Thursday :

1. (2 points) Write the chemical reaction for which $\Delta_r H = 4\Delta_f H(H_2O(l)) - 2\Delta_f H(CH_3OH(g)) + 2\Delta_f H(CO_2(g))$.

$2\ CH_3OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$

2. (3points) The enthalpy of formation of $NH_3(g)$ is -45.9 kJ/mol, the H_2 bond enthalpy is 436 kJ/mol, and the N_2 bond enthalpy is 945 kJ/mol. Calculate the N-H bond enthalpy.

$\frac{1}{2}\ N_2(g) + 3/2\ H_2(g) \rightarrow NH_3(g)$

$$\frac{1}{2}\times\Delta_b H(N\equiv N) + \frac{3}{2}\times\Delta_b H(H\text{-}H) - 3\times\Delta_b H(N\text{-}H) = \Delta_f H(NH_3(g))$$

$$\Delta_b H(N\text{-}H) = \frac{1}{3}\times\left(\frac{1}{2}\times\frac{945kJ}{mol} + \frac{3}{2}\times\frac{436kJ}{mol} - \left(-\frac{45.9kJ}{mol}\right)\right) = 390.5\ \text{kJ/mol}$$

$\Delta_b H(N\text{-}H) = 391$ kJ/mol

3. Below is an enthalpy diagram for the following reaction:

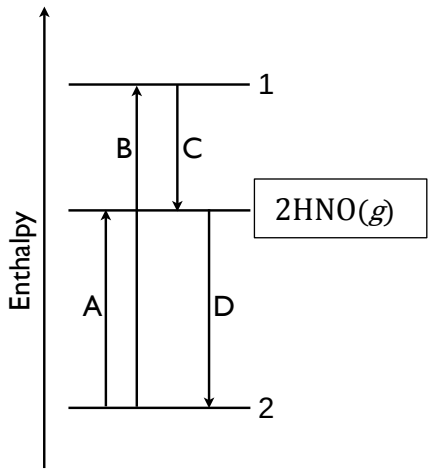
$$2HNO(g) \rightarrow H_2(g) + O_2(g) + N_2(g) \qquad \Delta_r H = -218\ \text{kJ/mol}$$

$$2H\text{-}N{=}O(g) \rightarrow N{\equiv}N(g) + H\text{–}H(g) + O{=}O(g)$$

a. (2 points) Using $HN0(g)$, $H(g)$, $O(g)$, N(g) and their stoichiometric coefficients, fill in the species for the horizontal lines.

1: $2H(g) + 2O(g) + 2N(g)$

2: $H_2(g) + O_2(g) + N_2(g)$



b. (3 points) For the labeled arrows on the diagram above, write the expression for the enthalpy change in terms of **only** bond enthalpies and enthalpies of formation.

A: $2\Delta_f H(HNO(g))$

B: $\Delta_b H(H\text{-}H) + \Delta_b H(O{=}O) + \Delta_b H(N{\equiv}N)$

C: $-2\,\Delta_b H(H\text{-}N) - 2\Delta_b H(N{=}O)$

Friday

1. (2 points) Write the chemical reaction for which

$$\Delta_r H = 3\Delta_f H(H_2O(l)) - \Delta_f H(C_2H_5OH(g)) + 2\Delta_f H(CO_2(g))$$

$$C_2H_5OH(g) + \mathbf{3O_2(g)} \rightarrow 2CO_2(g) + 3H_2O(l)$$

2. (3 points) The enthalpy of formation of $H_2O(g)$ is -241.8 kJ/mol, the H_2 bond enthalpy is 440.0 kJ/mol, and the O_2 bond enthalpy is 498.0 kJ/mol. Calculate the O-H bond enthalpy.

$$\mathbf{½\ O_2(g) + H_2(g) \rightarrow}\ H_2O(g)$$

$$\frac{1}{2} \times \Delta_b H(O{=}O) + \Delta_b H(H\text{-}H) - 2 \times \Delta_b H(O\text{-}H) = \Delta_f H(H_2O(g))$$

$$\Delta_b H(O\text{-}H) = \frac{1}{2} \times \left(\frac{1}{2} \times \frac{498kJ}{mol} + \frac{440kJ}{mol} - \left(-\frac{241.8kJ}{mol}\right)\right) = 465.4\ \text{kJ/mol}$$

$\Delta_b H(O\text{-}H) = 465.4$ kJ/mol

3. Diazene, N_2H_2, is a useful organic reagent. Below is an enthalpy diagram for the following reaction:

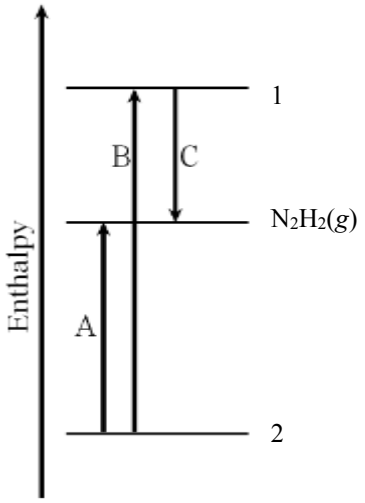
$$N_2H_2(g) \rightarrow N_2(g) + H_2(g) \qquad \Delta_r H = \text{-}200\ \text{kJ/mol}$$

$$H{-}N{=}N{-}H(g) \longrightarrow H{-}H\ (g) + N{\equiv}N(g)$$

a. (2 points) Using $N_2(g)$, $H_2(g)$, $N(g)$, $H(g)$ and their stoichiometric coefficients, fill in the labels for the following horizontal lines.

1: $2H(g) + 2N(g)$

2: $N_2(g) + H_2(g)$



b. (3 points) For the labeled arrows on the diagram above, write the expression for the enthalpy change in terms of **only** bond enthalpies and enthalpies of formation.

A: $\Delta_f H(N_2H_2(g))$

B: $\Delta_b H(H\text{-}H) + \Delta_b H(N{\equiv}N)$

C: $-2\,\Delta_b H(H\text{-}N) - \Delta_b H(N{=}N)$