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
99.80g	45.00 g	144.8 g	3.9400 g	−1.74°C

$m = V \rho = 100 mL \cdot 0.9989 \frac{g}{mL}$ 99.80 + 45.00 =

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:

$m = \frac{mol\ NaCl}{kg\ H_2O}$ $M_{NaCl} = 58.4428 \frac{g}{mol}$ $\therefore n = \frac{3.9400\ g}{58.4428 \frac{g}{m}} = 0.067416\ mol$

$m_{H_2O} = 0.144.8\ kg$

$\therefore m = \frac{0.067416\ mol}{0.1448\ kg}$ $\boxed{= 0.4656\ m}$

Q4.   *(1 pt)* If ΔT = |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*:

$\Delta T = |0°C − −1.74°C| = 1.74°C$ $\Delta T = i k_f \cdot m$

$K_{f water} = 1.86 \frac{°C}{m}$ $i = \frac{\Delta T}{k_f m} = \frac{1.74°C}{1.86 \frac{°C}{m} \cdot 0.4656 m}$

$m = 0.4656\ m$

$\boxed{= 2.01}$

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.

Since the literature value of i is 2 because NaCl disociates into 2 ions, my experimental i-value is very close at i = 2.01.

One possible error could be that I waited a large amount of time after the water reached 0°C so the solution could have been slightly warmer causing ΔT to increase which would increase the i-value.

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
99.80 g	45.00 g	144.8 g	4.2985 g	−1.02 °C

$m \approx V\rho = 100mL \cdot 0.998\frac{g}{mL}$

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):

$\Delta T = i \, k_f \, m$

$\therefore m = \frac{\Delta T}{i k_f} = \frac{1.02°C}{3(1.86\frac{°C}{m})} = \boxed{0.183 \frac{mol \, Ca(NO_3)_2}{kg \, water}}$

$i = 3$

$k_f = 1.86 \frac{°C}{m}$

$\Delta T = |0 + 1.02|$

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

$n = m \cdot m_{solvent} = 0.183 m \cdot 0.1448 \, kg \, water = \boxed{0.0265 \, mol \, Ca(NO_3)_2}$

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

$M = \frac{g}{mol} = \frac{4.2985 g}{0.0265 mol} = \boxed{162 \frac{g}{mol}}$

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.

$M_{actual} = 164.0878$

$M_{exp} = 162$

$error = \left|\frac{M_{exp} - M_{act}}{M_{act}}\right| \cdot 100\% = \left|\frac{162 - 164.0878}{164.0878}\right| \cdot 100\% = \boxed{1.27\%}$

- A possible source of error could be using an estimated i value rather than a calculated one. If the calculated value is greater than the estimated value, then the molality would be smaller, increasing the value of Molarity.

Freezing Point Depression (NaCl in water)

Freezing point
of pure water: 0°C

Freezing point of
water with NaCl: -1.74°C

Temperature (°C)

Time (min)

Freezing Point Depression (Ca(NO$_3$)$_2$ in water)

Freezing point
of pure water: 0°C

Freezing point of water
with Ca(NO$_3$)$_2$: -1.02°C

Temperature (°C)

Time (min)