Name: ____

Lab Instructor:__________________________________

PREPARATION FOR CHEMISTRY LAB: COMBUSTION

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1. What is a hydrocarbon?

2. What products form in the complete combustion of a hydrocarbon?

3. Combustion is an exothermic reaction. What does this mean?

4. Write the balanced chemical equation for the complete combustion of ethanol, $C_2H_5OH(l)$. Be sure to include the physical states: (s), (l), (g) in the equation.

5. The combustion of 5.84 grams of pentane, $C_5H_{12}(g)$, releases 286 kJ of energy. What is the heat of combustion of pentane in kJ/g and kJ/mol? (Heats of combustion are reported as negative quantities. The negative sign is used to show the release of heat.) *Example : If the combustion of 2.00 grams of a substance releases 14.0 kJ of energy, the heat of combustion of the substance would be reported as -7.00 kJ/g.*

6. What is the formula and the molar mass of cobalt(II) chloride?

   How many grams of cobalt(II) chloride are in 3.81 moles of cobalt(II) chloride?

   How many moles of cobalt(II) chloride are in 227 grams of cobalt(II) chloride?

COMBUSTION

A combustion reaction is the reaction of a substance with oxygen, usually with the rapid release of heat to produce a flame.

INTRODUCTION

There are similarities between the energy-producing reaction in the first stage of the Saturn V rocket that took astronauts to the moon and the energy-producing reactions of the human body. Both generate the same products, carbon dioxide (a gas) and water (a liquid), as well as energy. The combustion of fuel in the body is a controlled reaction consisting of many intermediate steps. In the body, heat is not released in one explosive outburst, like it is in a rocket, but the net result is the same.

In this lab we will collect and test some of the products formed in the combustion of an organic compound. We will also attempt to measure the energy that is released in the combustion of ethyl alcohol or ethanol, an industrial solvent and a component of some automobile fuels.

Heats of combustion (the energy released when a certain amount of a substance burns in oxygen) have practical importance. A buyer of coal is more interested in the heat of combustion than in the actual weight of the coal. A dietician is interested in knowing the number of calories that are obtained from various foods.

Review and/or review Sections 3-4.2, 3-5.1, 5-1, 5-2.1, 6-2, 6-3 in your textbook. Also, don't forget to use your index and glossary when necessary.

PROCEDURE

Remember to make written observations on the report sheet as you proceed.

PART 1: Collection and Tests of Combustion Products

A. There is a model arrangement of a petri dish, a candle, and an inverted funnel in the lab. Set up two units just like it side by side. Get about 20 mL of lime-water (clear, calcium hydroxide solution) in a beaker and pour some into one petri dish to a height of about 1 cm. Pour the same amount of DI water into the other dish. Add half a strip of litmus paper to each dish. Light both candles. Put the funnels in place but leave enough space between the lip of the dish and the funnel so that the candles will burn for about 15 min. Remove the funnels (HOT, USE TONGS). Extinguish and remove the candles.

If there is condensate on the inside wall of the funnels, apply a piece of cobalt(II) chloride paper (filter paper which has been soaked in an aqueous solution of cobalt(II) chloride, and dried) to each.

Add a few drops of 6 M HCl to each dish and swirl to mix.

B. Take a deep breath. Hold a clean watch glass about an inch from your mouth and exhale onto the watch glass. Repeat this procedure but hold a piece of cobalt(II) chloride paper against the dry watch glass with the tip of a finger and exhale onto the paper. Inhale and exhale onto the paper until you see and can describe a change in the appearance of the paper.

Place about 25 ml of clear lime-water in a beaker. Exhale through a drinking straw into the lime-water (blow bubbles) until you observe a change in the solution.

C. Tests for Water. Sealed tubes of cobalt(II) chloride and cobalt(II) chloride hexahydrate are available for examination. Do not open them.

Put a pinch (about 0.1 g) of cobalt(II) chloride hexahydrate in a 50 mL beaker. Add about 10 drops water. Put a pinch of cobalt(II) chloride hydrate in another 50 mL beaker. Add about 10 drops of ethyl alcohol. Put a pinch of cobalt(II) chloride hexahydrate on a dry watch glass. Heat the watch glass on a hot plate in the hood. Let it cool. Add a few drops of water.

D. Tests for Carbon Dioxide. Get about 25 mL of lime-water in a petri dish or beaker and add a small piece of dry ice (solid carbon dioxide) to it . Swirl to mix. Add a few drops of 6 M HCl to the dish and mix.

PART 2: Quantitative Measurement of the Heat of Combustion of Ethanol (C_2H_5OH)

You will begin this part of the experiment by preparing a calorimeter. A calorimeter is an instrument that is used to measure heat flow. The heat that is released in the combustion of the ethanol is absorbed by the calorimeter. The temperature change of the calorimeter is then related to the heat of combustion of ethanol (heat released in a reaction (combustion in this case) = heat gained by the calorimeter).

Weigh a 600 mL tall form beaker. Add about 450 mL of DI water and weigh it again. Put a small teflon-coated stir bar into the beaker with water and fit the beaker into a Styrofoam insulating jacket.

Weigh a 125 mL conical flask. Add about 10 mL of ethanol and weigh it again. Put the conical flask with ethanol into the insulated beaker and clamp it in place. The lower part of the flask should be completely surrounded by water. Set this assembly on a stir plate and start the stirring motor so that the bar spins **slowly.**

Slide a LabQuest temperature probe between the outer wall of the conical flask and the inner wall of the tall form beaker, into the water in the beaker. Wait a few minutes and record the initial temperature.

There is a demonstration unit set up in the lab.

Wind the free end of the copper wire igniter around a glass rod so that the coiled end will be within 2 cm of the surface of the ethanol in the conical flask. **Double check this setup before you go to the next step.**

Be careful that the LabQuest and the lead for the temperature probe do not contact the burner. Hold the glass rod and heat the copper screen igniter in a burner flame until it glows. **Quickly** lower the glowing igniter into the conical flask to burn the ethanol. When the temperature of the water has risen by 2 or 3 degrees, remove the coil (HOT). Record the final temperature. Remove the flask from the tall form beaker and cover with a watch glass. Allow the flask to cool. Dry the outside of the flask. Weigh the flask and remaining ethanol.

Disassemble and clean up the apparatus.

DATA AND ANALYSIS SHEET: COMBUSTION

Name: ____

Date _____________ Lab Partner _________________________________

PART 1A

Condensate? Yes ( ) No ( )

Description____

____

Reaction of condensate with test paper:____

____

Reaction with 6 M HCl:

In dish containing DI water: ____

____

In dish containing lime-water: ____

____

PART 1B, 1C, 1D

Exhalation on dry watch glass:____

____

Exhalation on dry watch glass and test paper:____

____

Exhalation into lime-water:____

____

Description of cobalt(II) chloride hexahydrate (color, physical state, degree of hydration, etc.):

____

____

cobalt(II) chloride hexahydrate + water: ____

____

cobalt(II) chloride hexahydrate + ethanol: ____

____

cobalt(II) chloride hexahydrate + heat: ____

____

Lime-water + CO_2 (dry ice): ____

Lime-water + CO_2 + HCl:____

Compare and discuss your observations and results from Part 1A with your observations and results from Parts 1B, 1C, and 1D.

PART 2

Mass of 600 mL beaker:___________________________

Mass of beaker and water:________________________

Mass of water:________________________

Initial temperature of water before combustion:_____________________

Mass of conical flask:______________________________

Mass of flask and ethanol:_________________________

Final temperature of water after combustion:______________________

Mass of flask and ethanol after combustion:________________

Mass of ethanol burned:______________________________

Molar mass of ethanol:_______________________________

Moles of ethanol burned:______________________________

Temperature change:_____________________

Calculations:

1. heat absorbed by water = mass of water x 4.184 J/g•^{o}C x temp change (°C)

2. heat absorbed by glassware =

   (mass of TALL FORM beaker + mass of conical flask) x 0.858 J/g•^{o}C x temp change (°C)

3. total heat absorbed by water and glassware:________________________________

4. total heat released in the combustion (= total heat absorbed by water and glassware): _________________

5. Heat of combustion per gram of ethanol, experimental:______________________________

6. Heat of combustion per mole of ethanol, experimental:_______________________________

   Heat of combustion per mole of ethanol, literature: <u>-1368 kJ/mol</u>

Based on your observations during this part of the experiment, discuss why your results for the heat of combustion per mole of ethanol might differ from the literature value.

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QUESTIONS ABOUT THIS LAB: COMBUSTION

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1. What experimental evidence suggests that one of the gaseous products in the burning of the candle is carbon dioxide?

2. When solid, cobalt(II) chloride hexahydrate is heated, what changes occur and how do you explain those changes?

3. Where in the experiment does the following reaction occur? What does the reaction tell you (what does the reaction test for)? Which of the five simple types of reactions (combustion, combination, decomposition, single-replacement, double replacement) would this reaction be classified as?

$$CaCO_3(s) + 2\ HCl(aq) \text{ ® } CaCl_2(aq) + H_2O(l) + CO_2(g)$$

4. 726 kJ of energy are released when 1.00 mole of methanol, $CH_3OH(l)$, burns completely in the oxygen in the atmosphere.

   How many kilojoules of energy are released when 28.3 grams of methanol burn completely in oxygen?

5. Write the equation for the complete combustion of methanol, $CH_3OH(l)$, in oxygen. Balance the equation using the smallest set of whole number coefficients possible and show the physical state (s, l, g) of each species in the appropriate manner in the equation.