

Answer Key

CHEMISTRY LAB: Heat of Solution of Ammonium Chloride

Data Table

initial temp water: measured to tenths place with units

mass of ammonium chloride: measured to hundredths with units

final temperature solution: measured to tenths place with units

Post-Lab Questions

1. $50.00 \text{ mL} \times \frac{0.997799 \text{ g}}{1 \text{ mL}} = \boxed{49.89 \text{ g H}_2\text{O}}$ 4 significant figures

← this number depends on initial temp. measured and recorded in data table

2. $q = C_s m \Delta T$

$C_s (\text{liquid}) = 4.184 \text{ J/g}^\circ\text{C}$

$m = \underbrace{49.89 \text{ g} + 4.55 \text{ g}}_{\text{both numbers depend on measurements}} = 54.44 \text{ g}$

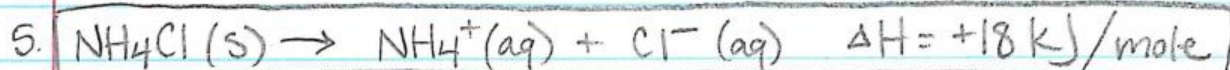
$\Delta T = 15.5^\circ\text{C} - 22.0^\circ\text{C} = -6.5^\circ\text{C}$

$q = (4.184 \text{ J/g}^\circ\text{C})(54.44 \text{ g})(-6.5^\circ\text{C}) = \boxed{-1500 \text{ J}}$ 2 significant figures

3. $4.55 \text{ g NH}_4\text{Cl} \times \frac{1 \text{ mole}}{53.4915 \text{ g}} = \boxed{0.0851 \text{ moles NH}_4\text{Cl}}$ 3 significant figures

4. $\Delta H = \frac{-q}{\text{mol}}$ $q = -1500 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = -1.5 \text{ kJ}$

$\Delta H = \frac{-(-1.5 \text{ kJ})}{0.0851 \text{ mol}} = \boxed{+18 \text{ kJ/mole}}$ 2 significant figures



6. enthalpy (kJ/mole) is an intensive property **A**

7. positive enthalpy, decrease in temperature
heat flows from surrounding to system **B**

8. positive enthalpy, endothermic [A]

9. separating the intermolecular forces in the solvent^(ΔH_1) and the solute^(ΔH_2) costs energy (positive enthalpy). Forming new intermolecular forces between them (ΔH_3) is thermodynamically favorable (negative enthalpy). Dissolving ammonium chloride has positive enthalpy, so $\Delta H_1 + \Delta H_2$ must be larger [A]

10. $\text{NH}_4\text{Cl}(s) \rightleftharpoons \text{NH}_4^+(aq) + \text{Cl}^-(aq)$ $K_{sp} = [\text{NH}_4^+][\text{Cl}^-]$
more soluble = larger K_{sp} [A]

11. percent error = $\frac{|\text{error}|}{\text{accepted}} \times 100\%$

$$\text{error} = 15 - 14.7 = 0.3 \text{ kJ}$$

$$\text{percent error} = \frac{0.3}{14.7} \times 100\% = \boxed{2\% \text{ error}}$$

1 significant figure

12. less NH_4Cl ends up in calorimeter than accounted for in the calculation of enthalpy, ΔT would be smaller [B]

13. less H_2O in the calorimeter than accounted for in the calculation of enthalpy, ΔT would be larger [A]

14. Since the student decided to make the change, we can assume that these amounts were accounted for in the calculation of enthalpy [C]

15. Again, we can assume the student accounted for the changed amounts in the calculation [C]

16. less NH_4Cl in solution, smaller ΔT [B]

$$17. m = \frac{\text{moles NH}_4\text{Cl}}{\text{kg H}_2\text{O}}$$

$$49.89 \text{ g H}_2\text{O} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.04989 \text{ kg H}_2\text{O}$$

$$m = \frac{0.0851 \text{ moles}}{0.4989 \text{ kg H}_2\text{O}} \quad \left. \vphantom{\frac{0.0851 \text{ moles}}{0.4989 \text{ kg H}_2\text{O}}} \right\} \begin{array}{l} \text{numbers depend} \\ \text{on measurement} \end{array}$$

$$m = \boxed{0.171 \text{ mol/kg}} \quad 3 \text{ significant figures}$$

18. [tie breaking question]

$$\Delta T_F = K_F m i$$

$$K_F = 1.853 \text{ K} \cdot \text{kg/mol}$$

$$m = 0.171 \text{ mol/kg} \quad \left\{ \begin{array}{l} \text{from previous} \end{array} \right\}$$

i = Van't Hoff factor.

NH_4Cl dissociates to 2 ions

$$\Delta T_F = (1.853 \text{ K} \cdot \text{kg/mol})(0.171 \text{ mol/kg})(2)$$

$$\Delta T_F = 0.634^\circ\text{C}$$

$$T_F = T_{F(\text{pure water})} - \Delta T_F = 0.000 - 0.634^\circ\text{C} = \boxed{-0.634^\circ\text{C}}$$

19. intensive A

20. physical A

