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CHEMISTRY WORKSHEET

# ICE TABLES

Course: SCH4U Grade 12 Chemistry

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## 50 Practice Problems with Answers and Detailed Solutions

**FULL** worksheet contains 50 representative problems on:

✓ Setting up ICE tables, ✓ Writing equilibrium expressions, ✓ Solving for x or for K, ✓ Rejecting impossible roots, ✓ Interpreting equilibrium shifts

All problems are designed to reflect style and difficulty commonly seen on quizzes, tests, and final exams. Detailed solutions are included to help students understand the reasoning behind every step.

| | |
|---|---|
| **PART A - FUNDAMENTAL PROBLEMS**<br>Problems 1-15. Simple calculations and basic applications | **PART B - INTERMEDIATE PROBLEMS**<br>Problems 16-30. Typical unit test questions involving multiple steps |
| **PART C - ADVANCED PROBLEMS**<br>Problems 31-40. More challenging calculations requiring deeper understanding | **PART D - CHALLENGE PROBLEMS**<br>Problems 41-50. Difficult exam-style questions combining multiple concepts |

SUITABLE FOR:
quizzes, unit tests and final exam preparation

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## Section 1. Essential Information

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# Section 2. Practice Problems

## Part A - Fundamental ICE Table Setup

**Problem 8**

For the reaction below, use an ICE table to calculate the equilibrium concentration of each substance. Initial concentrations: $[NO_2]$ = 0.8 mol/L; $[N_2O_4]$ = 0 mol/L. $K_c$ = 3.00

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$

## Part B - Intermediate Equilibrium Calculations

**Problem 16**

For the reaction below, use an ICE table to calculate the equilibrium concentration of each substance. Initial concentrations: $[N_2]$ = 0.5 mol/L; $[H_2]$ = 1.5 mol/L; $[NH_3]$ = 0 mol/L. $K_c$ = 2.00

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

## Part C - Advanced ICE Table Applications

**Problem 32**

For the reaction below, use an ICE table to calculate the equilibrium concentration of each substance. Initial concentrations: $[NO_2]$ = 0.3 mol/L; $[N_2O_4]$ = 0.5 mol/L. $K_c$ = 4.00

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$

## Part D - Challenge Problems

**Problem 45**

For the reaction below, only $PCl_5$ is placed in the container at the start. $K_c$ = 0.0500. Calculate the initial concentration of $PCl_5$ needed so that $[Cl_2]$ = 0.075 mol/L at equilibrium

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

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# Section 3. Solutions

## Problem 8 Solution

**Reaction:** $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

**Given:** Initial concentrations: $[NO_2]$ = 0.8 mol/L; $[N_2O_4]$ = 0 mol/L; $K_c$ = 3.00

**Find:** The equilibrium concentration of each substance

The reaction moves in the direction that forms the missing equilibrium species

| ICE | $NO_2$ | $N_2O_4$ |
|---|---|---|
| **Initial** | 0.8 | 0 |
| **Change** | -2x | +x |
| **Equilibrium** | 0.8 - 2x | x |

$K_c = [N_2O_4]/[NO_2]^2$

$K_c = (x)/(0.8 - 2x)^2 = 3.00$, so x = 0.254 mol/L

**Final answer:** $[NO_2]$ = 0.291 mol/L; $[N_2O_4]$ = 0.254 mol/L

## Problem 16 Solution

**Reaction:** $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

**Given:** Initial concentrations: $[N_2]$ = 0.5 mol/L; $[H_2]$ = 1.5 mol/L; $[NH_3]$ = 0 mol/L; $K_c$ = 2.00

**Find:** The equilibrium concentration of each substance

The reaction moves in the direction that forms the missing equilibrium species

| ICE | $N_2$ | $H_2$ | $NH_3$ |
|---|---|---|---|
| **Initial** | 0.5 | 1.5 | 0 |
| **Change** | -x | -3x | +2x |
| **Equilibrium** | 0.5 - x | 1.5 - 3x | 2x |

$K_c = [NH_3]^2/[N_2][H_2]^3$

$K_c = (2x)^2/(0.5 - x)(1.5 - 3x)^3 = 2.00$, so x = 0.243 mol/L

**Final answer:** $[N_2]$ = 0.257 mol/L; $[H_2]$ = 0.771 mol/L; $[NH_3]$ = 0.486 mol/L

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## Problem 32 Solution

**Reaction:** $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

**Given:** Initial concentrations: $[NO_2]$ = 0.3 mol/L; $[N_2O_4]$ = 0.5 mol/L; $K_c$ = 4.00

**Find:** The equilibrium concentration of each substance

$Q_c$ = 5.56, which is greater than $K_c$, so the mixture shifts left

| ICE | $NO_2$ | $N_2O_4$ |
|---|---|---|
| **Initial** | 0.3 | 0.5 |
| **Change** | +2x | -x |
| **Equilibrium** | 0.3 + 2x | 0.5 - x |

$K_c = [N_2O_4]/[NO_2]^2$

$K_c = (0.5 - x)/(0.3 + 2x)^2 = 4.00$, so x = 0.0227 mol/L

**Final answer:** $[NO_2]$ = 0.345 mol/L; $[N_2O_4]$ = 0.477 mol/L

## Problem 45 Solution

**Reaction:** $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

**Given:** Only $PCl_5$ is present initially. $K_c$ = 0.0500 and

the target equilibrium value is $[Cl_2]$ = 0.075 mol/L

**Find:** The initial concentration of $PCl_5$

Because $PCl_3$ and $Cl_2$ form in a 1:1 ratio, $[Cl_2]$ at equilibrium equals x

| ICE | $PCl_5$ | $PCl_3$ | $Cl_2$ |
|---|---|---|---|
| **Initial** | C | 0 | 0 |
| **Change** | -x | +x | +x |
| **Equilibrium** | C - x | x | x |

$K_c = ([PCl_3][Cl_2])/[PCl_5] = x^2/(C - x)$

x = 0.075 mol/L, so $0.0500 = x^2/(C - x)$. Therefore $C = x + x^2/K_c$ = 0.188 mol/L

**Final answer:** initial $[PCl_5]$ = 0.188 mol/L

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## Section 4. Answer Key

| Problem | Answer |
|---|---|
| 8 | $[NO_2]$ = 0.291 mol/L; $[N_2O_4]$ = 0.254 mol/L |
| 16 | $[N_2]$ = 0.257 mol/L; $[H_2]$ = 0.771 mol/L; $[NH_3]$ = 0.486 mol/L |
| 32 | $[NO_2]$ = 0.345 mol/L; $[N_2O_4]$ = 0.477 mol/L |
| 45 | initial $[PCl_5]$ = 0.188 mol/L |

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