Announcements

Wednesday, November 04, 2009

Exam 2 will be returned on Monday

Ch 6 MasteringChemistry due this Friday, Nov 6

Exp 10 lab report due next Monday, Nov 9

Materials lists due in D2L dropbox by 5pm tonight

ΔH and Hess's Law

Thermochemical state functions like ΔH are given for a certain chemical equation, where coefficients = # mol

1. Doubling coefficients doubles ΔH, etc.

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g);\ \Delta H = -483.6\ kJ$

$4\ H_2(g) + 2\ O_2(g) \rightarrow 4\ H_2O(g);\ \Delta H = 2(-483.6\ kJ) = -967.2\ kJ$

$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(g);\ \Delta H = \frac{1}{2}(-483.6\ kJ) = -241.8\ kJ$

2. Reversing an equation changes the sign of ΔH

$6\ H_2O(g) \rightarrow 6\ H_2(g) + 3\ O_2(g);\ \Delta H = -3(-483.6\ kJ) = 1458\ kJ$

3. Adding equations adds their ΔH values

Find ΔH_{rxn} for the following reaction:

$CO(g) + NO(g) \rightarrow CO_2(g) + \frac{1}{2}\ N_2(g);\ \Delta H = ?$

Use the following reactions with known ΔH values:

$CO(g) + \frac{1}{2}\ O_2(g) \rightarrow CO_2(g);\ \Delta H = -283.0\ kJ$

~~$N_2(g) + O_2(g) \rightarrow 2NO(g);\ \Delta H = 180.6\ kJ$~~

$\times -\frac{1}{2}$

$NO(g) \rightarrow \frac{1}{2} N_2(g) + \frac{1}{2} O_2(g)\quad \Delta H = -\frac{1}{2}(180.6\ kJ)$

sum: $CO(g) + NO(g) \rightarrow CO_2(g) + \frac{1}{2} N_2(g)\quad \Delta H = -283.0 - \frac{1}{2}(180.6)$

Hess's Law

sum = $-373.3\ kJ$

Hess's law practice

Find ΔH_{rxn} for the following reaction:

$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g);\ \Delta H = ?$

Use the following reactions with known ΔH values:

1. ~~$N_2(g) + O_2(g) \rightarrow 2\ NO(g);\ \Delta H = 180.6$ kJ~~
2. ~~$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g);\ \Delta H = -91.8$ kJ~~
3. ~~$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g);\ \Delta H = -483.6$ kJ~~

$-2(\#2) = 4NH_3 \rightarrow 2N_2 + 6H_2 \qquad \Delta H = -2(-91.8\ kJ)$

$2(\#1) : 2N_2 + 2O_2 \rightarrow 4NO \qquad \Delta H = 2(180.6\ kJ)$

$3(\#3) : 6H_2 + 3O_2 \rightarrow 6H_2O \qquad \Delta H = 3(-483.6\ kJ)$

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O \qquad \boxed{\Delta H = -906\ kJ}$

Standard enthalpies of formation

Standard thermodynamic states:

- gases: 1 atm
- liquids or solids: most stable form, 1 atm, 25 °C
- solutions: 1 *M* concentration

Some common standard states:

H_2 (g, 1 atm)	Fe (s)	Hg (ℓ)
Cl_2 (g, 1 atm)	Br_2 (ℓ)	I_2 (s)
C(*graphite*) (not C(diamond))		

Standard enthalpy of formation: ΔH_f^o ← standard state

enthalpy change when 1 mol of a compound is formed from its elements in their standard states

Write the chemical equation for ΔH_f^o of NaCl(*s*)

$Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$ heat xfer $= \Delta H_f^o$

elements in standard states

Write the chemical equation for ΔH_f^o of $NH_3(g)$

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

ΔH_f^o for any element in its standard state = 0

Using standard enthalpies of formation

Calculate ΔH^o for the following reaction using standard enthalpies of formation:

standard conditions

$$4\ NH_3(g) + 5\ O_2(g) \longrightarrow 4\ NO(g) + 6\ H_2O(g);\ \ \Delta H^o = ?$$

Compound	ΔH_f^o (kJ/mol)
$NH_3(g)$	-45.9
$O_2(g)$	0
$NO(g)$	90.3
$H_2O(g)$	-241.8

$$\Delta H^o_{rxn} = \Sigma\left[n\ \Delta H_f^o\ (\text{products})\right] - \Sigma\left[n\ \Delta H_f^o\ (\text{reactants})\right]$$

coeff (n); from table (ΔH_f^o)

$= 4\ \text{mol}\ (90.3\ \text{kJ/mol}) + 6\ \text{mol}\ (-241.8\ \text{kJ/mol})$ products

$- [4\ \text{mol}\ (-45.9\ \text{kJ/mol}) + 5\ \text{mol}\ (0\ \text{kJ/mol})]$ reactants

$= -906\ \text{kJ}$