

K_c = constant for molar concentration

K_p = constant for partial pressure

K_{sp} = solubility product (no denominator because reactants are solids)

K_a = acid dissociation constant for a weak acid.

K_b = Base dissociation constant for weak base.

K_w = describes the ionization of water (K_w = 1 x 10⁻¹⁴)

K_{eq} = equilibrium

Equilibrium Expression:
$$K = \frac{[HI]^2}{[H_2][I_2]}$$

Equilibrium Constant:
$$K = \frac{(1.29)^2}{(0.106)(0.022)} = 7.1 \times 10^2$$

- The equilibrium constant K tells us the relative amount of product and reactant at equilibrium.

Q is different than K because K is the [react] and [prod] at equilibrium.

Q predicts the direction of the reaction.

K >> 1 Products Favored

K << 1 Reactants Favored

Relationship Direction

Q > K Shift to left

Q = K Equilibrium

Q < K Shift to right

$$K_p = K_c(RT)^{\Delta n}$$

Concentration

↑ [reactant] or [product]
The reaction will move in the direction that will use up the added substance



If we add A rxn shifts forward (right) to use up A
• If we add C rxn will reverse(left) to use up C

↓ [reactant] or [product]
The reaction will move in the direction that will produce that substance

VOLUME

↑ volume the rxn will move in the direction that will produce more moles of gas

↓ volume the rxn will move in the direction that will produce less moles of gas

If there is no gas in the rxn or if the reactant and product have the same number of moles a Δ volume will have no effect on the rxn.

Le Chatelier's Principle States:
If the system is disrupted by a change in one of the above, or [components], the system will shift in the direction to counteract the disruption

Temperature

↑ temperature the rxn moves in the endothermic direction (+ ΔH)



↓ temperature the rxn moves in the exothermic direction (- ΔH)

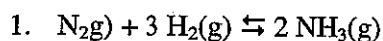


K only depends on temperature, catalysts have NO EFFECT on K

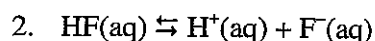
16 • Chemical Equilibria**PROBLEM SET #1**

For the following three reactions,

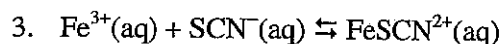
- write the K_{eq} expression in terms of concentration, K_c .
- given the equilibrium concentrations, state whether each equilibrium is product-favored, reactant-favored, or fairly even ($[products] \approx [reactants]$).
- calculate the value of K_c .



At equilibrium: $[N_2] = 1.50 \text{ M}$
 $[H_2] = 2.00 \text{ M}$
 $[NH_3] = 0.01 \text{ M}$



At equilibrium: $[HF] = 0.55 \text{ M}$
 $[H^+] = 0.001 \text{ M}$
 $[F^-] = 0.001 \text{ M}$



At equilibrium: $[Fe^{3+}] = 0.55 \text{ M}$
 $[SCN^-] = 0.001 \text{ M}$
 $[FeSCN^{2+}] = 0.001 \text{ M}$

Summarize:

Fill in the blanks with product-favored, reactant-favored, and approximately equal

K_c	state of equilibrium
$K_c \gg 1$	
$K_c \ll 1$	
$K_c \approx 1$	

4. Knowing that pure water has a density of 1g/1mL calculate the mass of 1.00 Liter of water.

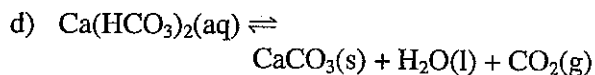
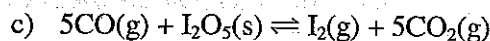
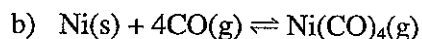
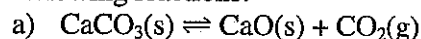
Calculate the number of moles in 1.00 L of H_2O .What is the concentration (M) of water in water?

At this temperature, can you get more moles of water into this Liter of water?

The $[H_2O]$ _____ (is / is not) constant.**Important Note:**

Since the concentrations of solids and liquids are constant, they are incorporated into the equilibrium constant, K_{eq} . That means, just leave them out of the K_c or K_p expression. Only include (g) and (aq)!

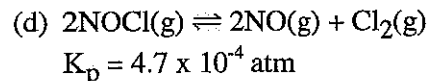
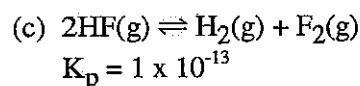
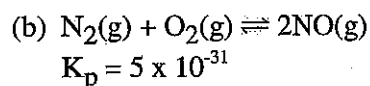
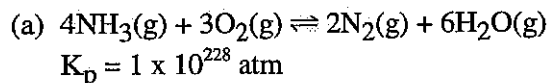
5. Write equilibrium expressions for each of the following reactions:



6. Write the equilibrium expression in terms of partial pressures (K_p) for each of the following reactions.

Rate the reactions in order of their increasing tendency to proceed toward completion:

— — — —



A Question That You Should Be Able To Answer:

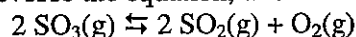
Why don't the K_p 's in (b) and (c) have units?

7. (a) Write the K_c expression for
 $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{SO}_3(\text{g})$

Calculate the value of K_c :

At equilibrium: $[\text{SO}_2] = 1.50 \text{ M}$
 $[\text{O}_2] = 1.25 \text{ M}$
 $[\text{SO}_3] = 3.50 \text{ M}$

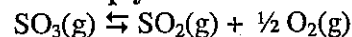
- (b) If we reverse the equation, it is:



Write the K_c expression for this equation and calculate the new value of K_c :

How does the expression and the value of K_c in 7(b) compare with those in 7(a)?

- (c) If we now multiply all of the coefficients by $\frac{1}{2}$:



Write the K_c expression for this equation and calculate the new value of K_c :

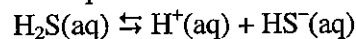
How do they compare with 7(b)?

- (d) What would happen to the K_c expression and its value if we doubled the coefficients?

Summarize:

Equation	K_c expression & Value
doubled	
reversed	
halved	

8. Consider an equilibrium that occurs in two steps:



- (a) Write the overall reaction.
 (b) How do the K_c 's for the two steps (K_{c1} & K_{c2}) relate to the K_c of the overall reaction (K_c)?

16 • Chemical Equilibria**PROBLEM SET # 2**

1. Consider the equilibrium: $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2 \text{SO}_3(\text{g})$ $K_c = 4.36 \text{ M}^{-1}$
Calculate the value of "Q" for a situation in which the concentrations are $[\text{SO}_2] = 2.00 \text{ M}$, $[\text{O}_2] = 1.50 \text{ M}$, and $[\text{SO}_3] = 1.25 \text{ M}$.

Does this mixture shift toward the reactants or products to reach equilibrium? _____

2. Study the discussion in your textbook about converting K_c and K_p . Write the K_p expression for the reaction in question 1 and calculate its value at 0°C . Remember, $R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$.

3. Consider the equilibrium $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$.

How would the following changes affect the partial pressures of each gas at equilibrium? (\uparrow , \downarrow , $=$)
 $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons \text{PCl}_5(\text{g})$

- | | | | |
|--|-------|-------|-------|
| a) addition of PCl_3 | _____ | _____ | _____ |
| b) removal of Cl_2 | _____ | _____ | _____ |
| c) removal of PCl_5 | _____ | _____ | _____ |
| d) decrease in the volume of the container | _____ | _____ | _____ |
| e) addition of He without change in volume | _____ | _____ | _____ |

4. How will each of the changes in question 3 affect the K_{eq} ? (\uparrow =increase; \downarrow =decrease; $—$ = unchanged)

a _____ b _____ c _____ d _____ e _____

5. Indicate how each of the following changes affects the amount of each gas in the system below, for which $\Delta H_{\text{reaction}} = +9.9 \text{ kcal}$.

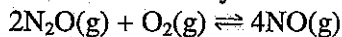


- | | | | | |
|--|-------|-------|-------|-------|
| a) addition of CO_2 | _____ | _____ | _____ | _____ |
| b) addition of H_2O | _____ | _____ | _____ | _____ |
| c) addition of a catalyst | _____ | _____ | _____ | _____ |
| d) increase in temperature | _____ | _____ | _____ | _____ |
| e) decrease in the volume of the container | _____ | _____ | _____ | _____ |

6. How will each of the changes in question 5 affect the equilibrium constant?

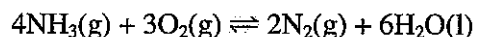
a _____ b _____ c _____ d _____ e _____

7. Consider the equilibrium: $2\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g})$
 How will the amount of chemicals at equilibrium be affected by



- | | | | |
|---|-----|-----|-----|
| a) adding N_2O | ___ | ___ | ___ |
| b) removing O_2 | ___ | ___ | ___ |
| c) increasing the volume of the container | ___ | ___ | ___ |
| d) adding a catalyst | ___ | ___ | ___ |

8. For the reaction,
 How will the concentration of each chemical be affected by



- | | | | | |
|--|-----|-----|-----|-----|
| a) adding O_2 to the system | ___ | ___ | ___ | ___ |
| b) adding N_2 to the system | ___ | ___ | ___ | ___ |
| c) removing H_2O from the system | ___ | ___ | ___ | ___ |
| d) decreasing the volume of the container | ___ | ___ | ___ | ___ |

9. Consider the equilibrium: $2\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 4\text{NO}(\text{g})$
 3.00 moles of $\text{NO}(\text{g})$ are introduced into a 1.00-Liter evacuated flask. When the system comes to equilibrium, 1.00 mole of $\text{N}_2\text{O}(\text{g})$ has formed. Determine the equilibrium concentrations of each substance. Calculate the K_c for the reaction based on these data.

	2 N_2O	O_2	4 NO
initial			
change			
equilibrium			

Remember: The "ice" box may be used with moles, molarity, or Liters (for gaseous equilibria)... never grams.

16 • Chemical Equilibrium

PRACTICE TEST

1. Consider the reaction system,
 $\text{CoO(s)} + \text{H}_2\text{(g)} \rightleftharpoons \text{Co(s)} + \text{H}_2\text{O(g)}$.

The equilibrium constant expression is

- a) $\frac{[\text{CoO}][\text{H}_2]}{[\text{Co}][\text{H}_2\text{O}]}$ d) $\frac{[\text{H}_2]}{[\text{H}_2\text{O}]}$
 b) $\frac{[\text{Co}][\text{H}_2\text{O}]}{[\text{CoO}][\text{H}_2]}$ e) $\frac{[\text{H}_2\text{O}]}{[\text{H}_2]}$
 c) $\frac{[\text{Co}][\text{H}_2\text{O}]}{[\text{H}_2]}$

2. Given the equilibrium,
 $2\text{SO}_2\text{(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{SO}_3\text{(g)}$, if this
 equilibrium is established by beginning with
 equal number of moles of SO_2 and O_2 in a
 1.0 Liter bulb, then the following *must* be
 true at equilibrium:

- a) $[\text{SO}_2] = [\text{SO}_3]$ d) $[\text{SO}_2] < [\text{O}_2]$
 b) $2[\text{SO}_2] = 2[\text{SO}_3]$ e) $[\text{SO}_2] > [\text{O}_2]$
 c) $[\text{SO}_2] = [\text{O}_2]$

Questions 3 & 4 refer to the following:

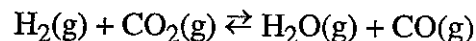
At a given temperature, 0.300 mole NO,
 0.200 mol Cl_2 and 0.500 mol ClNO were
 placed in a 25.0 Liter container. The
 following equilibrium is established:
 $2\text{ClNO(g)} \rightleftharpoons 2\text{NO(g)} + \text{Cl}_2\text{(g)}$

3. At equilibrium, 0.600 mol of ClNO was
 present. The number of *moles* of Cl_2 present
 at equilibrium is
- a) 0.050 d) 0.200
 b) 0.100 e) 0.250
 c) 0.150

4. The equilibrium constant, K_c , is:

- a) 4.45×10^{-4} d) 0.167
 b) 6.67×10^{-4} e) 1500
 c) 0.111

5. At 985°C , the equilibrium constant for the
 reaction,



is 1.63. What is the equilibrium constant for
 the reverse reaction?

- a) 1.63 d) 0.613
 b) 0.815 e) 1.00
 c) 2.66

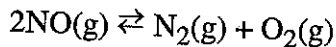
6. What is the relationship between K_p and K_c
 for the reaction, $2\text{ICl(g)} \rightleftharpoons \text{I}_2\text{(g)} + \text{Cl}_2\text{(g)}$?

- a) $K_p = K_c(\text{RT})^{-1}$ d) $K_p = K_c$
 b) $K_p = K_c(\text{RT})$ e) $K_p = K_c(2\text{RT})$
 c) $K_p = K_c(\text{RT})^2$

7. For the reaction $2\text{NO}_2\text{(g)} \rightleftharpoons \text{N}_2\text{O}_4\text{(g)}$, K_p at
 25°C is 7.3, when all partial pressures are
 expressed in atmospheres. What is K_c for
 this reaction? [$R=0.0821 \text{ L}\cdot\text{atm}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$]

- a) 4270 d) 179
 b) 0.0119 e) 2.06
 c) 0.291

8. 0.200 mol NO is placed in a one liter flask at 2273 K. After equilibrium is attained, 0.0863 mol N₂ and 0.0863 mol O₂ are present. What is K_c for this reaction?



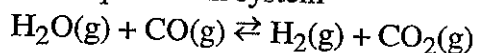
- a) 9.92 d) 39.7
b) 3.15 e) 0.576
c) 0.0372

9. $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$

At 25°C, 0.11 mole of N₂O₄ reacts to form 0.10 mol of N₂O₄ and 0.02 mole of NO₂. At 90°C, 0.11 mole of N₂O₄ forms 0.050 mole of N₂O₄ and 0.12 mole of NO₂. From these data we can conclude

- a) N₂O₄ molecules react by a second order rate law.
b) N₂O₄ molecules react by a first order rate law.
c) the reaction is exothermic.
d) N₂O₄ molecules react faster at 25°C than at 90°C.
e) the equilibrium constant for the reaction above increases with an increase in temperature.

10. For the equilibrium system

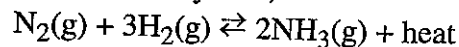


$$\Delta H = -42 \text{ kJ/mol}$$

K_c equals 0.62 at 1260 K. If 0.10 mole each of H₂O, CO, H₂ and CO₂ (each at 1260 K) were placed in a 1.0-Liter flask at 1260 K, when the system came to equilibrium...

	The temperature would	The mass of CO would
a)	decrease	increase
b)	decrease	decrease
c)	remain constant	increase
d)	increase	decrease
e)	increase	increase

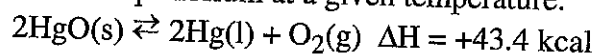
11. For the reaction system,



the conditions that would favor maximum conversion of the reactants to products would be

- a) high temperature and high pressure
b) high temperature, pressure unimportant
c) high temperature and low pressure
d) low temperature and high pressure
e) low temperature and low pressure

12. Solid HgO, liquid Hg, and gaseous O₂ are placed in a glass bulb and are allowed to reach equilibrium at a given temperature.



The mass of HgO in the bulb could be increased by

- a) adding more Hg.
b) removing some O₂.
c) reducing the volume of the bulb.
d) increasing the temperature.
e) removing some Hg.

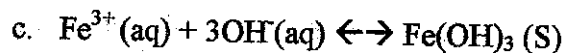
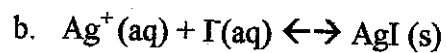
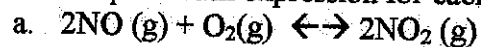
Answers: (Please use *CAPITAL* letters)

1.
2.
3.
4.
5.
6.

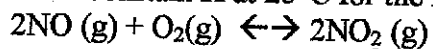
7.
8.
9.
10.
11.
12.

Chapter 13 Review

1. write the equilibrium expression for each of the following



2. Calculate the equilibrium constant K at 25°C for the reaction



If the equilibrium concentrations are $\text{NO} = 6.5 \times 10^{-5} \text{ atm}$ $\text{O}_2 = 4.5 \times 10^{-5} \text{ atm}$ $\text{NO}_2 = 0.55 \text{ atm}$

3. Of the equilibrium constant at 444°C for $2\text{HI}(\text{g}) \leftrightarrow \text{H}_2(\text{g}) + \text{I}_2(\text{g})$ is 1.39×10^{-2} , find the equilibrium constant for the reverse reaction at 444°C .

4. For each value of K predict the effect on the reaction.

$$K = 1$$

$$K = 10^{10}$$

$$K = 10^{-10}$$

5. The dissociation of acetic acid, CH_3COOH , has an equilibrium constant at 25°C of 1.8×10^{-5} .
The reaction is



If the equilibrium concentration of $\text{CH}_3\text{COOH} = 0.46$ moles in 0.500 L of water and the concentration of CH_3COO^- is 8.1×10^{-3} moles in the same 0.500 L calculate the concentration of H^+ for the reaction.

6. Indicate which has an effect on A. the speed of the reaction or B. the position of the equilibrium. (m)ark the appropriate line(s)

1. Catalyst

2. Pressure

3. Temperature

4. Concentration

A _____

A _____

A _____

A _____

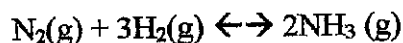
B _____

B _____

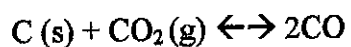
B _____

B _____

7. at 700K , the measured values of for the partial pressures of ammonia, hydrogen, and nitrogen are 0.400 atm , 7.20 atm, and 2.40 atm respectively. Calculate the K_p and K_c at 700K for the synthesis of ammonia:

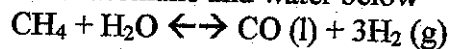


8. (Likely to see on AP) For the following process at 700°C , what is the partial pressure of each gas at equilibrium if the total pressure is 0.750 atm? Hint: use X to solve



$$K_p = 1.50$$

9. Given the reaction of methane and water below



$$K = 5.67$$

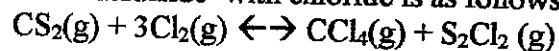
predict what direction the system will shift in order to reach equilibrium given the following initial values of Q.

a. $Q = 11.85$

b. $Q = 3.8 \times 10^{-4}$

c. $Q = 5.67$

10. The reaction of carbon disulfide with chloride is as follows



$$\Delta H = -238 \text{ kJ}$$

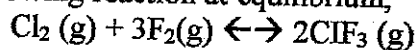
Predict the effect of the following change to the system on the direction of the equilibrium.

a. The pressure on the system is doubled by halving the volume

b. CCl_4 is removed as it is generated

c. Heat is added to the system

11. Given the following reaction at equilibrium,



a. Predict the effect if the pressure were reduced at a constant temperature.

b. Predict the effect if the volume were reduced by increasing the pressure at a constant temperature.

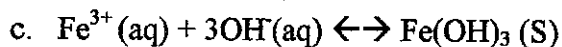
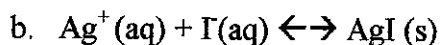
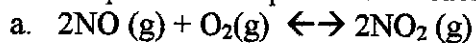


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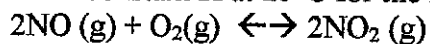
Name: _____ Date: _____

Chapter 13 Review

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2. Calculate the equilibrium constant K at 25°C for the reaction



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$$K = 1$$

$$K = 10^{10}$$

$$K = 10^{-10}$$

5. The dissociation of acetic acid, CH_3COOH , has an equilibrium constant at 25°C of 1.8×10^{-5} . The reaction is

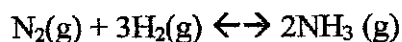


If the equilibrium concentration of $\text{CH}_3\text{COOH} = 0.46$ moles in 0.500 L of water and the concentration of CH_3COO^- is 8.1×10^{-3} moles in the same 0.500 L calculate the concentration of H^+ for the reaction.

6. Indicate which has an effect on A. the speed of the reaction or B. the position of the equilibrium. (mark the appropriate lines(s))

1. Catalyst	2. Pressure	3. Temperature	4. Concentration
A _____	A _____	A _____	A _____
B _____	B _____	B _____	B _____

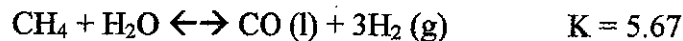
7. at 700K , the measured values of for the partial pressures of ammonia, hydrogen, and nitrogen are 0.400 atm , 7.20 atm, and 2.40 atm respectively. Calculate the K_p and K_c at 700K for the synthesis of ammonia:



8. (Likely to see on AP) For the following process at 700°C , what is the partial pressure of each gas at equilibrium if the total pressure is 0.750 atm? Hint: use X to solve



9. Given the reaction of methane and water below



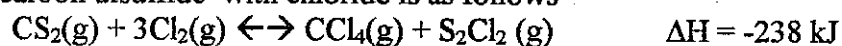
predict what direction the system will shift in order to reach equilibrium given the following initial values of Q.

a. $Q = 11.85$

b. $Q = 3.8 \times 10^{-4}$

c. $Q = 5.67$

10. The reaction of carbon disulfide with chloride is as follows



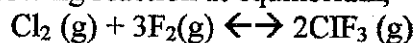
Predict the effect of the following change to the system on the direction of the equilibrium.

a. The pressure on the system is doubled by halving the volume

b. CCl_4 is removed as it is generated

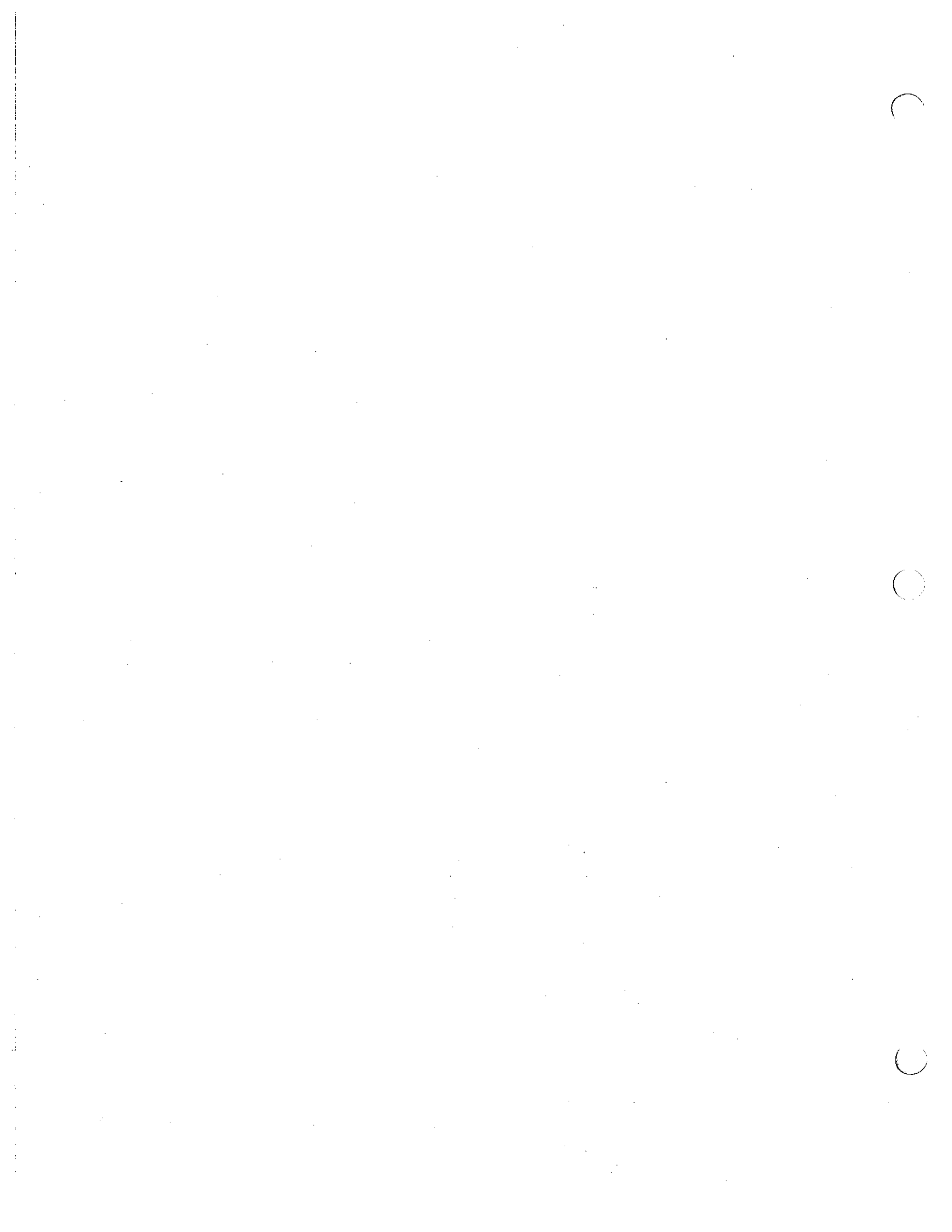
c. Heat is added to the system

11. Given the following reaction at equilibrium,



a. Predict the effect if the pressure were reduced at a constant temperature.

b. Predict the effect if the volume were reduced by increasing the pressure at a constant temperature.



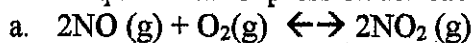
Name: _____

48pts

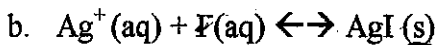
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Chapter 13 Review

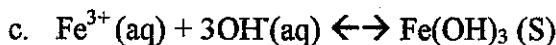
1. write the equilibrium expression for each of the following



$$\frac{[\text{NO}_2]^2}{[\text{NO}]^2 [\text{O}_2]}$$

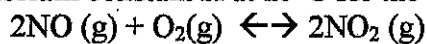


$$\frac{1}{[\text{Ag}^+][\text{I}^-]}$$



$$\frac{1}{[\text{Fe}^{3+}][\text{OH}^-]^3}$$

2. Calculate the equilibrium constant K at 25°C for the reaction

If the equilibrium concentrations are $\text{NO} = 6.5 \times 10^{-5} \text{ atm}$, $\text{O}_2 = 4.5 \times 10^{-5} \text{ atm}$, $\text{NO}_2 = 0.55 \text{ atm}$

$$K = \frac{[\text{NO}_2]^2}{[\text{NO}]^2 [\text{O}_2]} = \frac{[0.55]^2}{[6.5 \times 10^{-5}]^2 [4.5 \times 10^{-5}]} = 1.6 \times 10^{12}$$

3. Of the equilibrium constant at 444°C for $2\text{HI}(g) \leftrightarrow \text{H}_2(g) + \text{I}_2(g)$ is 1.39×10^{-2} , find the equilibrium constant for the reverse reaction at 444°C.

$$\frac{[\text{I}][\text{H}]}{[\text{HI}]^2} = K \quad \therefore \frac{1}{K} = \frac{1}{1.39 \times 10^{-2}} = 71.9$$

reverse

4. For each value of K predict the effect on the reaction.

$K = 1$

$K = 10^{10}$

$K = 10^{-10}$

$K = 1 \quad \text{Lib}$

 $K = 10^{10}$ = Far right / Forward $K = 10^{-10}$ = Far left / Reverse

20



5. The dissociation of acetic acid, CH_3COOH , has an equilibrium constant at 25°C of 1.8×10^{-5} . The reaction is



If the equilibrium concentration of $\text{CH}_3\text{COOH} = 0.46$ moles in 0.500 L of water and the concentration of CH_3COO^- is 8.1×10^{-3} moles in the same 0.500 L calculate the concentration of H^+ for the reaction.

4

$$\frac{\frac{8.1 \times 10^{-3} [x]}{.5}}{.46/5} = 1.8 \times 10^{-5} \quad x = \sqrt{0.001M}$$

6. Indicate which has an effect on A. the speed of the reaction or B. the position of the equilibrium. (m)ark the appropriate line(s)

8

	1. Catalyst	2. Pressure	3. Temperature	4. Concentration
Speed	A <u>↑</u>	A <u>↑</u>	A <u>↑</u>	A <u>↑</u>
= Liq	B <u>N/A</u>	B <u>↑ ↓</u> to shift to less n. ↑ K	B <u>↑ shift</u>	B <u>Shift Lib</u>

7. at 700K , the measured values of for the partial pressures of ammonia, hydrogen, and nitrogen are 0.400 atm, 7.20 atm, and 2.40 atm respectively. Calculate the K_p and K_c at 700K for the synthesis of ammonia:

4

$$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \leftrightarrow 2\text{NH}_3(\text{g})$$

$$K_p = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{.4^2}{2.4 \cdot 7.2^3} = 1.78 \times 10^{-4}$$

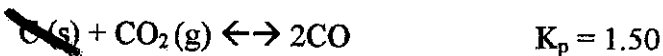
$$K_p = K_c(RT)^{\Delta n}$$

$$1.78 \times 10^{-4} = K_c(.0821 \cdot 700)^{-2}$$

$$K_c = 0.588$$

8. (Likely to see on AP) For the following process at 700°C , what is the partial pressure of each gas at equilibrium if the total pressure is 0.750 atm? Hint: use X to solve

4



$$K = \frac{[\text{CO}]^2}{[\text{CO}_2]} = \frac{[x]^2}{[.75 - x]} = 1.50$$

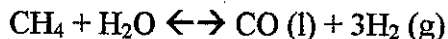
$P_T = .75$

$P_{\text{CO}} = .549$
atm

$P_{\text{CO}_2} = .201$
atm

20

9. Given the reaction of methane and water below



$$K = 5.67$$

predict what direction the system will shift in order to reach equilibrium given the following initial values of Q.

a. $Q = 11.85$

$$Q > K$$

Reverse/Left

b. $Q = 3.8 \times 10^{-4}$

$$Q < K$$

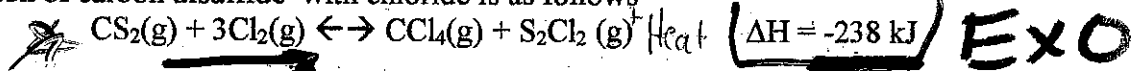
Forward/Right

c. $Q = 5.67$

$$Q = K$$

Equilibrium

10. The reaction of carbon disulfide with chloride is as follows



Predict the effect of the following change to the system on the direction of the equilibrium.

a. The pressure on the system is doubled by halving the volume

Forward/Right

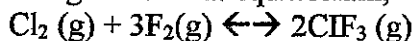
b. CCl_4 is removed as it is generated

Forward/Right

c. Heat is added to the system

Reverse/Left

11. Given the following reaction at equilibrium,



a. Predict the effect if the pressure were reduced at a constant temperature.

$\downarrow P \uparrow V$ Shift Left (favor more moles)

b. Predict the effect if the volume were reduced by increasing the pressure at a constant temperature.

$\uparrow P \downarrow V$ Shift Right

8

