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CHEMISTRY WORKSHEET

COMMON ION EFFECT

Course: SCH4U Grade 12 Chemistry

DOWNLOAD FULL WORKSHEET

50 Practice Problems with Answers and Detailed Solutions

FULL worksheet contains 50 representative problems on:

✓ weak acid common ions, ✓ weak base common ions, ✓ buffer pH, ✓ Ksp, ✓ solubility suppression, ✓ predicting precipitation ✓ precipitation thresholds

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

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: $K_a K_b = K_w$
$pH = -\log[H_3O^+]$, $[H_3O^+] = 10^{-pH}$ $pOH = -\log[OH^-]$, $[OH^-] = 10^{-pOH}$ $pH + pOH = 14.00$ $[H_3O^+][OH^-] = K_w = 1.0 \times 10^{-14}$	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	$K_a = 6.8 \times 10^{-4}$	$C_6H_5NH_2$	$K_b = 4.4 \times 10^{-10}$
HNO_2	$K_a = 4.5 \times 10^{-4}$	C_5H_5N	$K_b = 1.7 \times 10^{-9}$
HCN	$K_a = 3.5 \times 10^{-10}$	$N(CH_3)_3$	$K_b = 7.4 \times 10^{-5}$
HClO	$K_a = 3.2 \times 10^{-8}$	HCO_3^-	$K_{a2} = 4.7 \times 10^{-11}$

Section 2 - Practice Problems

Part A - Fundamental Problems

Problem 8

Benzoic acid has $K_a = 6.3 \times 10^{-5}$. Calculate the pH of a solution with 0.250 M $HC_7H_5O_2$ and 0.125 M $NaC_7H_5O_2$

Part B - Intermediate Problems

Problem 16

50.0 mL of 0.200 M CH_3COOH is mixed with 25.0 mL of 0.300 M $NaCH_3COO$. Calculate the pH. $K_a = 1.8 \times 10^{-5}$

Part C - Advanced Problems

Problem 32

A 1.00 L buffer contains 0.100 mol CH_3COOH and 0.100 mol $NaCH_3COO$.

0.0300 mol NaOH is added. Calculate the final pH. $K_a = 1.8 \times 10^{-5}$

Part D - Challenge Problems

Problem 45

100.0 mL of 0.100 M CH_3COOH is mixed with 20.0 mL of 0.100 M NaOH.

Calculate the pH after reaction. $K_a = 1.8 \times 10^{-5}$

Section 3 - Solutions

Problem 8 Solution

Given: $[HC_7H_5O_2] = 0.250$ M, $[C_7H_5O_2^-] = 0.125$ M, $K_a = 6.3 \times 10^{-5}$

Find: pH

$$HC_7H_5O_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + C_7H_5O_2^-{}_{(aq)}$$

ICE table

	$HC_7H_5O_2$	H_3O^+	$C_7H_5O_2^-$
Initial (M)	0.250	0	0.125
Change (M)	-x	+x	+x
Equilibrium (M)	0.250 - x	x	0.125 + x

$$K_a = x(0.125 + x)/(0.250 - x)$$

$$[H_3O^+] \approx K_a[HA]/[A^-] = (6.3 \times 10^{-5})(0.250)/(0.125)$$

$$[H_3O^+] = 1.26 \times 10^{-4} \text{ M}$$

$$pH = -\log(1.26 \times 10^{-4}) = 3.90$$

Final answer: pH = 3.90

Problem 16 Solution

Given: 50.0 mL of 0.200 M CH_3COOH and 25.0 mL of 0.300 M CH_3COO^-; $K_a = 1.8 \times 10^{-5}$

Find: pH after mixing

$n(CH_3COOH) = (0.0500\ L)(0.200\ mol/L) = 0.0100\ mol$

$n(CH_3COO^-) = (0.0250\ L)(0.300\ mol/L) = 0.00750\ mol$

Both species are diluted into the same final volume, so their concentration ratio equals their mole ratio. The mixture is a buffer.

$pK_a = -\log(1.8 \times 10^{-5}) = 4.74$

$pH = pK_a + \log(n(A^-)/n(HA))$

$pH = 4.74 + \log(0.00750/0.0100) = 4.62$

Final answer: pH = 4.62

Problem 32 Solution

Given: Initial n(CH_3COOH) = 0.100 mol, n(CH_3COO^-) = 0.100 mol, and n(NaOH) = 0.0300 mol; $K_a = 1.8 \times 10^{-5}$

Find: The final pH

Strong base reacts completely with the weak acid, converting it into conjugate base.

$$OH^-_{(aq)} + CH_3COOH_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)}$$

Stoichiometric reaction table

	CH_3COOH	OH^-	CH_3COO^-
Initial (mol)	0.100	0.0300	0.100
Change (mol)	-0.0300	-0.0300	+0.0300
After reaction (mol)	0.0700	0	0.130

$$pH = 4.74 + \log(0.130/0.0700) = 5.01$$

Final answer: pH = 5.01

Problem 45 Solution

Given: 100.0 mL of 0.100 M CH_3COOH is mixed with 20.0 mL of 0.100 M NaOH; $K_a = 1.8 \times 10^{-5}$

Find: pH after reaction

$n(CH_3COOH) = (0.1000\ L)(0.100\ M) = 0.0100\ mol$

$n(OH^-) = (0.0200\ L)(0.100\ M) = 0.00200\ mol$

$OH^-_{(aq)} + CH_3COOH_{(aq)} \rightarrow CH_3COO^-_{(aq)} + H_2O_{(l)}$

Stoichiometric reaction table

	CH_3COOH	OH^-	CH_3COO^-
Initial (mol)	0.0100	0.00200	0
Change (mol)	-0.00200	-0.00200	+0.00200
After reaction (mol)	0.00800	0	0.00200

The neutralization is incomplete, leaving both weak acid and conjugate base. This is a buffer.

$pH = 4.74 + \log(0.00200/0.00800) = 4.14$

Final answer: pH = 4.14

Section 4 - Answer Key

Problem	Answer
8	pH = 3.90
16	pH = 4.62
32	pH = 5.01
45	pH = 4.14