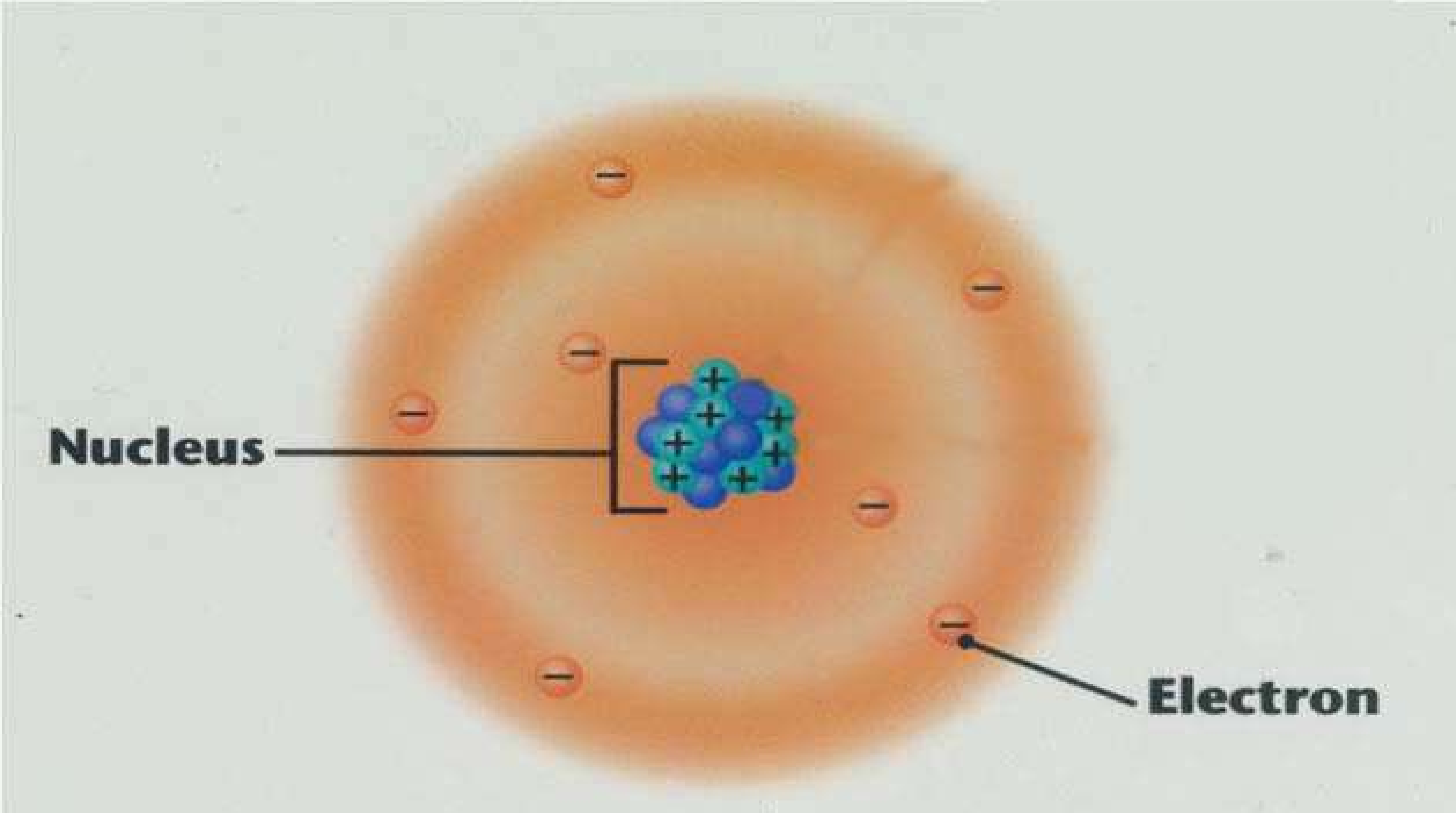
CHEMISTRY!!!

Part One:

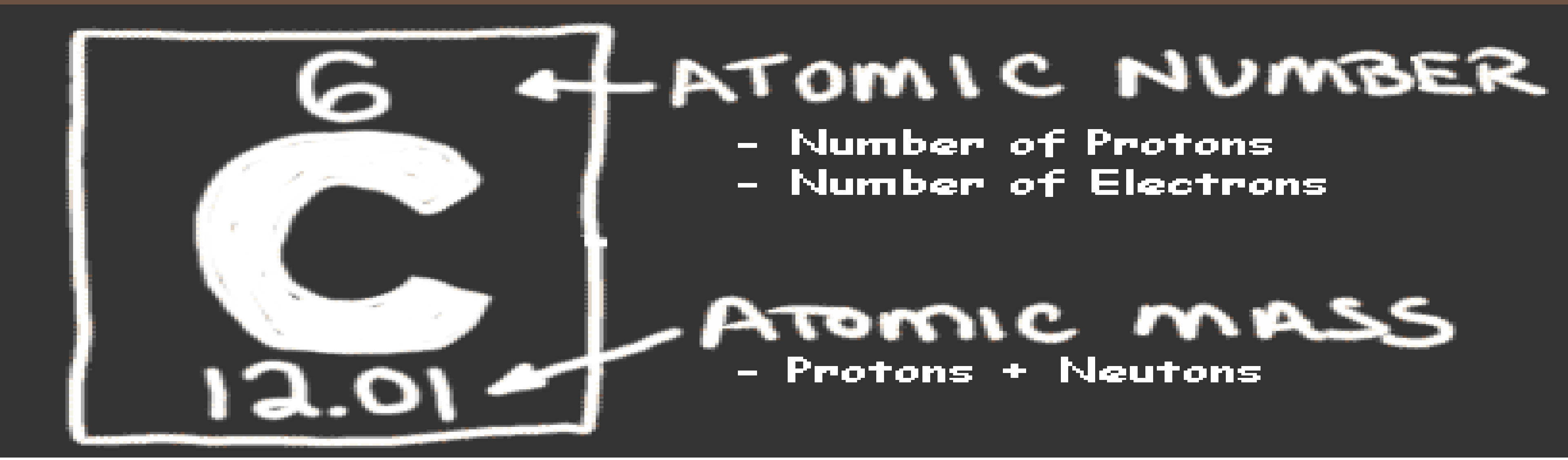
The Basic Atom
The Periodic Table

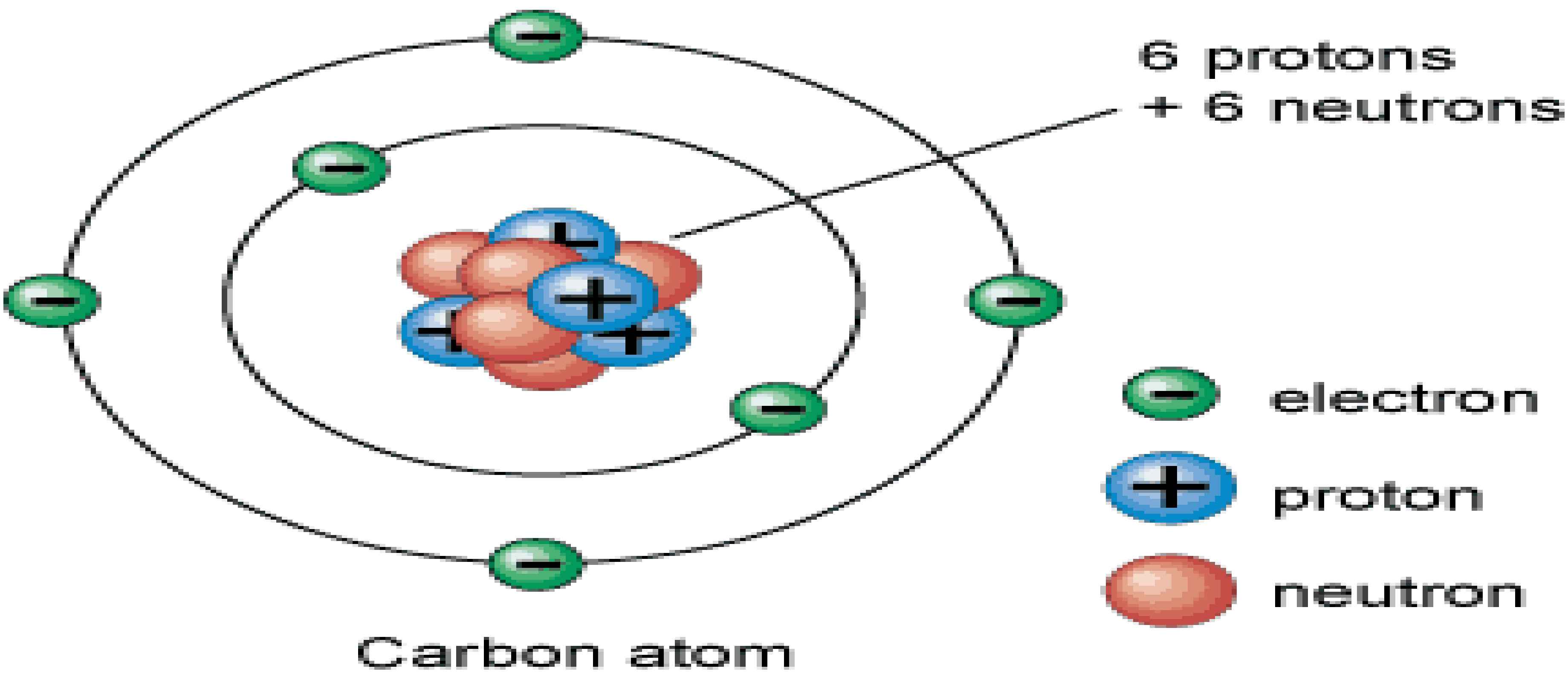
The Basic Atom



Basic Atom Vocabulary

- **Nucleus** - The very dense region, consisting protons and neutrons, at the center of an atom.
- **Proton** - A subatomic particle in the nucleus with a positive (+1) electric charge.
- **Neutron** – A subatomic particle in the nucleus with no charge (+0). (It is neutral)
- **Electron** – A subatomic particle ***<u>outside</u>*** of the nucleus with a negative (-1) charge.


6
C
12.01
ATOMIC NUMBER
- Number of Protons
- Number of Electrons
ATOMIC MASS
- Protons + Neutons


6 protons
+ 6 neutrons
electron
proton
neutron
Carbon atom

Basic Atom Vocabulary

- **Atomic Number** – The number of protons in the nucleus of an atom.
- In its normal state an atom will have the same number of electrons as it has protons.
- **Atomic Mass** – The number of protons + neutrons in the nucleus of an atom.

The Periodic Table Vocabulary

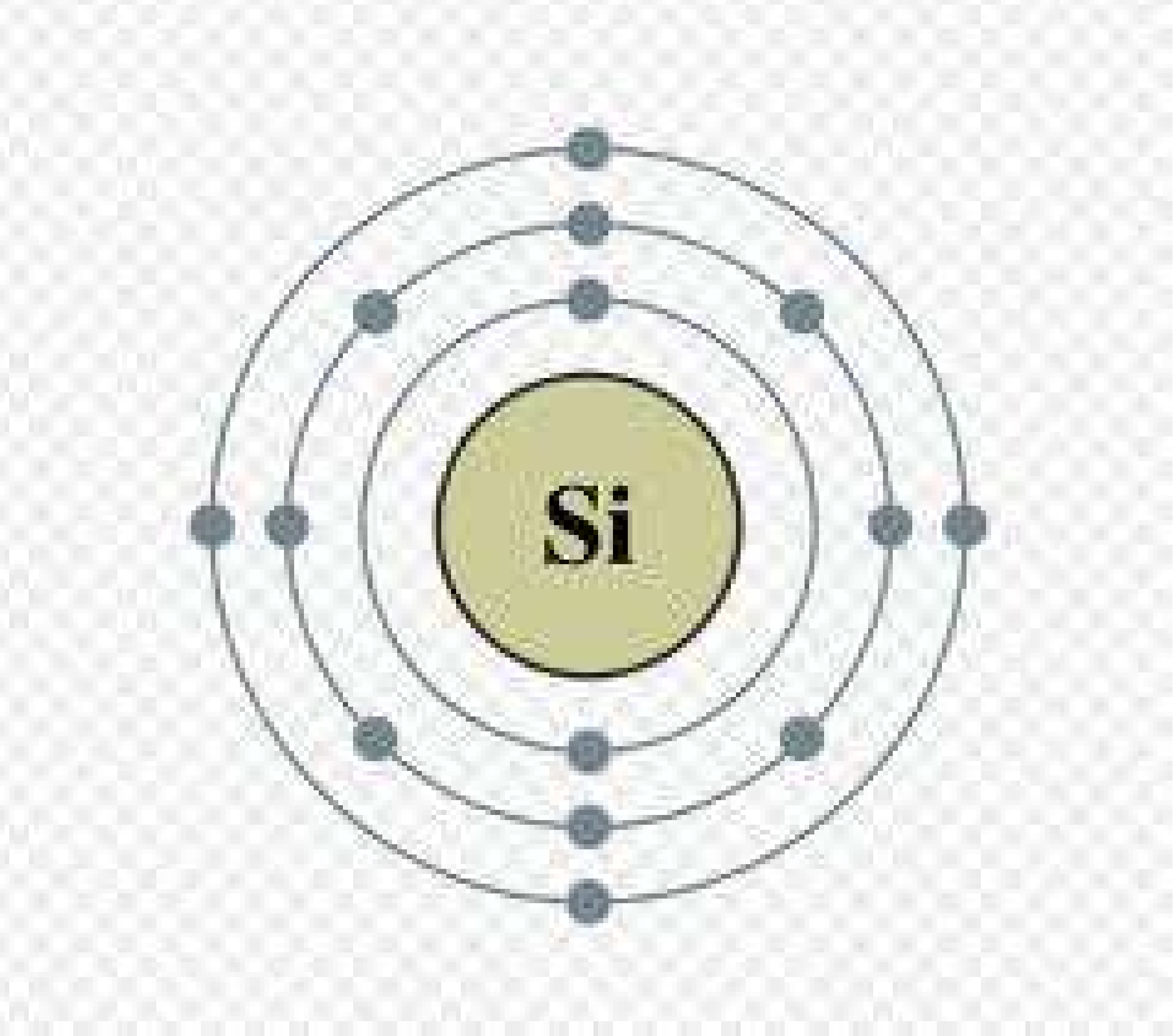
- Periods – Each row in the periodic table is called a ‘period.’

- Groups (Families) – Each column in the periodic table is called a group or family.

Periods

- Atoms, like onions, have layers of electrons.
- Each period represents another electron shell.
- Period one elements have one electron shell, period two elements have two electron shells… etc.

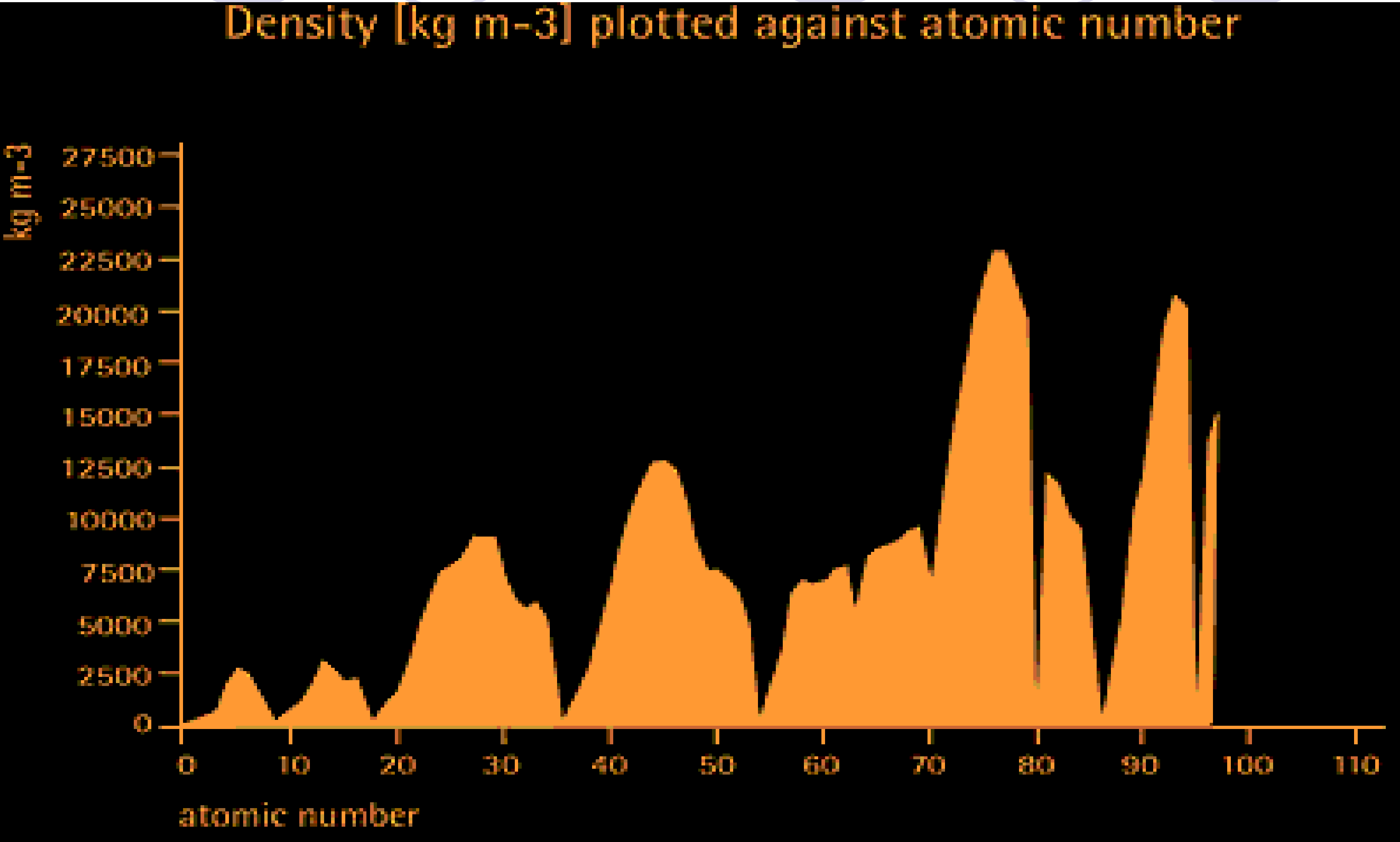
Silicon is in the third period so it has three layers of electrons surrounding it.



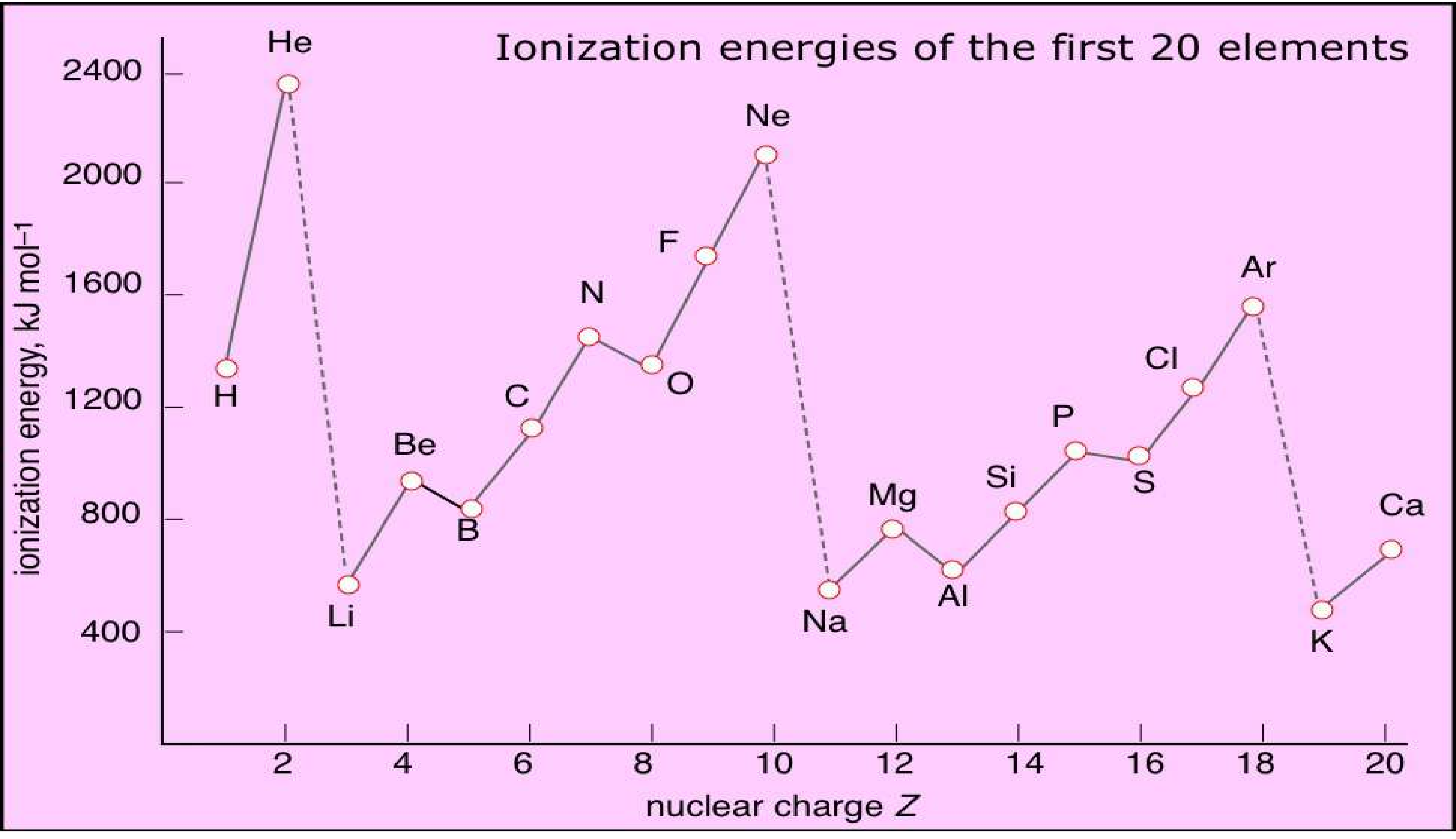
The properties of elements repeat every period.

- They repeat ‘periodically’ hence the name “Periodic Table”

What happens to density as you move across periods?



What happens to ionization energy as you move across a period? (Ionization energy means 'how hard is it to knock an electron off of the atom')

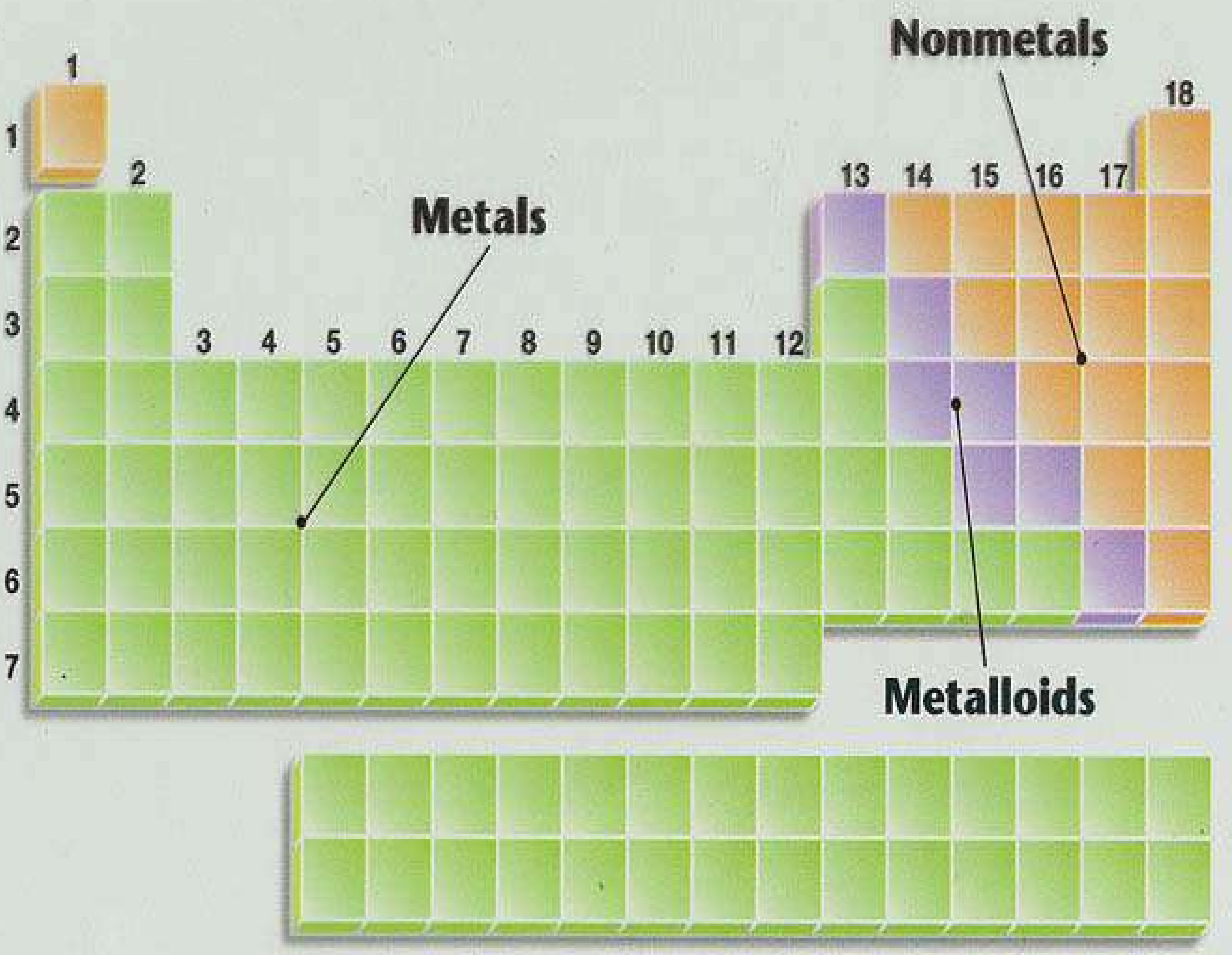


Groups/ Families

- Elements in a family share similar physical and chemical properties.
- Example: All group one metals will have the same reaction in water.
- $Li + H_20 \rightarrow LiOH + H_2$
- $Na + H_20 \rightarrow NaOH + H_2$
- $K + H_20 \rightarrow KOH + H_2$

The Periodic Table Vocabulary

- Metals - Like to bond with non-metals
- Non-Metals – Like to bond with metals.
- Metalloids – Have properties of metals and non-metals. Are known to bond with either.



Nonmetals
Metals
Metalloids
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Periodic Table

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 23.00	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 Ac 227.0	104 Rf (261)	105 Ha (262)	106 Unh (263)	107 Uns (262)		109 Une (267)									

Lanthanides	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinides	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Part Two:

Physical and Chemical Properties
Basic Chemistry Vocabulary

What are the chemical and physical properties associated with **metals**, **non-metals**, and **metalloids**?

Physical Properties:

- Physical properties can be observed without fundamentally changing the identity of the substance.
- You can test any physical property of a substance without destroying it.
- Examples of physical properties:
  - Density
  - Malleability
  - Hardness
  - Boiling Point
  - Freezing Point
  - Conductivity

Chemical Properties

- Chemical properties can only be observed during a chemical change which will change the identity of the substances.
- Once a substance goes through a chemical change it is ‘forever’ altered.
- Examples of chemical properties:
  - Flammability
  - Reactivity

Physical Properties vs. Chemical Properties

- No new substances are made during physical changes.
- New substances are made during chemical changes

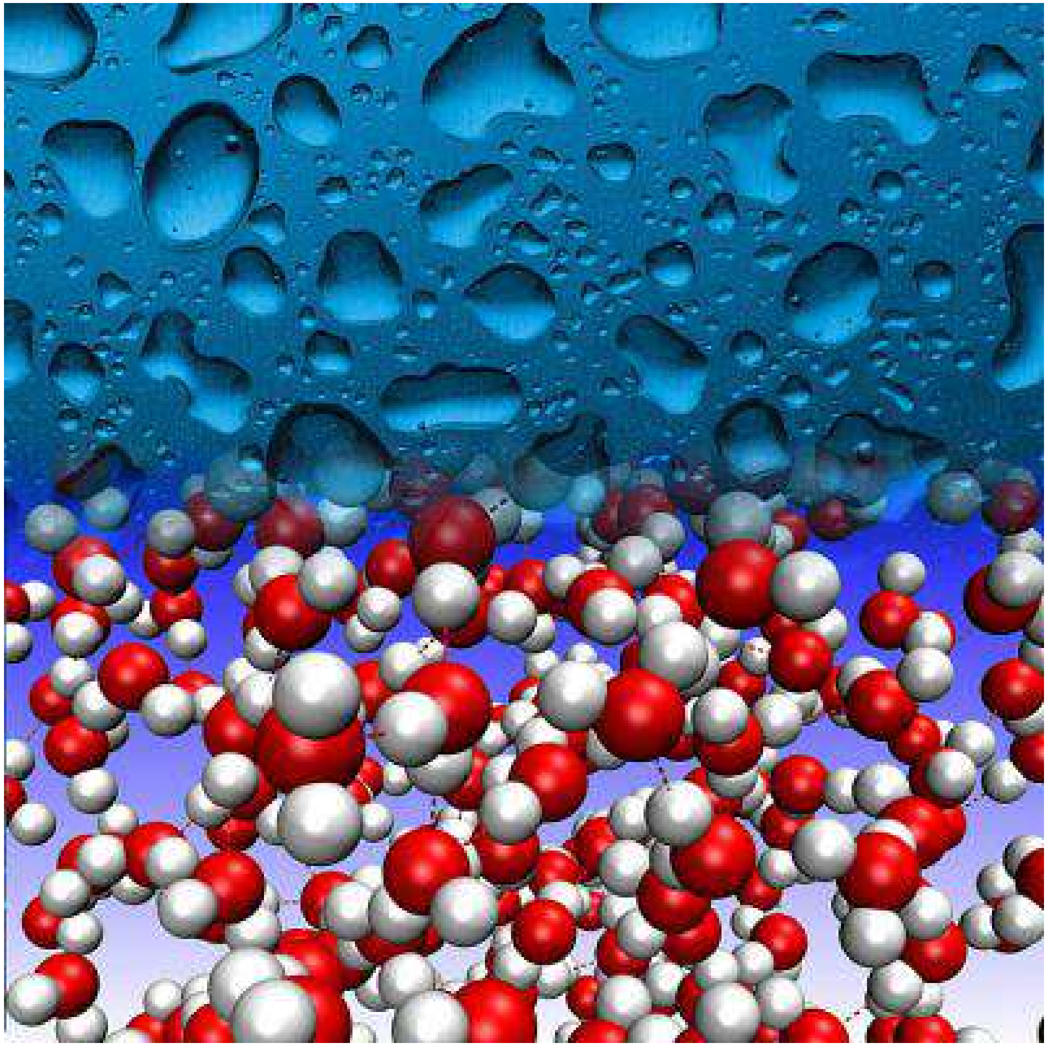
Basic Chemistry Vocabulary

- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

SUBSTANCE

- Something with uniform and unchanging composition.
- Examples:
  - Pure water – any sample you take will be H_2O molecules.
  - Pure Gold – Cut off any chunk and it will be made of gold atoms.

Any sample of gold will be made of gold atoms, any sample of water will be made of water molecules.



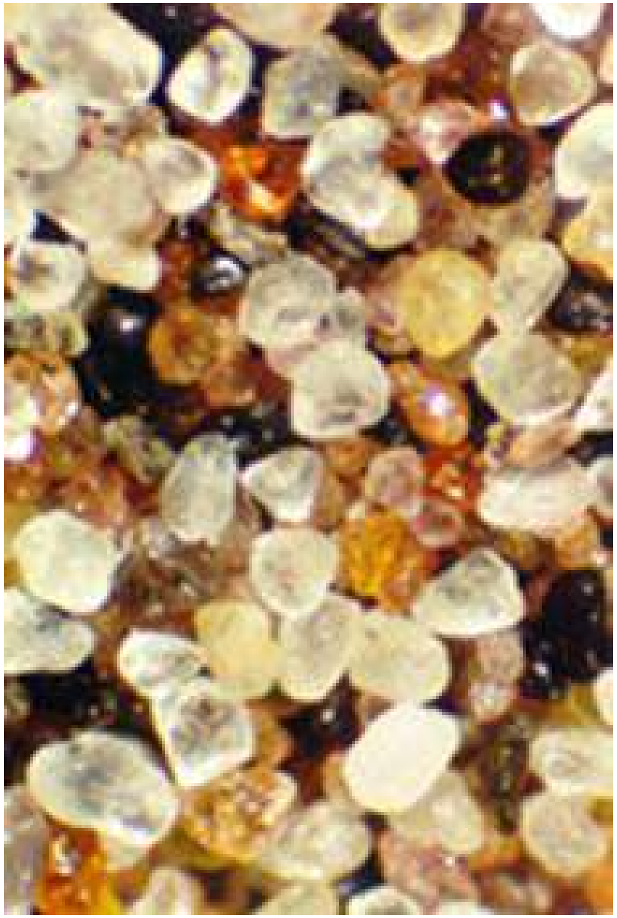
MIXTURE

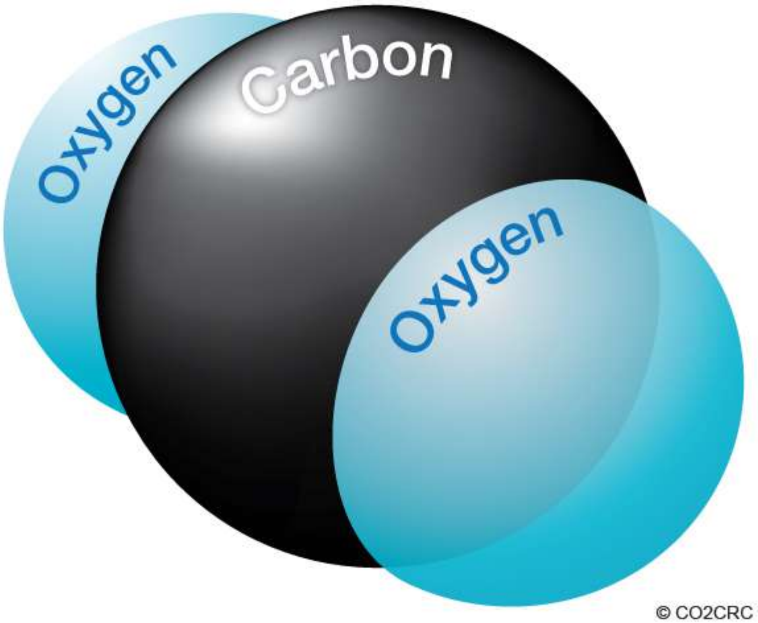
- A material composed of two or more substances that are ***not chemically combined***.
- Substances in a mixture can be separated using their physical properties.

Mixtures

- Example:
  - **Sand** is not made of one thing, it **is a mixture** of many tiny pulverized rocks that are in no way connected.
  - **Carbon Dioxide** is not made of one thing either, it is made of Carbon and Oxygen which are chemically combined and **cannot be separated**, hence it **is not a mixture.**

Mixtures can be separated, Molecules Cannot.





ELEMENT

- Basic substance on the periodic table.
- An element is as simple as a substance can get.
- Elements combine to make more complicated substance.

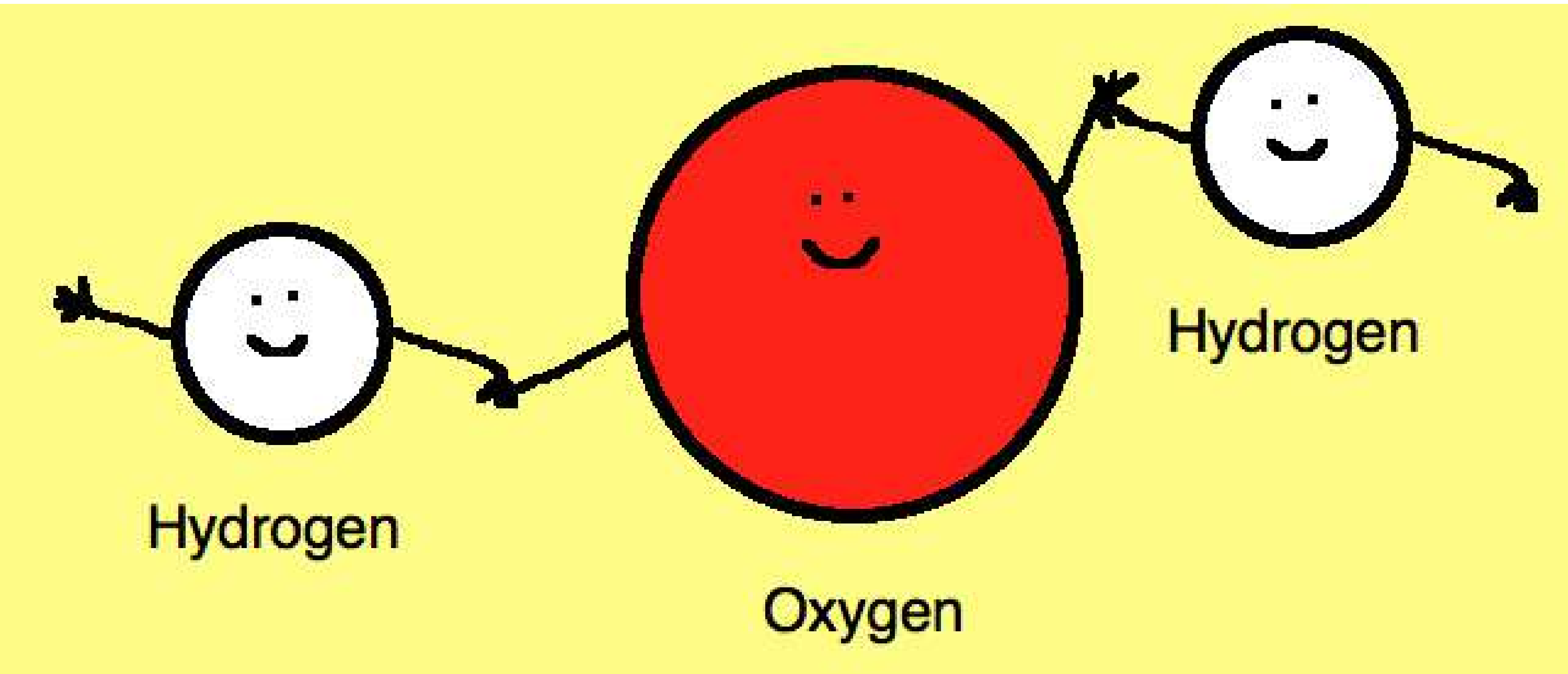
ATOM

- **The smallest piece of an element.**
- Cannot be divided any farther.
- A block of silver can be cut in half again and again until you have only one silver atom. If this atom is divided further it will no longer be silver.

MOLECULAR FORMULA

- Describes the type & number of elements in a molecule.

Three Atoms, Two Elements, One Water Molecule.



Molecular Formula = H_2O

MOLECULE

- Molecule – Two or more **atoms** joined by chemical bonds (all compounds are molecules).
- Examples:
  - CO_2 – Carbon dioxide
  - H_2O – Water
  - CH_4 – Methane
  - $C_{12}H_{22}O_{11}$ – Table Sugar

COMPOUND

- Two or more **elements** joined by chemical bonds.
- All compounds are molecules.
- Not all molecules are compounds.
- Example:
  - Oxygen molecules (O_2) have only oxygen in them. Since there is only one kind of element it is molecule but not a compound.

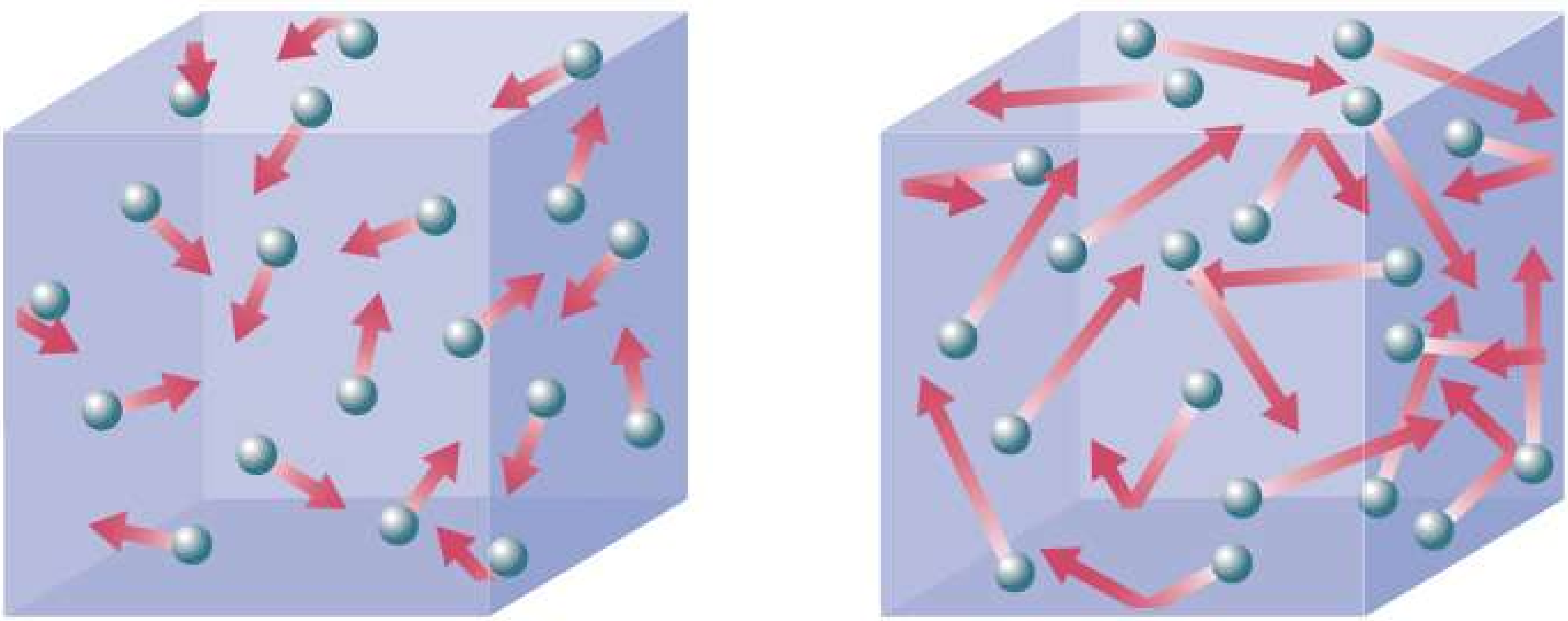
Part Three:

States of Matter
and Phase Changes

State of Matter

- The three states of matter are:
  - **Solid**
  - **Liquid**
  - **Gas**
- Most pure substances can exist in any of the three states.
- The Physical State of matter is related to temperature.

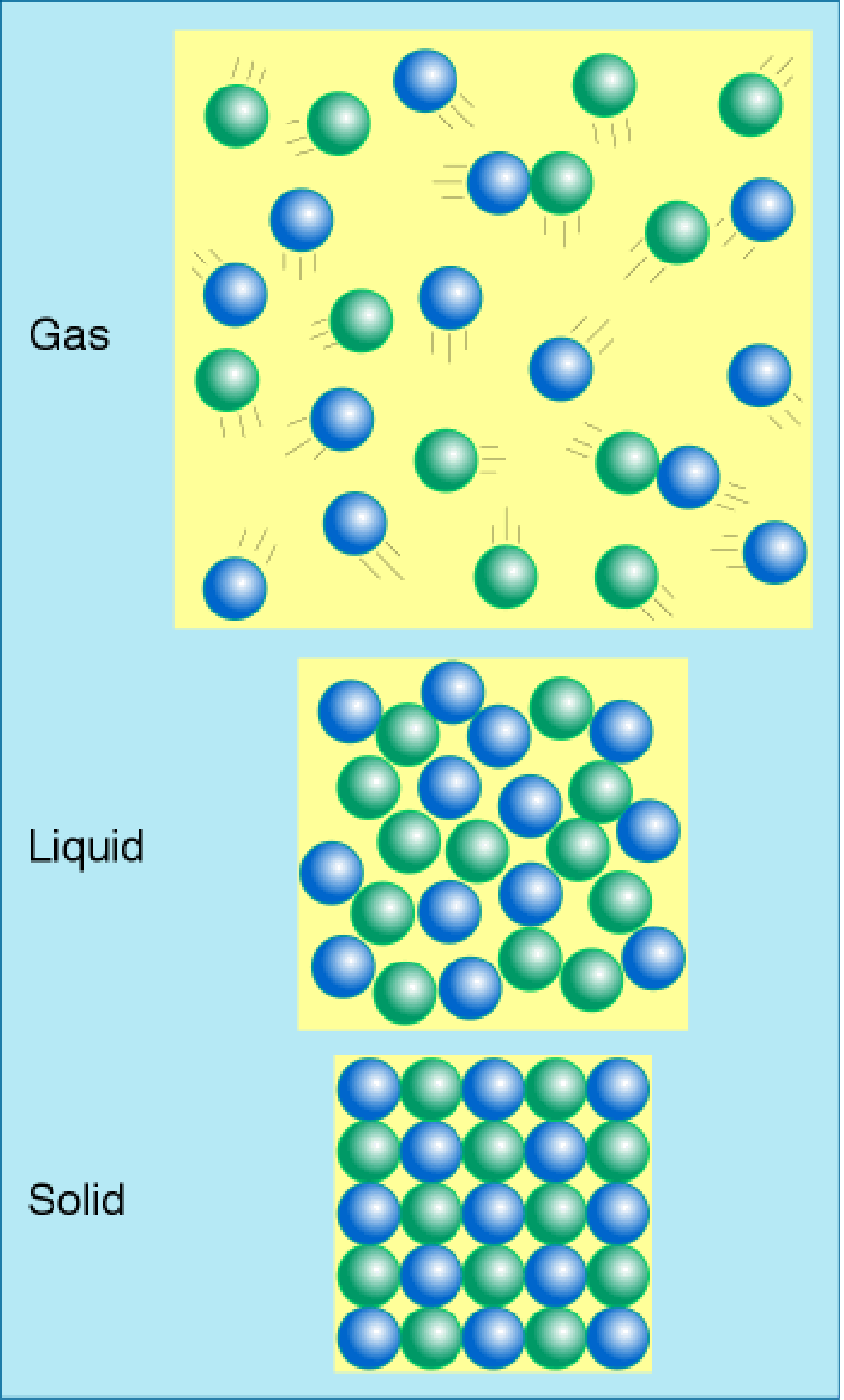
Particles of Hot air move faster than particles of Cold air.



Longer arrows mean higher average speed.

Temperature and State of Matter

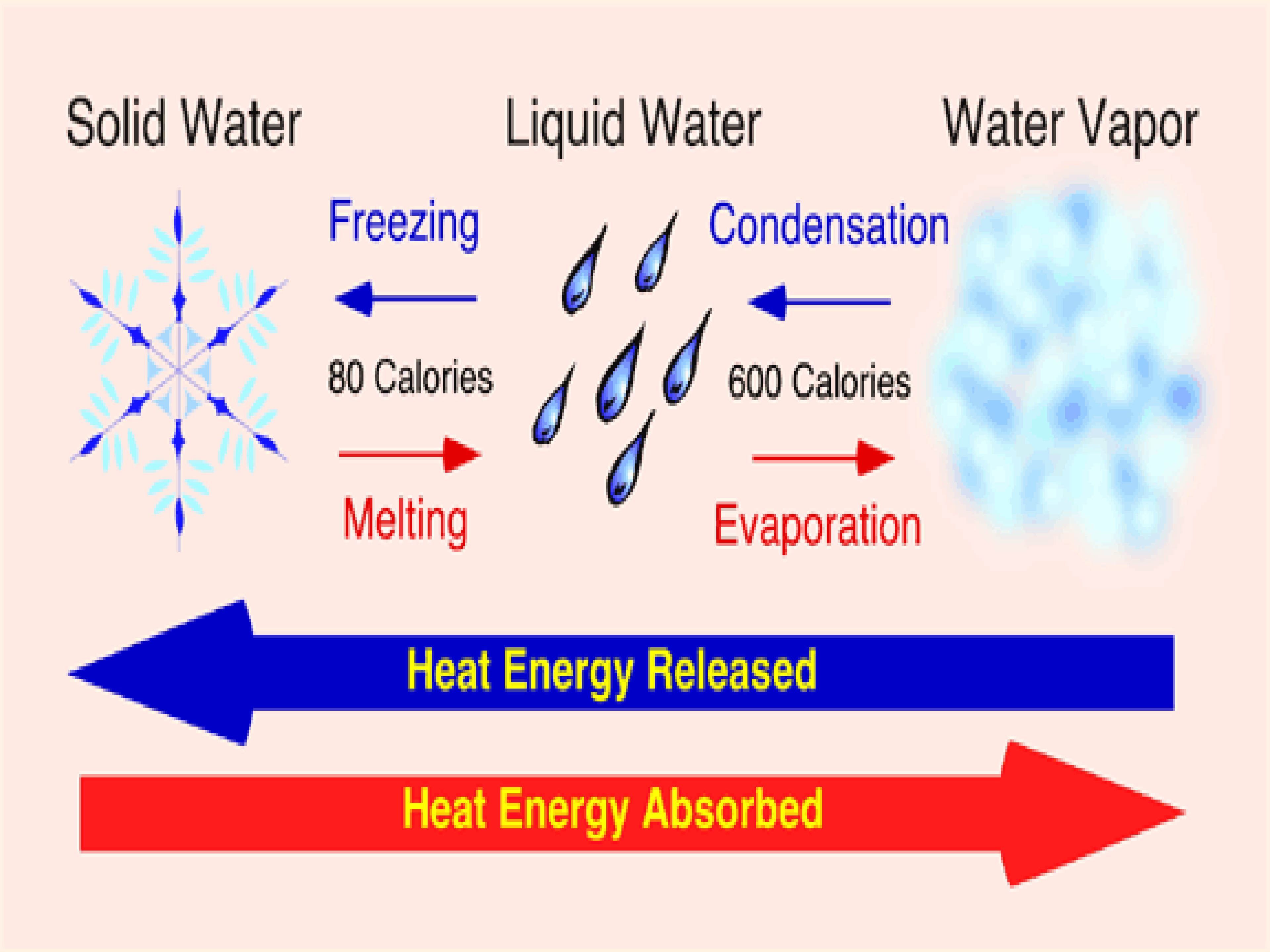
- The hotter a substance is, the faster its particles move.
- Eventually the particles in a **solid** substance vibrate so much that the substance **liquefies**.
- If the **liquid** particles continue to heat up, they will eventually have enough speed to fly away and evaporate becoming **gas**.



- **Gas** particles are moving too fast to stick together.
- Particles in a **liquid** are rolling over each other and mixing. They still have too much kinetic energy to form a uniform structure.
- Particles in a **solid** still vibrate, but their order remains consistent

Phase Changes and Energy

- Substances change from one state to the other when energy flows into or out of the substance.
- This is called a **Phase Change.**


Solid Water
Liquid Water
Water Vapor
Freezing
Condensation
80 Calories
600 Calories
Melting
Evaporation
Heat Energy Released
Heat Energy Absorbed

Temperature and Phase Change

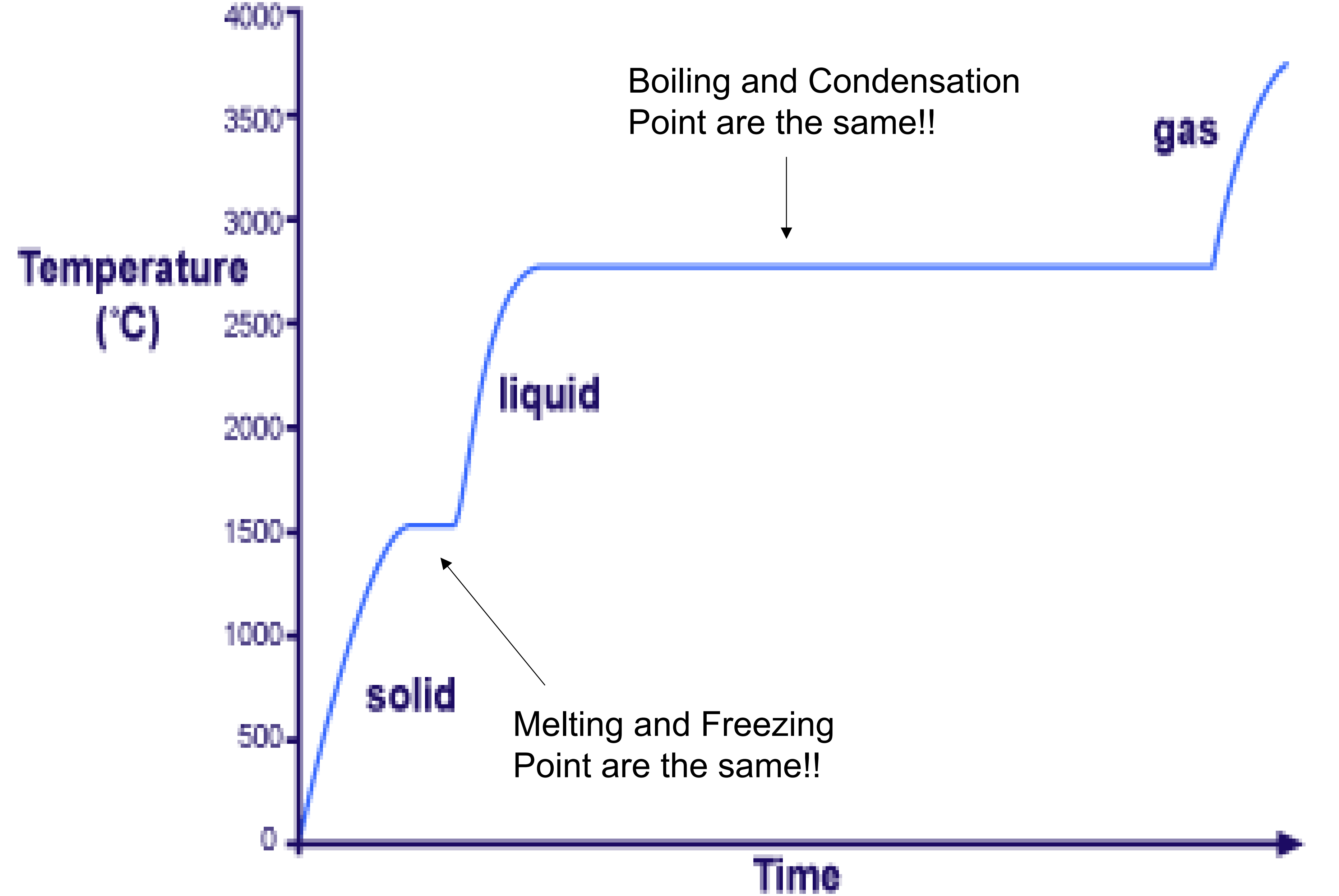
- Melting Point – The temperature where a solid substance becomes liquid.
- Sublimation Point – The temperature where a solid substance becomes gas.
- Freezing Point – The temperature where a liquid substance becomes solid.
- Boiling Point – The temperature where a liquid substance becomes gas.
- Deposition Point – The temperature where a gaseous substance becomes solid.
- Condensation Point – The temperature where a gaseous substance becomes liquid.

Iodine and Carbon Dioxide both undergo unusual phase changes near room temperature.

Put the following terms in order from hottest to coldest:

- Melting Temperature
- Boiling temperature
- Freezing Temperature
- Condensation temperature

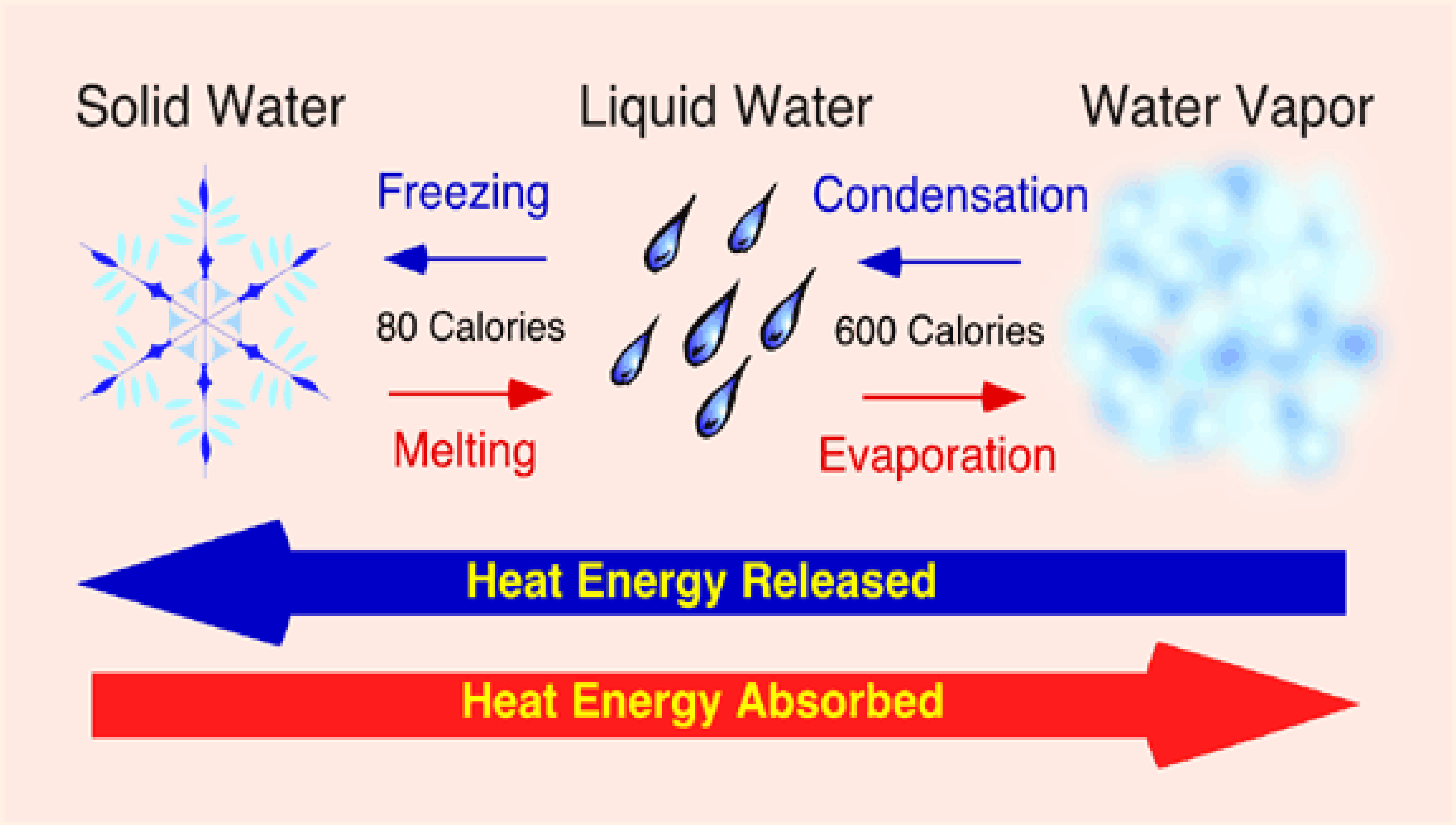
The temperature of a substance CANNOT move beyond a specific temperature until it has completely changed from one phase to another!!


Boiling and Condensation
Point are the same!!
gas
4000
3500
3000
Temperature
(°C)
2500
liquid
2000
1500
1000
solid
Melting and Freezing
Point are the same!!
500
0
Time

Energy Flow and Phase Change

- The Boiling point and Condensation point of a substance are identical.
- Melting point and Freezing point of a substance are identical.
- Water has a freezing point of 0° degrees Celsius.
- If water freezes ***and*** melts at zero degrees why does it change at all?

Whether a substance melts or freezes depends on whether energy is flowing into it or out of it.



Energy Flow and Phase Change

- When a phase change occurs energy flows into or out of a substance.
- When this happens the substance is called the ***system*** and the rest of the universe is called the ***surround***.
- When ice melts, heat energy is flowing from the **surround** (the air) into the **system** (the ice).

Part Four:

Conservation of Mass
Chemical Equations

The Law of Conservation of Mass

- Mass in the Universe remains constant.
- During a chemical reaction **MASS CANNOT BE CREATED OR DESTROYED.**
- In a chemical reaction the mass of the **products** must equal the mass of the **reactants**.

Chemical Equations

- Chemical Equations show the molecular formulas for the **Reactants** and the **Products**.
- **Reactants** are the substances you start with.
- **Products** are the new substances formed during the chemical reaction.

Example Chemical Equation

- The combustion of ethanol.
- $C_2H_6O + O_2 \rightarrow CO_2 + H_2O$
- Ethanol and Oxygen React to form Carbon Dioxide and Water.
- Which substances are products and which are reactants?

Conservation of Mass
Work Sheet

Combustion of Ethanol: Skeleton Equation.

$$C_2H_6O + O_2 \rightarrow CO_2 + H_2O$$

A skeleton equation is a chemical equation that is **UNBALANCED**.
Currently this equation breaks the law of conservation of mass.

Balancing Chemical Equations

- Start with the skeleton equation. None of the molecular formulas can be changed from this point on, only the number in front of each molecule (the coefficient) can be changed.
- Choose an element on one side of the equation.
- Count the number of atoms on the product and the reactant sides of the equation.
- If there is a different number on one side, try changing the coefficient in front of the substance on the other side.

Example: Balancing an equation

$$C_2H_6O + O_2 \rightarrow CO_2 + H_2O$$

The reactant side of the equation has two black carbons and the product side has only one. Where did the other carbon go?

You can change the coefficients, but you cannot change the molecular formula

- Example:
- $C_2H_6O + O_2 \rightarrow C_{\mathbf{2}}O_2 + H_2O$
- NO!!! You **Cannot** Change the molecular formula!! Carbon dioxide is the product, not "$C_{\mathbf{2}}O_2$".
- $C_2H_6O + O_2 \rightarrow 2CO_2 + H_2O$
- YEA!! You **Can** change the number of carbon dioxides. Now we have two carbons on both sides of the equation.
- Notice that we have also increased the number of oxygen atoms.

Combustion of Ethanol: Balanced Equation.

$$C_2H_6O + 3O_2 \rightarrow 3H_2O + 2CO_2$$

Notice that only the number of each substance has changed, NOT the identity of the substances.

Part Five:

Electron Shells
Chemical Bonding

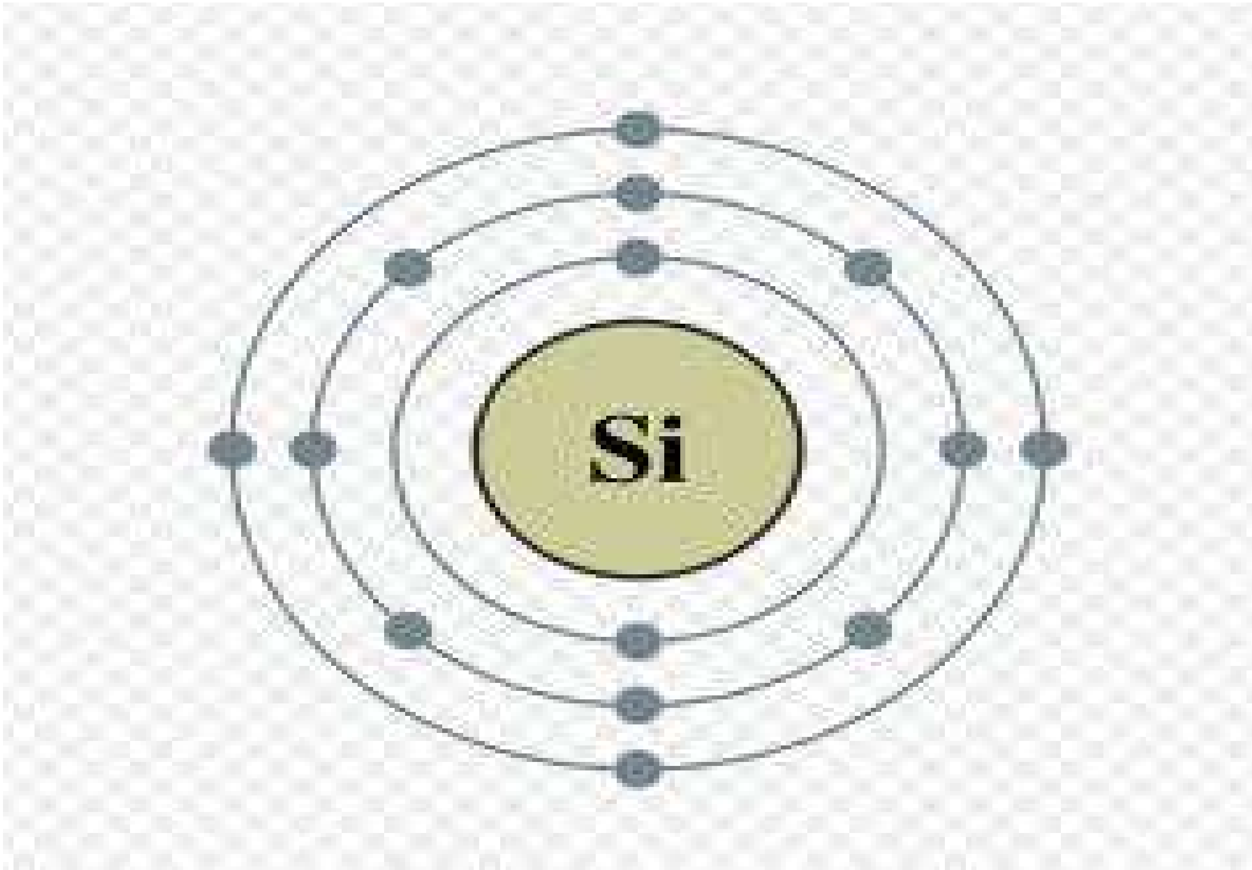
Chemical Bonding:

- Atoms can attach to one another with a CHEMICAL BOND.
- Chemical reactions occur when atoms bond together to form CHEMICAL BONDS.
- Atoms bond together to get a FULL VALENCE ELECTRON SHELL.

Electron Shells

- Atoms are surrounded by shells of electrons.
- Each period on the periodic table represents another electron shell.
- Most electron shells hold 8 electrons (except for energy level one which only holds 2 electrons).
- The outermost electron shell is called the **VALENCE SHELL**.

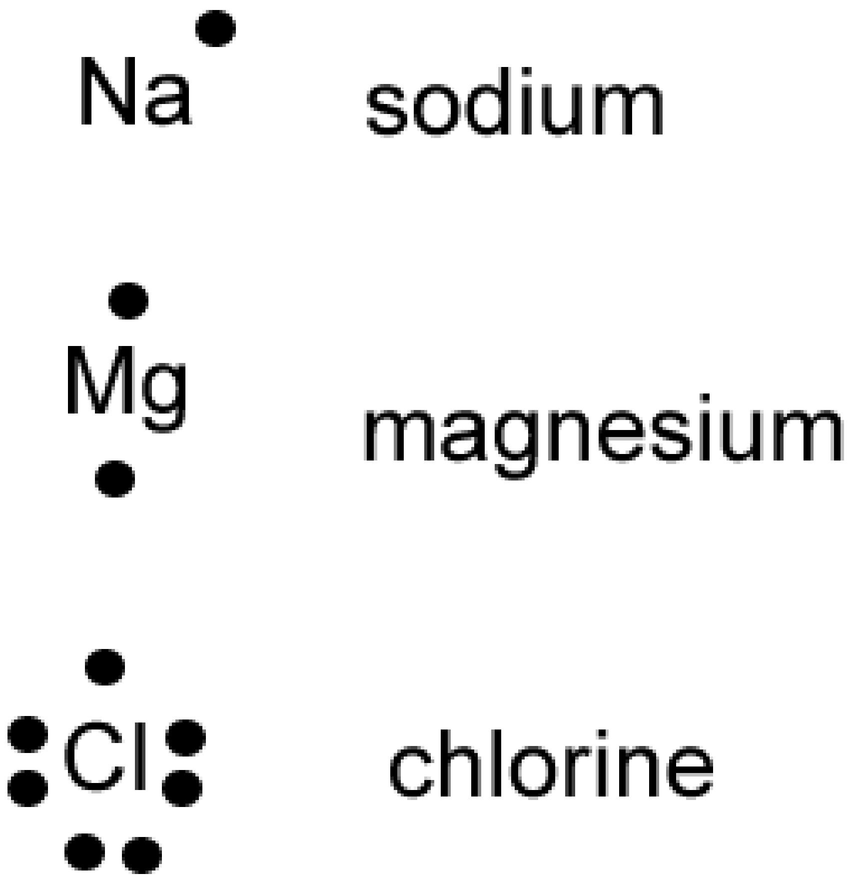
Silicon is in the third period so it has three layers of electrons surrounding it.



Silicon has Four electrons in its **VALENCE SHELL**

Electron Shells Work Sheet

Electron Dot Pictures.



- Electron dot pictures, or "Lewis Dot Structures" show you **how many electrons are in the valence shell** of a given element.

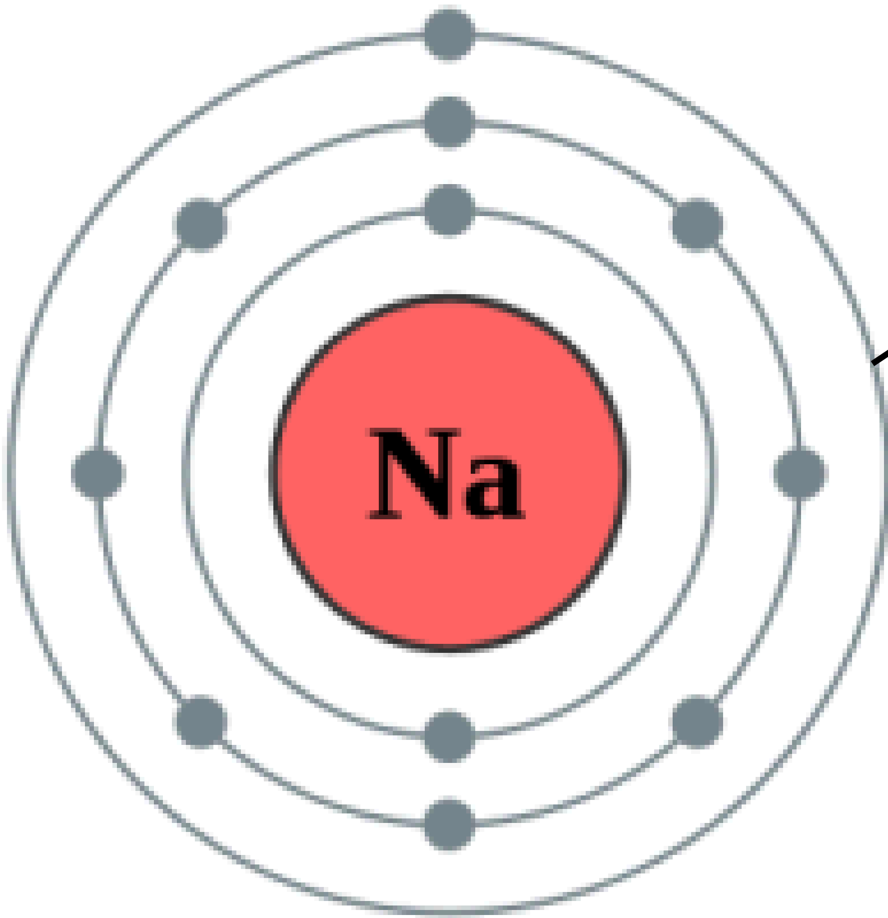
Valence Electrons and Bonding

- Atoms bond together to get a FULL VALENCE SHELL.
- **Each electron shell can hold 8 electrons**, except for shell number one which can only hold 2.
- **Full valence shells make the atom stable and happy.**
- Atoms give, take, or share electrons in order to get a full valence shell.

Ionic Bonding

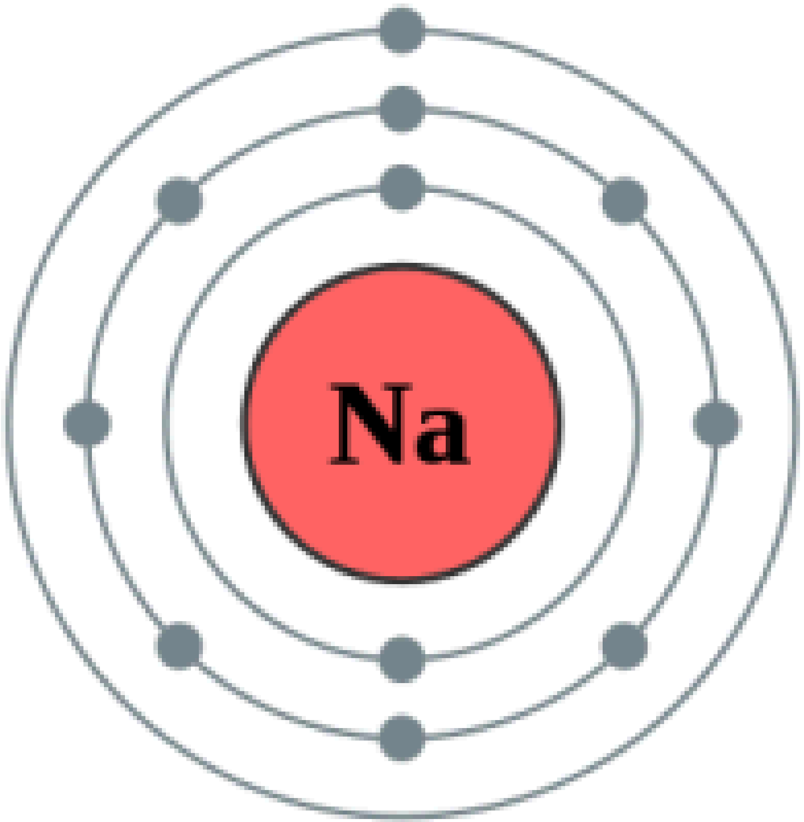
- Opposites attract

Sodium has a Problem



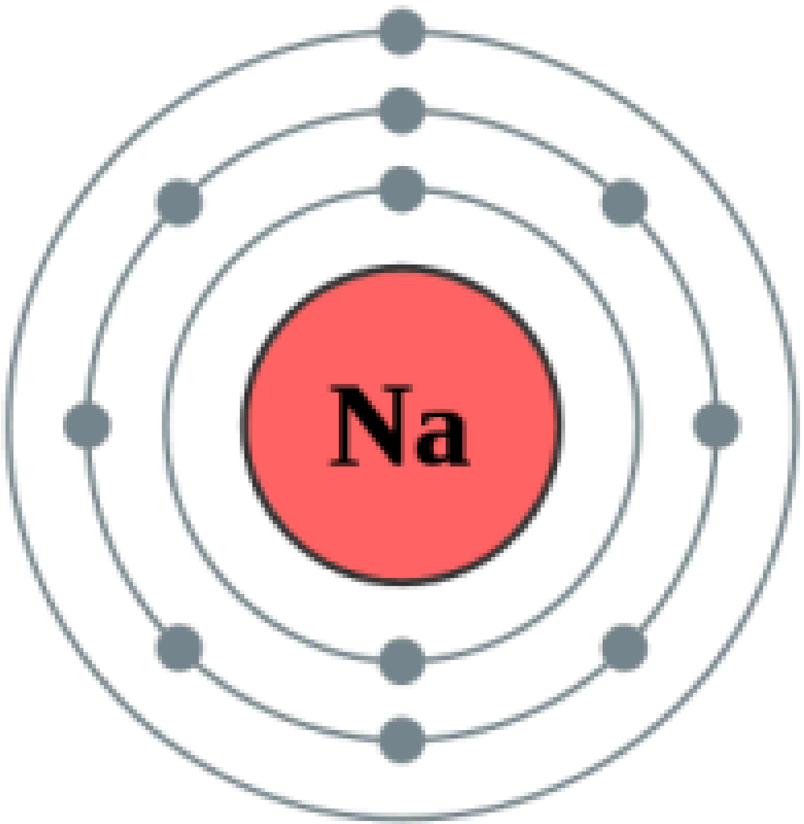
Aww gee, my valence Shell only has one electron ☹

What Should Sodium Do?



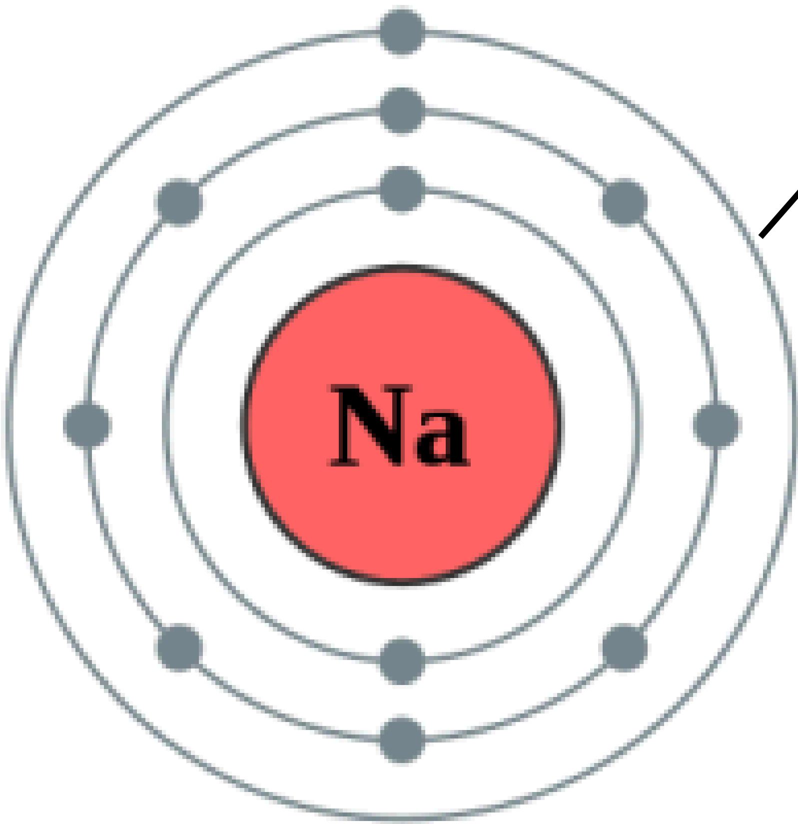
- Steal 7 electrons from someone else to get a complete 3rd electron shell?
- Give one electron away to get a complete 2nd electron shell?

Sodium needs a full valence shell to be stable



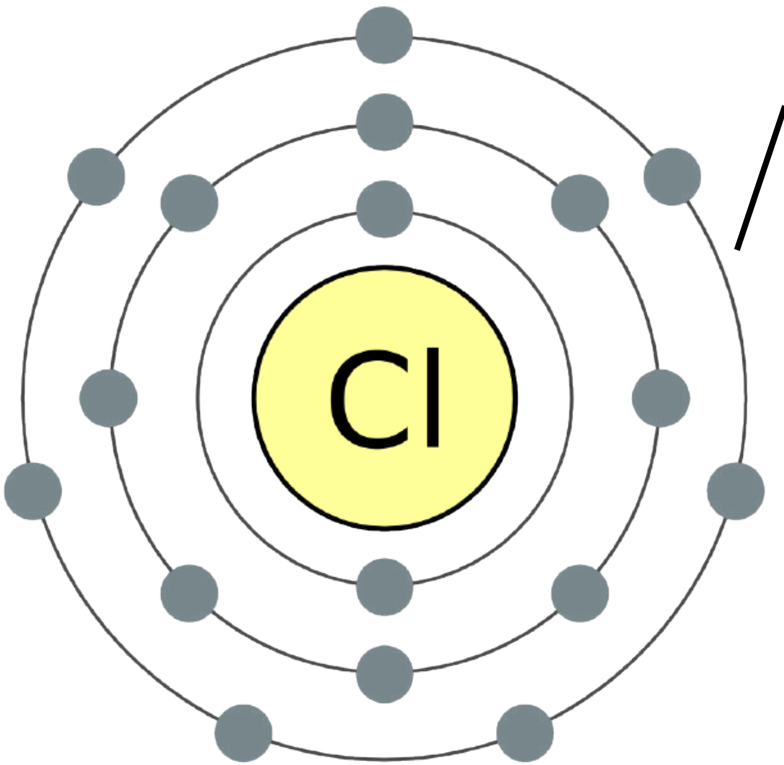
- Atoms cannot steal more than 3 electrons from other atoms.
- Sodium must give up one electron from is third shell to reveal a full second shell beneath!!

If Sodium gives up one electron from its valance shell it will reveal a full second electron shell.

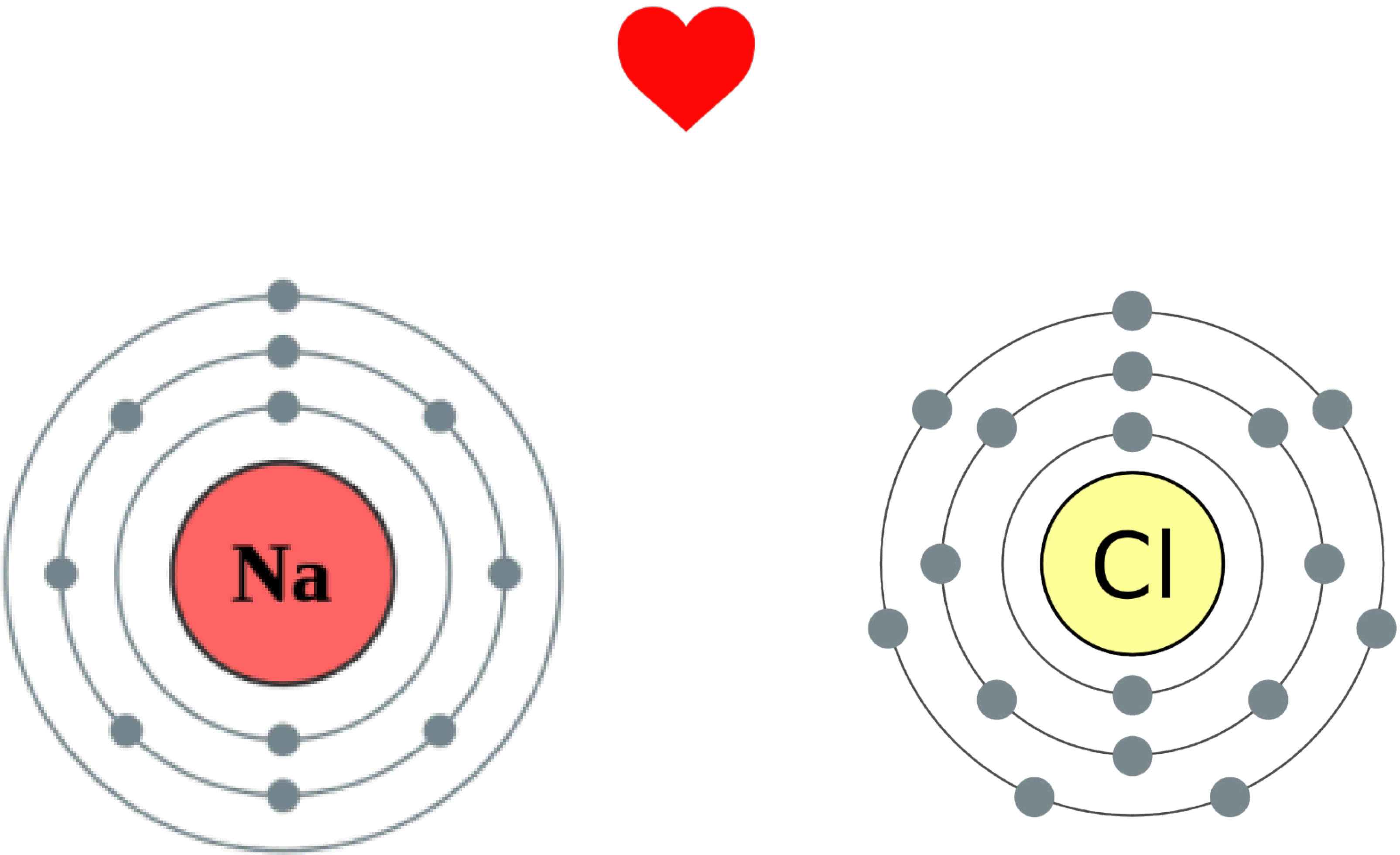


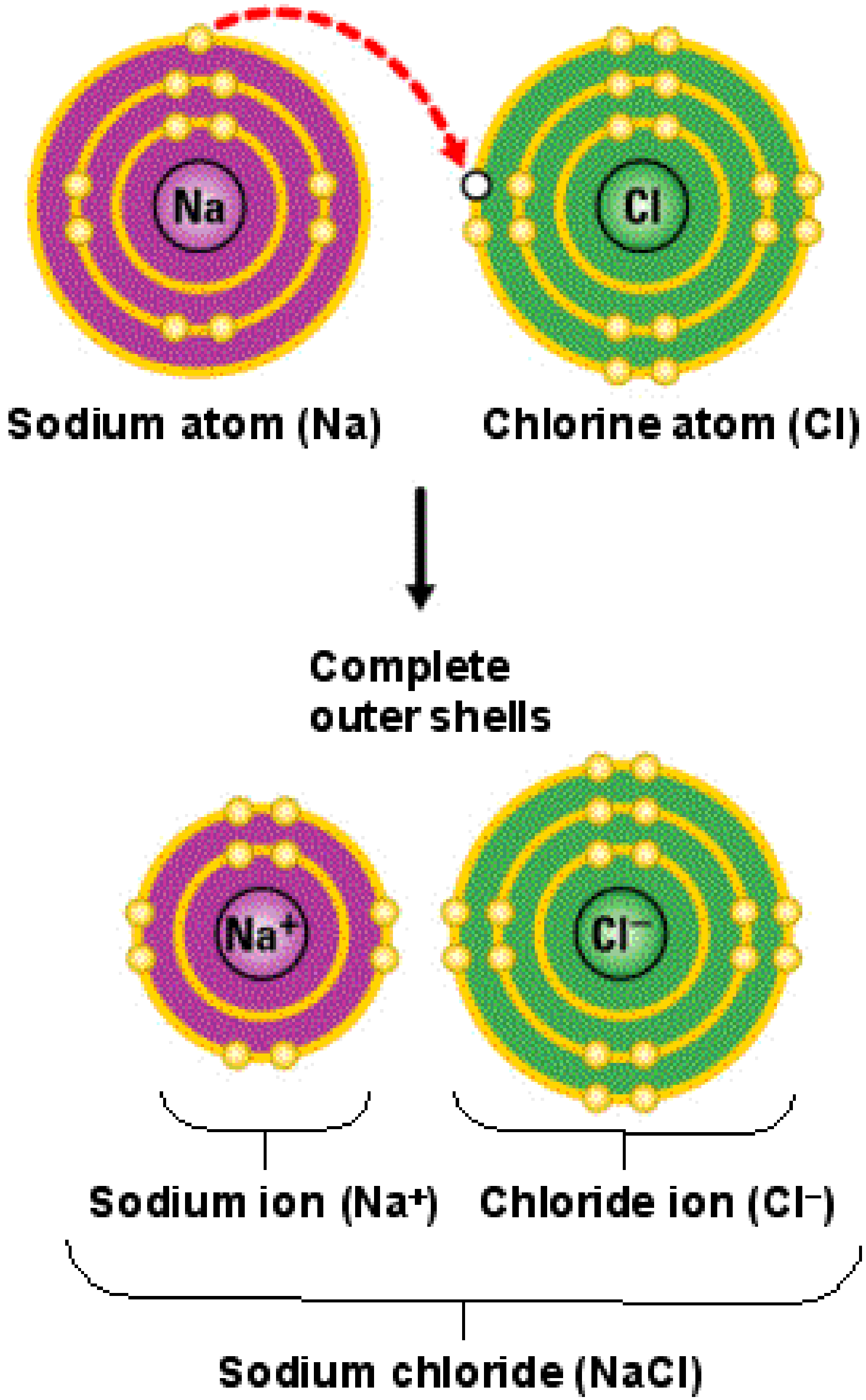
But who will take my electron?

Chlorine has a Problem



I only have 7 valence electrons…
☹
If only someone would give me one more…

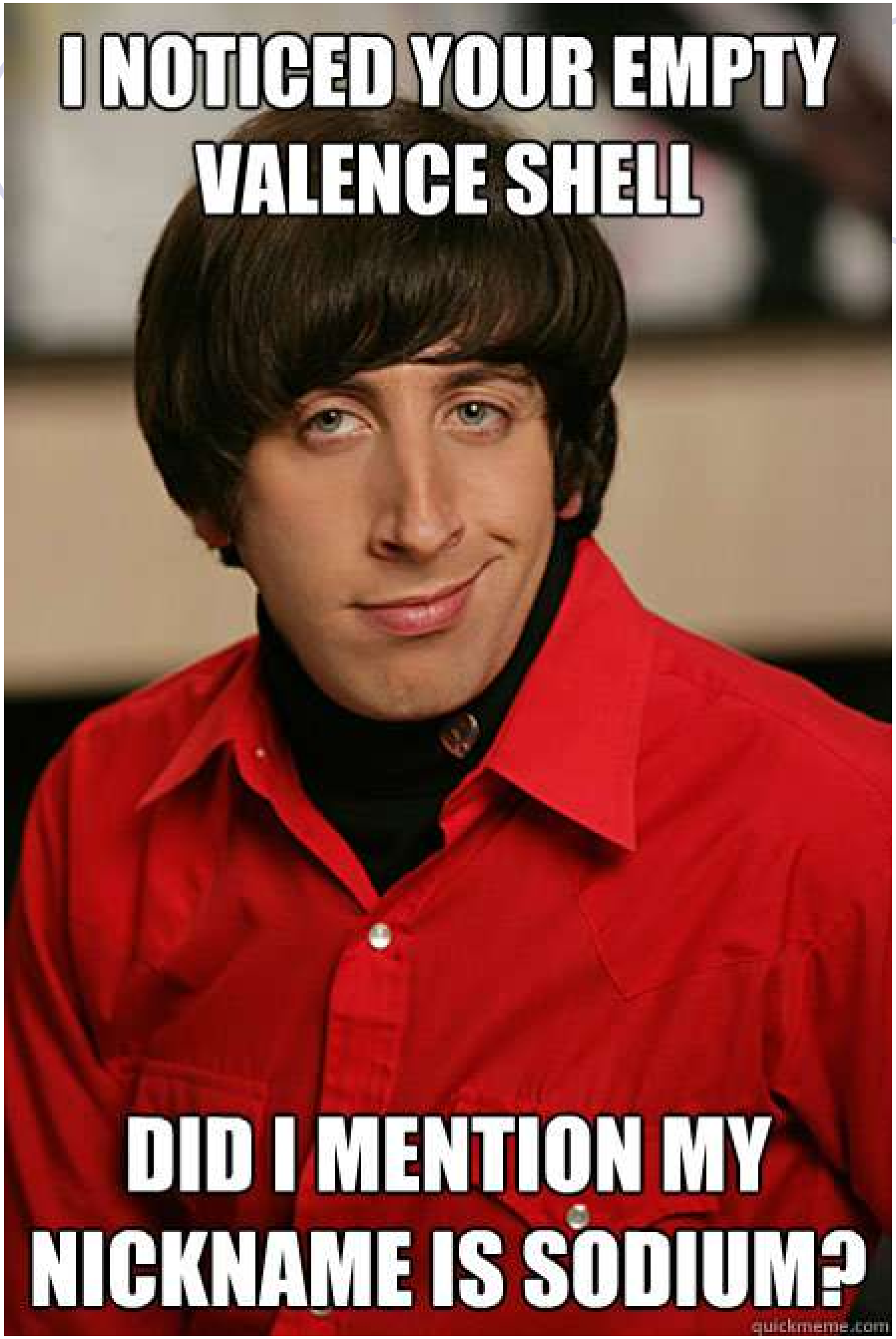

Na
Cl



- Losing an electron causes Sodium to become a +1 Ion
- Gaining an electron causes Chlorine to become a -1 Ion
- The opposite charges cause Sodium and Chlorine to stick together.
- This is called an **IONIC BOND**

IONIC BOND

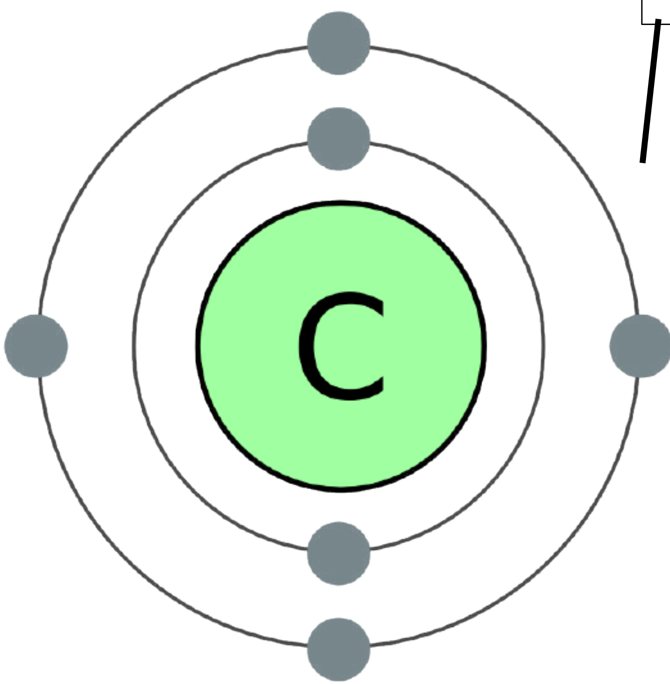
- The Magnetic Force That Holds Two Ions Together


I NOTICED YOUR EMPTY VALENCE SHELL
DID I MENTION MY NICKNAME IS SODIUM?
quickmeme.com

Covalent Bonding

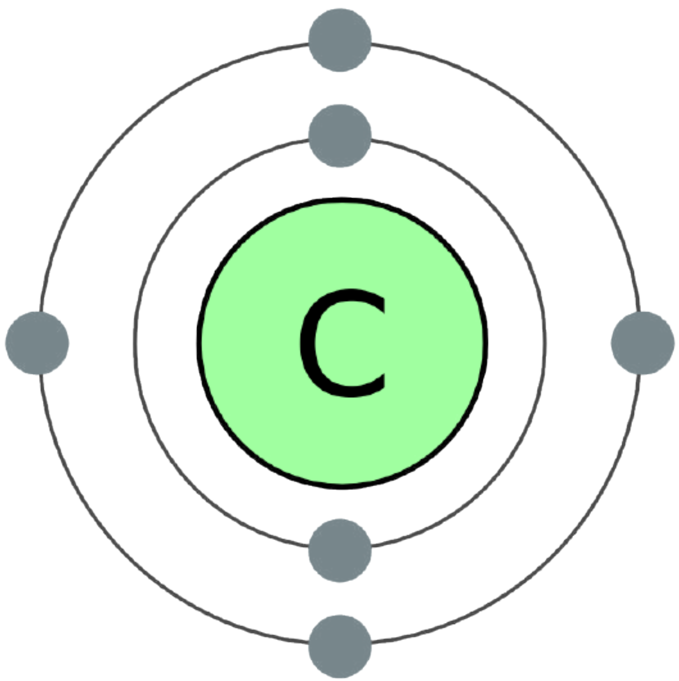
- Sharing is Caring

Carbon has a Problem



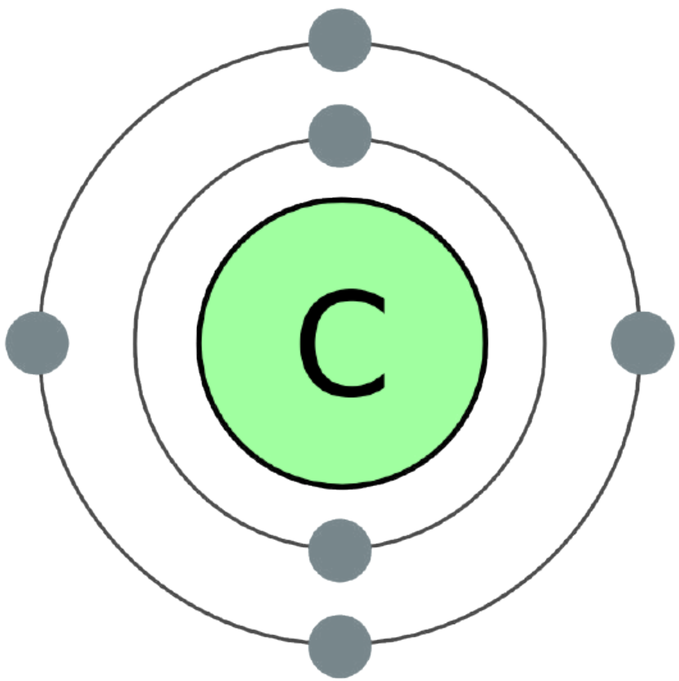
Well Shucks, I only have 4 electrons
In my valence shell ☹

What Should Carbon Do?

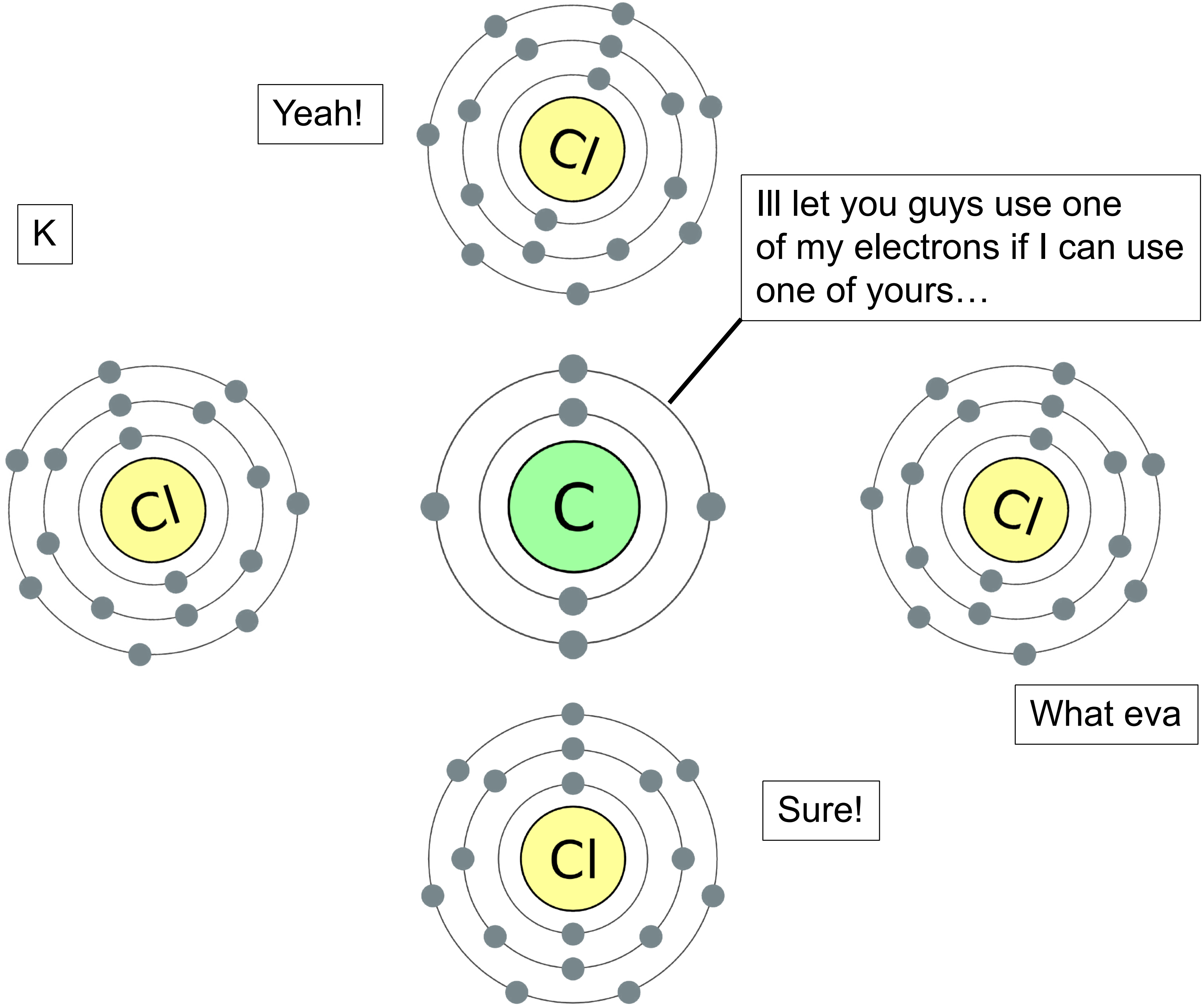


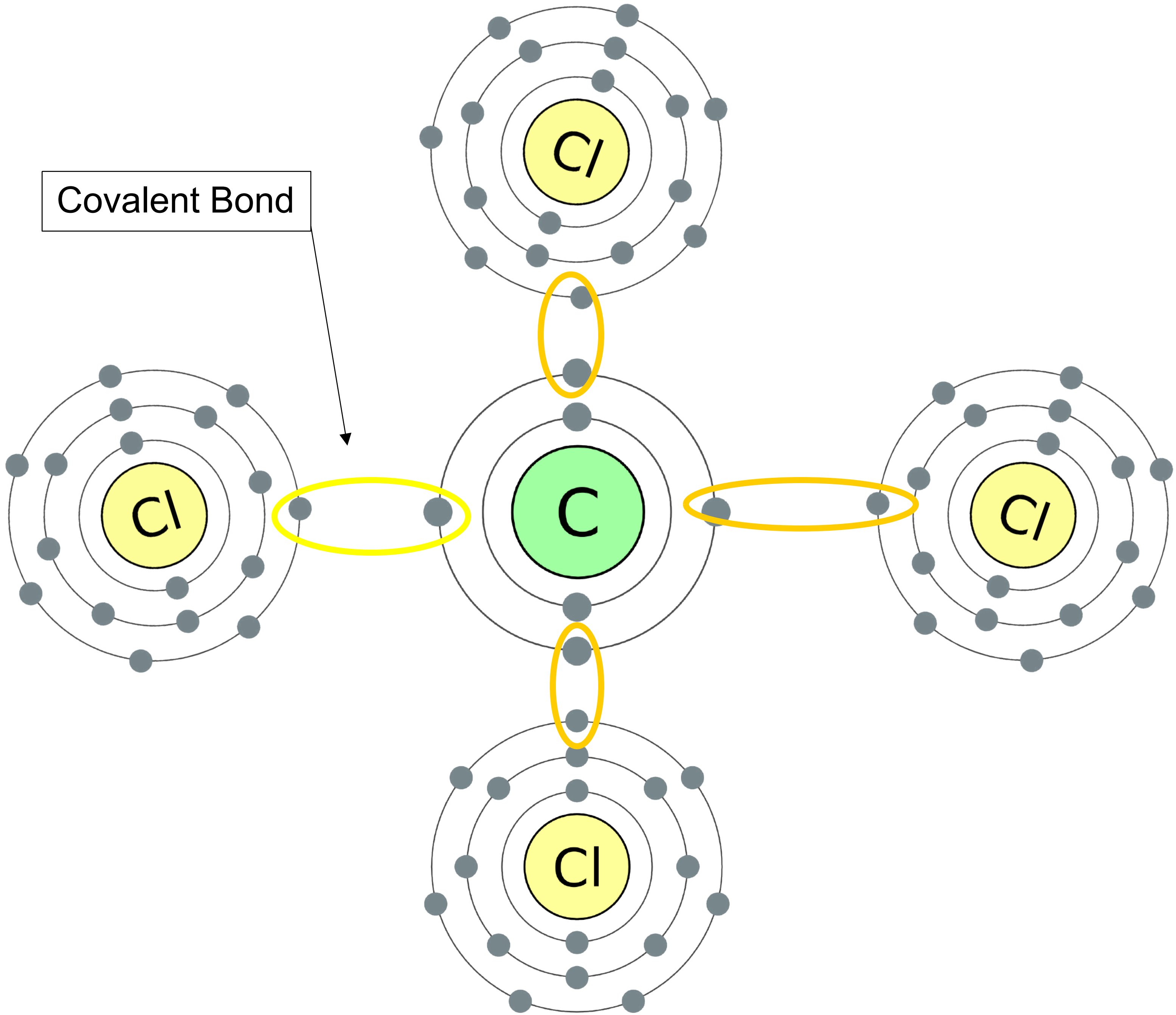
- Steal 4 electrons from someone else to get a full 2nd electron shell?
- Give up 4 electrons to reveal a full 1st electron shell beneath?

Carbon Needs a Full Valence Shell to be Stable



- Atoms cannot give or take more than 3 electrons.
- What can be done?!
- Carbon will have to **SHARE** electrons.


Yeah!
Cl
K
Ill let you guys use one of my electrons if I can use one of yours…
Cl
C
Cl
What eva
Cl
Sure!

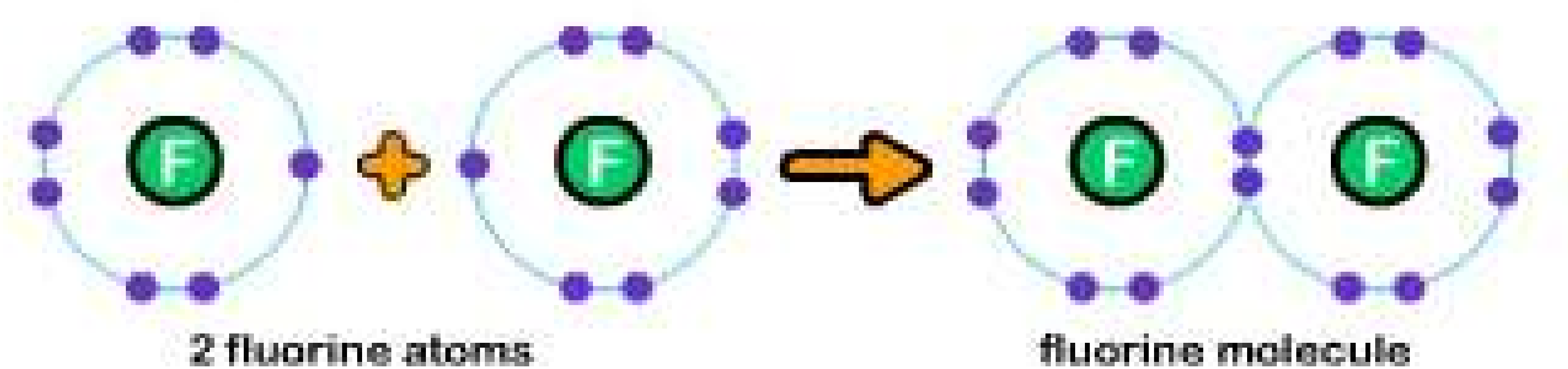

Covalent Bond
Cl
Cl
C
Cl
Cl

COVALENT BOND

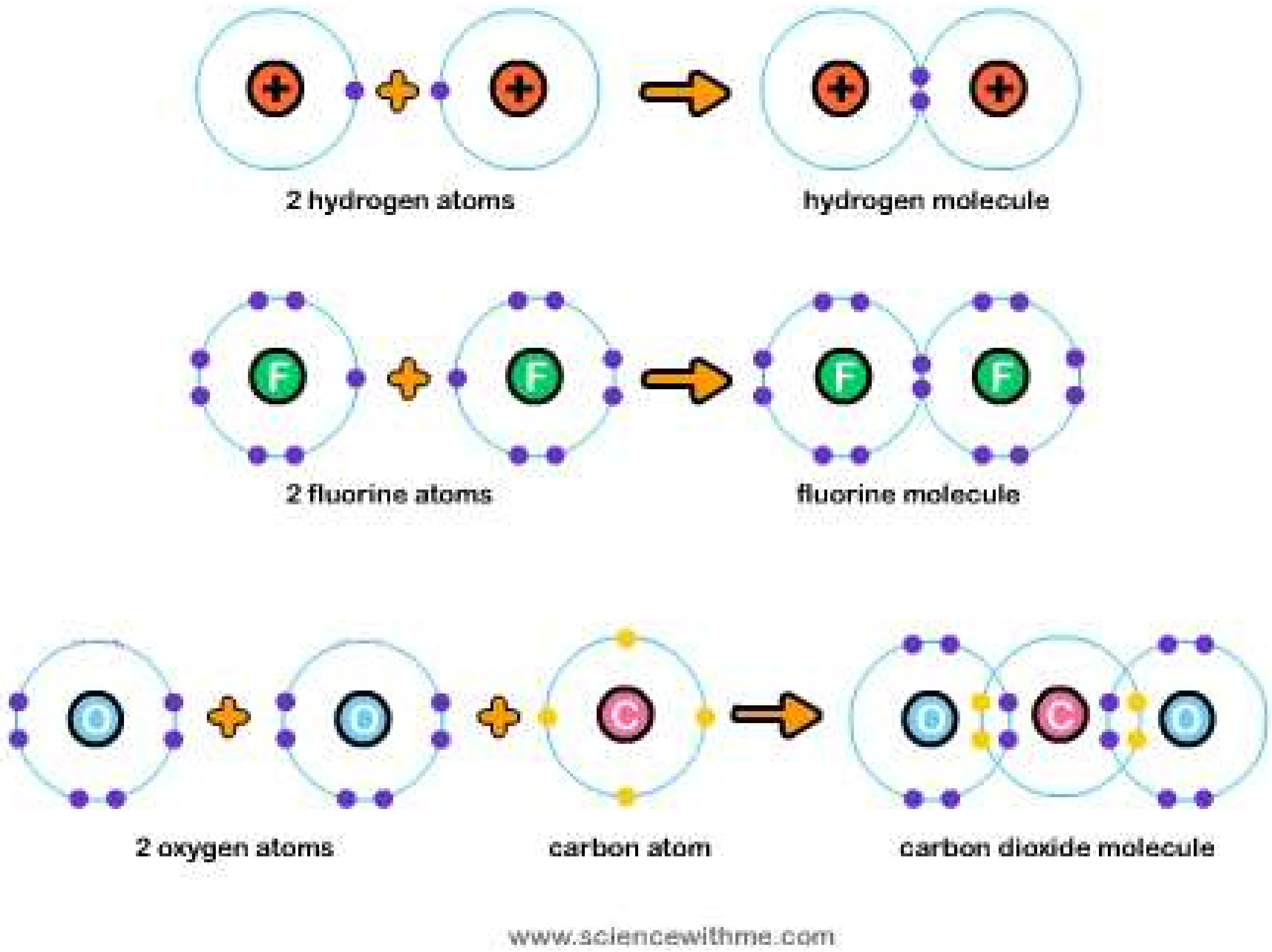
- A chemical bond in which two atoms share a pair of valence electrons

In a **Covalent Bond** two electrons are shared between the two atoms.

- Each covalent bond consists of two electrons.
- Both atoms in the bond get to consider the shared electrons as part of their valence shell.



Covalent bonds



Rules For Chemical Bonding

- ***All atoms involved in bonding must end with full valence shells.*** (two electrons for the 1st shell and eight for all other shells).
- Atoms cannot gain or lose more than 3 electrons.
- Atoms can share *any* two electrons to form a covalent bond.
- Atoms can share up to three pairs of electrons to form three covalent bonds.

Which of the following elements could bond? How would they bond?

- Lithium
- Magnesium
- Neon
- Potassium
- Carbon
- Silicon
- Nitrogen
- Oxygen
- Calcium
- Sulfur
- Fluorine
- Chlorine
- Bromine
- Phosphorous
- Sodium
- Hydrogen
- Beryllium
- Argon

Try bonding several pairs, triads, or quartets of elements.

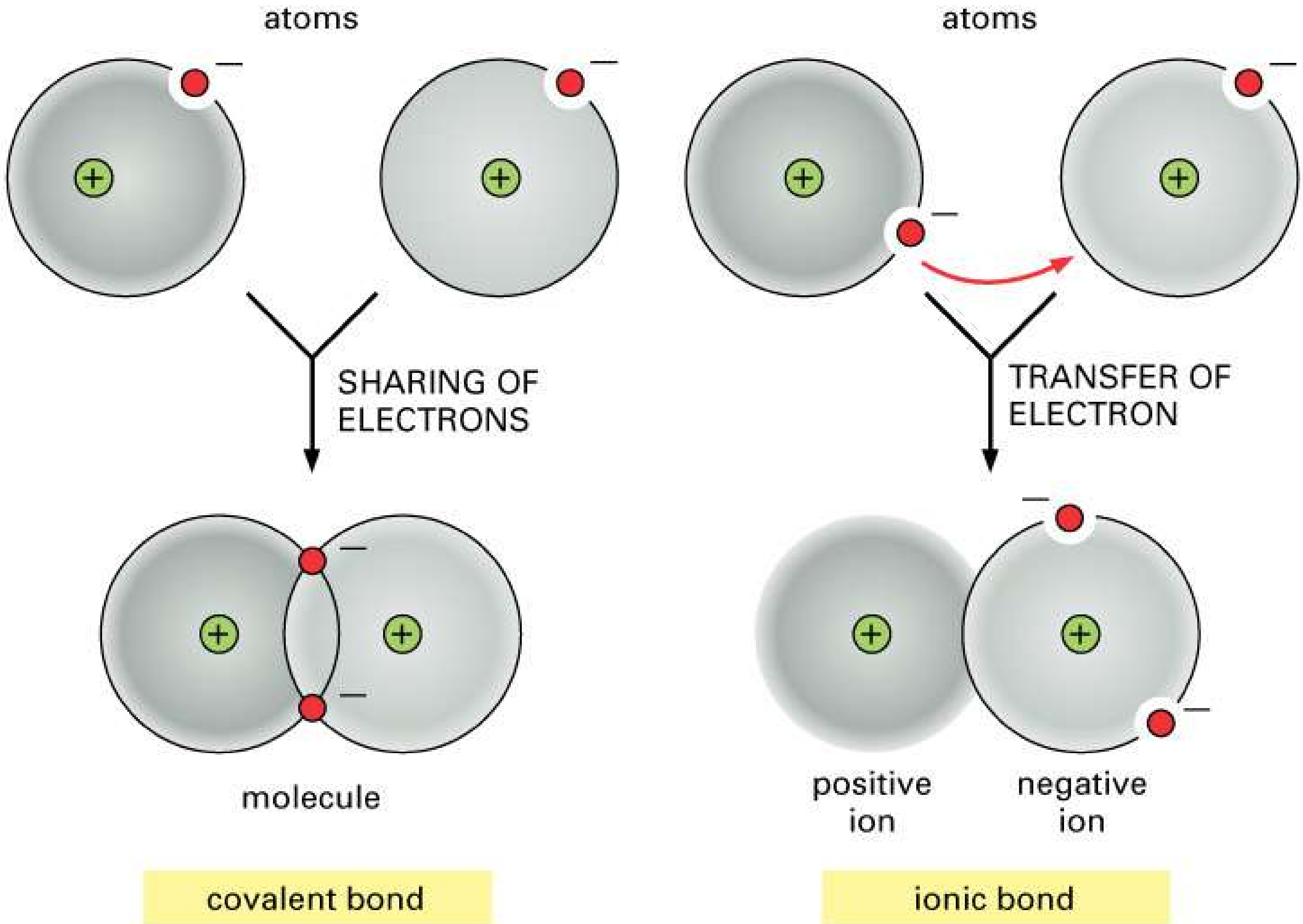


Figure 2.6 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Part Six:

- Recognizing a Chemical Reaction
- Determining the Products of a Chemical Reaction
- Reaction Rates

Recognizing a Chemical Reaction

- During a chemical reaction **NEW SUBSTANCES ARE FORMED!!**
- **That means that your reactants will be gone!!! The products are never the same as the reactants!!**
- Look for:
  - Bubbles
  - Color Change
  - Temperature Change
  - Precipitate (Solid substance appearing when two solutions are mixed)

Determining the products of a chemical reaction:

- Remember that during a chemical reaction the atoms in a compound break apart and find new partners to bond with.
- When determining the products of a chemical reaction remember a few simple rules…..

Rules for determining the products of a reaction:

- Determine which elements were in your reactants and separate them. (Example: Ethanol (C_2H_6O) will break apart into Carbon, Hydrogen, and Oxygen)

- Once you have determined which elements are involved in the reaction you can try to guess which ones might bond together to form products.

- **The reactants will not also be the products!!! Remember new substances are formed!!**

Basic rules for determining the products of a reaction:

- Metals bond with Non-metals (Note: Hydrogen acts as a metal).
- The following elements and compounds exist as gas at room temperature so if you see bubbles it was probably one of these gases:
  - Hydrogen (H2)
  - Nitrogen (N2)
  - Oxygen (O2)
  - Fluorine (F2)
  - Chlorine (Cl2)
  - Carbon-dioxide (CO_2)

Advanced rules for determining the products of a reaction:

- **Polyatomic Ions** (Ions made from more than one atom) stay together during reactions and act as one unit.
- These groups of ions act just like simple ions in an ionic bond (like Sodium (Na) ions and Chlorine (Cl) ions in Sodium Chloride).
- Positive ions & negative ions stick together to be neutral.
- A list of the common polyatomic ions can be found on the next slide.
- If you see one of these ions in your reactants, it will probably also be in your products.
- NOTE: the ion will change partners, but the group of atoms comprising the POLYATOMIC ION will remain intact.

Common Polyatomic Ions

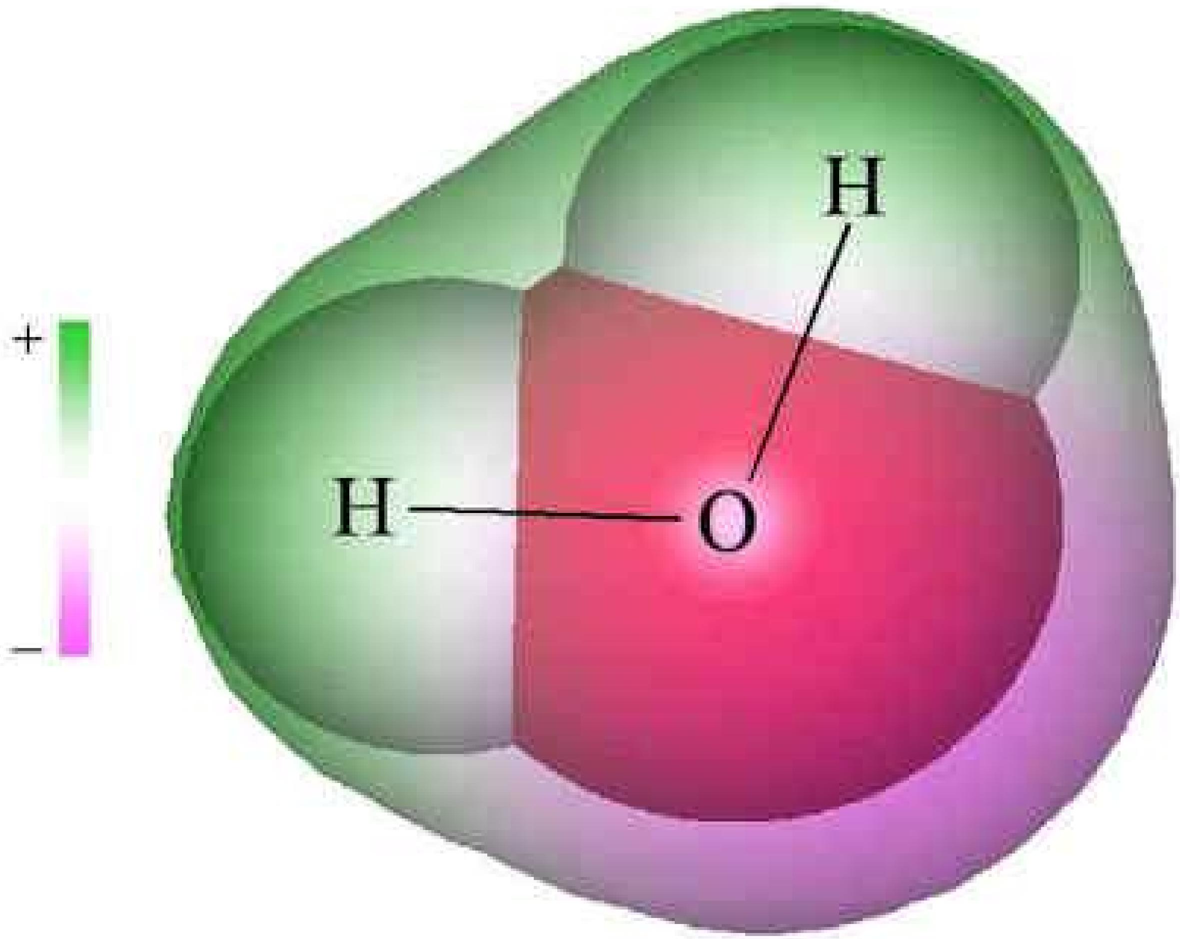
$C_2H_3O_2^-$	acetate	OH^-	hydroxide
NH_4^+	ammonium	ClO^-	hypochlorite
CO_3^{2-}	carbonate	NO_3^-	nitrate
ClO_3^-	chlorate	NO_2^-	nitrite
ClO_2^-	chlorite	$C_2O_4^{2-}$	oxalate
CrO_4^{2-}	chromate	ClO_4^-	perchlorate
CN^-	cyanide	MnO_4^-	permanganate
$Cr_2O_7^{2-}$	dichromate	PO_4^{3-}	phosphate
HCO_3^-	bicarbonate	SO_4^{2-}	sulfate
HSO_4^-	bisulfate	SO_3^{2-}	sulfite
HSO_3^-	bisulfite		

Things that affect reaction rate:

- Temperature
- Pressure
- Concentration of Reactants
- Surface area of reactants

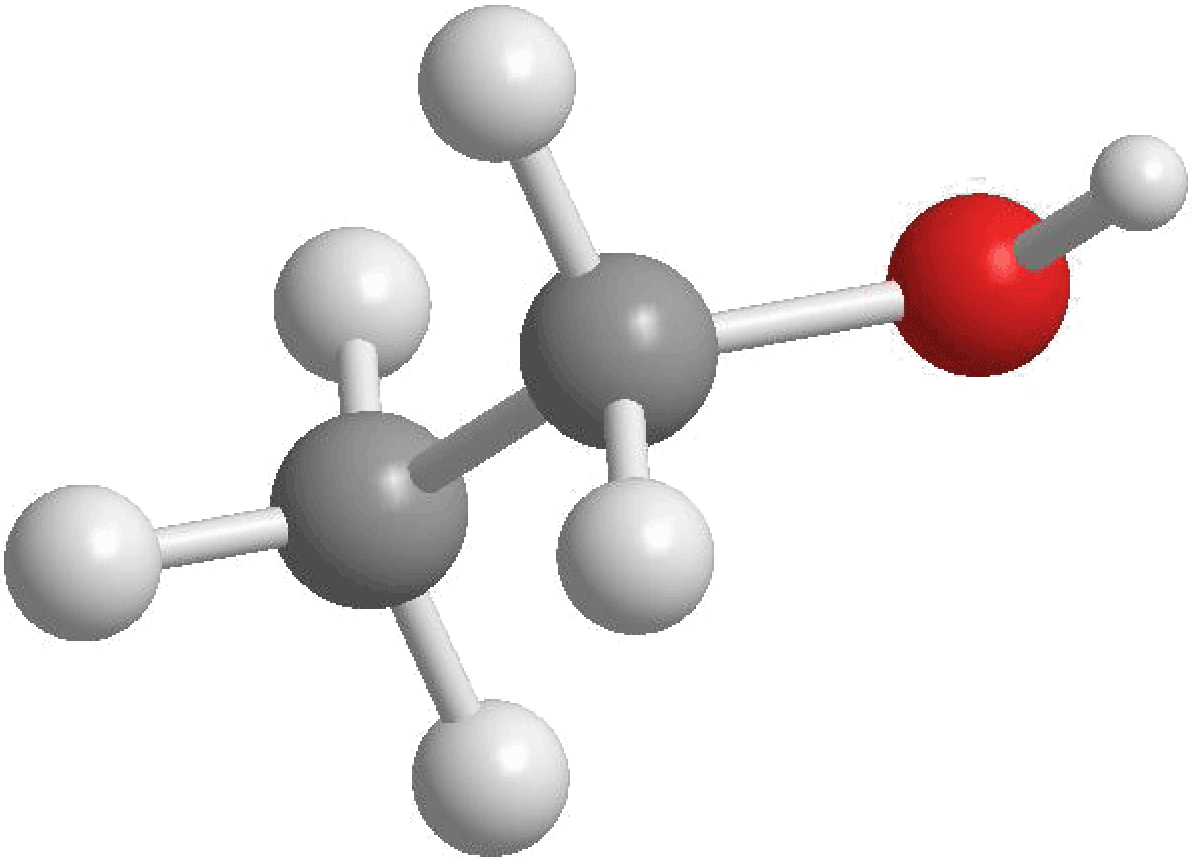
Vocabulary Review!!

Which words best describe the picture? #1



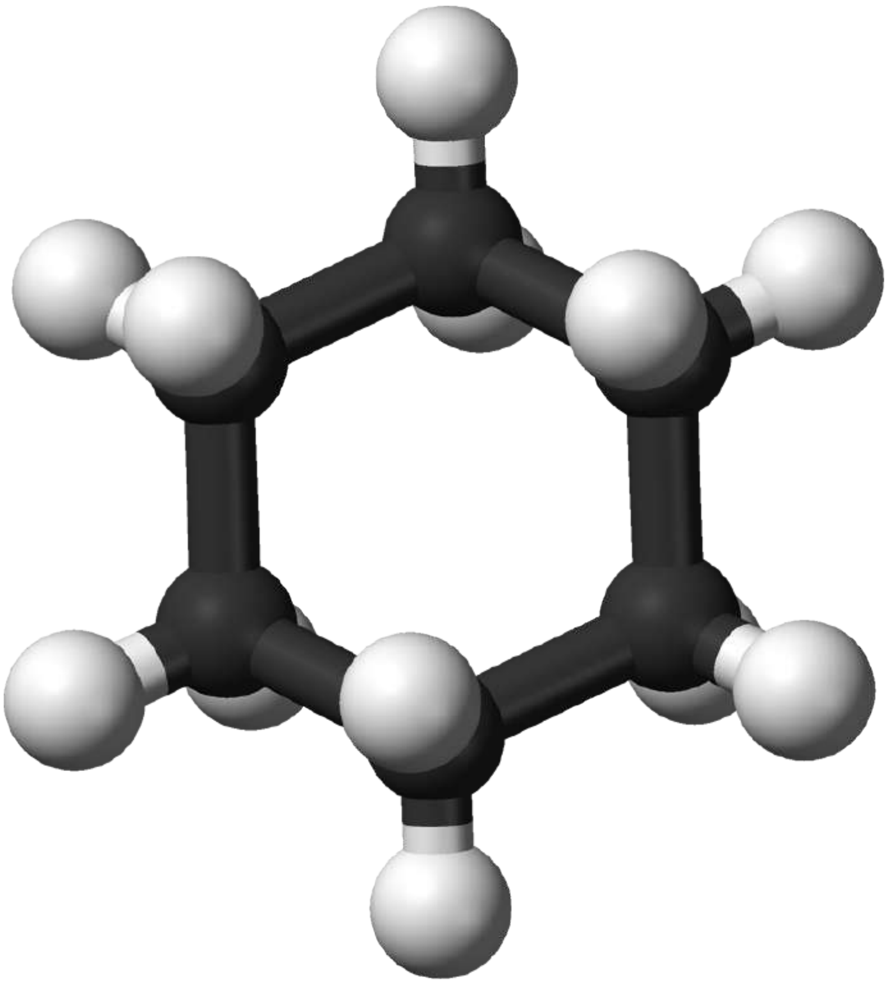
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #2



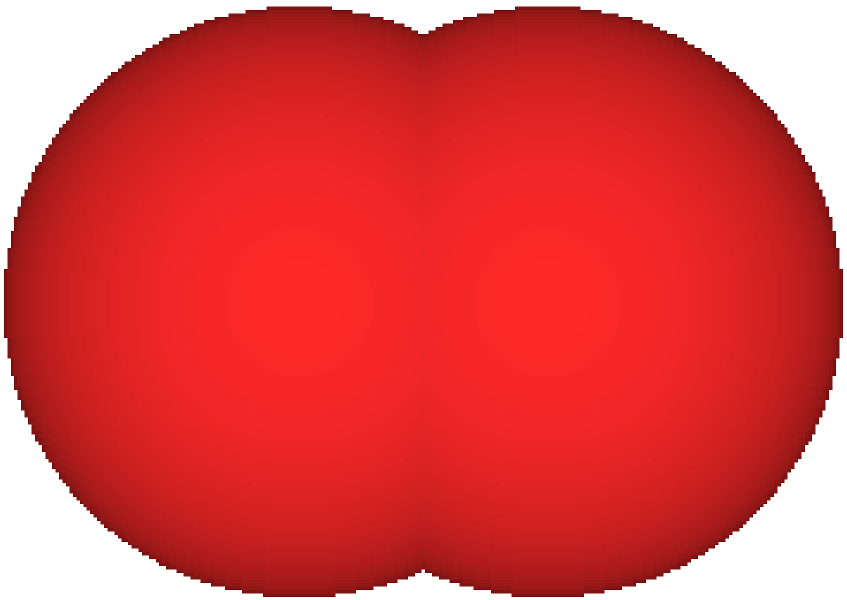
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #3



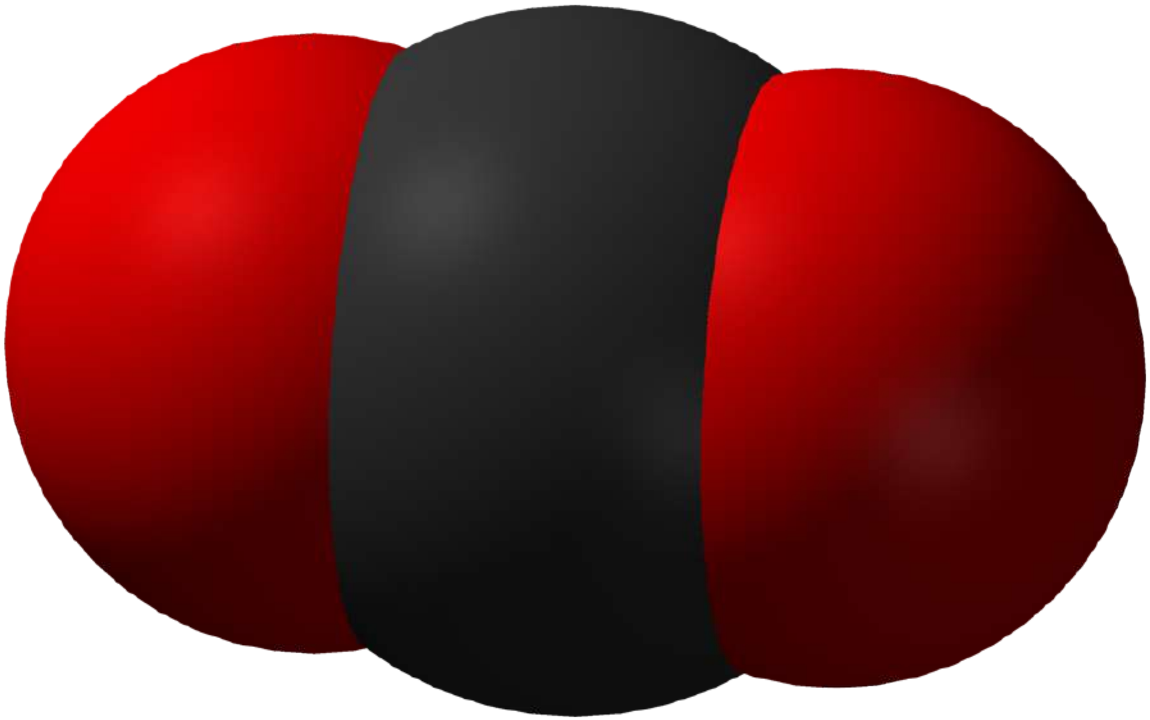
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #4



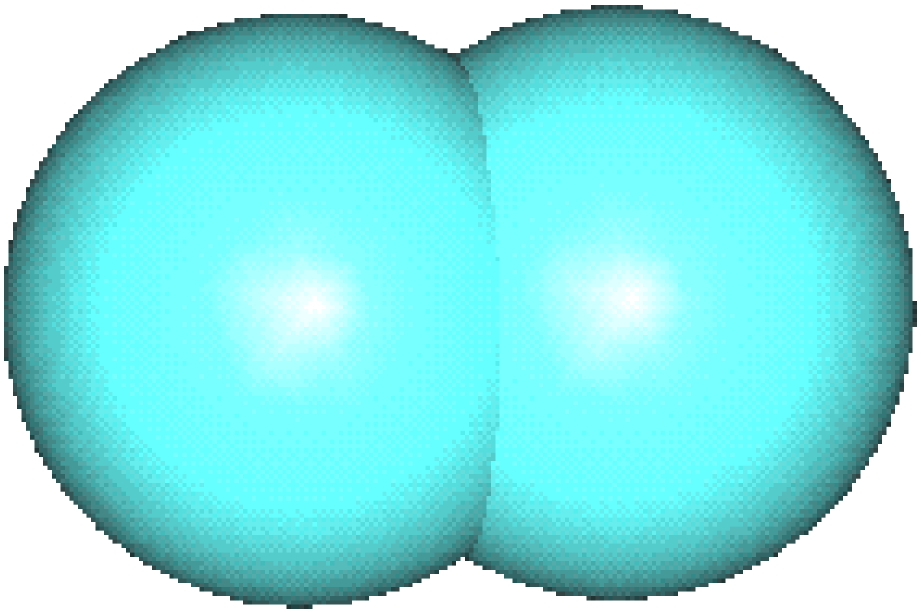
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #5



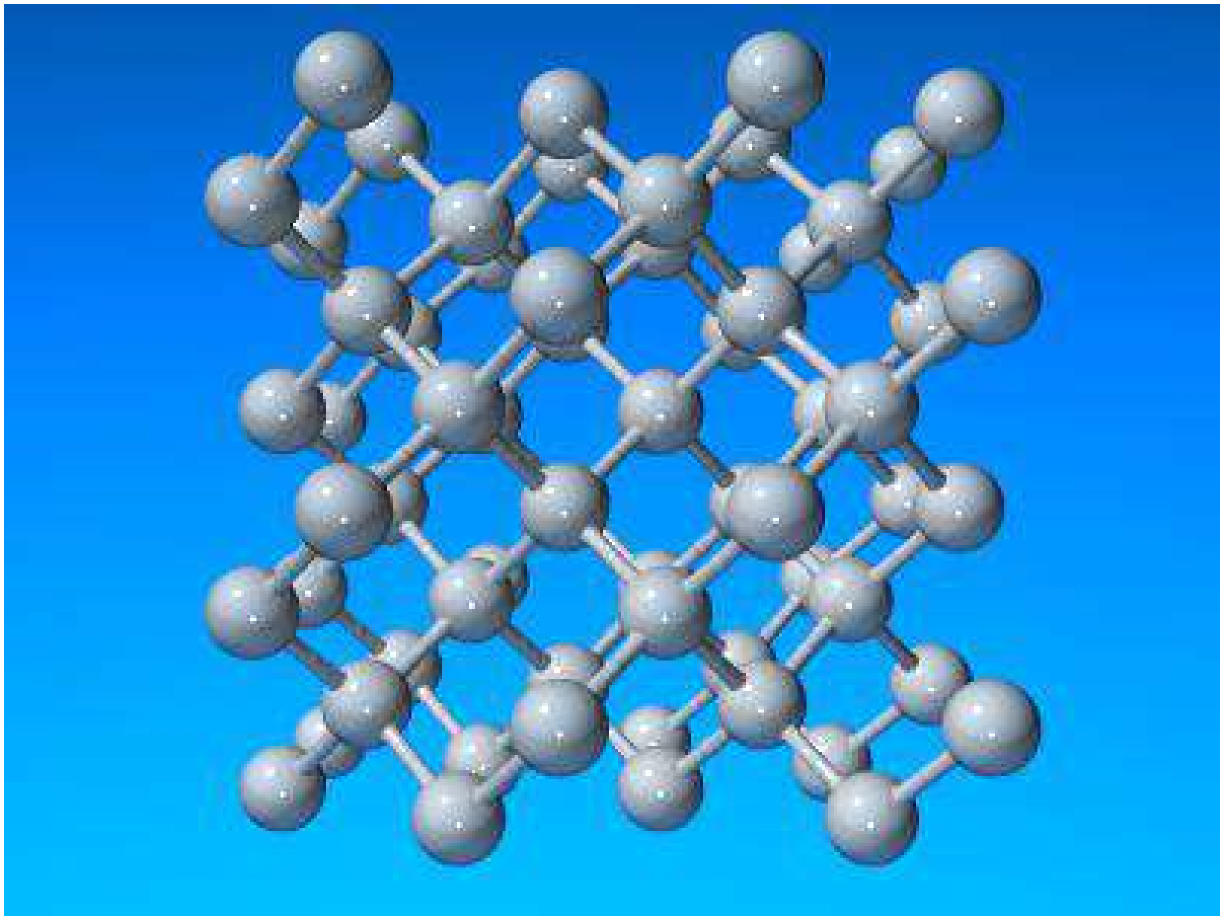
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #6



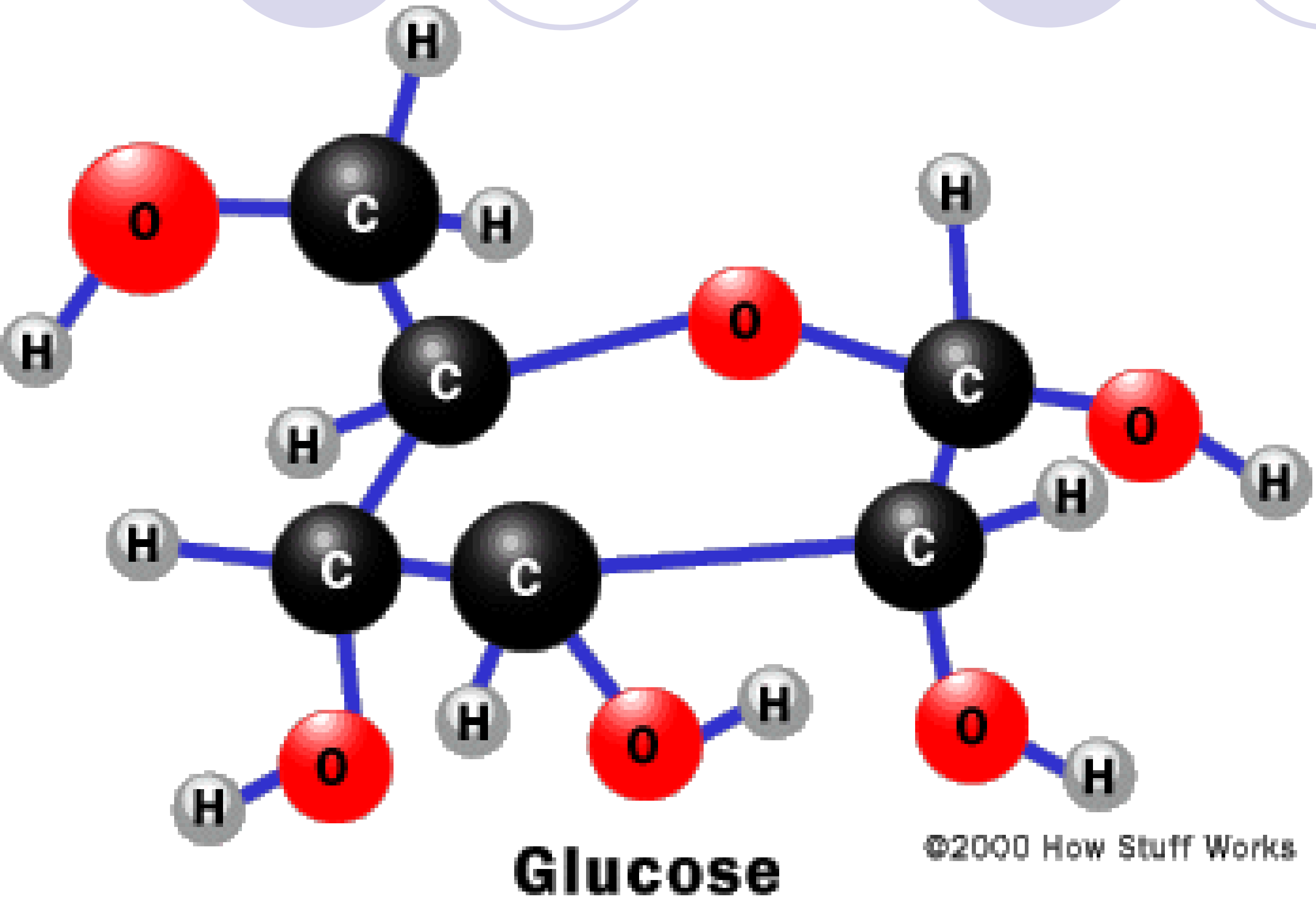
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #7



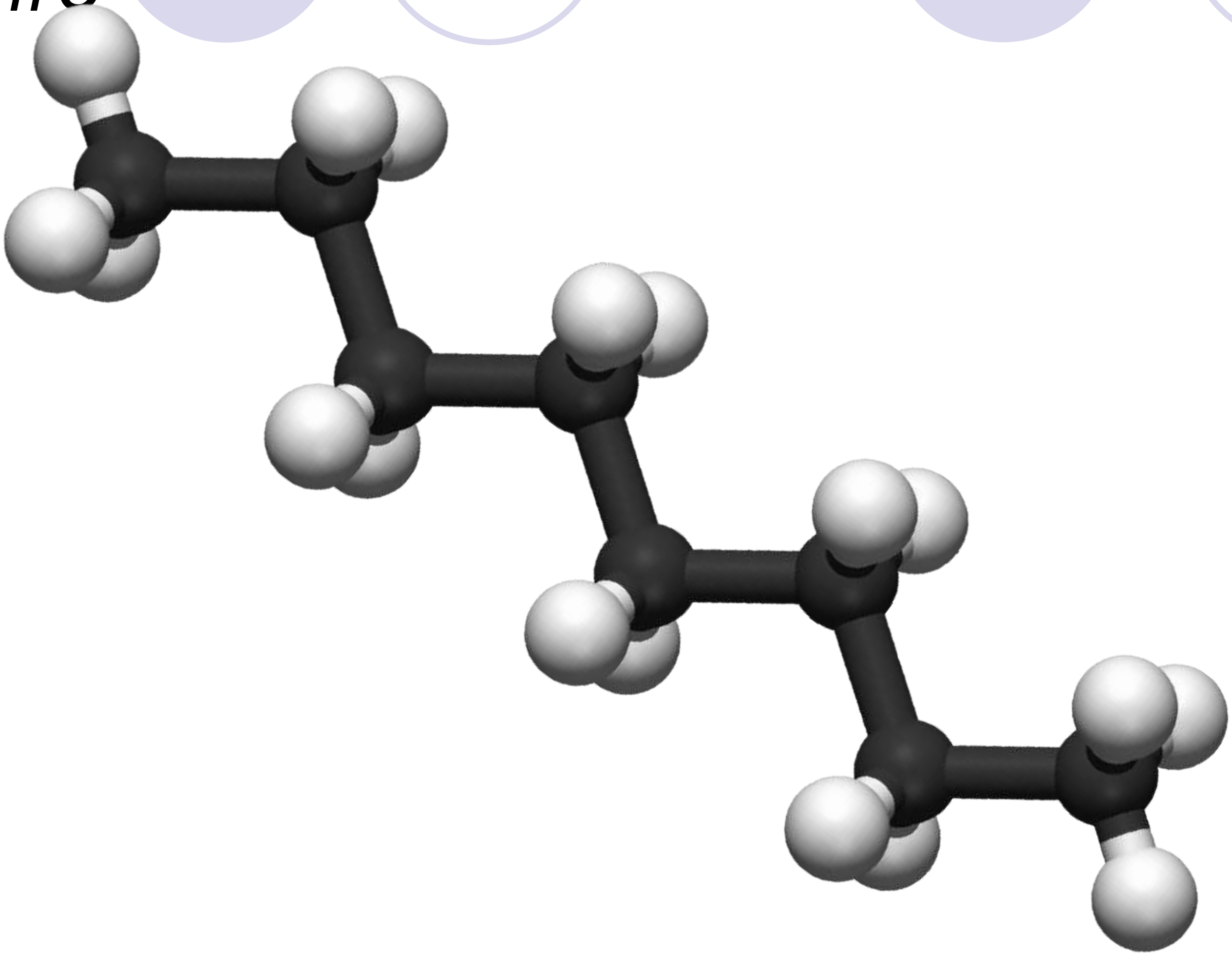
- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #8



- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Which words best describe the picture? #9



- Substance
- Mixture
- Element
- Atom
- Molecule
- Compound
- Molecular formula

Answers:

- Water = H_2O, Compound, Molecule, Substance, 3 Atoms, 2 Elements.
- Ethanol = C_2H_6O, Compound, Molecule, Substance, 9 Atoms, 3 Elements.
- Cyclohexane = C_6H_{12}, Compound, Molecule, Substance, 18 Atoms, 2 Elements.
- Oxygen = O_2, Molecule, Substance, 2 Atoms, 1 Element.
- Carbon dioxide = CO_2, Compound, Molecule, Substance, 3 Atoms, 2 Elements.
- Chlorine = Cl_2, Molecule, Substance, 2 Atoms, 1 Element.
- Diamond = $C_{X\ (repeating)}$, Molecule, Substance, Number of Atoms depends on the size of the diamond, 1 Element.
- Glucose Sugar = $C_6H_{12}O_6$, Compound, Molecule, Substance, 24 Atoms, 3 Elements.
- Octane = C_8H_{12}, Compound, Molecule, Substance, 20 Atoms, 2 Elements.