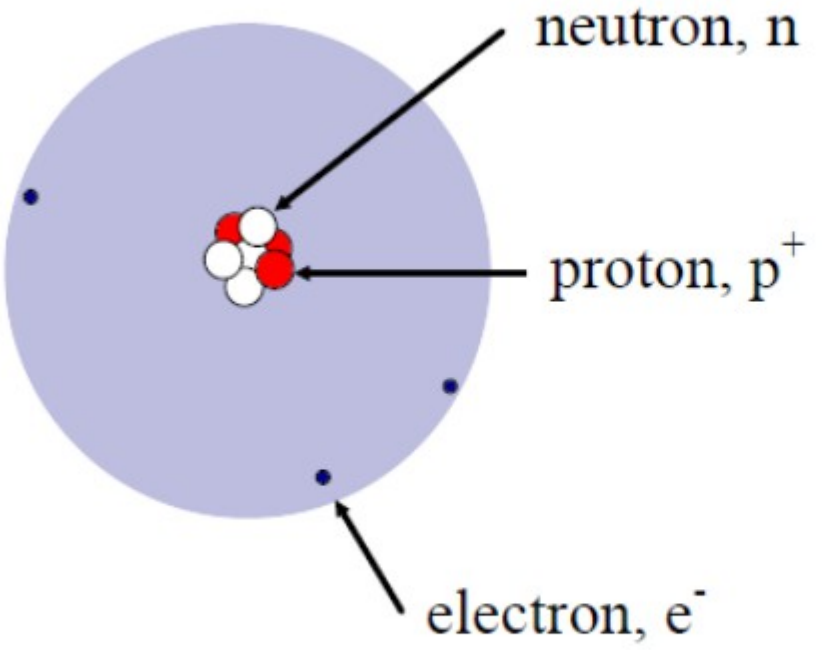


http://www.youtube.com/watch?v=pP_lZaOchE0
Dry ice bubbles

2.6 Melting point and boiling point



3. The Atom

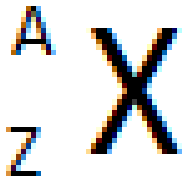


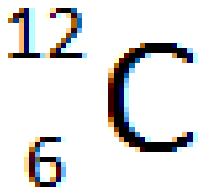
$^{7}_{3}Li$

An atom has no electrical charge!

number of p^+ = number of e^-

http://www.youtube.com/watch?v=lP57gEWcisY

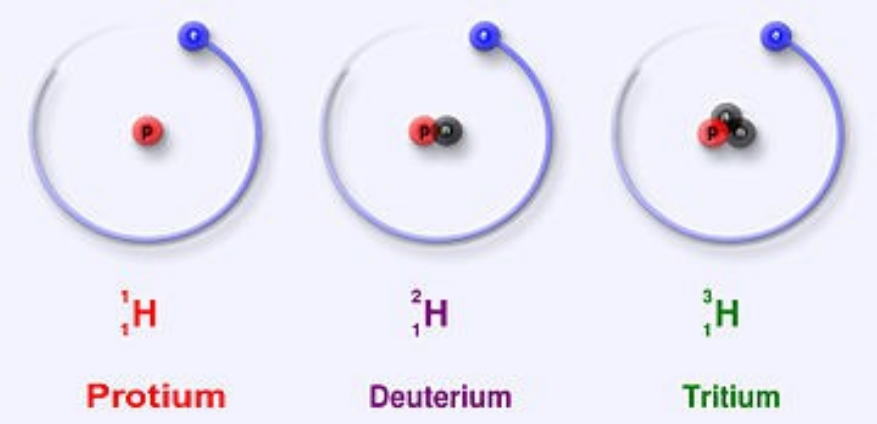




A = <u>mass number</u> = number of nucleons (n+p)
Z = <u>atomic number</u> = number of protons

All atoms with the same Z (= with the same number of protons) are atoms of the same element!

3.1 Isotopes



- Isotopes have:
  - Different mass number
  - The same atomic number

    → the same number of protons, but different number of neutrons

    → the same number of electrons

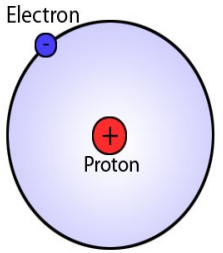
    → similar chemical properties, but different physical properties

http://www.periodicvideos.com/videos/mv_heavywater.htm

Ex 6. Complete the following table:

Symbol of isotop	Atomic number (Z)	Mass number (A)	Number of neutrons	Number of electrons
$^{14}_{6}C$	6			
	16		16	16
$^{238}_{92}U$				
	79	196		
	19		20	

3.2 Relative atomic mass



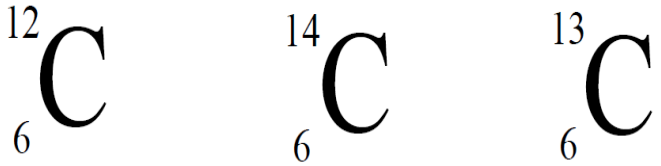
- Ex. Calculate the mass of one hydrogen-1 atom.

$$1{,}67 \cdot 10^{-27}\ \text{kg} \qquad (+\ 9{,}1\ 10^{-31}\ \text{kg}) =$$
$$0{,}000000000000000000000000167\ \text{g}$$

- Since the mass of an atom is very small, a relative atomic mass is used.
- The masses of atoms are compared with one another on a scale in which a single atom of of carbon-12 equals 12 units.
- For example, hydrogen has 1/12 of the mass of carbon-12.

Sub-atomic particle	Mass (kg)	Relative mass
proton	$1{,}67 \cdot 10^{-27}$ kg	1
neutron	$1{,}67 \cdot 10^{-27}$ kg	1
electron	$9{,}1 \cdot 10^{-31}$ kg	0,0005

- The elements seldom exist as just one isotope, but as a mixture of different isotopes.



- The atomic masses found in the periodic table are therefore not whole numbers, but <u>weighted mean values</u> of these isotopes.

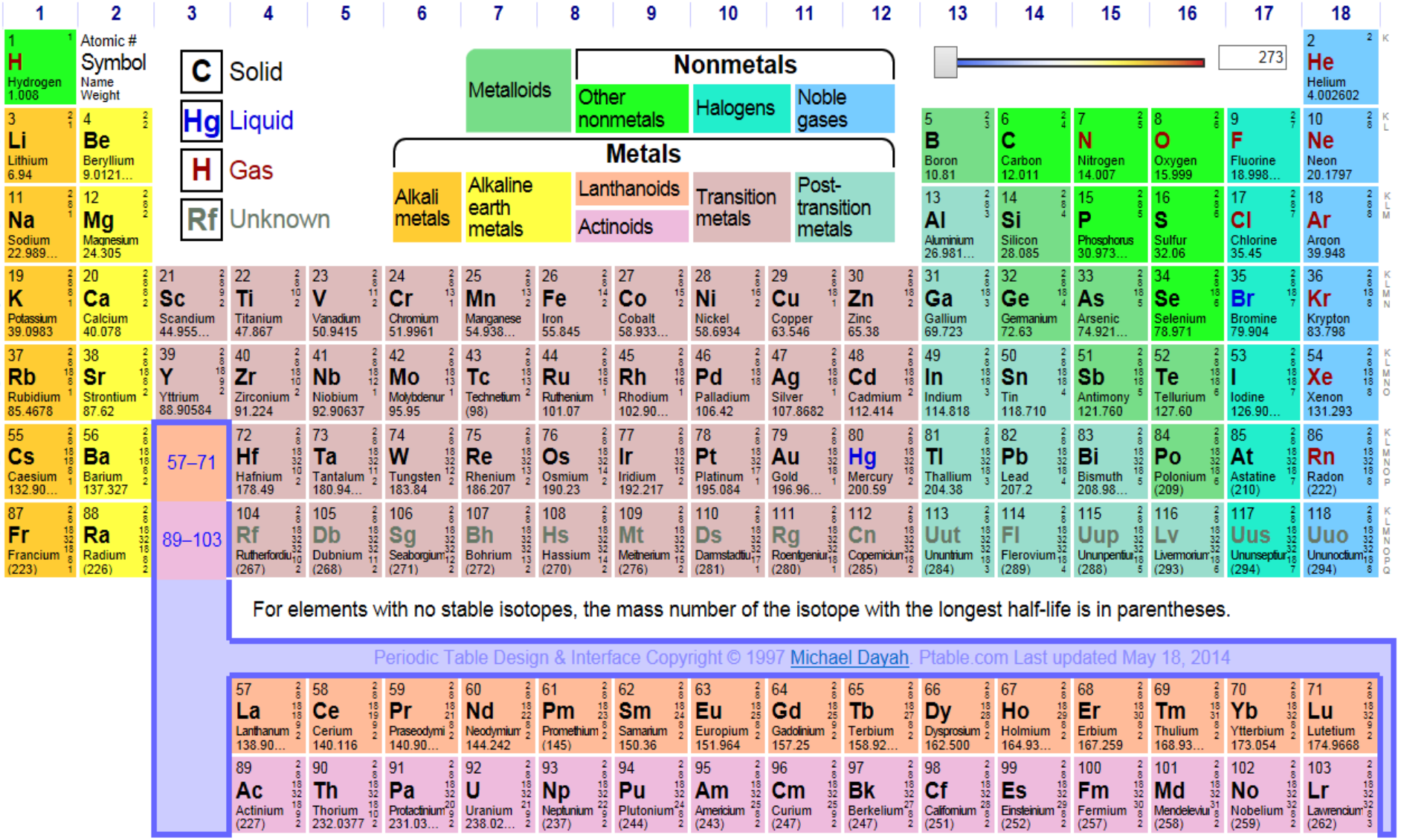
Ex 5. A sample of neon exists as a mixture of three isotopes. 90,51% of Ne-20, 0,27% of Ne-21 and 9,22% of Ne-22. Calculate the relative atomic mass of neon

A sample of argon exists as a mixture of three isotopes.

A = 36, relative abundance 0,337%
A = 38, relative abundance 0,0630%
A = 40, relative abundance 99,6%

Calculate the relative atomic mass of argon.

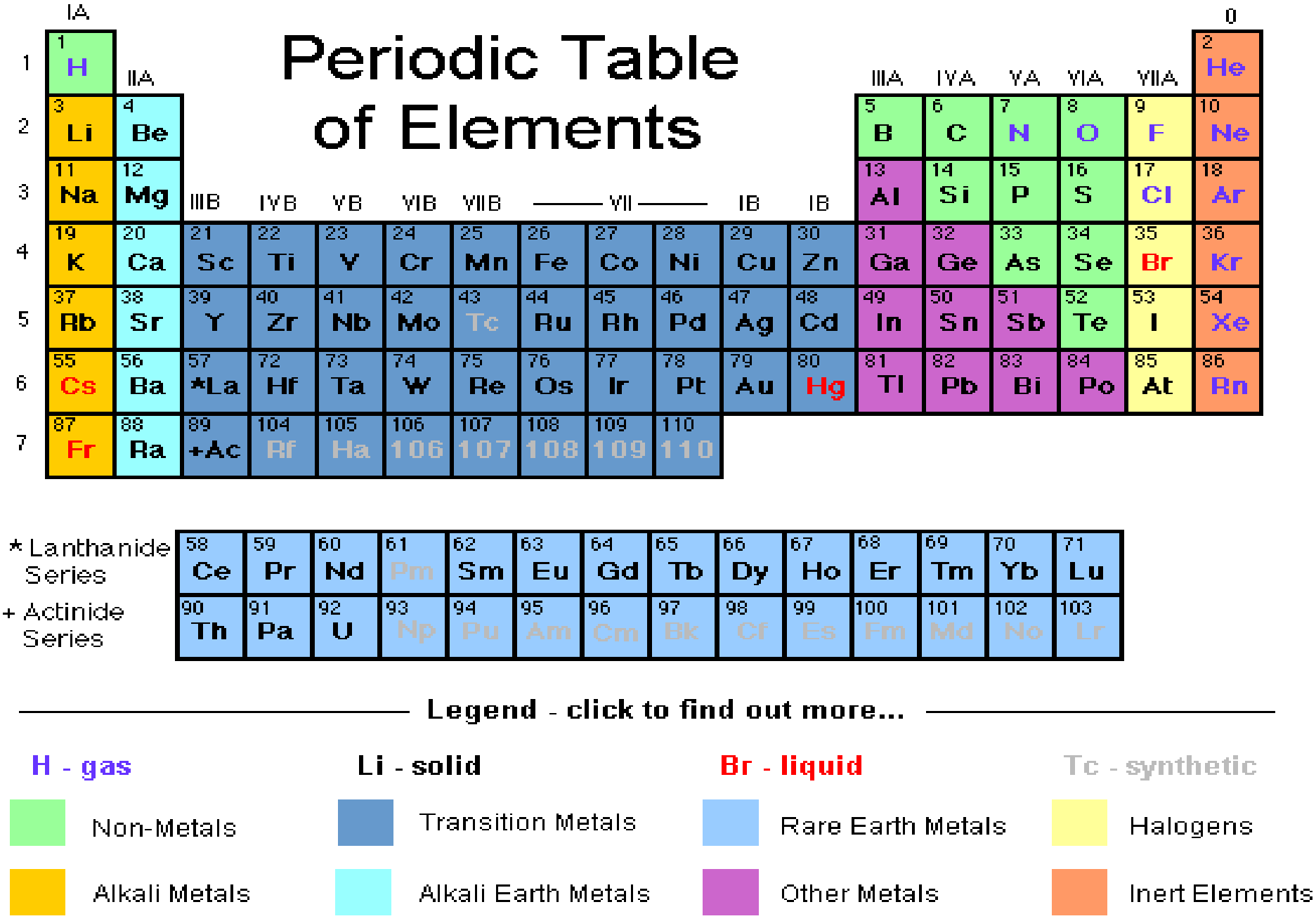
4.The periodic table



http://www.ptable.com/?lang=en

http://www.youtube.com/watch?v=zGM-wSKFBpo

http://deskarati.com/wp-content/uploads/2012/02/periodic-table.jpg



- The elements are arranged in order of increasing atomic number.

- Elements are classified as

  a) metals, e.g.

  b) metalloids,e.g.

  The six elements commonly recognised as metalloids are boron, silicon, germanium, arsenic, antimony and tellurium

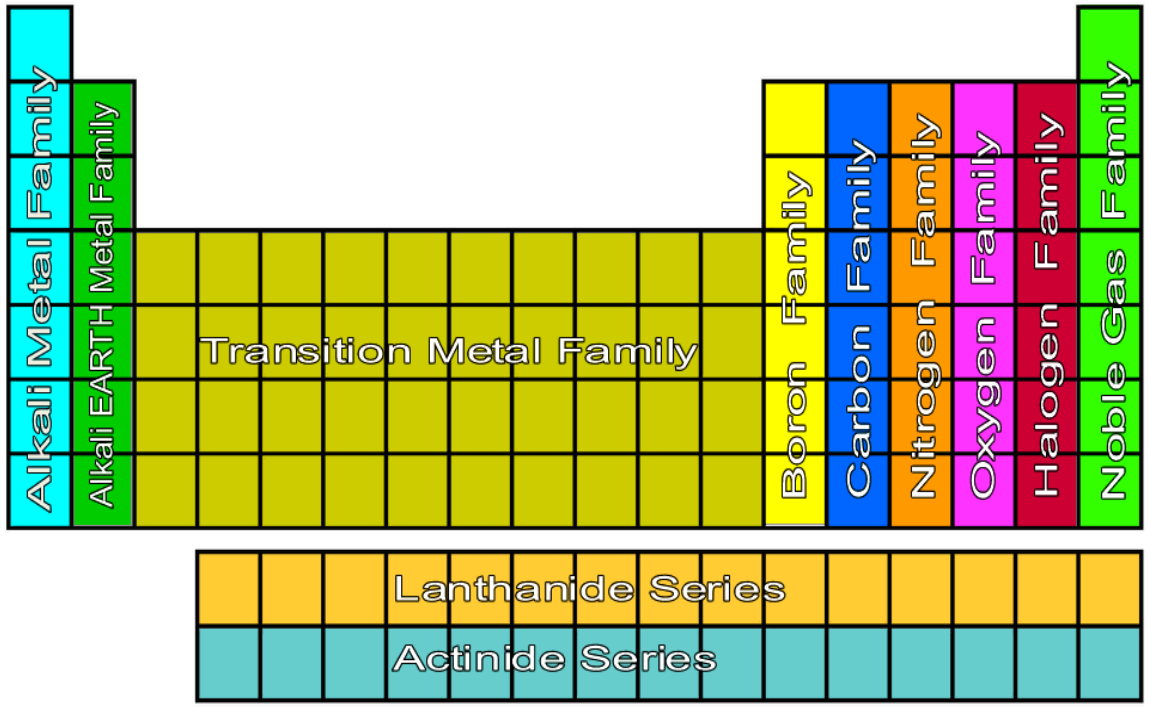
  c) non-metals,e.g.

- Group: All atoms in the same group or column (groups 1, 2, 3-8) have the same number of valence electrons = similar chemical properties

- Period: all elements in the same period have the same number of energy levels (electron shells)

Groups in the period table:

- 1. Alkali metals
- 2. Alkaline earth metals
- (Transition metals)
- 13. Boron group
- 14. Carbon group
- 15. Nitrogen grou
- 16. Oxygen group
- 17. Halogens
- 18. Noble gases



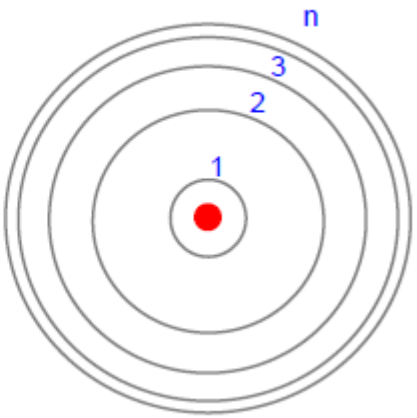
5. Electron arrangement

- Electrons are located on different energy levels around the nucleus because of:
  - the pull of the positively charged nucleus
  - the repulsion between electrons

- The energy of an electron is greater the further away it is located from the nucleus.

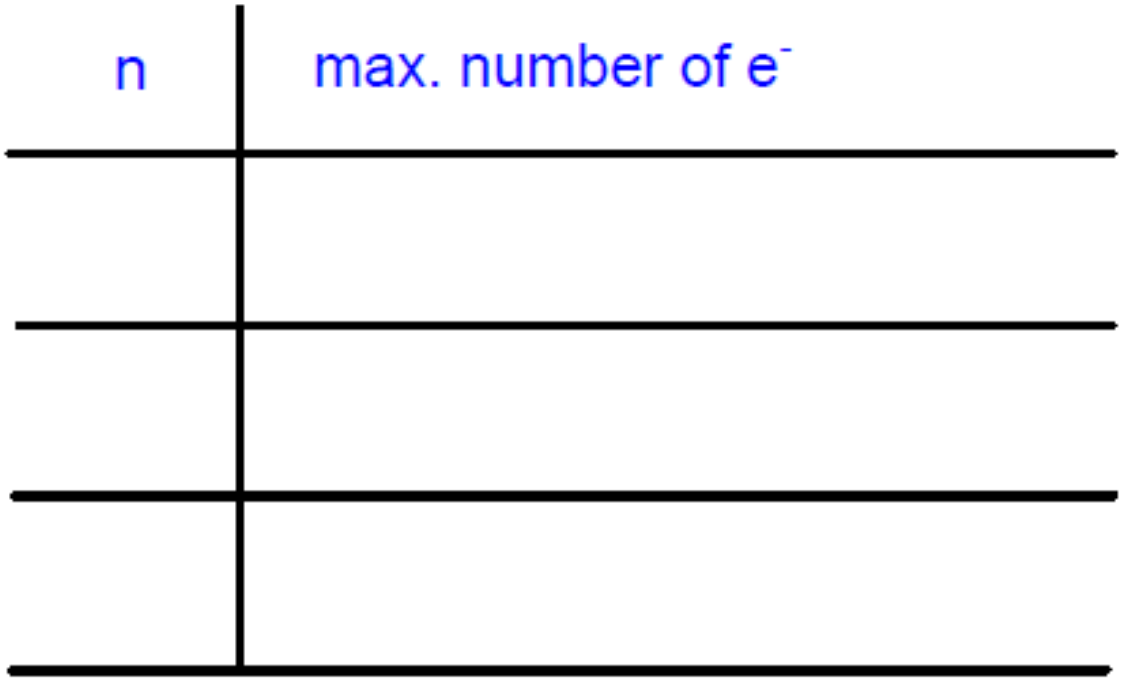
- Electrons wish to remain on the lowest possible energy level.

$n = 1, 2, 3, \ldots, n$



- Each energy level can be occupied by only a certain number of electrons.

- When one energy level is filled, the next energy level with higher energy begins to fill up.



5.1 Valence electrons

- The outermost electrons are called valence electrons and they determine the chemical properties of an element.

The group number in the periodic table equals the number of valence electrons in an atom.

5.2. Octet

- All atoms strives to an octet (= 8 electrons) on their outermost energy level.

- This structure has low energy and is therefore stable.

5.4 Ions

- The desire for an octet leads to so some atoms either donating (metals) or accepting (non-metals) electrons.

- When an atom loses electrons, a positive ion (= cation) is formed. Ex. sodium

- When an atom gains electrons, a negative ion (= anion) is formed. Ex. chlorine

	1	2	13	14	15	16	17	18
1	H •							He :
2	Li •	Be •	B •	• C •	• N :	• O :	: F :	: Ne :
3	Na •	Mg •	Al •	• Si •	• P :	• S :	: Cl :	: Ar :
4	K •	Ca •	Ga •	• Ge •	• As :	• Se :	: Br :	: Kr :
5	Rb •	Sr •	In •	• Sn •	• Sb :	• Te :	: I :	: Xe :
6	Cs •	Ba •	Tl •	• Pb •	• Bi :	• Po :	: At :	: Rn :
7	Fr •	Ra •						
	+1	+2	+3	±4	−3	−2	−1	

5.4.1 Positive ions (Cations)

Group 1	lithium sodium potassium
Group 2	magnesium calcium barium
Group 3 Other common cations	aluminium silver zinc hydrogen ammonium

5.4.2 Negative ions (Anions)

Group 6	oxide
	sulfide
Group 7	fluorine
	chlorine
	bromine
	iodine
Other common cations	nitrate
	sulfate
	carbonate
	hydrogencarbonate
	hydroxide
	phosphate

Consider the composition of the species W, X, Y and Z below. Which species is an anion?

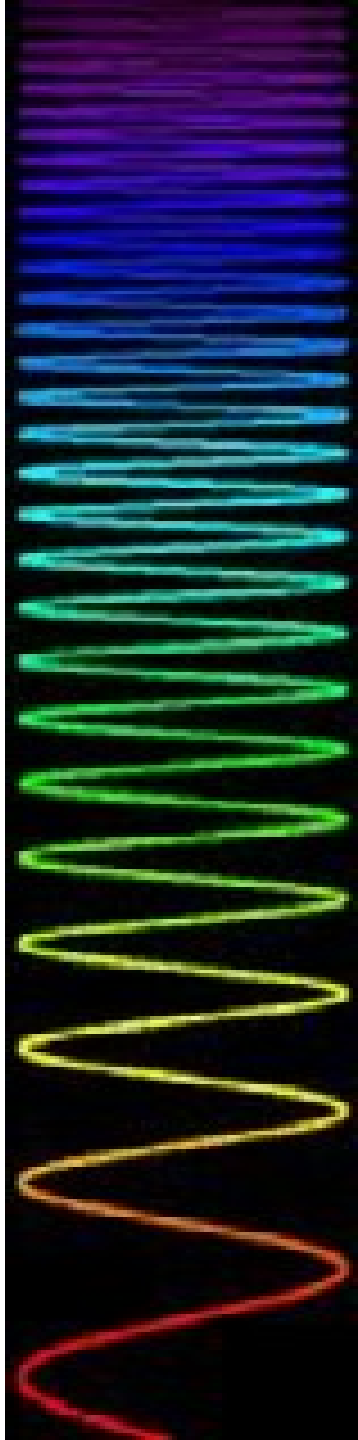
Species	Number of protons	Number of neutrons	Number of electrons
W	9	10	10
X	11	12	11
Y	12	12	12
Z	13	14	10

A. W
B. X
C. Y
D. Z

Demo: Flame test

- Metals often give different characteristic colours when heated strongly, e.g.

- K^+
- Pb^{2+}
- Cu^{2+}
- Ba^{2+}
- Na^+
- Ca^{2+}
- Sr^{2+}
- Li^+



6. Chemical bonding

The desire for an octet make atoms either

a) donating or accepting electrons
(= ionic bond) or

b) sharing electron pairs (= covalent bond)

6.1 Ionic compounds


+

→


element element chemical compound

https://www.youtube.com/watch?v=VBReOjo3ri8

- The formula of the ionic compound formed depends on the charges of the ions (which depends on the position of the element in the periodic table).
- The sum of the charges of the ions must be 0.

Li and F:

Ca and Cl:

Al and O:

Fe (II) and O:

6.2 Covalent bonding

- Atoms form covalent bonds by sharing 1-3 electrons if they can attain a noble gas structure by doing so.

- A molecule is a neutral group of atoms joined together by covalent bonds.

The number of valence electrons, hence the maximum number of bonds formed by the element, is deduced from the element's Lewis structure.

H and Cl:

H and O in water:

N and H in ammonia:

O and O:

H, C and N:

6.2.1 Covalent bonds

- Single bond: **One** shared electron pair with one electron from each atom.
- Double bond: **Two** shared electron pairs with two electrons from each atom.
- Triple bond: **Three** shared electron pairs with three electrons from each atom.

- Ex. Define the number of covalent bonds that the following non-metallic elements normally form.

  a) H

  b) C

  c) O

  d) F

  e) N

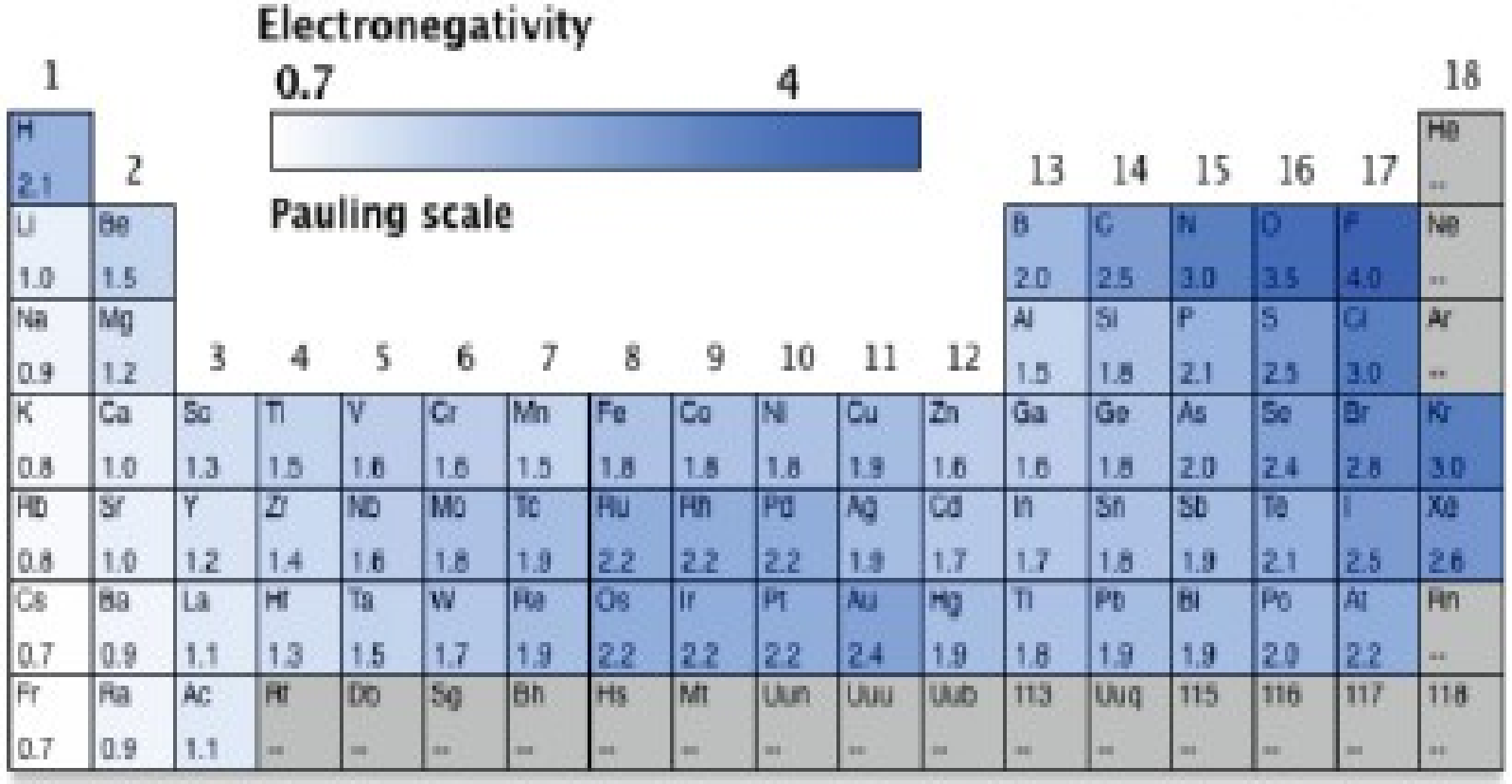
  f) Cl

  g) He

6.3 Electronegativity

- The electronegativities of the bonding elements determine whether the bond is ionic or covalent.

Electronegativity : a measure of an element's ability to attract a bonding pair of electrons.



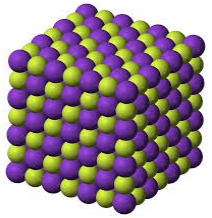
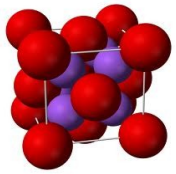
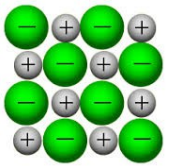
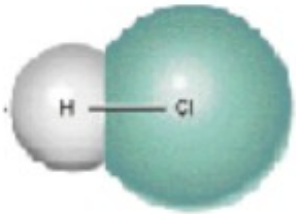
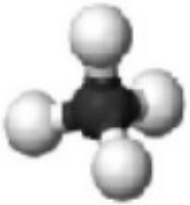
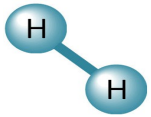
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 2.1																	He --
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne --
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar --
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2	Rn --
Fr 0.7	Ra 0.9	Ac 1.1	Rf --	Db --	Sg --	Bh --	Hs --	Mt --	Uun --	Uuu --	Uub --	113 --	Uuq --	115 --	116 --	117 --	118 --

Ce 1.1	Pr 1.1	Nd 1.1	Pm 1.2	Sm 1.2	Eu 1.1	Gd 1.2	Tb 1.2	Dy 1.2	Ho 1.2	Er 1.2	Tm 1.2	Yb 1.2	Lu 1.3
Th 1.3	Pa 1.5	U 1.7	Np 1.3	Pu 1.3	Am 1.3	Cm 1.3	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.5	Lr --

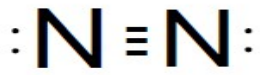
6.4 Bond polarity

- In a non-polar bond the electrons are shared equally
  - e.g.

- In a polar bond the electrons are shared unequally
  - *e.g. chlorine has a higher electronegativity value than hydrogen, and therefore attracts the bonding electrons more than hydrogen.*

Electronegativity Difference	Ionic Character %	Example	
3,2	92	KF	
Ionic bond			
2,6	82	Na_2O	
2,1	67	NaCl	
1,7			
Polar covalent bond			
0,9	19	HCl	
0,5			
0,4	4,0	CH_4	
Non-polar covalent bond		H_2	

6.4.1 Non-polar molecules



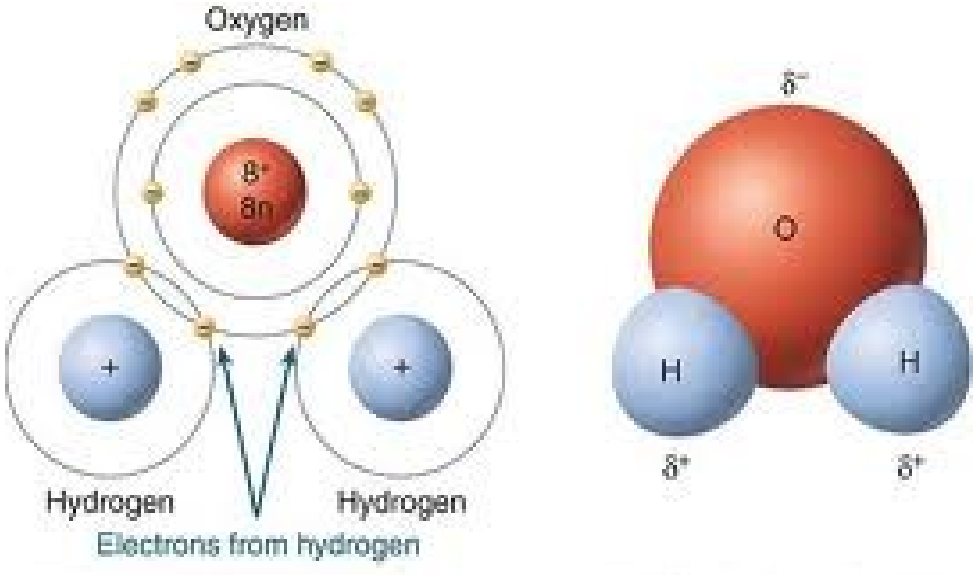
- *In a nitrogen molecule, the difference in electronegativites between the atoms is 0.*
- *The electron pairs in the covalent bond are shared equally between the two nitrogen atoms.*
- The bond is a <u>non-polar bond</u> and since the molecule has only non-polar bonds, it is a <u>non-polar molecule</u>.

- If polar bonds within a molecule cancel out, the molecule itself is non-polar.

$$O = C = O$$

6.4.2 Polar molecules

- In a polar molecule, some regions are slightly negative and some are slightly positive.
- A molecule that has two poles is called a dipolar molecule.



(a) Electron shells in a water molecule

(b) Distribution of partial charges in a water molecule

e.g. ammonia

- *In ammonia, the difference in electronegativities between nitrogen and hydrogen is 0,8.*
- *The more electronegative N draws the bond electrons toward itself and becomes slightly negatively charged. The hydrogen atom acquire a slightly positive charge.*
- The bonds are polar and the molecule becomes polar.

Ex. Which of the bonds is the most polar?
a) N - S b) Si – I c) N - Br d) C – Cl

Ex Which of the bonds is the least polar?
a) Hg – I b) P – I c) Si – F d) Mg – N

Ex. Determine which of the following compounds are molecules:

$NaCl$

BF_3

$CaCl_2$

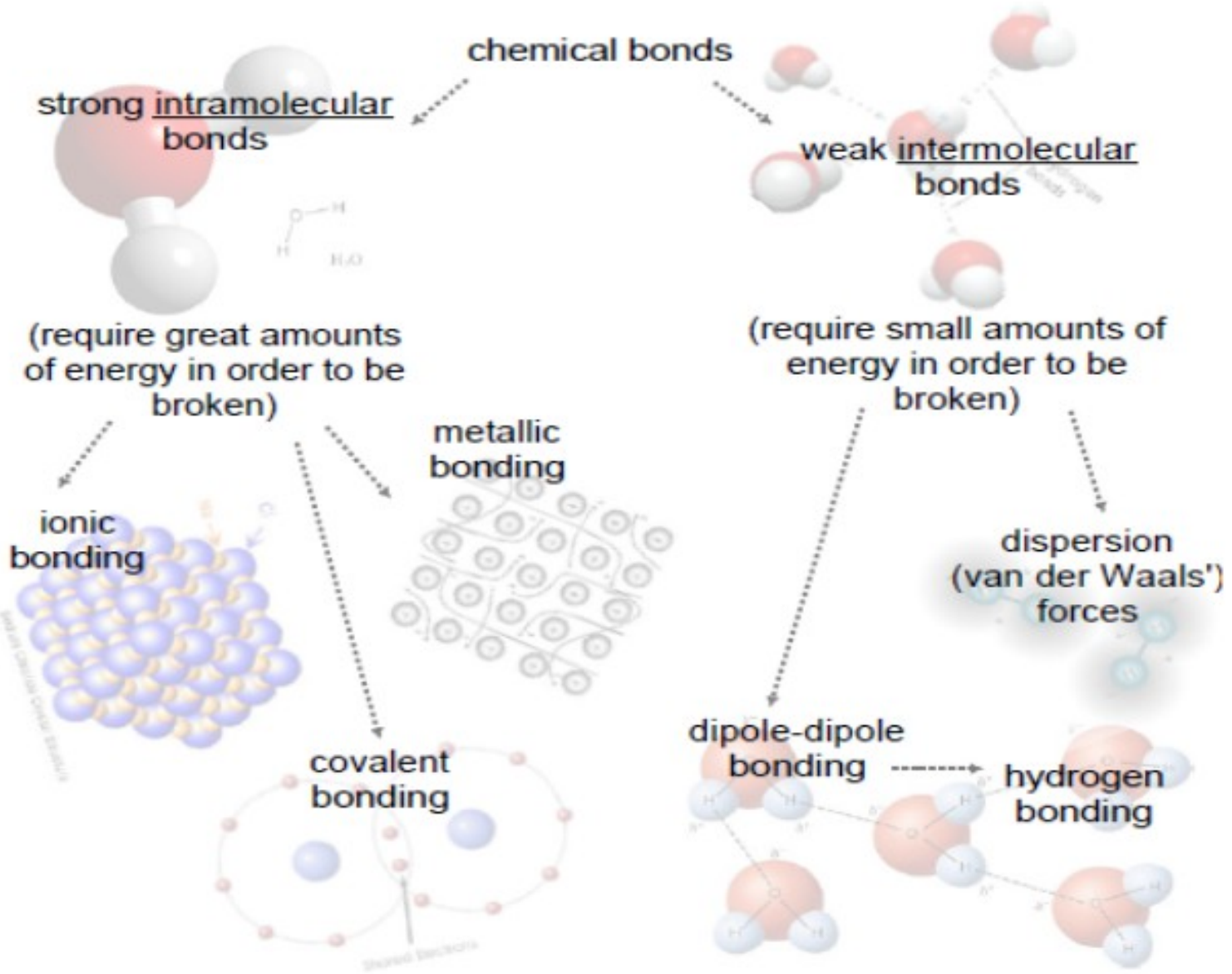
N_2O

P_4O_6

FeS

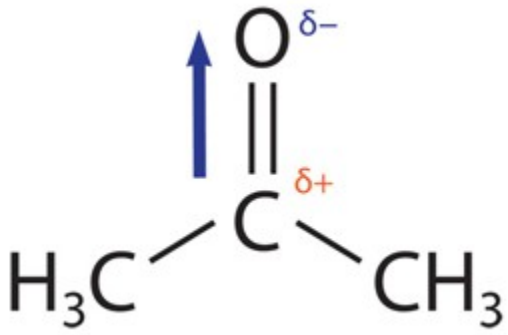
CBr_4

7. Weak intermolecular bonds



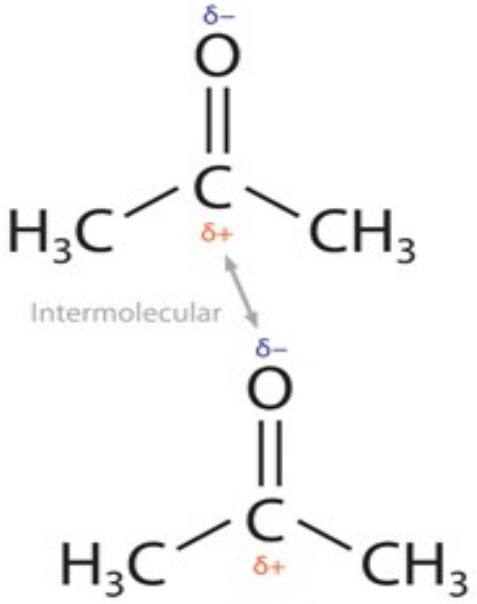
Acetone


Compare to Cutex®
equate
Regular
Nail Polish
Remover
protein enriched
for natural nails
10 FL OZ
(295 mL)

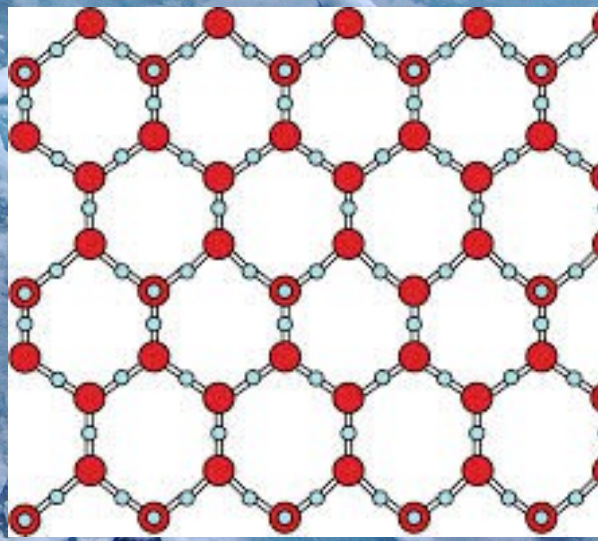

O
δ−
δ+
C
H3C
CH3

7.1. Dipole- dipole bonding

- The negative pole of one polar molecule is attracted to the positive pole of another polar molecule.



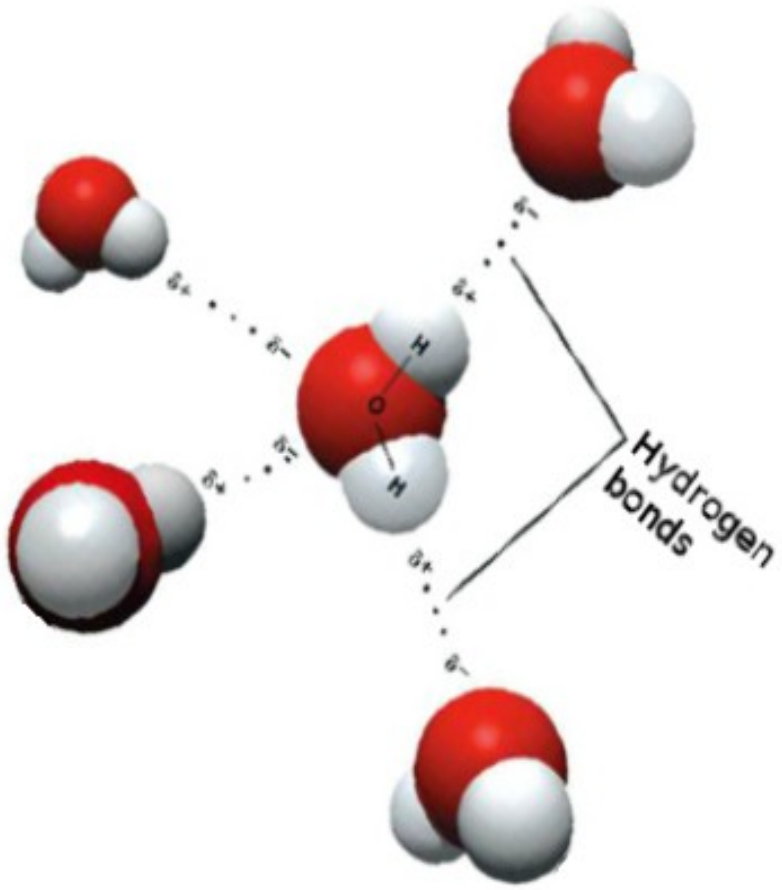
Water



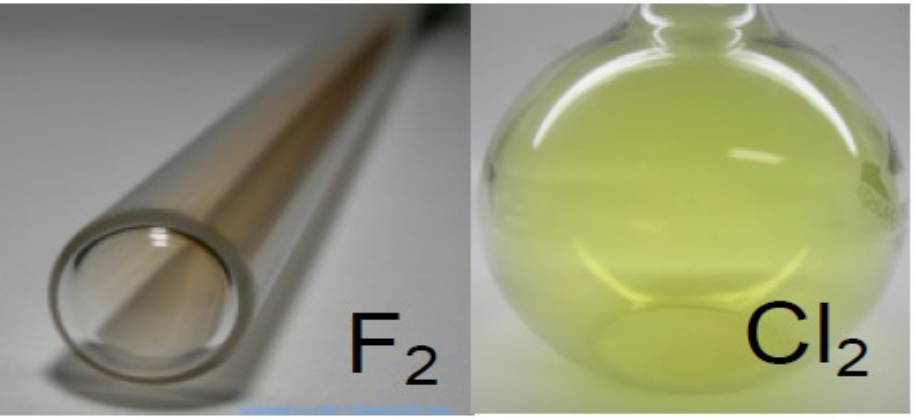
7.2 Hydrogen bonding

- Hydrogen bonds are a specific case of dipole-dipole bonds.

- They occur in molecules that have hydrogen directly bonded to oxygen, nitrogen or fluorine.




Neon
Lights

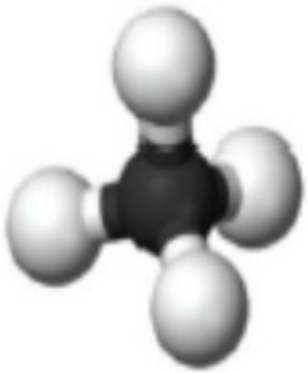

F_2
Cl_2


Br_2


I_2

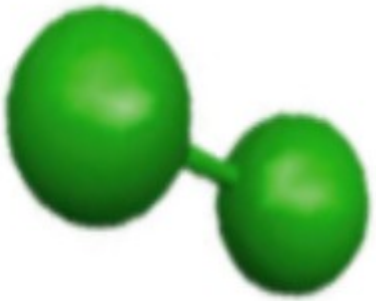
7.3 van der Waals´forces

- Between non-polar molecules there are only very weak van der Waals´forces (or dispersion forces).



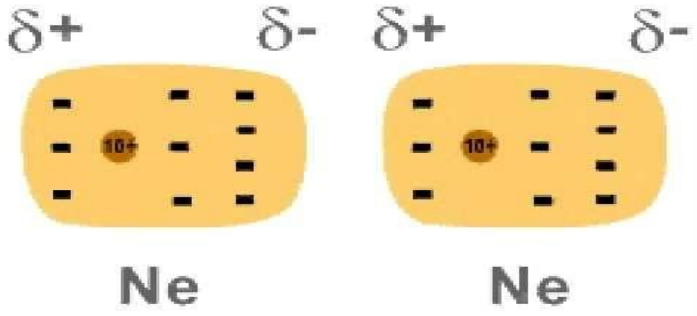
CH_4

CO_2



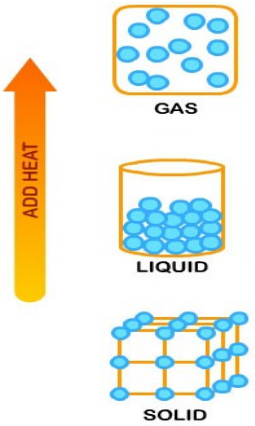
Cl_2

- *Van der Waal´s forces are due to the motions of electrons, which causes temporary dipoles.*
- *These forces generally increase in strength as the number of electrons in a molecule increases.*
- *These forces are so weak that non-polar molecules have low boiling-points (many of them are gases at room temperature).*



http://www.youtube.com/watch?v=3t1Jn_jrsQk

Summary



Ionic compounds
Strong ionic bonds between positive ion (=cations) and negative ions (=anions)

e.g. KF, Na_2O, NaCl

Metals
Strong metallic bonds between the metal atoms

e.g. Mg, Fe, Na, Ni

Molecules
Strong intramolecular covalent bonds between the atoms in the molecule

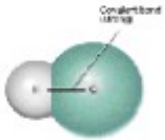
Atoms
The noble gases exist as single atoms

e.g. He, Ne, Ar, Kr, Xe, Kr

Polar molecules
e.g. H_2O, NH_3, HCl

Non-polar molecules
e.g. H_2, N_2, O_2, S_8, CH_4, CO_2

weak intermolecular dipole-dipole bonding
e.g. HCl



weak intermolecular hydrogen bonding

if H is directly bonded to O, N or F in a molecule
e.g H_2O, NH_3, HF

weak intermolecular van der Waals' forces