ENTHALPY AND THE FIRST LAW

NAME _____ SECTION _____

1. Energy in the form of heat can be either released (exothermic) or absorbed (endothermic) in a chemical reaction. This heat, called the enthalpy, is a driving force for chemical reactions. Predict which of the following spontaneous reactions are exothermic and which are endothermic.

   a. $H_2O(l) \rightarrow H_2O(g)$ @25 °C

   b. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

   c. $Ba(OH)_2 \bullet 8H_2O(s) + 2NH_4Cl(s) \rightarrow BaCl_2(aq) + 10H_2O(l) + 2NH_3(aq)$

   d. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ or (g)

   e. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

   f. $Al(s) + \frac{3}{2}Br_2(l) \rightarrow AlBr_3(s)$

2. A formation reaction is a chemical reaction depicting the formation of one mole of a substance from its naturally occurring elemental sources. Which of the reactions in question 1 are formation reactions?

3. A table of heats (enthalpies) of formation ($\Delta H°_f$) for selected substances is at the end of this DCI. Write the mathematical equation that relates the standard heat of reaction to the heats of formation of the reactants and products of the chemical reaction.

4. Calculate the heats of reaction for the chemical reactions in question 1.

5. The natural tendency for spontaneous chemical reactions is to release heat. Is the enthalpy an absolute predictor of spontaneity? Defend your answer.

Thermodynamic Values (25°C)

Substance and State	ΔH^0_f $\left(\frac{kJ}{mol}\right)$	ΔG^0_f $\left(\frac{kJ}{mol}\right)$	S^0 $\left(\frac{J}{K \cdot mol}\right)$	Substance and State	ΔH^0_f $\left(\frac{kJ}{mol}\right)$	ΔG^0_f $\left(\frac{kJ}{mol}\right)$	S^0 $\left(\frac{J}{K \cdot mol}\right)$
Aluminum				**Iodine**			
$AlBr_3(g)$	−526.3	−505	184	$I_2(s)$	0	0	116.7
$Al(s)$	0	0	28.32	$I_2(g)$	62.25	19.37	260.57
				$HI(g)$	25.94	1.30	206.3
Barium							
$BaCl_2(aq)$	−872	−823	123	**Magnesium**			
$Ba(OH)_2 \cdot 8H_2O(s)$	−3342	−2793	427	$Mg(s)$	0	0	33
				$Mg^{2+}(aq)$	−492	−456	−118
Bromine				$MgO(s)$	−601	−569	26.9
$Br_2(l)$	0	0	152.231				
$BrCl(g)$	14.64	−0.96	239.99	**Oxygen**			
				$O_2(g)$	0	0	205
Carbon				$O(g)$	249	232	161
$C(s)$ (graphite)	0	0	6	$O_3(g)$	143	163	239
$C(s)$ (diamond)	2	3	2				
$CO(g)$	−110.5	−137	198	**Nitrogen**			
$CO_2(g)$	−393.5	−394	214	$N_2(g)$	0	0	192
$CH_4(g)$	−75	−51	186	$NCl_3(g)$	230	271	−137
$CH_3OH(g)$	−201	−163	240	$NF_3(g)$	−125	−83.6	−139
$CH_3OH(l)$	−239	−166	127	$NH_3(g)$	−46	−17	193
$H_2CO(g)$	−116	−110	219	$NH_3(aq)$	−80	−27	111
$HCOOH(g)$	−363	−351	249	$NH_2CONH_2(aq)$	?	?	174
$HCN(g)$	135.1	125	202	$NO(g)$	90	87	211
$C_2H_2(g)$	227	209	201	$NO_2(g)$	34	52	240
$C_2H_4(g)$	52	68	219	$N_2O(g)$	82	104	220
$CH_3CHO(g)$	−166	−129	250	$N_2O_4(g)$	10	98	304
$C_2H_5OH(l)$	−278	−175	161	$N_2O_5(g)$	⁻42	134	178
$C_2H_6(g)$	−84.7	−32.9	229.5	$N_2H_3CH_3(l)$	54	180	166
$C_3H_6(g)$	20.9	62.7	266.9	$HNO_3(aq)$	−207	−111	146
$C_3H_8(g)$	−104	−24	270	$HNO_3(l)$	−174	−81	156
				$NH_4Cl(s)$	−314	−201	95
Chlorine				$NH_4ClO_4(s)$	−295	−89	186
$Cl_2(g)$	0	0	222.957				
$Cl_2(aq)$	−23	7	121	**Silver**			
$Cl^-(aq)$	−167	−131	57	$Ag(s)$	0	0	42.6
$HCl(g)$	−92	−95	187	$Ag^+(aq)$	105.6	77.1	72.7
				$AgBr(s)$	−100.4	−96.9	107.1
Fluorine				$AgCl_3(s)$	−127.1	−109.8	96.2
$F_2(g)$	0	0	203				
$F^-(aq)$	−333	−279	−14	**Sulfur**			
$HF(g)$	−271	−273	174	S(rhombic)	0	0	31.8
				S(monocl)	0.3	0.1	32.6
Hydrogen				$SO_2(g)$	−296.8	−300.2	248.8
$H_2(g)$	0	0	131	$SO_3(g)$	−395.7	−371.1	256.3
$H(g)$	217	203	115	$H_2S(g)$	−20.17	−33.0	205.6
$H^+(aq)$	0	0	0				
$OH^-(aq)$	−230	−157	−11	**Titanium**			
$H_2O(l)$	−286	−237	70	$TiCl_4(g)$	−763	−727	355
$H_2O(g)$	−242	−229	189	$TiO_2(s)$	−945	−890	50