Measurement and Communication:

1. Complete the following table of prefixes.

Factor	Prefix	Abbreviation
10^6	mega	M
10^3	kilo	K
10^2	hecto	h
10^1	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

2. A student weighed a mass 4 times and obtained the following masses:

25.5g, 29.6g, 23.6g, 27.3g

The actual value is known to be 10.20045g

What can be said about the accuracy and precision of the measurements?

-not accurate (correct) or precise (reproducable)

3. Write the following numbers in scientific notation with the same number of significant digits.

a) 0.000005187 5.187×10^{-6}

b) 7,247 7.247×10^{3}

c) 16,140 1.614×10^{4}

d) 0.0921 9.21×10^{-2}

4. Convert the following numbers from scientific notation into decimal form.

a) 4.562×10^6 4,562,000

b) 8.276×10^{-8} 0.00000008276

5. Complete the following calculations. Include all units and don't forget about sig figs.

a) 1.0068g + 2.15g + 8.3g = 11.5g

b) 21.05cm – 12.1cm = 9.0cm

c) $\frac{1.50 \times 10^{-2}\text{ mol}}{40.0\text{mL}} = 3.75 \times 10^{-4}\text{ mol/mL}$

d) $\frac{432.8\text{g}}{21.8\text{cm} \times (7.645\text{cm} - 3.58\text{cm})} = \frac{432.8\text{g}}{21.8\text{cm} \times 4.065} = 4.88\text{g/cm}^2$

6. Convert 12 milliamperes into megaamperes.

$12\,\cancel{\text{mA}} \times \frac{1\,\cancel{\text{A}}}{10^3\,\cancel{\text{mA}}} \times \frac{1\text{MA}}{10^6\,\cancel{\text{A}}} = 1.2 \times 10^{-8}\text{MA}$

7. Convert 42.6μmol/mL into mol/L.

$$\frac{42.6\,\cancel{\mu mol}}{\cancel{mL}} \times \frac{10^3\,\cancel{mL}}{1\,L} \times \frac{1\,mol}{10^6\,\cancel{\mu mol}} = 0.0426\ mol/L$$

8. Determine how many significant figures are in each of the following numbers:

a) 1.00300	6	e) 0.003050	4
b) 780.00	5	f) 7,000,800	5
c) 0.1110	4	g) 0.00567	3
d) 3000	1	h) 3.000	4

Mole Conversions:

1. Calculate the MOLAR MASS of the following substances.

a) $CuSO_4$

Cu: 1 x 63.5 = 63.5
S: 1 x 32.1 = 32.1
O: 4 x 16.0 = 64.0

159.6g/mol

b) $Ca(MnO_4)_2$

Ca: 1 x 40.1 = 40.1
Mn: 2 x 54.9 = 109.8
O: 8 x 16.0 = 128.0

277.9g/mol

2. Calculate the number of moles of CO_2 that would be present in 8.7×10^{18} molecules of CO_2.

$$8.7\times10^{18}\,\cancel{molecules} \times \frac{1\,mol}{6.022\times10^{23}\,\cancel{molecules}} = 1.4\times10^{-5}\ mol\ CO_2$$

3. How many grams of Copper would be present in 4.5×10^{-3} moles of Copper?

$$4.5\times10^{-3}\,\cancel{mol} \times \frac{63.5\,g}{1\,\cancel{mol}} = 0.29g$$

4. Calculate the mass (in g) of 2.7×10^{21} molecules of ammonia (NH_3): → 14.0 + 3.0 = 17.0g/mol

$$2.7\times10^{21}\,\cancel{molecules} \times \frac{1\,mol}{6.022\times10^{23}\,\cancel{molecules}} \times \frac{17.0g}{1\,mol} = 0.076g\ NH_3$$

5. Determine the mass (in grams) of one atom of Silver.

$$1\,\cancel{atom} \times \frac{1\,\cancel{mol}}{6.022\times10^{23}\,\cancel{atoms}} \times \frac{107.9g}{1\,\cancel{mol}} = 1.792\times10^{-22}\,g\ Ag$$

6. How many molecules are in 75.6g of $CH_3C(OH)_2CH_3$? → (12.0 x 3) + (16.0 x 2) + (1.0 x 8) = 76.0g

$$75.6\,\cancel{g} \times \frac{1\,mol}{76.0\,\cancel{g}} \times \frac{6.022\times10^{23}\,molecules}{1\,mol} = 5.99\times10^{23}\ molecules$$

7. What is the volume occupied by 15mg of $SbH_{3(g)}$ at STP?

$$15\,\cancel{mg} \times \frac{1\,\cancel{g}}{10^3\,\cancel{mg}} \times \frac{1\,\cancel{mol}}{124.8\,\cancel{g}} \times \frac{22.4L}{1\,\cancel{mol}} = 0.0027L\ SbH_3$$

Percentage Composition, Empirical and Molecular Formulae:

1. Write the empirical formula for each of the following compounds.

a) P_4O_{10} P_2O_5 c) $Pb_2(CO_3)_4$ $Pb(CO_3)_2$

b) Mg_2Cl_4 $MgCl_2$ d) N_2O_2 NO

2. Calculate the percentage composition by mass of each of the following compounds.

a) CO_2

Total mass $= (12.0\times1)+(16.0\times2) = 44.0 g/mol$

$\%C = \frac{12.0g}{44.0g} \times 100\% = 27.3\% C$

$\%O = \frac{32.0g}{44.0g} \times 100\% = 72.7\% O$

b) C_4H_8O Total mass $= (12.0\times4)+(1.0\times8)+(16.0\times1) = 72.0 g/mol$

$\%C = \frac{48.0g}{72.0g} \times 100\% = 66.7\% C$

$\%H = \frac{8.0g}{72.0g} \times 100\% = 11\ \% H$

$\%O = \frac{16.0g}{72.0g} \times 100\% = 22.2\% O$

3. Calculate the percentage composition of the bold species in each of the following compounds.

a) $Cu(\mathbf{NO_3})_2$

Total mass $= 187.5 g/mol$

NO_3 mass $= 2(14+(3\times16.0)) = 124.0 g/mol$

$\frac{124.0 g/mol}{187.5 g/mol} \times 100\% = 66.1\% NO_3$

b) $NaSCN \cdot \mathbf{5H_2O}$ Total mass $= 171.1 g/mol$

H_2O mass $= 90.0 g/mol$

$\%H_2O = \frac{90.0 g/mol}{171.1 g/mol} \times 100\% = 52.6\% H_2O$

4. a) A compound has the following composition: 24.24% C, 4.04% H and 71.72% Cl. What is the empirical formula of the compound?

mol C $= 24.24g \times \frac{1 mol}{12.0g} = 2.02 mol / 2.02 = 1$ E.F. $= CH_2Cl$

mol H: $4.04g \times \frac{1 mol}{1.0g} = 4.04 mol / 2.02 = 2$

mol Cl: $71.72g \times \frac{1 mol}{35.5g} = 2.02 mol / 2.02 = 1$

b) If the molecular mass of this compound is 99.5 g/mol, what is the molecular formula?

$n = \frac{\text{molecular molar mass}}{\text{empirical molar mass}} = \frac{99.5 g/mol}{49.5 g/mol} = 2$ Molecular formula $= C_2H_4Cl_2$

E.F. $= (1\times12.0)+(2\times1.0)+(1\times35.5) = 49.5 g/mol$

5. The molar mass of a compound is 58g/mol. What is the molecular formula of the compound if the empirical formula is C_2H_5?

$n = \frac{\text{molecular mass}}{\text{empirical mass}} = \frac{58 g/mol}{29.0 g/mol} = 2$ Molecular formula $= C_4H_{10}$

E.F. $= (2\times12.0)+(5\times1.0) = 29.0 g/mol$

Molarity Calculations:

→ 40.0g/mol

1. If a 4.50g sample of solid NaOH is dissolved to make 0.500L of solution, what is the molarity of the solution?

$$\frac{4.50\cancel{g}}{0.500L} \times \frac{1mol}{40.0\cancel{g}} = 0.225M$$

2. How many grams of Na_2CO_3 would be required to produce 400.0mL of 0.600M Na_2CO_3?

→ 106.0g

$$400.0\cancel{mL} \times \frac{1\cancel{L}}{10^3\cancel{mL}} \times \frac{0.600\cancel{mol}}{1\cancel{L}} \times \frac{106.0g}{1\cancel{mol}} = 25.4g\ Na_2CO_3$$

3. If 75.7g of Magnesium chloride are mixed with sufficient water to make a 0.885M solution, what is the volume of the solution? $MgCl_2 = 95.3g/mol$

$$75.7\cancel{g} \times \frac{1\cancel{mol}}{95.3\cancel{g}} \times \frac{1L}{0.885\cancel{mol}} = 0.898L$$

4. How many mL of 16.4 M H_2SO_4 are needed to prepare 755mL of 0.25M H_2SO_4?

$M_1 = 16.4M$

$V_1 = ?$

$M_2 = 0.25M$

$V_2 = 755mL$

$M_1V_1 = M_2V_2$

$V_1 = \frac{M_2V_2}{M_1}$

$V_1 = \frac{0.25M \times 755mL}{16.4M}$

$V_1 = 12mL$

Chemical Reactions and Equations:

1. Balance and classify the following chemical reactions.

	Type of Reaction
a) 2 $KNO_3 \rightarrow$ 2 $KNO_2 +$ 1 O_2	Decomposition
b) 1 $CaC_2 +$ 2 $O_2 \rightarrow$ 1 $Ca +$ 2 CO_2	Single Replacement
c) 1 $C_5H_{12} +$ 8 $O_2 \rightarrow$ 5 $CO_2 +$ 6 H_2O	Combustion
d) 1 $K_2SO_4 +$ 1 $BaCl_2 \rightarrow$ 2 $KCl +$ 1 $BaSO_4$	Double Replacement
e) 2 $KOH +$ 1 $H_2SO_4 \rightarrow$ 1 $K_2SO_4 +$ 2 H_2O	Neutralization
f) 1 $Ca(OH)_2 +$ 2 $NH_4Cl \rightarrow$ 2 $NH_4OH +$ 1 $CaCl_2$	Double Replacement
g) 4 $C_4H_9S +$ 29 $O_2 \rightarrow$ 16 $CO_2 +$ 4 $SO_2 +$ 18 H_2O	Combustion
h) 2 $C_{15}H_{30} +$ 45 $O_2 \rightarrow$ 30 $CO_2 +$ 30 H_2O	Combustion
i) 2 $BN +$ 3 $F_2 \rightarrow$ 2 $BF_3 +$ 1 N_2	Single Replacement
j) 2 $Na +$ 1 $ZnI_2 \rightarrow$ 2 $NaI +$ 1 Zn	Single Replacement

2. Classify, complete AND balance the following chemical equations. Type of Reaction

a) 1 $Ni_{(s)}$ + 1 $Cu(NO_3)_{2(aq)}$ → 1 Cu + 1 $Ni(NO_3)_2$ Single Replacement

b) 4 $Fe_{(s)}$ + 3 $O_{2(g)}$ → 2 Fe_2O_3 Synthesis

c) 2 $NaCl_{(s)}$ → 2 Na + 1 Cl_2 Decomposition

d) 1 $H_2SO_{4(aq)}$ + 2 $NaOH_{(aq)}$ → 2 H_2O + 1 Na_2SO_4 Neutralization

e) 2 $C_4H_{10(l)}$ + 13 $O_{2(g)}$ → 8 CO_2 + 10 H_2O Combustion

f) 2 $Ag_{(s)}$ + 1 $Cl_{2(g)}$ → 2 AgCl Synthesis

g) 1 $Cl_{2(g)}$ + 2 $KI_{(s)}$ → 2 KCl + 1 I_2 Single Replacement

h) 1 $Fe_{(s)}$ + 3 $AgCl_{(aq)}$ → 3 Ag + 1 $FeCl_3$ Single Replacement

i) 2 $AgNO_{3(aq)}$ + 1 $BaCl_{2(aq)}$ → 2 AgCl + 1 $Ba(NO_3)_2$ Double Replacement

j) 1 $BaCO_{3(aq)}$ + 1 $Sr(OH)_{2(aq)}$ → 1 $SrCO_3$ + 1 $Ba(OH)_2$ Double Replacement

k) 1 $C_2H_5OH_{(l)}$ + 3 $O_{2(g)}$ → 2 CO_2 + 3 H_2O Combustion

l) 1 $HNO_{3(aq)}$ + 1 $KOH_{(aq)}$ → 1 H_2O + 1 KNO_3 Neutralization

Energy of Reactions:

1. Define ENDOTHERMIC and EXOTHERMIC reactions.

Endothermic: heat is absorbed from the surroundings during the reaction

Exothermic: heat is released by the reaction into the surroundings

2. Classify the following reactions as either endothermic or exothermic.

a) $2C + O_2 \rightarrow 2CO_2$ + energy exothermic

b) N_2O_4 + energy $\rightarrow N_2 + 2O_2$ endothermic

c) AB + C → CB + A + 56.9kJ exothermic

d) AB + CD → AD + BC $\Delta H = -256.4kJ$ exothermic

Stoichiometry:

1. Ammonia combines with oxygen gas in the following reaction:

$$4\,NH_3 + 5O_2 \rightarrow 6H_2O + 4NO$$

a) How many moles of NH_3 are needed to combine with 3.57 moles of O_2 gas?

$$3.57\,\cancel{mol\ O_2} \times \frac{4\,mol\ NH_3}{5\,\cancel{mol\ O_2}} = 2.86\,mol\ \ NH_3$$

b) If 1.5 grams of NO is produced in the above reaction, how many grams of NH_3 were reacted?

$$1.5\,g\ NO \times \frac{1\,mol\ NO}{30.0\,g\ NO} \times \frac{4\,mol\ NH_3}{4\,mol\ NO} \times \frac{17.0\,g\ NH_3}{1\,mol\ NH_3} = 0.85\,g\ NH_3$$

2. $$3Na_2CO_3 + 2FeCl_3 \rightarrow 6NaCl + Fe_2(CO)_3$$

a) How many grams of NaCl will be produced from the reaction of 0.080moles of Na_2CO_3 with excess $FeCl_3$?

↳58.5g/mol

$$0.080\,mol\ Na_2CO_3 \times \frac{6\,mol\ NaCl}{3\,mol\ Na_2CO_3} \times \frac{58.5\,g\ NaCl}{1\,mol\ NaCl} = 9.4\,g\ NaCl$$

→162.3g/mol →106.0g/mol

b) How many grams of $FeCl_3$ would be needed to react with 4.2g of Na_2CO_3?

$$4.2\,g\ Na_2CO_3 \times \frac{1\,\cancel{mol\ Na_2CO_3}}{106.0\,g\ Na_2CO_3} \times \frac{2\,\cancel{mol\ FeCl_3}}{3\,\cancel{mol\ Na_2CO_3}} \times \frac{162.3\,g\ FeCl_3}{1\,\cancel{mol\ FeCl_3}} = 4.3\,g\ FeCl_3$$

3. $$3Mg + 2AlCl_3 \rightarrow 3MgCl_2 + 2Al$$

a) How many grams of $MgCl_2$ would be formed if 50.0mL of 0.200M $AlCl_3$ is reacted with excess Mg?

↳95.3g/mol

$$50.0\,\cancel{mL} \times \frac{1\,L}{10^3\,\cancel{mL}} \times \frac{0.200\,\cancel{mol\ AlCl_3}}{1\,L} \times \frac{3\,\cancel{mol\ MgCl_2}}{2\,\cancel{mol\ AlCl_3}} \times \frac{95.3\,g\ MgCl_2}{1\,\cancel{mol\ MgCl_2}}$$

$$= 1.43\,g\ MgCl_2$$

b) How many mL of 0.150M $AlCl_3$ would be needed to react completely with 2.00g of Mg?

$$2.00\,g\ Mg \times \frac{1\,\cancel{mol\ Mg}}{24.3\,g\ Mg} \times \frac{2\,\cancel{mol\ AlCl_3}}{3\,\cancel{mol\ Mg}} \times \frac{1\,L\ AlCl_3}{0.150\,\cancel{mol\ AlCl_3}} \times \frac{10^3\,mL\ AlCl_3}{1\,L\ AlCl_3}$$

$$= 366\,mL\ AlCl_3$$

Excess and Limiting Reagents/Percent Yield:

1. $2Fe_2S_3 + 9O_2 \rightarrow 2Fe_2O_3 + 6\ SO_2$

In a chemical reaction 6.92g of Fe_2S_3 is combined with 4.54g of oxygen gas.

a) Which reactant is the **LIMITING** reagent?

$$6.92g\ Fe_2S_3 \times \frac{1mol\ Fe_2S_3}{207.9g} \times \frac{2mol\ Fe_2O_3}{2mol\ Fe_2S_3} = 0.0333mol\ Fe_2O_3$$

$$4.54g\ O_2 \times \frac{1mol\ O_2}{32.0g\ O_2} \times \frac{2mol\ Fe_2O_3}{9mol\ O_2} = 0.0315mol\ Fe_2O_3$$

$\therefore O_2$ is limiting

b) How many grams of the **EXCESS** reactant will be **left over** after the reaction is complete?

$$4.54g\ O_2 \times \frac{1mol\ O_2}{32.0g\ O_2} \times \frac{2mol\ Fe_2S_3}{9mol\ O_2} \times \frac{207.9g\ Fe_2S_3}{1mol\ Fe_2S_3} = 6.55g\ Fe_2S_3 \text{ used up}$$

$\therefore 6.92g - 6.55g = 0.37g\ Fe_2S_3$ left over

c) How many grams of Fe_2O_3 can be formed in this reaction?

$$0.0315mol\ Fe_2O_3 \times \frac{159.6g\ Fe_2O_3}{1mol\ Fe_2O_3} = 5.03g\ Fe_2O_3$$

2. What mass of P_4 will be produced when 41.5g of $Ca_3(PO_4)_2$, 26.3g of SiO_2, and 7.80g of C are reacted according to the following balanced equation?

$$2\ Ca_3(PO_4)_2 + 6\ SiO_2 + 10C \rightarrow P_4 + 6CaSiO_3 + 10CO$$

$$41.5g\ Ca_3(PO_4)_2 \times \frac{1mol\ Ca_3(PO_4)_2}{310.3g\ Ca_3(PO_4)_2} \times \frac{1mol\ P_4}{2mol\ Ca_3(PO_4)_2} = 0.0669mol$$

$$26.3g\ SiO_2 \times \frac{1mol\ SiO_2}{60.1g\ SiO_2} \times \frac{1mol\ P_4}{6mol\ SiO_2} = 0.0729mol$$

$$7.80g\ C \times \frac{1mol\ C}{12.0g\ C} \times \frac{1mol\ P_4}{10mol\ C} = 0.0650mol \times \frac{124.0g\ P_4}{1mol\ P_4} = \boxed{8.06g\ P_4}$$

limiting

3. $4Al + 3O_2 \rightarrow 2Al_2O_3$

a) How many grams of aluminum oxide, Al_2O_3, would be expected to form in the reaction of 15.0g Al with 18.43g of oxygen gas?

$$15.0g\ Al \times \frac{1mol\ Al}{27.0g\ Al} \times \frac{2mol\ Al_2O_3}{4mol\ Al} \times \frac{102.0g\ Al_2O_3}{1mol\ Al_2O_3} = 28.3g\ Al_2O_3$$

limiting, so this much is made!

$$18.43g\ O_2 \times \frac{1mol\ O_2}{32.0g\ O_2} \times \frac{2mol\ Al_2O_3}{3mol\ O_2} \times \frac{102.0g\ Al_2O_3}{1mol\ Al_2O_3} = 39.2g\ Al_2O_3$$

b) If the actual yield of Al_2O_3 produced in the reaction was only 22.4g Al_2O_3, what would the PERCENT YIELD of the reaction be?

$$\%\ yield = \frac{actual}{theoretical} \times 100\% = \frac{22.4g}{28.3g} \times 100\% = 79.2\%\ yield$$