Today: continue with ch.9 (last day of new material for CK4) November 6th

Thursday: problem club w/ Kendall

Friday: Hess's law & lattice energy review

weekend: prepare for Expt 11
prepare for CK4

Sunday: problem club w/ Kendall

Monday: doors open @ 9:15

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q ← J or kJ extensive (varies from expt to expt)

ΔH universal kJ/mol

$\Delta H \xrightarrow{\div n} q$

$q \xrightarrow{\times n} \Delta H$

What is ΔH?

- Lab measurements
  - coffee cup calorimeter (fast, inexpensive)
    - $q_{cal} = m \cdot c \cdot \Delta T$
      - m → m_{soln}
      - c → $\left(4.184 \frac{J}{g \cdot deg}\right)$
    - $q_{cal} = C_m \cdot n \cdot \Delta T$
      - C_m → $(J/mol \cdot deg)$
  - (expensive) bomb calorimeter
    - q (heat capacity includes H_2O) $* \Delta T$
    - $q = \left(\frac{kJ}{deg}\right) * (deg)$
    - OR
    - $q = q_{empty\ bomb} + q_{H_2O}$
      - $q_{H_2O} = c \cdot m \cdot \Delta T$
    - $=$ heat capacity $* \Delta T + q_{H_2O}$
      - heat capacity → $\left(\frac{kJ}{deg}\right)$
- paper & pencil calcs
  - * look on next page of NOTES!

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

$\Delta H_{rxn} = \frac{q_{rxn}}{n}$

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Paper & Pencil calcs

- use ΔH_f° tables (page A9) (1st choice)
- use bond energies (not quite as good)

What is the heat of formation?

↳ the enthalpy associated with making 1 mole of a substance from its elements under normal conditions.

$\longrightarrow 1 NO_2 \quad \Delta H^\circ$

$\frac{1}{2}N_2(g) + O_2(g) \longrightarrow 1 NO_2 \quad \Delta H^\circ_f = +33.2 \text{ KJ/mol } NO_2$

$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow 1 NO \quad \Delta H^\circ_f = +91.3 \text{ KJ/mol NO}$

$2NO(g) + O_2(g) \longrightarrow 2NO_2(g) \quad \Delta H^\circ_{rxn} =$

Hess's Law (adding equations together)

$2NO(g) \rightarrow \cancel{N_2(g)} + \cancel{O_2(g)} \quad \Delta H^\circ = -182.6 \text{ KJ}$

$\cancel{N_2(g)} + \cancel{2O_2(g)} \longrightarrow 2NO_2 \quad \Delta H^\circ_f = 66.4 \text{ KJ/mol}$

$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \quad \Delta H^\circ_{rxn} = -116.2 \text{ KJ/mol}$

↳ exothermic

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$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $\Delta H°_{rxn} =$ ↳ -116.2 KJ

$\Delta H°_f$: $\frac{91.3\text{ KJ}}{\text{mol NO}}$ $\frac{0\text{ KJ}}{\text{mol } O_2}$ $\frac{33.2\text{ KJ}}{\text{mol } NO_2}$

*coeff. (moles): $*-2\text{ mol NO}$ $*-1\text{ mol } O_2$ $*2\text{ mol } NO_2$

$\Delta H_{rxn} =$ -182.6 KJ $\quad 0 \quad +66.4$ KJ $\quad -116.2$ KJ

Δ = final - initial

products - reactants

write the equation for the heat of formation of calcium phosphate.

$3Ca(s) + 2P(s) + 4O_2(g) \rightarrow 1Ca_3(PO_4)_2 \quad \Delta H°_f = ?$

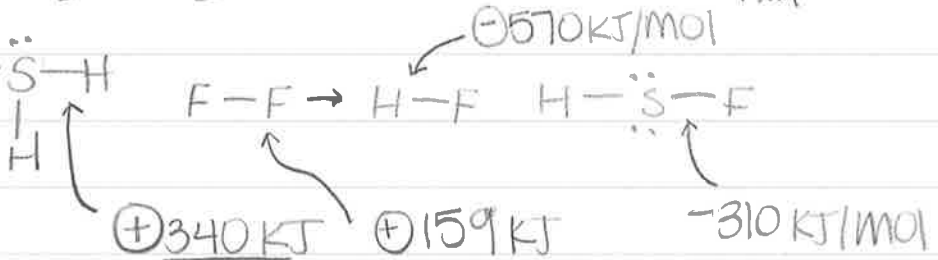
$2NH_3 + 3N_2O \rightarrow 4N_2 + 3H_2O(\ell) \quad \Delta H°_{rxn} = ?$

$\Delta H°_f$: -46.1 KJ/mol $\quad +82$ KJ/mol $\quad 0$ KJ/mol $\quad -286$ KJ/mol

$*-2\text{ mol} \quad *-3\text{ mol} \quad *0\text{ mol} \quad *3\text{ mol}$

$+92.2 \quad -246 \quad 0 \quad -858 \rightarrow \Delta H°_{rxn} = -1011.8$ KJ

$H_2S + F_2 \longrightarrow HF + HSF \quad \Delta H_{rxn} = ?$



add them all up!!!

↳ $= -381$ KJ $= \Delta H_{rxn}$

Chapter 9 Day 2 (Sections 9.8 – 9.10) & Section 6.7 6 November 2019

Table of Heats of Formation, ΔH_f^o,

	ΔH_f^o (kJ/mol):
$CH_4(g)$	-75
$CO(g)$	-111
$H_2O(g)$	-242
$H_2O(l)$	-286
$NH_3(g)$	-46
$NO_2(g)$	+33

1. Write the equation for ΔH_f^o for propanol, C_3H_7OH.

2. Use the ΔH_f^o data to calculate ΔH^o for the reaction:

$2\ CH_4(g) + 3\ O_2(g) \rightarrow 2\ CO(g) + 4\ H_2O(g)$ $\Delta H^o = ?$

3. Calculate the heat of vaporization for water.

$H_2O(l) \rightarrow H_2O(g)$ $\Delta H = ?$

4. Calculate the standard heat of combustion for $NH_3(g)$ (combustion of one mole NH_3) to produce $H_2O(g)$ and $NO_2(g)$. Hint start by calculating ΔH for this equation:

$4\ NH_3(g) + 7\ O_2(g) \rightarrow 4\ NO_2(g) + 6\ H_2O(l)$ $\Delta H^o = ?$

5. Calculate q for a reaction performed in a calorimeter, given that the contents of the calorimeter had a mass of 56.0 g and warmed up 5.2 deg. The contents were mostly water and so assume the specific heat to be 4.18 J/g deg.

6. Use the table of bond dissociation energies in our book (Table 7.2) to estimate ΔH for the gas phase reaction:

$CH_4 + F_2 \rightarrow CH_3F + HF$

7. Calculate the lattice energy $\Delta H_{lattice}$ for calcium hydride,

$CaH_2(s)$: $Ca^{2+}(g) + 2\ H^-(g) \rightarrow CaH_2(s)$ $\Delta H_{lattice} = ?$

You will need these values:

$Ca(s) \rightarrow Ca(g)$ $\Delta H_{sublimation} = +178$ kJ/mol

$Ca(g) \rightarrow Ca^+(g) + e^-$ $E_{i1} = +590$ kJ/mol

$Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ $E_{i2} = +1145$ kJ/mol

$H_2(g) \rightarrow 2\ H(g)$ $E_{bond\ dissociation} = +436$ kJ/mol

$H(g) + e^- \rightarrow H^-(g)$ $E_{electron\ affinity} = -73$ kJ/mol

$Ca(s) + H_2(g) \rightarrow CaH_2(s)$ $\Delta H_f^o = -186$ kJ/mol

Questions in final exam format (multiple choice):

8. How much heat is absorbed/released when 10.00 g of $NH_3(g)$ reacts in the presence of excess $O_2(g)$ to produce $NO(g)$ and $H_2O(l)$ according to:

$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(l)$ $\Delta H^o = -1168$ kJ

A. 171.5 kJ absorbed. B. 171.5 kJ released.

C. 686.0 kJ absorbed. D. 686.0 kJ released.

9. Determine the sign of ΔS^o for the following:

I. $C_6H_6(s) \rightarrow C_6H_6(l)$

II. $2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g)$

A. $\Delta S^o < 0$ for I and > 0 for II. B. $\Delta S^o < 0$ for I and II.

C. $\Delta S^o > 0$ for I and < 0 for II. D. $\Delta S^o > 0$ for I and II.

Now try these problems from the book:

Section 9.8. (Hess's law) Problems 15, 16, 38, 94, and 96

Section 9.9. (Using ΔH_f^o Table) Problems 17, 18, 98 – 116 (even)

Section 9.10. (Bond dissociation energies) Problems 19, 20, 118, and 120

Section 9.11 and 9.12 (Entropy and Free Energy) 21, 22, 23, 24, 40, 42, 126, 130, 132, 134, 138, 140.

Practice Quiz (pg 363): 11 – 15.