Northern Tutoring™

FREE SAMPLE

more worksheets with solutions

CHEMISTRY WORKSHEET

MIXED ACID-BASE EQUILIBRIUM PRACTICE

Course: SCH4U Grade 12 Chemistry

DOWNLOAD FULL WORKSHEET

50 Practice Problems with Answers and Detailed Solutions

FULL worksheet contains 50 representative problems on:

✓ strong acids and bases, ✓ weak acid and weak base ICE tables, ✓ conjugate pairs, ✓ salt hydrolysis, ✓ buffer calculations, ✓ titration points, ✓ mixed equilibrium reasoning

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 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 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

Section 1 - Essential Information

Salt hydrolysis happens when an ion from a salt reacts with water and changes $[H_3O^+]$ or $[OH^-]$. The main idea is to identify whether each ion comes from a strong acid, strong base, weak acid, or weak base.

Ion type	Hydrolysis behaviour	Main result
Cation from strong base	No important hydrolysis	Neutral effect
Anion from strong acid	No important hydrolysis	Neutral effect
Cation from weak base	$BH^+ + H_2O \rightleftharpoons B + H_3O^+$	Acidic solution
Anion from weak acid	$A^- + H_2O \rightleftharpoons HA + OH^-$	Basic solution
Weak acid + weak base salt	Both ions hydrolyze	Compare K_a (cation) and K_b (anion)

Key relationships

Weak acid model: HA reacts with water to form H_3O^+ and A^-.

$$HA_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Weak base model: B reacts with water to form BH^+ and OH^-.

$$B_{(aq)} + H_2O_{(l)} \rightleftharpoons BH^+_{(aq)} + OH^-_{(aq)}$$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

pH relationships at 25 °C	Conjugate pairs: $K_a \cdot K_b$
$pH = -\log[H_3O^+]$ $[H_3O^+] = 10^{-pH}$ $pOH = -\log[OH^-]$ $[OH^-] = 10^{-pOH}$ $pH + pOH = 14.00$ $[H_3O^+][OH^-] = K_w = 1.0 \times 10^{-14}$	use $K_b = K_w/K_a$ for a conjugate base and $K_a = K_w/K_b$ for a conjugate acid

For weak acid + weak base salts: $pH = 7.00 + \frac{1}{2}\log\left(\frac{\text{[Weak cation]}}{\text{[Weak anion]}}\right)$

For amphiprotic ions such as HCO_3^-: $pH = \frac{pK_{a1} + pK_{a2}}{2}$

Common constants used in this worksheet

Acid or base	Constant	Acid or base	Constant
CH_3COOH	$K_a = 1.8 \times 10^{-5}$	NH_3	$K_b = 1.8 \times 10^{-5}$
HF	$K_a = 6.8 \times 10^{-4}$	CH_3NH_2	$K_b = 4.4 \times 10^{-4}$
HNO_2	$K_a = 4.3 \times 10^{-4}$	C_5H_5N	$K_b = 1.7 \times 10^{-9}$
HCN	$K_a = 3.5 \times 10^{-10}$	$HCOOH$	$K_a = 1.8 \times 10^{-4}$
HCN	$K_a = 6.2 \times 10^{-10}$	HCO_3^-	$K_{a2} = 4.7 \times 10^{-11}$

Section 2 - Practice Problems

Part A - Fundamental Problems

Problem 8

A 0.150 mol/L weak base B has pH = 10.85. Calculate K_b

Part B - Intermediate Problems

Problem 16

Find the pH of 0.0800 mol/L HCOOH. Use $K_a = 1.8 \times 10^{-4}$

Part C - Advanced Problems

Problem 32

Find the pH of an amphiprotic HCO_3^- solution. Use $K_{a1} = 4.3 \times 10^{-7}$ and $K_{a2} = 5.6 \times 10^{-11}$ for carbonic acid

Part D - Challenge Problems

Problem 45

Equal volumes of 0.100 mol/L CH_3COOH and 0.100 mol/L NH_3 are mixed. Estimate the pH of the resulting salt solution. Use K_a for $CH_3COOH = 1.8 \times 10^{-5}$ and K_b for $NH_3 = 1.8 \times 10^{-5}$

Section 3 - Solutions

Part A - Fundamental Problems

Problem 8 Solution

Given pOH = 14.00 - 10.85 = 3.15

$[OH^-] = 10^{-3.15} = 7.08 \times 10^{-4}$ mol/L

ICE setup $K_b = x^2/(0.150 - x)$

$K_b = (7.08 \times 10^{-4})^2/(0.150 - 0.000708) = 3.36 \times 10^{-6}$

Final answer $K_b = 3.36 \times 10^{-6}$

Part B - Intermediate Problems

Problem 16 Solution

Equilibrium Let x = $[H_3O^+]$

ICE setup $K_a = x^2/(0.0800 - x) = 1.8 \times 10^{-4}$

x = 0.00371 mol/L

pH = -log(0.00371) = 2.431

Final answer pH = 2.43

Part C - Advanced Problems

Problem 32 Solution

Method For an amphiprotic ion, $pH \approx 1/2(pK_{a1} + pK_{a2})$

$pK_{a1} = -\log(4.3 \times 10^{-7}) = 6.37$

$pK_{a2} = -\log(5.6 \times 10^{-11}) = 10.25$

$pH \approx 1/2(6.37 + 10.25) = 8.31$

Final answer pH = 8.31

Part D - Challenge Problems

Problem 45 Solution

Method Equal moles react to form CH_3COO^- and NH_4^+

$$CH_3COOH_{(aq)} + NH_{3(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + NH_4^+{}_{(aq)}$$

Reasoning The conjugate base strength and conjugate acid strength are equal because $K_a(CH_3COOH) = K_b(NH_3)$

For this weak acid and weak base salt, $pH \approx 7.00 + 1/2(pK_a - pK_b)$

$pK_a = pK_b$, so $pH \approx 7.00$

Final answer pH = 7.00

Section 4 - Answer Key

8. Kb = 3.36 × 10-6 16. pH = 2.43 32. pH = 8.31 45. pH = 7.00		