ENHANCEMENT QUESTION: THERMOCHEMISTRY

1. Calculate the heat transferred when a 5.5 g nail is cooled from 37 ^{o}C to 25 ^{o}C. [*Specific heat of iron = 0.450 J/gK*] ***Answer: – 29.7 kJ***

2. If a gold ring with a mass of 5.5 g changes in temperature from 25.0 ^{o}C 28.0 ^{o}C, how much energy (in joules) has it absorbed? [*Specific heat capacity of gold = 0.129 J/g^{o}C*] ***Answer: + 2.13 kJ***

3. The addition of 250 J to 30.0 g of copper initially at 22.0 ^{o}C will change its temperature to what final value? [*c of Cu = 0.387 Jg^{-1}^{o}C^{-1}*] ***Answer: 43.5 ℃***

4. A quantity of 1.922 g of methanol (CH_3OH) was burned in a constant volume bomb calorimeter. Consequently, the temperature of the water rose by 4.20 ^{o}C. If the quantity of water surrounding the calorimeter was exactly 2000g and the heat capacity of the calorimeter was 2.02 kJ/^{o}C, calculate the molar heat of combustion of methanol. ***Answer: – 731.9 kJ mol^{-1}***

5. A 1.00 mol sample of propane, a gas used for cooking, was placed in a bomb calorimeter with excess oxygen and ignited. The initial temperature of the calorimeter is 25.000 ^{o}C and its total heat capacity was 97.1 kJ^{o}C^{-1}. The reaction raised the temperature of the calorimeter to 27.282 ^{o}C.
   a) How many J were liberated in this reaction? ***Answer: – 2.22 x 10^{5} J***
   b) What is heat of reaction of propane with oxygen expressed in kJ/mol of C_3H_8 burned? ***Answer: – 222 kJ mol^{-1}***

6. A quantity of 400 mL of 0.6 *M* HNO_3 is mixed with 400 mL of 0.3 M $Ba(OH)_2$ in coffee–cup calorimeter (simple calorimeter) that has a heat capacity of 387 J/^{o}C. The initial temperature of both solutions is the same at 18.88 ^{o}C. What is the final temperature of the solution? [*Heat of neutralization = –56.2 kJ/mol*] ***Answer: 22.49 ℃***

7. Nitrogen oxides undergo many interesting reactions. Calculate ΔH for the overall equation

$$2\ NO_2\ (g)\ +\ O_2\ (g)\ \rightarrow\ N_2O_5\ (s)$$

from the following equations:

$N_2O_5\ (s)\ \rightarrow\ 2\ NO\ (g)\ +\ O_2\ (g)$ $\quad \Delta H = +\ 223.7$ kJ
$NO\ (g)\ +\ O_2\ (g)\ \rightarrow\ NO_2\ (g)$ $\quad \Delta H = -\ 57.1$ kJ ***Answer: – 109.5 kJ***

8. The common lead-acid car battery produces a large burst of current, even at low temperatures, and is rechargeable. The reaction that occurs while recharging a "dead" battery is:

$$2\ PbSO_4\ (s)\ +\ 2\ H_2O\ (l)\ \rightarrow\ Pb\ (s)\ +\ PbO_2\ (s)\ +\ 2\ H_2SO_4\ (l)$$

Use the following equations to calculate ΔH_{rxn} of the above reaction.
$Pb\ (s)\ +\ PbO_2\ (s)\ +\ 2\ SO_3(g) \rightarrow\ 2\ PbSO_4(s)$ $\quad \Delta H = -\ 768$ kJ
$SO_3\ (g)\ +\ H_2O\ (l)\ \rightarrow\ H_2SO_4\ (l)$ $\quad \Delta H = -\ 132$ kJ ***Answer: + 504 kJ***

9. Oxidation of ClF by F_2 yields ClF_3, an important fluorinating agent:

$$ClF\,(g) + F_2\,(g) \rightarrow ClF_3\,(g)$$

Use the following thermochemical equation to calculate ΔH^o for the production of ClF_3:

$2\,ClF\,(g) + O_2\,(g) \rightarrow Cl_2O\,(g) + OF_2(g)$ $\quad \Delta H^o = +167.5$ kJ
$2\,F_2\,(g) + O_2\,(g) \rightarrow 2\,OF_2(g)$ $\quad \Delta H^o = -43.5$ kJ
$2\,ClF_3\,(g) + 2\,O_2\,(g) \rightarrow Cl_2O\,(g) + 3\,OF_2\,(g)$ $\quad \Delta H^o = +394.1$ kJ

Answer: – 135.1 kJ

10. Calculate the standard enthalpy of formation of CS_2 (l) given that:

C (graphite) + $O_2\,(g) \rightarrow CO_2\,(g)$ $\quad \Delta H^o_f = -393.5$ kJ
S (rhombic) + $O_2\,(g) \rightarrow SO_2\,(g)$ $\quad \Delta H^o_f = -296.1$ kJ
$CS_2\,(l) + 3\,O_2\,(g) \rightarrow CO_2\,(g) + 2SO_2\,(g)$ $\quad \Delta H^o_{rxn} = -1072$ kJ

Answer: + 86.3 kJ mol^{-1}

11. Calculate the lattice energy of calcium chloride ($CaCl_2$); given that:

Heat of sublimation of calcium = + 121 kJ/mol
First ionization energy of calcium = + 589.5 kJ/mol
Second ionization energy of calcium = + 1145 kJ/mol
Enthalpy of atomization of chlorine = + 121.4 kJ/mol
Electron affinity of chlorine = – 349 kJ/mol
Enthalpy of formation of $CaCl_2$ = – 795 kJ/mol ***Answer: – 2195.3 kJ mol^{-1}***

12. With the following data, calculate $\Delta H_{lattice}$ of CsCl (s):

Heat of sublimation of cesium = + 78.2 kJ
First ionization energy of cesium = + 375.7 kJ
Enthalpy of dissociation $\frac{1}{2}Cl_2(g)$ = + 122 kJ
Electron affinity of chlorine = – 349 kJ
Enthalpy of formation of CsCl(s) = – 442.8 kJ

Answer: – 669.7 kJ mol^{-1}

13. Construct a Born–Haber cycle to calculate the lattice energy of KBr based on the following data:

Standard enthalpy of formation of KBr = – 392 kJmol^{-1}
Enthalpy of sublimation of potassium = + 90 kJmol^{-1}
First ionization energy of potassium = + 420 kJmol^{-1}
Enthalpy of atomization of bromine = + 112 kJmol^{-1}
Electron affinity of bromine = – 342 kJmol^{-1}

Answer: – 672 kJ mol^{-1}