Science 20 Unit A CHEMISTRY

Chapter 1: Aqueous Solutions

1.1 Structure of matter

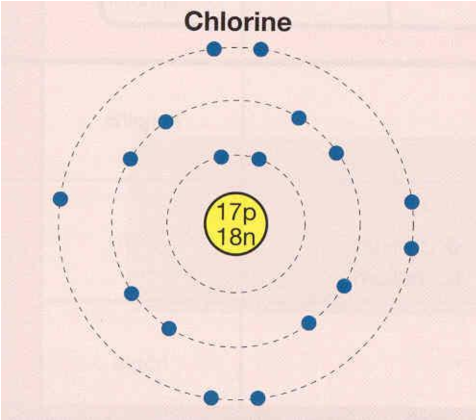
1.2 Atomic bonding & properties

1.3 Breaking bonds

1.4 Concentration

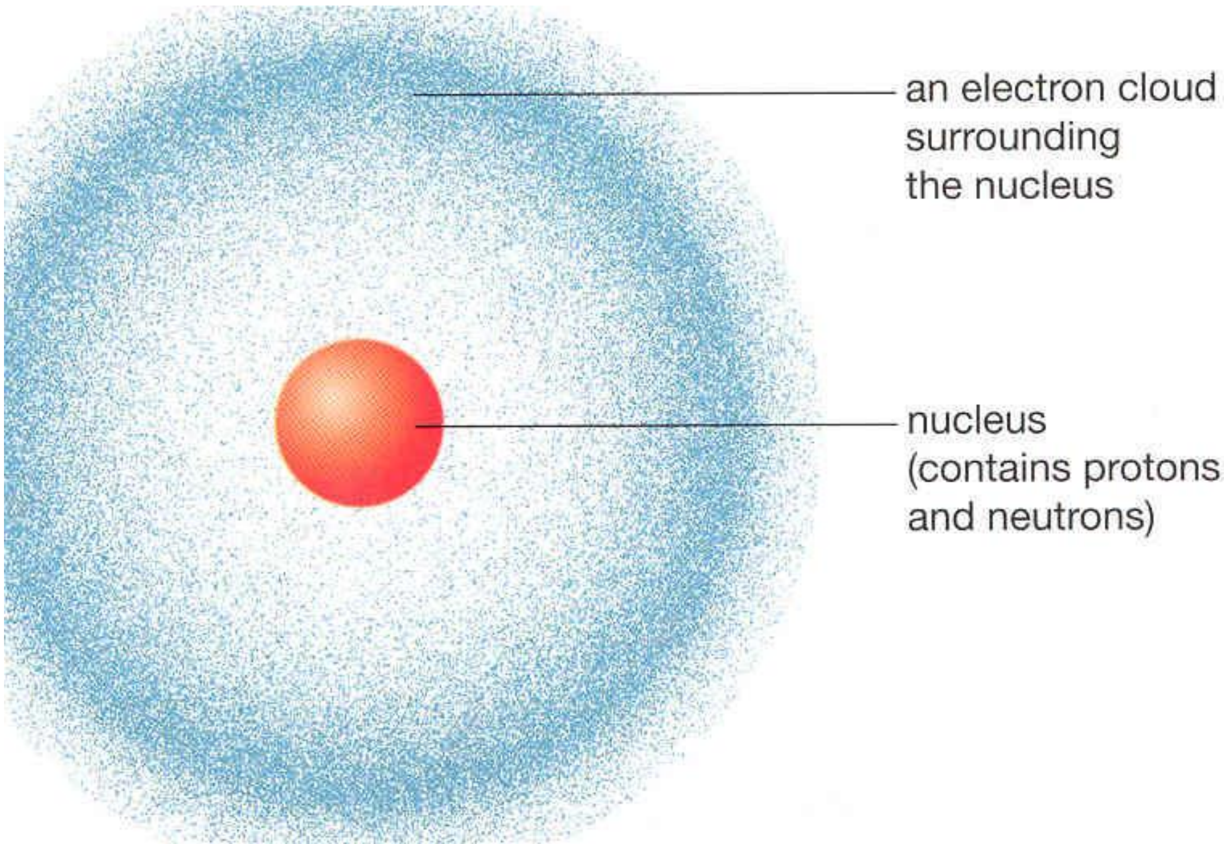
1.5 Calculating concentration

Lesson 1.1: The Structure of the atom



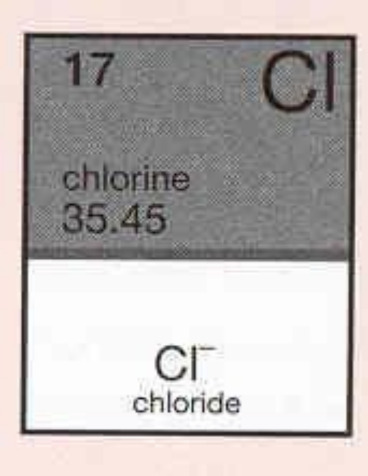
What are the parts of an atom?

1. Electrons (e-)
   - negative
2. Protons (p+)
   -positive
3. Neutrons (n)
   -neutral



What is the difference between atomic number, atomic mass & mass number?

- Atomic number is found on the periodic table. It represents the number of protons and electrons in a neutral atom. Identification number
- Atomic mass is found on the periodic table. It represents the average mass of an atom. (units are g/mol)
- Mass number of an average atom is the atomic mass rounded. It represents the number of protons and neutrons in the nucleus.

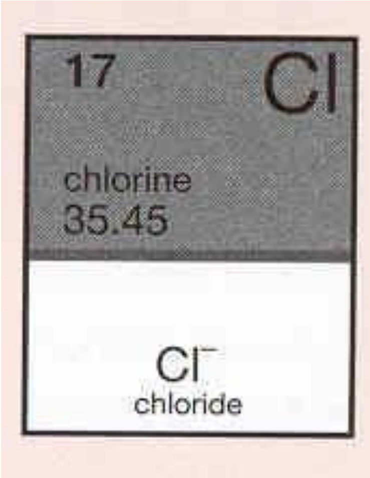


How do you determine the symbol and protons

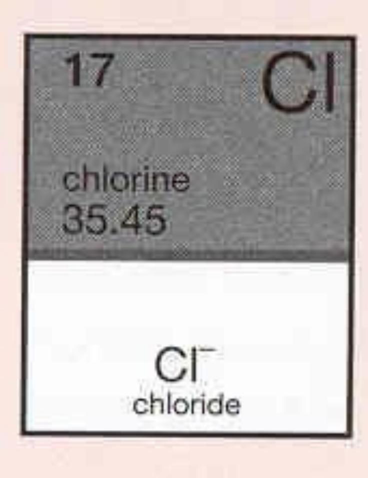
- Symbol: Use the atomic number or protons to look up the symbol on the periodic table
- Protons (p): Use the atomic number or symbol

EXAMPLE: What is the symbol and the number of protons if the atomic number is 17?

ANSWER: Cl with 17 protons.



How do you determine the neutrons, electrons & charge



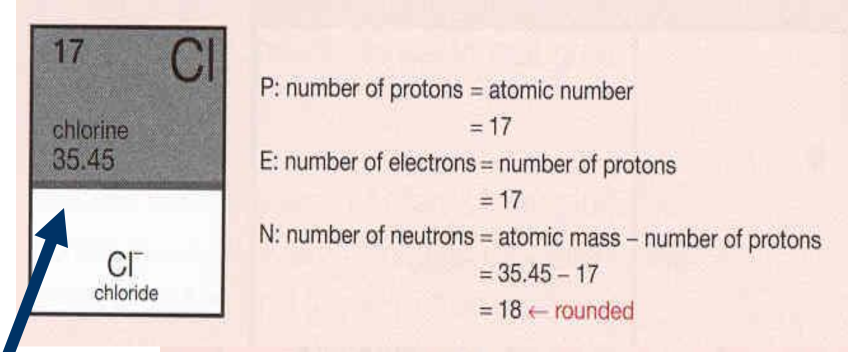
- Neutrons (n): the mass number minus atomic number
- Electrons (e): the same as the atomic number UNLESS there is a charge – with a negative charge add electrons; with a positive charge subtract electrons
- Charge: protons minus electrons (on periodic table)

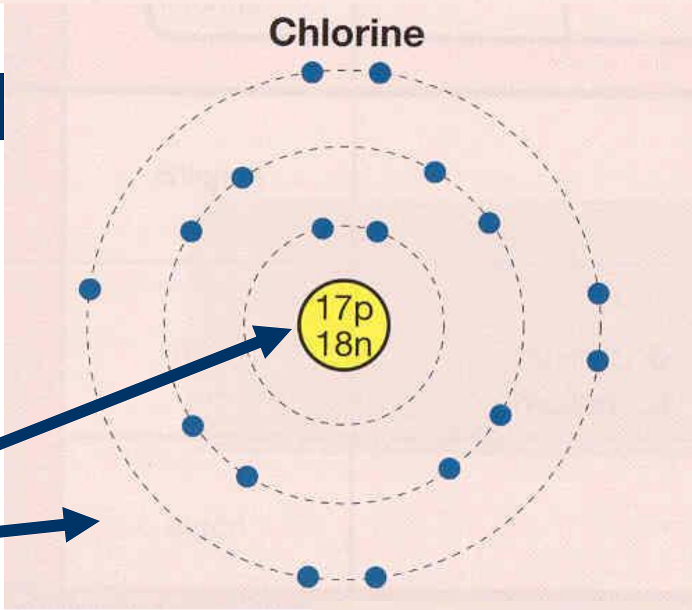
EXAMPLE: Provide the neutrons, charge and electrons for the chloride ion.

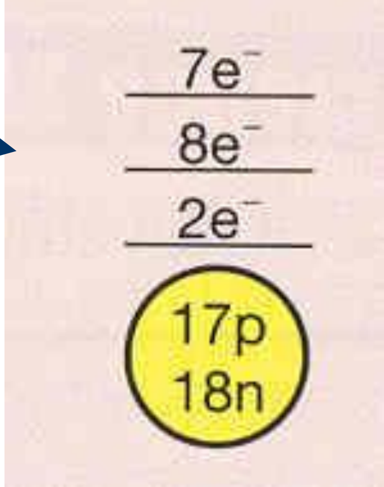
ANSWER: neutrons = 35 – 17 = 18; charge is 1-; electrons = 17 + 1 = 18

How does one draw a Bohr diagram?

1. Using the periodic table determine the number of protons, electrons & neutrons (PEN)
2. Draw the nucleus with p & n
3. Add dots or a number to each energy level to represent the electrons. Levels closest are filled first.

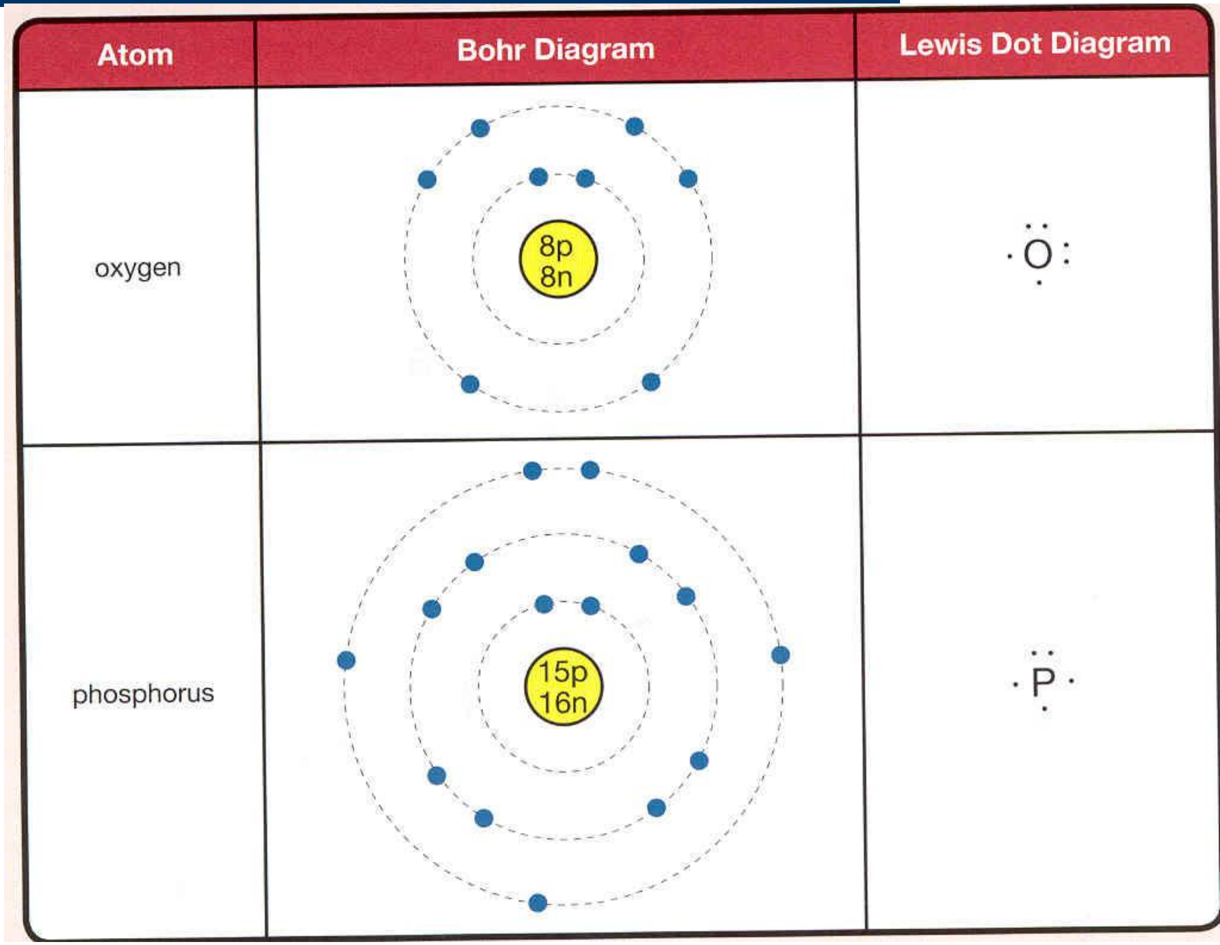






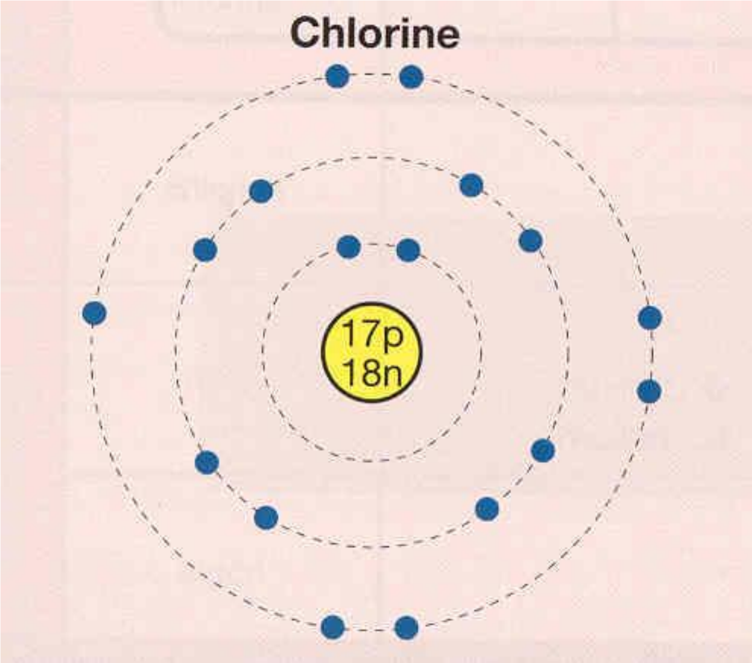
How does one draw a Lewis Dot diagram

1. Write the symbol to represent the nucleus and inner levels
2. Use a dot to represent each electron in the last level



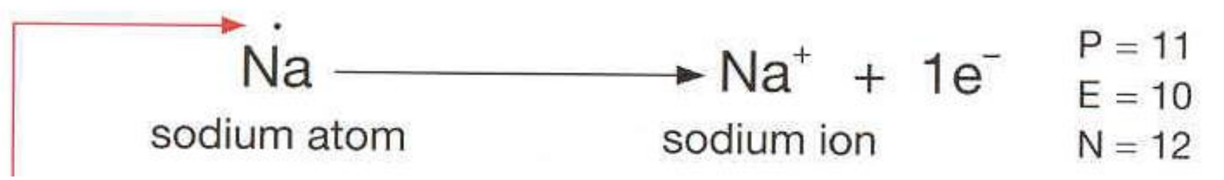
What are valence electrons?

- Valence electrons are electrons in the outer most energy level. Chlorine has 7 valence electrons.

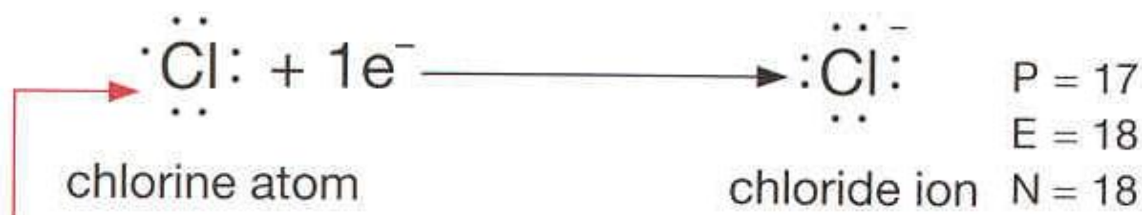


What can happen to valence electrons?

- Gain electrons to become a **cation** or positive ion.



- Lose electrons to become a **anion** or negative ion.



- Share electrons to form a **molecule**.

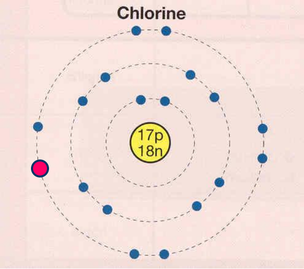
Check for understanding

1)

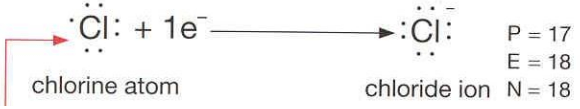
Answers to Check for understanding

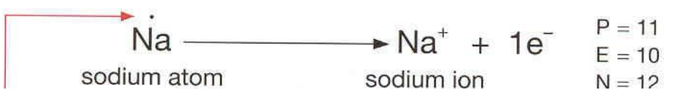
Lesson 1.2: Atomic Bonding & Properties

What are the four principles of bonding?

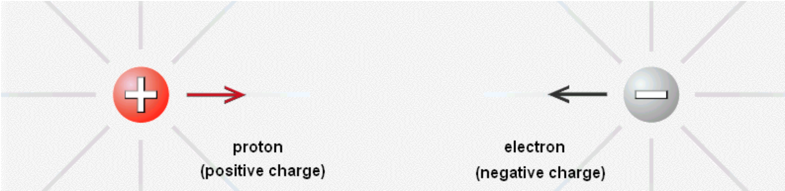


1. An atom is most stable when its outer energy level is <u>full</u>
2. Atoms can obtain full outer energy levels by <u>gaining, losing or sharing</u> electrons
3. If an atom gains electrons it becomes an <u>anion</u>.

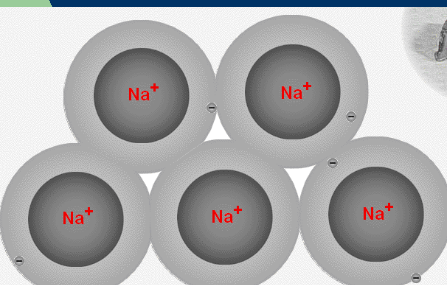


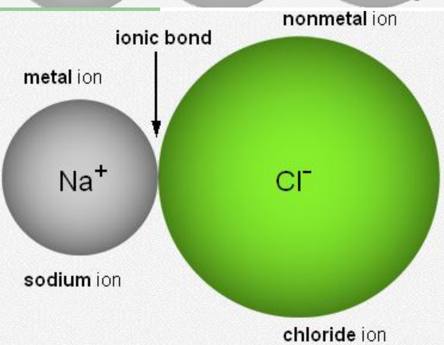


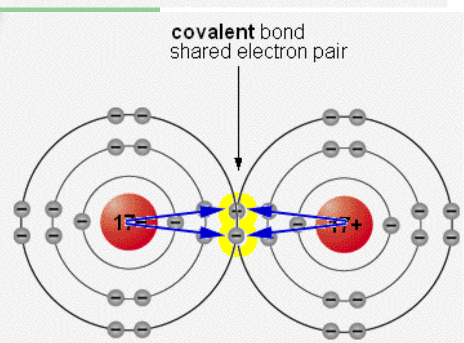
   If it loses electrons it becomes a <u>cation</u>
4. Negative charges <u>attract</u> positive charges; similar charges <u>repel</u>.



What are the three major types of bonds?





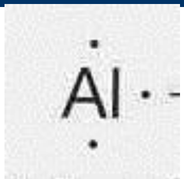


1. **Metallic**: a bond between positively charged metal ions(cations) and a sea of free moving electrons. eg) Na(s)
2. **Ionic**: a bond between a positive metal ion and a negative non-metal ion, formed after electrons have been transferred. eg) NaCl(s)
3. **Covalent**: a bond formed in molecular compound or diatomic element after two non-metals share electrons. Eg) $Cl_{2(g)}$

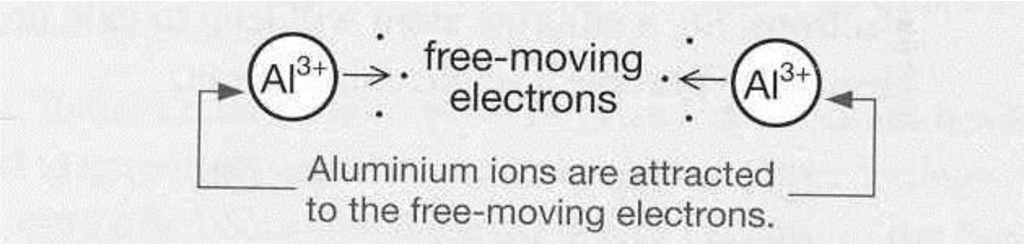
How does one draw the Atomic structure?

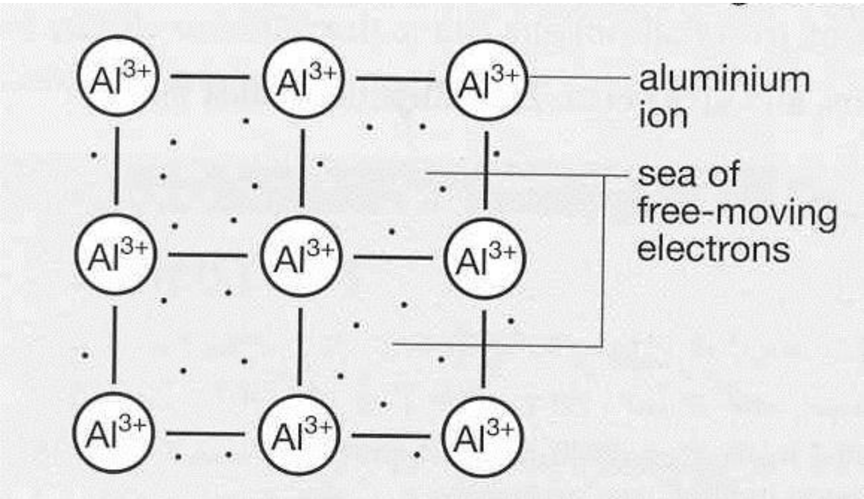
1. Draw the Lewis dot diagram for each atom
2. Place the atom(s) that needs the most electrons in the center
3. Connect the atoms so each atom's outer energy levels are filled
4. Make sure that the each atom have filled energy levels. If they don't repeat step 3).

An example of the atomic structure for metallic bonds.



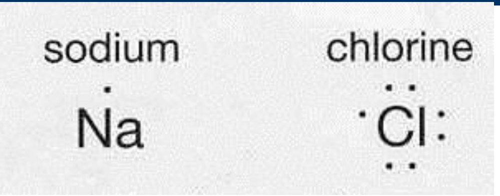
1. Lewis dot diagram
2. The valence electrons become free to make full levels
3. Place the metal ions together and add the sea of free moving electrons.

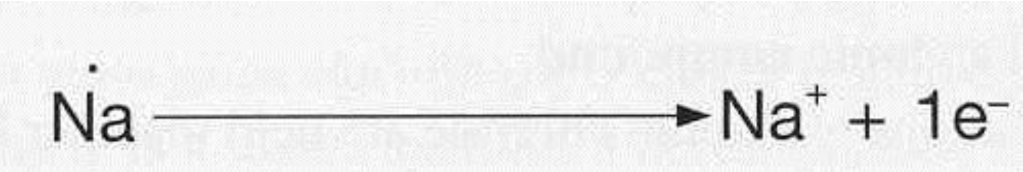


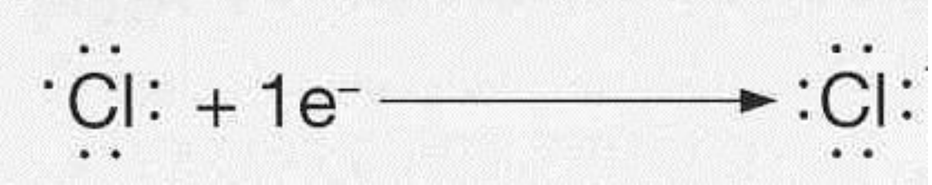


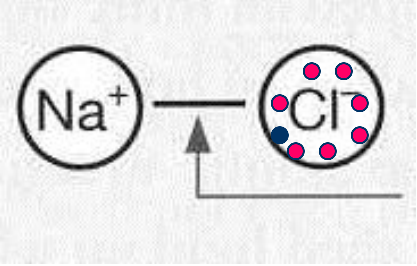
An example of the atomic structure for ionic bonds.

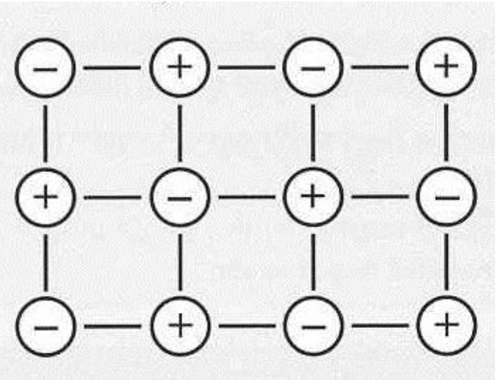
1. Lewis Dot diagrams
2. The metal loses e- & non-metal gains e-
3. A bond forms between the positive and negative ions





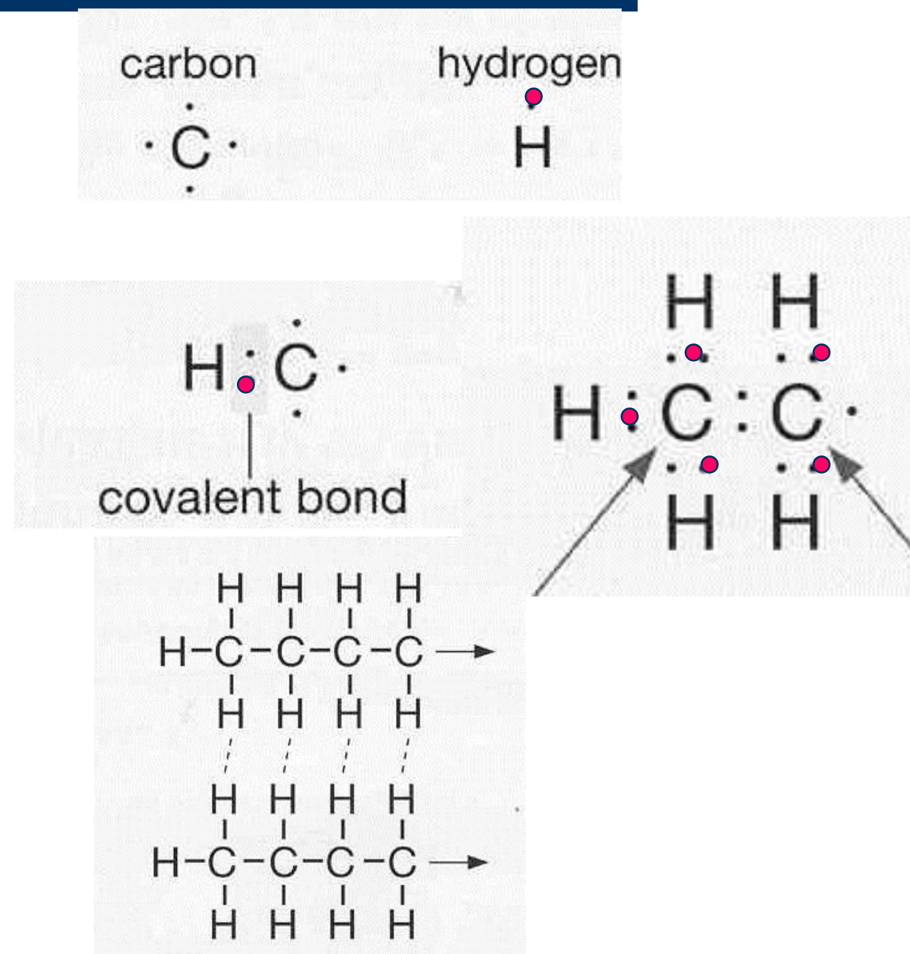






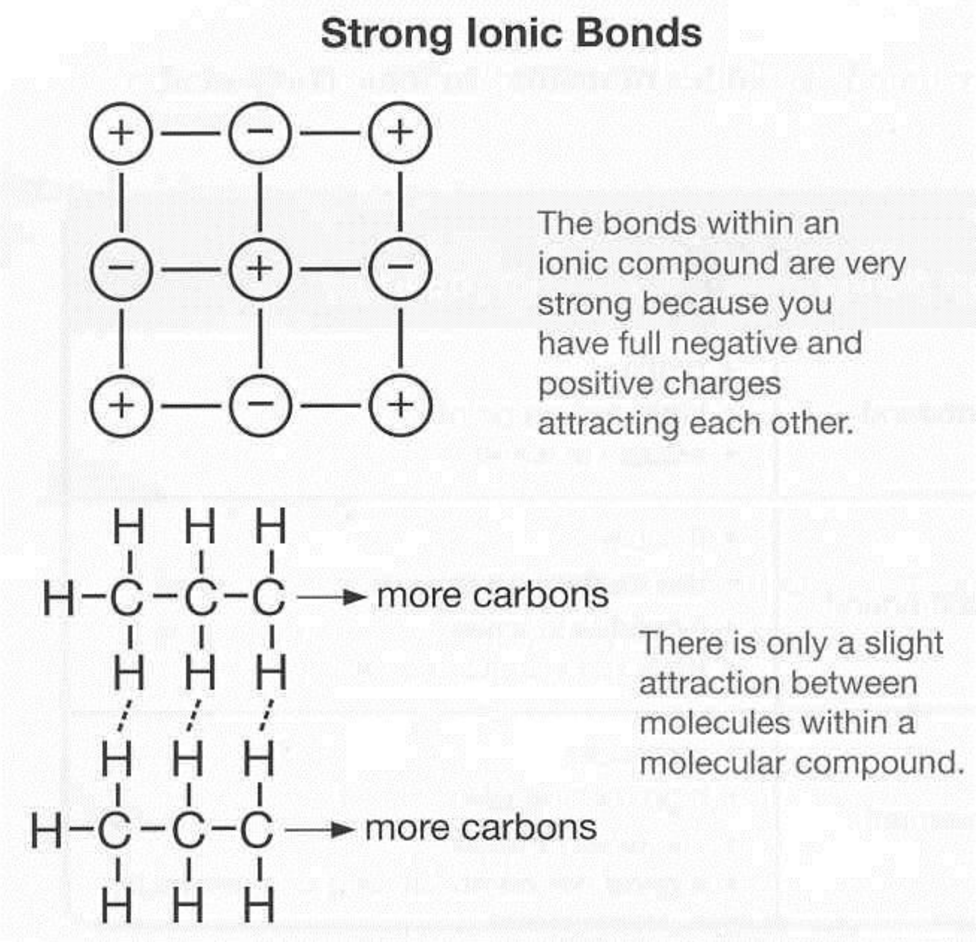
An example of the atomic structure for covalent bonds (molecular).

1. Lewis Dot Diagrams
2. Single electrons from one non-metal join with single electrons from another non-metal, until all the single electrons are gone
3. Adjacent compounds are slightly attracted to each other



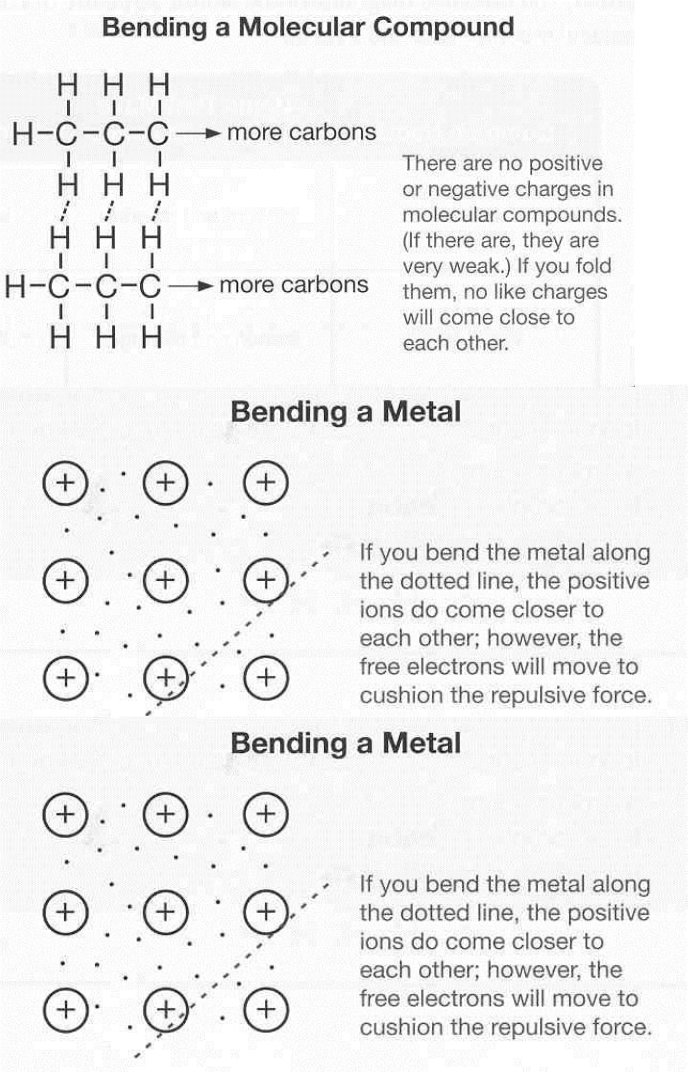
Why do ionic compounds have a higher melting point than molecular?

- Ionic compounds have a higher melting point because the attraction between compounds is very strong.
- Molecular compounds have a lower melting point because the attraction between compounds are weak.



Why do metals and plastics bend while ionic salts are brittle & break?

- Plastics bend because there are no like charges close to each other (no charges at all)
- Metals bend because the free electrons cushion the positive charges.
- Ionic compounds do not bend because like charges repel each other.

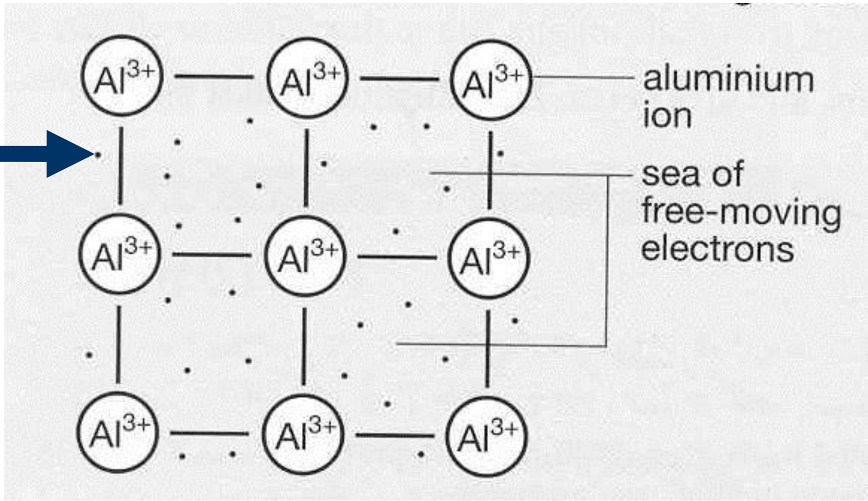


Why do metals conduct electricity & heat?

- The free moving electrons can move. The electrical or thermal energy is transferred from one electron to another and carried down the metal.

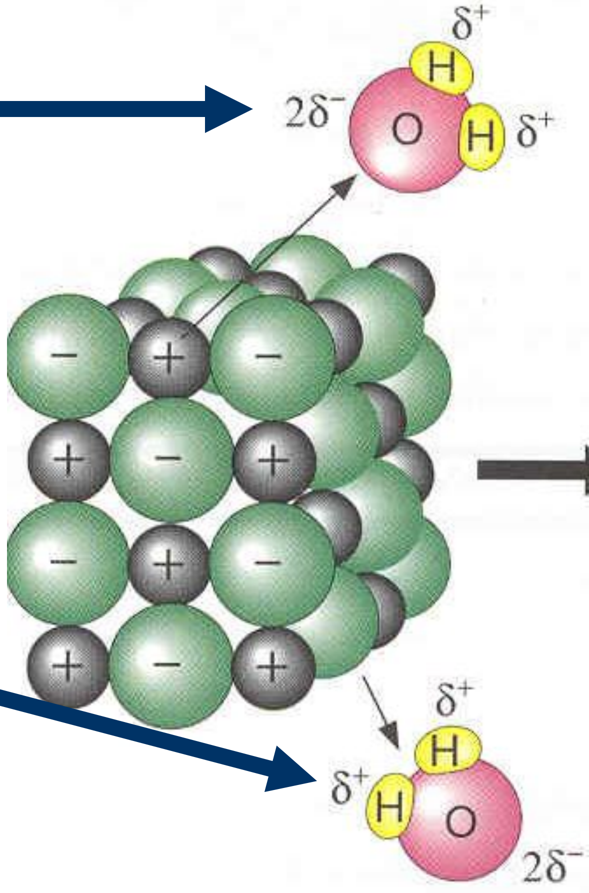
Electrical energy

Pushes e-



Why do ionic salts dissolve in water?

- Water has a negative region or pole around the oxygen that attracts and pulls the positive ion.
- At the same time a positive region or pole around the hydrogens attracts and pulls the negative ion.

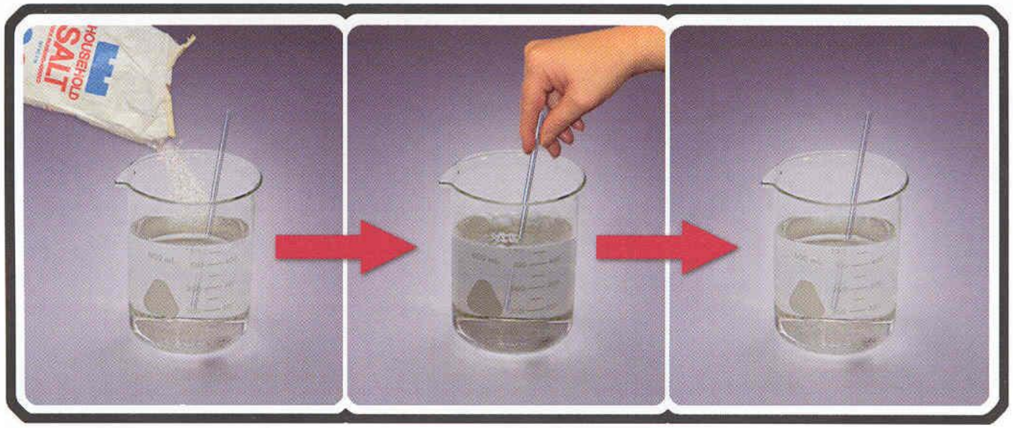


Check for understanding

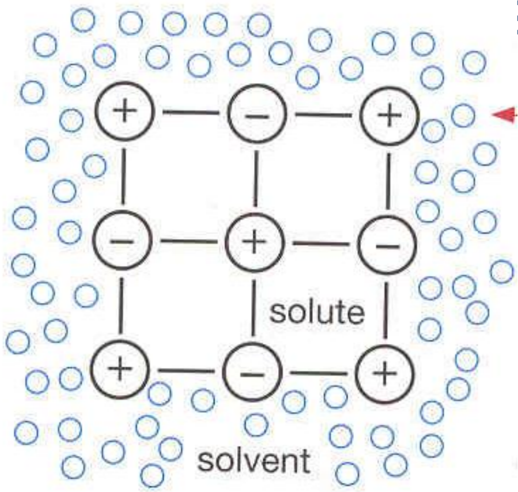
Answers to check for understanding

Lesson 1.3: Breaking Bonds

What is a solution?

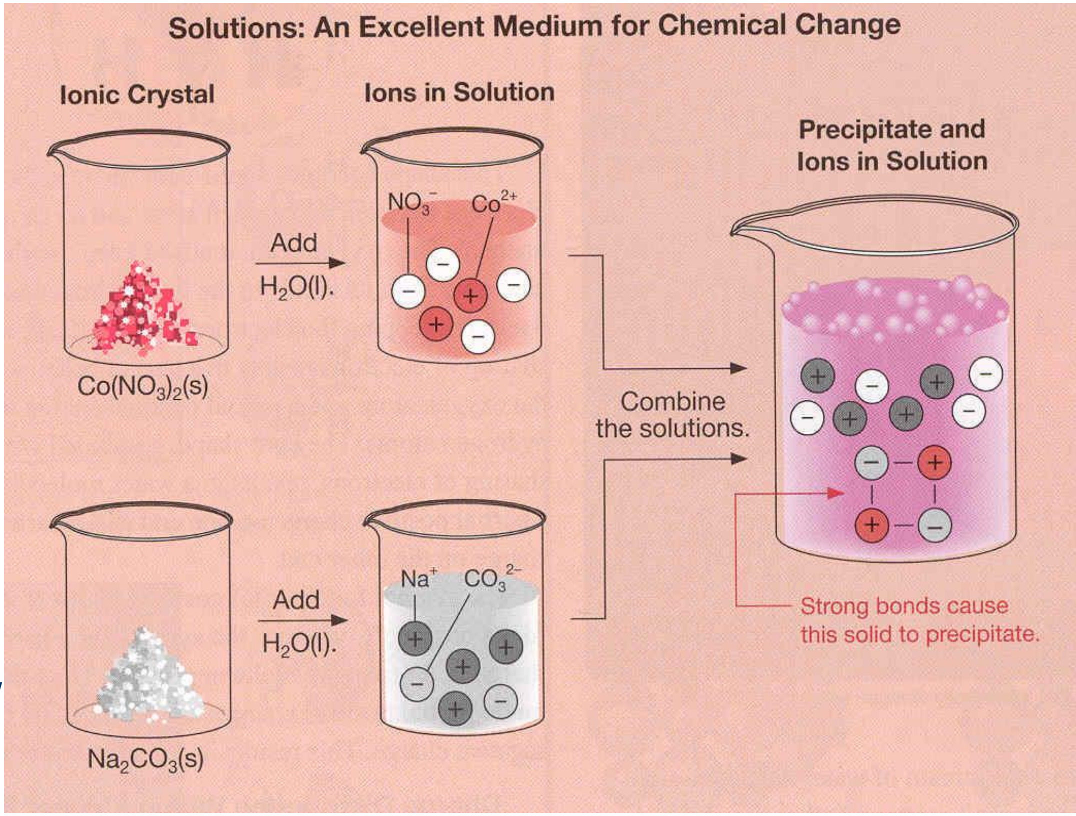


- **solution** – a homogenous mixture (look like one substance) of dissolved substances that contains a solute and a solvent.
- **aqueous solution** - solution where water is the solvent and the state is aqueous. Eg) $NaCl_{(aq)}$
  - **solute** – a substance in a solution whose bonds are broken by a solvent (a substance that dissolves) (usually a solid) eg) $NaCl_{(s)}$
  - **solvent** – a substance in a solution that breaks down the bonds of a solution. (usually a liquid like water) A mixture made up of more than one type of particle where the particles mingle with each other. Eg) $H_2O_{(l)}$



Why are solutions excellent medium for chemical change?

- Solutions are excellent for breaking bonds in a particular substance.
- This allows each ion to collide with ions and form new bonds.



What are evidences of chemical change?

- One cannot see the bonds break and form. However, if a **new substance** is produced, one can see the evidence of new bonds which are:

  -a change in **colour (not dissolving)**

  -a changed in odour

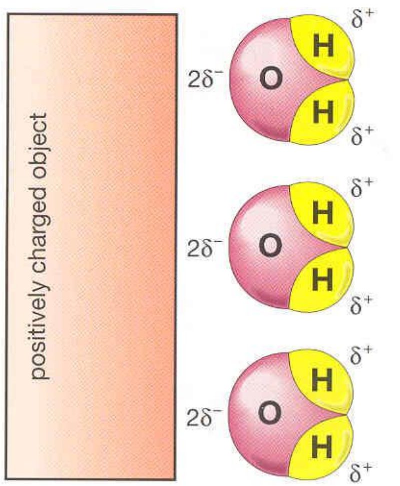
  -a change in state (usually gas or solid **precipitate**) (not evaporation)

  -a change of energy

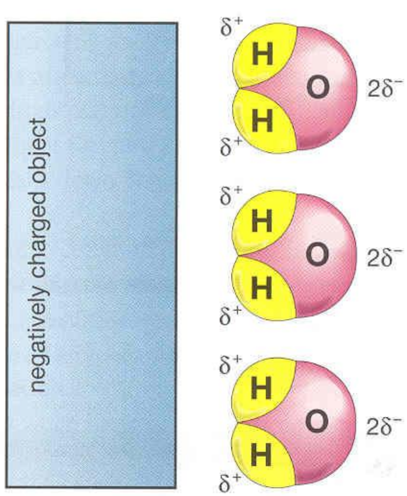
  - **exothermic** – a chemical change where heat is produced (energy is released into environment)
  - **endothermic** – a chemical change where energy is absorbed from the surrounding environment

Why is water a good solvent?

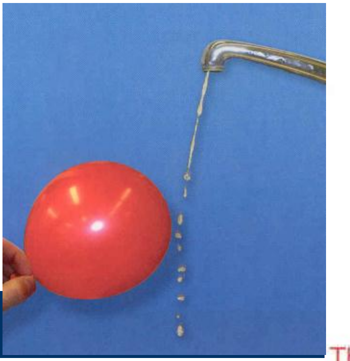
Attractive Properties of Water Molecules

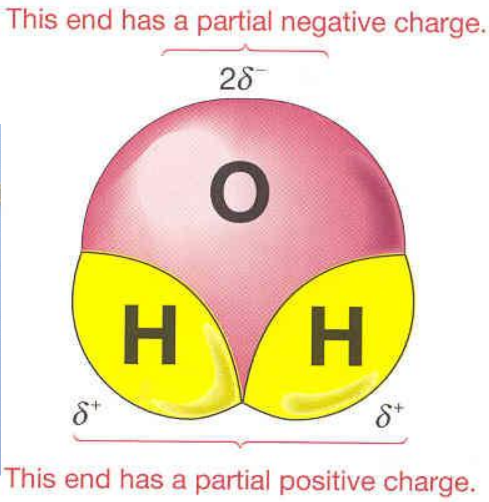


The negative end of each water molecule is attracted to a positively charged object.

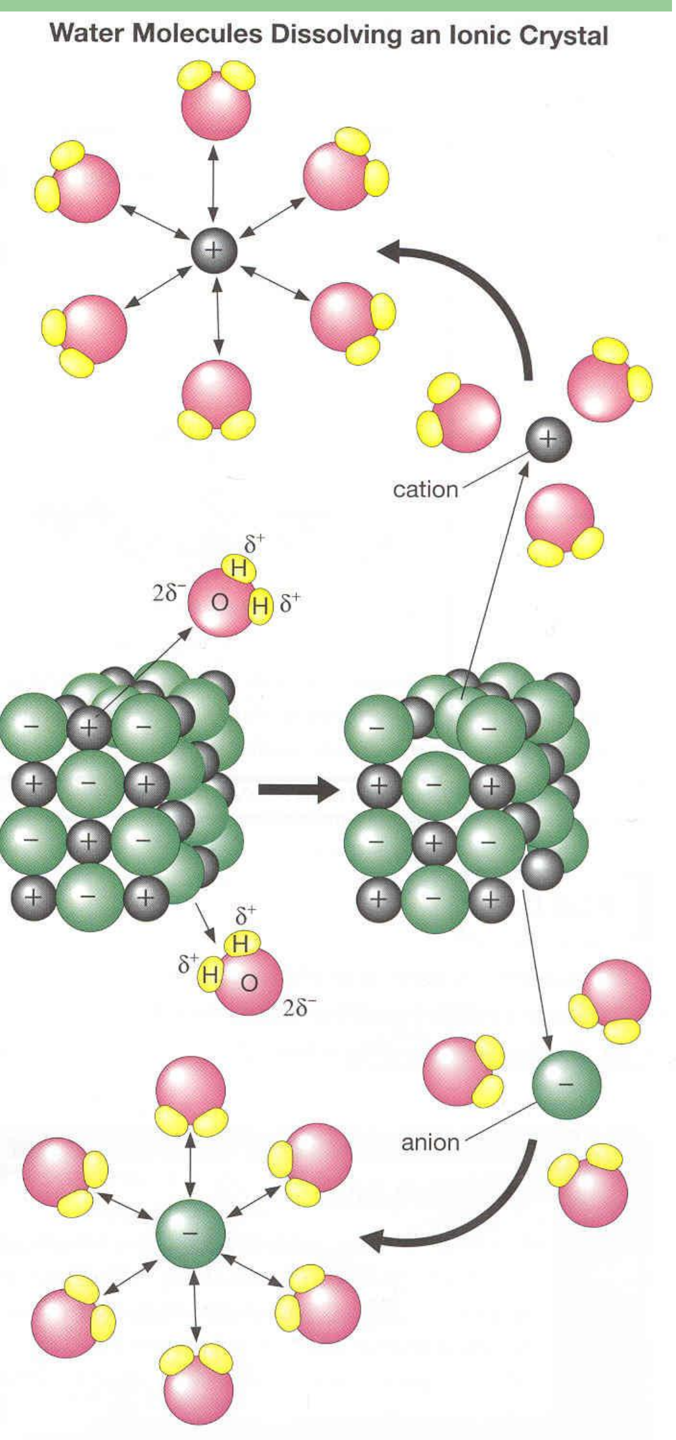


The positive end of each water molecule is attracted to a negatively charged object.





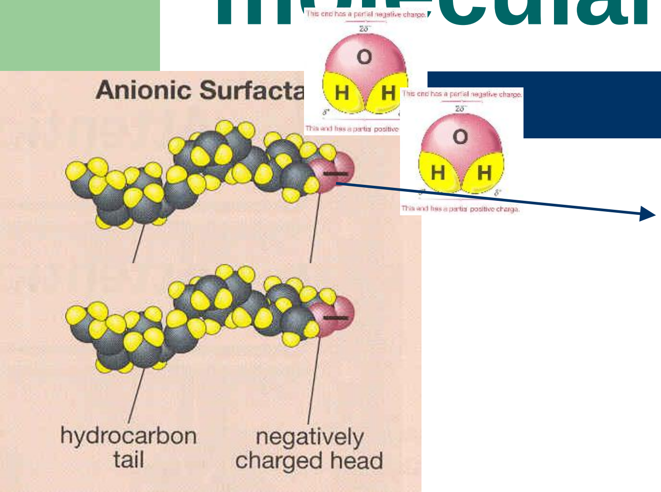
- Water is a good solvent because it is a **<u>polar molecule</u>** – a molecule with a partial positive charge and a partial negative charge.
- The negative pole at the oxygen attracts or pulls apart positively charged ions, molecules and objects
- The positive pole at the hydrogen attracts or pulls apart negatively charged ions, molecules and objects.

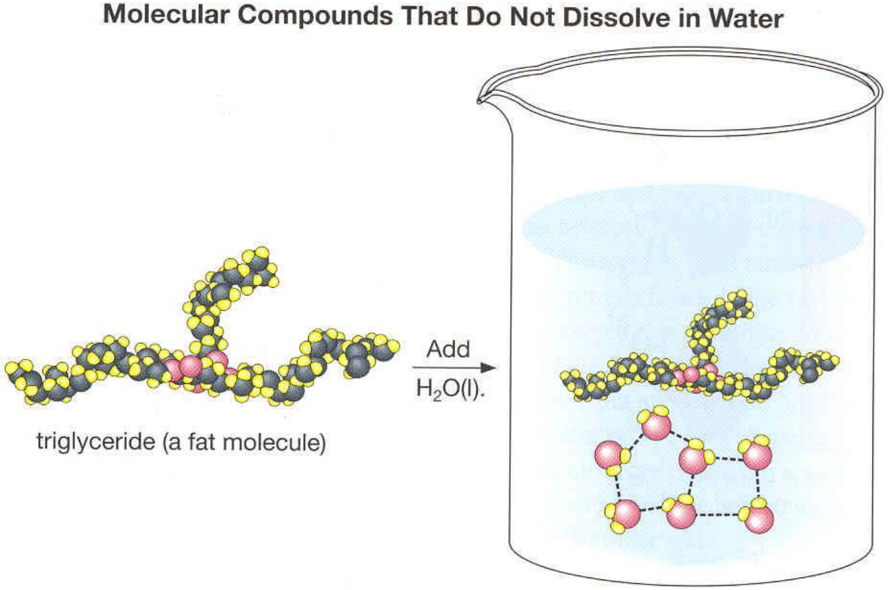


How does water dissolve an ionic salt?

- Water is a power solvent that pulls the ions apart. The oxygen in water pulls the cations (look at top left) & the hydrogen in water pulls the anions (look at bottom left).

Why does water dissolve some molecular compounds & not others?





- Some molecular compounds, like sucrose (sugar), are polar and have an oxygen with a slightly negative charge. The hydrogen in the water pull the whole sugar molecules away from each other.

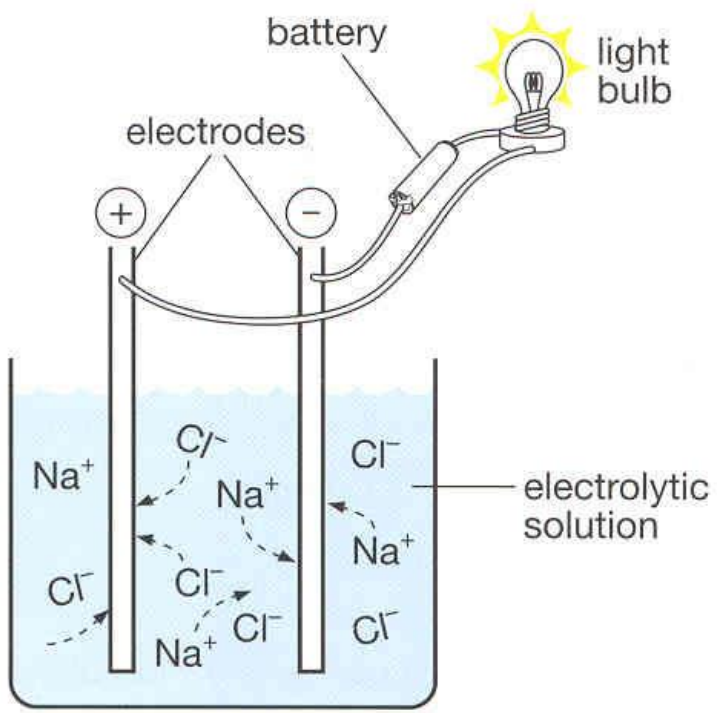
Other molecular compounds, like fat, are not polar and do not have a charge. These compounds do not dissolve in water.

What is the dissociation of Ionic compounds?

- The **dissociation** of ionic compounds is the separation of a **solid** ionic compound into its individual **aqueous** ions, after it dissolves in water.
  - Eg) $NaCl_{(s)} \xrightarrow{H2O(l)} Na^{+}_{(aq)} + Cl^{-}_{(aq)}$
  - Eg) $CaF_{\mathbf{2}(s)} \xrightarrow{H2O(l)} Ca^{2+}_{(aq)} + \mathbf{2}F^{-}_{(aq)}$
  - Eg) $Be(NO_3)_{\mathbf{2}(s)} \xrightarrow{H2O(l)} Be^{2+}_{(aq)} + \mathbf{2}NO_{3}^{-}{}_{(aq)}$
    - NOTE – always only two ions produced.
    - Water is not part of the equation (not a reaction – a physical change)
    - Ions are never **diatomic** eg) F- is not F2
    - **Complex** ions are not broken apart eg) NO3-
    - **Aq** means that the ion is surrounded by water

What is an electrolyte and an non-electrolyte?

Conductivity Meter and an Electrolyte



Dissociated ions can move toward the oppositely charged electrodes of the conductivity meter. The movement of ions (charges) completes the circuit of the conductivity meter.

- An **electrolyte** is a solution that conducts electricity. Ionic solutions are electrolytes. Eg) NaCl(aq)
- A **non-electrolyte** is a solution that does not conduct electricity. Molecular solutions are non-electrolytes. Eg) pure water

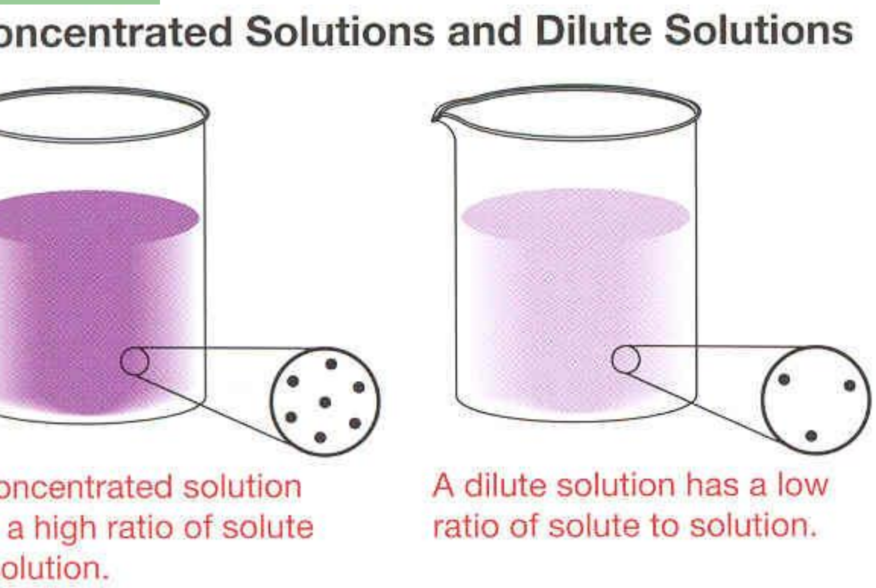
Check for understanding

Answers to check for understanding

Lesson 1.4 Solutions & Concentrations

What is concentration?

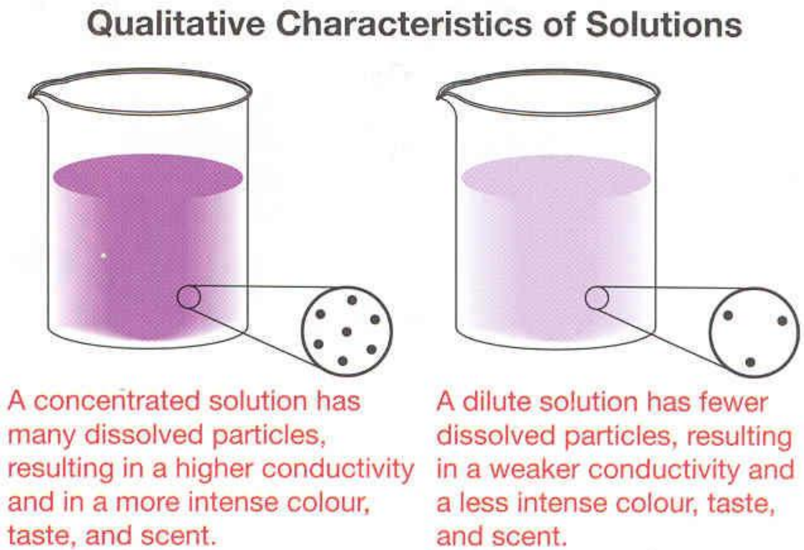
- **Concentration**: the amount or solute in a given amount of solvent (ratio of solute to solution)
  - **Concentrated:** a solution containing more solute for a given amount of solvent compared to another solution (higher ratio of solute to solution)
  - **Dilute**: a solution containing less solute for a given amount of solvent when compared to another solution. (lower ratio of solute to solution)
  - Eg) a 4.00 mol/L solution is twice as concentrated as a 2.00 mol/L solution



What does understanding concentrations help you answer?

- How much of the solute is in the product?
- What are the safe & acceptable limits for certain chemicals in food or drinking water?
- Can you save money by buying concentrated solutions and diluting them yourself?
- How can you make a solution with a given concentration and how can you dilute this solution?

What are qualitative evidences of concentrated and dilute solution?



Qualitative evidences of a concentrated solution:

1. Stronger Taste
2. Less Transparency
3. More Colour intensity
4. Strong odour(smell)
5. Stronger rate/speed of reaction

Check for understanding

Answers to check for understanding

Lesson 1.5 Calculating Concentration

What are the three main ways of communicating concentration?

EXPRESSING CONCENTRATION

	Symbol	Formula	Use
Percent by Volume	% *V/V*	$\frac{\text{mL of solute}}{\text{mL of solution}} \times 100\%$	communicating the volume of a liquid solute dissolved in the total volume of a solution
Parts Per Million	ppm	$\frac{\text{g of solute}}{\text{g of solution}} \times 10^6 \text{ ppm}$	communicating levels of a substance (like a pollutant) in very dilute aqueous solutions
Molar Concentration	C	$\frac{\text{mol of solute}}{\text{L of solution}}$	communicating the amount of moles of a pure substance dissolved in the total volume of a solution

How do you calculate percent by volume – example 1?

Example 1: A hair product requires 20.0 mL of hydrogen peroxide (H_2O_2) with enough water to make a 120 mL solution. Determine the percent by volume concentration.

Step 1: Formula - %V/V = Vsolute/Vsolution x 100

Step 2: Substitute - $\%V/V = \frac{20.0\ mL}{120\ mL} \times 100$

Step 3: Calculate - % V/V = 16.6<u>6</u>66 (rounds up)

Step 4: Round & Add Units - %V/V = ***<u>16.7</u>***

How do you calculate percent by volume – example 2?

Example 2: A repellent has 45.0% DEET in a 75 mL container. Determine the volume of DEET.

Step 1: Formula - %V/V = Vsolute/Vsolution x 100

Step 2: Substitute - $45.0\% = \frac{\text{Vsolute}}{75 \text{ mL}} \times 100$

Step 3: Rearrange $\frac{45.0 \times 75}{100} = \frac{\text{Vsolute}}{75} \times \cancel{\frac{100}{100}} \times \cancel{75}$

Calculate – 33.75 (round up)

Step 4: Round & Add Units - V = ***34 mL***

How do you calculate parts per million (ppm) – example 1?

A 200 g sample of water contains 5.4×10^{-3} g of mercury.

Step 1: formula:ppm=g of solute/g of solution$\times 10^6$

Step 2: substitute:ppm = $\frac{5.4\ E{-3}}{200} \times E6$

Step 3: calculate: ppm = 27

Step 4: round & units: ppm = ***27 ppm of mercury***

This water is not safe since the acceptable level is 0.001 ppm

How do you calculate parts per million (ppm) – example 2?

When a person smokes, they breath in about 200 ppm of carbon monoxide (CO). If one breath is about 9.6 g, then what is the mass of CO.

Step 1: formula:ppm=g of solute/g of solutionx10^6

Step 2: 200 = $\frac{\text{g of solute}}{9.6\text{ g}} \times 10^6$

Step 3: Rearrange $\frac{45.0 \times 9.6}{10^6} = \frac{\text{Vsolute}}{9.6} \times 10^6 \times 9.6$ / 10^6

Calculate – 33.**7**5 (round up)

Step 4: Round & Add Units – g of solute = ***34 mL***

How do you calculate molar concentration – example 1?

A sample of water taken from a nearby lake is found to have 0.0035 mol of salt in a 100-mL solution. Determine the concentration of the salt in the lake.

Step 1: Conc = mol of solute/L of solution

Step 2: Change mL to L: $100 \text{ mL} \times \frac{1.00\text{L}}{1000 \text{ mL}} = 0.100\text{L}$

Conc = 0.0035 mol/ 0.100 L

Step 3: C = 0.035

Step 4: C = **0.035 mol/L**

How do you calculate molar concentration – example 2?

You dissolve 30.0 g of sodium sulphate (Na_2SO_4) into 300mL.

a) Determine the number of moles of sodium sulphate in the solution.

Step 1: mol = mass (g)/Molar mass (g/mol) OR n=m/M

Step 2: n = 30.0g / 142.04 g/mol

Step 3: n = 0.211208…

Step 4: n = **<u>0.211 mol</u>**

<u>MOLAR mass (periodic table)</u>

Na2 = 22.99 x 2 = 45.98

S1 = 32.06 x 1 = 32.06

O4 = 16.00 x 4 = <u>64.00</u>

TOTAL 142.04g/mol

b) Calculate the molar concentration of this sodium sulphate solution.

Step 1: Conc = mol of solute / L of solution OR C=n/V

Step 2: C = 0.211 mol / 0.300 L (300mL/1000 = 0.300 L)

Step 3: C = 0.703333

Step 4: C = **<u>0.703 mol/L</u>**

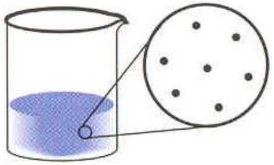
How do you make a standard solution?

Step 1: Find the moles of solute needed using n=CV (concentration x volume)

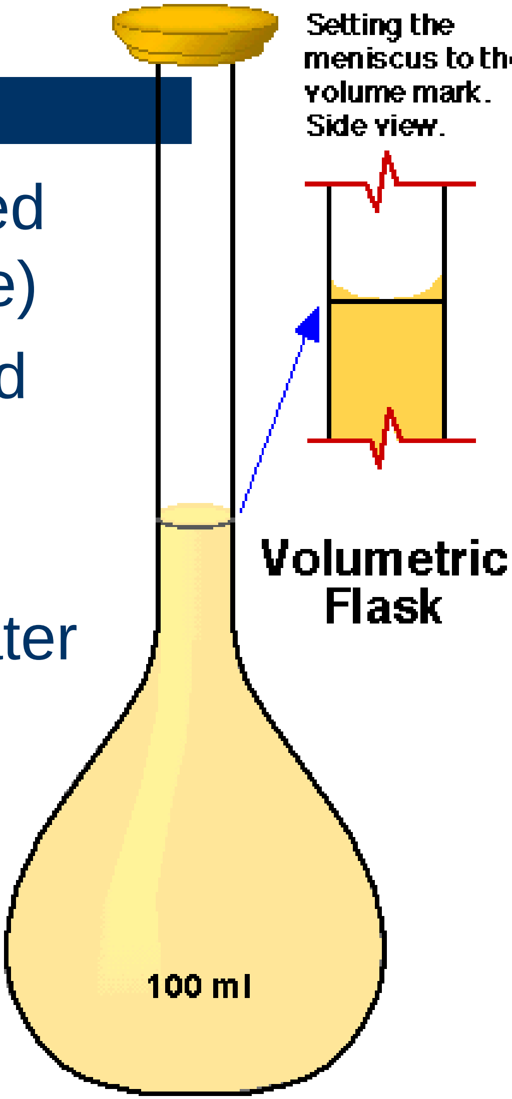
Step 2: Find the mass of solute needed using m=nM (moles x molar mass)

Step 3: Weigh the mass on a scale

Step 4: Mix in a beaker with a little water and transfer to a volumetric flask.

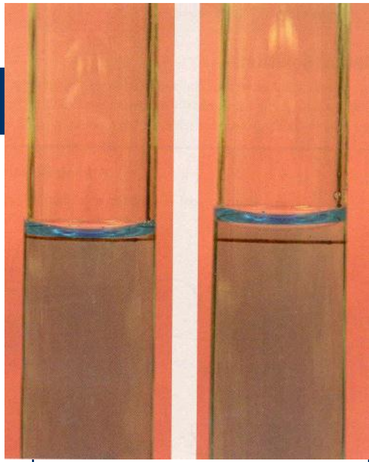


Step 5: Using a wash bottle or eye dropper, fill the volumetric flask to the meniscus line



Which is Correct?

Making a solution - example



- What are the steps to make a 100 mL of 0.200 mol/L solution of NaOH?

Step 1: Calculate moles – n = CV;

n = 0.200 mol/L x 0.100L; n = 0.0200 mol

Step 2: Calculate mass – m = nM;

m=0.0200mol x 40.00g/mol; m = 0.800 g

Step 3: Mix 0.800 g of NaOH in a beaker with 20 mL of water & pour into 100mL volumetric flask

Step 4: Using a wash bottle fill the flask to the meniscus line.

MOLAR MASS

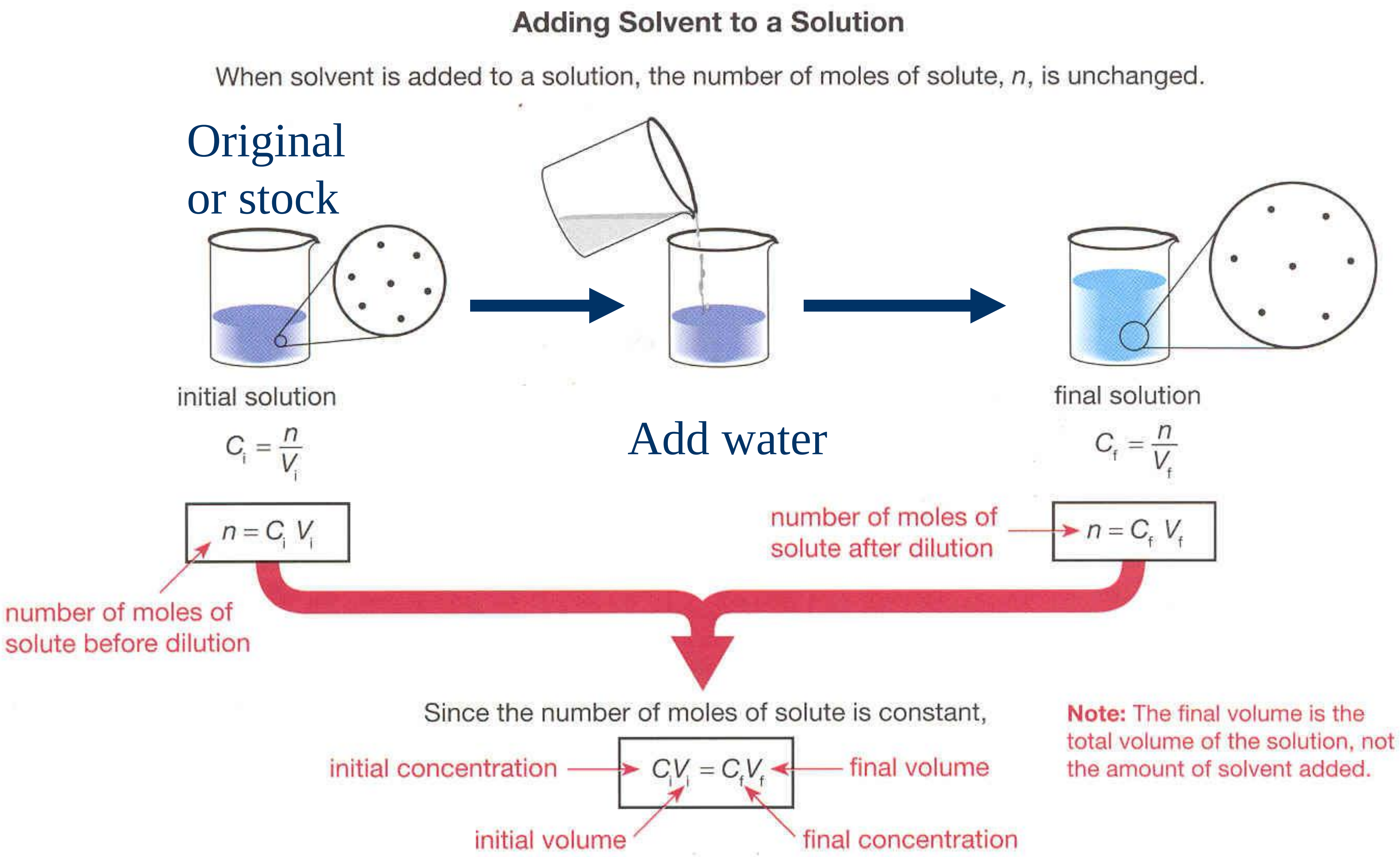
Na = 22.99

O = 16.00

H = 1.01

40.00

How do you calculate a dilution?



How do you dilute a solution?

1. Calculate the volume of the original needed ($V_i = C_fV_f/C_i$ OR $V_1=C_2V_2/C_1$) NOTE: Values related are usually close together. C_1 is bigger than C_2, BUT V_2 is bigger than V_1.
2. Remove the volume with a pipet and place into a volumetric flask
3. Using a wash bottle or eye dropper fill the volumetric flask with distilled water up to the the meniscus line. NOTE: The amount of water is V2-V1.

How do I calculate information during a dilution – example 1?

You have 65.0 mL of a 0.759 mol/L solution of chloride, $NaCl_{(aq)}$. Calculate the final concentration of the solution if it is diluted to a final volume of 100.0 mL.

Step 1: V_1=65.0mL, C_1=0.759 mol/L, V_2=100.0mL

$$C_1V_1 = C_2V_2 \quad \text{OR} \quad C_2 = C_1V_1/V_2$$

Step 2: C_2 = 0.759 mol/L x 65.0 mL /100.0 mL

Step 3: C_2 = 0.4933…

Step 4: C_2 = ***0.493 mol/L***

How do I calculate information during a dilution – example 2?

You have 65.0 mL of a 0.759 mol/L solution of chloride, $NaCl_{(aq)}$. Calculate the final concentration of a solution prepared by adding 100.0mL of **water** to the original solution.

Step 1: V_1=65.0mL, C_1=0.759 mol/L, V_2=100.0mL+65.0mL

$$C_1V_1 = C_2V_2 \quad \text{OR} \quad C_2 = C_1V_1/V_2$$

Step 2: C_2 = 0.759 mol/L x 65.0 mL /165.0 mL

Step 3: C_2 = 0.299

Step 4: C_2 = ***0.299 mol/L***

How do I calculate information during a dilution – example 3?

You have 65.0 mL of a 0.759 mol/L solution of chloride, $NaCl_{(aq)}$. How much **water** is added to the original to make 0.200 mol/L

Step 1: V_1=65.0mL, C_1=0.759 mol/L, C_2=0.200mol/L

$$C_1V_1 = C_2V_2 \quad \text{OR} \quad V_2 = C_1V_1/C_2$$

Step 2: V_2 = 0.759 mol/L x 65.0 mL /0.200mol/L

Step 3: V_2 = 246.675

Step 4: V_2 = 247

Step 5: water = V_2-V_1; water =247-65 = ***182mL***

How do I calculate information during a dilution – example 4?

You have 65.0 mL of a 0.759 mol/L solution of chloride, $NaCl_{(aq)}$. How much **water** evaporates from the original to make a 0.890 mol/L solution

Step 1: V_2=65.0mL, C_2=0.759 mol/L, C_1=0.890mol/L

$C_1V_1 = C_2V_2$ OR $V_1 = C_2V_2/C_1$

Step 2: V_1 = 0.759 mol/L x 65.0 mL /0.890mol/L

Step 3: V_2 = 55.432…

Step 4: V_2 = 55.4 mL

Step 5: water = V_2-V_1; water =65.0 – 55.4 = ***9.6 mL***

Diluting Acids

- When diluting acids always add water to the acid (A & W).
- A battery uses sulphuric acid. When the battery is being used to produce an electric current, the concentration of the acid decreases.
- When you charge a battery, the chemical reactions are reversed and the concentration of acid increases

Chapter 2

2.1 Compounds & Change

2.2 Gain & Loss of electrons

2.3 Reactivity of metals

2.4 Voltaic Cells

2.5 Electrolytic Cells

What are some of the key definitions

- **Monoatomic elements**: Single elements from the periodic table.
- **Diatomic elements**: Elements that pair up when they are by themselves. (Rule of 7 + H_2)
- **Polyatomic elements**: Elements that have 4 or 8 elements when they are by themselves (P_4 & S_8)
- **Ionic compounds**: made up of metal ions and non-metal ions. The charges should be balanced.
- **Molecular compounds**: made up of only non-metals and have prefixes in their name.
- **Coefficients**: the large numbers in front of a compound or element after you balance a chemical reaction

How do you write a balanced chemical equation

1. Translate the words into chemical formulas
   a) Watch for diatomic & polyatomic elements
   b) Balance ionic charges
   c) Use common names
2. Add coefficients to balance the atoms. Do not write 1's.

Solid silver + hydrogen sulfide gas + oxygen gas → solid silver sulfide + water

$Ag_{(s)} + HS_{(g)} + O_{(g)} \rightarrow AgS_{(s)} + H_2O_{(l)}$

$H_2S_{(g)} + O_{2(g)} \rightarrow Ag_2^{1+}S^{2-}_{(s)}$

$Ag_{(s)} + H_2S_{(g)} + O_{2(g)} \rightarrow Ag_2S_{(s)} + H_2O_{(l)}$

$\underline{\mathbf{4}}Ag_{(s)} + \underline{\mathbf{2}}H_2S_{(g)} + O_{2(g)} \rightarrow \underline{\mathbf{2}}Ag_2S_{(s)} + \underline{\mathbf{2}}H_2O_{(l)}$

How do you check if the equation is balanced?

- Divide the equation in half and check how many atoms are on each side. NOTE: Multiply the coefficient and subscripts. The coefficient belongs to all the elements in the compound.

$\underline{\mathbf{4}}Ag_{(s)} + \underline{\mathbf{2}}H_2S_{(g)} + O_{2(g)} \rightarrow \underline{\mathbf{2}}Ag_2S_{(s)} + \underline{\mathbf{2}}H_2O_{(l)}$

Ag =4	Ag = 2x2 = 4
H = 2x2 = 4	H = 2x2 =4
S = 2	S = 2
O = 2	O = 2

What is the mole ratio?

- The **mole ratio** is the comparison (dividing) of two coefficients in a balanced chemical equation. If one amount is given, the ratio can be used to find a required(unknown) amount.
  - **coefficient**$_r$: coefficient in front of the chemical with an amount that is ***required***.
  - **coefficient**$_g$: coefficient in front of the chemical with a ***given*** amount in moles.
  - n_r: number of moles ***required*** (looking for this)
  - n_g: number of moles ***given*** (amount provide in mol)
- Formula: $\frac{n_r}{n_g} = \frac{\text{coefficient}_r}{\text{coefficient}_g}$

How do I use the mole ratio to determine unknown quantities?

Example problem 2.1: Determine the amount of silver **required** to make **0.876 mol** of silver sulphide.

Step 1: Balanced reaction. Identify the required and given quantities & coeffients.

4 $Ag_{(s)}$ + 2 $H_2S_{(g)}$ + $O_{2(g)}$ → ***2***$Ag_2S_{(s)}$ + $2H_2O_{(l)}$

r=? g=0.876mol

Step 2: Set up mole ratio equation: $\frac{n_r}{0.876mol} = \frac{4 \; (Ag)}{2 \; (Ag_2S)}$

Step 3: Solve: **nr = 0.876mol x 4 / 2 = 1.75**

Step 4: Significant digits and units: **n_r = 1.75 mol of Ag**

Example 2.2: Aluminum reacts with oxygen to form aluminum oxide

a) If you react 6.25 mol of aluminum, how many moles of aluminum oxide will form?

Step 1: Balanced reaction. Identify the required and given quantities & coefficients.

4 $Al_{(s)}$ + $3O_{2(g)}$ → **2**$Al_2O_{3(s)}$

g=6.25mol r=?

Step 2: Set up mole ratio equation: **$\frac{n_r}{0.6.25mol} = \frac{2\ Al_2O_3)}{4\ (Al)}$**

Step 3: Solve: **nr = 6.25mol x 2 / 4 = 3.13**

Step 4: Significant digits and units: **n_r=3.13 mol of Al_2O_3**

Example 2.2: Aluminum reacts with oxygen to form aluminum oxide

a) Determine the number of moles of oxygen required to react with 6.25 mol of aluminum.

Step 1: Balanced reaction. Identify the required and given quantities & coefficients.

4 $Al_{(s)}$ + $3O_{2(g)}$ → **2**$Al_2O_{3(s)}$

g=6.25mol r=?

Step 2: Set up mole ratio equation: $\frac{n_r}{0.6.25mol} = \frac{3\ (O_2)}{4\ (Al)}$

Step 3: Solve: **nr = 6.25mol x 3 / 4 = 4.69**

Step 4: Significant digits and units: n_r = **4.69 mol of O_2**

Lesson 2.2 – The Gain and Loss of Electrons

Metals & Ores

Oxidation: the loss of electrons

Reduction: the gain of electrons

HINTS:

- OIL RIG
- LEO GER

Examples of REDOX – single replacement reactions

Lesson 2.3 – The Reactivity of Metals

Unique properties of Gold

Reactivity of metals and metal ions

- The more stable a metal atom is, the more reactive it is as an ion
- The more stable a metal ion is, the more reactive it is as a metal

Activity Series for metals and ions

Spontaneous reactions: metal ion is above another solid metal
Non-spontaneous: visa versa

Oxidizing & Reducing Agents

Lesson 2.4 – Using Voltaic Cells

Lesson 2.5 – The Electrolytic Cell

Chapter 3: Organic Chemistry

3.1 Carbon chains

3.2 Saturated and Unsaturated

3.3 Petroleum is the source

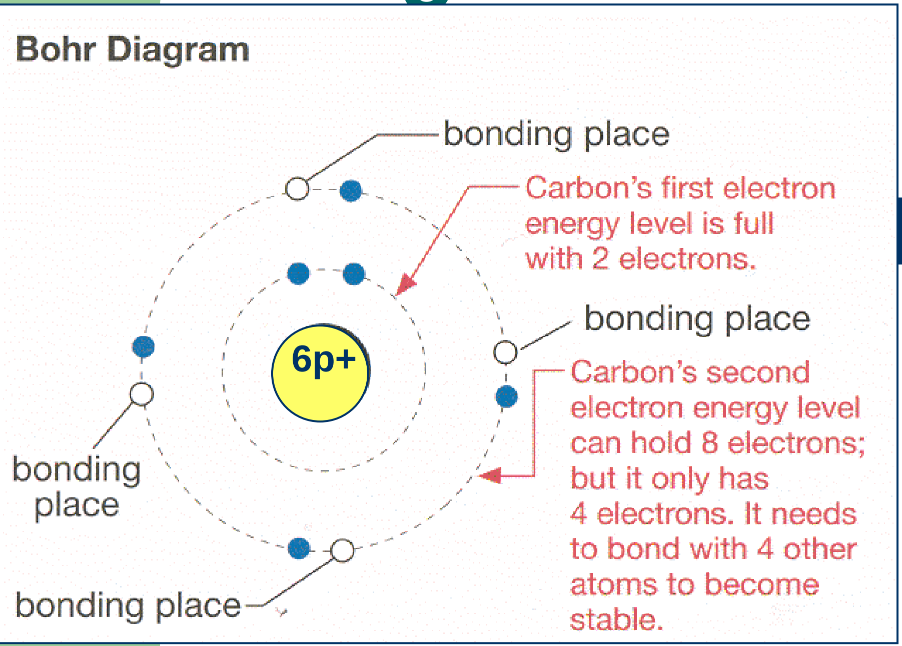
3.4 Everyday use

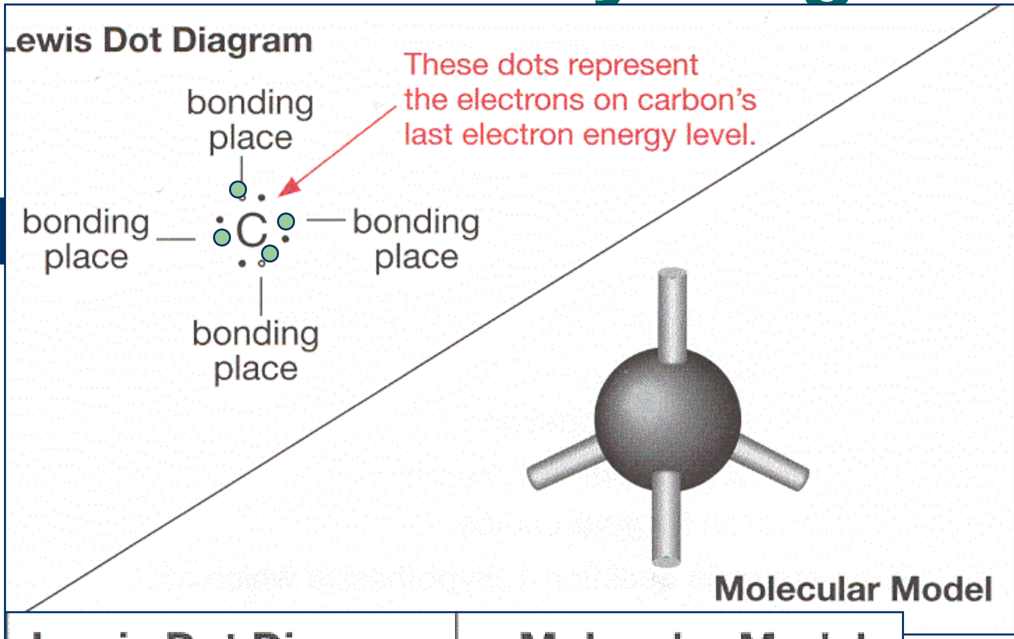
Lesson 3.1: Carbon Chains

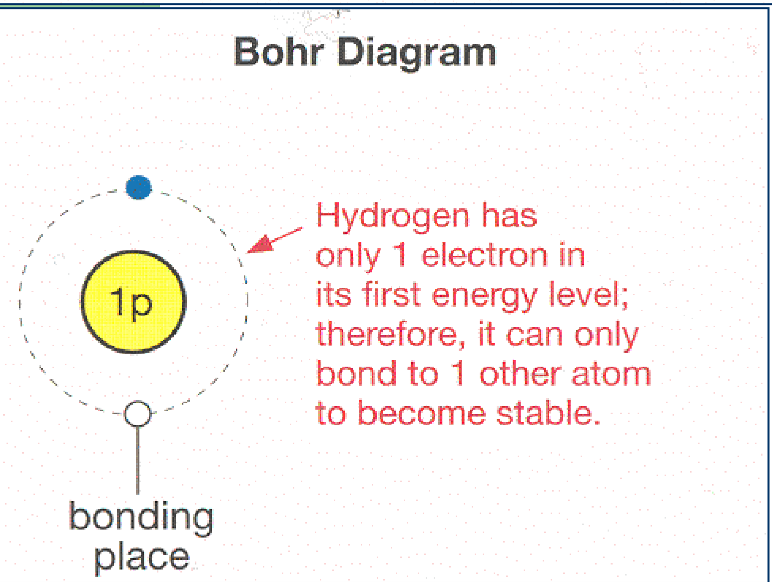
What are some common definitions?

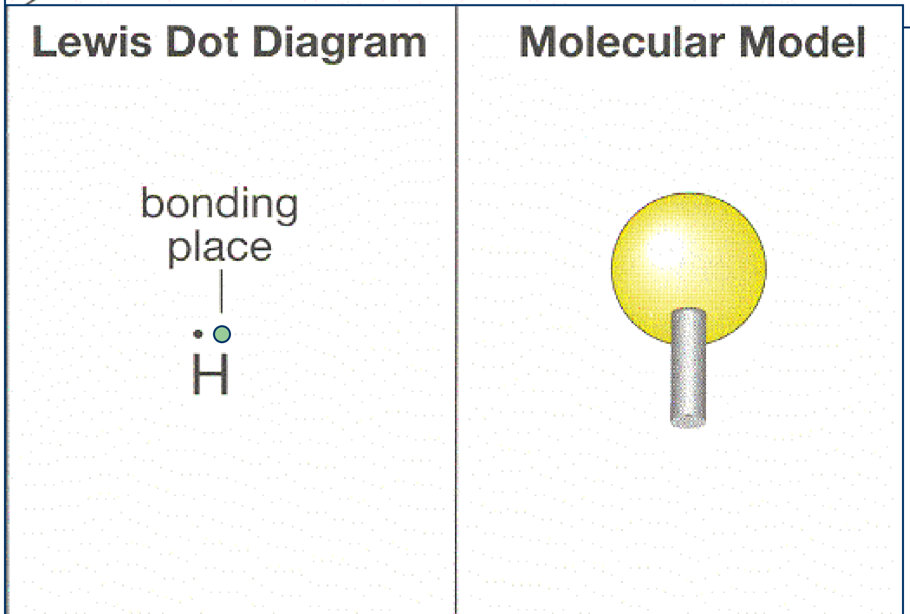
- Carbon-based compounds: compounds made with carbon. Eg) $CO_{2(g)}$ (carbon dioxide)
- Hydrocarbons: compounds made with hydrogen and carbon. Eg) $CH_{4(g)}$ (natural gas)
- Organic chemistry: the study of hydrocarbons found in living organisms or that come from living organisms. Eg) C_8H_{18} (octane in gasoline came from living organisms long ago)

What are the Bohr & Lewis diagrams for Carbon and Hydrogen

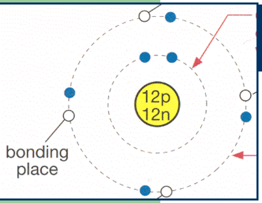


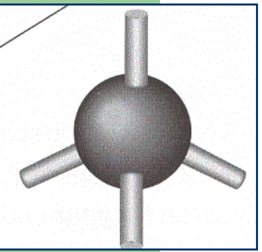






What does the Lewis dot diagram tell us about carbon and hydrogen?





- Carbon has four bonding places
- Carbon can share four electrons with four electrons from four other elements. This makes it very common and versatile. (95% of all molecular compounds have carbon)
- Carbon can share one, two or three electrons with another carbon to make single, double and triple bonds. It can not form quadruple bonds in the real world.
- Hydrogen has one bonding place. Hydrogen likes to share its electron with carbon.

How do you make long chains of carbon and hydrogen

- Place the number of carbon elements in a straight line.
  Eg) C C
- Share 2 electrons between the carbon elements (2 dots)
  Eg) C:C
- Add hydrogen around the carbon elements until each carbon has 4 bonds (8 dots) and each hydrogen has 1 bond (2 dots)

  Eg)

```
     H  H
  H :C  C: H
     H  H
```

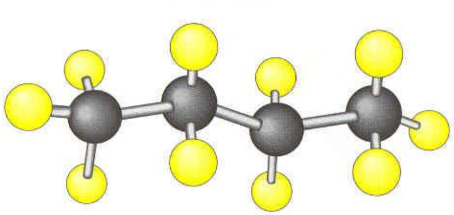
- Replace each pair of dots with a line.

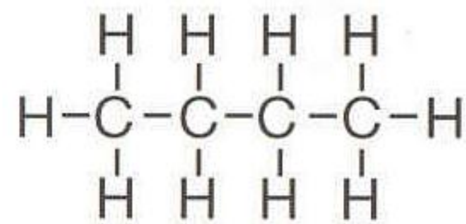
```
  H  H
H–C–C–H
  H  H
```

What are the three main types of hydrocarbons

- Single carbon-carbon bond: alkanes

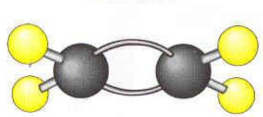
Butane

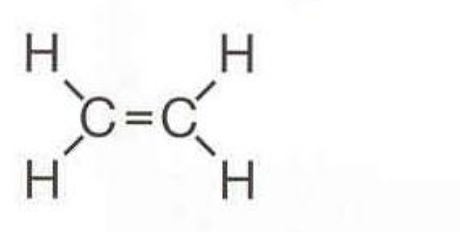




- Double carbon-carbon bond: alkenes

Ethene





- Triple carbon-carbon bond: alkynes

Ethyne

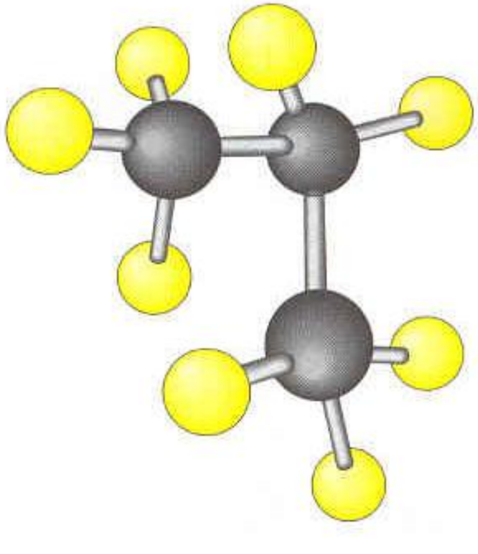
H−C≡C−H

H−C≡C−H

What are alkanes?

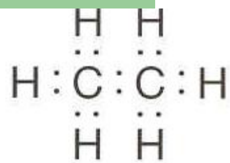
- Alkanes are hydrocarbons that contain only carbon-carbon single bonds. Their chemical formula looks like this: C_nH_{2n+2}; n = number of carbons. (Look at pg 9 in databook)
- Eg) propane has 3 carbons

$C_3H_{2x3+2} = C_3H_8$

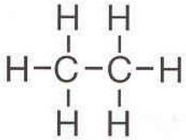


What are five ways to represent hydrocarbons? (examples next)

- Chemical formula – shows the symbols and number of carbon & hydrogen atoms. Eg) C_2H_6
- Lewis dot diagram – shows the symbols and the sharing of valence electrons (2 dots). Also shows the number & arrangement of carbon & hydrogen atoms



- Structural diagram – shows the symbols and the covalent bonds (single line). Also shows the number & arrangement of carbon & hydrogen atoms



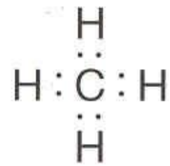
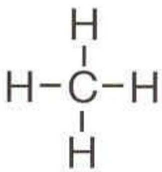
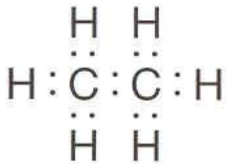
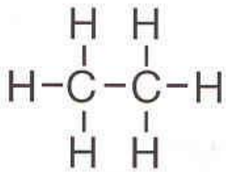
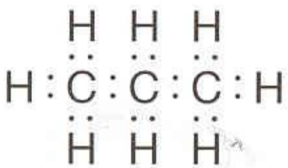
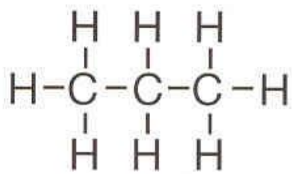
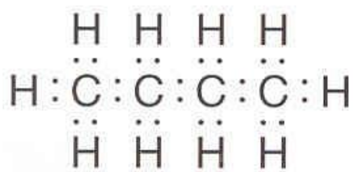
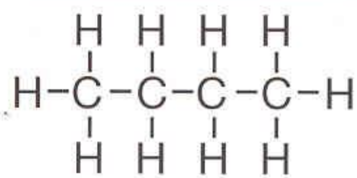
- Condensed structural diagram – shows the symbols and the carbon-carbon covalent bonds but omits carbon-hydrogen bonds.

CH_3-CH_3

- Line diagram – shows the carbon-carbon covalent bond with short lines at 90 angle. No symbols are used.

What are five ways to represent hydrocarbons – 4 examples?

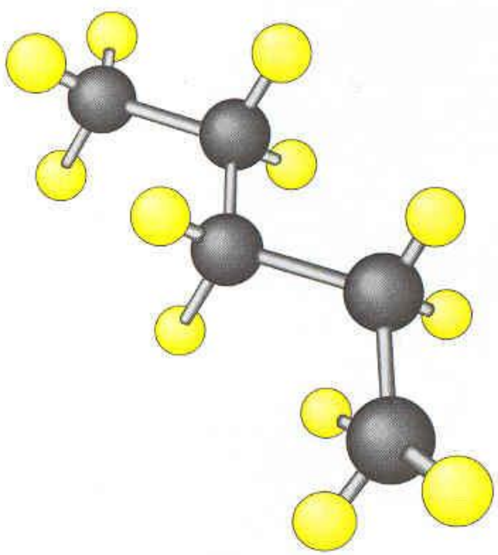
ALKANES

Compound	Chemical Formula	Lewis Dot Diagram	Complete Structural Diagram	Condensed Structural Diagram
methane	CH_4			CH_4
ethane	C_2H_6			CH_3-CH_3
propane	C_3H_8			$CH_3-CH_2-CH_3$
butane	C_4H_{10}			$CH_3-CH_2-CH_2-CH_3$

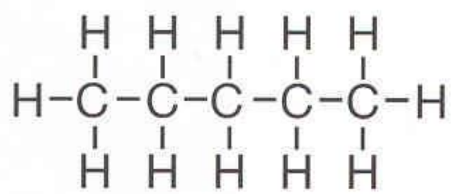
What are five ways to represent hydrocarbons- example showing molecular model and line diagram?

Example: How can the molecular formula of C_5H_{12} be represented?

Molecular Model



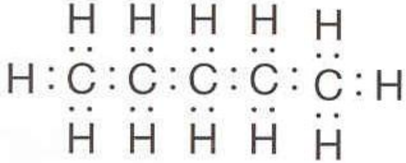
Complete Structural Diagram



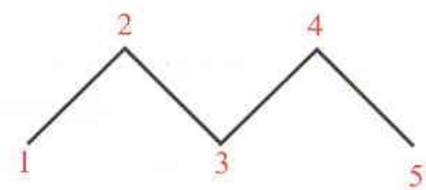
Condensed Structural Diagram

$CH_3-CH_2-CH_2-CH_2-CH_3$

Lewis Dot diagram



Line Structural Diagram



The end of each segment in the line structural diagram represents a carbon atom. Each of the five carbon atoms have been numbered for you.

This diagram assumes that a sufficient number of hydrogen atoms are attached to each carbon, so you do not have to add hydrogens to this diagram.

What are the names, formulas & applications for the first 10 alkanes?

COMMON ALKANES AND THEIR APPLICATIONS

Name	Formula	Applications
methane	$CH_4(g)$	gaseous fuel
ethane	$C_2H_6(g)$	gaseous fuel, starting compound for plastics
propane	$C_3H_8(g)$	gaseous fuel
butane	$C_4H_{10}(g)$	gaseous fuel
pentane	$C_5H_{12}(l)$	solvents
hexane	$C_6H_{14}(l)$	solvents, liquid fuel
heptane	$C_7H_{16}(l)$	solvents, liquid fuel
octane	$C_8H_{18}(l)$	solvents, liquid fuel
nonane	$C_9H_{20}(l)$	liquid fuel
decane	$C_{10}H_{22}(l)$	liquid fuel

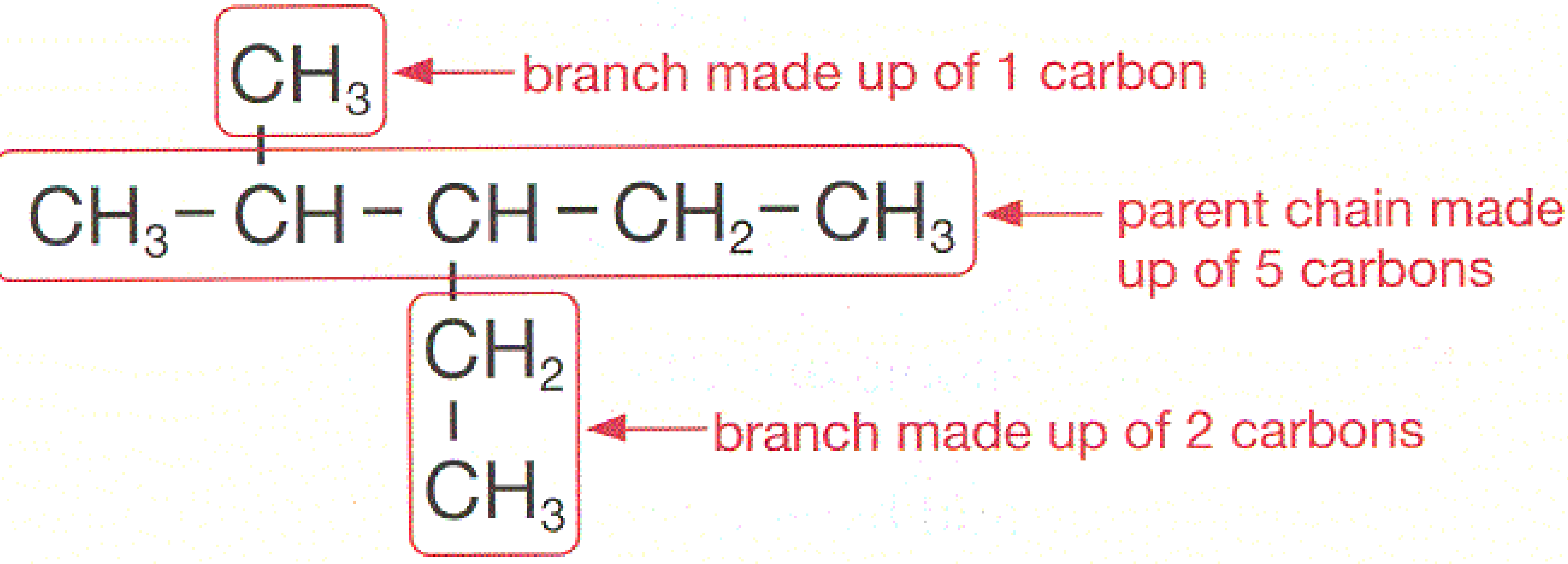
primary ingredients in gasoline (pentane to octane)

ingredients for jet fuel and diesel fuel (nonane and decane)

Common alkanes on pg. 11 of your databook

What are alkyl groups?

- **<u>Alkyl groups</u>** are branches of carbons off a masin chain of carbons.



How do you name branched alkanes using IUPAC rules?

Step 1: circle the longest continuous chain of carbon atoms – this is the parent. Name the parent (prefix + ***ane***) WARNING: the chain might be bent. Eg) 6 carbons is hex***ane***

Step 2: Place rectangles around all the branches. Name each branch (prefix + ***yl***). Eg) **1 C** in a branch is **meth*yl***; 2 Cs is eth***yl***; 3 Cs is prop***yl***

Step 3: Number the parent starting at the end nearest the first branch. These numbers communicate the location of the branches. Eg) if the methyl comes off the third carbon it would be **3**-methyl

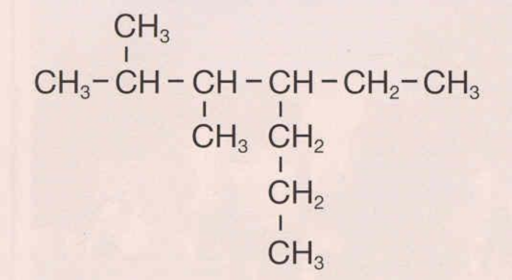
Step 4: Write branches with their numbers **a**lphabetically in front of the parent. If there are two or more branches with the same name, combine them into one name with a prefix Eg) 3-**m**ethyl, **2-ethyl** and **3 ethyl** would become 2,3-**die**thyl-3-**m**ethyl hexane

What are the prefixes for parents & branches?

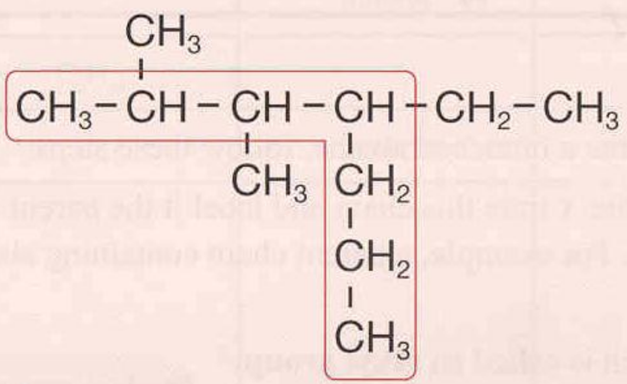
# of Carbons	Prefix	# of branches	prefix
1	meth	1	none
2	eth	2	di
3	prop	3	tri
4	but	4	tetra
5	pent	5	penta
6	hex	6	hexa
7	hept	7	hepta
8	oct	8	octa
9	non	9	nona
10	dec	10	deca

How do you name branched alkanes using IUPAC rules?

Name the following compound.

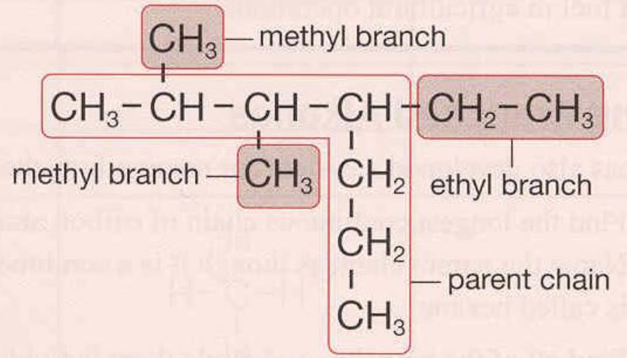


1



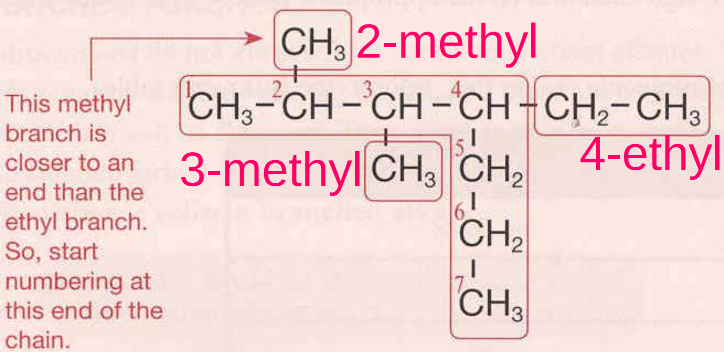
The longest chain has seven carbons. Therefore, the parent molecule is heptane.

2.



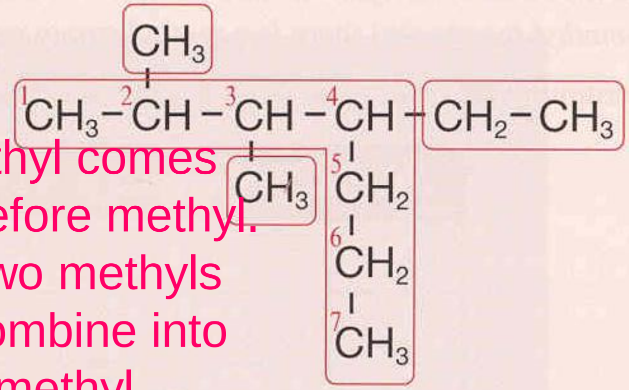
This molecule has two methyl branches and one ethyl branch.

3.



This molecule has a methyl branch on carbon 2, a methyl branch on carbon 3, and an ethyl branch on carbon number 4.

4.

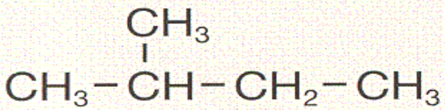


Ethyl comes before methyl.
Two methyls combine into dimethyl

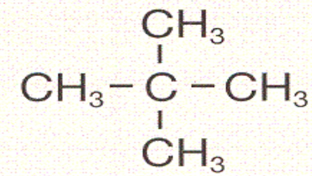
Ans:4-ethyl-2,3-***di***methyl heptane

15. Provide the IUPAC name for each compound given.

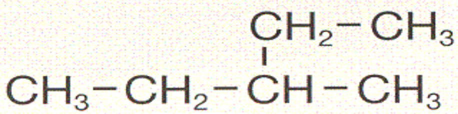
a.



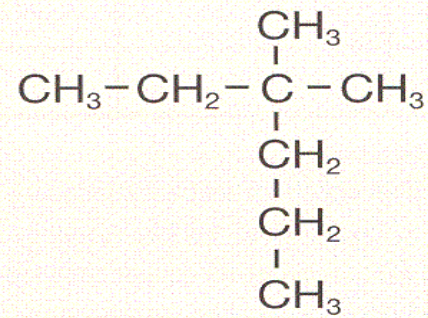
b.



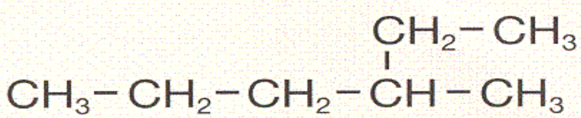
c.



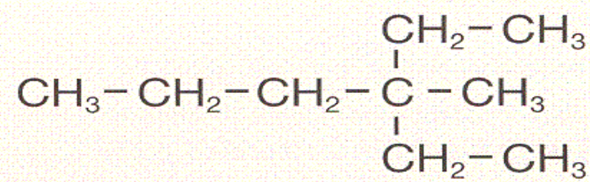
d.



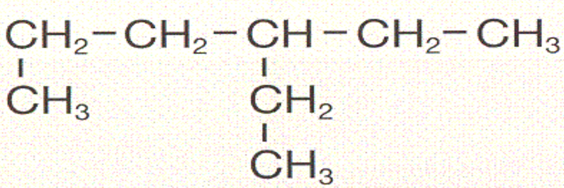
e.



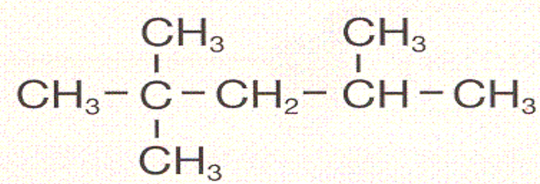
f.



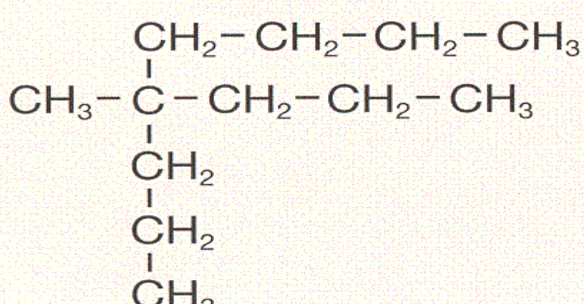
g.



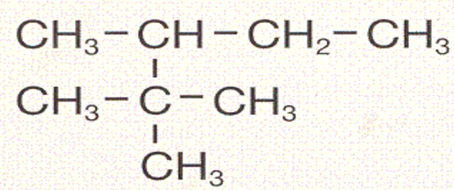
h.



i.



j.

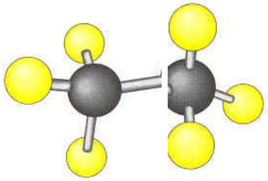


Lesson 3.2: Saturated & Unsaturated Hydrocarbons

What are saturated hydrocarbons?

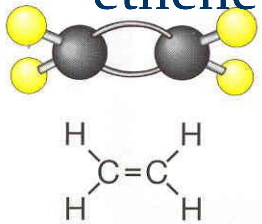
- Saturated hydrocarbons have carbons with the maximum number of hydrogens. They have single-single carbon bonds. Eg) C_2H_6

ethane

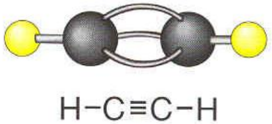


- Unsaturated hydrocarbons have carbons where some of the hydrogens have been removed to form double or triple carbon bonds. Eg) C_2H_4 (C_nH_{2n}) or C_2H_2 (C_nH_{2n-2})

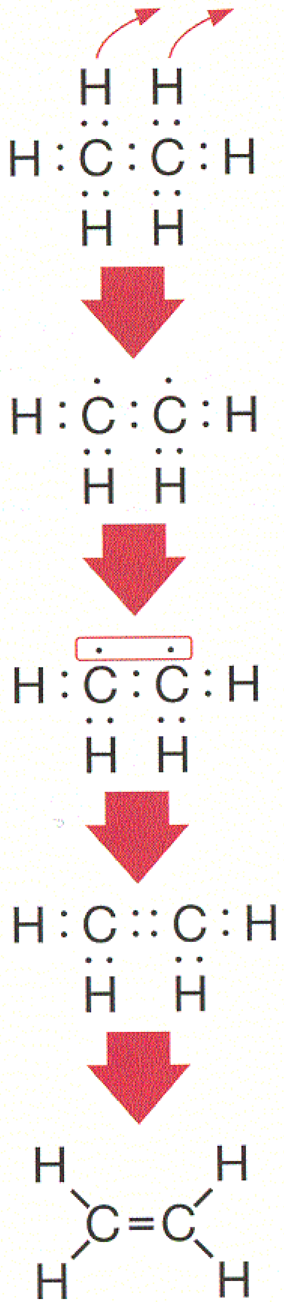
ethene



ethyne



Making a Double Bond



Two hydrogen atoms leave the carbon chain.

Both carbons have an unbonded electron. So, they are not stable until these unbonded electrons form a bond.

The closest thing to bond with is the electron from the other carbon.

Both carbons bond with each other to form a double bond. All carbon atoms are again stable.

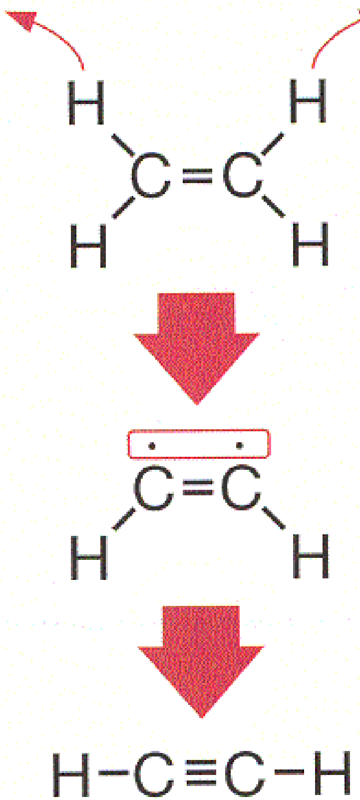
The complete structural diagram shows the twisting that occurs to accommodate the double bonds.

How do you make a double bond from a single bond?

- PRACTICE: Make a double bond in C_3H_8

How do you make a triple from a double bond?

Making a Triple Bond



Two hydrogen atoms leave the carbon chain on either side of a double bond.

The carbons are not stable until they form a bond. So, they bond, yet again, with each other to form a triple bond.

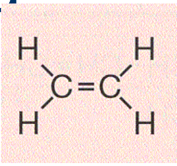
Each atom is stable in this molecule. The carbons each have four bonds: three from the other carbon and one from a hydrogen.

Note: Hydrocarbons with double and triple bonds are less stable than those with single bonds.

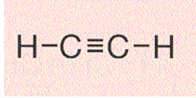
- Make the following into triple bonds
- H H H
H-C=C-C-H
H
H H H H
H-C-C=C-C-H
H H

How do you name hydrocarbons with double & triple bonds

- Alkenes: one carbon-carbon double with the formula $C_nH_{2n.}$ Eg) C_2H_4 is called eth***<u>ene</u>***



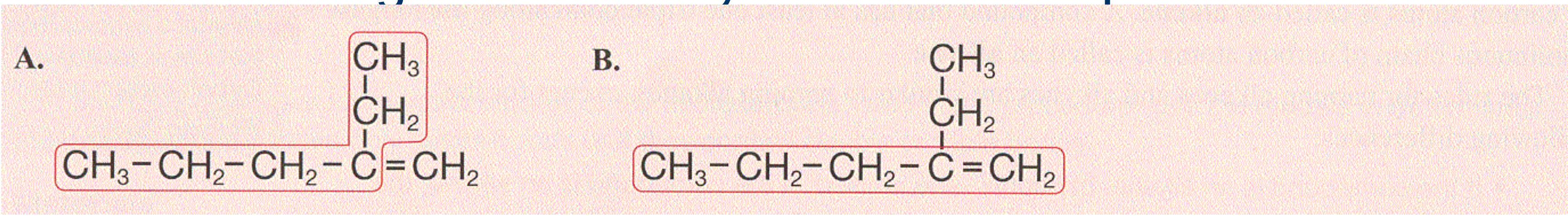
- Alkynes: one carbon-carbon triple with the formula C_nH_{2n-2} Eg) C_2H_2 is called eth***<u>yne</u>*** (acetylene)



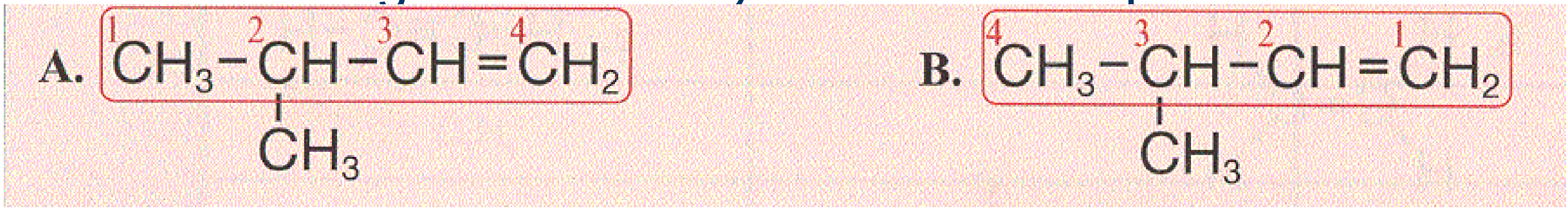
- The rules are similar to alkanes except:
  - The end of the parent changes from ***ane to ene or yne***
  - The double or triple bond must appear in the parent
  - Number the chain so the first carbon of the double or triple receives the lowest possible number
  - The ***number*** of the double or triple is communicated in front of the parent

Example problems

1. Which diagram correctly identifies the parent

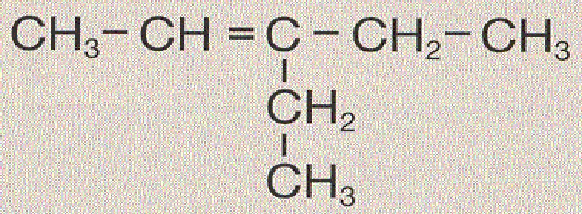


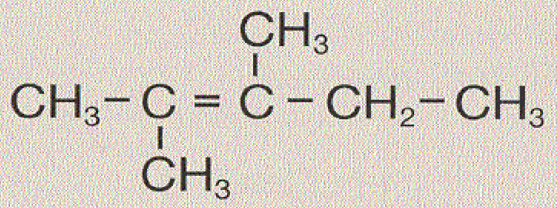
2. Which diagram correctly numbers the parent

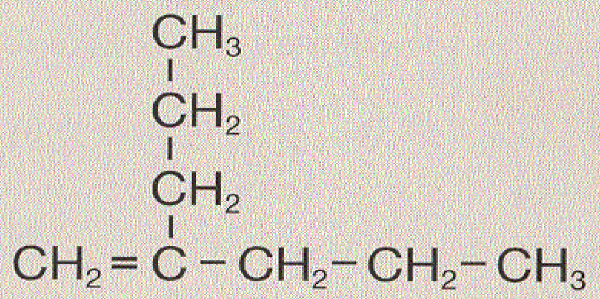


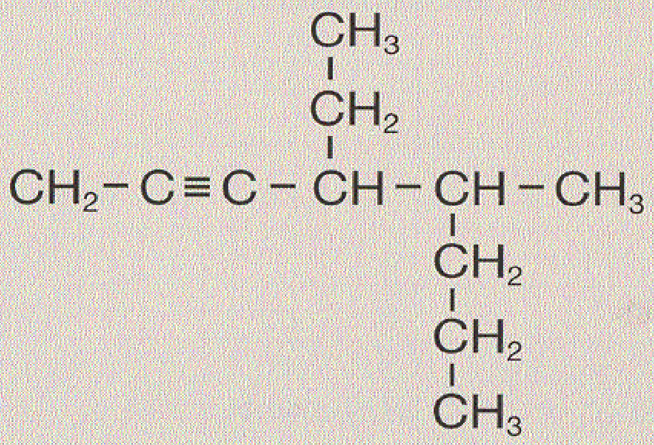
1. Name the correct hydrocarbons above

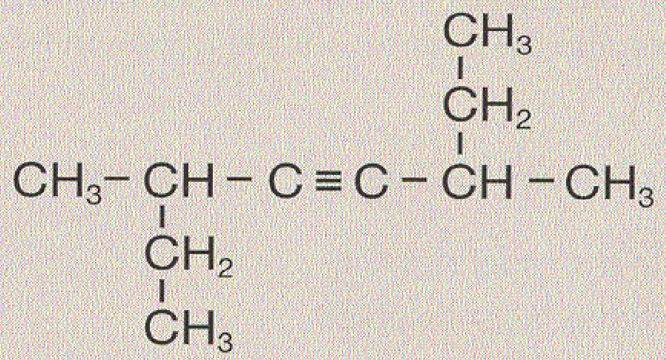
a. $CH_3-CH_2-CH=CH-CH_2-CH_3$

b. 

c. 

d. 

e. 

f. 

29. Draw condensed structural diagrams for the following compounds.

a. 1-hexene
b. 2-pentyne
c. 2-methyl-2-pentene
d. 2,5-dimethyl-3-heptyne

30. The following compounds are named incorrectly. Draw a complete structural diagram of the compound; then name it correctly.

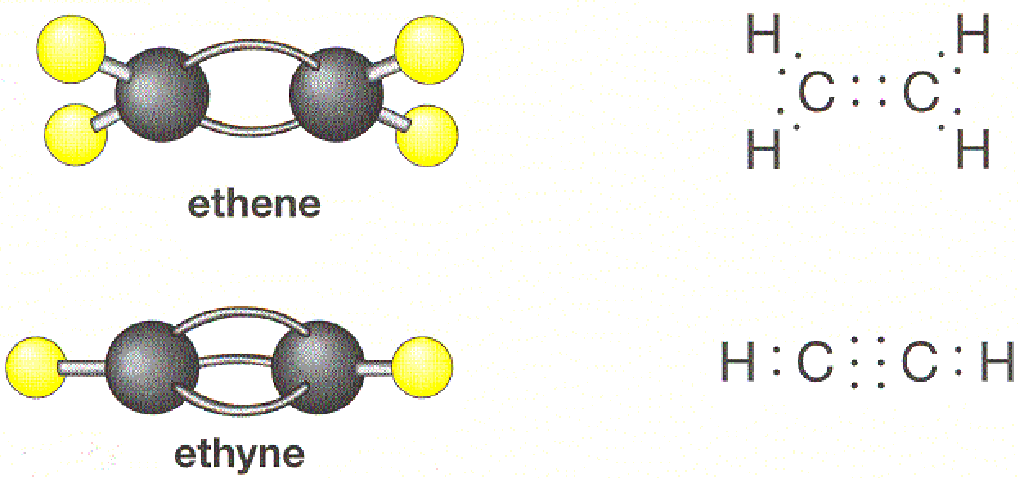
a. 3-butene
b. 2-methyl-4-pentene
c. 2-ethyl-2-pentene
d. 2,3-diethyl-2-hexene

What is the difference in the melting points and boiling points?

- The attraction between molecules increases as the number of carbons within the molecule increases. The stronger the attraction, the more energy (heat) is need to break the attraction between the molecules
- If a molecule in bigger, more energy (heat) is required to make it move.
- Therefore: The first four hydrocarbons are gases and the last six hydrocarbons are liquids.

What is the difference between the reactivity of hydrocarbons?

The Reactivity of Hydrocarbons



Recall that all electrons have a negative charge and, therefore, have a tendency to repel each other.

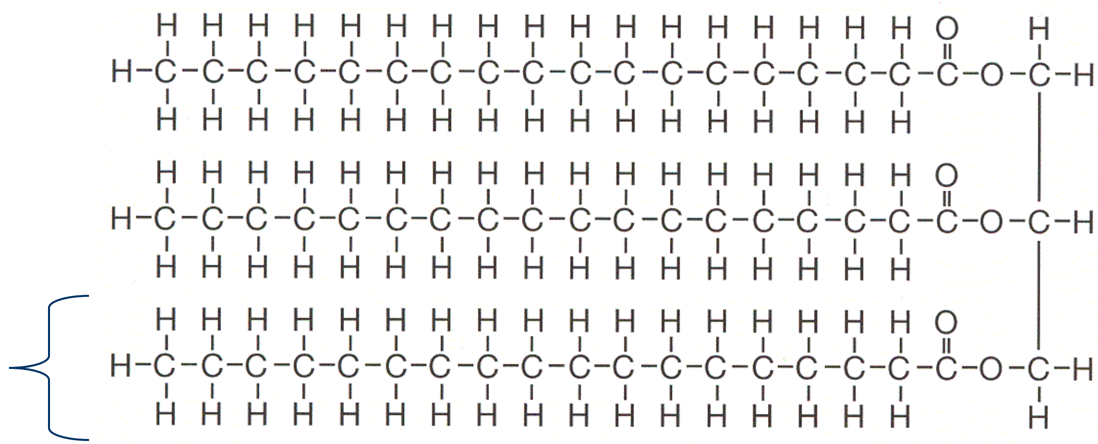
The close proximity of the electrons within double and triple bonds will increase the repulsion forces between the electrons. This repulsion force increases the stress within the bond and, therefore, increases the reactivity of the molecule.

Alkynes are the most reactive followed by alkenes

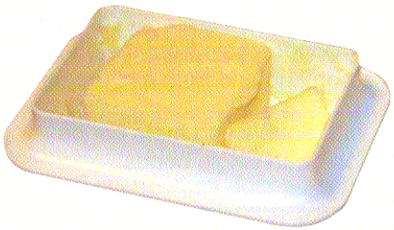
What are fatty acids?

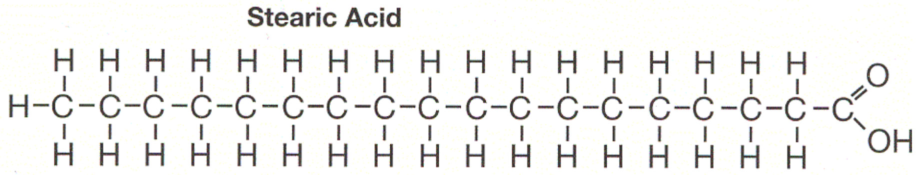
- Fats & oils are made of three connected chains of ***fatty acids*** – long chains of carbons with COO attached at one end.

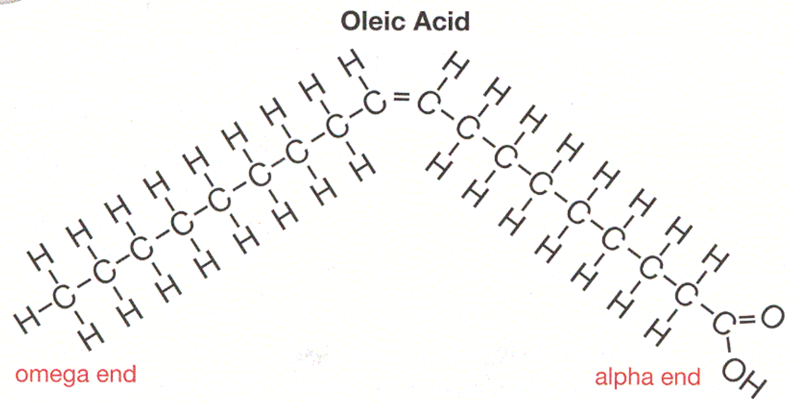
A Molecule of Animal Fat



What is the difference between animal fats and plant oils?







- The fatty acids in ***animal fat*** like butter (stearic acid) are ***saturated***
- The fatty acids in ***vegetable oil*** (oleic acid) are ***unsaturated*** (contain a double bond.)

Oil (oleic acid) is an ***omega-9*** fatty acid because the double bond is 9 carbons from the omega end (no COOH). It is a liquid because the fatty acids don't pack together closely & the bonds between molecules are weak.

What is the difference between mono- & poly- unsaturated fats?

- ***Monounsaturated fats*** are liquid fat molecules that have only one double bond.
- ***Polyunsaturated fats*** are liquid fat molecules that have more than one double bond.

PRACTICE: Draw a monounsaturated fatty acid

And a polyunsaturated fatty acid.

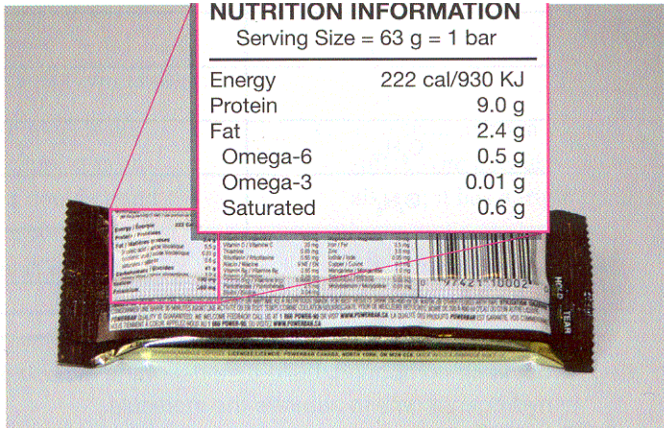
What are essential fatty acids?

- ***Essential fatty acids*** are monounsaturated fatty acids that are needed to ***form healthy cell membranes***, in the ***development of the brain*** and to ***produce hormones*** that regulate body functions.
- Essential fatty acids are omega-3 and omega-6 fatty acids.
- It is a challenge to get enough omega-3 fatty acids. Sources include flaxseeds, salmon & sardines.

PRACTICE:

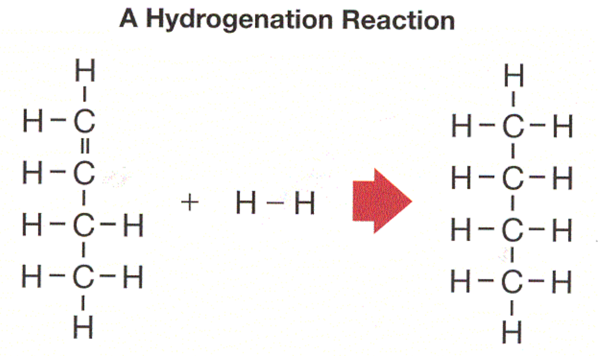
Draw an omega-3 fatty acid.

Explain how fat can be healthy.

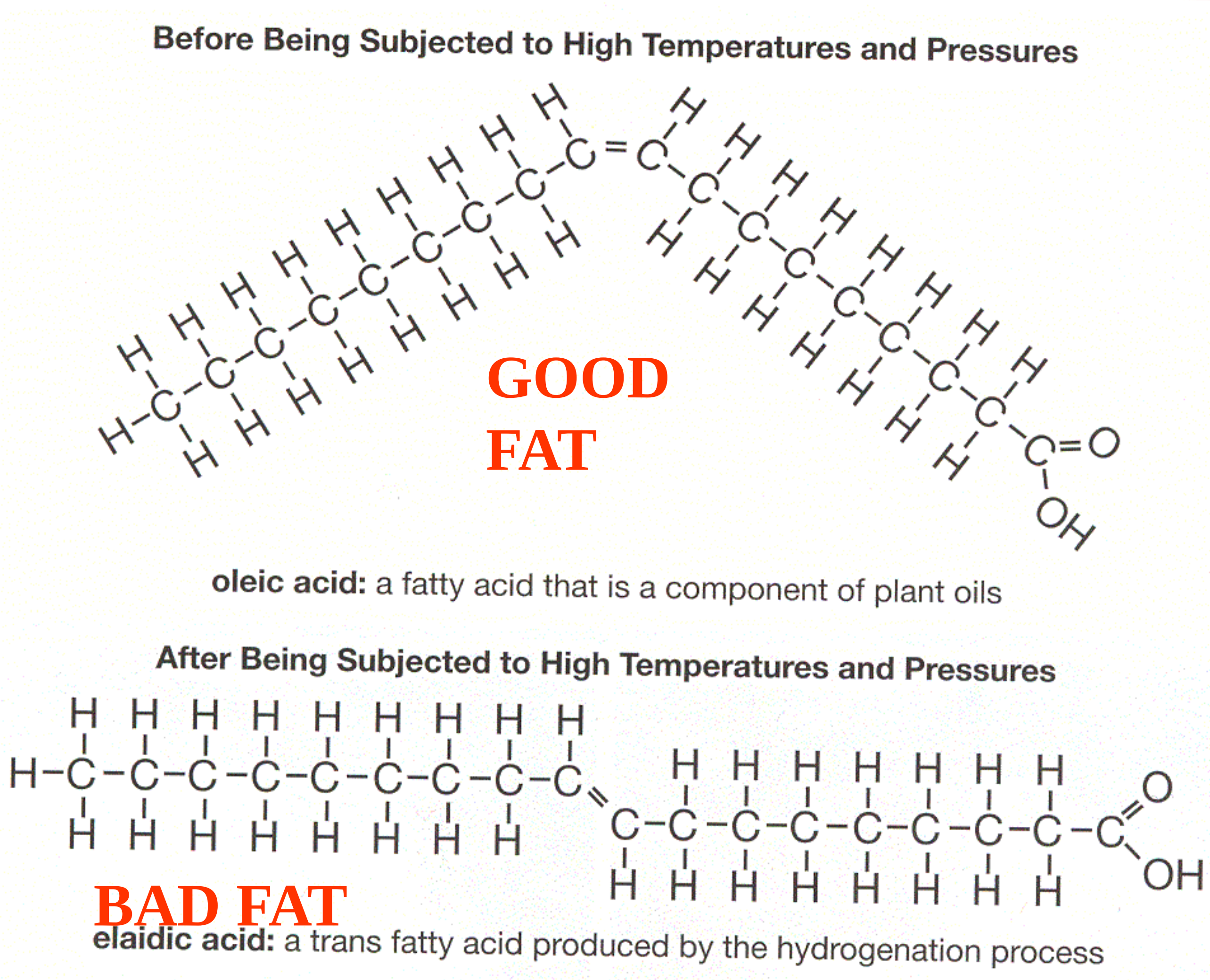


What trans fatty acids?

- To make a spreadable fat from vegetable oil, some of the double bonds needed to be broken
- To break some of the double bonds, hydrogen gas was bubbled through hot oil under pressure during a process called ***hydrogenation***.
- However, there was an unwanted side-effect (next slide)



Comparing Natural Fatty Acids and Industrially produced Tans Fatty acids



When heated during hydrogenation, the hydrogens around the double bond appeared across from each other or (trans)

This small change resulted in fat that was clogging arteries & increasing cholesterol

Summary on fats and oils

- Animal Fat
  - Saturated fat to make butter or lard

  Eg) CH_3–CH_2–CH_2–COOH

- Vegetable Oil
  - Polyunsaturated oil like canola oil.

    Eg) CH_2=C=CH–COOH
  - Monounsaturated
    - Hydrogenated trans fats to make soft margarine. NOT GOOD because they clog arteries

      H

      Eg) CH_3–C=C–COOH

      H
    - Natural oils like olive or peanut oil. GOOD because contain essential fatty acids – omega 3 & omega 6

      H H

      Eg) CH_3–C=C–COOH

Lesson 3.3: Petroleum is the source

What is petroleum?

- Petroleum is many liquid hydrocarbons formed over thousands of years, from the remains of organisms
- Each component is called a fraction. The process of separating and processing petroleum is called refining

How is petroleum separated into its fractions?

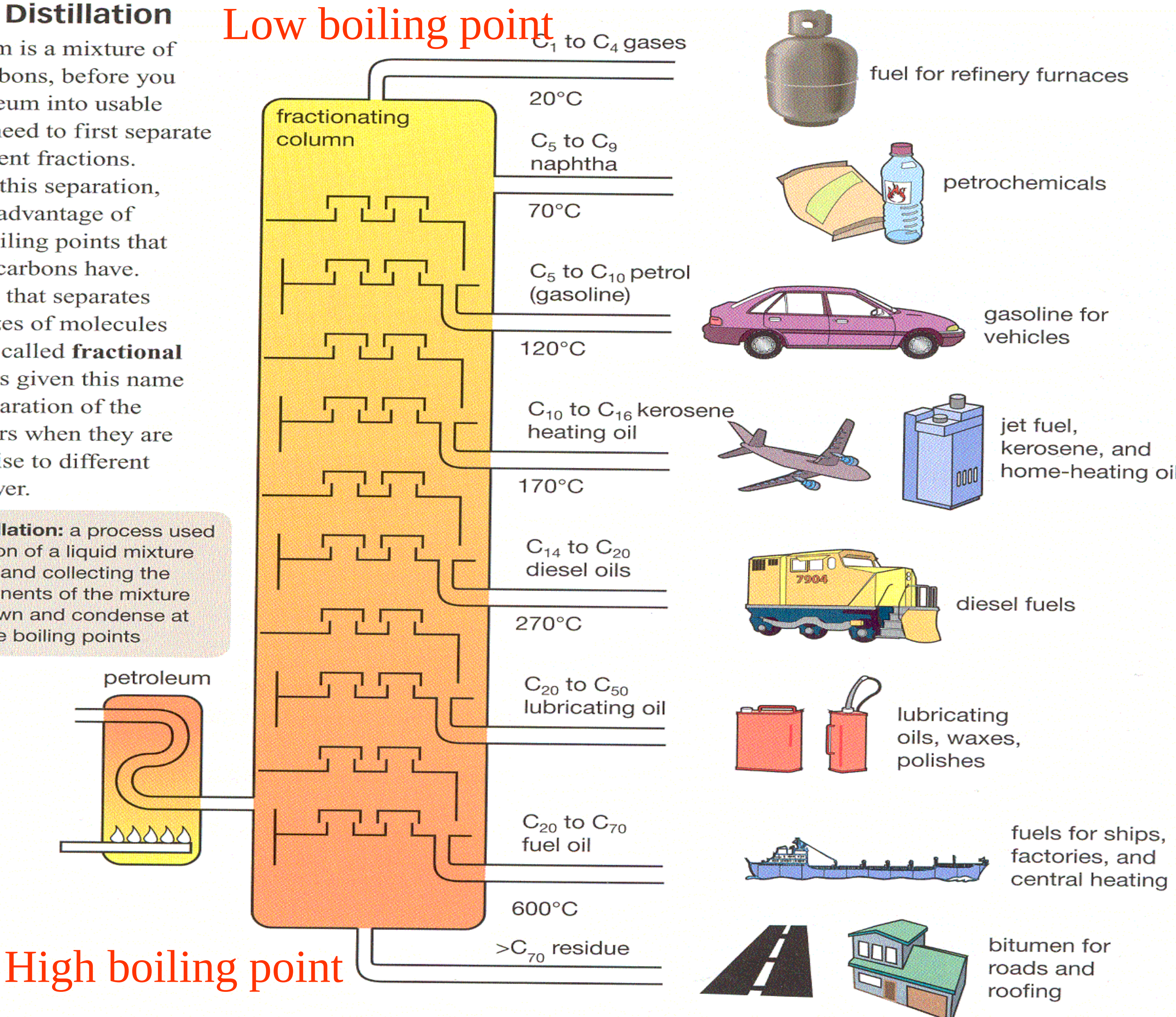
- The process that separates the different fractions is called fractional distillation:
  - Step 1: the petroleum is vaporized (turned into a gas) by a hot furnace
  - Step 2: the petroleum vapours are placed into a tall column
  - Step 3: the hot vapours rise inside the column and cool
  - Step 4: each fraction condenses to form liquids at different temperatures
  - Step 5: Fractions with high boiling points condense at the bottom of the column. Fractions with low boiling points condenses at the top of the column

Fractional Distillation

Since petroleum is a mixture of many hydrocarbons, before you can turn petroleum into usable products, you need to first separate it into its different fractions. To accomplish this separation, refineries take advantage of the different boiling points that different hydrocarbons have.

The process that separates the different sizes of molecules in petroleum is called **fractional distillation**. It is given this name because the separation of the molecules occurs when they are gases and can rise to different levels in the tower.

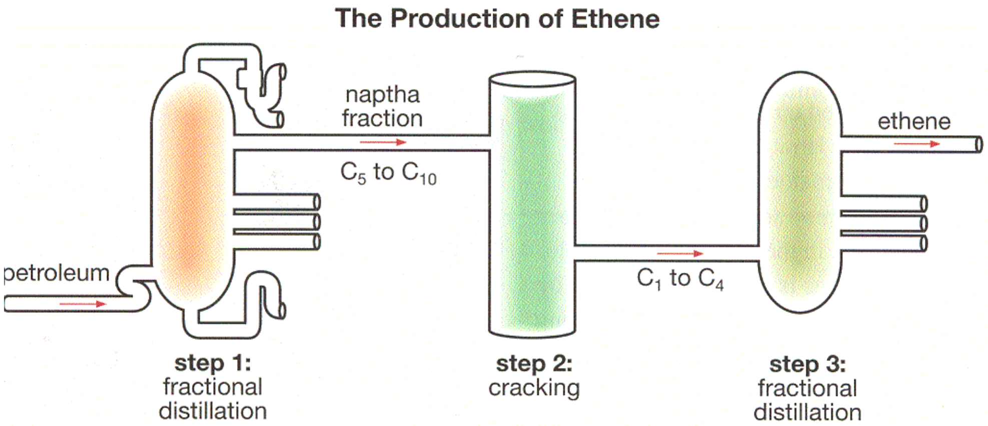
fractional distillation: a process used for the separation of a liquid mixture by vaporizing it and collecting the different components of the mixture as they cool down and condense at their appropriate boiling points



How are hydrocarbons processed?

- Smaller hydrocarbons are more useful than larger hydrocarbons because they are easily reacted.
- The breaking up of larger hydrocarbons is called cracking
- Eg) $C_8H_{18} \rightarrow$

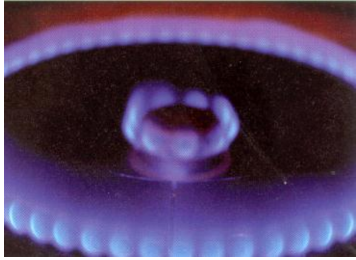
$2\ C_2H_4 + C_3H_6 + CH_4$



Lesson 3.4: Everyday Use of Hydrocarbons

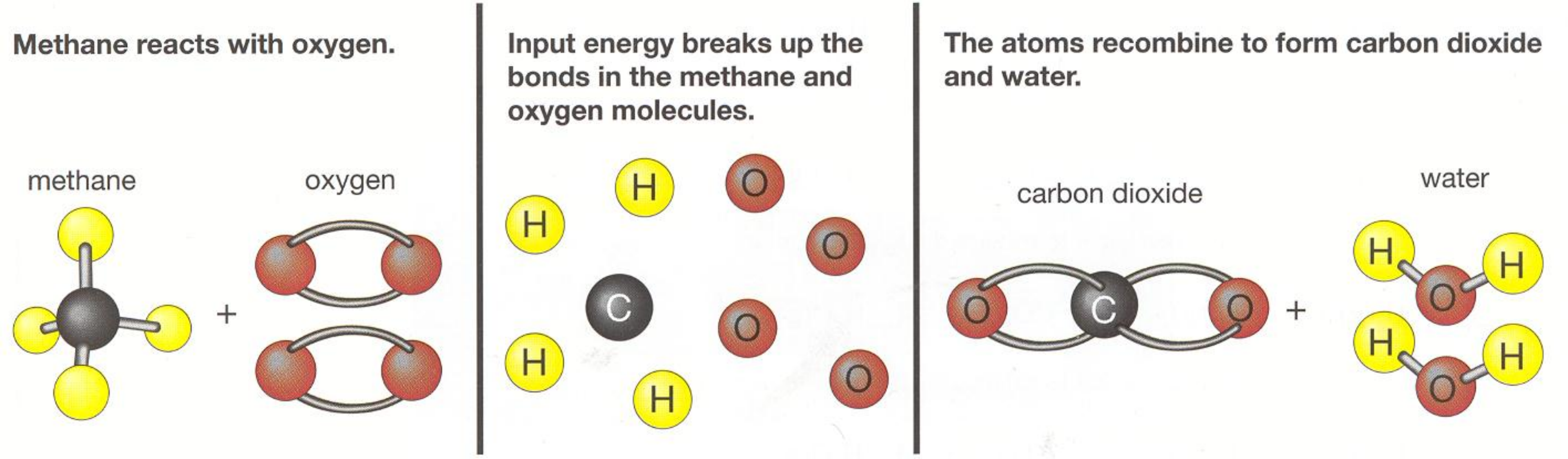
Hydrocarbons are:

- Relatively stable
- Bonds store lots of energy
- Are readily available



What is hydrocarbon combustion?

- Hydrocarbon combustion is the burning of hydrocarbons with oxygen to produce carbon dioxide, water & lots of energy.
- EG) methane burns: $CH_{4(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(g)}$



Comparing combustion reactions

- Longer hydrocarbons chains have more bonds than shorter hydrocarbons, therefore longer hydrocarbons:
  - Store a greater amount of energy
  - Require more oxygen
  - Produce more carbon dioxide, water and energy

How do you balance hydrocarbon combustion equations?

- Write out the formulas for the chemical equation. NOTE: O_2 is always used and CO_2 & H_2O are always produced
- Add coefficients to balance the carbon atoms
- Add coefficients to balance the hydrogen atoms
- Add coefficients to balance the oxygen atoms. NOTE:

Oxygen coefficient = total oxygen in products /2

Example: Propane burns

Solution Propane is on pg 9 of your databbook

a. ___ $C_3H_8(g)$ + ___ $O_2(g) \rightarrow$ ___ $CO_2(g)$ + ___ $H_2O(g)$

↓ Add coefficients to balance the carbon atoms.

1 $C_3H_8(g)$ + ___ $O_2(g) \rightarrow$ **3** $CO_2(g)$ + ___ $H_2O(g)$

↓ Add a coefficient to balance the hydrogen atoms.

1 $C_3H_8(g)$ + ___ $O_2(g) \rightarrow$ 3 $CO_2(g)$ + **4** $H_2O(g)$

↓ Add a coefficient to balance the oxygen atoms. 3x2 + 4x1= 10

1 $C_3H_8(g)$ + **5** $O_2(g) \rightarrow$ 3 $CO_2(g)$ + 4 $H_2O(g)$ 10/2 = 5

Recall that coefficients of 1 are normally not shown. Therefore, the balanced chemical equation is

$$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$$

Example: Octane burns

c. ___ $C_8H_{18}(l)$ + ___ $O_2(g) \rightarrow$ ___ $CO_2(g)$ + ___ $H_2O(g)$

↓ Add a coefficient to balance the carbon atoms.

__**1**__ $C_8H_{18}(l)$ + ___ $O_2(g) \rightarrow$ __**8**__ $CO_2(g)$ + ___ $H_2O(g)$

↓ Add a coefficient to balance the hydrogen atoms.

__1__ $C_8H_{18}(l)$ + ___ $O_2(g) \rightarrow$ __8__ $CO_2(g)$ + __**9**__ $H_2O(g)$

↓ Add a coefficient to balance the oxygen atoms.

__1__ $C_8H_{18}(l)$ + __**12.5**__ $O_2(g) \rightarrow$ __8__ $CO_2(g)$ + __9__ $H_2O(g)$

↓ Multiply all coefficients by 2.

__2__ $C_8H_{18}(l)$ + __**25**__ $O_2(g) \rightarrow$ __16__ $CO_2(g)$ + __18__ $H_2O(g)$

The balanced chemical equation is

$$2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$$

$8 \times 2 + 9 \times 1 = 25$

$25/2 = 12.5$

What is the environmental impact?

- The combustion of hydrocarbons produces a lot of carbon dioxide and water. Carbon dioxide traps heat contributing to a greenhouse effect.
- Too much carbon dioxide enhance the greenhouse effect, causing the earth to warm up and changing the climate.

How are polymers made?

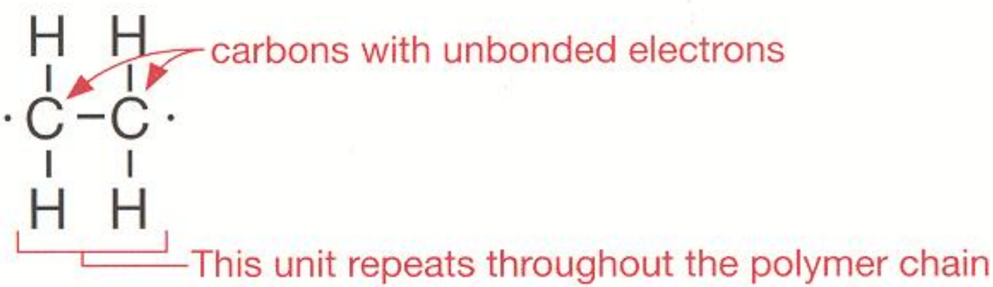
- The process of joining many short, unsaturated hydrocarbons is called ***polymerization***. The resulting hydrocarbon chain is called a ***polymer.***
- ***Plastic*** is a polymer made by joining many ethene (ethylene) molecules to make polyethene (polyethylene)

How is Polyethylene created?

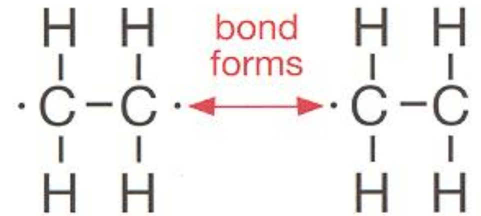
Creating Polyethylene

1) First, start with an ethene molecule.

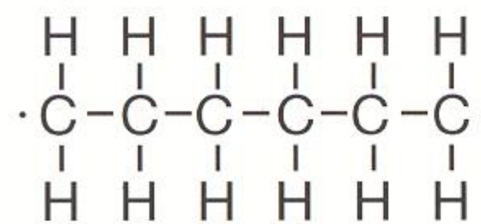
Carbons have unbonded electrons and look to bond with something else.



2) Another "broken" ethene molecule comes and forms a bond.



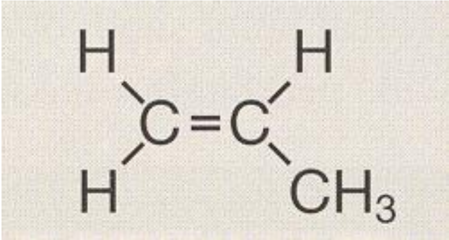
3) Many "broken" ethene molecules join together to make very long chains called polyethylene.



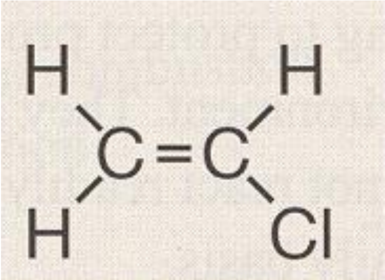
4) This results in the molecular formula of polyethylene.

What are some other polymers?

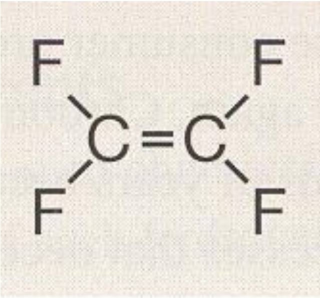
- Polypropylene – found in carpets & bottles & made from many propenes:



- Polyvinylchloride (PVC) – found in plastic wrap, synthetic leather and hoses & made from many vinylchlorides



- Polytetrafluoroethylene (Teflon) – found in frying pans, cooking utensils and electric insulation; made of many tetrafluoroethylenes

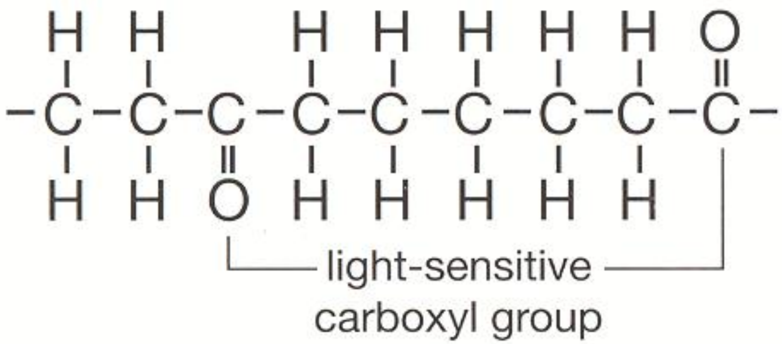


What are the environmental impacts of polymers?

- The problem with polymers is that they take a long time to decompose or degrade.
- Society is facing problems with the accumulation of discarded polymers
- Solutions:
  - Reduce: the use and buying products with excess packaging
  - Re-use: containers as storage and give old toys to charity
  - Recycle: plastic, glass and metal when possible
  - Rethink: what you do and buy

What are solutions to plastic collars on cans which hurt wildlife?

1) Cut each plastic collar/ring before discarding
2) Encourage the use of biodegradable polyethylene
3) Recycle the collars or rings



When this polymer is exposed to light, the long chains break at each carboxyl group. The remaining shorter sections can then be effectively broken down by natural processes.