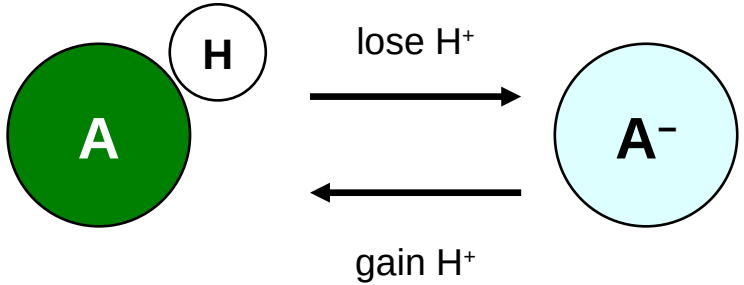
Essential Question

How does pH decide an acid's form?

Two Forms: HA and A^-

- HA: acid form, still has H^+
- A^-: base form, lost its H^+
- pH decides which form wins



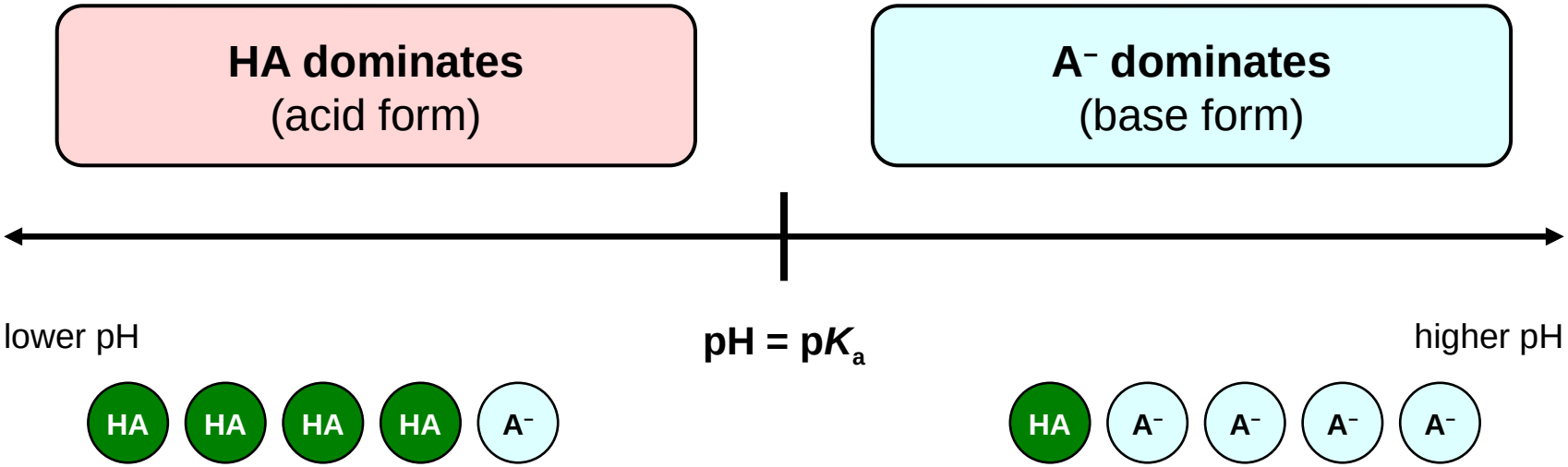
HA
protonated

A^-
deprotonated

$$HA + H_2O \rightleftharpoons H_3O^+ + A^-$$

Compare pH to pK_a

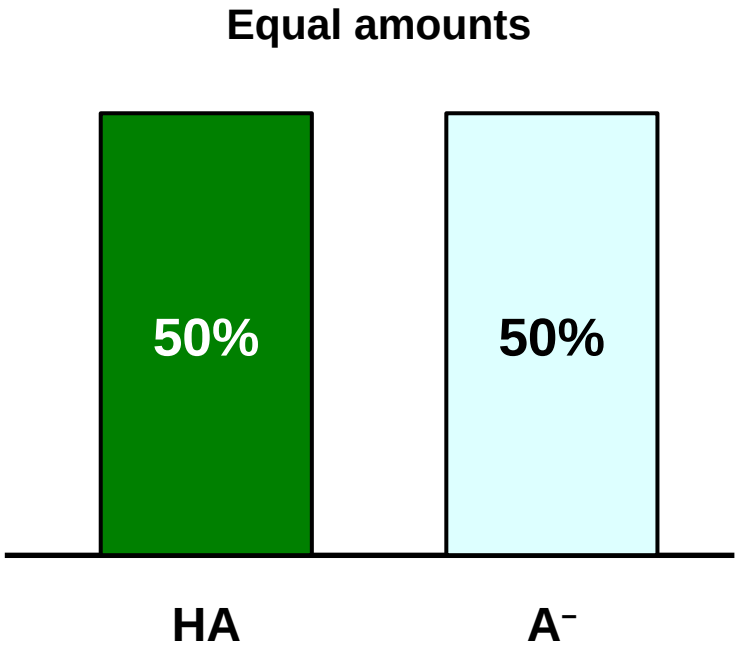
- pH < pK_a: more HA
- pH > pK_a: more A^-



When pH = pK_a

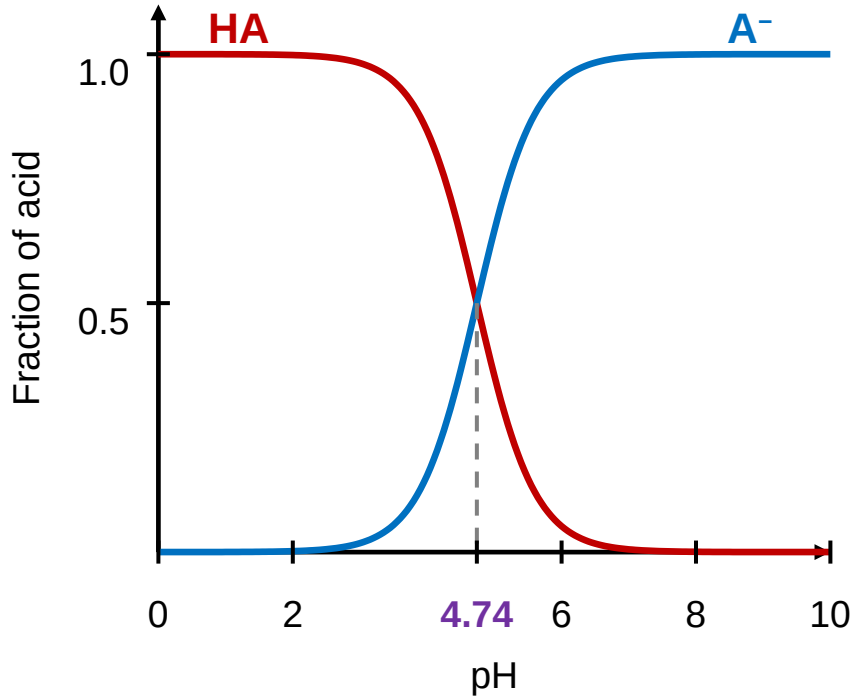
- pH = pK_a: [HA] = [A^-]
- Half HA, half A^-
- The 50/50 point

Acetic acid at pH 4.74:
half HA, half A^-



Distribution Diagram

- Fraction of each form vs. pH
- Curves cross at pH = pK_a
- Acetic acid: pK_a = 4.74

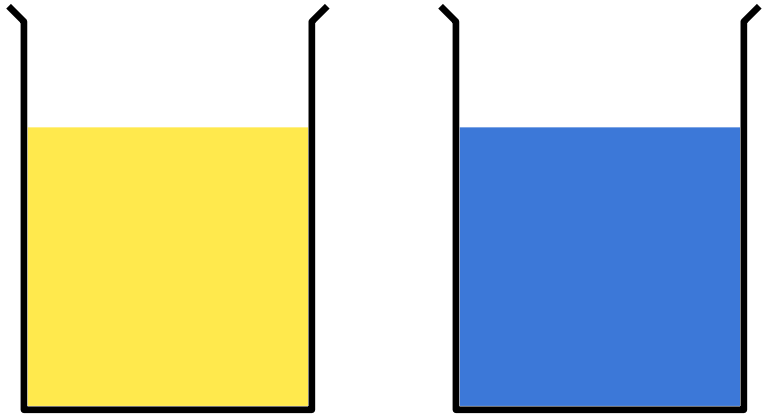


Indicators Are Weak Acids

- Indicator: a weak acid, HIn
- HIn and In^- have different colors

$$HIn + H_2O \rightleftharpoons H_3O^+ + In^-$$

Bromothymol blue:
HIn is yellow, In^- is blue

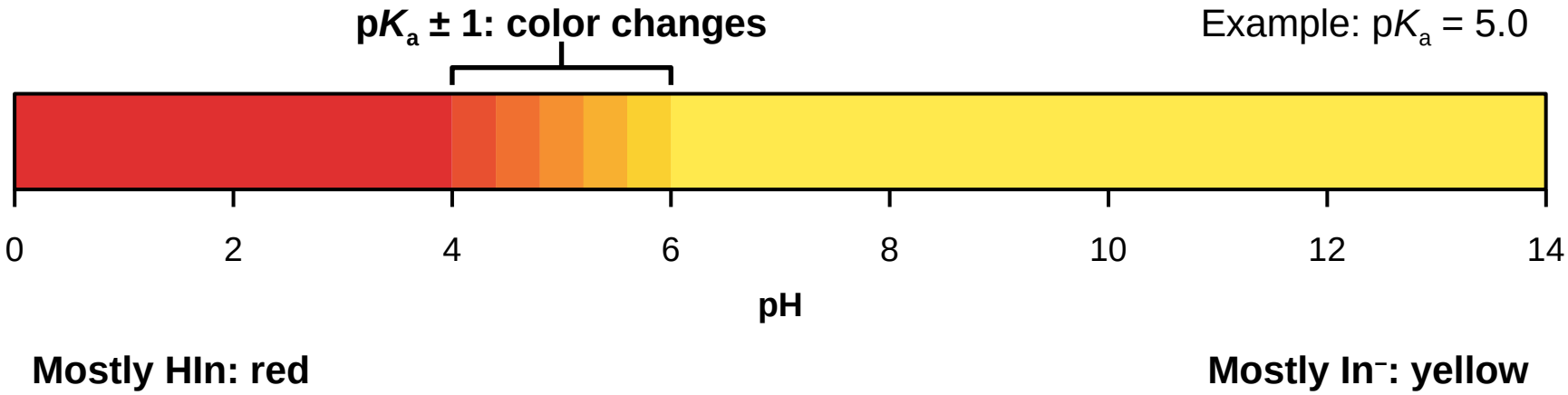


HIn
(acid form)

In^-
(base form)

Indicator Color Range

- Color changes near pH = pK_a
- Range: about pK_a ± 1



Choosing an Indicator

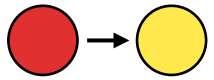
- pK_a near equivalence pH
- Color flips at equivalence

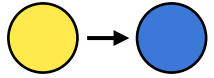
Indicator pK_a ≈ equivalence pH

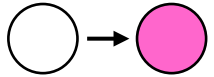
Methyl orange, pK_a ≈ 3.5
red → yellow

Bromothymol blue, pK_a ≈ 7.1
yellow → blue

Phenolphthalein, pK_a ≈ 9.4
colorless → pink







acid base

Example: Which Form Dominates?

Hypochlorous acid, HOCl, has a pK_a of 7.53.

A solution of HOCl is adjusted to pH 7.00.

Which species is present at the higher concentration, HOCl or OCl^-? Justify your answer.

pK_a = 7.53

pH = 7.00

Example: Pick the Indicator

A weak base is titrated with HCl. The pH at the equivalence point is about 5.3. Which indicator is the best choice? Justify your answer.

Equivalence
pH ≈ 5.3

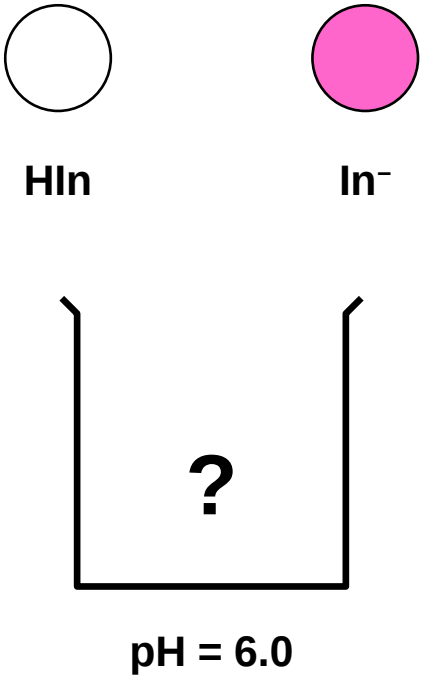
Methyl orange: pK_a = 3.5

Methyl red: pK_a = 5.0

Bromothymol blue: pK_a = 7.1

Example: Predict the Color

Phenolphthalein has a pK_a of 9.4. Its HIn form is colorless and its In^- form is pink. A few drops are added to a solution with pH 6.0. What color is the solution? Justify your answer.



Example: Ratio Above pK_a

HF has a pK_a of 3.17. In a solution with pH 4.17, is the ratio $[F^-]/[HF]$ greater than 1, less than 1, or equal to 1? Justify your answer.

pK_a = 3.17

pH = 4.17

$$[F^-] / [HF] = ?$$

Big Ideas

- pH < pK_a: HA dominates
- pH > pK_a: A^- dominates
- Indicator pK_a ≈ equivalence pH

pH < pK_a
more HA

pH = pK_a
[HA] = [A^-]

pH > pK_a
more A^-