Name: _____
Period: ___

**Lab: Heat of Solution**

**Introduction:**
Water ($H_2O$) is liquid with "bent" molecular structure such that water molecules are polar and are said to have a "dipole moment". The hydrogen end of a water molecule has a partial positive charge and the oxygen end of a water molecule has a partial negative charge. Neighbouring water molecules are held together by a strong form of dipole interactions called hydrogen bonds. When a substance is dissolved in water, the hydrogen bonds holding the water molecules together are broken and the water molecules are able to interact with the substance being dissolved. When an ionic compound is dissolved in water it will undergo dissociation and the ionic bond holding the ions together will be broken. The ions then become hydrated such that they are surrounded by water molecules. The water molecules will orient themselves so that the hydrogen end of the water molecule interacts with the negative ion (anion) of the ionic compound and the oxygen end of the water molecule interacts with the positive ion (cation) of the ionic compound. The interactions between a polar molecule and an ion are referred to as ion-dipole bonds.

The heat energy association with the dissolving, dissociation, and hydration of an ionic compound in water is called the enthalpy of solution. The enthalpy of solution of a compound can be either an endothermic process or an exothermic process depending on whether the total energy of intramolecular and intermolecular bonds broken is greater than or less than the total energy of bonds formed. A calorimetry experiment can be used to determine the enthalpy of solution and make inferences about the relative energy of bonds broken and bonds formed.
In this experiment, the heat of solution for lithium chloride and for ammonium nitrate will be determined. A given mass of each substance will be dissolved in water and the temperature change for each mixture will be determined.

The amount of heat associated with dissolving a compound in water can be calculated according to the following equation:

$$\Delta H = mc\Delta T$$

Where: m = the total mass of the mixture (g)
c = specific heat capacity (The specific heat capacity of each mixture can be approximated as that of water, 4.18 J/g ºC)
$\Delta T$ = the change in temperature (ºC)

Given the mass of each compound that is dissolved, the number of moles for each compound can be determined and therefore the enthalpy of solution for each substance can be calculated in kJ/mol. The experimental values can be compared to the actual values (which are given).

**Procedure:**
(1) Construct a calorimeter by placing two Styrofoam cups together. Determine the mass of the empty calorimeter and record. Obtain a calorimeter cover and a thermometer.
(2) Measure 50 mL of water and record the initial temperature.
(3) Measure approximately 2.5 g of lithium chloride into the calorimeter. Record the exact mass. Add the 50 mL of water into the calorimeter. Cover the calorimeter and use a thermometer to stir. Record the highest temperature reached by the mixture. Determine the mass of the mixture and the calorimeter (without cover). Record. Calculate the mass of the mixture. Record.
(4) Discard the mixture in the sink. Rinse and dry the calorimeter and thermometer.
(5) Measure another 50 mL of water and record the initial temperature.
(6) Measure approximately 2.5 g of ammonium nitrate into the calorimeter. Record the exact mass. Add the 50 mL of water into the calorimeter. Cover the calorimeter and use a thermometer to stir. Record the lowest temperature reached by the mixture. Determine the mass of the mixture and the calorimeter (without cover). Record. Calculate the mass of the mixture. Record.
(7) Discard the mixture in the sink. Rinse and dry the calorimeter and thermometer.

**Data:**

| **Compound** | **Mass of empty calorimeter (g)** | **Mass of compound (g)** | **Initial Temperature (ºC)** | **Final Temperature (ºC)** | **ΔT (ºC)** | **Mass of mixture and calorimeter (g)** | **Mass of mixture (g)** |
|---|---|---|---|---|---|---|---|
| lithium chloride | | | | | | | |
| ammonium nitrate | | | | | | | |

**Questions:**

*Lithium Chloride*

(1) (a) Calculate the moles of lithium chloride dissolved. _____

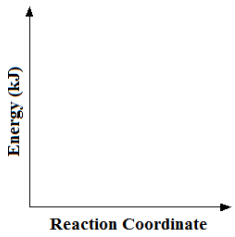
(b) Using the change in temperature and the mass of the mixture, calculate the heat of the mixture in Joules.

_____

(c) Calculate the enthalpy of solution (kJ/mol). Give the answer with the appropriate sign. _____

(d) Write a reaction for the dissociation of lithium chloride and include the heat value on the appropriate side of the reaction.

(e) Sketch a potential energy diagram for the reaction. Label ΔH.




(2) (a) Verify (by calculating ΔEN) that the bond lithium chloride can be classified as ionic.

ΔEN = _____

(b) Draw a diagram to show how a molecule of lithium chloride forms.

before: after:

(3) Draw a diagram to represent the dissociation reaction for one molecule of lithium chloride (before and after). Include a total of four water molecules in the diagram. Label each of the following types of bonds once for each location they appear in the diagram: hydrogen bond, ionic bond, ion-dipole bonds.

Which of these bonds are broken during dissolving? _____

Which of these bonds are broken during dissociation? _____

Which of these bonds are formed during hydration? _____

*Ammonium Nitrate*

(1) (a) Calculate the moles of ammonium nitrate dissolved. _____

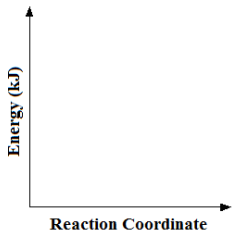
(b) Using the change in temperature and the mass of the mixture, calculate the heat of the mixture in Joules.

_____

(c) Calculate the enthalpy of solution (kJ/mol). Give the answer with the appropriate sign. _____

(d) Write a reaction for the dissociation of ammonium nitrate and include the heat value on the appropriate side of the reaction.

(e) Sketch a potential energy diagram for the reaction. Label ΔH.




(2) Draw the Lewis structure for the ammonium ion and for the nitrate ion. Calculate (show work) and label the formal charge on each atom.

ammonium:

nitrate:

(3) Draw a diagram to represent the dissociation reaction for one molecule of ammonium nitrate (before and after). Include a total of four water molecules in the diagram. Label each of the following types of bonds once for each location they appear in the diagram: hydrogen bond, covalent bonds, ionic bond, ion-dipole bonds.

Which of these bonds are broken during dissolving? _____

Which of these bonds are broken during dissociation? _____

Which of these bonds are formed during hydration? _____

Which of these bonds does not break/form in these processes? _____

**Conclusion:**
Energy is _____ to break bonds and _____ when bonds are formed. For a compound with an endothermic heat of solution, the energy of the all the bonds being broken is _____ than the energy of all the bonds being formed.
For a compound with an exothermic heat of solution, the energy of the all the bonds being broken is _____ than the energy of all the bonds being formed.

**Error Analysis:**
Calculate the percent errors for the enthalpy of solution of lithium chloride and of ammonium nitrate.

| **Compound** | **Enthalpy of Solution (kJ/mol)** |
|---|---|
| LiCl | –37 |
| $NH_4NO_3$ | +25 |

*lithium chloride*
The experimental value was ____ % _____ (higher or lower?) in *magnitude* than the actual value.

*ammonium nitrate*
The experimental value was ____ % _____ (higher or lower?) in *magnitude* than the actual value.