



T-08 Acid-Base Indicators and pH Determination & T-09 Solubility Rules

- Place pre-lab report on table for the TA to sign
- Hand in final lab report

Collect lab equipment:

- One piece of transparency and blank paper per group
- Even groups: prepare E8 droppers
- Odd groups: prepare E9 droppers



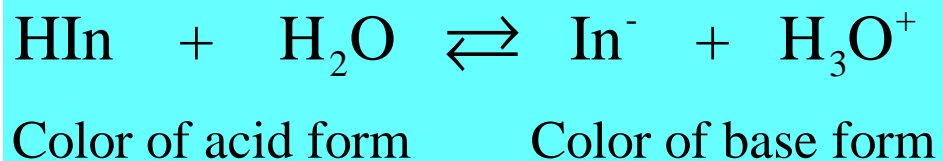
T-08 Acid-Base Indicators and pH Determination

Objective:

- To test the pH range of various acid-base indicators.
- To determine the pH values of salt solutions

Introduction:

- Acid-base indicators is a weak organic acid (HIn) or organic base (In)



$$K_a = \frac{[\text{H}_3\text{O}^+][\text{In}^-]}{[\text{HIn}]}$$

$$\frac{[\text{HIn}]}{[\text{In}^-]} = \frac{[\text{H}_3\text{O}^+]}{K_a}$$

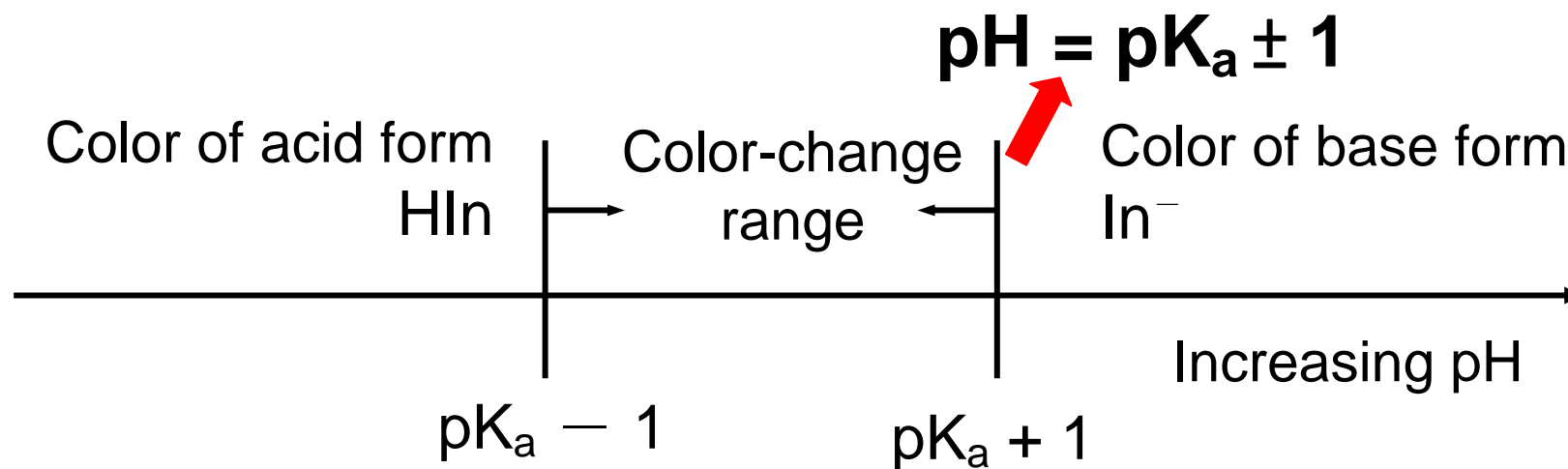
$$\frac{[\text{HIn}]}{[\text{In}^-]} \geq 10 \text{ color of acid form}$$

$$\frac{[\text{HIn}]}{[\text{In}^-]} \leq \frac{1}{10} \text{ color of base form}$$



Color of Acid-base Indicator Depends on pH of Solution

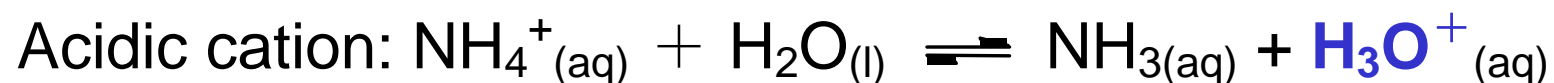
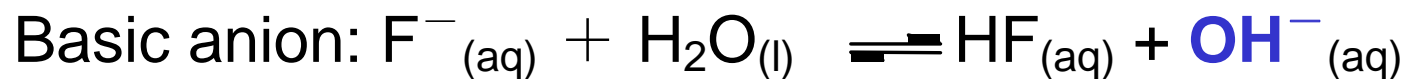
- $[\text{HIn}] \geq 10[\text{In}^-]$: reveal HIn color
- $[\text{In}^-] \geq 10[\text{HIn}]$: reveal In^- color
- $[\text{H}_3\text{O}^+] \geq 10K_a$, $\text{pH} < \text{p}K_a - 1$: HIn color
- $[\text{H}_3\text{O}^+] \leq K_a/10$, $\text{pH} > \text{p}K_a + 1$: In^- color





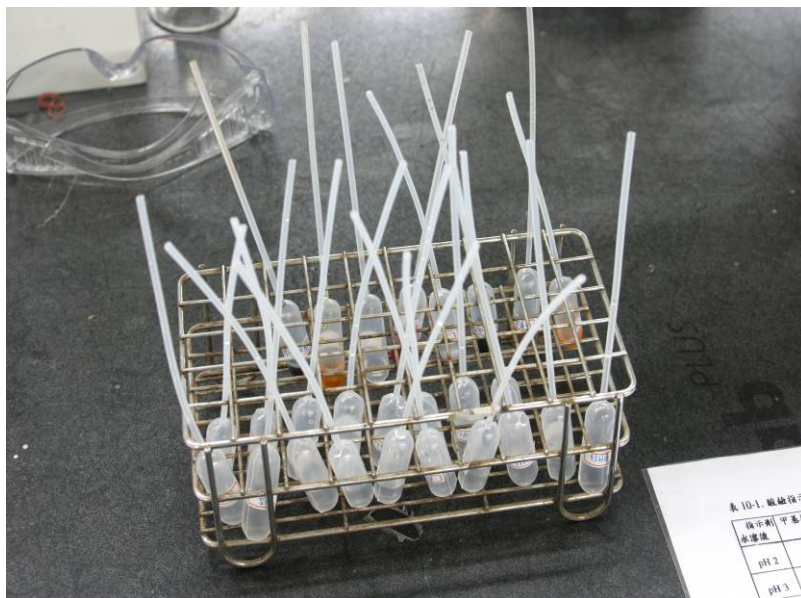
pH of Salt Solutions

- Cation (Na^+) of a strong base (NaOH): **neutral**
- Anion (Cl^-) of a strong acid (HCl): **neutral**
- Conjugate base (F^-) of a weak acid: **basic**
- Conjugate acid (NH_4^+) of a weak base: **acidic**
- Cation (Fe^{3+}) of transitional metals: **acidic**





Procedure 1: Prepare Plastic Droppers

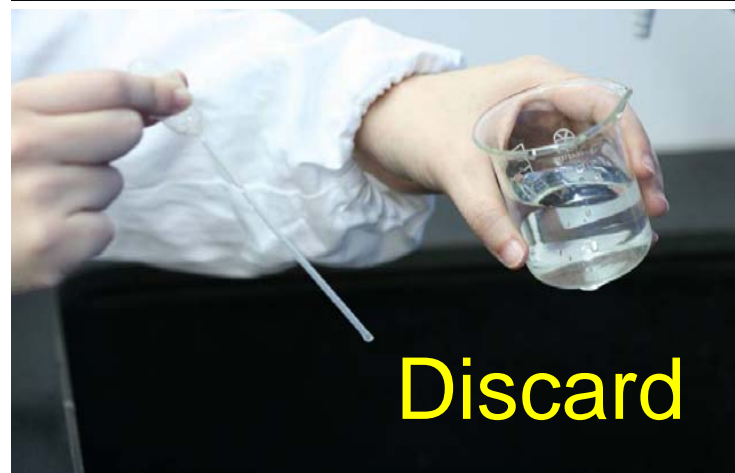


- Two groups share one set of plastic droppers
- Labels each dropper to indicate the reagents
- Draw about 1 mL of each chemical, invert droppers
- If the reagent in the dropper displays unusual coloring:
 - Discard the reagents from dropper
 - Draw clean distilled water from cup
 - Rinse and discard several times
 - Fill with fresh reagent



Cleaning Plastic Droppers Correctly


- Plastic droppers containing testing reagents should be **properly categorized**.
- If a dropper is contaminated during the experiment, discard the reagent and rinse the dropper several times with **distilled water**.





Procedure 2. Add Buffer/Salt Solution onto Transparency

表 10-1. 酸鹼指示劑顏色變化測試表



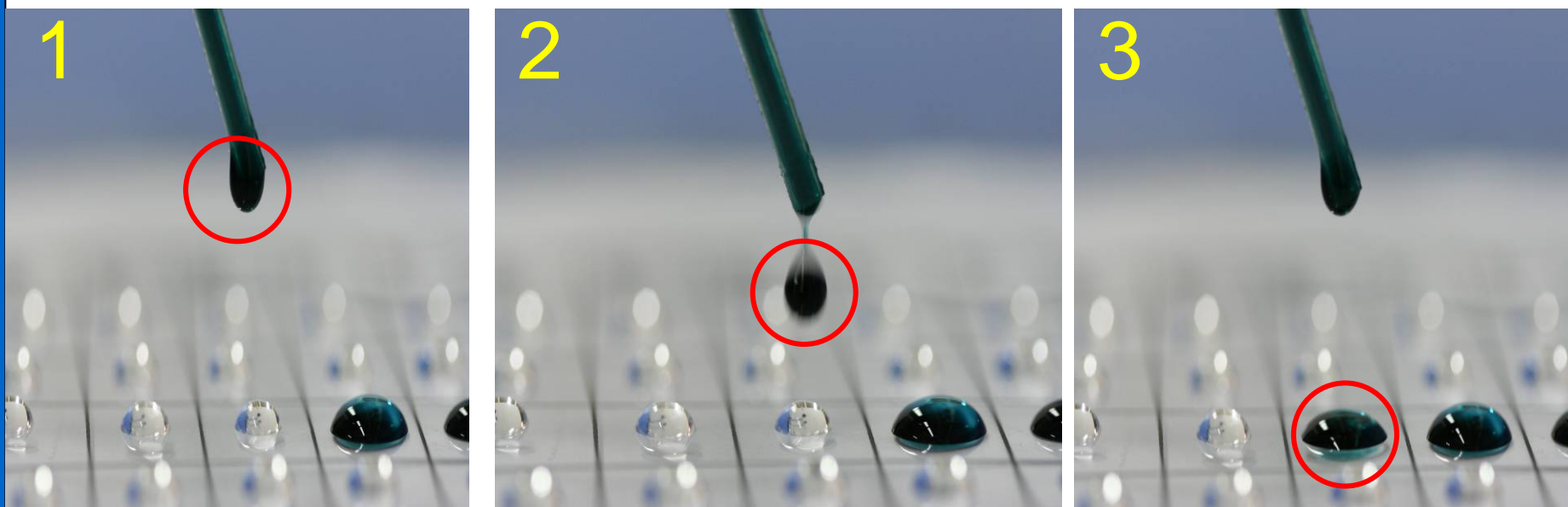
指示劑 水溶液	甲基橙	甲基紅	溴瑞香 草酚藍	酚紅	酚酞	高永貴 R	廣用 指示劑
pH 2							
pH 3							
pH 4							
pH 5							
pH 6							
pH 7							
pH 8							
pH 9							
pH 10							
pH 11							
pH 12							
pH 13							
1 M N ₂ H ₄ Cl							
1 M NaCl							
1 M NH ₄ OAc							
1 M NaOAc							
1 M NaHCO ₃							
空白							

75

- Take a piece of transparency and blank paper per group
- Add colorless pH and salt solutions row by row first.
- Then add the indicators column by column
- Keep every drop the same size
- **Do not touch the solution drops on the transparency to avoid contamination**



Procedure 3: Add Indicators



Do not touch the solution drops on the transparency to avoid contamination



Procedure 4: Record or Take Picture of Color Change

pH = 2~4

表 10-1. 酸性指示劑顏色變化測試表

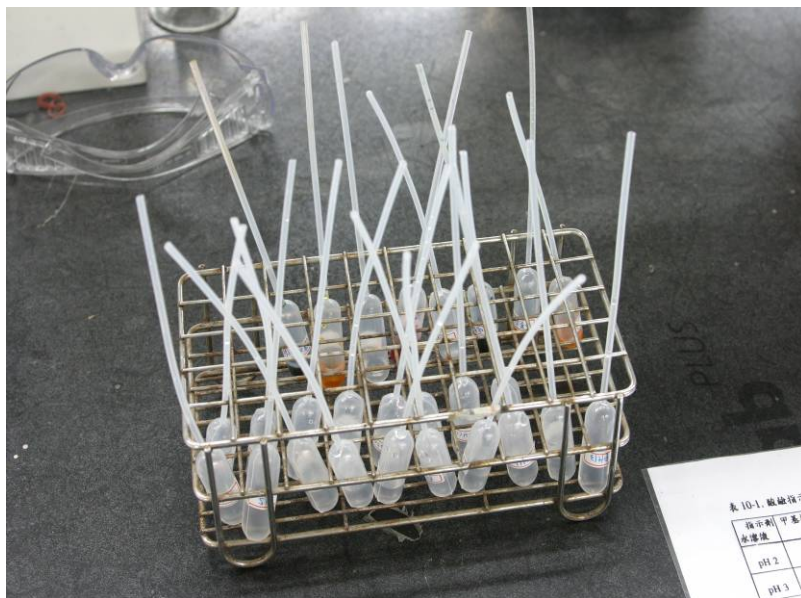
指示劑 水溶液	甲基橙	甲基紅	溴酚藍	酚紅	酚酞	萬來黃 R	廣用 指示劑
pH 2	紅	粉	黃	黃	無色	黃	紅
pH 3	紅	粉	黃	黃	無色	黃	紅
pH 4	橙	粉	黃	黃	無色	黃	紅
pH 5	黃	粉	黃	黃	無色	黃	紅
pH 6	黃	粉	綠	黃	無色	黃	紅
pH 7	黃	粉	藍	粉	無色	黃	紅
pH 8	黃	粉	藍	粉	無色	黃	紅
pH 9	黃	粉	藍	粉	無色	黃	紅
pH 10	黃	粉	藍	粉	無色	黃	紅
pH 11	黃	粉	藍	粉	無色	黃	紅
pH 12	黃	粉	藍	粉	無色	黃	紅
pH 13	黃	粉	藍	粉	無色	黃	紅
1 M NH ₄ Cl	黃	粉	藍	粉	無色	黃	紅
1 M NaCl	黃	粉	藍	粉	無色	黃	紅
1 M NH ₄ OAc	黃	粉	藍	粉	無色	黃	紅
1 M NaOAc	黃	粉	藍	粉	無色	黃	紅
1 M NaHCO ₃	黃	粉	藍	粉	無色	黃	紅
未知	橙	粉	黃	黃	無色	黃	紅

- Record the color changes
- Circle the range of color change for each indicator
- According to the color change, **determine the pH value of each salt solution**
- Phenolphthalein (alcoholic solution) has smaller surface tension and tends to spread out; it can be added last.

Record the color changes and determine the pH of the unknown test solution



Procedure 5: Clean & Recycle



- Using the wash bottle to rinse the transparency and discard into sink
- Wipe dry transparency with paper towel and hand it in along with blank paper
- Categorize the plastic droppers that containing testing reagents
- Invert the plastic droppers with the opening on top on test tube rack for the next class to use



T-09 Solubility Rules

- **Objective:** To verify solubility rules by using this experiment

- **Introduction:**

Solubility rules:

NO_3^- : All nitrate salts are **soluble**

CH_3COO^- : All acetate salts are **soluble**

Cl^- 、 Br^- 、 I^- : **All soluble**, except for Ag^+ , Hg_2^{2+} , Pb^{2+}

SO_4^{2-} : **All soluble**, except for Ca^{2+} , Sr^{2+} , Ba^{2+} , Pb^{2+} , Hg_2^{2+} , Ag^+

S^{2-} : All sulfides are **insoluble**, except for group IA, IIA cations and NH_4^+

OH^- : All hydroxides are **insoluble**, except for group IA cations and Ca^{2+} , Sr^{2+} , Ba^{2+}

CO_3^{2-} : All carbonate salts are **insoluble**, except those of group IA cations and NH_4^+

PO_4^{3-} : All phosphate salts are **insoluble**, except those of group IA cations and NH_4^+



Procedure 1: Prepare plastic droppers



- Two groups share one set of plastic droppers
- Label the droppers to indicate the reagents
- Draw about 1 mL of each chemical, invert droppers
- If the reagent in the dropper displays unusual coloring or precipitation
 - Discard the reagents from dropper
 - Draw clean distilled water from cup
 - Rinse and discard several times
 - Fill with fresh reagent



Procedure 2: Add the solution

Add cationic solutions row by row

表 9-2 溶解度法別一陰、陽離子沉澱反應測試表

陽離子 試劑	陽離子 (對照組)	陰 離 子 試 劑						
		OAc (Na ⁺)	Cl ⁻ (Na ⁺)	SO ₄ ²⁻ (Na ⁺)	OH ⁻ (Na ⁺)	CO ₃ ²⁻ (Na ⁺)	PO ₄ ³⁻ (Na ⁺)	S ²⁻ (NH ₄ ⁺)
Ag ⁺ (NO ₃)								
Pb ²⁺ (NO ₃)								
Cu ²⁺ (NO ₃)								
Bi ³⁺ (NO ₃)								
Fe ²⁺ (NO ₃)								
Co ²⁺ (NO ₃)								
Zn ²⁺ (NO ₃)								
Al ³⁺ (NO ₃)								
Mg ²⁺ (NO ₃)								
Ca ²⁺ (NO ₃)								
K ⁺ (NO ₃)								
NH ₄ ⁺ (NO ₃)								

- Take a piece of transparency and blank paper per group
- Add **cationic** reagents row by row first
- Then add the **anionic** reagents column by column
- Keep every drop the same size
- **Do not touch the solution drops on the transparency to avoid contamination**



Procedure 3: Observe and Record the Precipitation and/or Color Change

表 9-2 溶解度法別一陰、陽離子沉澱反應測試表

陽離子 試劑	陽離子 (對照組)	陰離子試劑						
		OAc (Na ⁺)	Cl ⁻ (Na ⁺)	SO ₄ ²⁻ (Na ⁺)	OH ⁻ (Na ⁺)	CO ₃ ²⁻ (Na ⁺)	PO ₄ ³⁻ (Na ⁺)	S ²⁻ (NH ₄ ⁺)
Ag ⁺ (NO ₃)								
Pb ²⁺ (NO ₃)								
Cu ²⁺ (NO ₃)								
Bi ³⁺ (NO ₃)								
Fe ³⁺ (NO ₃)								
Co ²⁺ (NO ₃)								
Zn ²⁺ (NO ₃)								
Al ³⁺ (NO ₃)								
Mg ²⁺ (NO ₃)								
Ca ²⁺ (NO ₃)								
K ⁺ (NO ₃)								
NH ₄ ⁺ (NO ₃)								

Blank paper as background

表 9-2 溶解度法別一陰、陽離子沉澱反應測試表

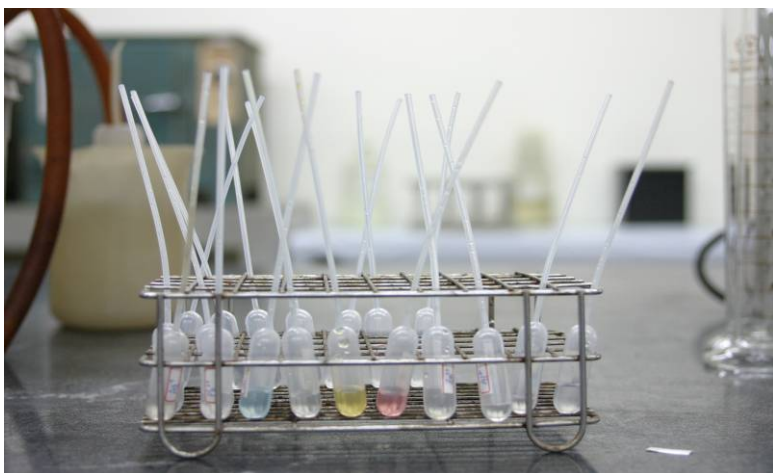
陽離子 試劑	陽離子 (對照組)	陰離子試劑						
		OAc (Na ⁺)	Cl ⁻ (Na ⁺)	SO ₄ ²⁻ (Na ⁺)	OH ⁻ (Na ⁺)	CO ₃ ²⁻ (Na ⁺)	PO ₄ ³⁻ (Na ⁺)	S ²⁻ (NH ₄ ⁺)
Ag ⁺ (NO ₃)								
Pb ²⁺ (NO ₃)								
Cu ²⁺ (NO ₃)								
Bi ³⁺ (NO ₃)								
Fe ³⁺ (NO ₃)								
Co ²⁺ (NO ₃)								
Zn ²⁺ (NO ₃)								
Al ³⁺ (NO ₃)								
Mg ²⁺ (NO ₃)								
Ca ²⁺ (NO ₃)								
K ⁺ (NO ₃)								
NH ₄ ⁺ (NO ₃)								

Black table top as background

Record: (1) any precipitation and color of the precipitate
(2) any color change of the solution



Procedure 4: Clean & Recycle



- Rinse the transparency with wash bottle and collect waste into beaker
- **Discard into waste container for heavy metals**
- Wipe dry the transparency with paper towel and hand it in along with blank paper
- Categorize plastic droppers, place on table for the next class to use



Notice

- Liquid waste that contains heavy waste must be **recycled**
- Hand in transparency after cleaning and drying
- Separate and categorize the droppers of the two experiments.
- The last class that does the experiment must empty and categorize the droppers, then tie with rubber band. Hand into the paper box.