Name _____ Honors Chemistry ___/___/___

Thermodynamics Practice Test
Part I: Please write the letter of the correct answer on the line. (4 points each)

Use the following answers for problems 1-4. You may use an answer more than once.
(A) ΔG (B) ΔS (C) Heat of vaporization (D) Heat of fusion (E) Specific heat

1. **A** If it has a negative value for a process, then the process occurs spontaneously.

2. **B** This is a measure of how the disorder or positional probability in a system is changing.

3. **C** This is the energy given off when a substance condenses.

4. **E** This is the amount of energy need to raise the temperature of one gram of a substance one degree Celsius.

5. **A** **$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$**
The reaction above is not spontaneous at standard conditions, but becomes spontaneous as the temperature decreases towards absolute zero. Which of the following is true at standard conditions?
(A) ΔS and ΔH are both negative
(B) ΔS and ΔH are both positive
(C) ΔS is negative and ΔH is positive
(D) ΔS is positive and ΔH is negative
(E) ΔS and ΔH are both equal to zero

6. **D** **$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$**
Based on the information in the table below, what is the ΔH for the above reaction?

Bond	Average Bond Energy (kJ/mol)
H-H	432
O=O	495
O-H	467

(A) +460 kJ (B) +425 kJ (C) +509 kJ **(D) -509 kJ** (E) -460 kJ

7. **A** Based on the information given below, what is the ΔH for the following reaction:
$C_2H_2(g) + 5/2\ O_2 \rightarrow 2CO_2(g) + H_2O$

Reaction	ΔH
$C(s) + O_2(g) \rightarrow CO_2(g)$	ΔH = -390 kJ/mol
$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$	ΔH = -290 kJ/mol
$2C(s) + H_2(g) \rightarrow C_2H_2(g)$	ΔH = +230 kJ/mol

(A) **-1300 kJ** (B) -1070 kJ (C) -840 kJ (D)-780 kJ (E) -680 kJ

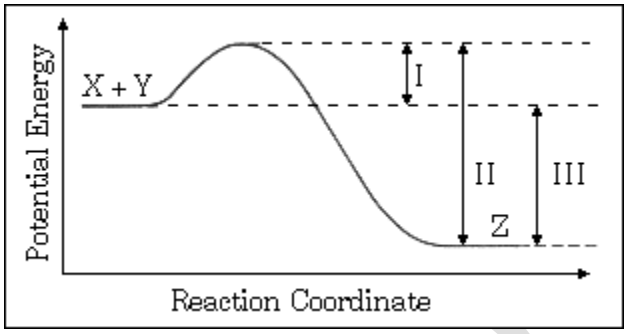
8. **C** The addition of a catalyst will have which of the following effects on a chemical reaction?
I. The enthalpy will decrease.
II. The entropy will decrease.
III. The activation energy will decrease.
(A) I only (B) II only **(C) III only** (D) I and II only (E) II and III only

9. **D** For which of the following processes will ΔS be positive?
I. $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$
II. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
III. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
(A) I only (B) II only (C) I and II only **(D) I and III only** (E) 1, II and III

10. **D**

The energy diagram for the reaction X + Y → Z is shown to the right. The addition of a catalyst to this reaction would cause a change in which of the indicated energy differences?

(A) I only (B) II only
(C) III only **(D) I and II only**
(E) I, II, and III



Part II: Solve each of the following. Please box your final answers. (4points each – 1 point penalty for wrong units or no units)

1. Consider the reaction: $O_3(g) + NO(g) \rightarrow O_2(g) + NO_2(g)$

	$O_3(g)$	$NO(g)$	O_2 (g)	$NO_2(g)$
Standard enthalpy of formation, ΔH_f^o, at 25ºC (kJ mol^{-1})	143	90.	0	33
Standard entropy of formation, ΔS^o, at 25ºC (J $mol^{-1}K^{-1}$)	239	211	205	240.

(a) Referring to the data in the table above, calculate the standard enthalpy change, ΔH^o, for the reaction at 25ºC. Be sure to show your work.

(b) Referring to the data in the table above, calculate the standard entropy change, ΔS^o, for the reaction at 25ºC. Be sure to show your work.

(c) Calculate ΔG for the reaction at 25ºC.

(d) Assuming negligible changes in ΔH and ΔS, at what temperature would the reaction NOT be spontaneous?

1a. ΔH = -200. kJ
1b. ΔS = -5 J/K
1c. ΔG = -199 kJ
1d. T > 40,000 K

2. $2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)\ \Delta H° = -114.1\ kJ,\ \Delta S° = -146.5\ J\ K^{-1}$

The reaction represented above is one that contributes significantly to the formation of photochemical smog.

(a) Calculate the quantity of heat released when 73.1 g of $NO(g)$ is converted to $NO_2(g)$.

(b) Calculate the value of the standard free-energy change, $\Delta G°$.

(c) Indicate whether the value of $\Delta G°$ would become more negative, less negative, or remain unchanged as the temperature is increased. Justify your answer.

(d) Use the data in the table below to calculate the value of the standard molar entropy, $S°$ for $O_2(g)$ at 25°C.

	Standard Molar Entropy, $S°$ ($J\ K^{-1}\ mol^{-1}$)
$NO(g)$	210.8
$NO_2(g)$	240.1

(e) Use the data in the table below to calculate the bond energy, in $kJ\ mol^{-1}$, of the nitrogen-oxygen bond in NO_2. Assume that the bonds in the NO_2 molecule are equivalent (i.e., they have the same energy).

	Bond Energy ($kJ\ mol^{-1}$)
Nitrogen-oxygen bond in NO	607
Oxygen-oxygen bond in O_2	495
Nitrogen-oxygen bond in NO_2	?

2a. ΔH = -139 kJ
2b. ΔG = -70.3 kJ
2c. less negative
2d. ΔS = 205.1 J/K
2e. 456 kJ/mol

3. Calculate the amount of energy needed to heat 2.25 kilograms of water from -14 ºC to 175 ºC. **You must draw a diagram to support your calculations.** C(s)= 2.09 J/g°C, C(l)= 4.184 J/g°C, C(g)= 2.01J/g°C, Melting Point: 0ºC, Boiling Point: 100ºC, H_{fus}= 335.0 J/g, H_{vap}= 2259.0 J/g

a. Stage 1: **65835 J**

b. Stage 2: **753750 J**

c. Stage 3: **941400 J**

d. Stage 4: **5082750 J**

e. Stage 5: **339187.5 J**

f. Total: **7182922.5 J → 7183 kJ**