Fossum
Chem 1A

Answers - Calorimetry Practice Problems

1. 5.000 g NH_3 + excess O_2, CH_4 — bomb - constant V, so ΔE will be obtained

find ΔH, ΔE for

$$2NH_{3(g)} + 3O_{2(g)} + 2CH_{4(g)} \rightarrow 2HCN_{(g)} + 6H_2O_{(l)}$$

$\frac{q_v}{x \text{ mol LR}} = \Delta E$ $\quad q_{cal} = C\Delta T$ $\quad \Delta T = 33.90 - 19.77 =$

$q_{cal} = (15.48 \text{ kJ}/°C)(14.13°C)$ $\quad \Delta T = 14.13$ °C

$q_{cal} = 218.7324$ kJ

$q_{rxn} = -q_{cal} = -218.7324$ kJ

We want: energy per 2 mol NH_3. (ΔE)

$$(5.000 \text{ g } NH_3)\left(\frac{1 \text{ mol } NH_3}{17.034 \text{ g } NH_3}\right) = 0.293530585 \text{ mol } NH_3$$

$$\frac{-218.7324 \text{ kJ}}{0.293530585 \text{ mol } NH_3} = -745.1775 \frac{\text{kJ}}{\text{mol } NH_3} \quad \frac{\times 2}{\times 2} = \frac{-1490. \text{ kJ}}{2 \text{ mol } NH_3}$$

So... ΔE = −1490. kJ

to find ΔH, need w_p $\quad \Delta E = q + w \quad \Delta E = \Delta H + w_p$

$w_p = -\Delta n_{gas} RT$

$\Delta n_{gas} = (\text{prod} - \text{react}) = (2) - (2+3+2) = -5$ mol gas

$w_p = -(-5 \text{ mol})(8.314 \text{ J/mol·K})(307.05 \text{ K}) = +12764$ J

w is ⊕ compression: more → less gas $\quad$ final T + 273.15 $\quad$ or ÷1000 → 12.764 kJ w_p

$\Delta H = \Delta E - w_p = -1490. \text{ kJ} - 12.764 \text{ kJ} = -1502.76$ kJ

ΔH = −1503 kJ

2. $Zn_{(s)} + 2HBr_{(aq)} \longrightarrow ZnBr_{2\,(aq)} + H_{2\,(g)}$

Styrofoam cup - open to the atmosphere   heat $q \Rightarrow \Delta H$

find LR $\Delta H = \dfrac{q_p}{x \text{ moles LR}}$

$$\left(0.7240\,g\,Zn\right)\left(\frac{1\text{ mol Zn}}{65.39\,g\,Zn}\right) = 0.0110\bar{7}2\text{ mol Zn}$$

$$\left(0.07500\,L\right)\left(\frac{0.8000\text{ mol HBr}}{L}\right) = 0.06000\text{ mol HBr}$$

Need: $\dfrac{2\text{ HBr}}{1\text{ Zn}}$ Have: $\dfrac{0.06000\text{ mol HBr}}{0.0110\bar{7}2\text{ mol Zn}} = 5.4\ \dfrac{\text{HBr}}{1\text{ Zn}}$ extra HBr so Zn is LR

$q_{rxn} = -q_{solution}$ $\Delta T = 25.08 - 19.81 = 5.27°C$

$q_{solution} = Cm\Delta T$ assume d solution = d water and C solution = C water

$$q_{solution} = \left(4.184\ \text{J/g°C}\right)\left(\underset{\text{solution}}{75.00g} + \underset{\text{Zn}}{0.7240g}\right)\left(5.27°C\right)$$

$q_{solution} = 16\bar{6}9.69\text{ J}$

$q_{rxn} = -16\bar{6}9.69\text{ J}$

$$\Delta H = \frac{q_{rxn}}{x\text{ moles LR}} = \frac{-16\bar{6}9.69\text{ J}}{0.0110\bar{7}2\text{ mol Zn}} = -15\bar{0}802.9\text{ J/mol Zn}$$

$\Delta H = -151$ kJ/mol Zn

so $\Delta H = -151$ kJ

to get ΔE, we need w.

$\Delta E = q + w = \Delta H + w_p$

$w = -\Delta n_{gas}RT$ $\Delta n_{gas} = (1 - 0) = 1$ mol

$w = -(1\text{ mol})(8.314\text{ J/mol·K})(298.23\text{ K}) = -247\bar{9}.484\text{ J}$

($298.23 = 25.08 + 273.15$)   or $-2.47\bar{9}484$ kJ

$W = -2.479$ kJ

W is ⊖

gas is produced - expansion

$$\Delta E = \Delta H + w_p = -15\bar{0}.8\text{ kJ} - 2.479\text{ kJ} = -15\bar{3}.279\text{ kJ}$$

$\Delta E = -153$ kJ