Heat of Dissolution/Neutralization Extra Practice: name: SOLUTIONS

1) Daniel wants to determine the molar heat of dissolution of zinc sulfate ($ZnSO_4$). He dissolves 7g of zinc sulfate in 175mL of water that is at 22°C. Once the salt dissolves completely the temperature of the water reaches 26.6°C.
   a) Calculate the molar heat of dissolution of zinc sulfate.
   b) Write the thermochemical equation for the dissolution of $ZnSO_4$.

Given:

$M_{ZnSO_4} = 161.5\ g/mol$

$m_{ZnSO_4} = 7g$

$C_{water} = 4.18$

$m_{water} = 175g$

$T_i = 22°C$, $T_f = 26.6°C$ } $\Delta T = 4.6°C$

$\Delta H_d = ???$

① $Q = mc\Delta T$

$Q = 175(4.18)(4.6)$

$Q = 3365\ J$

② $H_d = -Q$

$H_d = -3365\ J$

③ $n = \frac{m}{M}$

$n = \frac{7}{161.5}$

$n = 0.0433\ moles$

④ $\frac{0.0433\ moles}{1\ mole} = \frac{-3365\ J}{x}$

$x = -77635\ J$

⑤ $-77635\ J/mol \div 1000$

$\Delta H_d = -77.6\ kJ/mol$

2) Given that the molar heat of dissolution for silver nitrate ($AgNO_3$) is 23 kJ/mol. What mass of silver nitrate can be dissolved in 500mL if the temperature of the water decreases by -22°C ?

Given:

$\Delta H_d = 23\ kJ/mol$

$C_{water} = 4.18$

$m_{H_2O} = 500g$

$\Delta T = -22°C$

$m_{AgNO_3} = ???$

$M_{AgNO_3} = 169.9\ g/mol$

① $Q = mc\Delta T$

$Q = 500(4.18)(-22)$

$Q = -41800\ J$

② $H_d = -Q$

$H_d = +41800\ J$

③ $23\ kJ/mol$

$=$

$23000\ J/mol$

④ $\frac{23000\ J}{41800\ J} = \frac{1\ mol}{x}$

$x = 1.82\ moles$

⑤ $n = \frac{m}{M}$

$1.82 = \frac{m}{169.9}$

$m = 309g$

3) Paulie neutralizes 80mL of sodium hydroxide (NaOH) with 80mL of Acetic acid (CH_3COOH). Both the acid and base have a concentration of 1.25mol/L. During the neutralization it is observed that the temperature has risen from 22.3°C to 28.5°C. Calculate the molar heat of neutralization of the acetic acid.

Given:

$C_{CH_3COOH} = 1.25\ mol/L$

$V_{CH_3COOH} = 80mL$

$m_{H_2O} = 80mL + 80mL = 160mL\ (160g)$

$C_{H_2O} = 4.18$

$T_i = 22.3$, $T_f = 28.5$ $\}\ \Delta T = 6.2°C$

$\Delta H_n = ??$

① $Q = mc\Delta T$

$Q = 160(4.18)(6.2)$

$Q = 4165\ J$

② $H_n = -Q$

$H_n = -4165\ J$

③ $C = \frac{n}{V}$ $\quad n = 0.1\ moles$ (of acedic acid)

$1.25 = \frac{n}{0.08}$

④ $0.1\ moles = -4165\ J$

$1\ mole = x$

$x = -41650\ J/mole$

⑤ $-41650\ J/mol \div 1000$

$\Delta H_n = -41.6\ KJ/mol$

4) An acid and a base initially have a temperature of 25°C. If 400mL of the acid at 0.5mol/L was added to 200mL of the base at 1.3mol/L, what would be the final temperature attained of the mixture, if the molar heat of neutralization of the acid is -100 kJ/mol ?

Given:

$C_{acid} = 0.5\ mol/L$

$V_{acid} = 400mL$

~~$C_{Base} = 1.3mol/L$~~

$V_{Base} = 200mL$

$m_{water} = 400 + 200 = 600mL\ (600g)$

$C_{H_2O} = 4.18$

$\Delta H_{n\ Acid} = -100\ KJ/mol$

$T_i = 25°C$

$T_f = ???$

① $C = \frac{n}{V}$ $\quad 0.5 = \frac{n}{0.4}$

$n = 0.2\ moles\ of\ Acid$

② $-100\ KJ/mol = -100000\ J/mol$

③ $-100000\ J = 1\ mol$

$x = 0.2\ mol$

$x = -20000\ J$

④ $H_n = -Q$

$Q = +20000\ J$

⑤ $Q = mc\Delta T$

$20000 = 600(4.18)\Delta T$

$\Delta T = 7.97\ °C$

⑥ $\Delta T = T_f - T_i$

$7.97 = T_f - 25$

$T_f = 32.97°C$

$T_f = 33°C$

5) A 100mL solution of H_3PO_4 has an unknown concentration. It is neutralized with 250mL of base with a concentration of 0.75mol/L. The temperature of the water solution produced increases from 22°C to 27.5°C. What was the concentration of the H_3PO_4 solution used if it has a molar heat of neutralization of –57kJ/mol.

Given:

$V_{H_3PO_4} = 100mL\ (0.1L)$

$C_{H_3PO_4} = ???$

$m_{H_2O} = 100 + 250 = 350g$

$T_i = 22°C$, $T_f = 27.5°C$ $\}\ \Delta T = 5.5°C$

$\Delta H_n = -57\ KJ/mol$

① $Q = mc\Delta T$

$Q = 350(4.18)(5.5)$

$Q = 8047\ J$

② $H_n = -Q$

$H_n = -8047\ J$

③ $-57\ KJ/mole = -57000\ J/mol$

④ $-57000\ J = 1\ mol$

$-8047\ J = x$

$x = 0.141\ moles$

⑤ $C_{H_3PO_4} = \frac{n}{V}$

$C = \frac{0.141\ moles}{0.1\ L} = 1.41\ mol/L$