HC- Kinetics and Thermodynamics Test Review Stations

Station 1- Collision Theory and Factors Affecting Reaction Rate

1. Explain the collision theory of reactions.

2. Fill out the following table to review the factors affecting reaction rates:

Factor	Effect on Reaction Rate	Explanation
Temperature		
Concentration		
Surface Area		
Pressure (for gases)		
Nature of Reactants		

3. Define activation energy. How is the activation energy of a reaction like a wall or barrier?

4. How is the rate of a reaction influenced by a catalyst? How does a catalyst make this possible?

Practice Multiple Choice:

5. Which of the following reactions is likely to have the fastest reaction rate?
   a. $Zn\ (s) + S\ (s) \rightarrow ZnS\ (s)$
   b. $NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$
   c. $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$
   d. $CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$

6. Given the balanced equation representing a reaction:

   $$Zn\ (s) + 2HCl\ (aq) \rightarrow H_2\ (g) + ZnCl_2\ (aq)$$

   Which set of reaction conditions produces H_2 (g) at the fastest rate?
   a. a 1.0-g lump of Zn (s) in 50. mL of 0.5 M HCl (aq) at 20.°C
   b. a 1.0-g lump of Zn (s) in 50. mL of 0.5 M HCl (aq) at 30.°C
   c. 1.0-g of powdered Zn (s) in 50. mL of 1.0 M HCl (aq) at 20.°C
   d. 1.0-g of powdered Zn (s) in 50. mL of 1.0 M HCl (aq) at 30.°C

Station 2- Reaction Mechanisms

A reaction mechanism is the series of steps by which substances react. The slowest step in the series is the rate-determining step. Changes in concentration of a substance can change the rate of a reaction only if the substance is involved in the rate-determining step.

Answer the following questions given the following reaction mechanism:

Step 1 (slow): $A + B_2 \rightarrow C + D$
Step 2 (fast): $C + F \rightarrow B_2 + E$

1. Write the overall reaction: _____

2. Identify the intermediate: _____
   a. How did you determine that this is the intermediate?

3. Identify the catalyst: _____
   a. How did you determine that this is the catalyst?

4. Which step is considered the rate-determining step?

5. What will be the effect on the reaction rate if the concentration of A is increased? Why?

6. What will be the effect on the reaction rate if the concentration of F is increased? Why?

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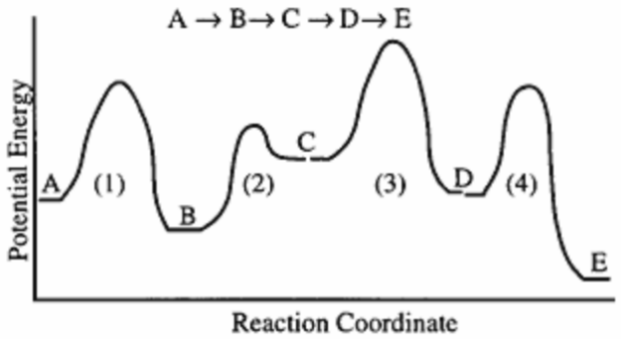
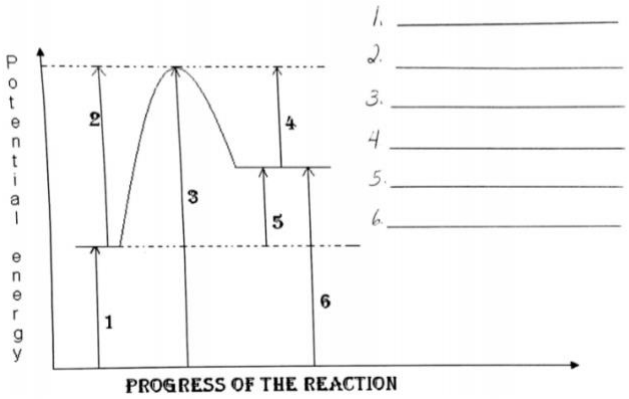
7. Which is the rate-determining step for this hypothetical reaction mechanism of the reaction A→E?



8. Fill in the blank:
   As activation energy increases, rate of a chemical reaction _____.

Station 3- Potential Energy Diagrams and Internal Energy

1. Label the numbered segments on the following potential energy diagram:



2. Which intervals on the diagram above will change with the addition of a catalyst?

3. On the PE diagram above, draw a dashed lined to indicated how the reaction pathway would change with the addition of a catalyst.

4. a. According to the PE diagram above, is the forward reaction endothermic or exothermic? Justify your response.

   b. Based on your answer to part a, what sign would the ΔH of this reaction have?

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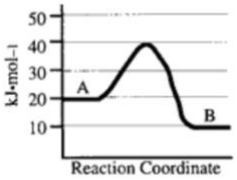
5. What is the ΔH for the reaction A→B, represented by the potential energy diagram to the right?



a) +10 b) +30 c) -30 d) -20 e) -10

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Internal Energy

Equation for calculating ΔU:

6. Circle the correct word from each pair in parentheses to complete the sentences:
   a. In the equation for ΔU, q stands for (work/heat). If the system absorbs energy from its surroundings, q will be (negative/positive). If the system releases energy to its surroundings, q will be (negative/positive).

   b. In the equation for ΔU, w stands for (work/heat). If the system does work on its surroundings, w will be (negative/positive). If the surroundings do work on the system, w will be (negative/positive).

7. A system absorbed 250. kJ of energy from its surroundings and the surroundings did 615 kJ of work on the system. Calculate the change in internal energy, in kJ.

Station 4- Enthalpy

Equation for calculating ΔH_{rxn}:

8. Circle the correct word from each pair in parentheses to complete the sentences:
   a. A -ΔH_{rxn} means that the reaction is (endothermic/exothermic) and energy is (absorbed/released). When writing a thermochemical equation, the amount of energy should be written in the (reactants/products).

   b. A +ΔH_{rxn} means that the reaction is (endothermic/exothermic) and energy is (absorbed/released). When writing a thermochemical equation, the amount of energy should be written in the (reactants/products).

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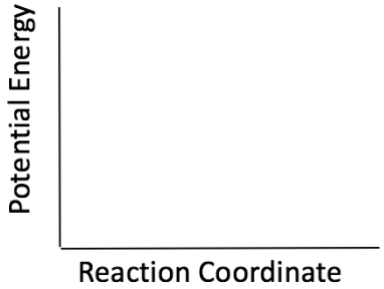
Use Reference Table I to answer the following information:

Methane undergoes a combustion reaction as demonstrated by the balanced equation:

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

9. Write a *thermochemical equation* for the combustion of methane.

10. Decide if this reaction would be classified as endothermic or exothermic. Then, sketch a general potential energy diagram for this reaction on the axes to the right.



11. Determine the ΔH of the *reverse* reaction.

12. Determine the ΔH of the reaction if 4 moles of H_2O (l) were produced.

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13. Use Table A-6 to calculate the ΔH_{rxn} for the following reaction:

$$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (g)$$

Station 5- Entropy

Equation for calculating ΔS_{rxn}:

1. Circle the correct word from each pair in parentheses to complete the sentences:
   a. A -ΔS_{rxn} means that entropy is (increasing/decreasing). Therefore, the system is going towards a more (ordered/disordered) state.

   b. A +ΔS_{rxn} means that entropy is (increasing/decreasing). Therefore, the system is going towards a more (ordered/disordered) state.

2. Fill out the following table to review the factors affecting entropy.

Factor	Effect on Entropy
Phase of matter	*Rank the phases of matter from least entropy to most entropy:*
Temperature	
Number of Particles	
Creating a mixture/solution	

3. Predict the sign of ΔS for each of the following:
   a. $CaCO_3$ (s) → CaO (s) + CO_2 (g): _____ Why? _____
   b. NH_3 (g) + HCl (g) → NH_4Cl (s): _____ Why? _____
   c. NaCl (s) → Na^+ (aq) + Cl^- (aq): _____ Why? _____

4. Circle the system from each pair that has the lower entropy:
   a. Completed jigsaw puzzle OR separate jigsaw puzzle pieces
   b. 50 mL of liquid water OR 50 mL of ice
   c. 10 g of calcium chloride crystals OR a solution containing 10 g of calcium chloride

5. NO (g) reacts with O_2 (g) to form NO_2 (g) according to the balanced equation:

   $$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g)$$

   Use the information on Table A-6 to calculate the ΔS_{rxn}.

Station 6- Spontaneous Reactions and Free Energy

Equation for calculating ΔG_{rxn}:

*Unit for T must be in _____!

1. Circle the correct word from each pair in parentheses to complete the sentences:
   a. A -ΔG_{rxn} means that the reaction is (spontaneous/nonspontaneous). The reaction can therefore be classified as (endergonic/exergonic).
   b. A +ΔG_{rxn} means that the reaction is (spontaneous/nonspontaneous). The reaction can therefore be classified as (endergonic/exergonic).

2. Under which conditions of enthalpy (ΔH) and entropy (ΔS) is a reaction *always* spontaneous?
   a. When the reaction is endothermic and entropy increases
   b. When the reaction is endothermic and entropy decreases
   c. When the reaction is exothermic and entropy increases
   d. When the reaction is exothermic and entropy decreases

3. Evaluate the following two statements:
   I. An exothermic reaction is always a spontaneous reaction BECAUSE
   II. Exothermic reactions release heat to the surroundings.

   a. I is *TRUE*, II is *FALSE*
   b. I is *FALSE*, II is *TRUE*
   c. I and II are *BOTH FALSE*
   d. I and II are *BOTH TRUE* but II *IS NOT* a correct explanation of I
   e. I and II are *BOTH TRUE* and II *IS* a correct explanation of I

4. For the decomposition of $CaCO_3$ (s) to CaO (s) and CO_2 (g)at 298 K the ΔH_{rxn} is 178.5 kJ/mol and the ΔS_{rxn} is 161.6 J/K·mol. Calculate the free energy change of the reaction, then state if the reaction is spontaneous or nonspontaneous at this temperature.

Find the following reactions in Table I. In the table below list the value for Δ H. Examine the reaction and estimate whether Δ S is positive, negative, or zero (no change). State whether the reaction will *always occur*, *never occur*, *occur only at high temperatures*, or *only occur at low temperatures*.

Reaction	**Δ H(kJ)**	**Δ S**	**<u>will occur</u>**
example) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	-91.8	(-)	only @ low temps

5. $Li^+(aq) + Br^-(aq) \rightarrow LiBr(s)$
6. $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$
7. $NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$