Thermochemistry Practice

1. Consider the reaction of nitrogen dioxide and water to form aqueous nitric acid and nitrogen monoxide gas.

3NO2(*g*) + H2O(*l*) → 2HNO3(*aq*) + NO(*g*) ΔH° = ?

1. Calculate the ΔH° for this reaction of nitrogen dioxide and water, using the following equations and their ΔH°s. (6 points)

2NO(*g*) + O2(*g*) → 2NO2(*g*) ΔH° = −173kJ

2N2(*g*) + 5O2(*g*) + 2H2O(*l*) → 4HNO3(*aq*) ΔH° = −255 kJ

N2(*g*) + O2(*g*) → 2NO(*g*) ΔH° = 181 kJ

3NO2(*g*) → 3NO(*g*) + 3/2O2(*g*) ΔH°1 = −3/2(−173kJ)

N2(*g*) + 5/2O2(*g*) + H2O(*l*) → 2HNO3(*aq*) ΔH°2 = ½(−255 kJ)

2NO(*g*) → N2(*g*) + O2(*g*) ΔH°3 = −(181 kJ)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3NO2(*g*) + H2O(*l*) → 2HNO3(*aq*) + NO(*g*)

ΔH°rxn = ΔH°1 + ΔH°2 + ΔH°3 = −**49 kJ**

1. How much heat is evolved or absorbed when 750.0 mL of 3.50 M HNO3 is formed? (If you are unable to get an answer to part *a*, you should still set up this part.) (4 points)

750.0 mL soln \* 3.50 mol HNO3 \*−49 kJ = -64 kJ

 1000 mL 2 mol HNO3

1. In the last step of the copper experiment you react metallic aluminum with a water solution of copper (II) chloride to form solid copper and aqueous aluminum chloride. The heat capacity of the calorimeter is 315 J/oC. In the reaction 210.0 g of water and 0.534 g of Al is reacted with excess CuCl2 (aq). The temperature rises from 22.33 oC to 27.69 oC. (csolution = 4.07 J/g\* oC) (8 points)

2 Al (s) + 3 CuCl2 (aq) 🡪 2 AlCl3 (aq) + 3 Cu (s)

1. Determine q of reaction

∆T = 27.69 oC - 22.33 oC = 5.36 oC

q soln = 210.534 g \* 4.07 J/g\* oC\*5.36 oC =4593 J = 4.593 kJ

q Cal =315 J/oC \* 5.36 oC =1688.4 J =1.688 kJ

q rxn = -( q soln + q Cal) = -(4.593 kJ +1.688 kJ) = -6.281 kJ

1. Determine ∆H rxn (in terms of Al)

∆H rxn = (-6.281 kJ/ 0.534 g Al) \* (27 g Al /1mol Al) = -318 kJ/mol Al

1. Methyl hydrazine (CH6N2) is commonly used as a liquid rocket fuel. The combustion of methylhydrazine with oxygen produces nitrogen, carbon dioxide and water. (9 points)

2CH6N2 + 5O2 🡪 2N2 + 2CO2 + 6H2O ∆H = -2340.0 kJ

* 1. How much energy is released when 25.0 g of methylhydrazine burns in excess oxygen?

25. 0 g CH6N2 \* ( 1 mol CH6N2 / 46.078 g CH6N2) \* (-2340.0 kJ /2 mol CH6N2) = -635 kJ

* 1. Determine ∆H f of Methylhydrazine (CH6N2)

-2340.0 kJ = 6mol\*(-241.8 kJ/mol) + 2 mol\* (-393.5 kJ/mol) – (2 mol \* ∆H f( CH6N2)

-2340.0 kJ = -2237.8 kJ – (2 mol \* ∆H f( CH6N2)

(-2 mol \* ∆H f( CH6N2) = -102.2 kJ

∆H f( CH6N2 )= 51.1 kJ

* 1. Write the chemical equation that represents the ∆H f of Methylhydrazine

C (s) + 3 H2 (g) + 2 N2 (g) 🡪 CH6N2

1. A cup of coffee you ordered at McDonald's spilled in your lap and you suffered third degree burns to 6 percent of your body. McDonald's says that it serves its coffee at 85°C, but acknowledged that a burn hazard exists with any food substance served above 60°C.

If you had wanted to make the coffee safer, how much ice ***(at a temperature of 0°C)*** would you have had to add to the cup (let's say it was a 12 oz or 340 g cup) to bring the temperature down from 85°C to 60°C? Let's assume that 1.) Coffee has the same heat capacity as water, and 2.) No heat is lost to the coffee cup or surroundings. (10 points)

 mice \*333 J/g + mice \*(4.184 J/goC) (60oC) = -(340 g cup \*(4.184 J/goC) (-25oC))

mice \*333 J/g + mice \*(251.04 J/g) = 35564 J

mice \*584.04 J/g =35564 J

mice = 60.9 g ice

b) In the process of melting ice, is the ice experiencing positive or negative enthalpy (explain)?

The process of melting ice is a poiitive enthalpy since ice is the system and it is accept heat in order to loosen its attraction to other water molecules to become a liquid

1. Substitute natural gas (SNG) is a mixture containing methane gas that can be use as a fuel. One reaction for the production of SNG is shown below.



Calculate the ΔHo rxn for the above process based on the table of bond dissociation energies given

ΔH = Σ(bonds broken) –Σ(bonds formed)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 4 CO + | 8 H2 | 🡪 | 3 CH4 + | CO2 + | 2 H2O |
| Broken Bonds |  | Bonds Formed |
| 4(C≡O) =4 mol\* (1072 kJ/ mol) |  | 3(4(C-H)) =12 mol \*(414 kJ/ mol)  |
| 8(H-H) = 8 mol\* (436 kJ/ mol) |  | 2(C=O) = 2 mol \*(736 kJ/ mol) |
|  |  | 2(2(O-H)) = 4 mol \*(464 kJ/ mol) |

ΔH = [4(1072) + 8(436)]kJ –[12(414) + 2(736) + 4(464)]kJ

Δ**H = -520 kJ**