



Unit 7 Comprehensive Review Problems

Topics 7.1-7.13

30 Problems

Target: 2-3 Hours

AP Chemistry - Equilibrium Mastery | K-Chemistry.com

Student Name: _____

Score: _____



Instructions

- **Comprehensive Coverage:** All Unit 7 topics from 7.1 (Introduction to Equilibrium) through 7.13 (Solubility Equilibria)
- **Mixed Format:** Multiple choice (15 problems), short answer (10 problems), calculations (5 problems)
- **Show all work** for calculation problems to receive full credit
- **No calculator** for Section 1; **calculator allowed** for Sections 2-4
- **Formula Sheet:** Refer to your Unit 7 Formula Sheet for equilibrium expressions and constants
- **Study Schedule:** Complete Problems 1-15 today (Sunday), 16-25 on Tuesday, 26-30 on Friday



Topics Covered

- ✓ 7.1 Introduction to Equilibrium

✓ 7.2 Direction of Reversible Reactions

✓ 7.3 Reaction Quotient & Equilibrium Constant

✓ 7.4 Calculating K

✓ 7.5 Magnitude of K

✓ 7.6 Properties of Equilibrium Constant

✓ 7.7 Calculating Equilibrium Concentrations

✓ 7.8 Representations of Equilibrium

✓ 7.9 Introduction to Le Châtelier's Principle

✓ 7.10 Reaction Quotient vs K

✓ 7.11 Le Châtelier - Stress on System

✓ 7.12 Le Châtelier - Change in Concentration

✓ 7.13 Solubility Equilibria (K_{sp})

Section 1: Multiple Choice - Conceptual (No Calculator)

Problems 1-15 | 2 points each

Problem 1

2 pts

7.1 Equilibrium Basics

Which of the following is TRUE about a system at chemical equilibrium?

- (A) The forward and reverse reaction rates are both zero
- (B) The concentrations of reactants and products are equal
- (C) The forward and reverse reaction rates are equal
- (D) The reaction has gone to completion

Problem 2

2 pts

7.3 Reaction Quotient

For the reaction: $2\text{A(g)} + \text{B(g)} \rightleftharpoons 3\text{C(g)}$

The correct expression for the reaction quotient Q is:

(A) $Q = [\text{C}]^3 / ([\text{A}]^2 \times [\text{B}])$

(B) $Q = [\text{A}]^2 \times [\text{B}] / [\text{C}]^3$

(C) $Q = 3[\text{C}] / (2[\text{A}] \times [\text{B}])$

(D) $Q = [\text{A}] \times [\text{B}] / [\text{C}]$

Problem 3

2 pts

7.5 Magnitude of K

A reaction has $K_{\text{eq}} = 1.2 \times 10^{-8}$ at 298 K. Which statement is correct?

- (A) Products are strongly favored at equilibrium
- (B) Reactants are strongly favored at equilibrium
- (C) Equal amounts of reactants and products exist at equilibrium
- (D) The reaction does not reach equilibrium

Problem 4

2 pts

7.6 Properties of K

For the reaction: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, $K_c = 0.50$

What is the value of K_c for the reverse reaction: $2\text{NH}_3(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$?

(A) 0.50

(B) -0.50

(C) 2.0

(D) 0.25

Problem 5

2 pts

7.10 Q vs K

For a reaction with $K = 100$, if $Q = 50$ at a given moment, the reaction will:

(A) Proceed in the forward direction to reach equilibrium

(B) Proceed in the reverse direction to reach equilibrium

(C) Be at equilibrium

(D) Not proceed in either direction

Problem 6

2 pts

7.9 Le Châtelier's Principle

For the exothermic reaction: $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) + \text{heat}$

Which change will shift the equilibrium to the RIGHT?

(A) Increasing temperature

(B) Removing SO_2

(C) Adding O_2

(D) Decreasing pressure

Problem 7

2 pts

7.11 Le Châtelier - Pressure

Consider the equilibrium: $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$

If the volume of the container is DECREASED (pressure increased), what happens?

(A) Equilibrium shifts toward N_2O_4 (fewer moles of gas)

(B) Equilibrium shifts toward NO_2 (more moles of gas)

(C) No shift; K remains constant

(D) The reaction stops

Problem 8

2 pts

7.2 Direction of Reaction

For the reaction: $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$, $K_c = 50$

If $[\text{H}_2] = 0.10 \text{ M}$, $[\text{I}_2] = 0.10 \text{ M}$, and $[\text{HI}] = 0.50 \text{ M}$, then Q equals:

(A) 2.5

(B) 25

(C) 50

(D) 0.04

Problem 9

2 pts

7.8 Equilibrium Representations

Which of the following does NOT appear in an equilibrium constant expression?

(A) Aqueous ions

(B) Gases

(C) Pure solids

(D) Dissolved molecules

Problem 10

2 pts

7.13 Solubility Equilibria

For $\text{AgCl(s)} \rightleftharpoons \text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq})$, the solubility product expression K_{sp} is:

(A) $K_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-] / [\text{AgCl}]$

(B) $K_{\text{sp}} = [\text{Ag}^+][\text{Cl}^-]$

(C) $K_{\text{sp}} = [\text{AgCl}] / [\text{Ag}^+][\text{Cl}^-]$

(D) $K_{\text{sp}} = [\text{Ag}^+] + [\text{Cl}^-]$

Problem 11

2 pts

7.12 Le Châtelier - Concentration

For the equilibrium: $\text{Fe}^{3+}(\text{aq}) + \text{SCN}^{-}(\text{aq}) \rightleftharpoons \text{FeSCN}^{2+}(\text{aq})$
(colorless) + (colorless) \rightleftharpoons (deep red)

If you ADD Fe^{3+} to the solution, what will you observe?

- (A) Solution becomes lighter (less red)
- (B) Solution becomes darker (more red)
- (C) No color change
- (D) Solution becomes colorless

Problem 12

2 pts

7.6 K Relationships

Given: $\mathbf{A} \rightleftharpoons \mathbf{B}$, $K_1 = 4.0$

And: $\mathbf{B} \rightleftharpoons \mathbf{C}$, $K_2 = 2.0$

What is K for the overall reaction: $\mathbf{A} \rightleftharpoons \mathbf{C}$?

(A) 2.0

(B) 6.0

(C) 8.0

(D) 0.50

Problem 13

2 pts

7.11 Catalyst Effect

Adding a catalyst to a reaction at equilibrium will:

- (A) Shift equilibrium toward products
- (B) Shift equilibrium toward reactants
- (C) Change the value of K
- (D) Allow equilibrium to be reached faster, but not shift position

Problem 14

2 pts

7.13 Common Ion Effect

The solubility of AgCl will DECREASE when:

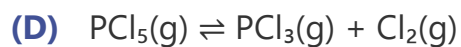
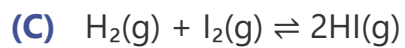
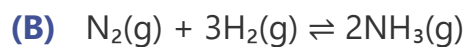
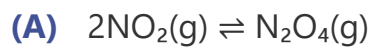
- (A) NaCl is added to the solution
- (B) Water is added to dilute the solution
- (C) Temperature is increased
- (D) K_{sp} increases

Problem 15

2 pts

7.4 K_c vs K_p

For which reaction is $K_p = K_c$?



Section 2: Short Answer (Calculator Allowed)

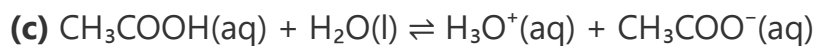
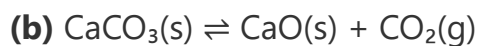
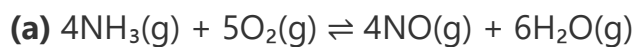
Problems 16-25 | 4 points each

Problem 16

4 pts

7.3 Writing K Expressions

Write the equilibrium constant expression (K_c) for each of the following reactions:



Your Answer:

Problem 17

4 pts

7.10 Q vs K Prediction

For the reaction: $\text{CO(g)} + 2\text{H}_2\text{(g)} \rightleftharpoons \text{CH}_3\text{OH(g)}$, $K_c = 14.5$ at 500 K

At a certain moment, $[\text{CO}] = 0.30 \text{ M}$, $[\text{H}_2] = 0.10 \text{ M}$, and $[\text{CH}_3\text{OH}] = 0.60 \text{ M}$.

- (a) Calculate the reaction quotient Q.
- (b) In which direction will the reaction proceed to reach equilibrium?
- (c) Explain your reasoning.

Your Work & Answer:

Problem 18

4 pts

7.9 Le Châtelier Analysis

Consider the equilibrium: $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}(\text{g})$, $\Delta H = +180 \text{ kJ}$

Predict the effect of EACH change on the equilibrium position (shift left, shift right, or no shift):

- (a) Adding N_2
- (b) Removing NO
- (c) Increasing temperature
- (d) Decreasing volume (increasing pressure)
- (e) Adding a catalyst

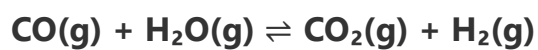
Your Answer:

Problem 19

4 pts

7.4 Calculating K from Data

At equilibrium at 700 K, a 2.0 L container holds 0.40 mol CO, 0.30 mol H₂O, 0.80 mol CO₂, and 0.80 mol H₂.



Calculate the value of K_c for this reaction. Show all work.

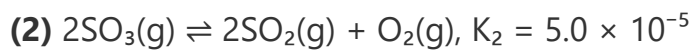
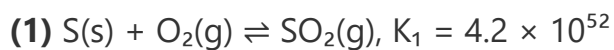
Your Work & Answer:

Problem 20

4 pts

7.6 K Manipulations

Given the following equilibria at 25°C:



Calculate K for the reaction: $2\text{S(s)} + 3\text{O}_2\text{(g)} \rightleftharpoons 2\text{SO}_3\text{(g)}$

Hint: Manipulate the given reactions to obtain the target equation.

Your Work & Answer:

Problem 21

4 pts

7.13 K_{sp} Calculations

The K_{sp} of silver chromate (Ag_2CrO_4) is 1.1×10^{-12} at 25°C .



Calculate the molar solubility of Ag_2CrO_4 in pure water. Show all work including ICE table.

Your Work & Answer:

Problem 22

4 pts

7.8 Particulate Diagrams

Consider the reaction: $\text{A}_2(\text{g}) + \text{B}_2(\text{g}) \rightleftharpoons 2\text{AB}(\text{g})$

Initial mixture contains 6 molecules A_2 and 6 molecules B_2 . At equilibrium, 8 molecules of AB are present.

- (a) How many molecules of A_2 remain at equilibrium?
- (b) How many molecules of B_2 remain at equilibrium?
- (c) Calculate K for this reaction in terms of number of molecules.
- (d) Draw a particulate diagram showing the equilibrium mixture.

Your Work & Diagram:

Problem 23

4 pts

7.12 Le Châtelier - Quantitative

At equilibrium, a reaction vessel contains $[\text{N}_2] = 0.20 \text{ M}$, $[\text{O}_2] = 0.10 \text{ M}$, and $[\text{NO}] = 0.040 \text{ M}$.



If 0.10 mol/L of N_2 is ADDED to the 1.0 L container, will the equilibrium concentration of NO increase, decrease, or remain the same? Explain using Le Châtelier's Principle.

Your Explanation:

Problem 24

4 pts

7.13 Common Ion Effect

Will a precipitate form when 50.0 mL of 0.0020 M AgNO_3 is mixed with 50.0 mL of 0.0010 M NaCl ?

$$K_{\text{sp}}(\text{AgCl}) = 1.8 \times 10^{-10}$$

Show your work by calculating Q and comparing to K_{sp} .

Your Work & Answer:

Problem 25

4 pts

7.5 K Interpretation

Three reactions have the following equilibrium constants at 298 K:

Reaction A: $K = 5.6 \times 10^{-15}$

Reaction B: $K = 1.2$

Reaction C: $K = 8.4 \times 10^7$

- (a) Which reaction is most product-favored?
- (b) Which reaction has approximately equal amounts of reactants and products at equilibrium?
- (c) For Reaction A, will you find mostly reactants or mostly products at equilibrium?
- (d) Explain the relationship between K value and equilibrium position.

Your Answer:

Section 3: Advanced Calculations (Calculator Required)

Problems 26-30 | 6 points each

Problem 26

6 pts

7.7 ICE Table - Full Calculation

At 500 K, $K_c = 170$ for the reaction:



A 1.0 L flask initially contains 0.50 mol PCl_3 and 0.50 mol Cl_2 . Calculate the equilibrium concentrations of all species.

Required: Complete ICE table, equilibrium expression, algebraic solution, and final answers with units.

Your Complete Solution:

Problem 27

6 pts

7.7 ICE Table - Small K

The reaction $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$ has $K_c = 6.5$ at 298 K.

If you start with $[\text{NO}_2] = 0.80 \text{ M}$ and no N_2O_4 , what are the equilibrium concentrations?

Hint: Check if the 5% approximation is valid. If not, use quadratic formula.

Your Complete Solution:

Problem 28

6 pts

7.4 K_p to K_c Conversion

At 1000 K, $K_p = 2.4 \times 10^{-3}$ for the reaction:



(a) Calculate K_c for this reaction.

(b) If initial pressures are $P_{\text{SO}_3} = 0.50 \text{ atm}$, $P_{\text{SO}_2} = 0$, $P_{\text{O}_2} = 0$, calculate the equilibrium partial pressures.

$$K_p = K_c (RT)^{\Delta n}, \text{ where } R = 0.0821 \text{ L} \cdot \text{atm} / (\text{mol} \cdot \text{K})$$

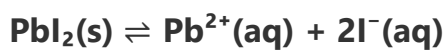
Your Complete Solution:

Problem 29

6 pts

7.13 K_{sp} - Common Ion

Calculate the molar solubility of PbI_2 in a 0.10 M KI solution.



$$K_{sp}(PbI_2) = 9.8 \times 10^{-9}$$

Important: Account for the common ion (I^{-}) from KI dissociation!

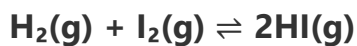
Your Complete Solution:

Problem 30 - CHALLENGE

6 pts

7.7 & 7.10 Combined

At 400°C, $K_c = 64$ for the reaction:



A mixture initially contains $[\text{H}_2] = 0.50 \text{ M}$, $[\text{I}_2] = 0.30 \text{ M}$, and $[\text{HI}] = 0.40 \text{ M}$.

- (a) Calculate Q and determine the direction of reaction.
- (b) Set up an ICE table with the correct direction.
- (c) Calculate the equilibrium concentrations of all species.

Challenge: This problem requires determining reaction direction FIRST before setting up ICE table!

Your Complete Solution:

Teacher: Mr. Hisham Mahmoud

Unit 7: Equilibrium Comprehensive Review | **Total Points:** 100

 **Study Plan: Problems 1-15 (Sunday) | 16-25 (Tuesday) | 26-30 (Friday)**

 **Master Unit 7 → Excel in Unit 8 (Acids & Bases)!**