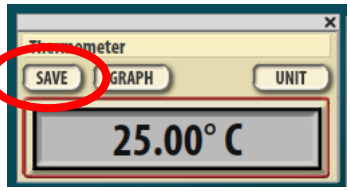
EXPERIMENT 2. COLLIGATIVE PROPERTIES

PART A. DETERMINATION OF THE VAN'T HOFF FACTOR

1. Open the Beyond Labz Virtual ChemLab program, then under the "Worksheets" menu, expand "Colligative Properties" and select "**Freezing Point Depression**". The lab will be set up with a beaker containing 45.00 g of ice, a coffee cup calorimeter and a sample of NaCl on the balance.

2. Check that the stirrer in the calorimeter is on (you should be able to see the shaft rotating), click **SAVE** on the thermometer to begin recording data, then empty the beaker of ice into the calorimeter by dragging it over to the top of the coffee cup:



3. The calorimeter has been pre-filled with 100 mL of water – if the density of water at 25°C is 0.998 $\frac{g}{mL}$, determine the exact mass of water in the calorimeter and record it in your Lab Report.

4. Record the exact mass of the pre-weighed NaCl in your Lab Report (if you cannot clearly read the balance screen, click on the balance to zoom in).

5. Once the temperature inside the calorimeter has reached 0°C, add the NaCl to the water by dragging the sample from the balance and hovering it above the calorimeter. Observe the temperature until it reaches a minimum, wait an additional 30 seconds, then click **STOP** on your thermometer screen to stop recording data.

6. Open your virtual Lab Book to view the calorimetry data, then record the lowest temperature of your NaCl / H_2O solution on your Data Table; this is the freezing point of the salt water solution.

7. Copy the time and temperature data from your virtual Lab Book and paste it into Google Sheets (or a similar computer-based graphing program) for later use.

8. Clean up your lab bench by clicking on the red waste bin.

PART B. DETERMINATION OF MOLAR MASS

9. From the Stockroom, select the "**Freezing Point Depression – NaCl**" experiment from the clipboard. This will set up your lab room in the same manner as in Part A.

10. Make certain the stirrer in the calorimeter is on, click **SAVE** on the thermometer screen to start recording data, then empty the beaker of ice into the water.

11. Drag the pre-weighed NaCl from the balance into the red waste bin, then double-click on the bottle of NaCl to return it to the Stockroom counter.

12. Head to the Stockroom and double-click on the bottle of NaCl to replace it on its proper storage shelf. From the Salts shelf, select a bottle of $Ca(NO_3)_2$ by double-clicking on it – this should move the bottle down to the Stockroom counter. Return to the lab, then drag the $Ca(NO_3)_2$ bottle to the spotlighted space on your lab bench next to the balance.

13. Click on the balance area to zoom in. Drag a piece of weigh paper onto the balance, tare it, then click on the bottle lid to open it. Use the appropriate spatula (chosen from the label on the bottle) to transfer approx. 4-4.5 g of $Ca(NO_3)_2$ onto the weigh paper; you will need to use a few scoops, and if you accidentally take too much solid, dispose of the sample into the red waste bin and start again. Record the exact mass of $Ca(NO_3)_2$ in your Lab Report.

14. Once the temperature inside the calorimeter has reached 0°C, add the $Ca(NO_3)_2$ to the calorimeter and observe the temperature change until it reaches a minimum, wait an additional 30 seconds, then click **STOP** on your thermometer screen to stop recording data.

15. Open your virtual Lab Book to view the calorimetry data, then record the lowest temperature of your $Ca(NO_3)_2$ / H_2O solution on your Data Table.

16. Copy the time and temperature data from your virtual Lab Book and paste it into Google Sheets (or a similar computer-based graphing program) for later use.

17. Clean up your lab bench by clicking on the red waste bin, then exit the lab room.

Part A. Determination of the van't Hoff Factor

Q1. *(0.5 pt)* Complete the table below for your NaCl experiment:

Mass of Water	Mass of Ice	Mass of Water + Ice	Mass of NaCl	FP of salt water

Q2. *(2 pt)* Create the thermogram for this part of the experiment, where your graph must include a proper title and labeled axes. Add a blank page to the end of this lab report, then paste your graph onto that page. *A screenshot of your Beyond Labz simulation plot will not count for credit.*

Q3. *(2 pt)* Use the masses of water, ice and NaCl to calculate the molality of your NaCl solution:

Q4. *(1 pt)* If $\Delta T = |$ FP pure water – FP of solution $|$, calculate ΔT, then use ΔT and your molality from Q3 to calculate the van't Hoff factor of NaCl *based on your experimental data*:

Q5. *(2 pt)* How does your experimental *i*-value compare to the literature (ideal) value of *i* for NaCl? Propose at least one source of error in this experiment, where your error must support whether your experimentally-determined value of *i* was too high or too low.

Part B. Determination of Molar Mass

Q6. *(0.5 pt)* Complete the table below for your $Ca(NO_3)_2$ experiment:

Mass of Water	Mass of Ice	Mass of Water + Ice	Mass of $Ca(NO_3)_2$	FP of salt water

Q7. *(2 pt)* Create the thermogram for your $Ca(NO_3)_2$ data, then paste it onto your added page beneath your NaCl thermogram from Part A.

Q8. *(1 pt)* Use ΔT to calculate the molality of your aqueous $Ca(NO_3)_2$ solution, where you may assume full dissociation of the salt (i.e. an ideal value of *i*):

Q9. *(1 pt)* Use your answer from Q8 and the mass of solvent to calculate the moles of $Ca(NO_3)_2$:

Q10. *(1 pt)* Calculate the molar mass of $Ca(NO_3)_2$ *based on your experimental data*:

Q11. *(2 pt)* Calculate the percent error between your experimental molar mass of $Ca(NO_3)_2$ and its actual molar mass. Next, propose at least one source of error in this experiment, where your error must support whether your experimental molar mass was too high or too low.