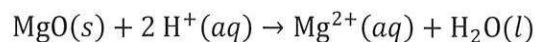


## Unit 4: AP Free Response Practice #4 [2013 FR #3, 10 points]



4. A student was assigned to the task of determining the enthalpy change for the reaction between solid MgO and aqueous HCl represented by the net ionic equation above. The student uses a polystyrene cup calorimeter and performs four trials. Data for each trial are shown in the table below.

Trial	Volume of 1.0 M HCl (mL)	Mass of MgO(s) Added (g)	Initial Temperature of Solution (°C)	Final Temperature of Solution (°C)
1	100.0	0.25	25.5	26.5
2	100.0	0.50	25.0	29.1
3	100.0	0.25	26.0	28.1
4	100.0	0.50	24.1	28.1

- (b) a. Which is the limiting reactant in all four trials, HCl or MgO? Justify your answer. [1 point]
- b. The data in one of the trials is inconsistent with the data in the other three trials. Identify the trial with the inconsistent data and draw a line through the data from that trial in the table above. Explain how you identified the inconsistent data. [1 point]

For parts (c) and (d), use the data from one of the other three trials (i.e., not from the trial you identified in part (b) above.) Assume the calorimeter has a negligible heat capacity and that the specific heat of the contents of the calorimeter is 4.18 J/(g °C). Assume that the density of the HCl(aq) is 1.0 g/mL.

- c. Calculate the magnitude of  $q$ , the thermal energy change, when the MgO was added to the 1.0 M HCl(aq). Include units with your answer. [2 points]
- d. Determine the student's experimental value of  $\Delta H^\circ$  for the reaction between MgO and HCl in units of kJ/mol<sub>rxn</sub>. [2 points]
- e. Enthalpies of formation for substances involved in the reaction are shown in table below. Using the information in the table, determine the accepted value of  $\Delta H^\circ$  for the reaction between MgO(s) and HCl(aq). [2 points]

Substance	$\Delta H_f^\circ$ (kJ/mol)
MgO(s)	-602
H <sub>2</sub> O(l)	-286
H <sup>+</sup> (aq)	0
Mg <sup>2+</sup> (aq)	-467

- f. The accepted value and the experimental value do not agree. If the calorimeter leaked heat energy to the environment, would it help account for the discrepancy between the values? Explain. [1 point]

$$a.) 1.0 \text{ M} \times 0.100 \text{ L} = 0.10 \text{ mol HCl} \times \frac{1 \text{ MgO}}{2 \text{ HCl}} = 0.050 \text{ mol MgO}$$

$$0.50 \text{ g MgO} \times \frac{1 \text{ mol MgO}}{40.3 \text{ g MgO}} = 0.0124 \text{ mol MgO} < 0.050 \text{ mol MgO}$$

$\Rightarrow$  MgO is limiting! (or:  $\Delta T$  changed when amount of MgO added was changed, so MgO must be limiting  $\hat{u}$ )

b) Trial 1 is inconsistent b/c  $\Delta T$  should be proportional to the amount of  $MgO$  added. In trials 2 & 4, 0.5g  $MgO$  gave a  $\Delta T \approx 4^\circ C$ , and in trial 3 0.25g  $MgO$  gave  $\Delta T \approx 2^\circ C$ , but in trial 1 the ratio is  $\frac{1}{2}$  of the other trials.

$$c) q_{cal} = mC\Delta T = (100.g + 0.50g) \underset{\substack{\text{using trial 2} \\ \text{b/c } d = 1.0g/mL}}{4.18 \frac{J}{g \cdot ^\circ C}} (29.1 - 25.0) = 1700 J$$

$$d) \Delta H_{rxn}^\circ = \frac{q_{rxn}}{\text{mol}_{rxn}} \left. \begin{array}{l} \\ \end{array} \right\} 0.0124 \text{ mol } MgO \cdot \frac{1 \text{ mol}_{rxn}}{1 \text{ mol } MgO} = 0.0124 \text{ mol}_{rxn}$$

$$\Delta H_{rxn}^\circ = \frac{q_{rxn} = -q_{cal}}{0.0124 \text{ mol}_{rxn}} = \boxed{-140 \text{ kJ/mol}_{rxn}}$$

$$e) \Delta H_{rxn}^\circ = \sum \Delta H_f^\circ(\text{pr}) - \sum \Delta H_f^\circ(\text{re})$$

$$= [Mg^{2+} + H_2O] - [MgO + 2H^+]$$

$$= [-467 + -286] - [-602 + 2(0)]$$

$$= -753 + 602 = \boxed{-151 \text{ kJ/mol}_{rxn}}$$

f) Yes, b/c the experimental value of  $-140 \text{ kJ/mol}_{rxn}$  was less negative than the accepted value of  $-151 \text{ kJ/mol}_{rxn}$ . If the calorimeter leaked heat energy, calculated  $\Delta T$  would be less than expected, leading to a smaller calculated  $q$  + thus a less negative  $\Delta H^\circ$ .