

## MULTIPLE CHOICE.

- 1) Equilibrium is reached in a chemical reaction when 1) A  
 A) The rates of the opposing reactions become equal  
 B) The reactants are completely consumed  
 C) The forward and reverse reactions stop  
 D) The concentrations of all reactants and products become equal
- 2) In which direction will the point of equilibrium shift when the concentration of iron(III) ion decreases in the following equilibrium? 2) C  

$$\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons \text{Fe}(\text{SCN})_2^{2+}(\text{aq})$$
 A) Shift to the right      B) No shift      C) Shift to the left
- 3) In which direction will the point of equilibrium shift when the pressure is increased in the following equilibrium? 3) A  

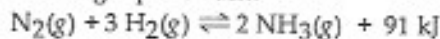
$$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$$
 A) Shift to the right      B) No shift      C) Shift to the left
- 4) In which direction will the point of equilibrium shift when a catalyst is added to the following equilibrium system? 4) A  

$$2 \text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{NO}_2(\text{g}) + 113 \text{ kJ}$$
 A) No shift      B) Shift to the right      C) Shift to the left
- 5) In the following equilibrium, 5) A  

$$\text{NaCl}(\text{s}) \rightleftharpoons \text{Na}^{+}(\text{aq}) + \text{Cl}^{-}(\text{aq})$$
 When chloride ion is added, the concentration of sodium ion will  
 A) decrease      B) increase      C) not change
- 6) Ammonia, an essential chemical for modern civilization, is produced from the forward reaction of the following equilibrium 6) D  

$$\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g}) + 92.5 \text{ kJ}$$
 From the equilibrium, which of the following would favor the production of ammonia?  
 A) Reducing the concentration of ammonia  
 B) Increasing the pressure  
 C) Increasing the concentration of nitrogen gas  
 D) All of the above
- 7) Which one of the following factors would affect the rate of the chemical reaction? 7) D  
 A) Temperature      B) Concentration of reactants  
 C) Catalyst      D) All of the above

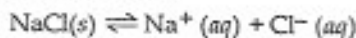
- 8) Which of the following ways would the point of equilibrium shift toward to right (product) in the following equilibrium? 8) \_\_\_\_\_



- A) Reduce the concentrations of  $\text{NH}_3(\text{g})$   
 B) Increase the temperature of the reaction.  
 C) Use better catalyst  
 D) Increase the pressure of the system.  
 E) Lower the temperature of the reaction.  
 F) Reduce the pressure of the system.  
 G) Increase the concentrations of  $\text{N}_2(\text{g})$  and/or  $\text{H}_2(\text{g})$  or both

A, D, E, G

- 9) Critical thinking: The solubilities of most ionic compounds increase as the temperature increases, such as table salt: 9) \_\_\_\_\_

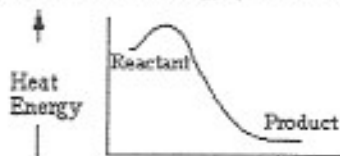


which of the following must be true?

- A) The crystallization process is exothermic.  
 B) The dissolving process is exothermic.  
 C) The crystallization process is endothermic.  
 D) The dissolving process is endothermic.

A, D

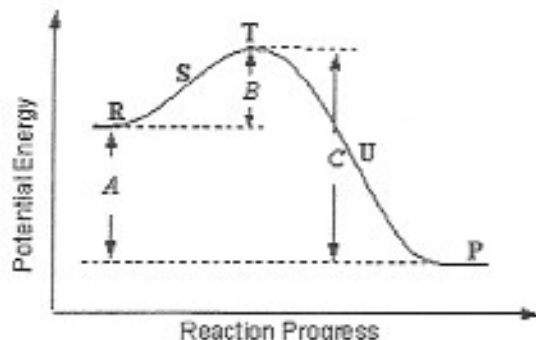
- 10) The reaction energy profile as shown below indicates the reaction is \_\_\_\_\_.



- A) exothermic.      B) isothermic.      C) endothermic.      D) quasithermic.

10) A

- 11) The question below refer to the following diagram: 11) \_\_\_\_\_



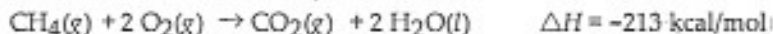
The activation energy of the forward reaction ( $\text{R} \rightarrow \text{P}$ ) is

- A) A       B) B      C) C      D) B+C

11) B

PROBLEMS. Show work with proper Significant Figures and Units to receive credit.

- 12) For the combustion of methane,



- a. How many kilocalories of energy are released from 5.0 mol of methane? *1,069 kcal ARE RELEASED.*  
 b. How many moles of methane are needed to give 100. kcal heat? *0.469 mol ARE NEEDED*

A)  $X \text{ kcal} = 5.0 \text{ mol CH}_4 \cdot \frac{-213 \text{ kcal}}{\text{mol}} = -1,069 \text{ or } -1.07 \times 10^3$

B)  $X \text{ mol} = 100 \text{ kcal} \cdot \frac{1 \text{ mol}}{-213 \text{ kcal}} = 0.469 \text{ mol}$

Unit Test on Rates of Reactions and Equilibrium

1. Consider the following reaction:  $\text{PCl}_5(\text{g}) \leftrightarrow \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ .

- a) If at equilibrium the concentration of  $\text{PCl}_5$  is 2 M, the concentration of  $\text{PCl}_3$  is 3 M and the concentration of  $\text{Cl}_2$  is 4 M, calculate the equilibrium constant.

$$K = \frac{[\text{PRODUCT}]}{[\text{REACTANT}]} = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{(3\text{M})(4\text{M})}{2\text{M}} = 6$$

- b) Will more reactants or more products be produced if the pressure decreases? Explain.

MORE PRODUCTS, SINCE DECREASING PRESSURE WILL SHIFT TOWARD THE SIDE WITH GREATER NUMBER OF MOLES.

- c) Assume the reaction is endothermic. In order to increase the amount of products would you want to increase or decrease the temperature? Explain.

INCREASE TEMPERATURE BECAUSE FOR AN ENDOOTHERMIC REACTION, HEAT IS ON THE REACTANT AND SHIFT WILL BE TOWARD PRODUCT TO USE UP HEAT.

2. The amount of products of a certain reaction increased when the temperature was raised. Is the reaction endothermic or exothermic? (Hint: think of LeChatelier's Principle and whether the energy would be written on the left or right side of the equation.)

ENDOOTHERMIC

3. Nitrogen and hydrogen gases react to form ammonia:  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \leftrightarrow 2\text{NH}_3(\text{g})$ . It is an exothermic reaction.

- a) Would more  $\text{NH}_3(\text{g})$  be produced if the pressure was increased? Explain.

YES, INCREASE PRESSURE FAVORS FEWER MOLES.

- b) Would more  $\text{NH}_3(\text{g})$  be produced if the temperature was increased? Explain.

NO, THIS IS EXOTHERMIC, HEAT IS ON THE PRODUCT SIDE SO INCREASE IN TEMPERATURE WILL SHIFT TO REACTANT SIDE TO USE UP HEAT.

- c) Describe what would happen if some  $\text{H}_2$  were removed from the container.

IF  $\text{H}_2$  IS REMOVED, SHIFT WILL BE SAME SIDE WHERE  $\text{H}_2$  IS TO REPLACE IT, SO SHIFT TO THE LEFT (REACTANT SIDE).

4. Consider the following equilibrium:  $\text{SO}_2\text{Cl}_2(\text{g}) \leftrightarrow \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$ . The  $\Delta H$  of the reaction is 121.4 kJ. Consider LeChatelier's principle when answering the following questions.

- a) Would more  $\text{SO}_2\text{Cl}_2$  be produced if the pressure was increased? Explain.

YES, INCREASE PRESSURE FAVORS FEWER MOLES.

- b) Would more  $\text{SO}_2\text{Cl}_2$  be produced if the temperature was increased? Explain.

NO, THIS IS ENDOOTHERMIC ( $\Delta H = 121.4\text{kJ}$ ) SO HEAT IS IN THE REACTANT SIDE. INCREASE TEMPERATURE SHIFTS TO THE RIGHT (PRODUCT) TO USE UP HEAT.

- c) Describe what would happen if some  $\text{Cl}_2$  were removed from the container.

IF  $\text{Cl}_2$  IS REMOVED, SHIFT WILL POINT TO THE SAME SIDE WHERE  $\text{Cl}_2$  IS TO REPLACE IT, SO SHIFT TO THE RIGHT (PRODUCT SIDE).