

## Measuring Enthalpy Changes and Gas Laws Worksheet

As you work through the steps in the lab procedures, record your experimental values and the results on this worksheet.

**Data Table A:** Heat of Solution

Initial temperature of water	°C
Temperature of solution after addition to CaCl <sub>2</sub>	°C
$\Delta T_{1A}$ ( $T_{\text{final}} - T_{\text{initial}}$ ) for dissolution of CaCl <sub>2</sub>	°C
Initial temperature of water	°C
Temperature of solution after addition to NH <sub>4</sub> NO <sub>3</sub>	°C
$\Delta T_{2A}$ ( $T_{\text{final}} - T_{\text{initial}}$ ) for dissolution of NH <sub>4</sub> NO <sub>3</sub>	°C

**Question 1:** For dissolution of CaCl<sub>2</sub>, please answer a - c.

- Was heat given off or absorbed? Could you feel it?
- Was the process exothermic or endothermic?
- Did the entropy increase, decrease, remain the same or can you not tell from your results?

**Question 2:** For dissolution of NH<sub>4</sub>NO<sub>3</sub>, please answer a - c.

- Was heat given off or absorbed? Could you feel it?
- Was the process exothermic or endothermic?
- Did the entropy increase, decrease, remain the same or can you not tell from your results?

**Question 3:** Which chemical would you use in a cold pack,  $\text{CaCl}_2$  or  $\text{NH}_4\text{NO}_3$ ?

**Data Table B:** Heat of Reaction

	Temperature	Observations
Initial $\text{FeCl}_3$ solution	°C	
Solution after addition of NaOH	°C	
$\Delta T_{1B}$	°C	

**Question 4:** For the reaction of  $\text{FeCl}_3$  and NaOH, please answer a - d.

- What evidence indicates that a reaction occurred?
- Did the reaction give off or absorb heat? Could you feel it?
- Did the entropy increase, decrease, remain the same or can you not tell from your results?
- Was the reaction spontaneous? Justify your answer.

**Data Table C:** Heat of Neutralization

	Temperature	Observations
Initial NaOH solution	°C	
Solution after addition of water	°C	
$\Delta T_{1C}$	°C	
Solution after addition of HCl	°C	
$\Delta T_{2C}$	°C	
Solution after addition of HNO <sub>3</sub>	°C	
$\Delta T_{3C}$	°C	
Solution after addition of HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	°C	
$\Delta T_{4C}$	°C	

**Question 5:** In which test tubes was there evidence for a reaction?

**Question 6:**

- Were the temperature changes about the same or very different for the reactions?
- Can you account for this result? Hint: write the reaction equations and compare them.

**Question 7:** Did the entropy increase, decrease, remain the same or can you not tell from your results?

**Table D:** Temperature and Time During the Heating of Water

Elapsed time, min	Temperature, °C	Observations
0.0		
0.5		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0		
8.5		
9.0		
9.5		
10.0		

Elapsed time, min	Temperature, °C	Observations
13.0		
13.5		
14.0		
14.5		
15.0		
15.5		
16.0		
16.5		
17.0		
17.5		
18.0		
18.5		
19.0		
19.5		
20.0		
20.5		
21.0		
21.5		
22.0		
22.5		
23.0		

Elapsed time, min	Temperature, °C	Observations
10.5		
11.0		
11.5		
12.0		
12.5		

Elapsed time, min	Temperature, °C	Observations
23.5		
24.0		
24.5		
25.0		

Record the following.

Time at which all the ice has (just) melted	min
Time at which bubbles first appear	min
Time at which steam first appear	min
Time at which true boiling begins	min

**Question 8:**

- a. Were there times when the temperature stayed constant for several readings?
  
  
  
  
  
  
  
  
  
  
- b. What was happening during these times?

**Question 9:** What happened to the entropy of the system for each of the following processes? Did it increase greatly, increase slightly, decrease greatly, decrease slightly, stay the same or can you not tell from your results?

- a. As the ice melted?
  
  
  
  
  
  
  
  
  
  
- b. As the water was heated?
  
  
  
  
  
  
  
  
  
  
- c. As the water boiled?

**Data Table E:** Volume vs. Pressure

60 mL syringe		20 mL syringe	
Volume (mL)	Pressure (torr)	Volume (mL)	Pressure (torr)
0 + 4		0 + 4	
10 + 4		5 + 4	
20 + 4		10 + 4	
30 + 4		15 + 4	
40 + 4		20 + 4	

**Question 10:**

a. Prepare a graph of the 60-mL syringe data in Excel<sup>®</sup>, by plotting the volume on the  $x$ -axis and the pressure on the  $y$ -axis. Be sure to use proper labeling and include a title. For assistance in the format of a graph, please see “Preparing Graphs” under Lab Safety and Practices in the lab manual. For assistance using Excel<sup>®</sup>, please consult with your TA. Finally, upload your graphs as an Excel<sup>®</sup> file with a maximum size of 1 MB. (*You will upload this file in the WebAssign question.*)

b. When the volume increases, what is the effect on the pressure?

c. When the volume decreases, what is the effect on the pressure?

d. What type of relationship is this between variables?