Name: **Period:**   **Seat#:**

Required Sections: (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.)
> **Prelab:** Purpose, Prelab Questions, Materials, Reagent Table, Procedures, and set up Data Tables before you get to class.
> **During Lab:** Data section – Fill out your data table that is already set up from the prelab.
> **Post-lab:** Calculation section, Discussion Questions section, Post-Lab Two Pager done on separate Worksheet.

<u>REMINDER - USE R-15 TO ENSURE YOU FOLLOW ALL GUIDELINES/EXPECATIONS/ REQUIREMENTS</u>

<u>Introduction</u>
In this experiment, you will study the rate of evaporation, and the temperature changes caused by the evaporation, of several liquids and relate the temperature changes to the strength of intermolecular forces of attraction. Temperature Probes will be placed in various liquids. Evaporation occurs when the probe is removed from the liquid's container. This evaporation is an endothermic process that results in a temperature decrease. For the molecule to break free from the attractive forces of a liquid state (and evaporate) the molecules must absorb a certain amount of energy from their surroundings. The more molecules that evaporate over a given time (the rate of evaporation), the larger the expected temperature decrease. The rate of evaporation and the magnitude of a temperature decrease is, like viscosity and boiling temperature, related to the strength of intermolecular forces of attraction.

You will need to examine the molecular structure of the molecules to determine the types of intermolecular forces present, consider the relative strengths of the forces present, and use that information to explain the lab data you collect.

<u>Objectives</u>
In this experiment, you will
- Study the rates of evaporation, and the temperature changes caused by the evaporation of several liquids.
- Relate the lab data to the strength of intermolecular forces of attraction.
- Rank the various compounds based on the strength of their intermolecular forces of attraction.

<u>Prelab Questions</u> – *do not recopy the questions, just paraphrase them into your answers!*
Create a table like the one you see below, and fill in the missing information.

Substance	Formula	Lewis Structure	Boiling Point (°C)	Types of IMFs Present	Predicted Ranking *1 = lowest IMFs, highest ΔT* *4 = highest IMFs, lowest ΔT*
acetone	C_3H_6O				
ethanol	C_2H_5OH				
n-hexane	C_6H_{14}				
water	H_2O				

<u>Materials</u> – *don't forget to use an MSDS to do your reagent table! Remember that a * means it should be in your reagent table!*

Chemicals
- ∗ Acetone
- ∗ Ethanol
- ∗ n-hexane
- • water

Equipment
- Computer with USB port, or a USB adaptor
- LabQuest Mini
- Logger Pro
- Vernier Temperature Probe
- Test tubes x4

- Test tube rack
- 4 pieces of filter paper (2.5cm x 2.5cm)
- small rubber band
- Masking tape

⚠️ **SAFETY PRECAUTIONS**
DANGER: *The compounds used in this experiment are flammable and poisonous. Avoid inhaling their vapors. Avoid contacting them with your skin or clothing. Be sure there are no open flames in the lab during this experiment. Notify your teacher immediately if an accident occurs.*

Google Folder with Most MSDS Files
https://tinyurl.com/2cyva3ku
To help speed up your reagent table!

Flinn's MSDS Website
https://www.flinnsci.com/sds/
For anything that isn't in my Google folder.

Procedure – *Remember to make a flow chart, include diagrams/drawings of steps/equipment etc.*

1) Connect the Temperature Probes to the LabQuest Mini and Logger Pro. Set the data collection for 8 minutes. *NOTE* you can stop data collection sooner if you have reached the minimum temperature. It may not take a full 8 minutes to reach the minimum temperature.

2) Prepare a piece of masking tape, each about 10 cm long, to be used to tape the probe in position during Step 6.

3) Wrap the tip of the probe with pieces of filter paper secured by small rubber bands as shown in Figure 1. Roll the filter paper around the probe tip in the shape of a cylinder. Hint: First slip the rubber band on the probe, wrap the paper around the probe, and then finally slip the rubber band over the paper. The paper should be even with the probe end.

Figure 1

4) Stand the probe in the acetone container. Make sure the containers do not tip over.

5) After the probe has been in the liquids for at least 30 seconds, click or tap Collect to start data collection.

6) Monitor the temperature for 15 seconds to establish the initial temperature of the liquid. Remove the probe from the liquid and tape it so the probe tip extend 5 cm over the edge of the table top as shown in Figure 1. *NOTE* if there is a drip of liquid hanging from the paper, touch the drop to the side of the test tube to get rid of it.

7) Examine the graph of temperature vs. time. Based on your data, determine the maximum temperature, T_1, and minimum temperature, T_2. Record T_1 and T_2.

8) Subtract to determine ΔT, the temperature change during evaporation.

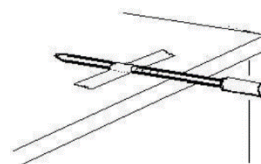9) Repeat Steps 3–8 so that you have two trials of each liquid.

Data Tables - *Remember, you need to make sure your data tables have all required elements!*

1. Record data.
2. Glue in a copy of your graph(s) under your data tables. Make sure your graph has a key indicating the name of each substance.

Substance	Trial 1		Trial 2		ΔT $(T_2 - T_1)$ (°C)	Average ΔT
	T_1 (°C)	T_2 (°C)	T_1 (°C)	T_2 (°C)		
acetone						
ethanol						
n-hexane						
water						

Post Lab Discussion Questions – *Do not recopy the questions, just paraphrase them into your answer.*

1. Based on the data collected, rank the compounds from the largest to smallest overall change in temperature. Then rank the compounds from fastest to slowest rate of evaporation. *(*hint* you should have read the background paragraph on the front of the handout already!)*

2. Which compound has the strongest IMFs according to this data? Which has the weakest?

3. Explain your results based on the IMFs present in each compound.

4. Does your prediction from the pre-lab match your results? Explain why or why not in terms of the IMFs present.

5. Imagine you performed this lab again, but this time you included a few more compounds. Make a prediction ranking them from smallest to largest ΔT values based on the intermolecular forces they each possess. Copy and fill out the table like you did in the prelab.

6. For any of the substances in the chart that possess identical types of IMFs, explain what led you to choose the ranking you did. Example: if two substances both only have LDFs, why did you put one higher than the other?

7. Consider the following scenario: A student plots a graph of ΔT values of the four alcohols versus their respective molecular weights, with molecular weight on the horizontal axis and ΔT on the vertical axis. They find a direct relationship between the molecular weight and the ΔT. The student wants to use this graph to claim that the magnitude of London

Substance	Formula	Lewis Structure	Types of IMFs Present	Predicted Ranking 1 = lowest IMFs, highest ΔT 8 = highest IMFs, lowest ΔT
acetone	C_3H_6O			
ethanol	C_2H_5OH			
n-hexane	C_6H_{14}			
water	H_2O			
1-propanol	C_3H_7OH			
1-butanol	C_4H_9OH			
n-pentane	C_5H_{12}			
methanol	CH_3OH			

Forces increases with increasing molecular weight. Do you agree or disagree with the student claiming London Force is based on molecular weight? Why or why not? If not, what does the magnitude of London Forces actually depend on?