Name: _____ Date: _____

60 total

Chemistry 30

Thermodynamics: Energy Changes in Chemical Reactions

I. Multiple Choice

Circle the best answer **20**

1. The temperature scale that uses absolute zero as its starting point is the:

   A. Kelvin scale
   B. Celsius scale
   C. Fahrenheit scale
   D. Newton scale

2. Chemical reactions that require a net ***input*** of energy are:

   A. spontaneous
   B. incomplete
   C. exothermic
   D. endothermic

3. The SI unit for energy is the:

   A. pascal
   B. joule
   C. watt
   D. mole

4. Stored energy is called:

   A. kinetic energy
   B. heat energy
   C. potential energy
   D. solar energy

5. The average kinetic energy of a sample of matter is measured as its:

   A. specific heat
   B. thermal conductivity
   C. temperature
   D. entropy

6. When excess heat is released during a chemical reaction, the energy term appears

   A. as a product, and ΔH is negative.
   B. as a product, and ΔH is positive.
   C. as a reactant, and ΔH is positive.
   D. as a reactant, and ΔH is negative.

7. A device used to measure the amount of heat exchanged during a chemical reaction is called a(n):

   A. colorimeter
   B. calorimeter
   C. spectrometer
   D. Ångstrom

8. Consider the following reactions:

I. $H_2(g) + I_2(g) \rightarrow 2\ HI(g) + 3.0$ kcal

II. $N_2(g) + O_2(g) \rightarrow 2\ NO$ $\Delta H = -43$ kcal

III. $H_2O(g) + C(s) + 32$ kcal $\rightarrow CO(g) + H_2(g)$

IV. $8\ SO_3(g) \rightarrow S_8(s) + 12\ O_2(g)$ $\Delta H = +95$ kcal

The endothermic reactions are:

A. I and II
B. II and IV
C. III and IV
D. III only

9. The thermochemical equation for the production of water is:

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l) + 136.6 \text{ kcal}$$

The heat of formation, $\Delta H_f°$, for $H_2O(l)$ is:

A. -136.6 kcal
B. -68.3 kcal
C. +136.6 kcal
D. +68.3 kcal

10. The thermochemical reaction for the decomposition of nitrogen dioxide is:

$$2\ NO_2(g) \rightarrow N_2(g) + 2\ O_2(g) + 16.2 \text{ kcal}$$

The heat of formation, $\Delta H_f°$, of nitrogen dioxide, $NO_2(g)$ is:

A. -16.2 kcal
B. -8.1 kcal
C. +16.2 kcal
D. +8.1 kcal

11. The heat of a reaction, ΔH, may be calculated by:

A. $\Delta H = \sum \Delta H_{products} - \sum \Delta H_{reac\tan ts}$
B. $\Delta H = \sum \Delta H_{products} + \sum \Delta H_{reac\tan ts}$
C. $\Delta H = \sum \Delta H_{reac\tan ts} - \sum \Delta H_{products}$
D. $\Delta H = \sum \Delta H_{products} \times \sum \Delta H_{reac\tan ts}$

12. Given the following heats of formation for several compounds, determine which compound is likely to be the most stable compound.

A. $NH_3(g)$ $\Delta H_f = -46.2$ kJ/mol
B. $PH_3(g)$ $\Delta H_f = 5.4$ kJ/mol
C. $CO_2(g)$ $\Delta H_f = -393.5$ kJ/mol
D. $NO(g)$ $\Delta H_f = +90.4$ kJ/mol

13. The First Law of Thermodynamics states that

A. The entropy of pure crystals at absolute zero is zero.
B. During chemical reactions energy may be converted from one form to another but it cannot be created or destroyed.
C. The enthalpy change for any reaction depends only on the energy states of the final products and initial reactants and is independent of the pathway or the number of steps between the reactant and product.
D. Spontaneous chemical reactions always tend towards an increase in entropy.

14. In general, how does entropy change when a solid changes to a liquid:

A. entropy will remain the same
B. it depends on the temperature of the system
C. entropy will decrease
D. entropy will increase

USE THE FOLLOWING INFORMATION TO ANSWER QUESTIONS 15 – 16

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -94.05$ kcal

$CO_2(g) \rightarrow CO(g) + \frac{1}{2} O_2(g)$ $\Delta H = +67.64$ kcal

15. The heat of formation, ΔH_f, for CO_2 is:

A. -67.64 kcal
B. -94.05 kcal
C. +67.64 kcal
D. +26.41 kcal

16. The heat of formation, ΔH_f, for CO is:

A. -161.69 kcal/mol
B. +161.69 kcal/mol
C. -26.41 kcal/mol
D. +26.41 kcal/mol

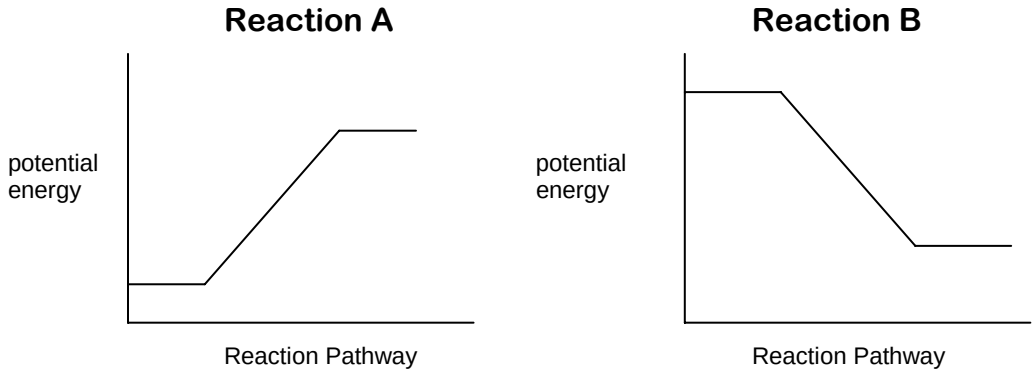
17. Consider the following reaction:

$$NH_3(l) + \text{heat} \rightarrow NH_3(g)$$

Which one of the following statements is **TRUE:**

A. entropy increases and enthalpy decreases
B. entropy is unchanged and enthalpy decreases
C. both entropy and enthalpy decrease
D. both entropy and enthalpy increase

18. Consider the following potential energy diagram:



Which statement concerning the reactions illustrated above is **TRUE:**

A. Reaction A is exothermic while Reaction B is endothermic
B. Reaction A is endothermic while Reaction B is exothermic
C. Reaction A will most likely be spontaneous while Reaction B is unlikely to be spontaneous
D. Reaction A releases heat while Reaction B absorbs heat

19. A reaction will **ALWAYS** be spontaneous when

A. enthalpy increases and entropy increases
B. enthalpy increases and entropy decreases
C. enthalpy decreases and entropy decreases
D. enthalpy decreases and entropy increases

20. Which one of the following conditions is **ALWAYS** true for a spontaneous reaction:

A. $\Delta H_f^\circ = 0$
B. $\Delta S > 0$
C. $\Delta G < 0$
D. $\Delta S < 0$

Part II. Short Answer — 40 marks

- Show work for all calculations. Use extra paper if you need more room, but be sure to include the question number.
- **Clearly indicate** your final answer for all questions by circling or underlining the answer.
- Be sure to read the directions for all questions carefully so you do not lose marks for not answering a question completely.

1. Given the following table of ΔH_f, ***5 marks***

(a) Calculate ΔH for the reaction: $2\ NaF + MgS \rightarrow Na_2S + MgF_2$

Compound	$\Delta H_f°$ (kJ/mol)
NaF	-569
MgS	-347
Na_2S	-373
MgF_2	-1102

(b) Is the reaction endothermic or exothermic?

(c) Rewrite the equation, placing the energy tem as part of the equation.

2. Using the Table of Thermochemical Data provided, write heat of formation reactions for the following. Include the energy term as part of the equation. You do not need to include physical state for the reactants. ***6 marks***

(a) $FeS_2(g)$

(b) HF(g)

(c) KOH(s)

3. Phosphorus trichloride, PCl_3, is a compound used in the manufacture of pesticides and gasoline additives. How much heat energy is required to raise the temperature of 96.7 g PCl_3 from 31.7°C to 69.2°C? The specific heat of PCl_3 is 0.874 J/g°C. Formula required: $Q = m\ c\ \Delta T$ ***3 marks***

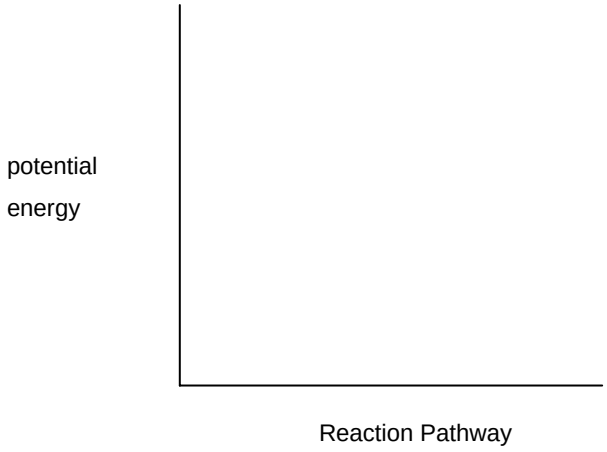
4. The following reaction is known as the water gas reaction (carbon is present as graphite):

$$H_2O(g) + C(s) + 134\ kJ \rightarrow CO(g) + H_2(g)$$

(a) Write this equation in a different but equivalent way (with the energy change removed from the equation and written as ΔH). **1 mark**

(b) Is this reaction endothermic or exothermic? **1 mark**

(c) Sketch as simple potential energy diagram for this reaction. Include values on the Y-axis that would produce the enthalpy change indicated by the reaction. **2 marks**



(d) On the basis of **ENTHALPY** change, do you predict that this reaction will be spontaneous under standard conditions? **Why**? **2 marks**

(e) Without calculating a value for ΔS, would you predict the reaction will be spontaneous or not based on **ENTROPY** changes? **Why**? **2 marks**

(f) Calculate ΔG for the reaction at 25°C (298 K). It is NOT necessary to calculate ΔH and ΔS first. Refer to the attached Table of Thermochemical Data. **4 marks**

(g) Is the reaction spontaneous or not at room temperature? How do you know? **2 marks**

5. The thermite reaction is spectacular and exothermic. Iron(III) oxide, Fe_2O_3, and metallic aluminum produce molten iron and aluminum oxide in a few seconds, according to the equation:

$$Fe_2O_3(s) + 2\ Al(s) \rightarrow Al_2O_3(s) + 2\ Fe$$

(a) Given the following, calculate ΔH for the thermite reaction. Show your work. ***4*** **marks**

$2\ Al(s) + \frac{3}{2} O_2\ (g) \rightarrow Al_2O_3(s)$ $\quad \Delta H = -1670$ kJ

$2\ Fe(s) + \frac{3}{2} O_2\ (g) \rightarrow Fe_2O_3(s)$ $\quad \Delta H = -822$ kJ

(b) How much heat energy will be released when 1000.0 g of iron is produced by this reaction? ***2*** **marks**

6. Consider the following reaction:

$$2\ Al(s) + 3\ Cl_2(g) \rightarrow 2\ AlCl_3(s)$$

Also given for this reaction: $\Delta H = -704$ kJ

$\Delta S = 1{,}110$ J/K

(a) Calculate ΔG for this reaction at 200°C. Show your work clearly. ***4 marks***

(b) Will the reaction be spontaneous at this temperature? How do you know? ***2 mark***