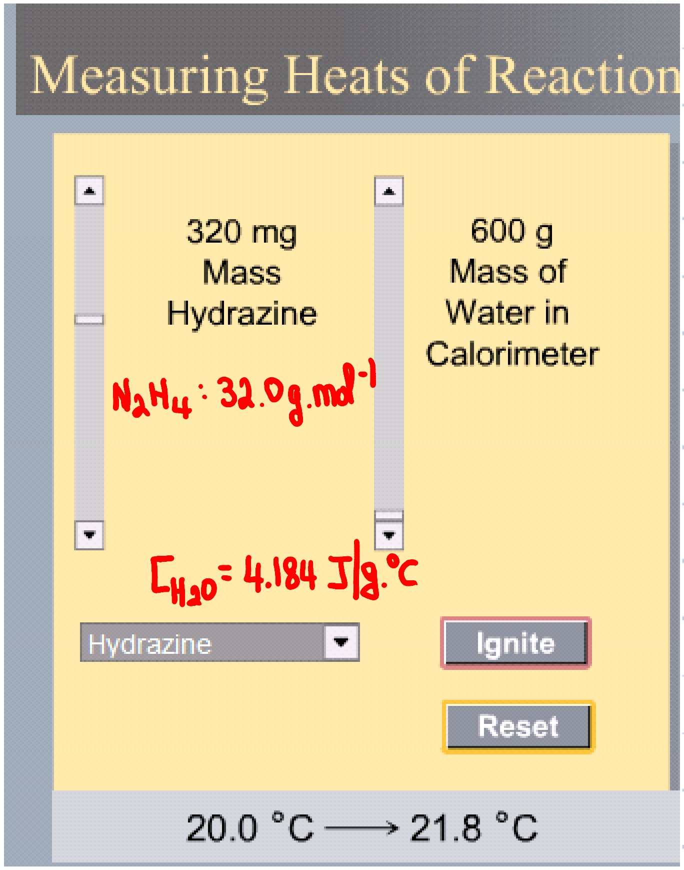
Announcements – Lecture XX I– Monday, June 23rd

1. **Final Lab:** Tuesday, June 25th, ISB 155 (A-C)
   (Pre-Lab Quiz – TA Evaluation in Class Owls)

2. **Exam III:** Friday, June 27th, In Class
   3 or 4 questions will be taken from Lab Owls:-
   3.4 , 4.2 , 4.5 , 5.5 , 5.6

C: Determining Enthalpy Change – Calorimetry – 1st Approximation



N_2H_4 : 32.0 g.mol^{-1}

C_{H_2O} = 4.184 J/g.°C

$\Delta T = 21.8 - 20.0 = 1.8°C$

$q_{H_2O} = m \times C \times \Delta T$

$= 600 \times 4.184 \times 1.8 = 4.52 \times 10^3$ J

Σq's $= 0$: $q_{RXN} + q_{H_2O} = 0$

$q_{RXN} = -q_{H_2O}$

$= -4.52 \times 10^3$ J

$\frac{320 \text{ mg}}{} \Big| \frac{1 \text{ g}}{1000 \text{ mg}} = 0.32$ g

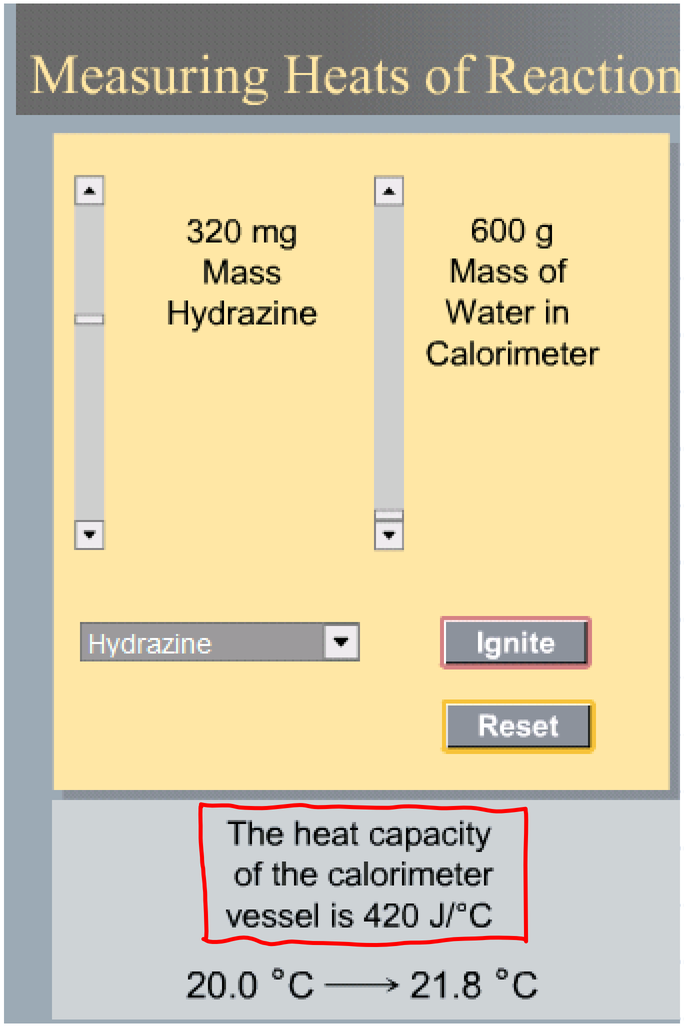
$\frac{0.32 \text{ g}}{} \Big| \frac{1 \text{ mol}}{32.0 \text{ g}} = 0.01$ mol

$q_{RXN} = \frac{-4.52 \times 10^3 \text{ J}}{0.01 \text{ mol}} = -4.52 \times 10^5$ J.mol^{-1}

OR

-452 kJ.mol^{-1}

C: Determining Enthalpy Change – Calorimetry – Modified



$q_{H_2O} = 4.52 \times 10^3$ J … see previous slide

$q_{cal} = m \times C \times \Delta T$

↳ Calorimeter Constant

"Heat capacity of the calorimeter

$= 420$ J/°C $\times 1.8$°C $= 756$ J

$\Sigma q\text{'s} = 0$

$q_{RXN} + q_{H_2O} + q_{cal} = 0$

$q_{RXN} = -(q_{H_2O} + q_{cal})$

$= -(4.52 \times 10^3 + 756)$

$= -5.27 \times 10^3$ J

$q_{RXN} = \dfrac{-5.27 \times 10^3 \text{ J}}{0.01 \text{ mol}} = -5.27 \times 10^5 \text{ J.mol}^{-1}$

OR

-527 kJ.mol^{-1}

↑ (0.01 mol) see previous slide

Quiz 17 Class #: ____ Last Name: ______________________

A chunk of silver weighing 19.7 grams and originally at 97.48°C is dropped into an insulated cup containing 76.6 grams of water at 23.38°C. Assuming that all of the heat is transferred to the water, the final temperature of the water is: 24.44 °C

Heat Capacity : H_2O = 4.184 J/g°C Ag = 0.237 J/g°C

$q_{H_2O} = m \times C \times \Delta T$

$= 76.6 (4.184) \Delta T$

$= 320.49 (T_f - 23.38)$

$= 320.49 T_f - 7493.16$

$q_{Ag} = m \times C \times \Delta T$

$19.7 (0.237) \Delta T$

$4.6689 (T_f - 97.48)$

$4.6689 T_f - 455.12$

$\Sigma q\text{'s} = 0$

$q_{H_2O} + q_{Ag} = 0$

$320.49 T_f - 7493.16 + 4.6689 T_f - 455.12 = 0$

$325.16 T_f - 7948.28 = 0$

$325.16 T_f = 7948.28$

$T_f = \frac{7948.28}{325.16} = 24.44°C$

5.4 Enthalpy Changes and Chemical Reactions

C: Determining Enthalpy Change – Calorimetry

A **0.242g** sample of napthalene ($C_{10}H_8$) is burned in a bomb calorimeter containing **1025g** of water. How much will the temperature rise

Heat capacity of the calorimeter = 802 J/°C
Heat of combustion $C_{10}H_8$ = -5.15x10³ kJ/mol
Heat capacity of water = 4.184 J/g.°C

$C_{10}H_8$: $10(12.01) + 8(1.01) = 128.18\,g.mol^{-1}$

$$\frac{0.242g \;|\; 1\,mol}{\;|\; 128.18g} = 1.89\times10^{-3}\,mol$$

$q_{RXN} = -5.15\times10^{6}\,J.mol^{-1}\,(1.89\times10^{-3}\,mol)$
$= -9.72\times10^{3}\,J$

$q_{RXN} + q_{H_2O} + q_{cal} = 0$

$q_{H_2O} + q_{cal} = -q_{RXN} = 9.72\times10^{3}\,J$

$q_{H_2O} = m \times C \times \Delta T$
$= 1025 \times 4.184 \times \Delta T = 4.29\times10^{3}\,\Delta T$

$q_{cal} = 802\,\Delta T$

$q_{H_2O} + q_{cal} = 9.72\times10^{3}$

$4.29\times10^{3}\,\Delta T + 802\,\Delta T = 9.72\times10^{3}$
$5.09\times10^{3}\,\Delta T = 9.72\times10^{3}$
$\Delta T = \frac{9.72\times10^{3}}{5.09\times10^{3}} = 1.91°C$

5.5 Hess's Law

A: Hess's Law

Given the standard enthalpy changes for the following two reactions:

(1) $2\,Pb(s) + O_2(g) \longrightarrow 2\,PbO(s)$ $\Delta H° = -434.6$ kJ

(2) $Pb(s) + Cl_2(g) \longrightarrow PbCl_2(s)$ $\Delta H° = -359.4$ kJ

what is the standard enthalpy change for the reaction:

(3) $2\,PbCl_2(s) + O_2(g) \longrightarrow 2\,PbO(s) + 2\,Cl_2(g)$ $\Delta H° = ?$

2... x2 + Reversed $2\,PbCl_2(s) = 2\,Pb(s) + 2\,Cl_2(g)$ $\Delta H° = -2(-359.4)$

1... as is $2\,Pb(s) + O_2(g) = 2\,PbO(s)$ $\Delta H° = -434.6$

$2\,PbCl_2(s) + O_2(g) = 2\,PbO(s) + 2\,Cl_2(g)$ $\Delta H° = 284.2$ kJ

Hess's Law:

Reverse a Reaction ... Reverse the sign of $\Delta H°$.

Multiply Reaction by an integer ... Multiply $\Delta H°$ by the integer.

Add two or more Reactions ... Add up the $\Delta H°$'s of each.

5.5 Hess's Law

A: Hess's Law

Given the standard enthalpy changes for the following two reactions:

(1) $Ni(s) + Cl_2(g) \longrightarrow NiCl_2(s)$ $\Delta H° = -305.3$ kJ

(2) $Pb(s) + Cl_2(g) \longrightarrow PbCl_2(s)$ $\Delta H° = -359.4$ kJ

what is the standard enthalpy change for the reaction:

(3) $Ni(s) + PbCl_2(s) \longrightarrow NiCl_2(s) + Pb(s)$ $\Delta H° = ?$

1. as is — $Ni(s) + Cl_2(g) = NiCl_2(s)$ $\Delta H° = -305.3$
2. Reversed — $PbCl_2(s) = Pb(s) + Cl_2(g)$ $\Delta H° = 359.4$

$Ni(s) + PbCl_2(s) = NiCl_2(s) + Pb(s)$ $\Delta H° = 54.1$ kJ

$\Delta H°_{RXN} = \Delta H°_1 - \Delta H°_2$

5.6 Standard Heats of Reaction

A: Standard Heat of Formation

ΔH_f^o: The standard molar enthalpy of formation is the enthalpy change for the formation of 1 mole of a compound from its elements in their standard states.

$\Delta H_f^o\ CH_4(g) = -74.9\ kJ.mol^{-1}$ $\qquad C(gr) + 2H_2(g) = CH_4(g)$

$\Delta H_f^o\ NiCl_2(s) = -305\ kJ.mol^{-1}$ $\qquad Ni(s) + Cl_2(g) = NiCl_2(s)$

$\Delta H_f^o\ PbCl_2(s) = -359\ kJ.mol^{-1}$ $\qquad Pb(s) + Cl_2(g) = PbCl_2(s)$

$\Delta H_f^o\ Cl_2(g) = 0$ $\qquad Cl_2(g) = Cl_2(g)$

→ The ΔH_f^o for the formation of any element in its standard state is zero

5.6 Standard Heats of Reaction

A: Standard Heat of Formation and Hess's Law

Given the standard enthalpy changes for the following two reactions:

(1) $Ni(s) + Cl_2(g) \longrightarrow NiCl_2(s)$ $\Delta H° = -305.3$ kJ $\Delta H_f^{\circ}\ NiCl_2(s)$

(2) $Pb(s) + Cl_2(g) \longrightarrow PbCl_2(s)$ $\Delta H° = -359.4$ kJ $\Delta H_f^{\circ}\ PbCl_2(s)$

what is the standard enthalpy change for the reaction:

(3) $Ni(s) + PbCl_2(s) \longrightarrow NiCl_2(s) + Pb(s)$ $\Delta H° = ?$

$Ni(s)$: $\Delta H_f^{\circ} = 0$; $Pb(s)$: $\Delta H_f^{\circ} = 0$

1. As is: $Ni(s) + Cl_2(g) = NiCl_2(s)$ $\Delta H° = -305.3$
2. Reversed: $PbCl_2(s) = Pb(s) + Cl_2(g)$ $\Delta H° = 359.4$

$Ni(s) + PbCl_2(s) = NiCl_2(s) + Pb(s)$ $\Delta H° = 54.1$ kJ

$\Delta H^{\circ}_{RXN} = \Delta H^{\circ}_1 - \Delta H^{\circ}_2$

$\Delta H^{\circ}_{RXN} = \Sigma \Delta H_f^{\circ}\ Products - \Sigma \Delta H_f^{\circ}\ Reactants$?

$\Delta H^{\circ}_{RXN} = \Delta H_f^{\circ}\ NiCl_2(s) + \Delta H_f^{\circ}\ Pb(s) - \Delta H_f^{\circ}\ Ni(s) - \Delta H_f^{\circ}\ PbCl_2(s)$

$\Delta H^{\circ}_{RXN} = \Delta H^{\circ}_1 + 0 - 0 - \Delta H^{\circ}_2$

$\Delta H^{\circ}_{RXN} = \Delta H^{\circ}_1 - \Delta H^{\circ}_2$

$$\Delta H^{\circ}_{RXN} = \Sigma \Delta H_f^{\circ}\ Products - \Sigma \Delta H_f^{\circ}\ Reactants$$

5.6 Standard Heats of Reaction

A: Standard Heat of Formation and Hess's Law

Using standard heats of formation, calculate the standard enthalpy change for the following reaction.

$$2CO_2(g) + 5H_2(g) \longrightarrow C_2H_2(g) + 4H_2O(g)$$

$$\Delta H^\circ_{RXN} = \Sigma \Delta H^\circ_f \text{ Products} - \Sigma \Delta H^\circ_f \text{ Reactants}$$

$$= \Delta H^\circ_f C_2H_2(g) + 4\Delta H^\circ_f H_2O(g) - 2\Delta H^\circ_f CO_2(g) - 5\Delta H^\circ_f H_2(g)$$

$$\hookrightarrow = 0$$

$$= \Delta H^\circ_f C_2H_2(g) + 4\Delta H^\circ_f H_2O(g) - 2\Delta H^\circ_f CO_2(g)$$

Simply look these values up!