# ☺ AP CHEMISTRY SUMMER ASSIGNMENT ☺

Welcome to AP chemistry and one of the toughest classes you will ever love. To be successful in chemistry there are several basic skills you must master. The first and most important is to know the names and formulas of elements and compounds.

I am really excited you are taking this class and look forward to getting to know each of you as we begin the journey of really learning chemistry and preparing for the **national AP test on Friday, May 6, 2022**.

**This packet is due the first week back to school on Friday that week August 13, 2021.**

**WWW.YOUTUBE.COM**

**RESOURCE TO USE THROUGHOUT THE PACKET: TYLER DeWITT CHANNEL**

**Section A: Element Names**: Be sure to know the names and symbols of the elements below

Elements cannot be broken down into simpler substances. Distinguished by the number of protons(atomic #)

| 1-50 | | 51-100 | |
|---|---|---|---|
| **NAME** | **SYMBOL** | **NAME** | **SYMBOL** |
| Hydrogen | | **Antimony** | |
| Helium | | Tellurium | |
| Lithium | | Iodine | |
| Beryllium | | Xenon | |
| Boron | | Cesium | |
| Carbon | | Barium | |
| Nitrogen | | Lanthanum | |
| Oxygen | | Cerium | |
| Fluorine | | Praseodymium | |
| Neon | | Neodymium | |
| **Sodium** | | Promethium | |
| Magnesium | | Samarium | |
| Aluminum | | Europium | |
| Silicon | | Gadolinium | |
| Phosphorus | | Terbium | |
| Sulfur | | Dysprosium | |
| Chlorine | | Holmium | |
| Argon | | Erbium | |
| **Potassium** | | Thulium | |
| Calcium | | Ytterbium | |
| Scandium | | Lutetium | |
| Titanium | | Hafnium | |

| | | | |
|---|---|---|---|
| Vanadium | | Tantalum | |
| Chromium | | **Tungsten** | |
| Manganese | | Rhenium | |
| **Iron** | | Osmium | |
| Cobalt | | Iridium | |
| Nickel | | Platinum | |
| **Copper** | | **Gold** | |
| Zinc | | **Mercury** | |
| Gallium | | Thallium | |
| Germanium | | **Lead** | |
| Arsenic | | Bismuth | |
| Selenium | | Polonium | |
| Bromine | | Astatine | |
| Krypton | | Radon | |
| Rubidium | | Francium | |
| Strontium | | Radium | |
| Yttrium | | Actinium | |
| Zirconium | | Thorium | |
| Niobium | | Protactinium | |
| Molybdenum | | Uranium | |
| Technetium | | Neptunium | |
| Ruthenium | | Plutonium | |
| Rhodium | | Americium | |
| Palladium | | Curium | |
| **Silver** | | Berkelium | |
| Cadmium | | Californium | |
| Indium | | Einsteinium | |
| **Tin** | | Fermium | |

## What is chemistry?

Chemistry can be described as the science that deals with matter, and the changes that matter undergoes. It is sometimes called the central *science* because so many naturally occurring phenomena involve chemistry and chemical change.

## Scientific problem solving

Scientific (logical) problem solving involves three steps;

1. State the problem and make observations. Observations can be *quantitative* (those involving numbers or measurement) or *qualitative* (those not involving numbers).
2. Formulate a possible explanation (this is known as a *hypothesis*).
3. Perform experiments to test the hypothesis. The results and observations from these experiments lead to the modification of the hypothesis and therefore further experiments.

Eventually, after several experiments, the hypothesis may graduate to become a *theory*. A theory gives a universally accepted explanation of the problem. Of course, theories should be constantly challenged and may be refined as and when new data and new scientific evidence comes to light. Theories are different to *laws*. Laws state what general behavior is observed to occur naturally. For example, the *law of conservation of mass* exists since it has been consistently observed that during all chemical changes mass remains unchanged (i.e., it is neither created nor destroyed).

## States of matter and particles representations

All matter has two distinct characteristics. It has mass and it occupies space. Properties associated with the three states of matter, and the behaviors of the particles that make up each, are summarized below.

**SOLIDS**

- Have a definite shape and definite volume.
- The particles in a solid are packed tightly together and only vibrate relatively gently around fixed positions.
- Does not flow
- Diffusion is slow

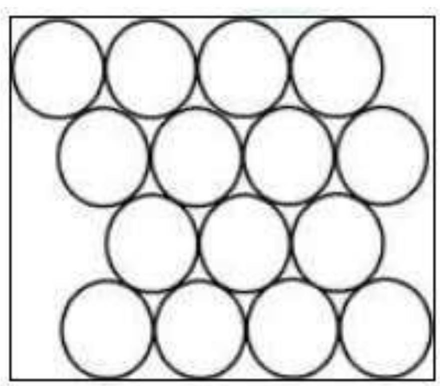
**LIQUIDS**

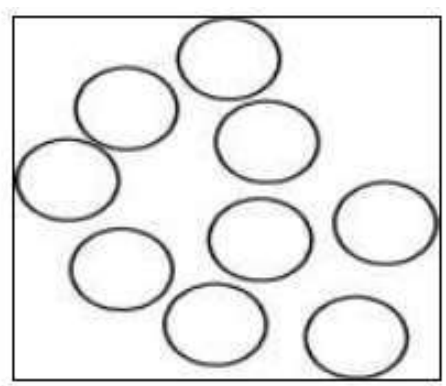
- Takes the shape of their container, but does not expand to fill the container
- Has a definite volume.
- The particles are free to move around one another.
- flows readily
- diffusion is slow

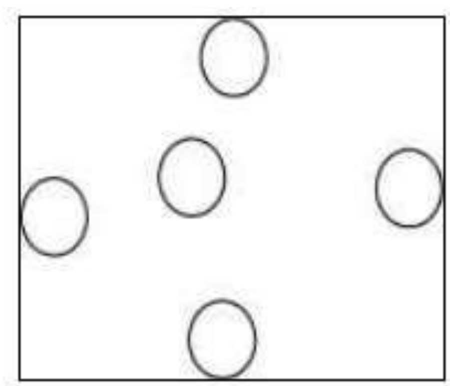
**GASES**

- No definite shape or volume.
- Particles spread apart filling all the space of the container
- interactions between the particles are considered to be negligible.
- compressible
- flows readily
- diffusion is rapid

The circles in the diagrams below represent the relative positions and movements of the particles in the three states of matter. **Expect** to see many such ***particulate representations*** during the AP Course.







Examples of physical changes of state.

SOLID → LIQUID **Melting**
LIQUID → SOLID **Freezing**
SOLID → GAS **Sublimation**
GAS → SOLID **deposition**

GAS → LIQUID **Condensing**
LIQUID → GAS **Boiling**

**<u>Locate a periodic table online that breaks the table into general categories of:</u>**
**Metals, nonmetals, and metalloids**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | 2 |
| 3 | 4 | | | | | | | | | | | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |
| 55 | 56 | 57* | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 |
| 87 | 88 | 89** | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58* | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| 90** | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |

**<u>Coloring – make sure you can see the numbers & fill in the chemical symbol in the blanks</u>**

1) Color/shade the metals a light color of your choice (yellow/red/pink/orange)
2) Color/shade the nonmetals a light color of your choice (blue/green/purple)
3) Color/shade the metalloids a contrasting color to one you have already picked

**<u>Which elements are diatomic? There are 7 of them. Write them below.</u>**

1)
2)
3)
4)
5)
6)
**7)**

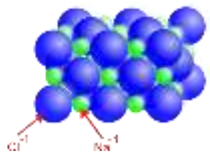
**<u>What are the only two liquid elements?</u>** ____________________ & __________________

**SECTION B) [WWW.YOUTUBE.COM](http://www.youtube.com)**
**TYLER DEWITT SEARCH = "COMPOUNDS" WATCH ANY VIDEO ON IONIC OR MOLECULAR COMPOUNDS TO HELP WITH THIS SECTION**
**COMPOUNDS AND THEIR NAMING SYSTEMS**

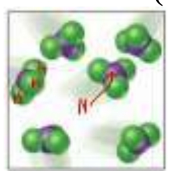
Nomenclature is just a fancy sounding word for "naming system". We name five classes of compounds as follows:

1. Molecular
2. ionic
3. acids
4. complex ions
5. organic

Ionic Solid



Molecular (example is ammonia $NH_3$)



Of course they all have their own set of rules to follow just to make things especially difficult. It's really not that bad, but it does require a LOT of practice – and I do mean a LOT!! The first thing you need to be able to do is to recognize what kind of compound it is from either the name or the formula. For that, you need a basic understanding of the periodic table. So let's start there. The periodic table is divided into three basic sections; metals, metalloids or semi-metals, and non-metals (which includes the halogens and noble gases) On the attached periodic table the metals are yellow, the metalloids are green, and the non-metals are blue. Notice hydrogen over there on the far left. He's blue. He's a non-metal. He seems kind of misplaced, but there's a reason he's over there that we'll learn about later. It has to do with valence electrons. So here's the most basic outline I can come up with:

If the compound starts with a metal or ammonium it's **ionic**. (Notice the period.)

If the compound starts with a **nonmetal or metalloid it's definitely molecular**, but it may be an acid or organic. The general rule of thumb is that if it starts with hydrogen it's probably an acid, and if it starts with carbon ***and*** contains hydrogen it's organic.

If it has a charge, then it's technically an ion, not a compound (as compounds are, by definition, neutral) therefore it is probably a complex ion.

So the main point is that you need to know where your metals and non-metals are because that's the key to recognizing what kind of compound you are dealing with so that you know what naming rules to use.

**B)i - Naming molecular compounds:**

**These are super simple – Two nonmetals only (located right of metalloid line)**

**1. All compounds end in - ide**
**2. Use prefixes to indicate # of atoms**
**3. A vowel (o or a) at the end of a prefix is dropped if the element name begins with a vowel.**
**(ex – tetroxide) drop "a"**

| | | | |
|---|---|---|---|
| **mono-** | **1** | **hexa-** | **6** |
| **di-** | **2** | **hepta-** | **7** |
| **tri-** | **3** | **octa-** | **8** |
| **tetra-** | **4** | **nona-** | **9** |
| **penta-** | **5** | **deca-** | **10** |

**example $N_2O_4$ – dinitrogen tetroxide (notice 'a' in tetra dropped)**

## B)i Molecular compounds

1. $CO_2$ ________________________
2. $CCl_4$ ________________________
3. $SO_3$ ________________________
4. $N_3P_5$ ________________________
5. nitrogen monoxide __________
6. carbon disulfide __________
7. phosphorous tribromide __________
8. silicon dioxide ___________
9. $C_3Br_6$ _________________________
10. $O_4F_8$ __________________________
11. $P_4Cl_7$ _________________________
12. $NF_9$ __________________________
13. silicon tetrafluoride ____________
14. diphosphorous decoxide ___________
15. sulfur hexabromide ____________
16. sulfur dichloride ____________

## B)ii - Ionic Compounds – These are a bit more complicated, but still not that bad. DO NOT USE PREFIXES WITH IONIC COMPOUNDS!!!!!!!!!!!!

Ionic compounds are form from a metal or ammonium (positive cation) and a nonmetal (negative anion) or negative polyatomic ion. Let's start with the binary ionic compounds.

**Binary Ionic**

If neutral atoms **lose** or **gain** electrons it will cause **ions** to form.
Loss of electrons gives positive(+) ions.
Gain of electrons gives negative(-) ions.
**Cation** - atom or group of atoms with a positive charge.
**Metals** tend to form cations by losing electrons.
**Naming cations** - use the element name and add ion to it. Ex: Na (sodium) → $Na^{+1}$ **Sodium Ion**

So where does the charge come from. Every atom wants to have a full outer shell/valence shell of electrons and be stable. In order to do that an atom lose or gain electrons to resemble the valence electrons of a noble gas. Every element in column one will lose one electron in order to look like the noble gas just before it. In doing so it will form a +1 charge. Elements in column 2 will form +2 ions, column 3 forms +3, but it stops there for the positive ones.

**Anion** - atom or group of atoms with a negative charge.
**Nonmetals** tend to form anions by gaining electrons.
**Naming anions**: drop ending and add **-ide**
Ex - Cl = chlorine → $Cl^{-1}$ chlor**ide**
S = sulfur → $S^{-2}$ sulf**ide**

Elements in column 5 want to gain 3 to get to an octet and look like the noble gas closest to it so they are all -3 charge ( $P^{-3}$, $N^{-3}$, $As^{-3}$) column 6 gains 2 to get to 8 (O, S, Se, Te all -2), and then the halogens in column 7 all gain 1 electron and form -1 charges (F, Cl, Br, I) forget about At because he is radioactive.

**So….drum roll, Ionic compounds** are formed when one cation and one anion join together.
Remember one basic rule….**they all must cancel out to have a zero net charge**.

$Na^{+1} + Cl^{-1} \rightarrow NaCl$
$Ca^{+2} + Cl^{-1} \rightarrow CaCl_2$
$Na^{+1} + O^{-2} \rightarrow Na_2O$

$Al^{+3} + Cl^{-1} \rightarrow AlCl_3$
$Na^{+1} + P^{-3} \rightarrow Na_3P$

$Ca^{+2} + P^{-3} \rightarrow Ca_3P_2$
$Al^{+3} + O^{-2} \rightarrow Al_2O_3$

**Now you try some** ☺….YOU WILL HAVE TO FIND THE CHARGES FIRST.

**B)ii WRITE THE COMPOUNDS FROM THE CHARGES…..**

1. Lithium and Chlorine $\underline{Li^{+1}}$ + $\underline{Cl^{-1}}$ → _____
2. Lithium and Sulfur ____ + _____ → _____
3. Beryllium and Oxygen ____ + _____ → _____
4. Beryllium and Iodine ____ + _____ → _____
5. Potassium and Nitrogen ____ + _____ → _____
6. Magnesium and Phosphorus ____ + _____ → _____

Sometimes you will have an element that is in the middle of the table (transition metals) where you cannot tell the charge. In this case you must be given a roman numeral in the name to know the charge on the metal. If you are given the formula you then must work backward to find the roman numeral to put into the name. There are exceptions to this, of course, and I'll get to those in a bit.

Iron(III)sulfide → $Fe^{+3}$ will react with $S^{-2}$ to give $Fe_2S_3$
Irons gets the charge from the roman numeral III

If you were given $Fe_2S_3$ and asked to name it you would have to include a roman numeral in the name. All transition metals and group 4A and 5A metals need a roman numeral. The exceptions to that are silver(Ag), cadmium(Cd), and zinc (Zn). They always have the same charge and are therefore exempt from needing a roman numeral. Silver is always +1, $Ag^{+1}$ Zinc and Cadmium are always +2 for $Zn^{+2}$ and $Cd^{+2}$

**B)ii continued** - Try a few of these

7. Copper (I) and Sulfur ____ + _____ → _____
8. Lead (IV) and Nitrogen ____ + _____ → _____
9. Iron (II) and Bromine ____ + _____ → _____

Let's Try some naming now for binary ionic compounds and watch for those that need roman numerals…which remember is only transition metals and group 4A and 5A metals. Columns 1A, 2A, and 3A do not get them.

**B)iii**

1. $SrF_2$ ________________________
2. $BaI_2$ ________________________
3. $Fe_2O_3$ ________________________
4. CrS ________________________
5. $Li_2S$ ________________________
6. $AlCl_3$ ______________________
7. $V_2S_3$ ______________________
8. $PbCl_4$ ______________________
9. $SnF_2$ ______________________
10. MnO ______________________

Now let's do some with **polyatomic ions**, this is from the pink sheet you were given along with the summer assignment. A polyatomic ion is a group of atoms with a charge. You must learn them and be very familiar with them as we will have compounds quizzes weekly throughout the year.

**MEMORIZE THE PINK SHEET THIS SUMMER!!!!!!!!! I have put the pink sheet(will be white here) at the very end of this summer assignment. You need to learn this sheet as it is quite important!!!!**

These compounds follow the same rules in getting the net charge to equal zero. The only difference is when you use **more than one polyatomic ion you must put parenthesis around the polyatomic ion** needing more than one to balance the charge. See the examples

**$Ca^{+2} + CO_3^{-2} \rightarrow CaCO_3$ – only one carbonate so no ( ) needed**
**$Ca^{+2} + OH^{-1} \rightarrow Ca(OH)_2$ - use ( ) showing more than one hydroxide**
**$Al^{+3} + SO_4^{-2} \rightarrow Al_2(SO_4)_3$ – use ( ) showing more than one sulfate**
**$Na^{+1} + PO_4^{-3} \rightarrow Na_3PO_4$ - one phosphate so no ( ) needed**
**$Ga^{+3} + NO_3^{-1} \rightarrow Ga(NO_3)_3$ – use ( ) showing more than one nitrate**
**Now you try some…☺ criss cross them in the square…I did one for you.**

**B)iv**

| | $Cl^{-1}$ | $CO_3^{-2}$ | $OH^{-1}$ | $SO_4^{-2}$ | $PO_4^{-3}$ | $NO_3^{-1}$ |
|---|---|---|---|---|---|---|
| $Na^{+1}$ | | | | | | |
| $NH_4^{+1}$ | | $(NH_4)_2CO_3$ | | | | |
| $Ca^{+2}$ | | | | | $Ca_3(PO_4)_2$ | |
| $Zn^{+2}$ | | | | | | |
| $Fe^{+3}$ | | | | | | |
| $Co^{+3}$ | | | | | | |

**B) v**

Now put them all together and practice naming formulas for everything You must use roman numerals on the transition metals, prefixes on two nonmetals only, and no prefixes if there is metal or polyatomic present anywhere in the compound. All binary ionic and molecular end in –ide.

1. KCl ______________________________
2. $Na_2CO_3$ ______________________________
3. BeO ______________________________
4. $CCl_4$ ______________________________
5. $N_2O$ ______________________________
6. $Au_3PO_3$ ______________________________
7. $AgNO_3$ ______________________________
8. $Ni_2S_3$ ______________________________
9. $S_3F_7$ ______________________________
10. $Br_5I_{10}$ ______________________________
11. $Fe(OH)_3$ ______________________________
12. $(NH_4)_2S$ ______________________________
13. MnO ______________________________
14. $MgCl_2$ ______________________________
15. $K_2CrO_4$ ______________________________
16. NaOH ______________________________
17. $BaSO_4$ ______________________________
18. $Sr_3N_2$ ______________________________
19. $Cu(MnO_4)_2$ ______________________________
20. $ZnI_2$ ______________________________
21. $C_2O_4$ ______________________________
22. $Pb(C_2H_3O_2)_2$ ______________________________
23. GeO ______________________________
24. $Li_2S$ ______________________________
25. $PCl_9$ ______________________________
26. $Pt_3P_2$ ______________________________
27. $Sn(OH)_2$ ______________________________
28. $V_2O_4$ ______________________________
29. $Ca_3(PO_4)_2$ ______________________________
30. $N_2O_5$ ______________________________
31. $Al_2(Cr_2O_7)_3$ ______________________________
32. $SiO_2$ ______________________________
33. $CoBr_3$ ______________________________
34. $CrF_2$ ______________________________
35. $F_7S_8$ ______________________________
36. $Rb_2O$ ______________________________
37. $P_3Br_6$ ______________________________
38. $CsClO_3$ ______________________________
39. $CaCl_2$ ______________________________
40. $K_2SO_4$ ______________________________

**B) vi - Hydrates**
Hydrates are ionic formula units with water molecules associated with them. The water molecules are incorporated into the solid structure of the ions. Strong heating can generally drive off the water in these salts. Once the water has been removed the salts are said to be anhydrous (without water).

To name a hydrate use the normal name of the ionic compound followed by the term 'hydrate' with an appropriate prefix to show the number of water molecules per ionic formula unit. For example, $CuSO_4 \cdot 5H_2O$ is copper (II) sulfate pentahydrate

**B) vi - Name the following compounds:**

1) $Mg(OH)_2 \cdot 4H_2O$ ___________________________________

2) $BaSO_4 \cdot 8H_2O$ _______________________________________

**Write the formula for the following**:

3) Calcium acetate trihydrate _________________________

4) Copper(II)Chromate nonahydrate _________________________

## Section C – Scientific Notation (tyler dewitt – search scientific notation)

Scientific Notation is an efficient way to express very large or small numbers and make them easier to handle. All scientific notation have a 1-9 digit followed by a decimal place and raised to a particular power (multiplied by 10). The number of decimal places in ordinary notation is determined by the power of 10. Moving the decimal left makes the numbers get larger or more positive. Moving decimal to the right makes it smaller or more negative.

$3.5 \times 10^5 = 350{,}000$ or $3.5 \times 10^{-5} = 0.000035$

## Convert to either standard or scientific notation: Section C
**We use scientific notation the entire course so you MUST be proficient with them!!**

1) $5.63 \times 10^{-3}$ ________________________________

2) $6.7 \times 10^{5}$ ________________________________

3) $1.01 \times 10^{3}$ ________________________________

4) $9.899 \times 10^{-5}$ ________________________________

5) 24500 ________________________________

6) 0.000985 ________________________________

7) 0.333 ________________________________

**<u>Section D) Temperature Scales – CELSIUS AND KELVIN are used exclusively in AP chem but since we live in the USA I gave you some ºF as a reference point.</u>**

Celsius to Kelvin K = ºC + 273
Kelvin to Celsius ºC = K - 273

Celsius to Fahrenheit ºF = (1.8 (ºC)) + 32
Fahrenheit to Celsius $\frac{(ºF - 32)}{1.8}$

## <u>Convert the following:</u>

1) 122ºC to ºF _________________

2) 55.0ºF to ºC __________________

3) 330K to ºF ___________________

4) 25ºC to K ____________________

5) -40ºF to K ____________________

6) When discussing a change in temperature, why will it not matter if the temperature change is recorded in Celsius or Kelvin?

## <u>Section E) Density (search Tyler DeWitt – "density" for extra help)</u>

The Density of a substance refers to its mass per unit of volume. It is the measure of how much material is in a volume of space. $D = \frac{\text{mass}}{\text{volume}}$

**Water for instance has a density of 1.0 grams per 1 milliliter of volume. It is written as follows:**
**1.0 g/mL or 1.0 g/cm$^3$ (1mL = 1cm$^3$)**

When a substance is more dense than another object it will sink in that medium. (ex. Lead in water)
If it is less dense it will float. (helium balloon in air)

1) An object has a mass of 10.0 grams and a volume of 2.00mL. What is the density of the object?

2) If a metal chunk has a density of 11.4 g/mL and a volume of 1.75mL, what is the mass of the metal?

3) A 17.0gram foam block has a density of .405g/mL, what is the volume of the block?

## Section F - The Metric System – The bolded ones are most frequently used!!!!

- Easier to use - a decimal system based on the power of 10.
- It has two parts a prefix and a base unit and the prefix tells you how many times to divide or multiply by 10.

**Prefixes**

T--G--M--k-h-da-Base-d-c-m - - μ - - n - - p
Each "–" represents a power of 10

- Tera - T (means 1,000,000,000,000)
- Giga - G (means 1,000,000,000)
- Mega – M (means 1,000,000)
- **kilo - k** (means 1000)
- hecto - h (means 100)
- deca(deka) da (means 10)

- **Base units (grams, Liters, meters) (1)**
- deci - d (.1)
- **centi – c (.01)**
- **milli - m (.001)**
- **micro - μ ($10^{-6}$)**
- **nano – n ($10^{-9}$)**
- pico – p ($10^{-12}$)

**SI base units (we use all of these)!!!**

- Length – meter
- Mass – kilogram
- Time - second
- Temperature - Kelvin
- Amount of substance - mole
- Electric Current – ampere

**Derived SI Units(comes from the base units)**

- Length x length – square meter $m^2$
- Volume – $cm^3$ from cm x cm x cm
- Molar Mass – grams per mole
- Molarity – moles per Liter - M

**Volume**

- 1 L = 1000 mL = 1000 $cm^3$
- **1 mL = 1 $cm^3$ = 1 gram of water**
- **1 mL water = 1 gram of water = 20 drops**

**Mass**

- 1 lb. = 454 grams 1kg = 2.206 lbs.

**Length**

- 1 foot = 12 inches
- 1 yard = 3 feet
- 1 mile = 5280 feet = 1.609 km
- 1 inch = 2.54 cm

**www.youtube.com – Tyler DeWitt – Search "conversion factors" or "factor label method"**

**STEPS FOR FACTOR LABEL METHOD (see examples on the next page)**
**1.DRAW A CONVERSION GRID AND PLACE WHAT YOU HAVE ON THE TOP LEFT SIDE.**
**2 PLACE WHAT YOU ARE CONVERTING TO ON TOP.**
**3. PLACE WHAT YOU ARE CONVERTING FROM ON BOTTOM.**
**4. WHICH ONE IS BIGGER? GIVE IT A "1"**
**5. HOW MUCH OF THE SMALLER ONE EQUALS THE BIGGER ONE.**
**6. MULTIPLY ACROSS THE TOP AND DIVIDE BY THE BOTTOM**
**7. CANCEL OUT ALIKE UNITS**

**Conversions examples using factor label method**

- convert 5.6 m to millimeters $\quad \dfrac{\mathbf{5.6\ m}}{\ } \Bigg| \dfrac{\mathbf{1000mm}}{\mathbf{1m}} \quad$ = 5,600 mm

- convert 0.45 kg to mg $\quad \dfrac{\mathbf{.45\ kg}}{\ } \Bigg| \dfrac{\mathbf{1x10^6\ mg}}{\mathbf{1kg}} \quad$ = 450,000 mg

- convert 3,500 nm to cm $\quad \dfrac{\mathbf{3{,}500\ nm}}{\ } \Bigg| \dfrac{\mathbf{1\ cm}}{\mathbf{1x\ 10^7\ nm}} \quad$ = 0.00035 cm

**Section F - Try these**

1. 350.0 mL to nL
2. 0.0270 Mbytes to bytes
3. 3.0 ft to m
4. 1000.0 mm to km
5. 5.50 x 1015 pg to g
6. 8750 $dm^3$ to $m^3$
7. 27.0 $cm^3$ to $mm^3$
8. 4.82 in. to m
9. 3785 feet to cm
10. 5720 g to lbs
11. 36 mm to feet
12. 80.0 km to mi

## Section G) - ATOMIC STRUCTURE (There was a test question on 2021 test this year on this very topic!!!) It may be simple but often overlooked.

**atom**: the smallest piece of an element that retains the properties of that element.

**nucleus**: a dense region in the center of an atom. The nucleus is made of protons and neutrons, and contains almost all of an atom's mass.

**proton**: a subatomic particle found in the nucleus of an atom. It has a charge of +1, and a mass of 1 atomic mass unit (amu).

**neutron**: a subatomic particle found in the nucleus of an atom. It has no charge (is neutral), and has a mass of 1 amu.

**electron**: a subatomic particle found *outside* the nucleus of an atom. It has charge of −1 and a mass of 0 amu (really about $^1/_{2000}$ amu). Atoms can gain, lose, or share electrons in chemical reactions.

**charge**: positive and negative charges cancel each other out, so the charge of an atom is the difference between the number of positive charges (protons) and negative charges (electrons) it has. For example, a chlorine atom with 17 protons (+17) and 18 electrons (−18) would have a charge of −1. (It's negative because it has more negatives than positives.)

**neutral atom**: an atom with a charge of zero (positives = negatives).

**ion**: an atom or molecule that has a positive or negative charge, because it has either more negatives (electrons) than positives (protons), or more positives (protons) than negatives (electrons).

**atomic number**: the identity of an atom is based on the amount of (positive) charge in its nucleus. (This works because the nucleus cannot be given to or shared with another atom.) The atomic number is the number of protons in the nucleus. Each element has a unique atomic number.

**mass number**: the mass of an atom is the mass of its nucleus. (The electrons are so small that we can ignore their mass.) Because protons and neutrons each have a mass of 1 amu, the mass number for the atom is just the number of protons + neutrons that the atom has.

**isotopes**: atoms of the same element (same atomic number = same # of protons), but that have different numbers of neutrons (and therefore different mass numbers) from each other.
Isotopes are described by their mass numbers. For example, carbon-12 has 6 protons and 6 neutrons, which gives it a mass number of 12. Carbon-14 has 6 protons and 8 neutrons, which gives it a mass number of 14.

**element symbol**: a one- or two-letter abbreviation for an element. (New elements are given temporary three-letter symbols.) The first letter in an element symbol is always capitalized. Other letters in an element symbol are always lower case. *This is important to remember.* For example, Co is the element cobalt, but CO is the compound carbon monoxide, which contains the elements carbon and oxygen.

**chemical symbol**: a shorthand notation that shows information about an element, including its element symbol, atomic number, mass number, and charge. For example, the symbol for a sodium-23 ion with a +1 charge would be:

***Shorthand Notation*** $^{23}_{11}\mathrm{Na}^{+1}$

This notation shows the element symbol for sodium (Na) in the center, the atomic number (11, because it has 11 protons) on the bottom left, the mass number (23, because it has 11 protons + 12 neutrons = 23 amu) on the top left, and the charge (+1, which means it lost one of its electrons in a chemical reaction) on the top right.

**Hyphen Notation** – **the above symbol would be sodium-23**

For hyphen notation use the element name then the mass number. Sometimes the mass number is higher or lower than the number on the periodic table due to extra neutrons in the nucleus. Again this is called and isotope and some of these isotopes are radioactive.

**Section G)**

1) Write the hyphen notation for calcium with 20 protons and 20 neutrons:

2) Write the shorthand notation for phosphorus with 16 neutrons, 15 protons, and a -3 charge.

3) Write the hyphen notation for the following: $^{25}_{12}\mathrm{Mg}^{+2}$

4) Write the shorthand notation for copper-64 and a +1 charge.

5) How many electrons are in the atom in #4?

## Section H - Average Atomic Mass – (Tyler DeWitt – search "Average atomic mass")

**mass number:** the mass of *one individual atom* (protons + neutrons). Always a whole number.
**abundance:** the percentage of atoms of an element that are one specific isotope.
**average atomic mass:** the estimated *average* of the mass numbers *of all of the atoms* of a particular element in the universe (or at least on Earth).

**Problem: How to solve → (Mass A)(%A) + (Mass B)(%B) + (Mass C)(%C) + ….**

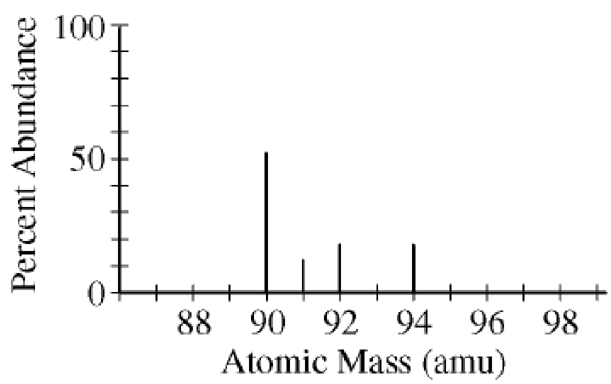
What is the average atomic mass of copper?

1) Copper consists of 69.17% 63Cu with an atomic mass of 62.929598 u and 30.83% 65Cu with a mass of 64.927793 u.

2) Naturally occurring magnesium is composed of 78.99% of $^{24}Mg$, with an atomic mass of 23.9850 u., 10.00% of $^{25}Mg$ with an atomic mass of 24.9858 u, and 11.01% of $^{26}Mg$, with an atomic mass of 25.9826 u. Use this data to calculate the average atomic mass of magnesium.

3) Naturally occurring chlorine is a mixture of two isotopes. In every sample of this element 75.77% of the atoms are $^{35}Cl$ and 24.23% are atoms of $^{37}Cl$. The accurately measured atomic mass of $^{35}Cl$ is 34.9689 u and that of $^{37}Cl$ is 36.9659 u. From this data, calculate average atomic mass of chlorine.

4) Using the graph below. Find the element and its average atomic mass using the process above.



# Section I) Molar Mass (search Tyler DeWitt – "moles")

Now that you can name compounds there are a few basic things we need to know how to do with the compounds. The first and most important is being able to use a compound to find its molar mass. Sometimes this is also referred to as the molecular mass or gram formula mass. For this we have to use the periodic table. On the periodic table there is a small whole number called the **atomic number**. This number represents protons and can also be electrons in a neutral atom. The other number in the boxes on the periodic table is called the **atomic mass** and is the weighted average of all the isotopes of that atom based on their percent abundance. This atomic mass is what we will use to find the molar mass of a substance.

To find the molar mass of a compound like water, $H_2O$ you will take how many you have of each atom in the compound and multiply it by its atomic mass on the periodic table. Then you add them all together and you have the molar mass of the substance. The units for molar mass are grams per mole which can be written as g/mole or g mol$^{-1}$, which you will see both of during the AP class

2 H x 1.008 = 2.016
<u>1 O x 16.00 = 16.00 +</u>
= 18.02 grams per mole

This molar mass can now be used to solve basic problems in conversions, for example:
How many grams are in 10.0 moles of water?

$$\begin{array}{c|c} \textbf{10.0 moles} & \textbf{18.02 g} \\ \hline & \textbf{1 mole} \end{array} = \boxed{\textbf{180.2 g}}$$

Or
How many moles are in 150.0 grams of water?

$$\begin{array}{c|c} \textbf{150.0 grams} & \textbf{1 mole} \\ \hline & \textbf{18.02g} \end{array} = \boxed{\textbf{8.32 mol}}$$

Also, in 1 mole of any substance there are $6.02 \times 10^{23}$ particles, called Avogadro's number. We can also then implement that into the equation as follows.
**How many grams are in $2.50 \times 10^{24}$ molecules of water? (abbreviation for molecules = mc)**

$$\begin{array}{c|c|c} \mathbf{2.50 \times 10^{24}}\textbf{ molecules} & \textbf{1 mole} & \textbf{18.02 g} \\ \hline & \mathbf{6.02 \times 10^{23}}\textbf{ mc} & \textbf{1 mole} \end{array} = \boxed{\textbf{78.3 grams}}$$

Now you try a few on the next page…. ☺

**<u>Section I</u>**
1. Determine the number of moles represented by 13.25 grams of Copper (II) Sulfate. (0.08302 moles)

2. How many grams of phosphorus are represented by 2.34 x $10^{23}$ phosphorus trichloride molecules? (12.0g)

3. How many grams of ammonium ions are represented by 6.441 x $10^{22}$ ions? (1.93 g)

4. How many molecules of water are there in 1.222 grams of water? (4.08 x $10^{22}$)

**Section J** – **Of all the sections please watch these videos if you need instruction. Very HELPFUL!!!**

***Tyler DeWitt Search - Find video titled: "Determining the mole Ratio" and "Molar Ratio Chemistry" and "Mole Ratio Practice Problems"***

## Stoichiometry…a step further…

Stoichiometry applies the mole concept to the balanced chemical equation. (Stoichiometry means the relationships among the quantities of reactants and products involved in chemical reactions; it is derived from the Greek words ***stoicheion*** "element" and ***metron*** "measure".) The coefficients are called "stoichometric coefficients".

### Molar Ratios

We can write **TWO** conversion factors using the stoichiometric coefficients of a balanced equation for any two species in a reaction.

FOR EXAMPLE: $4\ Fe\ (s) + 3\ O_2\ (g) \longrightarrow 2\ Fe_2O_3\ (s)$

COMPARE Fe to $O_2$: $\frac{4\ \text{mol Fe}}{3\ \text{mol } O_2}$ OR $\frac{3\ \text{mol } O_2}{4\ \text{mol Fe}}$

COMPARE Fe to $Fe_2O_3$: $\frac{4\ \text{mol Fe}}{2\ \text{mol } Fe_2O_3}$ OR $\frac{2\ \text{mol } Fe_2O_3}{4\ \text{mol Fe}}$

COMPARE $O_2$ to $Fe_2O_3$: $\frac{3\ \text{mol } O_2}{2\ \text{mol } Fe_2O_3}$ OR $\frac{2\ \text{mol } Fe_2O_3}{3\ \text{mol } O_2}$

The ratios written above are called molar ratios and are used in the factor-label method of problem solving as a "bridge" (conversion factor) between the ***two different species!***

Using the balanced chemical equation $4\,Fe\,(s) + 3\,O_2\,(g) \longrightarrow 2\,Fe_2O_3\,(s)$
determine the number of moles of iron (III) oxide that can be prepared from 8 moles of iron metal?

$$\frac{8\ \cancel{\text{mol Fe}}}{} \;\Big|\; \frac{2\ \text{mol}\ Fe_2O_3}{4\ \cancel{\text{mol Fe}}} = 4\ \text{mol}\ Fe_2O_3$$

OR:
How many moles of iron metal are needed to prepare 8 mol of iron (III) oxide?

$$\frac{8\ \cancel{\text{mol}\ Fe_2O_3}}{} \;\Big|\; \frac{4\ \text{mol Fe}}{2\ \cancel{\text{mol}\ Fe_2O_3}} = 16\ \text{mol Fe}$$

## <u>YOU TRY: (all answers to section J are at the end of the section)</u>

1) How many moles of iron (III) oxide can be prepared from 6 moles of oxygen?

2) How many moles of oxygen are needed to prepare 12 moles of iron (III) oxide?

**We can also compare two reactants (or two products) as in the following examples.**
**EXAMPLE:**
**How many moles of iron metal are needed to react completely with 6 moles of oxygen?**

$$\frac{6\ \cancel{\text{mol}\ O_2}}{} \;\Big|\; \frac{4\ \text{mol Fe}}{3\ \cancel{\text{mol}\ O_2}} = 8\ \text{mol Fe}$$

**How many moles of oxygen are required to react completely with 12 moles of iron metal?**

$$\frac{12\ \cancel{\text{mol Fe}}}{} \;\Big|\; \frac{3\ \text{mol}\ O_2}{4\ \cancel{\text{mol Fe}}} = 9\ \text{mol}\ O_2$$

YOU TRY:
3) How many moles of iron metal are required to react completely with 12 moles of oxygen?

4) How many moles of oxygen are required to react completely with 36 moles of iron metal?

**Lithium oxide is formed by the reaction of lithium metal with oxygen gas.**
**Write balanced chemical equation for this reaction, and then answer the following questions.**

$$4\ Li_{(s)} + O_{2(g)} \rightarrow 2\ Li_2O_{(s)}$$

#5a) How many moles of lithium are needed to react completely with 3 moles of oxygen?

b) How many moles of oxygen are required to react completely with 16 moles of lithium?

c) How many moles of lithium oxide can be produced from 4 moles of oxygen?

d) How many moles of oxygen are required to produce 6 moles of lithium oxide?

Let's return to our original equation:

$4\ Fe\ (s) + 3\ O_2\ (g) \longrightarrow 2\ Fe_2O_3\ (s)$

Suppose we desire (for some strange reason) to produce 4 moles of iron (III) oxide. We know from the stoichiometric coefficients that we need 8 moles of iron. But, how do we get 8 moles of iron? We are certainly NOT going to count out eight times Avogadro's number of atoms!!! (Unless we are really really bored – not to mention immortal!) Fortunately, there is an easier way. We know from the periodic table that one mole of iron has a mass of 55.85 grams. So, how much iron should we weigh out if we want 8 moles? The obvious answer is 8 times 55.85 grams and that is correct. How do we set this up using the factor-label method?

$$4\ \cancel{\text{mol } Fe_2O_3} \times \frac{4\ \cancel{\text{mol Fe}}}{2\ \cancel{\text{mol } Fe_2O_3}} \times \frac{55.85\ \text{grams Fe}}{1\ \cancel{\text{mol Fe}}} = 446.8\ \text{grams Fe}$$

Suppose we needed to know how much iron would react completely with 8 moles of oxygen.

$$8\ \cancel{\text{mol } O_2} \times \frac{4\ \cancel{\text{mol Fe}}}{3\ \cancel{\text{mol } O_2}} \times \frac{55.85\ \text{grams Fe}}{1\ \cancel{\text{mol Fe}}} = 595.7\ \text{grams Fe}$$

What if we wanted to know how much iron (III) oxide could be produced from 12 moles of iron metal?

$$\frac{12\ \cancel{\text{mol Fe}}}{} \left|\ \frac{2\ \cancel{\text{mol } Fe_2O_3}}{4\ \cancel{\text{mol Fe}}}\ \right|\ \frac{159.7 \text{ grams } Fe_2O_3}{1\ \cancel{\text{mol } Fe_2O_3}} = 958.2 \text{ grams } Fe_2O_3$$

## Write the balanced equation for the combustion of propane, then answer the questions.

$$1\ C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(g)}$$

6) How many grams of propane are required to react with 15 moles of oxygen?

7) How many grams of oxygen are required to produce 8 moles of water?

8) How much water, in grams, could be produced by the combustion of 2 moles of propane?

We can now carry all of this a step further. Suppose we needed to know how much iron metal is required to produce exactly 100.0 grams of iron (III) oxide (according to our original equation)?

$$\frac{100.0\ \cancel{\text{g } Fe_2O_3}}{} \left|\ \frac{1\ \cancel{\text{mol } Fe_2O_3}}{159.7\ \cancel{\text{g } Fe_2O_3}}\ \right|\ \frac{4\ \cancel{\text{mol Fe}}}{2\ \cancel{\text{mol } Fe_2O_3}}\ \left|\ \frac{55.85 \text{ g Fe}}{1\ \cancel{\text{mol Fe}}}\right. = 69.94 \text{ g Fe}$$

Notice that we first; must convert our mass to moles using the molar mass of the substance. (When in doubt, covert to moles) Then, and ONLY then, can we make our comparison of the two substances using the molar ratio from the balanced chemical equation. Once we know the moles needed, we can easily convert to mass using the molar mass of the substance.

The following is a “road map” for all mass-to-mass stoichiometric problems.

$$\textbf{mass A} \xrightarrow[\textbf{moles A}]{\textbf{Divide by molar mass A}} \quad \xrightarrow[\textbf{moles B}]{\textbf{multiply by ratio B/A}} \quad \xrightarrow[\textbf{mass B}]{\textbf{multiply by molar mass B}}$$

**YOU TRY:** Answer the following questions

**The thermite reaction involves a reaction between iron (III) oxide and aluminum metal.**

$$Fe_2O_{3(s)} + 2\ Al_{(s)} \rightarrow 2\ Fe_{(s)} + Al_2O_{3(s)}$$

9) How much aluminum is required to produce 125.0 grams of molten iron?

10) How many grams of iron (III) oxide are required to react completely with 62.3 grams aluminum?

11) How many grams of iron metal can be produced by the reaction of $1.20 \times 10^5$ grams of iron (III) oxide?

12) How many grams of aluminum oxide can be produced by reaction $4.71 \times 10^3$ grams of aluminum?

13) How many grams of iron (III) oxide are required to produce $5.00 \times 10^2$ grams of aluminum oxide?

14) How much iron can be produced by the reaction of 65.0 kg of aluminum?

**Section J Answers:**

| | | | |
|---|---|---|---|
| **1)** | **4 mol $Fe_2O_3$** | **11)** | **$8.39 \times 10^4$ g Fe** |
| **2)** | **18 mol $O_2$** | **12)** | **$8.90 \times 10^3$ g $Al_2O_3$** |
| **3)** | **16 mol Fe** | **13)** | **783 g $Fe_2O_3$** |
| **4)** | **27 mol $O_2$** | **14)** | **$1.35 \times 10^5$ g Fe** |

**5)**
- **(a) 12 mol Li**
- **(b) 4 mol $O_2$**
- **(c) 8 mol $Li_2O$**
- **(d) 3 mol $O_2$**

**6)** **132.3 g $C_3H_8$**

**7)** **320.0 g $O_2$**

**8)** **144.1 g $H_2O$**

**9)** **60.38 g Al**

**10)** **184 g $Fe_2O_3$**

# Common Chemical Ions

| Cations +1 | | Anions –1 | |
|---|---|---|---|
| Ammonium (only + polyatomic ion) | $NH_4^{+1}$ | Acetate | $C_2H_3O_2^{-1}$ |
| | | Perchlorate | $ClO_4^{-1}$ |
| | | Chlorate | $ClO_3^{-1}$ |
| Hydrogen | $H^{+1}$ | Chlorite | $ClO_2^{-1}$ |
| Silver | $Ag^{+1}$ | Hypochlorite | $ClO^{-1}$ or $OCl^{-1}$ |
| | | Cyanide | $CN^{-1}$ |
| | | Hydride | $H^{-1}$ |
| | | Hydrogen Carbonate/bicarbonate | $HCO_3^{-1}$ |
| | | Hydrogen Sulfate/bisulfate | $HSO_4^{-1}$ |
| | | Hydroxide | $OH^{-1}$ |
| | | Nitrate | $NO_3^{-1}$ |
| | | Nitrite | $NO_2^{-1}$ |
| | | Permanganate | $MnO_4^{-1}$ |
| | | Azide | $N_3^{-1}$ |
| | | Thiocyanate | $SCN^{-1}$ |

| Cations +2 | | Anions –2 | |
|---|---|---|---|
| | | Peroxide | $O_2^{-2}$ |
| Cadmium | $Cd^{+2}$ | Carbonate | $CO_3^{-2}$ |
| Zinc | $Zn^{+2}$ | Chromate | $CrO_4^{-2}$ |
| | | Dichromate | $Cr_2O_7^{-2}$ |
| | | Oxalate | $C_2O_4^{-2}$ |
| | | Sulfate | $SO_4^{-2}$ |
| | | Sulfite | $SO_3^{-2}$ |
| | | Thiosulfate | $S_2O_3^{-2}$ |
| | | Silicate | $SiO_3^{-2}$ |

| Cations +3 | | Anions –3 | |
|---|---|---|---|
| Aluminum | $Al^{+3}$ | Phosphate | $PO_4^{-3}$ |
| Gallium | $Ga^{+3}$ | Phosphite | $PO_3^{-3}$ |
| | | Borate | $BO_3^{-3}$ |

Common Transition Metals that exhibit multiple oxidation states

| | | | | |
|---|---|---|---|---|
| Cr +2, +3, +6 | Pt +2, +4 | Cu +1, +2 | $Hg_2^{+2}$ $Hg^{+2}$ | Au +1, +3 |
| Fe +2, +3 | Pd +2, +4 | | | |
| Co +2, +3 | Sn +2, +4 | | | |
| Ni +2, +3 | Pb +2, +4 | | | |
| | Mn +2, +4 | | | |

# Other Compounds to Memorize

Strong Acids (all others are weak) **MUST MEMORIZE THE 6 STRONG ACIDS**

| Binary | | Oxyacids (PAsSeS) | |
|---|---|---|---|
| $HCl$ | Hydrochloric Acid | $HClO_4$ | *Perchloric Acid* |
| $HBr$ | Hydrobromic Acid | $HNO_3$ | Nitric Acid |
| $HI$ | Hydroiodic Acid | $H_2SO_4$ | Sulfuric Acid (1st $H^+$ only) |

**Other Common Acids**

| | |
|---|---|
| $H_3PO_4$ | Phosphoric Acid |
| $HC_2H_3O_2$ | Acetic Acid |
| $H_2CO_3$ | Carbonic Acid |

| $P^{-3}As^{-3}Se^{-2}S^{-2}$ | | | other | | |
|---|---|---|---|---|---|
| per | $O_5$ | ate | per | $O_4$ | ate |
| | $O_4$ | ate | | $O_3$ | ate |
| | $O_3$ | ite | | $O_2$ | ite |
| hypo | $O_2$ | ite | hypo | $O$ | ite |

other (F, Br, I, N, all -1)
(C, Si -2)

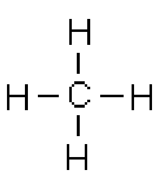
**Oxyacids use –ic with –ate endings**
**-ous with –ite endings**

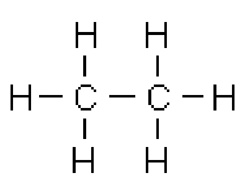
Miscellaneous

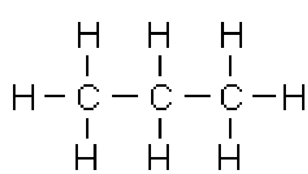
| | |
|---|---|
| $H_2O_2$ | Hydrogen Peroxide |
| $NH_3$ | Ammonia |
| $C_6H_6$ | Benzene |

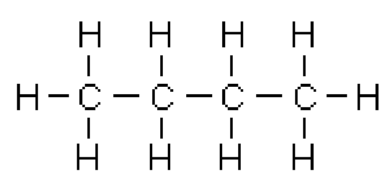
## Alkanes ($C_nH_{(2n+2)}$)

| | |
|---|---|
| *Methane* | $CH_4$ |
| *Ethane* | $C_2H_6$ |
| *Propane* | $C_3H_8$ |
| *Butane* | $C_4H_{10}$ |
| *Pentane* | $C_5H_{12}$ |
| *Hexane* | $C_6H_{14}$ |
| *Heptane* | $C_7H_{16}$ |
| *Octane* | $C_8H_{18}$ |
| *Nonane* | $C_9H_{20}$ |
| *Decane* | $C_{10}H_{22}$ |


Methane


Ethane


Propane


Butane

# AP® CHEMISTRY EQUATIONS AND CONSTANTS

Throughout the exam the following symbols have the definitions specified unless otherwise noted.

| | | | | | |
|---|---|---|---|---|---|
| L, mL | = | liter(s), milliliter(s) | mm Hg | = | millimeters of mercury |
| g | = | gram(s) | J, kJ | = | joule(s), kilojoule(s) |
| nm | = | nanometer(s) | V | = | volt(s) |
| atm | = | atmosphere(s) | mol | = | mole(s) |

## ATOMIC STRUCTURE

$E = h\nu$

$c = \lambda\nu$

$E$ = energy

$\nu$ = frequency

$\lambda$ = wavelength

Planck's constant, $h = 6.626 \times 10^{-34}$ J s

Speed of light, $c = 2.998 \times 10^{8}$ m s$^{-1}$

Avogadro's number $= 6.022 \times 10^{23}$ mol$^{-1}$

Electron charge, $e = -1.602 \times 10^{-19}$ coulomb

## EQUILIBRIUM

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}, \text{ where } a\,A + b\,B \rightleftarrows c\,C + d\,D$$

$$K_p = \frac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}$$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

$$K_b = \frac{[OH^-][HB^+]}{[B]}$$

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$
$$= K_a \times K_b$$

$$\text{pH} = -\log[H^+],\ \text{pOH} = -\log[OH^-]$$

$$14 = \text{pH} + \text{pOH}$$

$$\text{pH} = \text{p}K_a + \log\frac{[A^-]}{[HA]}$$

$$\text{p}K_a = -\log K_a,\ \text{p}K_b = -\log K_b$$

Equilibrium Constants

$K_c$ (molar concentrations)

$K_p$ (gas pressures)

$K_a$ (weak acid)

$K_b$ (weak base)

$K_w$ (water)

## KINETICS

$$[A]_t - [A]_0 = -kt$$

$$\ln[A]_t - \ln[A]_0 = -kt$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$$

$$t_{1/2} = \frac{0.693}{k}$$

$k$ = rate constant

$t$ = time

$t_{1/2}$ = half-life

## GASES, LIQUIDS, AND SOLUTIONS

$$PV = nRT$$

$$P_A = P_{total} \times X_A, \text{ where } X_A = \frac{\text{moles A}}{\text{total moles}}$$

$$P_{total} = P_A + P_B + P_C + \ldots$$

$$n = \frac{m}{\boldsymbol{M}}$$

$$K = {}^\circ C + 273$$

$$D = \frac{m}{V}$$

$$KE_{molecule} = \frac{1}{2}mv^2$$

Molarity, $M$ = moles of solute per liter of solution

$$A = \varepsilon bc$$

$P$ = pressure
$V$ = volume
$T$ = temperature
$n$ = number of moles
$m$ = mass
$\boldsymbol{M}$ = molar mass
$D$ = density
$KE$ = kinetic energy
$v$ = velocity
$A$ = absorbance
$\varepsilon$ = molar absorptivity
$b$ = path length
$c$ = concentration

Gas constant, $R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$
$= 0.08206 \text{ L atm mol}^{-1}\text{ K}^{-1}$
$= 62.36 \text{ L torr mol}^{-1}\text{ K}^{-1}$

1 atm = 760 mm Hg = 760 torr

STP = 273.15 K and 1.0 atm

Ideal gas at STP = $22.4 \text{ L mol}^{-1}$

## THERMODYNAMICS / ELECTROCHEMISTRY

$$q = mc\Delta T$$

$$\Delta S^\circ = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$$

$$\Delta H^\circ = \sum \Delta H_f^\circ \text{ products} - \sum \Delta H_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \sum \Delta G_f^\circ \text{ products} - \sum \Delta G_f^\circ \text{ reactants}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$= -RT \ln K$$
$$= -nFE^\circ$$

$$I = \frac{q}{t}$$

$$E_{cell} = E^\circ_{cell} - \frac{RT}{nF}\ln Q$$

$q$ = heat
$m$ = mass
$c$ = specific heat capacity
$T$ = temperature
$S^\circ$ = standard entropy
$H^\circ$ = standard enthalpy
$G^\circ$ = standard Gibbs free energy
$n$ = number of moles
$E^\circ$ = standard reduction potential
$I$ = current (amperes)
$q$ = charge (coulombs)
$t$ = time (seconds)
$Q$ = reaction quotient

Faraday's constant, $F$ = 96,485 coulombs per mole of electrons

$$1 \text{ volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$$