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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

Problems 1-15. Simple calculations and basic applications

PART B - INTERMEDIATE PROBLEMS

Problems 16-30. Typical unit test questions involving multiple steps

PART C - ADVANCED PROBLEMS

Problems 31-40. More challenging calculations requiring deeper understanding

PART D - CHALLENGE PROBLEMS

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

This page includes only the formulas and habits needed to solve calorimetry problems efficiently.

Formula	Use
$q = m \cdot c \cdot \Delta T$	Heat gained or lost by a substance
$\Delta T = T_f - T_i$	Temperature change with sign
$q_{\text{cal}} = C_{\text{cal}} \Delta T$	Heat absorbed by a calorimeter
$q_{\text{sys}} = -q_{\text{surrounds}}$	Sign convention for coffee-cup and bomb calorimetry
$q_{\text{cal}} + q_{\text{sys}} = 0$	Heat exchange between substances
$\Delta H = q_{\text{surrounds}}$	Enthalpy change at constant pressure

Important definitions: coffee-cup calorimetry is usually constant pressure, so q_p can be used for ΔH . Bomb calorimetry is constant volume, so the result is commonly treated as ΔU for ICNMR-style calculations.

Fast method: clarify what gains heat, clarify what loses heat, convert volumes to masses when density is given, calculate ΔT carefully, include C_{cal} when provided, then apply the sign convention at the end.

Important notes: for dilute aqueous solutions, use density = 1.00 g/mL and $c = 4.184 \text{ J/g } ^\circ\text{C}$ only when stated or clearly assumed. For reactions, the solution and calorimeter are surroundings, while the chemical reaction is the system.

Common mistakes: using only one solution volume after mixing, forgetting that $q_{\text{surrounds}}$ has the opposite sign of q_{sys} , ignoring the limiting reagent, mixing J and kJ, and using the sample mass instead of moles when a molar amount is requested.

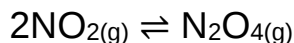
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Section 2. Practice Problems

Part A - Fundamental ICE Table Setup

Problem 8

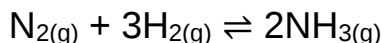
For the reaction below, use an ICE table to calculate the equilibrium concentration of each substance. Initial concentrations: $[\text{NO}_2] = 0.8 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0 \text{ mol/L}$. $K_c = 3.00$



Part B - Intermediate Equilibrium Calculations

Problem 16

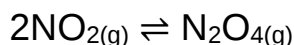
For the reaction below, use an ICE table to calculate the equilibrium concentration of each substance. Initial concentrations: $[\text{N}_2] = 0.5 \text{ mol/L}$; $[\text{H}_2] = 1.5 \text{ mol/L}$; $[\text{NH}_3] = 0 \text{ mol/L}$. $K_c = 2.00$



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: $[\text{NO}_2] = 0.3 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0.5 \text{ mol/L}$. $K_c = 4.00$



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 $[\text{Cl}_2] = 0.075 \text{ mol/L}$ at equilibrium



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Section 3. Solutions

Problem 8 Solution



Given: Initial concentrations: $[\text{NO}_2] = 0.8 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0 \text{ mol/L}$; $K_c = 3.00$

Find: The equilibrium concentration of each substance

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

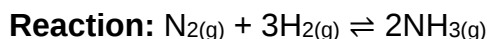
ICE	NO_2	N_2O_4
Initial	0.8	0
Change	-2x	+x
Equilibrium	$0.8 - 2x$	x

$$K_c = [\text{N}_2\text{O}_4]/[\text{NO}_2]^2$$

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

Final answer: $[\text{NO}_2] = 0.291 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0.254 \text{ mol/L}$

Problem 16 Solution



Given: Initial concentrations: $[\text{N}_2] = 0.5 \text{ mol/L}$; $[\text{H}_2] = 1.5 \text{ mol/L}$; $[\text{NH}_3] = 0 \text{ mol/L}$; $K_c = 2.00$

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

$$K_c = [\text{NH}_3]^2/[\text{N}_2][\text{H}_2]^3$$

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

Final answer: $[\text{N}_2] = 0.257 \text{ mol/L}$; $[\text{H}_2] = 0.771 \text{ mol/L}$; $[\text{NH}_3] = 0.486 \text{ mol/L}$

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Problem 32 Solution



Given: Initial concentrations: $[\text{NO}_2] = 0.3 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0.5 \text{ mol/L}$; $K_c = 4.00$

Find: The equilibrium concentration of each substance

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

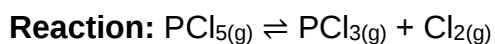
ICE	NO_2	N_2O_4
Initial	0.3	0.5
Change	+2x	-x
Equilibrium	$0.3 + 2x$	$0.5 - x$

$$K_c = [\text{N}_2\text{O}_4]/[\text{NO}_2]^2$$

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

Final answer: $[\text{NO}_2] = 0.345 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0.477 \text{ mol/L}$

Problem 45 Solution



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

the target equilibrium value is $[\text{Cl}_2] = 0.075 \text{ mol/L}$

Find: The initial concentration of PCl_5

Because PCl_3 and Cl_2 form in a 1:1 ratio, $[\text{Cl}_2]$ at equilibrium equals x

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

$$K_c = ([\text{PCl}_3][\text{Cl}_2])/[\text{PCl}_5] = x^2/(C - x)$$

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

Final answer: initial $[\text{PCl}_5] = 0.188 \text{ mol/L}$

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Section 4. Answer Key

Problem	Answer
8	$[\text{NO}_2] = 0.291 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0.254 \text{ mol/L}$
16	$[\text{N}_2] = 0.257 \text{ mol/L}$; $[\text{H}_2] = 0.771 \text{ mol/L}$; $[\text{NH}_3] = 0.486 \text{ mol/L}$
32	$[\text{NO}_2] = 0.345 \text{ mol/L}$; $[\text{N}_2\text{O}_4] = 0.477 \text{ mol/L}$
45	initial $[\text{PCl}_5] = 0.188 \text{ mol/L}$

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