SCH 4U1-a

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CHAPTER 5 TEST - Thermochemistry

Knowledge /15	Inquiry /15	Application /9

PART A: THINKING/INQUIRY (15 marks)

1. In a coffee cup calorimeter, a student mixes 1.60 g of ammonium nitrate, $NH_4NO_3(s)$, with 75.0 g of water at an initial temperature of 25.00°C. After dissolution of the salt, the final temperature of the calorimeter contents is 23.34°C. Calculate the molar enthalpy for the dissolution of ammonium nitrate. Assume the density and specific heat capacity of the resulting solution is similar to that of liquid water. (5 marks)
USE GRASP!

G: $m_{NH_4NO_3} = 1.60\,g$
$m_{H_2O} = 75.0\,g$
$c_{H_2O} = 4.18\,J/g°C$
$\Delta T = 23.34°C - 25.00°C$
$= -1.66°C$
$M_{NH_4NO_3} = 80.06\,g/mol$

R: ΔH_d of $NH_4NO_{3(s)}$

A: ① $q = mc\Delta t$
② $n = \frac{m}{M}$
③ $\Delta H = n\Delta H_d$

S: ① $q = mc\Delta t$
$= 75.0\,g\,(4.18\,J/g°C)(-1.66°C)$
$= -520.41\,J$
$\therefore \Delta H = 520.41\,J = 0.52041\,kJ$

② $n_{NH_4NO_3} = \frac{m_{NH_4NO_3}}{M}$
$= \frac{1.60\,g}{80.06\,g/mol}$
$= 0.0198\,mol$

③ $\Delta H = n\Delta H_d$
$\frac{\Delta H}{n} = \Delta H_d$
$\frac{0.52041\,kJ}{0.0198\,mol}$
$26.28335\,kJ/mol$

$\therefore \Delta H_d$ of $NH_4NO_{3(s)}$ is $26.3\,kJ/mol$

2. Determine the enthalpy change for the following reaction **given the numbered reactions** below: (6 marks)

$$3\,C_{(s)} + 4\,H_{2(g)} \rightarrow C_3H_{8(g)}$$

(1) $C_3H_{8(g)} + 5\,O_{2(g)} \rightarrow 3\,CO_{2(g)} + 4H_2O_{(l)}$ $\times -1$ $\quad \Delta H_1 = -2220\,kJ$
(2) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\times 3$ $\quad \Delta H_2 = -394\,kJ$
(3) $H_{2(g)} + 1/2\,O_{2(g)} \rightarrow H_2O_{(l)}$ $\times 4$ $\quad \Delta H_3 = -286\,kJ$

~~$3CO_{2(g)} + 4H_2O_{(l)} \rightarrow C_3H_{8(g)} + 5O_{2(g)}$~~ $\quad \Delta H = 2220\,kJ$
$3C_{(s)} + 3O_{2(g)} \rightarrow 3CO_{2(g)}$ $\quad \Delta H = -1182\,kJ$
$4H_{2(g)} + 2O_{2(g)} \rightarrow 4H_2O_{(l)}$ $\quad \Delta H = -1144\,kJ$

↓

$3C_{(s)} + 4H_{2(g)} \rightarrow C_3H_{8(g)}$ $\quad \Delta H = -106\,kJ$

$\therefore \Delta H = -106\,kJ$

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3. Use standard enthalpies of formation to calculate the enthalpy change for the following neutralization reaction (4 marks)

$HCl_{(g)} + NaOH_{(s)} \rightarrow NaCl_{(s)} + H_2O_{(l)}$

$\Delta H_r^\circ = \Sigma n_p \times \Delta H_p^\circ - \Sigma n_r \times \Delta H_r^\circ$

① ΔH_f° : NaCl = −411.2 kJ/mol
H_2O = −285.8 kJ/mol
HCl = −92.3 kJ/mol
NaOH = −425.6 kJ/mol

② $\Delta H_r^\circ = [1\text{mol}(-411.2\text{kJ/mol}) + 1\text{mol}(-285.8\text{kJ/mol})] - [1\text{mol}(-92.3\text{kJ/mol}) + 1\text{mol}(-425.6\text{kJ/mol})]$

$\Delta H_r^\circ = -179.1\text{ kJ}$

PART B: APPLICATION (9 marks)

1. Explain the enthalpy change(s) involved in the following, using the terms **system** and **surroundings** to help in your explanation. Point form is fine! (2 marks each - 4 marks total)

(a) After swimming in the ocean, water droplets evaporate from your skin on a hot summer day.

- heat from the sun is transfered to the water droplet
- the sun is the surroundings and the water is the system
- the water will absorb the heat and evaporate in an endothermic reaction

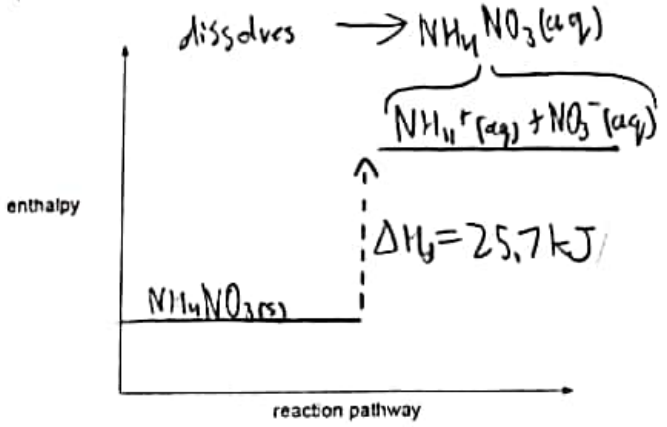
(b) Pigs roll in the mud, which dries on their skin, to keep cool.

- heat from the warm pig is transfered to the cold mud
- the pig is the system and the mud is the surroundings
- heat is transfer from system to surrounding in a exothermic reaction

2. A cold pack consists of an inner pouch containing solid ammonium nitrate, $NH_4NO_{3(s)}$, and an outer pouch of water. Twisting the pack breaks the inner pouch and allows the water and ammonium nitrate to mix. As the ammonium nitrate **dissolves**, the temperature of the surrounding environment decreases. The energy change per mol of ammonium nitrate dissociated is 25.7 kJ.

a) Classify the reaction as endothermic or exothermic. endothermic (1 mark)

b) Sketch a potential energy diagram for the reaction. Label the change in enthalpy, ΔH. (2 marks)



- $NH_4NO_{3(s)}$ absorbs heat and therefore surrounding becomes colder
- endothermic reaction

c) Write a **thermochemical equation** for this reaction. (2 mark)

$NH_4NO_{3(s)} \xrightarrow{H_2O} NH_4NO_{3(aq)}$ $\Delta H_f = 25.7$ kJ

OR $NH_4NO_{3(s)} + 25.7\text{ kJ} \xrightarrow{H_2O} NH_4^+NO_{3(aq)}$

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