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CHEMISTRY WORKSHEET

RATE LAW

Course: SCH4U Grade 12 Chemistry

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50 Practice Problems with Answers and Detailed Solutions

FULL worksheet contains 50 representative problems on:

✓ reaction order from rate laws, ✓ units of rate constants, ✓ rate-change factors, rate calculations, ✓ k calculations, initial-rate tables, ✓ pseudo-first-order conditions, ✓ elementary-step rate laws

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 Summary

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

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

Fast method: identify what gains heat, identify 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 $q_{surrounds}$ has the opposite sign of q_{system} , ignoring the limiting reagent, mixing J and kJ, and using the sample mass instead of moles when a molar answer is requested.

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Section 2. Practice Problems

Part A. Fundamental Skills

Problem 8

A first-order reaction has an initial rate of $0.00480 \text{ mol}/(\text{L}\cdot\text{s})$ when $[\text{A}] = 0.240 \text{ mol/L}$. Calculate k

Rate law: $\text{rate} = k[\text{A}]$

Part B. Intermediate Initial-Rate Problems

Problem 16

Use the initial-rate data to determine the rate law, the overall order, and k

Experiment	[A] mol/L	[B] mol/L	Initial rate mol/(L·s)
1	0.100	0.100	2.50×10^{-4}
2	0.200	0.100	5.00×10^{-4}
3	0.100	0.200	1.00×10^{-3}

Part C. Advanced Rate-Law Applications

Problem 32

Use the initial-rate data to determine the rate law and k

Experiment	[A] mol/L	[B] mol/L	[C] mol/L	Initial rate mol/(L·s)
1	0.100	0.100	0.100	2.00×10^{-4}
2	0.200	0.100	0.100	4.00×10^{-4}
3	0.100	0.200	0.100	8.00×10^{-4}
4	0.100	0.100	0.300	2.00×10^{-4}

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Part D. Challenge Problems

Problem 45

A reaction has the true rate law $\text{rate} = k[A][B]^n$. Under pseudo-first-order conditions, the observed constant is $k' = k[B]^n$. When $[B]$ is 0.100 mol/L, $k' = 0.0300$ 1/s. When $[B]$ is 0.300 mol/L, $k' = 0.0900$ 1/s. Determine n and k .

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Section 3. Solutions

Part A. Fundamental Skills

Problem 8 Solution

Given: rate = $0.00480 \text{ mol}/(\text{L}\cdot\text{s})$, $[A] = 0.240 \text{ mol/L}$, first order

Find: k

$$\text{rate} = k[A]$$

$$k = \text{rate}/[A] = 0.00480/0.240 = 0.0200 \text{ 1/s}$$

Final answer: $k = 2.00 \times 10^{-2} \text{ 1/s}$

Part B. Intermediate Initial-Rate Problems

Problem 16 Solution

Given: initial-rate data for A and B

Find: orders in A and B, overall order, and k

Compare experiments where only one concentration changes. From experiments 1 and 2, $[A]$ doubles while $[B]$ is constant, and the rate doubles. Therefore A is first order

From experiments 1 and 3, $[B]$ doubles while $[A]$ is constant, and the rate increases from 2.50×10^{-4} to 1.00×10^{-3} , which is a factor of 4. Since $2^2 = 4$, B is second order

$$\text{rate} = k[A][B]^2$$

$$k = \text{rate}/([A][B]^2) = (2.50 \times 10^{-4})/((0.100)(0.100)^2) = 0.250 \text{ L}^2/(\text{mol}^2\cdot\text{s})$$

Final answer: rate = $k[A][B]^2$; overall order = 3; $k = 0.250 \text{ L}^2/(\text{mol}^2\cdot\text{s})$

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Part C. Advanced Rate-Law Applications

Problem 32 Solution

Given: initial-rate data for A, B, and C

Find: rate law and k

Compare experiments 1 and 2 to isolate A. [A] doubles and the rate doubles, so A is first order

Compare experiments 1 and 3 to isolate B. [B] doubles and the rate increases by a factor of 4, so B is second order. Compare experiments 1 and 4 to isolate C. [C] triples and the rate is unchanged, so C is zero order

$$\text{rate} = k[A][B]^2$$

$$k = (2.00 \times 10^{-4}) / ((0.100)(0.100)^2) = 0.200 \text{ L}^2/(\text{mol}^2 \cdot \text{s})$$

Final answer: rate = $k[A][B]^2$; C is zero order; $k = 0.200 \text{ L}^2/(\text{mol}^2 \cdot \text{s})$

Part D. Challenge Problems

Problem 45 Solution

Given: k' changes from 0.0300 1/s to 0.0900 1/s when [B] changes from 0.100 mol/L to 0.300 mol/L

Find: order n in B and true k

Because $k' = k[B]^n$, k' changes with [B] in the same order pattern as the rate would [B] triples and k' triples. Therefore $n = 1$

$$k' = k[B]$$

$$k = k'/[B] = 0.0300/0.100 = 0.300 \text{ L}/(\text{mol} \cdot \text{s})$$

Final answer: $n = 1$ and $k = 0.300 \text{ L}/(\text{mol} \cdot \text{s})$

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Section 4. Answer Key

Problem	Answer
8	$2.00 \times 10^{-2} \text{ 1/s}$
16	rate = $k[A][B]^2$; overall order = 3; $k = 0.250 \text{ L}^2/(\text{mol}^2 \cdot \text{s})$
32	rate = $k[A][B]^2$; C is zero order; $k = 0.200 \text{ L}^2/(\text{mol}^2 \cdot \text{s})$
45	$n = 1$; $k = 0.300 \text{ L}/(\text{mol} \cdot \text{s})$

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