Molar Heat of Reaction

Textbook, p. 195

1. *a)* $HClO_{3(s)} \rightarrow H^{+}_{(aq)} + ClO_3^{-}{}_{(aq)}$ Exothermic

   b) $HI_{(g)} \rightarrow H^{+}_{(aq)} + I^{-}_{(aq)}$ Exothermic

   c) $KNO_{3(s)} \rightarrow K^{+}_{(aq)} + NO_3^{-}{}_{(aq)}$ Endothermic

   d) $CuSO_{4(s)} \rightarrow Cu^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$ Exothermic

   e) $Li_2CO_{3(s)} \rightarrow 2Li^{+}_{(aq)} + CO_3^{2-}{}_{(aq)}$ Exothermic

p 195.

#2) $\Delta H_d = ?$ KJ/mol

$m_{H_2O} = 20g$

$\Delta H = 50°C$

$m_{NaOH} = 4g$

① Determine quantity of heat transfered to water

$Q = mc\Delta T$

$Q = 20(4.18)(50)$

$Q = 4180$ J ← (+) value means heat absorbed

② Since heat was absorbed by water than the dissolution of 4g of NaOH must have released this heat!

$\Delta H_d = -Q$

$\Delta H_d = -4180$ J

③ To determine molar heat we must first determine how many moles of NaOH we are dealing with.

$n = \frac{m}{M}$ $n = \frac{4g}{40g/mol} = 0.1$ mole

④ Determine heat involved for 1 mol of dissolution of NaOH

$-4180\,J = 0.1\,mol$

$x = 1\,mole$

$x = -41800$ J ← for 1mole

⑤ $\Delta H_d = -41800$ J/mole

÷1000

$\Delta H_d = -41.8$ KJ/mol (EXO)

#3) $m_{KClO_3} = 24.42\,g$

$m_{H_2O} = 1\,Kg = 1000\,g$

$\Delta T = -2\,^{\circ}C$

$\Delta H_d = ?\ KJ/mol$

(1) Determine Quantity of heat transfered to water

$Q = mC\Delta T$

$Q = (1000)(4.18)(-2)$

$Q = -8368\ J$ ← (-) value means heat released by water

(2) Since heat was released by water than the dissolution of 24.42g of $KClO_3$ must have absorbed this heat

$\Delta Hd = -Q$

$\Delta H_d = -(-8368)$

$\Delta Hd = 8368\ J$

(3) To determine molar heat we must first determine how many moles of $KClO_3$ we are dealing with.

($M_{KClO_3} = 122.5$ g/mol) $n = \frac{m}{M}$ $n = \frac{24.42}{122.5} = 0.199$ moles

(6) Write dissolution equation:

$KClO_{3(s)} + 42\ KJ/mol \rightarrow K^+_{(aq)} + ClO_3^-{}_{(aq)}$

(4) Determine heat involved for 1mole of dissolution of $KClO_3$.

$\begin{array}{ccc} 0.199\ \text{moles} & = & 8368\ J \\ 1\ \text{mole} & = & x \end{array}$

$x = 42050\ J$ ← for 1 mole

(5) $\Delta H_d = 42050\ J/mol$

$\div 1000$

$\Delta H_d = 42\ KJ/mol$ (ENDO)

#11)

$m_{KOH} = 250mL$

$m_{HNO_3} = 250mL$

$m_{H_2O} = 500mL$
(from neutralization)

$C_{KOH} = 0.5 mol/L$

$C_{HNO_3} = 0.5 mol/L$

$T_i = 23.5°C$
$T_f = 27°C$
$\Delta T = 3.5°C$

$\Delta H_n = ?$ KJ/mole

① Calculate heat transfered to/from water

$Q = mC\Delta T$

$Q = 500(4.18)(3.5)$

$Q = 7315 J$ ← (+) value means heat absorbed by water

② Since heat was absorbed by water during neutralization, than the neutralization must have released this heat!

$\Delta H_n = -Q$

$\Delta H_n = -7315 J$

③ Since both the acid and the base have same volumes and concentrations we can use the info from either to calculate the number of moles we are dealing with.

$C = \frac{n}{V}$ $\quad 0.5 = \frac{n}{0.25L}$ $\quad n = 0.125$ moles

④ Determine heat involved for 1 mole of acid or base in neutralization:

$$\begin{array}{ccc} 0.125 \text{ moles} & = & -7315 J \\ 1 \text{ mole} & = & x \end{array}$$

$x = -58520 J$ ← for 1 mole

⑤ $\Delta H_n = -58520 J/mole$
$\div 1000$

$\Delta H_n = -58.52$ KJ/mol

#5) Salt = ???

$n = 1 \text{ mole}$

$m_{H_2O} = 1000 mL = 1000 g$

$\Delta T = -5.5\,^{\circ}C$

(Refer to P.420 of text)

① Determine quantity of heat transfered to/from water

$Q = mc\Delta T$

$Q = 1000(4.18)(-5.5)$

$\underline{Q = -22990 \text{ J}}$ ← (−) value means heat released

② Since heat was released by water than the dissolution of 1 mol of the salt must have absorbed heat.

$\Delta H_d = -Q$

$\Delta H_d = -(-22990)$

$\underline{\Delta H_d = 22990 \text{ J}}$

③ Since 22990 J of heat was absorbed when 1 mole of salt was dissolved, then the molar heat of dissolution is:

$\Delta H_d = 22990 \text{ J/mol}$

$\div 1000$

$\underline{\underline{\Delta H_d = 22.99 \text{ KJ/mole}}}$

④ Refer to P.420 of text:

$\Delta H_d = 22.99 \text{ KJ/mol} = \underline{\underline{AgNO_3}}$

Unknown salt

#6) GET READY TO WORK! BACKWARDS.

$m_{CuSO_4} = 8g$

$m_{H_2O} = 100g$

$T_i = 20°C$

$T_f = ???$

$\Delta H_{d\ (CuSO_4)} = -68\ kJ/mole$ ← TEXT BOOK

$M_{CuSO_4} = 159.6\ g/mol$

① Refer to P.420 of text for $\Delta H_{d\ (CuSO_4)}$

$\Delta H_{d\ (CuSO_4)} = -68\ kJ/mol$

or

$\Delta H_{d\ (CuSO_4)} = -68000\ J/mol$

② Find # of moles of $CuSO_4$

$n = \frac{m}{M}$ $n = \frac{8}{159.6}$ $n = 0.05$ moles

③ Determine the heat released during the dissolution of 0.05 moles (8g) of $CuSO_4$

$1\ mole = -68000\ J$

$0.05\ moles = x$

$x = -3400\ J$ ← heat released during dissolution

④ If dissolution reaction released energy, then the surrounding water absorbed this heat.

$Q = -\Delta H_d$

$Q = -(-3400)$

$Q = 3400\ J$ ← energy absorbed by water

→

(5) Calculate temperture change (ΔH) of water

$$Q = mC\Delta T$$

$$3400 = 100(4.18)\Delta T$$

$$\frac{3400}{100(4.18)} = \Delta T$$

$$8.1°C = \Delta T$$

(6) Calculate temperture final of water

$$\Delta T = T_f - T_i$$

$$8.1 = T_f - 20$$

$$T_f = 28.1\ °C$$

#8)

$m_{KOH} = ???$

$m_{H_2O} = 100g$

$T_i = 25°C$
$T_f = 80°C$
$\Delta T = 55°C$

$M_{KOH} = 56 g/mol$

① Determine Quantity of heat transfered to/from water

$Q = mc\Delta T$

$Q = (100)(4.18)(55)$

$Q = 22990\ J$ ← (+) value means heat absorbed

② Since Water absorbed heat, then dissolution of KOH must have released heat.

$\Delta H_d = -Q$

$\Delta H_d = -22990\ J$

(however we still don't know how much KOH it took release this heat)

③ Refer to P. 420 of text for ΔH_d of KOH.

$\Delta H_{d\ (KOH)} = -55\ kJ/mole$

or

$\Delta H_{d\ (KOH)} = -55000\ J/mole$

④ Determine how many moles of KOH were used in our dissolution.

$1 mole = -55000\ J$

$x = -22990\ J$

$x = 0.42$ moles of KOH

⑤ Determine mass of KOH

$n = \frac{m}{M}$ $0.42 = \frac{m}{56}$ $m = 56(0.42)$

$m = 23.5g$

#10)

$C_{NaNO_3} = 0.1\ mol/L$

$V_{NaNO_3} = 2L$

$m_{H_2O} = 2L = 2000g$

$\Delta H_{d\ NaNO_3} = 21\ kJ/mole$

$T_i = 24°C$

$T_f = ???$

(1) Determine # of moles of $NaNO_3$

$0.1\ mole = 1L$

$x = 2L$

$x = 0.2\ moles$ of $NaNO_3$

(2) Refer to P. 420 of text for molar heat of $NaNO_3$

$\Delta H_{d\ NaNO_3} = 21\ KJ/mole$

or

$\Delta H_{d\ NaNO_3} = 21000\ J/mole$

(3) Determine the heat for the dissolution of 0.2 moles of $NaNO_3$.

$1\ mole = 21000\ J$

$0.2\ moles = x$

$x = 4200\ J$ ← (+) value means heat absorbed

(4) Since dissolution reaction absorbed heat, then the surrounding water must have released heat!

$Q = -\Delta H_d$

$Q = -4200\ J$

→

(5) Determine temperture change (ΔT)

$$Q = mc\Delta T$$

$$-4200 = 2000(4.18)\Delta T$$

$$\frac{-4200}{2000(4.18)} = \Delta T$$

$$-0.5°C = \Delta T$$

(6) Determine final temperture (T_f)

$$\Delta T = T_f - T_i$$

$$-0.5 = T_f - 24$$

$$T_f = 23.5°C$$