Laney College Chem 30A
Professor Scott Beaver

Homework #8
4/16/2016

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[M2015E3P] 1. How much heat is gained or lost when a) 1 mole and b) 1kg (1000 g) of chlorine gas (Cl_2) reacts in the following equation? Show the correct sign number of significant figures for ΔH. Also state whether the reaction is exothermic or endothermic.

$$2\ Al\ (s) + 3\ Cl_2\ (g) \rightarrow 2\ AlCl_3 + 337\ kcal \qquad \Delta H = -337\ kcal/mol\text{-}rxn$$

a) $(1\ mol\ Cl_2)\left(\frac{1\ mol\ rxn}{3\ mol\ Cl_2}\right)\left(\frac{-337\ kcal}{mol\ rxn}\right) = -112\ kcal$

b) $(1000\ g\ Cl_2)\left(\frac{mol\ Cl_2}{70.90\ g\ Cl_2}\right)\left(\frac{1\ mol\ rxn}{3\ mol\ Cl_2}\right)\left(\frac{-337\ kcal}{mol\ rxn}\right) = -1590\ kcal$

ΔH for 1 mol Cl_2 = −112 kcal

ΔH for 1 kg Cl_2 = −1590 kcal

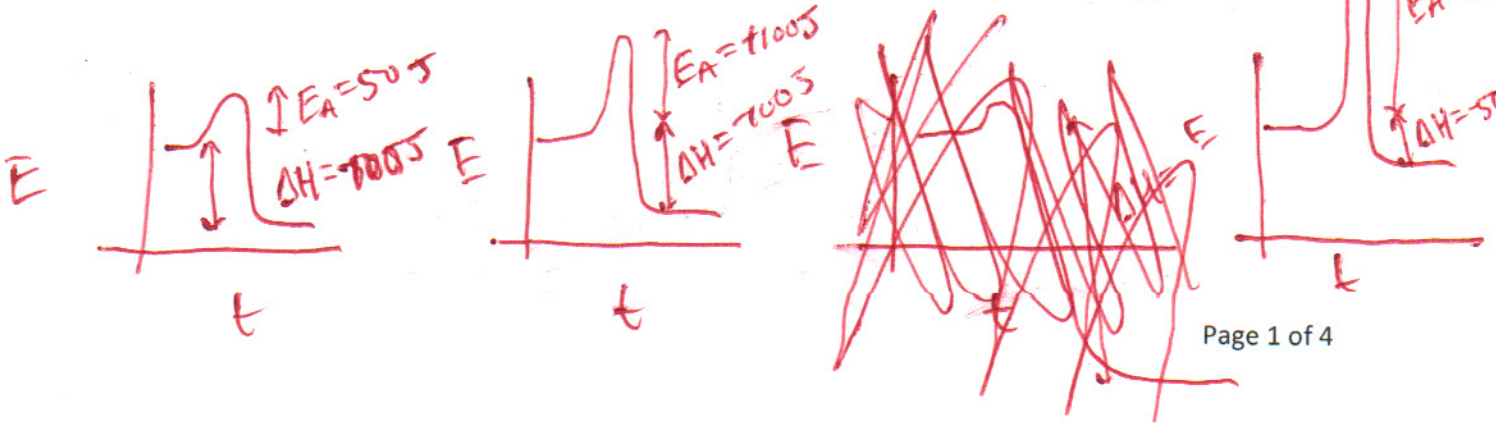
Exothermic or endothermic? Exo, heat produced, ΔH < 0

2. Draw 3 reaction diagrams (energy vs. time) side by side, using the same scale. Label the reactants, products, activation energy, enthalpy change, and both axes.

a) exothermic reaction releasing 100 J of energy with activation energy 50 J.

b) exothermic reaction releasing 100 J of energy with activation energy 100 J.

c) exothermic reaction releasing 50 J of energy with activation energy 200 J.



3. Convert the following units:

a) 4.184 J → cal $(4.184\,J)\left(\frac{1\,cal}{4.184\,J}\right) = 1.000\,cal$ (4 s.f.)

b) 4.184 kJ → kcal $(4.184\,kJ)\left(\frac{1000\,J}{1\,kJ}\right)\left(\frac{1\,cal}{4.184\,J}\right)\left(\frac{1\,kcal}{1000\,cal}\right)$

$= 1.000\,kcal$ 4 s.f.

or, $4.184\,kJ = 1\,kcal$

c) 523 J → Cal (food calories)

$(523\,J)\left(\frac{1\,cal}{4.184\,J}\right)\left(\frac{1\,Cal}{1000\,cal}\right) = 0.125\,Cal$

d) 6.0 Cal → cal

6000 cal or $\frac{6.0 \times 10^3\,cal}{2\,s.f.}$

e) 9000 cal → J

$(9000\,cal)\left(\frac{4.184\,J}{1\,cal}\right) = 40{,}000\,J$ (1 s.f.)

[131 E2P-1] 4. Calculate the heat, in Joules, required for the following

a) heating 25.0 g of water from 20.0 °C to 60.0 °C (c = 4.184 J/°C g for water)

$\Delta H = m C_p \Delta T = (25.0\,g)\left(4.184\,\frac{J}{°C\,g}\right)(40.°C) = 4184\,J$

4180 J 3 s.f.

b) heating 25.0 g water from 60.0 °C to 100.0 °C

same $\Delta T = 40.°C \Rightarrow$ 4180 J

c) heating 25.0 g of water from 20.0 °C to 100 °C

path a) + b) above $= 4184\,J + 4184\,J$

$= 8368\,J$

d) heating 25.0 g copper from 60.0 °C to 100.0 °C (c = 0.385 J/°C g for copper) 8370 J 3 s.f.

$\Delta H = m C_p \Delta T = (25.0\,g)\left(0.385\,\frac{J}{°C\,g}\right)(40.°C) = 385\,J$

e) cooling 25.0 g copper from 20.0 °C to -20.0 °C

$\Delta H = -385\,J$ (negative as d))

Name: _____

5. Use the below expression for Gibbs Free Energy ΔG to determine if water will spontaneously boil at 300K, 350 K, and 400 K. For water, ΔH_{vap} = 40.68 kJ/mol and ΔS_{vap} = 118.89 J/mol·K. Show 3 calculations for ΔG, and watch your units. Indicate as spontaneous or not at each temperature.

$$\Delta G = \Delta H - T\Delta S$$

$\Delta G = 40.68 \frac{kJ}{mol} - (300K)\left(\frac{0.11889\ kJ}{mol\ K}\right)$

$= +5.01$ kJ/mol

spontaneous

$\Delta G = 40.68 \frac{kJ}{mol} - (350K)\left(\frac{0.11889\ kJ}{mol \cdot K}\right)$

$= -0.93$ kJ/mol

$\Delta G = 40.68 \frac{kJ}{mol} - (400K)\left(\frac{0.11889\ kJ}{mol \cdot K}\right)$

$= -6.88$ kJ/mol

$\Delta G(300\ K)$ = _____ Spontaneous? No

$\Delta G(350\ K)$ = _____ Spontaneous? yes

$\Delta G(400\ K)$ = _____ Spontaneous? yes

Name: _____

5. Use the Le Chatlier principle to predict the effects on the below equilibrium.

$$\underbrace{N_2(g) + O_2(g)}_{2\text{ mol gas}} \rightleftharpoons \underbrace{2\,NO(g)}_{2\text{ mol gas}} \quad \Delta H = +43\text{ kcal/mol } (+180\text{ kJ/mol})$$

a. Does the NO level increase, decrease, or stay the same when more O_2 is added?

add O_2, more stress on left, shift right →

[NO↑]

b. What happens to N_2 when more O_2 is added?

add O_2, more stress on left, shift right

[N_2↓]

c. What happens to NO when the total pressure is increased?

Nothing. 2 mol gas ⇌ 2 mol gas.

d. What happens to NO when the temperature is increased?

Heat + N_2 + O_2 ⇌ 2NO endothermic

add heat, shift right, [NO↑] Heat is reactant.

e. What happens to NO when a catalyst is added?

[Nothing] Catalyst affects rate getting to Equilibrium, but not the Equilibrium itself.

6. Write an equilibrium constant expression (capital K) for the above reaction in #5.

$$K = \frac{[NO]^2}{[N_2][O_2]}$$