Stoichiometry Review Package

For a visual practice on balancing equations and limiting/excess reagents go to:

https://phet.colorado.edu/en/simulation/balancing-chemical-equations

https://phet.colorado.edu/en/simulation/reactants-products-and-leftovers

The following questions are based on the material covered so far. I will post full answers on my website (https://blogs.ubc.ca/rchatrath/) halfway through spring break to give you time to do the questions on your own. Please attempt the questions by yourself. You will not learn by copying. Stoichiometry follows a pattern. Understanding the general steps taken to solve a problem will help you in solving different questions.

Make use of the material in your workbook. Attempt all the practice problems for the sections. The section review questions are a valuable resource.

The test covers section 4.1, 4.2, enthalpy notation in 4.4 (recognizing whether a reaction is exothermic or endothermic from the energy term associated with the reaction or from the classification of the reaction, as well as defining the two terms), 4.5, and 4.6.

Do not forget to do the stoichiometry relay questions from the previous class. Answers for those will also be posted on my website with full solutions.

Sample questions:
Multiple Choice

1. Which one of the following is a definition of a chemical reaction?

   a) Making new bonds between atoms as the old ones are broken

   b) Change in physical properties as in mixing two substances

   c) Change in the characteristics of the atomic nucleus

   d) Change in the state of a substance due to temperature changes

2. If a reaction occurs in a beaker and the beaker becomes hot,

   a) The reaction goes to completion

   b) The reaction is endothermic

   c) The reaction does not proceed

   d) The reaction is exothermic THERE WAS A MISTAKE HERE

3. Copper in its metal state is best represented by

   a) (aq)

   b) (s)

   c) (l)

   d) (g)

4. How many grams of solute are there in a 2.5 L solution of 0.5 molar NaCl?
   a) 73.1 g
   b) 146.1 g
   c) 29.2 g
   d) 91.3 g
5. How many litres of oxygen are required to produce 60.3g of MgO in the following reaction?
$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$
   a) 14.9L
   b) 22.4L
   c) 16.8L
   d) 33.6L
6. $N_2 + 3H_2 \rightarrow 2NH_3$ What is the mole ratio of N_2:H_2?
   a) 1:3
   b) 3:2
   c) 2:3
   d) 1:1
7. What compound(s) are likely to be produced in the following reaction: $Li + H_2O \rightarrow$
   a) $LiH + O_2$
   b) $LiOH + H_2$
   c) LiH_2O
   d) The reaction does not occur

Short answer

1. Exothermic vs Endothermic
   a) Define each term and state the difference
   b) Give an example of a reaction **TYPE** for each

Enthalpy (ΔH):
change in energy of reactants and products before and after a chemical/physical change

Exothermic	**Endothermic**
• "exo" – external or outside • $\Delta H = -$ • $E_{absorbed} < E_{released}$	• "endo" – internal or within • $\Delta H = +$ • $E_{absorbed} > E_{released}$

• An exothermic rxn is a rxn that is **accompanied by a release of energy in the form of heat and/or light** • Energy released is associated with the formation of bonds • $\boldsymbol{reactants \rightarrow products + energy}$ Example of reaction type: • **Synthesis** • **Combustion**	• An endothermic reaction is a reaction that **requires the input of energy** • Energy is required to break bonds of the starting material • $\boldsymbol{reactants + energy \rightarrow products}$ Example of reaction type: • **Decomposition**

***Bolded terms are important**

2. The formation of water releases 572 kJ/mol. Write the balanced chemical equation for the synthesis of water and include the energy term in a
   a) Thermochemical equation format (page 201 in your workbooks)

   $\boldsymbol{2H_2(g) + O_2(g) \rightarrow 2H_2O\ (l) + 572\ \mathrm{kJ/mol}}$

   b) ΔH notation (page 202)

   $\boldsymbol{2H_2(g) + O_2(g) \rightarrow 2H_2O\ (l) \qquad \Delta H = -527\ kJ/mol}$

3. Explain the difference between coefficients and subscripts in a chemical equation

Coefficients	**Subscripts**
• The numbers that are in front of a chemical species that multiplies the entire chemical species that follows • Used to balance chemical equations • The only thing that can be changed to balance a chemical equation Example: • $2\ Bd = 2 \times Bd$ (two bread slices) • $2N =$ two single nitrogen atoms • $2N \neq (does\ not\ equal)\ N_2$	• Denote whether the atom is diatomic, triatomic, etc. • Changing the subscript, changes the molecule • Should not be altered when balancing a chemical equation Example: • N_3 = azide, triatomic • N_2 = nitrogen gas, diatomic • Halogens, N, O, H written as diatomic

4. Limiting reagent/reactant vs Excess reagent/reactant
   a) Define each term and state the difference

Limiting reagent/reactant:	**Excess reagent/reactant:**
• The reactant that is totally consumed when a reaction is completed • The Limits the amount of product that can be formed	• The reactant that remains once the limiting reactant is completely consumed • Left over, or **in xs**

b) Given the following scenario, define which is the limiting reagent and which is the excess reagent: a 1L solution containing 0.5M lead (II) nitrate and 1.5M potassium iodide $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

$moles\ of\ Pb(NO_3)_2 = 1L \times 0.5M = 0.5\ moles\ of\ Pb(NO_3)_2$ given

$$0.5\ moles\ of\ Pb(NO_3)_2\ given \times \frac{2\ mole\ of\ KI}{1\ mole\ of\ Pb(NO_3)_2} = 1\ mole\ of\ KI\ required$$

$moles\ of\ KI = 1L \times 1.5M = 1.5\ moles\ of\ KI$ given

$$1.5\ moles\ of\ KI\ given \times \frac{1\ mole\ of\ Pb(NO_3)_2}{2\ moles\ of\ KI} = 0.75\ mole\ of\ Pb(NO_3)_2\ required$$

$$moles\ of\ Pb(NO_3)_2\ given\ (0.5) < mole\ of\ Pb(NO_3)_2\ required (0.75)$$

$$\therefore Pb(NO_3)_2\ is\ our\ limiting\ reagent/reactant$$

$$moles\ of\ KI\ given\ (1.5) > moles\ of\ KI\ required$$

$$\therefore KI\ is\ in\ xs$$

Calculations

1. Cu + 2AgNO$_3$ → Cu(NO)$_3$ + 2Ag

a) When 9.35g of copper reacts with 8.90g of AgNO$_3$ to make silver
   i. What is the limiting reactant?

$$9.35g\ of\ Cu \times \frac{1mole\ Cu}{63.5g\ Cu} = 0.147\ moles\ of\ Cu\ given$$

$$0.147\ moles\ of\ Cu\ given \times \frac{2\ moles\ AgNO_3}{1\ mole\ Cu} = 0.294\ moles\ of AgNO_3\ required$$

$$8.90\text{g AgNO3} \times \frac{1mole\ AgNO_3}{169.9g\ AgNO_3} = 0.0524\ mol\ of\ AgNO_3\ given$$

$$0.0524\ mol\ of\ AgNO_3\ given \times \frac{1mole\ Cu}{2\ mole\ AgNO_3} = 0.0262\ moles\ of\ Cu\ required$$

$$moles\ of\ Cu\ given (0.147) > moles\ of\ Cu\ required\ (0.262)$$

$$moles\ of\ AgNO_3\ given\ (0.0524) < moles\ of\ AgNO_3\ required\ (0.294)$$

$$\therefore AgNO_3\ is\ the\ limiting\ reagent/reactant$$

ii. How much silver is produced in grams?

Start with amount of limiting reactant/reagent given: 8.90g of $AgNO_3$

$$8.90\text{g } AgNO_3 \times \frac{1mole\ AgNO_3}{169.9g\ AgNO_3} \times \frac{2\ moles\ Ag}{2\ moles\ AgNO_3} \times \frac{107.87g}{1\ mole\ Ag} = 5.65g\ of\ Ag$$

b) If the students obtain a yield of 70%, how much silver did they collect?

$$Percentage\ yield = \frac{amount\ of\ product\ obtained}{amount\ of\ product\ expected} \times 100\%$$

$$\frac{Percentage\ yield}{100\%} \times amount\ of\ product\ expected = amount\ of\ product\ obtained$$

$$\frac{70\%}{100\%} \times 5.66g\ of\ Ag = 3.69g\ of\ Ag\ collected/obtained$$

2. The following question is based on the combustion of pentane (C_5H_{12})

a) Write the balanced equation

$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$

b) What is the mass of CO_2 produced when 100.0 of C_5H_{12} is burned?

$$100.0\text{g of } C_5H_{12} \times \frac{1mole\ \ C_5H_{12}}{72.17g\ \ C_5H_{12}} \times \frac{5\ mole\ CO_2}{1\ mole\ \ C_5H_{12}} \times \frac{44.01g}{1\ mole\ CO_2} = 304.9g\ of\ CO_2$$

c) What volume of O_2 is required to make 70.0g of CO_2 at STP?

$$70.0g\ of\ CO_2 \times \frac{1mole\ CO_2}{44.01g\ CO_2} \times \frac{8\ mole\ O_2}{5\ mole\ CO_2} \times \frac{22.4L}{1\ mole\ O_2} = 57.0L\ of\ O_2$$

d) At STP what volume of O_2 is required to make 48.0L of CO_2?

$$48.0L\ of\ CO_2 \times \frac{1mole\ CO_2}{22.4L\ CO_2} \times \frac{8\ mole\ O_2}{5\ mole\ CO_2} \times \frac{22.4L}{1\ mole\ O_2} = 76.8L\ of\ O_2$$

e) How many molecules of C_5H_{12} react with 15.0g of O_2?

$$15.0g\ of\ O_2 \times \frac{1mole\ O_2}{32.00g\ O_2} \times \frac{1\ mole\ C_5H_{12}}{8\ mole\ CO_2} \times \frac{6.022\times10^{23} molecules}{1\ mole\ C_5H_{12}}$$

$$= 3.53\times10^{21} molecules\ of\ C_5H_{12}$$

3. When 5.00g of $KClO_3$ is heated it decomposes according to the equation:

$$2KClO_3 \rightarrow 2KCl + 3O_2$$

a) Calculate the theoretical yield of oxygen.

$$5.00g\ of\ KClO_3 \times \frac{mole\ of\ KClO_3}{122.55g} \times \frac{3\ mol\ O_2}{2\ mol\ KClO_3} \times \frac{32.00g}{mol\ O_2} = 1.96g\ of O_2$$

b) Give the % yield if 1.78 g of O_2 is produced.

$$Percentage\ yield = \frac{amount\ of\ product\ obtained}{amount\ of\ product\ expected} \times 100\%$$

$$Percentage\ yield = \frac{1.78g}{1.96g} \times 100\% = 90.8\%$$

c) How much O_2 would be produced if the percentage yield was 78.5%?

$$Percentage\ yield = \frac{amount\ of\ product\ obtained}{amount\ of\ product\ expected} \times 100\%$$

$$\frac{Percentage\ yield}{100\%} \times amount\ of\ product\ expected = amount\ of\ product\ obtained$$

$$\frac{78.5\%}{100\%} \times 1.96g = amount\ of\ product\ obtained$$

$$1.54g = amount\ of\ product\ obtained$$