# 🧪 ICE Tables Practice Worksheet

*AP Chemistry - Unit 7 Equilibrium | K-Chemistry.com*

**Student Name:** _____

**Score:** _____

## 📋 Instructions

- **Critical Skill:** ICE tables are essential for Unit 7 (equilibrium) and Unit 8 (weak acids/bases)
- **Show all work** - Set up ICE table → Write equilibrium expression → Solve → Check units
- **Assumptions:** When x is small (< 5% of initial concentration), you can approximate
- **Check your work:** Does Q equal K at equilibrium? Are concentrations positive?
- **Target Time:** 90 minutes (9 min per problem average for Problems 1-10)

## Section 1: Basic Equilibrium (Problems 1-5)

### Problem 1

At 500 K, the equilibrium constant $K_c$ for the reaction below is 0.040.

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

If you start with 2.00 M $PCl_5$ and no products, what are the equilibrium concentrations of all species?

| | $PCl_5$ | $PCl_3$ | $Cl_2$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 2

The equilibrium constant $K_p = 4.5 \times 10^{-3}$ at 720 K for the reaction:

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

A reaction vessel initially contains $P_{N_2} = 1.0$ atm, $P_{H_2} = 3.0$ atm, and $P_{NH_3} = 0$ atm. Calculate the equilibrium partial pressures.

| | $N_2$ | $H_2$ | $NH_3$ |
|---|---|---|---|
| Initial (atm) | | | |
| Change (atm) | | | |
| Equilibrium (atm) | | | |

**Work Space:**

## Problem 3

For the reaction **$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$**, $K_c$ = 54.0 at 425°C.

If a 1.0 L flask initially contains 0.80 mol $H_2$, 0.80 mol $I_2$, and 0 mol HI, what is the equilibrium concentration of HI?

| | $H_2$ | $I_2$ | HI |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 4

At 700 K, $K_p$ = 0.140 for the reaction:

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

A mixture initially contains $P_{SO_2}$ = 0.50 atm, $P_{O_2}$ = 0.50 atm, and $P_{SO_3}$ = 0 atm. Find all equilibrium pressures.

| | $SO_2$ | $O_2$ | $SO_3$ |
|---|---|---|---|
| Initial (atm) | | | |
| Change (atm) | | | |
| Equilibrium (atm) | | | |

**Work Space:**

## Problem 5

The decomposition of $N_2O_4$ has $K_c$ = 0.36 at 100°C:

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

If $[N_2O_4]_{initial}$ = 0.100 M and $[NO_2]_{initial}$ = 0 M, calculate equilibrium concentrations.

| | $N_2O_4$ | $NO_2$ |
|---|---|---|
| Initial (M) | | |
| Change (M) | | |
| Equilibrium (M) | | |

**Work Space:**

## Section 2: Weak Acids & Bases (Problems 6-10)

### Problem 6

Calculate the pH of a 0.15 M solution of acetic acid ($CH_3COOH$). $K_a = 1.8 \times 10^{-5}$

**$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$**

| | $CH_3COOH$ | $H^+$ | $CH_3COO^-$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 7

A 0.20 M solution of ammonia ($NH_3$) has $K_b = 1.8 \times 10^{-5}$. Calculate the pH.

**$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$**

| | $NH_3$ | $NH_4^+$ | $OH^-$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 8

Hypochlorous acid (HOCl) has $K_a = 3.5 \times 10^{-8}$. What is the pH of a 0.050 M HOCl solution?

**$HOCl(aq) \rightleftharpoons H^+(aq) + OCl^-(aq)$**

| | HOCl | $H^+$ | $OCl^-$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 9

Calculate the percent ionization of 0.10 M hydrofluoric acid (HF). $K_a = 6.8 \times 10^{-4}$

**$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$**

Hint: Percent ionization = $([H^+]_{eq} / [HF]_{initial}) \times 100\%$

| | HF | $H^+$ | $F^-$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 10

Pyridine ($C_5H_5N$) is a weak base with $K_b = 1.7 \times 10^{-9}$. Calculate the pH of a 0.25 M pyridine solution.

**$C_5H_5N(aq) + H_2O(l) \rightleftharpoons C_5H_5NH^+(aq) + OH^-(aq)$**

| | $C_5H_5N$ | $C_5H_5NH^+$ | $OH^-$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Section 3: Solubility Equilibria - $K_{sp}$ (Problems 11-15)

### Problem 11

Calculate the molar solubility of AgCl in pure water. $K_{sp} = 1.8 \times 10^{-10}$

**$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$**

| | AgCl(s) | $Ag^+$ | $Cl^-$ |
|---|---|---|---|
| Initial (M) | — | | |
| Change (M) | — | | |
| Equilibrium (M) | — | | |

**Work Space:**

## Problem 12

What is the molar solubility of $PbCl_2$ in pure water? $K_{sp} = 1.7 \times 10^{-5}$

**$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$**

| | $Pb^{2+}$ | $Cl^-$ |
|---|---|---|
| Initial (M) | | |
| Change (M) | | |
| Equilibrium (M) | | |

**Work Space:**

## Problem 13

Calculate the solubility of $Mg(OH)_2$ in grams per liter. $K_{sp} = 5.6 \times 10^{-12}$

Molar mass $Mg(OH)_2$ = 58.32 g/mol

**$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$**

| | $Mg^{2+}$ | $OH^-$ |
|---|---|---|
| Initial (M) | | |
| Change (M) | | |
| Equilibrium (M) | | |

**Work Space:**

## Problem 14 - Common Ion Effect

What is the molar solubility of AgCl in a 0.10 M NaCl solution? $K_{sp} = 1.8 \times 10^{-10}$

**$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$**

*Challenge: NaCl provides $Cl^-$ ions → common ion effect!*

| | $Ag^+$ | $Cl^-$ |
|---|---|---|
| Initial (M) | | |
| Change (M) | | |
| Equilibrium (M) | | |

**Work Space:**

## Problem 15 - pH and Solubility

Calculate the molar solubility of $Fe(OH)_2$ in a solution buffered at pH = 9.0.

$K_{sp} = 4.9 \times 10^{-17}$

**$Fe(OH)_2(s) \rightleftharpoons Fe^{2+}(aq) + 2OH^-(aq)$**

*Advanced: pH = 9.0 means pOH = 5.0, so $[OH^-] = 1.0 \times 10^{-5}$ M*

| | $Fe^{2+}$ | $OH^-$ |
|---|---|---|
| Initial (M) | | |
| Change (M) | | |
| Equilibrium (M) | | |

**Work Space:**

## Section 4: Advanced - Buffers & Multiple Equilibria (Problems 16-20)

### Problem 16 - Buffer Solution

A buffer contains 0.50 M $CH_3COOH$ and 0.50 M $CH_3COONa$. Calculate the pH.

$K_a = 1.8 \times 10^{-5}$

**$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$**

**Work Space:**

### Problem 17

What is the pH after adding 0.10 mol HCl to 1.0 L of the buffer in Problem 16?

**Work Space:**

## Problem 18

Calculate $[H^+]$ in a 0.10 M $H_2CO_3$ solution. $K_{a1} = 4.3 \times 10^{-7}$

**$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$**

| | $H_2CO_3$ | $H^+$ | $HCO_3^-$ |
|---|---|---|---|
| Initial (M) | | | |
| Change (M) | | | |
| Equilibrium (M) | | | |

**Work Space:**

## Problem 19

A mixture initially contains 0.40 M CO and 0.40 M $H_2O$. At equilibrium, $[CO_2]$ = 0.20 M. Calculate $K_c$.

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

| | CO | $H_2O$ | $CO_2$ | $H_2$ |
|---|---|---|---|---|
| Initial (M) | | | | |
| Change (M) | | | | |
| Equilibrium (M) | | | | |

**Work Space:**

## Problem 20 - Challenge!

At 100°C, $K_p$ = 60.6 for the reaction:

**$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$**

A 2.0 L flask initially contains 0.80 mol NOBr. Calculate equilibrium pressures (assume ideal gas, R = 0.0821 L·atm/(mol·K), T = 373 K).

**Work Space:**

### K-Chemistry.com - From "I Don't Get It" to "I Ace It"

**Teacher:** Mr. Hisham Mahmoud

**Unit 7:** Equilibrium | **Connection:** Essential for Unit 8 (Acids & Bases)

📚 **Practice Daily** • 🎯 **Master ICE Tables** • 💪 **You've Got This!**