Name_____ **Honors Chemistry** **___/___/___**

Hess's Law Answers

1. What is heat of reaction for the following reaction?

$C_{graphite}(s) \rightarrow C_{diamond}(s)$

The following is known.

$C_{graphite}(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H° = -394$ kJ	
$C_{diamond}(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H° = -396$ kJ	**(flip = +396)**
$C_{graphite}(s) \rightarrow C_{diamond}(s)$	**$\Delta H° =$ 2 kJ**	

2. Calculate the heat of reaction for the following reaction.

$2NO_2(g) \rightarrow N_2O_4(g)$

The following is known.

$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$	$\Delta H° = 67.7$ kJ	**(flip = -67.7 kJ)**
$N_2(g) + 2O_2(g) \rightarrow N_2O_4(g)$	$\Delta H° = 9.7$ kJ	
$2NO_2(g) \rightarrow N_2O_4(g)$	**$\Delta H° = -58.0$ kJ**	

3. Calculate the heat of reaction for the following reaction:

$NO(g) + O(g) \rightarrow NO_2(g)$

The following is known.

$2O_3(g) \rightarrow 3O_2(g)$	$\Delta H° = -427$ kJ	**(flip and ½ = +213.5 kJ)**
$O_2(g) \rightarrow 2O(g)$	$\Delta H° = 495$ kJ	**(flip and ½ = +247.5 kJ)**
$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$	$\Delta H° = -199$ kJ	**(keep the same)**
$NO(g) + O(g) \rightarrow NO_2(g)$	**$\Delta H° = -233$ kJ**	

4. Calculate the heat of reaction for the following reaction:

$C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2H_2O(l)$

The following is known.

$C_6H_4(OH)_2(aq) \rightarrow C_6H_4O_2(aq) + H_2(g)$	$\Delta H° = 177.4$ kJ	**(keep the same)**
$H_2(g) + O_2(g) \rightarrow H_2O_2(aq)$	$\Delta H° = -191.2$ kJ	**(flip = +191.2 kJ)**
$H_2(g) + ½O_2(g) \rightarrow H_2O(g)$	$\Delta H° = -241.8$ kJ	**(double = -483.6 kJ)**
$H_2O(g) \rightarrow H_2O(l)$	$\Delta H° = -43.8$ kJ	**(double = -87.6 kJ)**
$C_6H_4(OH)_2(aq) + H_2O_2(aq) \rightarrow C_6H_4O_2(aq) + 2H_2O(l)$		**$\Delta H° = -202.6$ kJ**

5. Calculate the heat of reaction for the following reaction:

$Ca(s) + C(s) + 3/2O_2(g) \rightarrow CaCO_3(s)$

The following is known.

$Ca(s) + 2C(s) \rightarrow CaC_2(s)$	$\Delta H° = -62.8$ kJ	**(keep the same)**
$CO_2(g) \rightarrow C(s) + O_2(g)$	$\Delta H° = 393.5$ kJ	**(keep the same)**
$CaCO_3(s) + CO_2(g) \rightarrow CaC_2(s) + 5/2O_2(g)$	$\Delta H° = 1538$ kJ	**(flip = -1538 kJ)**
$Ca(s) + C(s) + 3/2O_2(g) \rightarrow CaCO_3(s)$	**$\Delta H° = -1207$ kJ**	

6. Calculate the heat of reaction for the following reaction:

$2P(s) + 5Cl_2(g) \rightarrow 2PCl_5(s)$

The following is known.

$PCl_5(s) \rightarrow PCl_3(g) + Cl_2(g)$	$\Delta H° = 87.9$ kJ	**(flip and x2 = -175.8 kJ)**
$2P(s) + 3Cl_2(g) \rightarrow 2PCl_3(g)$	$\Delta H° = -574$ kJ	**(keep the same)**
$2P(s) + 5Cl_2(g) \rightarrow 2PCl_5(g)$	**$\Delta H° = -750.$ kJ**	

7. Use the information in the table to calculate the enthalpy of this reaction.

$C_2H_6(g) + 7/2\ O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Reaction	$\Delta H_f°$, kJ·mol^{-1}	What I did
$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$	–84.7	**Flip the reaction**
$C(s) + O_2(g) \rightarrow CO_2(g)$	–393.5	**x2**
$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$	–285.8	**x3**

(A) –764 kJ **(B) –1560 kJ** (C) –1664 kJ (D) –3120 kJ (E) -595 kJ

8. Given these reactions:

$A \rightarrow 2B$	$\Delta H° = 40$ kJ	**(keep the same = 40)**
$B \rightarrow C$	$\Delta H° = -50$ kJ	**(multiply by 2 = -100)**
$2C \rightarrow D$	$\Delta H° = -20$ kJ	**(flip the reaction = +20)**

Calculate ΔH for the reaction; $D + A \rightarrow 4C$.

(A) –100 kJ (B) –60 kJ **(C) –40 kJ** (D) 100 kJ (E) -30 kJ

9. $C_2H_6(g) + 7/2O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H° = -1427.7$ kJ

If the enthalpy of vaporization for $H_2O(l)$ is 44.0 kJ/mol, what is $\Delta H°$ for this reaction if $H_2O(l)$ is formed instead of $H_2O(g)$?

$H_2O(l) \rightarrow H_2O(g)$ $\Delta H° = 44.0$ kJ (flip and multiply by 3 = -132.0 kJ)

(A) –1295.7 kJ (B) –1383.7 kJ (C) –1471.7 kJ **(D) –1559.7 kJ** (E) -1515.7 kJ

10. Given the thermochemical equations:

$Br_2(l) + F_2(g) \rightarrow 2BrF(g)$	$\Delta H° = -188$ kJ	**(flip and divide by 2 = +94 kJ)**
$Br_2(l) + 3F_2(g) \rightarrow 2BrF_3(g)$	$\Delta H° = -768$ kJ	**(divide by 2 = -384 kJ)**

Determine $\Delta H°$ for the reaction: $BrF(g) + F_2(g) \rightarrow BrF_3(g)$ $\Delta H° = ?$

(A) -956 kJ (B) -580 kJ **(C) -290 kJ** (D) -478 kJ (E) 580 kJ

11. Given these two standard enthalpies of formation:

Reaction 1: $S(s) + O_2(g) \rightleftharpoons SO_2(g)$	$\Delta H° = -295$ kJ/mole	**(flip and multiply by 2 = +590 kJ)**
Reaction 2: $S(s) + \frac{3}{2} O_2(g) \rightleftharpoons SO_3(g)$	$\Delta H° = -395$ kJ/mole	**(multiply by 2 = -790 kJ)**

What is the heat of reaction for $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ under the same conditions?

(A) -1380 kJ/mole (B) -690. kJ/mole (C) -295 kJ/mole **(D) -200. kJ/mole** (E) -100. kJ/mole

12. Given the following information:

Reaction 1: $H_2(g) + ½ O_2(g) \rightarrow H_2O(l)$	$\Delta H° = -286$ kJ	**(flip)**
Reaction 2: $CO_2(g) \rightarrow C(s) + O_2(g)$	$\Delta H° = 394$ kJ	**(multiply by 2)**
Reaction 3: $2CO_2(g) + H_2O(l) \rightarrow C_2H_2(g) + \frac{5}{2} O_2(g)$	$\Delta H° = 1300$ kJ	**(flip)**

Find $\Delta H°$ for the reaction: $C_2H_2(g) \rightarrow 2C(s) + H_2(g)$

(A) -226 kJ (B) -113 kJ (C) 113 kJ (D) 226 kJ (E) 452 kJ

Additional Practice Problems

1. Calculate the $\Delta H°$ the following problems using Hess's law.

Given:	$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	$\Delta H° = -23$ kJ	**(divide by 2)**
	$3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$	$\Delta H° = -39$ kJ	**(flip and divide by 6)**
	$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$	$\Delta H° = +18$ kJ	**(flip and divide by 3)**
Find:	$FeO + CO \rightarrow Fe + CO_2$	**$\Delta H° = -11$ kJ**	

2. Calculate the $\Delta H°$ the following problems using Hess's law.

Given:	$P_4 + 6Cl_2 \rightarrow 4PCl_3$	$\Delta H° = -1225.6$ kJ	**(keep the reaction as is)**
	$P_4 + 5O_2 \rightarrow P_4O_{10}$	$\Delta H° = -2967.3$ kJ	**(flip the reaction)**
	$PCl_3 + Cl_2 \rightarrow PCl_5$	$\Delta H° = -84.2$ kJ	**(flip and multiply by 6)**
	$PCl_3 + ½ O_2 \rightarrow Cl_3PO$	$\Delta H° = -285.7$ kJ	**(multiply by 10)**
Find:	$P_4O_{10} + 6PCl_5 \rightarrow 10Cl_3PO$	**$\Delta H° = -610.1$ kJ**	

3. Calculate the $\Delta H°$ the following problems using Hess's law.

Given:	$Sr + ½ O_2 \rightarrow SrO$	$\Delta H° = -592$ kJ	**(keep the reaction as is)**
	$SrO + CO_2 \rightarrow SrCO_3$	$\Delta H° = -234$ kJ	**(keep the reaction as is)**
	$C + O_2 \rightarrow CO_2$	$\Delta H° = -394$ kJ	**(keep the reaction as is)**
Find:	$Sr + C + 3/2\ O_2 \rightarrow SrCO_3$	**$\Delta H° = -1220.$ kJ**	