Answer Key

Calorimetry Questions

1. The molar enthalpy of solution for ammonium chloride is +14.8 kJ/mol. What is the final temperature observed when 20.0 g of ammonium chloride is added to 125 mL of water with an initial temperature of 20.0°C? (9.4°C)

2. A pellet of potassium hydroxide having a mass of 0.648 g is dissolved in 40.0 mL of water in an insulated cup. The temperature of the water increases from 22.6°C to 27.8°C. What is the molar enthalpy of solution for KOH? Assume that the solution has a density and specific heat capacity equal to that of water. (-75 kJ/mol)

3. 1.44g of naphthalene ($C_{10}H_8$) was burned to heat water from 20.3°C to 26°C. If the mass of the water is 2.5kg, calculate the molar enthalpy of combustion of naphthalene. (-5314 kJ/mol)

4. The water inside a hot water tank is heated by the combustion of methane gas. If the temperature of 160L of water inside the tank is increased from 25°C to 90°C, determine the mass of methane gas that needs to be combusted. The molar enthalpy of combustion for methane is -890.5 kJ/mol
(784 g CH_4)

5. You were asked to mix 20.0 mL of a 1.0 M HCl solution with 100.0 mL of a 1.0 M NaOH solution. The initial temperature of both solutions was 18.9°C. The temperature of the final solution was 21.1°C. Assume HCl and NaOH have the same specific heat capacity and density as water. What is the ΔH/mol for the neutralization of HCl? (-55 kJ/mol)

↑ ΔH or Q/mol

A not B

1) $\Delta H = +14.8 \frac{kJ}{mol}$

"4 step reverse"

$T_f = ?$
$m = 20.0\,g\ NH_4Cl$
$vol = 125\,mL$ water
$T_i = 20.0\,^\circ C$

iii) $20.0\,g\ NH_4Cl \times \frac{1\,mol\ NH_4Cl}{53.5\,g} \times \frac{+14.8\,kJ}{1\,mol} \times \frac{1000\,J}{1\,kJ} =$

(14 + 1×4 = 4; 35.5)

$+5532.7\,J \rightarrow \underline{+5533\,J} =$ ii) Q sub

i) $= \underline{-5533\,J} =$ Q water

$$\frac{Q_{water}}{mC} = \frac{m_{water} \cdot C_{water} \cdot \Delta T_{water}}{m \cdot C}$$

$$\frac{-5533\,J}{(125\,mL \times \frac{1\,g}{1\,mL})(4.19 \frac{J}{g \cdot C})} = \Delta T$$

$$-10.56\,^\circ C = \Delta T$$

$\Delta T = T_f - T_i$
$+T_i \qquad +T_i$

$-10.56\,^\circ C + 20.0\,^\circ C = T_f = 9.4\,^\circ C$

2) ΔH_{soln} KOH (a base ∴ exo)

$Q = mc\Delta T$

i) $Q = \left(40.0\,mL \times \frac{1\,g}{1\,mL}\right)\left(\frac{4.19\,J}{g\cdot°C}\right)(27.8°C - 22.6°C)$

$= 8715.2 \rightarrow +8720\,J$ (≫ 2sf)

ii) $Q_{sub} = -8720\,J$

$39.1 + 16 + 1 = 56\,g$ } $\frac{56\,g}{1\,mol}$

iii) $n_{sub} = 0.648\,g \times \frac{1\,mol\,KOH}{56\,g} = 0.1157\,mol\ KOH$

iv) $\Delta H = \frac{Q}{n} = \frac{-8720\,J}{0.1157\,mol} = -75\,\frac{kJ}{mol}$ (2sf)

3) i) $Q = mc\Delta T$

$= \left(2.5\,\cancel{kg} \times \frac{1000\,g}{1\,\cancel{kg}}\right)\left(\frac{4.19\,J}{g\cdot\cancel{°C}}\right)(26°C - 20.7°C)$

$= 59707.5\,J \rightarrow 6\ \text{sf}\ \ 59.7\,kJ$

ii) $Q_{sub} = -59.7\,kJ$

$12\times10 = 120$, $1\times8 = 8$ } $128\,g/1\,mol$

iii) $1.44\,g\ C_{10}H_8 \times \frac{1\,mol}{128\,g} = 0.01125\,mol\ C_{10}H_8$

iv) $\Delta H = \frac{Q}{n} = \frac{-59.7\,kJ}{0.01125\,mol} = -5300\,\frac{kJ}{mol} = \Delta H$

4) i) $Q = mc\Delta T = \left(160\,L \times \frac{1000\,mL}{1\,L} \times \frac{1\,g}{1\,mL}\right)\left(\frac{4.19\,J}{g\cdot°C}\right)(90°C - 25°C)$

$= 435760\,J \rightarrow 436\,000\,J$

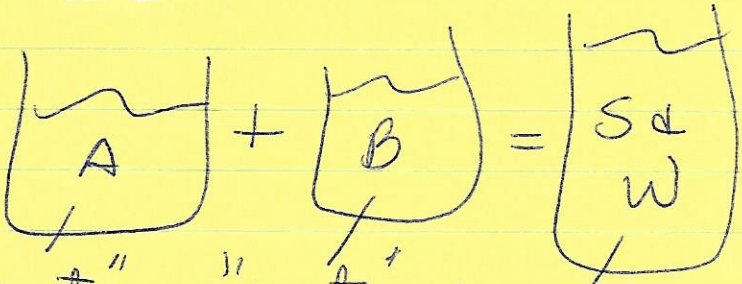
ii) $Q_{sub} = -436\,000\,J$

iii) $n_{sub} = ?n \times \frac{\Delta H}{\Delta H} = \frac{Q}{n} \times \frac{n}{\Delta H}$ $\quad n = \frac{Q}{\Delta H} = \frac{-436000\text{J}}{-890500\text{J}/\text{mol}} = 490.\text{ mol}$

iv) $\Delta H = \frac{Q}{n} = -890.5\ \text{kJ/mol} \times \frac{1000\text{J}}{1\ \text{kJ}} = -890500\text{J/mol}$

then $490.\text{ mol } CH_4 \times \frac{16\text{g } CH_4}{1\text{ mol}} = 7840\text{ g } CH_4$

5. $A + B = S + W$



"water" "water" "water"

i) $Q_{water} = (120.0\text{mL} \times \frac{1\text{g}}{1\text{mL}})(4.19\frac{\text{J}}{\text{g}\cdot^\circ\text{C}})(21.1^\circ\text{C} - 18.9^\circ\text{C})$

$= 1106.16\text{J} \rightarrow 1110\text{J}$

ii) $Q_{sub} = -1110\text{J}$

iii) $n_{sub} = 20.0\text{mL A} \times \frac{1.0\text{ mol A}}{1\text{L}} \times \frac{1\text{L}}{1000\text{mL}} = 0.0200\text{ mol HCl}$

iv) $\Delta H = \frac{Q}{n_{Acid}} = \frac{-1110\text{J}}{0.0200\text{ mol}} = -56\frac{\text{kJ}}{\text{mol}} = \Delta H$

ΔH only for A or B not both.