## Atomic Structure

An atom is made up of protons and neutrons (both found in the nucleus) and electrons (found in the orbitals surrounding the nucleus). The atomic number of an element is equal to the number of protons. If the atom is neutral then the atomic number also equals the number of electrons. A charge written in the upper right corner indicates that the number of electrons has been altered. The mass number (different than the average atomic mass) is the sum of the protons and neutrons.

Nitrogen- 15 (+3) cation

Mass Number 15 N +3 ion charge

Atomic #  7

7 protons

8 neutrons (15-7)

4 electrons (normally 7 but +3 means loses 3 electrons)

Complete the following table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Element/Ion | Atomic  Number | Mass Number | # Protons | # Neutrons | # Electrons |
| 1 H |  |  |  |  |  |
| 1H +1 |  |  |  |  |  |
| 12 C |  |  |  |  |  |
| 7Li + |  |  |  |  |  |
| 35Cl -1 |  |  |  |  |  |
| 39K |  |  |  |  |  |
| 24Mg +2 |  |  |  |  |  |
| 74As -3 |  |  |  |  |  |
| 108Ag |  |  |  |  |  |
| 108Ag +1 |  |  |  |  |  |
| 33S-2 |  |  |  |  |  |
| 238U |  |  |  |  |  |

Isotopes and Average Atomic Mass

Elements come in a variety of isotopes, meaning they are made up of atoms with the same atomic number but different mass numbers due to varying numbers of neutrons. A weighted average can be taken of the mass numbers of each isotope. The average is called the average atomic mass and appears in the box on the periodic table.

Cesium has three naturally occurring isotopes, cesium-133, cesium-132 and cesium- 134. The percent abundance of each is 75 %, 20 % and 5 % respectively. Determine the average atomic mass of cesium.

X .75 = 99.75

X .20 = 26.4

X .05 = 6.7

132.85 amu

Determine the average atomic mass of the following elements.

1. 80 % 127 I, 17 % 126I, 3 % 128I \_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. 15 % 55Fe, 85 % 56Fe \_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. 99% 1H, 0.8 % 2H, 0.2 % 3H \_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. 95 % 14N, 3 % 15N, 2% 16N \_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. 98 % 12 C, 2 % 14 C \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Electron Configuration

Electrons are distributed in orbitals with principal quantum numbers of 1 – 7, sublevels, (s,p,d,f), orientations (s has 1, p has 3, d has 5 and f and 7) and spin (two electrons are allowed in each orbital). Use your periodic table or the diagonal rule to place electrons into orbitals

Draw the orbital notation for sodium:

Sodium has 11 electrons:

Orbital notation: \_\_ \_\_ \_\_ \_\_ \_\_ \_\_

1s 2s 2p 3s

Electron configuration: 1s22s22p63s1

\* remember Hund’s Law

Draw both the orbital notation and write the electron configurations for:

1. Cl
2. N
3. Al
4. O

Valence Electrons

Valence electrons are defined as the electrons in the largest energy level. They are always the electrons in the s and p sublevels, so the number of valence electrons can never exceed 8. You can determine the number of valence electrons from the electron configuration or by looking at the element’s placement on the periodic table.

Carbon: 1s22s22p2

Largest energy level is 2 where a total of 4 electrons reside (look at superscripts). Therefore the valence is 4

Determine the number of valence each of the following has.

|  |  |  |  |
| --- | --- | --- | --- |
| Element | # Valence e- | Element | # Valence e- |
| Fluorine |  | Lithium |  |
| Phosphorus |  | Zinc |  |
| Calcium |  | Carbon |  |
| Nitrogen |  | Iodine |  |
| Iron |  | Oxygen |  |
| Argon |  | Barium |  |
| Potassium |  | Aluminum |  |
| Helium |  | Hydrogen |  |
| Magnesium |  | Xenon |  |
| Sulfur |  | Copper |  |

Periodic Table

The Periodic Table is organized in groups and periods. The elements in a group are placed together because they have many similarities. Also from the periodic table, one can compare various trends like atomic radius, electronegativity, reactivity and ionization energy

1. In what group are the most active metals located? \_\_\_\_\_\_\_\_\_\_\_\_
2. In what group are the most active nonmetals located? \_\_\_\_\_\_\_\_\_
3. As you go from left to right across a period, the atomic size (increases / decreases)
4. As you travel down a group, the atomic size (decreases / increases)? why \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. In what group is the highest electronegative element found?\_\_\_\_\_
6. In what group is the lowest electronegative element found? \_\_\_\_\_
7. Elements of group 2 are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. As you go from left to right across the periodic table, the elements go from (metals/ nonmetals) to (metals/ nonmetals).
9. Group 18 elements are called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. What sublevel are filling in across the transition elements? \_\_\_\_\_
11. Which element in group 2 is most likely to lose an electron? \_\_\_\_
12. Elements within a group have the same number of \_\_\_\_\_\_\_\_
13. The majority of elements on the periodic table are (metals/nonmetals).
14. Which element in group 16 is most likely to gain an electron? \_\_\_\_\_\_

Nomenclature

Writing formulas and naming compounds depends entirely on the type of bonding present in the substance. The first question that must be asked is: is the substance ionic, covalent or an acid?

Naming Compounds:

Covalents: write first nonmetal name with prefix if there is a subscript, write second nonmetal name always with prefix and ide ending.

Acids: If two nonmetals, write hydro – nonmetal stem – ic acid

If polyatomic ion (no hydro) change polyatomic ion ending:

ate ic

ite ous

Ionics: write metal name then either nonmetal name with ide ending or polyatomic ion name. Decide if metal needs Roman numeral

Write the correct name for the following substances. Decide whether you need to follow covalent, ionic or acid rules.

1. CO2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. CO \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. SO2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. SO3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. N2O \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. NO \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. CaCO3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. KCl \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. FeSO4 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. LiBr \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

11. MgCl2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

12. FeCl3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13. Zn3(PO4)2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. NH4NO3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15. HNO3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

16. HCl \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

17. H2SO4 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

18. H2SO3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

19. HC2H3O2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

To write formulas correctly, again you have to ask yourself the question, what type of bonding exists? Is it ionic (starts with a metal), covalent (two nonmetals), or and acid (has acid in the name)

Writing Formulas

Covalent: write first nonmetal symbol using prefix for subscript. Then write second nonmetal symbol using its prefix for its subscript.

Ionic: write metal symbol. Write second part of formula using the ending as a guide. It is ends in ide write a nonmetal symbol. If it ends in ate or ite write a polyatomic symbol. The swap and drop oxidation numbers to get subscripts.

Acids: write H. If hydro in name, write a nonmetal symbol and swap and drop oxidation numbers. If no hydro in name write polyatomic ion formula using ending as guide. The swap and drop oxidation numbers for subscripts.

Write the correct formulas for the following chemical names.

1. ammonium phosphate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. iron (II) oxide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. iron (III) oxide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. carbon monoxide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. calcium chloride \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. potassium nitrate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. magnesium hydroxide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. aluminum sulfate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. copper (II) sulfate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. lead (IV) chromate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

11. diphosphorus pentoxide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

12. carbonic acid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

13. potassium permanganate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. sodium carbonate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15. hydrobromic acid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

16. zinc nitrate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

17. aluminum sulfite \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Gram Formula or Molar Mass

Molar mass is the mass of one mole of a substance. If it is a single element, it is equal to the mass off the periodic table measured in grams. If the substance is a formula, you must dissect the formula and add everything up off the periodic table.

Determine the molar mass of the following:

1. KMnO4 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 2. KCl \_\_\_\_\_

3. Na2SO4 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 4. Ca(NO3)2 \_\_\_\_\_\_\_\_\_\_\_

5. Al2(SO4)3 \_\_\_\_\_\_\_\_\_\_\_\_\_ 6. (NH4)3PO4 \_\_\_\_\_\_\_\_\_\_\_

Percent Composition

Percent Composition is an analysis of a chemical’s content using masses. Here is how it is calculated.

% Comp. = mass element x 100

mass of compound

Determine the % composition of the element specified in the following:

1. % K in KMnO4 \_\_\_\_\_\_\_\_\_\_
2. % P in (NH4)3PO4 \_\_\_\_\_\_\_\_\_\_
3. % H2O in CuSO4 ∙ 5H2O \_\_\_\_\_\_\_\_\_\_
4. % N in Mg (NO3)2 \_\_\_\_\_\_\_\_\_\_
5. % O in Al2(SO4)3 \_\_\_\_\_\_\_\_\_\_

### Mole Conversions

**1 mole = Molar Mass (off PT in g) = 6.02 x 10 23 atoms or molecules = 22.4 L (of gas at STP)**

Read the problem and identify the unit you are starting with and the unit you are trying to convert to.

Set up factor label and put given in the upper left.

Choose the two parts of the above conversion factor and place them so that units cancel.

Multiple across the top and divide by anything on the bottom.

1. Convert 25 g NaCl into moles. \_\_\_\_\_\_\_\_\_\_

2. Convert 4.3 moles CO2 to molecules \_\_\_\_\_\_\_\_\_\_

3. Determine the mass of 33.6 L of O2 at STP \_\_\_\_\_\_\_\_\_\_

4. What is the mass of 7.21 x 10 24 atoms P? \_\_\_\_\_\_\_\_\_\_

5. Convert 0.25 moles Na2SO4 to grams \_\_\_\_\_\_\_\_\_\_

6. Determine the mass of 0.50 moles Al2(SO4)3 \_\_\_\_\_\_\_\_\_\_

Empirical Formulas

An empirical formula is a formula where the subscripts are reduced. Most of the ionic formulas that we work with are also empirical formulas.

**Steps**

Cross out % and make grams if given %

Convert grams to moles for each element

Divide each moles answer by the smallest

The whole numbers obtained in step 3 are your subscripts. If a .5 number is obtained in step 3 multiply all answers by 2.

1. What is the empirical formula for a substance that is 75 % carbon and 25 % hydrogen?
2. What is the empirical formula for a substance that is 52.7 % potassium and 47.3 % chlorine?
3. What is the empirical formula for a substance that is 22.1 % aluminum, 25.4 % phosphorus and 52.5 % oxygen?
4. What is the empirical formula for a substance that is 13 % magnesium and 87 % bromine?
5. What is the empirical formula for a substance that is 32.4 % sodium, 22.5 % sulfur, and 45.1 % oxygen?

### Molecular (True) Formulas

A molecular or true formula is one where the subscripts are not reduced or simplified. Many organic formulas are molecular, like glucose C6H12O6.

**Steps**

You must have the empirical formula first.

Divide the mass given in the problem by the molar mass of the empirical formula.

Use the whole number answer from number 3 to multiply the subscripts.

1. The empirical formula of a compound is NO2. Its molecular molar mass is 92 g/mol. What is the molecular formula?
2. The empirical formula of a compound is CH2. Its molecular molar mass is 70 g/mol. Determine the molecular formula.
3. A compound is found to be 40.0 % carbon, 6.7 % hydrogen, and 53.5 % oxygen. Its molecular mass is 60.0 g/mol. What are the empirical and molecular formulas?

Balancing Equations

Balance the equation listed below

An equation is balanced when it adheres to the Law of Conservation of Matter or Mass. In other words:

Mass reactants = Mass products

# atoms of each element of reactant = # atoms of each element of product

Coefficients (whole numbers in front of symbols or formulas) are used to balance equations

1. \_\_\_\_\_N2 + \_\_\_\_\_H2 → \_\_\_\_\_ NH3

1. \_\_\_\_\_ NaCl + \_\_\_\_\_F2 → \_\_\_\_\_ NaF + \_\_\_\_\_Cl2
2. \_\_\_\_\_AgNO3 + \_\_\_MgCl2 → \_\_\_ AgCl + \_\_\_Mg(NO3)2
3. \_\_\_\_\_CH4 + \_\_\_\_\_O2 → \_\_\_\_\_CO2 + \_\_\_\_\_ H2O
4. \_\_\_\_\_ C8H18 + \_\_\_\_\_O2 → \_\_\_\_\_ CO2 + \_\_\_\_H2O
5. \_\_\_\_\_P + \_\_\_\_\_O2 → \_\_\_\_\_ P2O5

1. \_\_\_\_\_S8 + \_\_\_\_\_O2 → \_\_\_\_\_ SO3
2. \_\_\_\_CO2 + \_\_\_\_\_H2O → \_\_\_\_\_C6H12O6 + \_\_\_\_\_O2

1. \_\_\_CaCO3 + \_\_\_HCl → \_\_\_CaCl2 + \_\_\_H2O + \_\_\_CO2

### Translating Equations

Predict the products of the reactions below. In order to complete the problem you may want to follow the steps below.

**Steps**

Translate from words to formulas.

When writing a formula that is ionic be sure to criss-cross the oxidation numbers. Watch for Diatomics! (H2,N2,O2,F2,Cl2,Br2,I2)

Balance the equation.

1. aluminum bromide + chlorine yield aluminum chloride + bromine
2. potassium chlorate when heated yields potassium chloride and oxygen gas
3. calcium hydroxide + phosphoric acid yield calcium phosphate and water
4. hydrogen + nitrogen monoxide yield water + nitrogen

Types of Reactions

A reaction occurs when bonds are broken or formed. Indicators of a chemical reaction include: color change, heat exchange, precipitate formation or gas production (bubbling).

**5 Types**

Synthesis – A + B AB

Decomposition – AB A + B

Combustion – CxHy + O2 H2O + CO2

Single Replacement A + BC AC + B (look at activity series)

Double Replacement – AB + CD AD + CB (look for precipitate)

Identify the type of reaction represented in each equation below.

1. 2H2 + O2 → 2 H2O \_\_\_\_\_\_\_\_\_\_\_\_\_
2. 2H2O → 2 H2 + O2 \_\_\_\_\_\_\_\_\_\_\_\_\_
3. Zn + H2SO4 → ZnSO4 + H2 \_\_\_\_\_\_\_\_\_\_\_\_\_
4. 2 CO + O2 → 2CO2 \_\_\_\_\_\_\_\_\_\_\_\_\_
5. 2HgO → 2Hg + O2 \_\_\_\_\_\_\_\_\_\_\_\_\_
6. 2KBr + Cl2 → 2KCl + Br2 \_\_\_\_\_\_\_\_\_\_\_\_\_
7. CaO + H2O → Ca(OH)2 \_\_\_\_\_\_\_\_\_\_\_\_\_
8. AgNO3 + NaCl → AgCl + NaNO3 \_\_\_\_\_\_\_\_\_\_\_\_\_
9. 2H2O2 → 2H2O + O2 \_\_\_\_\_\_\_\_\_\_\_\_\_
10. Ca(OH)2 + H2SO4 → CaSO4 + 2H2O \_\_\_\_\_\_\_\_\_\_\_\_\_

### Predicting Products

Predict the products of the reactions below. In order to complete the problem you may want to follow the steps below.

**Steps**

Translate the reactants from words to formulas

Identify the reaction pattern (type) to follow.

Write the products by criss-crossing oxidation numbers for compounds. Watch for Diatomics! (H2,N2,O2,F2,Cl2,Br2,I2)

Balance the equation.

1. aluminum + iron (III) chloride →
2. silver nitrate + zinc chloride
3. sulfuric acid + sodium hydroxide
4. acetic acid + copper
5. hydrogen peroxide (catalyzed by manganese dioxide)

Stoichiometry

In a stochiometry problem, you are given the amount of one reactant or product and you are assigned the task of determining the amount of any other reactant or product. The key to relating two different chemicals in an equation is the mole ratio which comes from the COEFFICIENTS. The problems may be mass-mass, mole-mole, mass-mole, or mass-volume. Below are the steps to completing any stoichiometry problem.

**Stoichiometry Steps**

Get a balanced equation.

Write the given and X above the equation with units

Write mole ratio (coefficients) below equation

Do a mole conversion to convert the bottom units to match the top units of the equation. If the unit on top is….

in grams – use molar mass off PT.

in atoms or molecules – use 6.02 x 10 23

in L at STP - use 22.4 L

in moles – you do not need to do anything

in kJ – write the heat value below the equation

5. Cross multiply and solve for X

1. How many moles are required to complete react with two moles of nitrogen?

N2 + 3 H2 → 2 NH3

1. What volume of oxygen gas is produced at STP by decomposing 6.0 moles of potassium chlorate?

2KClO3 → 2KCl + 3O2

### How many moles of HCl are required to react with 125 g of Zn?

Zn + 2 HCl → ZnCl2 + H2

1. How many molecules of water are produced if 2.0 g of sodium sulfate are produced in the equation below?

H2SO4 + 2 NaOH → 2 H2O + Na2SO4

1. How many grams of NH3 are produced by reacting 50.0 g of nitrogen?

N2 + 3 H2 → 2 NH3

1. What volume of hydrogen (at STP) is required to react with the nitrogen in the above reaction?

N2 + 3 H2 → 2 NH3

1. What mass of phosphorus must react with 32.5 g of oxygen?

2P + 5O2 → 2P2O5

1. Determine the amount of heat produced when 100. g of CH4 combust.

CH4 + 2O2 → CO2 + 2H2O + 1063 kJ

### Limiting Reactants

The limiting reactant is the reactant that runs out first. When it is gone the reaction stops. Almost always, when there are two reactants, one is a limiting and one is the excess reactant. You will be given two numbers in these problems. Sometimes the problem will just ask you to identify the limiting reactant. Other times it will ask for how much product will be formed.

**Steps**

Again get balanced equation.

Write both givens with units above equation – no X.

Set up the moles ratio and match units.

Calculate the value for each fraction. Whichever is smaller is the limiting reactant.

If required, then put an X over one of the products and solve like normal stoichiometry using LR.

1. Determine the limiting reactant when 10 go of Li react with 10 g of H2O.

2Li + 2H2O → 2LiOH + H2

1. Determine the limiting reactant when 4.7 moles of oxygen react with 100. g of C3H7OH.

2C3H7OH + 9O2 → 6CO2 + 8H2O

1. What mass of water is produced in the above reaction?

2C3H7OH + 9O2 → 6CO2 + 8H2O

Combined Gas Law

The combined gas law is Boyle’s, Charles’, and Gay-Lussac’s gas laws all put together. Within the one combined gas law you can see all three of the individual gas laws.

**P1V1 = P2V2**

**T1 T2**

P1 = Initial pressure P2 = new pressure

V1 = Initial volume V2= new volume

T1 = Initial temperature in K T2 = new temperature

Use this formula for changing conditions. Look for words that mean change – increase, decrease, rise, lowers new, original

**Temperature must be in Kelvin K = C + 273**

1. Determine the volume if 1.5 atm of gas at 20° C in a 3.0 L vessel are heated to 30° C at a pressure of 2.5 atm.\_\_\_\_\_\_\_\_\_
2. A sample of oxygen gas occupies a volume of 250 mL at 740 torr of pressure. What will the volume be when the pressure is increased to 800 torr? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. A sample of nitrogen occupies a volume at 250 mL at 25° C. What will it occupy at 95° C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. What is the temperature in Celsius when 2.5 L of gas at 22° C and 600 mm of Hg are transferred to a 1.8 L vessel at 760 mm of Hg? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. Determine the volume at STP of a gas originally occupying 7.3 L at 25° C and 70 kPa. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. A gas at 33° C and 100 kPa is heated to 75° C. What is the new pressure? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Graham’s Law of Diffusion

Graham’s Law of Diffusion basically says that a light gas travels faster than a heavier gas. Use the molar masses off the Periodic Table to determine the heavy versus the lighter gas.

**# times faster = heavy/light**

Heavy = molar mass of heavy gas

Light = molar mass of lighter gas

There are no units on the answer

1. Which gas is faster - Carbon tetrachloride or Bromine gas? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. How much faster is hydrogen gas than sulfur trioxide gas? \_\_\_\_\_\_\_\_\_\_\_
3. If helium is placed in one end of an evacuated tube and dinitrogen monoxide is placed in the other end, where will the two gases meet? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. How much faster is helium gas than xenon gas? \_\_\_\_\_\_\_\_\_\_

Ideal Gas Law

The ideal gas law is the only gas law that relates the four measurable aspects of gases – moles, volume, pressure and temperature. It is NOT used for changing conditions like the combined is. It is the one law where you must be picky about the units.

**PV = nRT**

P = pressure(must be in atm or kpa)

V = volume (must be in L)

n = moles (may need to convert grams to moles)

R = universal gas constant = 0.0821 if pressure is in atm

= 8.31 if pressure is in kpa

T = temperature (must be in Kelvin)

**K = C + 273**

1. How many moles of oxygen will occupy a volume of 2.5 L at 1.2 atm and 25° C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What pressure will be exerted by 25 g of CO2 at a temperature of 25° C and a volume of 500 mL? \_\_\_\_\_\_\_\_\_\_\_\_
3. What mass of argon occupies 4.3 L at 70 kPa and 20° C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Dalton’s Law of Partial Pressures

### Dalton’s Law of Partial Pressures is a relatively easy law that says that the sum of the pressures of the individual gases in a mixture is equal to the total pressure of that mixture. The key word to this law is mixture. However, there is a special circumstance when this law is used and it is when a gas is produced in lab via water displacement or “collected over water”.

**Ptotal = P1 + P2 + P3**

***Patmospheric = Pdry gas + PH2O***

P1, P2, and P3 = the pressure of each individual gas and must have the same units

PH2O = pressure of water vapor left behind during water displacement. It depends on the temperature and is looked up on a table

1. What is the total pressure of a mixture of gases if the oxygen’s pressure is 75 kPa, the nitrogen’s pressure is 120 kPa and the carbon dioxide’s pressure is 33 kPa? \_\_\_\_\_\_\_\_\_\_

Is this mixture at standard pressure? \_\_\_\_\_\_\_\_

1. What is the pressure of the carbon dioxide gas if a mixture is at standard pressure and the oxygen is at 0.37 atm and the nitrogen is at 450 mm Hg? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is the pressure of oxygen gas that is collected over water at 25 C at an atmospheric pressure of 800 mm of Hg? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. A 32 mL sample of hydrogen is collected over water at 20 C and 750 mm of Hg. What is the volume of the dry gas at STP? (Vapor pressure of water at 20 C = 17.5 mm of Hg) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Solubility Curve

Answer the following questions about the solubility curve located in your reference tables.

1. What salt is least soluble in water at 20 ° C\_\_\_\_\_\_\_\_\_
2. How many grams of potassium chloride can be dissolved in 200 g of water at 80 °C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. At 40 °C, how much potassium nitrate can be dissolved in 300g of water? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Which salt shows the least change in solubility from 0 -100 °C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. At 30 °C, 90 g of sodium nitrate is dissolved in 100 g of water. Is this solution saturated, unsaturated, or supersaturates? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. A saturated solution of potassium chlorate is formed in one hundred grams of water. If the saturated solution is cooled from 80 °C to 50° C, how many grams of precipitate are formed? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. What compounds show a decrease in solubility for 0 – 100 °C? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_why\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. Which salt is most soluble at 10 °C? \_\_\_\_\_\_\_\_\_\_\_\_\_
9. Which salt is least soluble at 50 °C? \_\_\_\_\_\_\_\_\_\_\_\_
10. Which salt is least soluble at 90 °C? \_\_\_\_\_\_\_\_\_\_\_\_\_

Colligative Properties

Colligative properties are properties of a solvent that are changed when a solute is added. They include melting/freezing point, boiling/condensing point. The boiling point of a solution is always higher than that of a pure solvent, and the freezing point of a solution is always lowers than that of the pure solvent. To determine how much higher or lower use the formula below.

**T = m Kfp or bp D.F**

\* T is the change in the boiling or freezing point.

\* m is the molality of the solution

\* Kfp or bp is the boiling or freezing point constant for the solvent.

\* D.F is the dissociation constant of the solute – how many ions are in the formula. Covalently bonded substances have a D. F = 1

\*\* Greater concentrations impact the boiling points and freezing point more than weak ones

\*\* Ionic solutes impact boiling and freezing point more than covalent solutes

1. What is the boiling point of a 0.50 m salt water solution? (Kbp = 1.86)
2. Determine which of the following will freeze at the lowest temperature: 1.5 m sugar water, 1.5 m salt water, 1.5 m CaCl2 in water, and pure water.
3. What is the new boiling point if water if 50.0 g of ethylene glycol (antifreeze molar mass = 62 g/mole) are added to 50.0 g of water?

Electrolytes and Nonelectrolytes

Electrolytes are substances that when placed in water dissociate (separate) into ions which allow the solution to conduct electricity. Substances that contain ionic bonds are electrolytes along with acids and bases. Nonelectrolytes contain covalent bonds. Classify the following as either an electrolyte or nonelectrolyte.

|  |  |  |
| --- | --- | --- |
| **Compound** | **Electrolyte** | **Nonelectrolyte** |
| NaCl |  |  |
| CH3OH (methanol) |  |  |
| C3H5(OH)3 (glycerol) |  |  |
| C6H12O6 |  |  |
| HCl |  |  |
| NaOH |  |  |

## Molarity

Molarity is one of about a dozen ways to measure the concentration or strength of a solution. Other ways include molality, mole fraction, % by volume, % by mass, or normality. However, molarity seems to be the most commonly used method.

Molarity = Moles Solute

Liter of Solution

The solute must be converted to moles using the molar mass of the periodic table

The volume of solution or solvent must be in liters. Use “King Henry…” (KHDBdcm) to complete the metric conversion

Molarity is abbreviated with a capital M

1. What is the molarity when 107 g of NaCl are dissolved in 1.0 L of solution? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is the molarity of a solution in which 100.g of AgNO3 are dissolved in 500. mL of solution?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How many grams of KNO3 should be used to prepare 2.00 L of a 0.500 M solution? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Like Dissolves Like

Liquids can dissolve substances that contain the same type of overall polarity. However, if two substances do not have the same type of overall polarity, they will not be soluble in each other or, in other words, will be immiscible. An example of two immiscible substances are oil and water because water is a polar substance overall and oil is nonpolar overall. Water is special because and is called the universal solvent because, although it is polar, it can dissolve both polar and ionic substances.

|  |  |  |
| --- | --- | --- |
| Substance | Dissolve in Water | Dissolve in Oil |
| CCl4 |  |  |
| NaCl |  |  |
| Ca(NO3)2 |  |  |
| I2 |  |  |
| NH3 |  |  |

## Chemical vs. Physical Properties

A physical property is a property that can be observed and determined without destroying the object. For example; color, shape, mass, length and odor are all physical properties.

A chemical property indicated how a substance reacts with something else. The original substance is fundamentally changed in observing a chemical property.

Classify the following properties as either chemical or physical properties.

|  |  |  |
| --- | --- | --- |
| Property | Physical | Chemical |
| Blue color |  |  |
| Density |  |  |
| Flammability |  |  |
| Solubility |  |  |
| Reacts with acid to form H2 |  |  |
| Supports combustion |  |  |
| Sour taste |  |  |
| Melting point |  |  |
| Reacts with water to form gas |  |  |
| Reacts with base to form water |  |  |
| Hardness |  |  |
| Boiling point |  |  |
| Can neutralize a base |  |  |
| Luster |  |  |

Physical vs. Chemical Changes

In a physical change, the original substance still exists and has only changed in form. In a chemical change, bonds have been broken or formed and a new substance is produced. Chemical changes are also accompanied by an energy exchange.

Classify the following as chemical or physical changes

1. Salt dissolves in water. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. Hydrochloric acid reacts with potassium hydroxide to produce salt and water \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
3. A pellet of sodium is sliced in two \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
4. Water is heated and changed to steam \_\_\_\_\_\_\_\_\_\_\_\_\_\_.
5. Potassium chlorate is heated and decomposed to potassium chloride and oxygen \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
6. Iron rusts. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. When placed in water a sodium pellet catches fire as hydrogen gas is liberated and sodium hydroxide forms. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
8. Evaporation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
9. Ice melting \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
10. Milk sours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
11. Sugar dissolves in water \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
12. Wood rotting \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
13. Grass growing via photosynthesis \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
14. A tire is inflated with air \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
15. Food is digested in the stomach \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
16. Water is absorbed by a paper towel \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Mixtures or Pure Substances

All matter can be classified as either a mixture or a pure substance. If it is a mixture it can further be classified as homogenous or heterogenous. If it is a pure substance it can be either a compound or an element.

**Matter**

**Pure Substance** **Mixture**

(separated by physical means)

(made in any proportion)

**Elements** **Compounds** **Homogenous** **Heterogenous**

On PT 2 or more atoms well blended identifiable parts

Symbols bonded together solution/alloys easily separated

One type Formulas H2O

Of atom

Classify the following as pure substances or mixtures.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Type of Matter | Pure Substance | | Mixture | |
|  | Element | Compound | Heterogenous | Homogenous |
| Chlorine |  |  |  |  |
| Water |  |  |  |  |
| Soil |  |  |  |  |
| Sugar water |  |  |  |  |
| Oxygen |  |  |  |  |
| Carbon dioxide |  |  |  |  |
| Rocky road ice cream |  |  |  |  |
| Air |  |  |  |  |
| Iron |  |  |  |  |
| Brass |  |  |  |  |

## Solids/Liquids/Gases

The Kinetic Molecular Theory helps to describe the behavior and characteristics of solids, liquids and gases. Basically it states that all the properties unique to a particular state of matter are due to:

The spacing of the particles

The motion of the particles

The energy of the particles

In the table below first identify the state of matter the property is referring to. It may refer to more than one state. Then identify the part of the kinetic molecular theory responsible for this property.

|  |  |  |
| --- | --- | --- |
| Property | State of Matter | Due to spacing, motion and/or energy |
| Compressible |  |  |
| Diffuse |  |  |
| High Density |  |  |
| Organized |  |  |
| Take shape of container |  |  |
| Expansion |  |  |
| Definite volume |  |  |
| Very low density |  |  |
| Fluid |  |  |
| Have mass |  |  |
| Undergo boiling |  |  |

Bonding

A bond forms when an atom tries to become more stable. It wants to satisfy the octet rule – have eight valence electrons.

There are a variety of ways an atom can bond. They are:

Metallic – between two metals resulting in a sea of mobile electrons

Ionic – between a metal and a nonmetal or polyatomic ion. Results from a transfer of electrons from metal to nonmetal. Form positive and negative ions. (electronegativity difference greater than 1.7)

Covalent – between two nonmetals due to the sharing of electrons. There are two types of covalent bonds:

Polar – an uneven sharing – usually two different nonmetals (electronegativity difference of 0.3-1.7) create dipole

Nonpolar – equal sharing of electrons – usually between two identical nonmetals. (electronegativity difference less than 0.3)

Identify the following as being metallic, ionic, polar covalent, or nonpolar covalent bonds. Do not stress about finding the electronegativities to determine the bonds type.

1. Cu – Cu \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Na – O \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. LiCl \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. I - I \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. C – H \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. B – F \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. Zn – Zn \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. CrF3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. O2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Lewis Dot Diagrams

A Lewis dot diagram is used to show how the electrons in a bond are distributed. If the bond is an ionic bond, the Lewis Dot Structures shows the electron transfer and resulting ions. If the bond is covalent the Lewis Dot Structure shows the electron sharing. For covalent bonds the rules are:

1. Draw a skeleton of the structure (identify the center atom

2. Count the total number of valence electrons (Use PT)

3. Distribute electrons so that each atom has eight dots around it.

4. If you run out of dots and every atom is not satisfying the octet rule, try double (sharing 4 electrons) or even triple bonds (sharing 6 electrons between two atoms)

5. Exceptions: H is happy with 2 electrons and B is happy with 6 electrons

Complete the Lewis Dot Structures for the following ionic compounds or covalent molecules. For the covalent molecules also predict the shape as linear, bent, trigonal planar, trigonal pyramidal or tetrahedral.

1. NF3 2. SiI4
2. CaO 4. MgBr2
3. O2 6. OF2
4. F2 8. BCl3

Overall Polarity

The bonding that occurs between two atoms has an impact on the overall polarity of a substance. The overall polarity impacts the substance’s properties like phase, solubility in water (“like dissolves like”), ability to conduct electricity etc. To determine the overall polarity use these guidelines:

If the bonding is metallic its overall polarity is a metal.

If the bonding is ionic its overall polarity is an ionic salt.

If the bonding is nonpolar it is considered nonpolar overall.

If the bonding is polar covalent, then you must look at the symmetry of the molecule (lone pairs around center atom).

If **symmetrical** – no lone pairs - (linear, trigonal planar and tetrahedral shapes) then it is **nonpolar overall.**

If the shape is **asymmetrical** - has lone pairs - (bent or trigonal pyramidal shapes) then it is **polar overall**.

Predict the overall polarity of the following substances.

1. NF3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. CaO \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. MgBr2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. SiI4 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
5. F2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
6. O2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. OF2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. Cu –Cu \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. BCl3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Zn – Zn \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Predicting Properties

Once the **overall polarity** is known, then the general properties of a substance can be determined.

Ionic Salts – have high melting points, dissolve to dissociate into ions and create a solution that conducts electricity, dissolve in water, and are all solids.

Metals – very high melting points, conduct electricity as solids, are all solids (except mercury), do not dissolve in water

Nonpolar – lowest melting points, do not dissolve in water, never conduct electricity, frequently gases.

Polar – low melting points, dissolve in water, never conduct electricity, and can be any phase.

Fill in, completely, the following table for each substance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Substance | Melting Point (high/low) | Dissolve in water? | Ability to Conduct Electricity | Phase |
| CaO |  |  |  |  |
| F2 |  |  |  |  |
| O2 |  |  |  |  |
| OF2 |  |  |  |  |
| Zn- Zn |  |  |  |  |
| SiI4 |  |  |  |  |
| NF3 |  |  |  |  |
| Cu-Cu |  |  |  |  |
| MgBr2 |  |  |  |  |