

Name:

Date:

Period:

Seat #:

**STATION 1 • MASS ACTION EXPRESSIONS**

Write the mass action expression for the equilibrium:  $\text{Fe}_3\text{O}_4(\text{s}) + 4 \text{H}_2(\text{g}) \rightleftharpoons 3 \text{Fe}(\text{s}) + 4 \text{H}_2\text{O}(\text{g})$

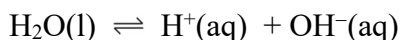
Write the mass action expression for the equilibrium:  $\text{Ca}(\text{OH})_2(\text{s}) \rightleftharpoons \text{Ca}^{2+}(\text{aq}) + 2 \text{OH}^{-}(\text{aq})$

The equilibrium constant,  $K_c = 7.9 \times 10^{-6}$ , is this equilibrium system reactant or product-favored. \_\_\_\_\_

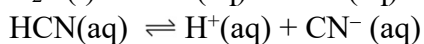
**Chemical Equilibrium**

**STATION 2 • MANIPULATING K**

Given:

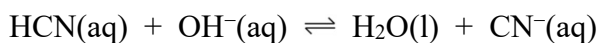


$$K_c = 1 \times 10^{-14}$$



$$K_c = 4.0 \times 10^{-10}$$

Calculate  $K_c$  for this reaction:



$$K_c = ???$$

This reaction is \_\_\_\_\_-favored.

## Chemical Equilibrium

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### STATION 3 • K<sub>p</sub> & K<sub>c</sub>

Consider the equilibrium:  $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ .

At 100°C, the equilibrium concentrations for this system are:

$$[\text{NO}] = 0.52 \text{ M}; \quad [\text{O}_2] = 0.24 \text{ M}; \quad [\text{NO}_2] = 0.18 \text{ M}$$

Write the expression for K<sub>c</sub> and calculate its value at this temperature?

What is Δn for this system? \_\_\_\_\_

Write the expression for K<sub>p</sub> and calculate its value at this temperature.

## Chemical Equilibrium

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### STATION 4 • LE CHÂTELIER'S PRINCIPLE

Consider the gaseous equilibrium:  $2\text{CCl}_4(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{COCl}_2(\text{g}) + 2\text{Cl}_2(\text{g}) \quad \Delta H = +35 \text{ kJ}$

Predict the effect each change would have on the concentrations of the each substance.

Add CCl <sub>4</sub>	_____	_____	_____	_____
Remove Cl <sub>2</sub>	_____	_____	_____	_____
Add COCl <sub>2</sub>	_____	_____	_____	_____
Increase temperature	_____	_____	_____	_____
Reduce container volume	_____	_____	_____	_____
Add a catalyst	_____	_____	_____	_____
Remove O <sub>2</sub>	_____	_____	_____	_____
Add He to increase pressure	_____	_____	_____	_____

A different equilibrium shifts toward the reactants when the temperature is increased. From this observation, you know that the reaction is \_\_\_\_\_ (exothermic / endothermic).

## Chemical Equilibrium

### STATION 5 • ICE BOX PROBLEM

Consider the equilibrium:  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$

If 0.200 mol  $\text{SO}_3(\text{g})$  is placed a 0.500 Liter container, it is found that 0.050 mole of  $\text{O}_2(\text{g})$  is in the container at equilibrium. Fill in the ICE box and determine the  $K_c$  for this reaction.

	$\text{SO}_2$	$\text{O}_2$	$\text{SO}_3$
<i>Initial</i>			
<i>Change</i>			
<i>Equilibrium</i>			

## Chemical Equilibrium

### STATION 6 • ANOTHER ICE BOX PROBLEM

At  $985^\circ\text{C}$ , the equilibrium constant,  $K_c$ , for the reaction,  $\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g})$ , is 1.63.

If 2.00 moles each of  $\text{H}_2(\text{g})$  and  $\text{CO}_2(\text{g})$  are placed in a 1.00-Liter container and allowed to come to equilibrium, determine the equilibrium concentrations of the four chemicals.

	$\text{H}_2$	$\text{CO}_2$	$\text{H}_2\text{O}$	$\text{CO}$
<i>Initial</i>				
<i>Change</i>				
<i>Equilibrium</i>				

## Chemical Equilibrium

### STATION 7 • TEST QUOTIENT, Q

Consider the equilibrium:  $2\text{NO}(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}_2(g)$ .  $K_c = 0.499$

The system is set up with the following concentrations:

$$[\text{NO}] = 0.50 \text{ M}; \quad [\text{O}_2] = 0.25 \text{ M}; \quad [\text{NO}_2] = 0.25 \text{ M}$$

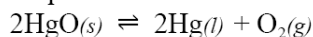
This reaction will \_\_\_\_\_ (shift right, shift left, remain unchanged).

Justify your prediction.

## Chemical Equilibrium

### STATION 8 • NChO PROBLEMS

33. Mercury(II) oxide,  $\text{HgO}$ , is decomposed upon heating according to this equation.



What is the equilibrium expression for this process?

- (A)  $K = \frac{[\text{Hg}]^2[\text{O}_2]}{[\text{HgO}]^2}$       (B)  $K = \frac{[\text{Hg}][\text{O}_2]}{[\text{HgO}]}$   
(C)  $K = [\text{Hg}][\text{O}_2]$       (D)  $K = [\text{O}_2]$

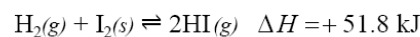
34. Consider this reaction.



What conditions of temperature and pressure will produce the highest yield of  $\text{NOCl}$  at equilibrium?

- |     | <i>T</i> | <i>P</i> |
|-----|----------|----------|
| (A) | high     | high     |
| (B) | high     | low      |
| (C) | low      | high     |
| (D) | low      | low      |

Questions 32 and 33 should both be answered with reference to this system.



32. Which would increase the equilibrium quantity of  $\text{HI}(g)$ ? Assume the system has reached equilibrium with all three components present.

- I. increasing pressure      II. increasing temperature  
(A) I only      (B) II only  
(C) Both I and II      (D) Neither I nor II

33. What is the equilibrium constant expression for this system?

- (A)  $K = \frac{[\text{HI}]^2}{[\text{H}_2][\text{I}_2]}$       (B)  $K = \frac{[\text{H}_2][\text{I}_2]}{[\text{HI}]^2}$   
(C)  $K = \frac{2[\text{HI}]}{[\text{H}_2][\text{I}_2]}$       (D)  $K = \frac{[\text{HI}]^2}{[\text{H}_2]}$

## Chemical Equilibrium – Not assessed. Challenge Problem

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### STATION 9 • PREDICTING REACTIONS

A solution of hydrochloric acid is added to a solution of potassium nitrite.

(i) Balanced equation:

(ii) What are the oxidation states of the N atom before and after the reaction?

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