Scientific Notation / Conversion Factors

Scientific notation: A quicker way of expressing large and small numbers that uses a *significand* times ten to an *exponent*.

[ ] → $6.7 \text{ X } 10^4$ ← [ ]

Converting between scientific notation and standard form:

Examples:

$3{,}720000 = 3.72 \times 10^6$	$0.0196 = 1.96 \times 10^{-2}$
$8.9 \times 10^5 = 890000$	$6.2 \times 10^{-7} = .00000062$

Fill in the blanks below based on the examples above.

- If the number is 10 or greater, the decimal point has to move to the _____, and the power of 10 will be __________ and equal to how many times the decimal __________.
- If the number is smaller than 1, the decimal point has to move to the ________, so the power of 10 will be ___________ and equal to how many times the decimal ___________.

Using scientific notation in multiplication and division:

Examples:

$(3.5 \text{ x } 10^4) \text{ x } (2.0 \text{ x } 10^3) = 7.0 \text{ x } 10^7$	$\frac{8.0 \, x \, 10^8}{2 \, x \, 10^3} = 4.0 \, x \, 10^5$
$(3.0 \text{ x } 10^4) \text{ x } (6.0 \text{ x } 10^{-8}) = 18 \text{ x } 10^{-4} = 1.8 \text{ x } 10^{-3}$	$\frac{7.0 \, x \, 10^4}{2.0 \, x \, 10^{-8}} = 3.5 \, x \, 10^{12}$

Fill in the blanks below based on the examples above.

- When multiplying, __________ the significands and __________ the exponents.
- When dividing, __________ the significands and __________ the exponents.

Scientific notation practice

1) Convert a and b to scientific notation and convert c to standard form.
   a. 550,000,000
   b. 0.00000076
   c. $2.5 \text{ x } 10^8$

2) Compute the following expressions:
   a. $(2.5 \text{ x } 10^3) \text{ x } (5 \text{ x } 10^2) =$
   b. $(1.6 \text{ x } 10^5) \div (2 \text{ x } 10^2) =$
   c. $(2.5 \text{ x } 10^3) \text{ x } (5 \text{ x } 10^{-1}) =$
   d. $(4.0 \text{ x } 10^{-3}) \div (2.0 \text{ x } 10^{-6}) =$

Conversion factors

Examples:

$\frac{360\ seconds}{} x \frac{1\ minute}{60\ seconds} = 6\ minutes$	$\frac{7.3kg}{} x \frac{1000g}{1\ kg} = 7.3\ x\ 10^3 g$
$\frac{4\ years}{} x \frac{365\ days}{1\ year} = 1460\ days$	$\frac{2.5\ miles}{} x \frac{5280\ feet}{1\ mile} = 1.32\ x\ 10^4\ feet$

What observations do you have based on the examples above?

Fill in the blanks below based on the examples above.

Conversion factors are used to convert between two different ____________. The numerator is the unit you are converting ______ and the denominator is the unit you're converting _______. The numerator and denominator must be __________ to each other.

Conversion factor practice

1 kilogram	=	1000 grams
5280 feet	=	1 mile
33 students	=	1 class

1) Convert 7.5kg to grams.

2) How many feet are in 3 miles?

3) How many people in a school with 25 classes?

4) In 1898, the USS Maine exploded off the coast of Cuba. Experts are still uncertain how the explosion occurred. For some carbon based explosives, the energy let off is quite significant. For every 1 gram of carbon burned, 30kJ of energy are released. If the USS Maine will sink if 1000kJ of energy are released, will 13g of carbon be enough to sink the boat? Justify your answer with a complete sentence.

________g Carbon = _________kJ

Converting between molecules and atoms

Examples:

How many atoms of hydrogen are there in 15 water molecules (H_2O)? $\frac{15\ H_2O\ molecules}{}\ x\ \frac{2\ H\ atoms}{1\ H_2O\ molecule} = 30\ H\ Atoms$	How many molecules of CH_4 can form from 20 hydrogen atoms? $\frac{20\ H\ atoms}{}\ x\ \frac{1\ CH_4\ molecule}{4\ H\ atoms} = 5\ CH_4\ molecule$

What observations do you have based on the examples above?

Modeling:

1) How many carbon atoms are there in 7 molecules of glucose ($C_6H_{12}O_6$)?

2) If an experiment detects 9 molecules of CO_2, how many atoms of carbon are there?

Practice:

3) How many hydrogen atoms are in 3 molecules of ethanol (CH_5OH)?

4) How many units of Na_2O can form from 16 sodium atoms?

Chemical reactions

Reading:

Chemical reactions occur all around us and are vital for most of life's daily functions. The way food is digested, the way cars work, and the way batteries power our electronics are all examples of chemical reactions. In a chemical reaction, atoms rearrange but are never created or destroyed. This is because of a principle called *conservation of mass*, which means that mass is not created or destroyed in a chemical reaction. Whatever mass there is in the beginning, the reactants, is equal to the mass in the end, the products.

Example reaction: Two gaseous hydrogen molecules react with one gaseous oxygen molecule to form two molecules of liquid water.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

What observations do you have based on the example above?

Practice:

1) Write the equations that are represented by the following sentences.
   a. One solid carbon atom reacts with two gaseous fluorine molecules to form one gaseous molecule of carbon tetrafluoride.

   b. A molecule of carbon tetrahydride (methane) burns with two oxygen molecules to produce two water molecules and one molecule of carbon dioxide. All compounds are in the gas phase.

   c. One molecule of glucose ($C_6H_{12}O_6$ – solid) reacts with six molecules of gaseous oxygen to create six molecules of liquid water and six molecules of gaseous carbon dioxide.

2) Write sentences describing the following reactions:
   a. $NaCl(aq) \rightarrow Na^+(aq) + Cl^-(aq)$

Aqueous sodium chloride dissociates in water to form ____

   b. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

_____ atoms of _______________ burn with _______________________________________ to produce

____

   c. $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

__________________________________ are broken apart into ____

____

Read the scenario and answer the remaining questions in complete sentences, using academic language.

Gold is mined and refined through a very complex and expensive process. Gold occurs in the earth most commonly bound to other elements. In order to obtain pure gold, scientists must remove gold from the minerals it occurs in. Sodium cyanide (NaCN) is added to crushed up gold ore to form the complex aurocyanide ($Au(CN)_2^-$) ion, which can be dissolved in water. The water is then removed, which takes the gold away from the majority of the other elements in the ore.

$$4Au(s) + 8NaCN(aq) + O_2(aq) + 2H_2O(l) \rightarrow 4Na[Au(CN)_2](aq) + 4NaOH(aq)$$

A) Write the reaction in a sentence.

________________ atoms, __________ sodium cyanide units, __________ dissolved oxygen molecule(s), and __________________ react to form ______ units of aqueous sodium aurocyanide and ________ units of __________ sodium hydroxide.

B) If there are 100 molecules of oxygen before the reaction, will there be more, less, or the same amount of oxygen molecules at the end of the reaction? Explain.

C) If the reaction proceeds and makes 150 units of sodium aurocyanide ($Na[Au(CN)_2]$), how many atoms of gold are in the sodium aurocyanide produced?

D) How many molecules of cyanide (CN) are contained in the 150 units of sodium aurocyanide?

Balancing Chemical Reactions

Examples:

$\underline{2}\,HCl_{(aq)} + \underline{1}\,Mg(OH)_{2(aq)} \rightarrow \underline{2}\,H_2O_{(l)} + \underline{1}\,MgCl_{2(aq)}$
$\underline{1}\,SiO_2(s) + \underline{4}\,HF(aq) \rightarrow \underline{1}\,SiF_4(g) + \underline{2}\,H_2O(l)$

What observations do you have based on the examples above?

Modeling:

1) $\_\_\_K(s) + \_\_\_B_2O_3(s) \rightarrow \_\_\_K_2O(s) + \_\_\_B(s)$

2) $\_\_\_Fe_{(s)} + \_\_\_Cl_{2(g)} \rightarrow \_\_\_FeCl_{4(aq)}$

Practice:

3) $\_\_SnO_2(s) + \_\_H_2(g) \rightarrow \_\_Sn(s) + \_\_H_2O(l)$

4) $\_\_K(s) + \_\_\ MgBr_2(s) \rightarrow \_\_\ KBr(s) + \_\_\ Mg(s)$

5) $\_\_\_\_\ H_2O(l) + \_\_\_\_\ O_2(g) \rightarrow \_\_\_\_\ H_2O_2(l)$

6) $\_\_\_Na(s) + \_\_\_O_2(g) \rightarrow \_\_\_Na_2O(s)$

7) $\_\_Rb(s) + \_\_NO_3(g) \rightarrow \_\_Rb_2O(s) + \_\_N_2(g)$

8) $\_\_\_\ S_8(s) + \_\_\_\_O_2(g) \rightarrow \_\_\_\_\ SO_3(g)$

Read the scenario and answer the remaining questions in complete sentences, using academic language.

Propane (C_3H_8) is a gaseous hydrocarbon commonly used for cooking on grills. The propane is burnt in the presence of oxygen to form carbon dioxide and gaseous water. The reaction releases heat, which can cook meat.

A) Write the reaction for the combustion of propane and then balance the equation.

$\rightarrow$

B) Why is it important to balance chemical equations?

C) If 52 molecules of propane are burnt, how many carbon atoms participate in the reaction?

D) Given your answer for C, how many molecules of carbon dioxide do you think form? Defend your answer with a calculation or an explanation.

E) If there isn't enough oxygen present, carbon monoxide can form instead of carbon dioxide. Carbon monoxide is very poisonous, which is why you should only grill in well ventilated areas. Balance the reaction below for the incomplete combustion of propane.

$$\_\_C_3H_8(g) + \_\_O_2(g) \rightarrow \_\_CO(g) + \_\_H_2O(g)$$

Molecular ratios

Examples:

How many molecules of water will be produced when 3 molecules of propane are burnt? $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\frac{3\ molecules\ C_3H_8}{} x \frac{4\ molecules\ H_2O}{1\ molcules\ C_3H_8} = 12\ molecules\ H_2$ 12 molecules of H_2O are produced when 3 molecules of propane are burnt.
How many molecules of propane are needed to react with 50 molecules of oxygen? $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ $\frac{50\ molecules\ O_2}{} x \frac{1\ molecules\ C_3H_8}{5\ molecules\ O_2} = 10\ molcules\ C_3H_8$

What observations do you have based on the examples above?

Modeling:

$1\ S_8(s) + 12\ O_2(g) \rightarrow 8\ SO_3(g)$

1) How many molecules of oxygen are needed to produce 4.0×10^5 molecules of sulfur trioxide gas?

Practice:

2) How many molecules of sulfur (S_8) are needed to make 48 molecules of sulfur trioxide?

3) If Bernard burns 5×10^{22} molecules of sulfur, how many molecules of oxygen will he need?

4) Sulfur trioxide is poisonous. If we breathe more than, let's say, 6.0×10^{24} molecules of sulfur trioxide, we'll die. If 1.5×10^{23} molecules of sulfur are burnt in oxygen, will enough sulfur trioxide be produced to kill us?

The mole

Reading:

A scientist named Amedeo Avogadro developed this new unit. Instead of just counting 2, 3, 12, or 144 atoms at once, Avogadro decided to count 6.02×10^{23} atoms at once. He called this new group ***a mole***.

$$1 \text{ mole} = 602{,}000{,}000{,}000{,}000{,}000{,}000{,}000 = 6.02 \times 10^{23}$$

Avogadro based this number on careful measurements of carbon-12. One mole is the number of carbon atoms in 12g of carbon-12. Scientists still use this unit to count any type of particle. For example:

1 mole H_2O = 6.02×10^{23} molecules H_2O

1 mole NaCl = 6.02×10^{23} ionic particles NaCl

1 mole Ca = 6.02×10^{23} atoms Ca

1 mole CO_2 = 6.02×10^{23} molecules CO_2

Example:

If 5 moles of chlorine gas react with aluminum, how many moles of aluminum chloride will be produced?

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$$

$$\frac{5\ moles\ Cl_2}{} x \frac{2\ mols\ AlCl_3}{3\ mol\ Cl_2} = 3.33\ mols\ AlCl_3$$

How many molecules of chlorine gas are needed to produce 4 moles of aluminum chloride?

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$$

$$\frac{4\ moles\ AlCl_3}{} x \frac{3\ moles\ Cl_2}{2\ moles\ AlCl_3} = 6\ moles\ Cl_2$$

$$\frac{6\ moles\ Cl_2}{} x \frac{6.02\ x\ 10^{23}\ molecules\ Cl_2}{1\ mole\ Cl_2} = 36.12\ x\ 10^{23}\ or\ 3.612\ x\ 10^{24}\ molecules\ Cl_2$$

What observations do you have based on the examples above?

Modeling:

1) How many molecules of argon are in a 7 mole sample of argon?

2) How many moles of iron (III) phosphate ($FePO_4$) will be produced if 1.5×10^{23} units of sodium phosphate react completely?

$$Fe(NO_3)_3(aq) + Na_3PO_4(aq) \rightarrow 3NaNO_3(aq) + FePO_4(s)$$

Practice:

3) 1.5 x 10^{23} ducks is how many moles of ducks?

4) How many atoms are in 3.0 moles of iron in a nail?

Use the reaction below for questions 5-9.

$$\_\_\_Fe_2O_3(s) + \_\_\_Al(s) \rightarrow \_\_\_Fe(l) + \_\_\_Al_2O_3(s)$$

5) Balance the equation.

6) If 3 moles of aluminum react, how many atoms of aluminum are reacting?

7) How many moles of iron are produced when 7 moles of iron(III) oxide react with aluminum?

8) How many units of aluminum oxide are produced if 4 moles of aluminum react?

9) If 1 mole of iron(III) oxide reacts, how many atoms of aluminum are needed?

Read the scenario and answer the remaining questions in complete sentences, using academic language.

You want to impress your parents by cooking dinner with salt that you made yourself! Salt is made of sodium (Na) and chlorine (Cl_2) reacting to yield sodium chloride (NaCl). Although stable when combined, sodium is explosive in water and chlorine is a toxic gas so you need to be careful when handling these chemicals. You need 3.01×10^{23} formula units of sodium chloride to successfully cook your dinner.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

A) As the reaction proceeds, what happens to the amount of sodium, chlorine, and sodium chloride that you have?

B) How many formula units of sodium chloride will form when 0.5 moles of sodium react completely?

C) How many formula units of sodium chloride will form when 0.5 moles of chlorine react completely?

D) If 0.5 moles of sodium and 0.5 moles of chlorine react, how many formula units of sodium chloride will form? (Hint: think about which reactant will run out first)

E) Will you have enough sodium chloride to successfully cook your dinner?

Read the scenario and answer the remaining questions in complete sentences, using academic language.

An unknown compound containing only hydrogen and carbon is burnt completely to produce water and carbon dioxide. The water and carbon dioxide are captured in the amounts shown in the table below.

___???????(g) + ___O_2(g) → ___H_2O(g) + ___CO_2(g)	
Water collected	Carbon dioxide collected
6.02×10^{23} molecules	1.204×10^{24} molecules

A) How many moles of water and carbon dioxide were collected?

B) How many moles of hydrogen were in the unknown sample?

C) How many moles of carbon were in the unknown sample?

D) What is the ratio of carbon to hydrogen in the unknown compound? Is this ratio the same as the subscripts of the molecular formula?

Molar Mass

Examples:

How many grams of hydrogen peroxide (H_2O_2) are contained in 3 moles of hydrogen peroxide? $2\ H_2O(l) + 1\ O_2(g) \rightarrow 2\ H_2O_2(l)$ Molar Mass H_2O_2 = 2 x 1.0g/mol + 2 x 16.0g/mol = 34.0g/mol $\frac{3\ mol\ H_2O_2}{} x \frac{34.0\ g\ H_2O_2}{1\ mol\ H_2O_2} = 102.0g\ H_2O_2$
How many grams of oxygen are needed to produce 4 moles of hydrogen peroxide? $2\ H_2O(l) + 1\ O_2(g) \rightarrow 2\ H_2O_2(l)$ Molar mass O_2 = 2 x 16.0 g/mol = 32g/mol $\frac{4\ moles\ H_2O_2}{} x \frac{1\ mol\ O_2}{2\ mol\ H_2O_2} = 2\ mol\ O_2$ $\frac{2\ mol\ O_2}{} x \frac{32.0\ g\ O_2}{1\ mol\ O_2} = 64.0\ g\ O_2$

What observations do you have based on the examples above?

Modeling:

$$2Fe_{(s)} + 3Cl_{2(g)} \rightarrow 2FeCl_{3(aq)}$$

1) How many moles of iron (III) chloride will be produced if 112g of iron fully react with chlorine gas?

2) If 81g of iron (III) chloride are produced during a reaction, how many grams of chlorine gas must have been used?

Practice:

Use the reaction below for questions 1 and 2

$$3Mn(s) + 2O_2(g) \rightarrow Mn_3O_4(s)$$

1) How many grams of Mn_3O_4 will form if 8 moles of O_2 react fully?

2) How many grams of Mn are required to produce 57g of Mn_3O_4?

Use the reaction below for questions 3-5

$$Os(s) + 3F_2(g) \rightarrow OsF_6(s)$$

3) How many moles of fluorine gas are found in a sample that weighs 19.0g?

4) When 190g of osmium reacts completely, how many grams of OsF_6 will form?

5) A certain scientist needs to produce 200g of OsF_6. If they react 171g of fluorine, will they produce enough OsF_6?

Title:	Balancing Chemical Equations
Standard:	*5.a Students know how to balance chemical reactions and explain them conceptually using the concept of conservation of mass.*

1) What is the law of conversation of mass and how does it connect to chemical reactions?

2) Which option obeys the law of conservation of mass?
   a) $2Li + O_2 \rightarrow 1Li_2O$
   b) $4Li + O_2 \rightarrow 2Li_2O$
   c) $5Li + O_2 \rightarrow Li_2O$
   d) $Li + O_2 \rightarrow Li_2O$

3) Which option shows that no mass is created or destroyed in a chemical reaction?
   a) $Mn + O_2 \rightarrow MnO_7$
   b) $7Mn + 2O_2 \rightarrow 2MnO_7$
   c) $1Mn + 7O_2 \rightarrow 2MnO_7$
   d) $2Mn + 7O_2 \rightarrow 2MnO_7$

4) Balance the equations below.

$$\_\_\_Pb(s) + \_\_\_NaNO_3(aq) \rightarrow \_\_\_Pb(NO_3)_2(aq) + \_\_\_Na(s)$$

$$\_\_\_C_2H_6(g) + \_\_\_O_2(g) \rightarrow \_\_\_CO_2(g) + \_\_\_H_2O(l)$$

$$\_\_\_Te_8(s) + \_\_\_F_2(g) \rightarrow \_\_\_TeF_6(l)$$

Title:	Relating reactants and products
Standard:	*5.b Students can relate reactants to products using a chemical reaction and can convert from molecules A to molecules B or moles A to moles B.*

Use the reaction below for questions 1-3

$$2Mn(s) + 7O_2(g) \rightarrow 2MnO_7(s)$$

1) What will occur to the amount of reactants and products as the reaction proceeds?

2) How many moles of oxygen gas are needed to react completely with 4 moles of manganese?

3) If you react one mole of manganese with one mole of oxygen, will they both be used up completely? Explain.

Use the reaction below for questions 4-6

$$4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$$

4) How many molecules of oxygen are required to completely react with 16 x 10^8 atoms of lithium?

5) Imagine there are originally 100 molecules of oxygen. If 40 atoms of lithium react, how many molecules of oxygen are left?

6) If 5 moles of lithium oxide reacted backwards to produce reactants, how many total moles of reactants would be produced?

Title:	The mole
Standard:	*5.c Students know the definition of a mole and Avogadro's number and can use it to convert from molecules to moles.*

1) Are 1 dozen and 1 mole equal to each other or is one bigger than the other? Explain.

2) How was the mole defined?

3) Rank the following amounts from the least numerous to the most numerous.
   a. 3 moles
   b. 3 dozen
   c. 150,000,000,000
   d. 1
   e. 1×10^{30}
   f. ½ a mole
   g. 6.02×10^{23}

4) How many molecules are contained in a sample of gas that has 3.5 moles of krypton gas?

5) Magnesium burns extremely brightly in air and is often used in fireworks. If there are 1.2×10^{23} atoms of magnesium in a firework, and for proper functioning the device needs at least 2 moles of magnesium, will the firework work? Justify your answer with a complete sentence and show all work.

5) Given the reaction below, how many molecules of oxygen would be required to produce 4 moles of MnO_7?

$$2Mn(s) + 7O_2(g) \rightarrow 2MnO_7(s)$$

Title:	Molar mass
Standard:	*5.d Students know how to calculate the number of grams in one mole of any compound based on the formula.*

1) Calculate the molar masses for the follow chemicals. Include units.
   a. Caffeine: $C_8H_{10}N_4O_2$
   b. Water: H_2O
   c. Table sugar (sucrose): $C_{12}H_{22}O_{11}$
   d. Iron (III) oxide (rust): Fe_2O_3
   e. Oxygen: O_2
   f. Carbon Dioxide: CO_2

2) How many atoms are in 31g of phosphorous?

3) Rank the following from high to low gram molecular mass (molar mass).
   a. Hf
   b. HF
   c. $Sr(OH)_2$
   d. AgOH
   e. PH_3

4) How many grams of chromium are present in a can that contains 2.5 moles of chromium?

5) Mrs. Larkin is thirsty and asks Mr. Larkin to go get her 5 moles of H_2O. Mr. Larkin uses his scale to measure out 100g of H_2O. Has he given her too much, too little, or just the right amount of water? Justify your answer with a complete sentence and show all work.

Title:	Converting from grams of one chemical to grams of another chemical
Standard:	*5.e Students know how to covert from grams A to grams B, or any other two step conversion in a reaction.*

Use the following reaction for problems 1-4

$$ZnS(s) + 2O_2(g) \rightarrow 2ZnO(s) + SO_2(g)$$

1) How many moles of sulfur dioxide are produced when 194g of zinc sulfide react completely with oxygen?

2) If 32g of O_2 react fully, how many grams of zinc sulfide must have also been used up?

3) How many molecules of sulfur dioxide can be produced from 16g of oxygen gas?

4) If more than 40g of sulfur dioxide are produced in an unvented area, a monkey in the room will die of acid burns to the lungs. When Dante reacts 48.5g of zinc sulfide completely, does the monkey die?

Read the scenario and answer the remaining questions in complete sentences, using academic language.

The production of nitric acid (HNO_3) often begins with the unbalanced reaction shown below. Often times in industrial processes, the chemical reaction does not proceed perfectly. There are usually other side reactions which use up the reactants instead. Chemists often calculate a percent yield, which is a quick way of expressing how well a reaction is occurring according to plan. The equation for percent yield is shown below.

__$NH_3(g)$ + __$O_2(g)$ → __$NO(g)$ + __$H_2O(g)$

$$Percent\ Yield = \frac{Actual\ Yield}{Calculated\ Yield}\ x\ 100\%$$

A) Balance the reaction and explain why it is important to balance reaction equations.

B) If 3 moles of NH_3 are used in the process, how many molecules of NH_3 were used?

C) If 34g of NH_3 and 64g of O_2 are combined in a reaction chamber, is there enough NH_3 to react with all of the O_2?

D) What is the percent yield of the reaction if only 30g of NO is produced after 68g of NH_3 reacts fully?

Extra Practice

___$CH_4(g)$ + __$O_2(g)$ → __$CO_2(g)$ + __$H_2O(g)$

1) Balance the reaction above and explain why equations must be balanced.

2) If 3 moles of methane (CH_4) are burnt completely, how many moles of water are produced?

3) If 9g of water are collected after the reaction, how many grams of methane were burnt?

4) If 16g of methane is combined with 64g of oxygen, is there enough oxygen to react all of the methane?