

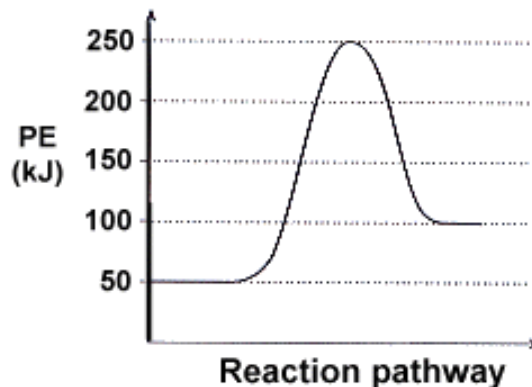
Unit 13: Rates and Equilibrium- Funsheets

Part A: Reaction Diagrams

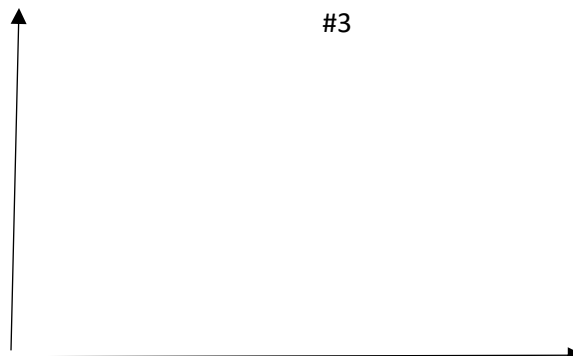
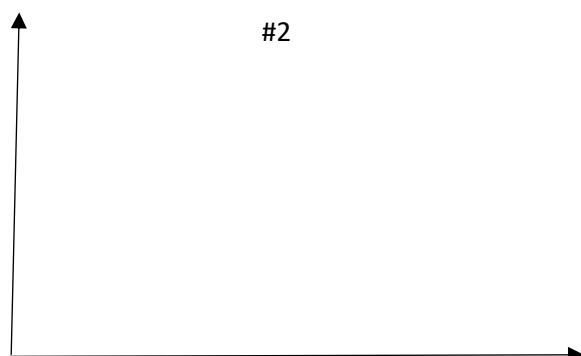
1) Answer the following questions based on the potential energy diagram shown here:

- Does the graph represent an endothermic or exothermic reaction? _____
- Label the position of the reactants, products, and activated complex.
- Determine the heat of reaction, ΔH , (enthalpy change) for this reaction. _____
- Determine the activation energy, E_a for this reaction.

- How much energy is released or absorbed during the reaction? _____
- How much energy is required for this reaction to occur? _____
- Draw a dashed line on the diagram to indicate a potential energy curve for the reaction if a catalyst is added.



- Sketch a potential energy curve below that is represented by the following values of ΔH and E_a (activation energy). You may make up appropriate values for the y-axis (potential energy). $\Delta H = -100$ kJ and $E_a = 20$ kJ
- Sketch a potential energy curve below that is represented by the following values of ΔH and E_a (activation energy). You may make up appropriate values for the y-axis (potential energy). $\Delta H = +45$ kJ and $E_a = 100$ kJ



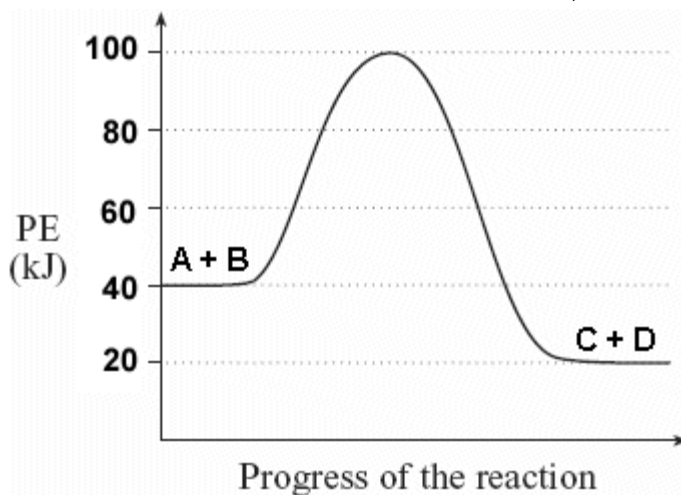
4) Answer the following questions based on the potential energy diagram shown here:

- Does the graph represent an endothermic or exothermic reaction?

- Determine the heat of reaction, ΔH , (enthalpy change) for this reaction.

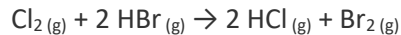
- How much energy is released or absorbed during the reaction?

- How much energy is required for this reaction to occur? _____

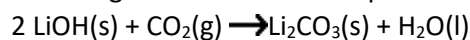


Part B: Hess's Law- Include units and show ALL WORK!

- 1) The standard heats of formation of HCl (g) and HBr (g) are -92.0 kJ/mol and -36.4 kJ/mol respectively. Diatomic gases have a heat of formation of 0 kJ Using this information, calculate ΔH for the following reaction:



- 2) Use the given standard enthalpies of formation to determine the heat of reaction of the following reaction:



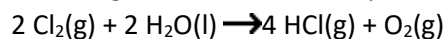
$$\Delta H^\circ_f \text{LiOH}(\text{s}) = -487.23 \text{ kJ/mole}$$

$$\Delta H^\circ_f \text{Li}_2\text{CO}_3(\text{s}) = -1215.6 \text{ kJ/mole}$$

$$\Delta H^\circ_f \text{H}_2\text{O}(\text{l}) = -285.85 \text{ kJ/mole}$$

$$\Delta H^\circ_f \text{CO}_2(\text{g}) = -393.5 \text{ kJ/mole}$$

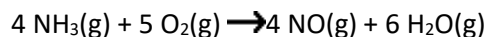
- 3) Use the given standard enthalpies of formation to determine the heat of reaction of the following reaction:



$$\Delta H^\circ_f \text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mole}$$

$$\Delta H^\circ_f \text{HCl}(\text{g}) = -92.3 \text{ kJ/mole}$$

- 4) Calculate ΔH°_f (kJ) for the following reaction from the listed standard enthalpies of formation:



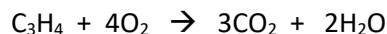
$$\Delta H^\circ_f \text{NH}_3(\text{g}) = -46.1 \text{ kJ}$$

$$\Delta H^\circ_f \text{NO}(\text{g}) = +90.2 \text{ kJ}$$

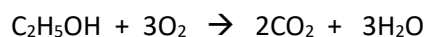
$$\Delta H^\circ_f \text{H}_2\text{O}(\text{g}) = -241.8 \text{ kJ}$$

- 5) The standard enthalpy of formation of propane, C_3H_8 , is -103.6 kJ/mole. Calculate the heat of combustion of C_3H_8 . The heats of formation of $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are -394 kJ/mole and -285.8 kJ/mole respectively. Diatomic molecules have a heat of formation of 0 kJ/mole. $\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O}$

- 6) The standard enthalpy of formation of propyne, C_3H_4 , is +185.4 kJ/mole. Calculate the heat of combustion of C_3H_4 . The heats of formation of $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are -394 kJ/mole and -285.8 kJ/mole respectively.



- 7) The standard enthalpy of formation of ethanol, $\text{C}_2\text{H}_5\text{OH}$, is -277.7 kJ/mole. Calculate the heat of combustion of $\text{C}_2\text{H}_5\text{OH}$. The heats of formation of $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\text{l})$ are -394 kJ/mole and -285.8 kJ/mole respectively.



Part C: Vocabulary and Concepts

- 1) Fill in the blanks: When the products have _____ potential energy than the reactants, the ΔH values is positive. When the products have _____ potential energy than the reactants, the ΔH values is negative.
- 2) Indicate whether the following are endothermic (ENDO) or exothermic (EXO):
 - a. _____ The burning of wood to produce a hot flame.
 - b. _____ $4\text{Fe}(s) + 3\text{O}_2(g) \rightarrow 2\text{Fe}_2\text{O}_3(s) + \text{energy}$
 - c. _____ A test tube that feels cold to the touch after two substances have been mixed.
 - d. _____ $\text{C}(s) + 2\text{F}_2(g) \rightarrow \text{CF}_4(g) \quad \Delta H^\circ = -680 \text{ kJ}$
- 3) According to the Collision Theory, in order for a reaction to occur molecules must _____ with enough _____ and in the proper _____.
- 4) Explain why all reactions have an activation energy, using your knowledge of collision theory.

- 5) Describe how the activation energy of a reaction affects the overall rate of the chemical reaction.

- 6) Model the following reaction and use your model to explain how the atoms are rearranged. Be sure to balance and include a key. $___ \text{N}_2(g) + ___ \text{H}_2(g) \leftrightarrow ___ \text{NH}_3(g)$

- 7) What is a reversible reaction?

- 8) What is an activated complex? _____

- 9) A _____ speeds up a chemical reaction by lowering the _____ energy.

- 10) What is enthalpy? _____

- 11) What is Hess's Law? _____

- 12) *Circle the correct answer:* If something is (endothermic/exothermic) more heat goes from surroundings into the system. The ΔH value is (positive/negative).

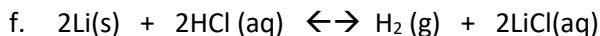
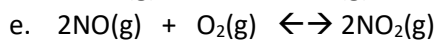
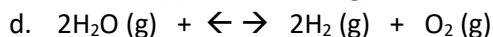
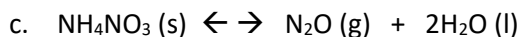
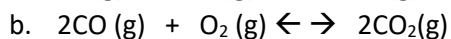
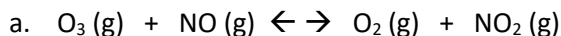
- 13) *Circle the correct answer:* If something is (endothermic/exothermic) more heat goes from the system into the surroundings. The ΔH value is (positive/negative).

- 14) What law explains that during a chemical reaction mass is not created or destroyed just rearranged to create new products? _____

- 15) What law explains that energy is not created or destroyed just transferred between system and surroundings?

Part D: Equilibrium Expressions and Constants- Answer the following and show all work.

1) Write the following equilibrium expression in each box:



a.

b.

c.

d.

e.

f.

2) Equilibrium is established in the reversible reaction: $2\text{A}(\text{aq}) + \text{B}(\text{aq}) \rightleftharpoons \text{A}_2\text{B}(\text{aq})$.

The equilibrium concentrations are $[\text{A}] = 0.55\text{M}$, $[\text{B}] = 0.33\text{M}$, and $[\text{A}_2\text{B}] = 0.43\text{M}$. What is the equilibrium expression and value of the equilibrium constant, K_c for this reaction?

3) What is the equilibrium expression and equilibrium constant if the equilibrium concentrations are as follows:

PCl_5 is 0.0096M , PCl_3 is 0.0247M , and Cl_2 is 0.0247M ? $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$

4) At a certain temperature, a container has an equilibrium mixture consisting of 0.102M of NH_3 , 1.03M N_2 , and 1.62M of H_2 . Calculate the K_c for the equilibrium system. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$

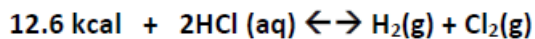
5) What is the equilibrium expression and equilibrium constant if the equilibrium consists of 10.0g of NaOH , 0.50M HCl , 1.0L H_2O , and 0.88M NaCl . $\text{NaOH}(\text{s}) + \text{HCl}(\text{aq}) \rightleftharpoons \text{H}_2\text{O}(\text{l}) + \text{NaCl}(\text{aq})$

6) At a given temperature, the K_c for the reaction below is 1.40×10^{-2} . If the concentrations of H_2 and I_2 at equilibrium are $2.00 \times 10^{-4}\text{M}$, find the concentration of HI . $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$

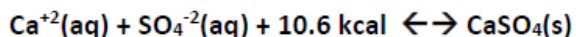
Part E: Le Chatelier's Principle

- 1) State Le Chatelier's Principle: _____

- 2) Predict which way the following equilibrium systems will shift when the total pressure is increased. (Note: some may have no shift)
- a. $N_2(g) + O_2(g) \leftrightarrow 2NO(g)$ _____
- b. $2SO_2(g) + O_2(g) \leftrightarrow 2SO_3(g)$ _____
- c. $4NH_3(g) + 5O_2(g) \leftrightarrow 4NO(g) + 6H_2O(g)$ _____
- 3) $N_2O_4(g)$ is a colorless gas and $NO_2(g)$ is a dark brown gas. Use Le Chatelier's principle to explain why a flask filled with $NO_2(g)$ and $N_2O_4(g)$ will get darker when heated. Use the equation: $N_2O_4(g) + \text{heat} \leftrightarrow 2NO_2(g)$
- _____
- _____
- 4) List at least 3 ways to increase amount of oxygen gas in the following reaction.
- $H_2O_2(aq) \leftrightarrow H_2(g) + O_2(g) \quad \Delta H = +187.00 \text{ kJ}$
- a. _____
- b. _____
- c. _____
- 5) Complete the following chart by writing left, right, or none for the equilibrium shift. Write decrease, increases, or remains the same for the concentrations of reactants and products.



Stress	Equilibrium Shift	$[H_2]$	$[Cl_2]$	$[HCl]$
1. Add H_2	Left	_____	decreases	increases
2. Add Cl_2			_____	
3. Add HCl				_____
4. Remove H_2		_____		
5. Remove Cl_2			_____	
6. Remove HCl				_____
7. Increase Temperature				
8. Decrease Temperature				
9. Increase Pressure				
10. Decrease Pressure				



(Remember that pure solids and liquids do not affect equilibrium values.)

Stress	Equilibrium Shift	Amount of CaSO ₄ (s)	[Ca ⁺²]	[SO ₄ ⁻²]
1. Add CaSO ₄ (s)		_____		
2. Add CaCl ₂ (adds Ca ⁺²)			_____	
3. Add MgSO ₄ (adds SO ₄ ⁻²)				_____
4. Remove SO ₄ ⁻²				_____
5. Increase temperature				
6. Decrease temperature				
7. Increase Pressure				
8. Decrease Pressure				

Part F: Vocabulary and Concepts

- Provide an example of a heterogeneous reaction and an example of a homogeneous reaction. Support your answer.
- List 5 factors that affect the rate of a reaction:
 - _____
 - _____
 - _____
 - _____
 - _____
- Using the collision theory explain why the rate of a reaction increases when pressure is increased.
- The process of milk spoiling is a chemical reaction. Using your knowledge of rates of chemical reactions and collision theory, explain why we keep milk in the refrigerator.
- It has been observed that more gas station fires occur on hot days than on cold days. Explain this phenomenon using your knowledge of collision theory.

- 6) What is chemical equilibrium?
- 7) What is equal at chemical equilibrium?
- 8) What is constant at chemical equilibrium?
- 9) At the macroscopic level a system at equilibrium appears to be unchanging. Is it also unchanging at the molecular level? Explain.
- 10) True or False: At equilibrium the amount of reactants is equal to the amount of products. _____
- 11) What is the formula for writing an equilibrium expression?
- 12) What do brackets [] indicate? _____
- 13) List 2 examples of enzymes and explain their function.
- 14) Model a reaction at equilibrium. Be sure to consider concentration, the fact the equilibrium is dynamic, and rates of forward and reverse reactions. Be sure to include a key. $3A + B \rightleftharpoons A_3B$

