⚖️ 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: **2A(g) + B(g) ⇌ 3C(g)**

The correct expression for the reaction quotient Q is:

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

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

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

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

Problem 3

2 pts

7.5 Magnitude of K

A reaction has $K_{eq} = 1.2 \times 10^{-8}$ 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: $\mathbf{N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)}$, $K_C = 0.50$

What is the value of K_C for the reverse reaction: $\mathbf{2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)}$?

(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: **$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) + heat$**

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: $\mathbf{N_2O_4(g) \rightleftharpoons 2NO_2(g)}$

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: **$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$**, $K_c = 50$

If $[H_2] = 0.10$ M, $[I_2] = 0.10$ M, and $[HI] = 0.50$ 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 $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$, the solubility product expression K_{sp} is:

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

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

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

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

Problem 11

2 pts

7.12 Le Châtelier - Concentration

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

(colorless) + (colorless) ⇌ (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: **A** ⇌ **B**, K_1 = 4.0

And: **B** ⇌ **C**, K_2 = 2.0

What is K for the overall reaction: **A** ⇌ **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 $K_p = K_c$?

(A) $2NO_2(g) \rightleftharpoons N_2O_4(g)$

(B) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(C) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(D) $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

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:

(a) $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

(b) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

(c) $CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$

Your Answer:

Problem 17

4 pts

7.10 Q vs K Prediction

For the reaction: **$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$**, K_c = 14.5 at 500 K

At a certain moment, [CO] = 0.30 M, [H_2] = 0.10 M, and [CH_3OH] = 0.60 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: $\mathbf{N_2(g) + O_2(g) \rightleftharpoons 2NO(g)}$, $\Delta H = +180$ 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 H_2O, 0.80 mol CO_2, and 0.80 mol H_2.

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

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:

(1) $S(s) + O_2(g) \rightleftharpoons SO_2(g)$, $K_1 = 4.2 \times 10^{52}$

(2) $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$, $K_2 = 5.0 \times 10^{-5}$

Calculate K for the reaction: $\mathbf{2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g)}$

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.

$Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$

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: $\mathbf{A_2(g) + B_2(g) \rightleftharpoons 2AB(g)}$

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 $[N_2]$ = 0.20 M, $[O_2]$ = 0.10 M, and [NO] = 0.040 M.

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

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?

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

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:

$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$

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 **$2NO_2(g) \rightleftharpoons N_2O_4(g)$** has K_C = 6.5 at 298 K.

If you start with $[NO_2]$ = 0.80 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:

$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

(a) Calculate K_c for this reaction.

(b) If initial pressures are $P_{SO_3} = 0.50$ atm, $P_{SO_2} = 0$, $P_{O_2} = 0$, calculate the equilibrium partial pressures.

> $K_p = K_c(RT)^{\Delta n}$, where $R = 0.0821$ L·atm/(mol·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.

$PbI_2(s) \rightleftharpoons Pb^{2+}(aq) + 2I^-(aq)$

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

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:

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

A mixture initially contains $[H_2]$ = 0.50 M, $[I_2]$ = 0.30 M, and [HI] = 0.40 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)!**