CHE 111 - Homework - Ch 9b

OER 9.3-9.4 **Enthalpy and Formation and Hess's Law Problems** Score: _____/55

Name: ______________________________ Date: ______________________

[3 pt] 1. The most common type of work encountered in chemical systems is given by the equation $w = -P\Delta V$. Define each variable and give the typical units of each variable.

[4 pt] 2. How much work (in Joules) is required to inflate a ballon from 0.10 L to 2.00 L against an outside pressure of 0.85 atm (Rangely). What does the sign of the answer indicate about the work performed? 2. ______________

[4 pt] 3. How much work (in kJ) is done by the following reaction: _1_ $C_2H_4(g)$ + _1_ $H_2(g) \longrightarrow$ _1_ $C_2H_6(g)$ given that 500.0 mL of C_2H_4 and 500.0 mL of H_2 react together to produce 750.0 mL of the product? Is energy flowing into or out of the system? 3. ______________

[5 pt] 4. Answer the following questions about Enthalpy:
(a) Define Enthalpy (ΔH) using words.
(b) Define Enthalpy using a mathematical equation.
(c) Give the name and standard units for each variable.
(d) Is Enthalpy a state function?
(e) Under what conditions are ΔH and ΔE essentially equal?

[3 pt] 5. For the reaction _1_ $CH_4(g)$ + _2_ $O_2(g) \longrightarrow$ _1_ $CO_2(g)$ + _2_ $H_2O(g)$ would you expect ΔE or ΔH to be larger. Explain.

[2 pt] 6. What does the superscript ° mean when added to ΔH. (or in other words what is the difference between ΔH and ΔH°)

[4 pt] 7. Given the reaction: __1__ $CaO(s)$ + __3__ $C(s) \longrightarrow$ __1__ $CaC_2(s)$ + __1__ $CO(g)$ $\Delta H^\circ_{rxn} = 464.8$ kJ

(a) How much heat (in kJ) is evolved or absorbed in the reaction of 233.0 g of calcium oxide with enough carbon to produce calcium carbide? 7(a) ____________

(b) Is the process exothermic or endothermic? 7(b) ____________

[5 pt] 8. Given the reaction: __2__ $Na(s)$ + __2__ $H_2O(l) \longrightarrow$ __2__ $NaOH(aq)$ + __1__ $H_2(g)$ $\Delta H^\circ_{rxn} =$ -368.4 kJ

(a) How much heat (in kJ) is evolved or absorbed in the reaction of 1.00 grams of Na reacts with 24.0 grams of H_2O. 8(a) ____________

(b) Is the reaction exothermic or endothermic? 8(b) ____________

[5 pt] 9. Calculate ΔH°_f (in kJ/mol) for benzene given the following reaction: 9. ____________

__2__ $C_6H_6(l)$ + __15__ $O_2(g) \longrightarrow$ __12__ $CO_2(g)$ + __6__ $H_2O(l)$ with $\Delta H^\circ_{rxn} =$ -6534 kJ.

Compare the value you calculated with the tabulated value of 49.1 kJ/mol. What is the Percent Error in your Calculation? Additional information from Appendix G might be required to solve this problem.

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[5 pt] 10. Methyl tert-butyl ether (MTBE, $C_5H_{12}O$, ΔH_f° = -313.6 kJ/) is an additive to gasoline added to boost octane ratings. Write a balanced reaction for its combustion and calculate the standard heat of combustion (for combustion reactions this is the same as ΔH_{rxn}) in kJ. Additional information from Appendix G might be required to solve this problem. ΔH_f of MTBE is -313.6 kj/mol. When you write the chemical reaction be sure to use H_2O(l) instead of the normal gas state as we want to include the heat that is generated in the reaction and not subtract the amount it would take to go from (l) to (g). 10. ______

[5 pt] 11. What is Hess's Law? What are the 5 rules used when solving a Hess's law type problem?

[5 pt] 12. Calculate ΔH° for the reaction _1_ $CH_4(g) +$ _2_ $Cl_2(g) \longrightarrow$ _1_ $CH_2Cl_2(g) +$ _2_ $HCl(g)$ using the following reactions: 12. ______

_1_ $CH_4(g) +$ _1_ $Cl_2(g) \longrightarrow$ _1_ $CH_3Cl(g) +$ _1_ $HCl(g))$ ΔH° = -98.3 kJ

_1_ $CH_3Cl(g) +$ _1_ $Cl_2(g) \longrightarrow$ _1_ $CH_2Cl_2(g) + HCl(g)$ ΔH° = -104 kJ

[5 pt] 13. Calculate ΔH° for the reaction _1_ $H(g) +$ _1_ $Br(g) \longrightarrow$ _1_ $HBr(g)$ using the following reactions: 13. ______

_1_ $H_2(g) \longrightarrow$ _2_ $H(g)$ ΔH° = 436.4 kJ

_1_ $Br_2(g) \longrightarrow$ _2_ $Br(g)$ ΔH° = 192.5 kJ

_1_ $H_2(g) +$ _1_ $Br_2(g) \longrightarrow$ _2_ $HBr(g)$ ΔH° = -72.4 kJ

14. **Bonus:** Calculate ΔH_f° for the reaction $\frac{1}{2}H_2(g) + \frac{1}{2}N_2(g) + \frac{3}{2}O_2(g) \longrightarrow HNO_3(aq)$ 14. ____________
using the reactions given below. (Hint: you will need fractional coefficients)
(1) $3NO_2(g) + H_2O(l) \longrightarrow 2HNO_3(aq) + NO(g)$ ΔH° = -138.4 kJ
(2) $2NO + O_2(g) \longrightarrow 2NO_2(g)$ ΔH° = -114.0 kJ
(3) $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$ ΔH° = -1169.6 kJ
(4) $2NH_3(l) \longrightarrow 3H_2(g) + N_2(g)$ ΔH° = 92.2 kJ
(5) $2H_2O(l) \longrightarrow 2H_2(g) + O_2(g)$ ΔH° = 571.6 kJ