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CHEMISTRY WORKSHEET

INTEGRATED RATE LAW

Course: SCH4U Grade 12 Chemistry

DOWNLOAD FULL WORKSHEET

50 Practice Problems with Answers and Detailed Solutions

FULL worksheet contains 50 representative problems on:

✓ zero-, first-, and second-order integrated rate laws; ✓ half-life; ✓ graph linearization; ✓ k units; ✓ order from data

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
$q = m \times \Delta T$	Heat gained or lost by a substance
$\Delta T = T_f - T_i$	Temperature change with sign
$q_{sol} = C_{sol} \Delta T$	Heat absorbed by a calorimeter
$q_{reaction} = -q_{surroundings}$	Sign convention for coffee-cup and bomb calorimetry
$q_{hot} + q_{cold} = 0$	Heat exchange between substances
$\Delta H = q_{reaction}$	Molar enthalpy 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 SCH4U-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_{sol} 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 J/(g·°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 $q_{reaction}$ has the opposite sign of $q_{surroundings}$, ignoring the limiting reagent, mixing J and kJ, and using the sample mass instead of moles when a molar answer is requested.

Section 2 - Practice Problems

Part A - Fundamental Problems (Problems 1-15)

Problem 8

A second-order reaction has $[A]_0$ = 0.500 mol/L and k = 0.120 L/(mol·min). Calculate [A] after 8.00 min

Part B - Intermediate Problems (Problems 16-30)

Problem 16

A first-order reaction has k = 2.50 × 10^{-3} 1/s and $[A]_0$ = 1.20 mol/L. Calculate [A] after 8.00 min

Part C - Advanced Problems (Problems 31-42)

Problem 32

A plot of ln[A] versus time gives the line y = -0.0260t - 0.223, where t is in minutes. Determine the order, k, $[A]_0$, and [A] after 50.0 min

Part D - Challenge Problems (Problems 43-50)

Problem 45

A reaction gives the following data

t = 0, 25.0, 50.0 s; [A] = 0.500, 0.333, 0.250 mol/L

Determine the order, k, and the time required for [A] to reach 0.100 mol/L

Section 3 - Solutions

Problem 8 Solution

Given: $[A]_0$ = 0.500 mol/L, k = 0.120 L/(mol·min), t = 8.00 min

Find: $[A]_t$

Use the second-order integrated rate law and solve for the reciprocal concentration first

$1/[A]_t = 1/[A]_0 + kt$

$1/[A]_t = 1/0.500 + (0.120)(8.00)$

$1/[A]_t = 2.00 + 0.960 = 2.960$ L/mol

$[A]_t = 1/2.960 = 0.3378$ mol/L

Significant figures: Final concentration is reported to three significant figures

Final answer: [A] = 0.338 mol/L

Problem 16 Solution

Given: k = 2.50 × 10^{-3} 1/s, $[A]_0$ = 1.20 mol/L, t = 8.00 min

Find: $[A]_t$

Convert time to seconds first because k is in 1/s, then use the first-order law

$\ln([A]_t/[A]_0) = -kt$

t = 8.00 min × 60.0 s/min = 480 s; $\ln([A]_t/1.20) = -(2.50 \times 10^{-3})(480)$

$\ln([A]_t/1.20) = -1.20$

$[A]_t = 1.20 \times e^{(-1.20)} = 0.361$ mol/L

Significant figures: Final concentration is reported to three significant figures

Final answer: [A] = 0.361 mol/L

Problem 32 Solution

Given: ln[A] versus time line: y = -0.0260t - 0.223

Find: Order, k, $[A]_0$, and [A] at 50.0 min

A linear ln[A] plot identifies first-order kinetics. Slope = -k and intercept = $\ln[A]_0$

$\ln[A]_t = -kt + \ln[A]_0$

k = 0.0260 1/min; $\ln[A]_0 = -0.223$; $\ln[A]_{50} = -0.0260(50.0) - 0.223$

$[A]_0 = e^{(-0.223)} = 0.800$ mol/L

$\ln[A]_{50} = -1.523$

$[A]_{50} = e^{(-1.523)} = 0.218$ mol/L

Significant figures: All final numerical values are reported to three significant figures

Final answer: First-order; k = 0.0260 1/min; $[A]_0 = 0.800$ mol/L; $[A]_{50} = 0.218$ mol/L

Problem 45 Solution

Given: Concentration data at 0, 25.0, and 50.0 s, target [A] = 0.100 mol/L

Find: Order, k, and target time

Check 1/[A], because the reciprocals 2.00, 3.00, and 4.00 increase evenly

$1/[A]_t = 1/[A]_0 + kt$

k = (4.00 - 2.00)/50.0; 1/0.100 = 1/0.500 + kt

k = 0.0400 L/(mol·s)

10.0 = 2.00 + (0.0400)t

t = 8.00/0.0400 = 200 s, which is 2.00×10^2 s

Significant figures: Final values are reported to three significant figures

Final answer: Second-order; k = 0.0400 L/(mol·s); t = 2.00×10^2 s

Section 4 - Answer Key

Problem	Answer
8	[A] = 0.338 mol/L
16	[A] = 0.361 mol/L
32	First-order; k = 0.0260 1/min; $[A]_0$ = 0.800 mol/L; $[A]_{50}$ = 0.218 mol/L
45	Second-order; k = 0.0400 L/(mol·s); t = 2.00 × 10² s