Experiment 2: A Tall Drink of Water (Pre-Lab)

1) a. Enthalpy of dissolution of the compound $X^+Y^=$

The enthalpy of dissolution of the compound $X^+Y^=$ is the enthalpy change in kJ that occurs when one mole of the compound fully dissolves in water.

$$X^+Y^-{}_{(s)} \rightarrow X^+{}_{(aq)} + Y^-{}_{(aq)}$$

b. Lattice energy of the compound $X^+Y^=$

The lattice energy of the compound $X^+Y^=$ is the energy in kJ that is released when one mole of the compound is created from its gaseous ions.

$$X^+{}_{(g)} + Y^-{}_{(g)} \rightarrow X^+Y^-{}_{(s)}$$

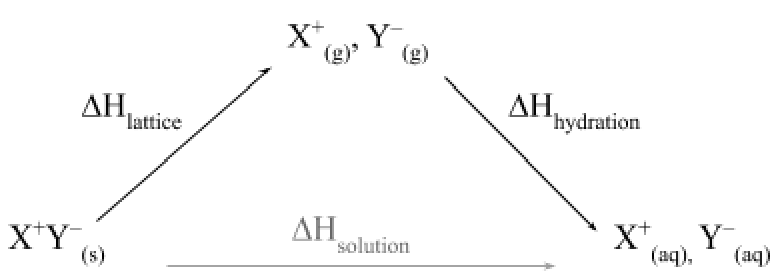
c. Enthalpy of hydration of the gaseous ion $Z^+{}_{(g)}$

The enthalpy of hydration of the gaseous ion $Z^+{}_{(g)}$ is the enthalpy change in kJ that occurs when one mole of gaseous ions is dissolved in water.

$$Z^+{}_{(g)} \rightarrow Z^+{}_{(aq)}$$

2) Explain how the above three enthalpy changes are related. Use a diagram to explain if appropriate.

Lattice energy and enthalpy of hydration can be used to find the enthalpy of solution of a compound. The lattice energy corresponds to the lattice enthalpy, which is the amount of energy required to separate a compound into its gaseous ions. This enthalpy value will always be positive, because it is an endothermic process. Then, we can use the enthalpy of hydration to find the enthalpy change that occurs when these gaseous ions dissolve in water. This will be a negative value, because the process is exothermic. By taking the sum of the lattice enthalpy and enthalpy of hydration, the enthalpy of solution can be found.



3) a. The enthalpy of solution of solid ammonium chloride

$$\Delta H_{sol'n} = \Delta H_{lattice} + \Delta H_{hydration}$$
$$= 705\ \text{kJ/mol} + (-307\ \text{kJ/mol} + (-381\ \text{kJ/mol}))$$
$$= +17\ \text{kJ/mol}$$

b. The enthalpy of solution of solid ammonium nitrate

$$\Delta H_{sol'n} = \Delta H_{lattice} + \Delta H_{hydration}$$
$$= 646\ \text{kJ/mol} + (-307\ \text{kJ/mol} + (-314\ \text{kJ/mol}))$$
$$= +25\ \text{kJ/mol}$$

4) a. Assuming that the heat capacity for coffee is the same as that of water, 4.18 Jg-1K-1, calculate the energy needed to warm 210 cm^3 of coffee by 40°C.

$$q = mc\Delta T$$
$$= (210\ \text{g})\left(\frac{4.18\ \text{J}}{\text{g K}}\right)(40\ \text{K})$$
$$= 35112\ \text{J}$$
$$= 35.1\ \text{kJ}$$

b. Use this value to hence calculate the minimum mass of CaO in the can for it to function as specified.

$$x\ \text{g CaO} = 35.1\ \text{kJ}\left(\frac{1\ \text{mol CaO}}{82\ \text{kJ}}\right)\left(\frac{56.078\ \text{g}}{1\ \text{mol CaO}}\right)$$
$$= 24.0\ \text{g CaO}$$