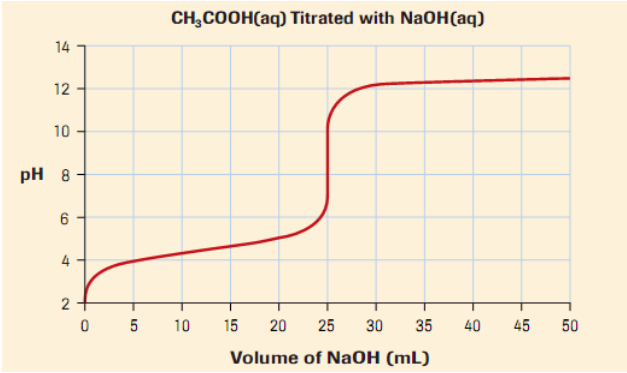
Part 3 - Interpret titration curves and identify buffering regions - pgs 751-762

- a graph showing the continuous change of pH during an acid–base titration, continued until the titrant is in great excess, is called a **pH curve** (titration curve) for the reaction



- The pH curve can help us determine a few important pieces of information:

    - pH at endpoint - this helps us pick an indicator for a titration
    - pH of initial sample
    - volume of the titrant needed to reach the equivalence point

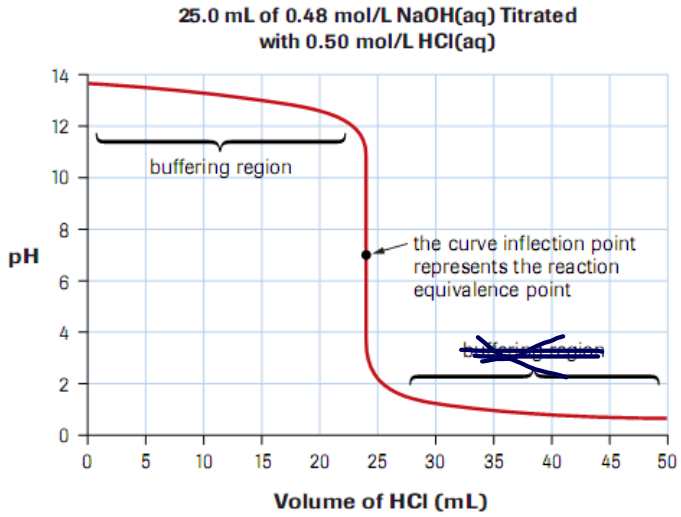
- **Endpoint** refers to that point in a titration analysis where the addition of titrant is stopped. The endpoint is defined (empirically) by the observed color change of an indicator.

    - Endpoints are easily detectable because pH changes a great deal, and very abruptly, as the reaction solution changes

- **Equivalence** point refers to that point in any chemical reaction where chemically equivalent amounts of the reactants have been combined. The equivalence point is defined (theoretically) by the stoichiometric ratio from the reaction equation.

- There must be a strong acid or a strong base involved in the titration in order to get a noticeable endpoint.

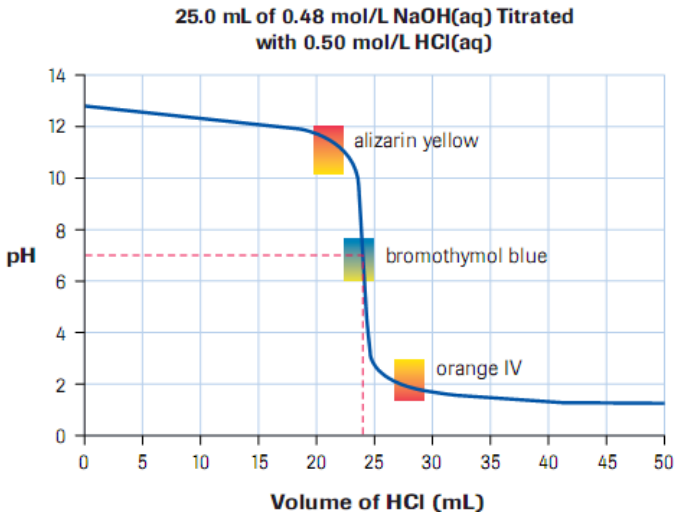
Why, for most of a titration, does the pH hardly change at all?



At the equivalence point, the moles of the acid equal the moles of the base.

$OH^-(aq)$	+	$H_3O^+(aq)$	$\rightarrow 2\ H_2O(l)$
25 mL × 0.48 mol/L		24 mL × 0.50 mol/L	
12 mmol		12 mmol	

Choosing indicators for titrations



- An indicator is chosen so that its **pH range** includes the equivalence point of the titration.

- A pH curve is used to determine the equivalence point

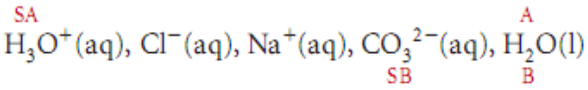
pH curves with Polyprotic acids or bases

- Polyprotic acids can lose more than one proton, and polyprotic bases can gain more than one proton, in Brønsted–Lowry transfers

- If more than one proton transfer actually occurs in the course of a titration, chemists believe the process occurs as a series of single-proton transfer reactions

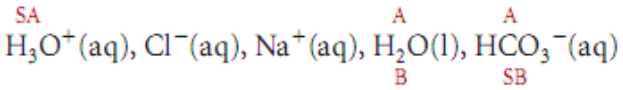
Example: Addition of $HCl_{(aq)}$ to $Na_2CO_{3(aq)}$

The first reaction that occurs is



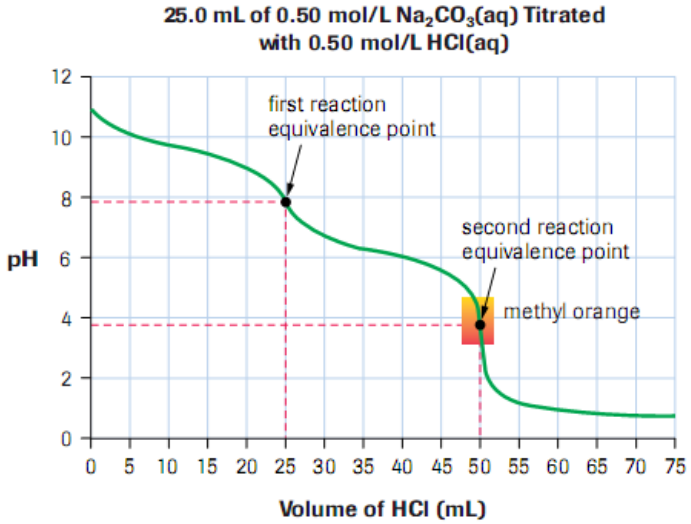
$$H_3O^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + HCO_3^-(aq)$$

After all the $CO_3^{2-}{}_{(aq)}$ is used up, then $HCO_3^-{}_{(aq)}$ is the strongest base and it reacts with the $HCl_{(aq)}$ that is still being added



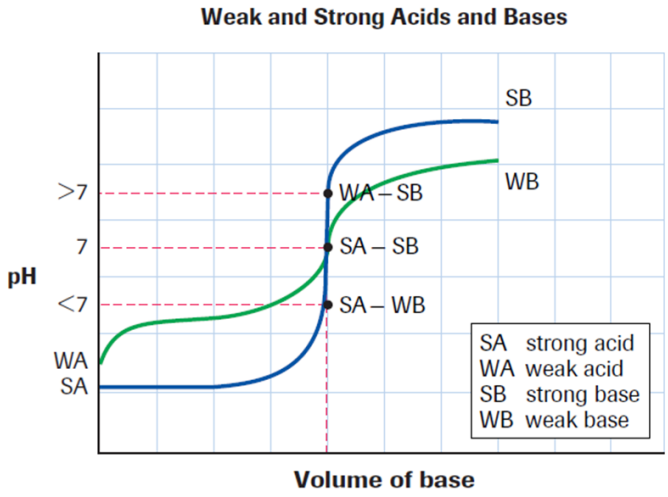
$$H_3O^+(aq) + HCO_3^-(aq) \rightarrow H_2O(l) + H_2CO_3(aq)$$

- There are two quantitative reactions in this titration, so we get two endpoints on our pH curve

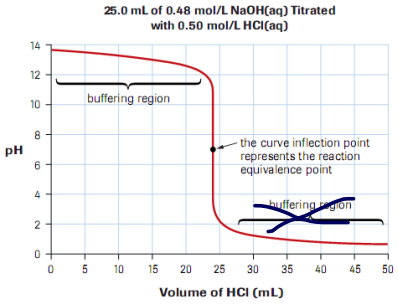


pH Curve Shape versus Acid and Base Strength

- Based on the strength of the acid and base reacting, we will see differences in our pH curves



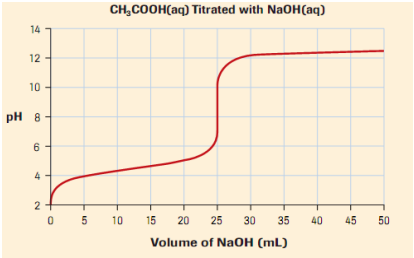
Strong monoprotic acid titrated with a strong base



- buffer regions are flat
- the endpoint is always at a pH of 7.
- at the equivelance point, there is only $H_2O_{(l)}$

$$OH^-_{(aq)} + H_3O^+_{(aq)} \rightarrow 2H_2O_{(l)}$$

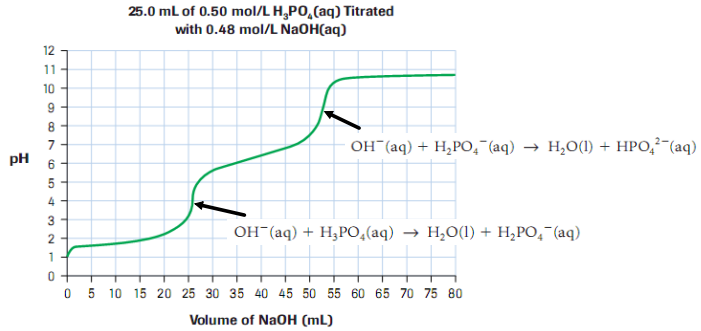
Weak monoprotic acid titrated with a strong base



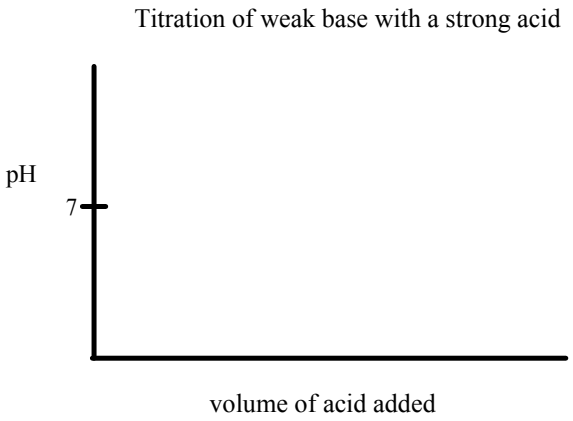
- sharp change in pH at first
- pH at endpoint above 7

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

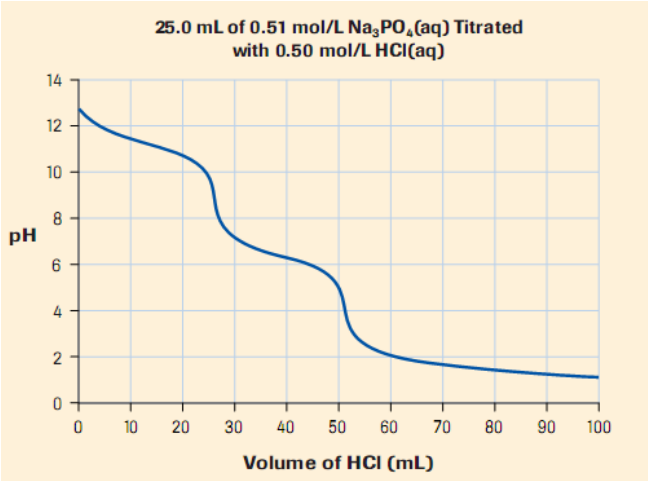
Weak polyprotic acid titrated with a strong base



Weak monoprotic base titrated with a strong acid



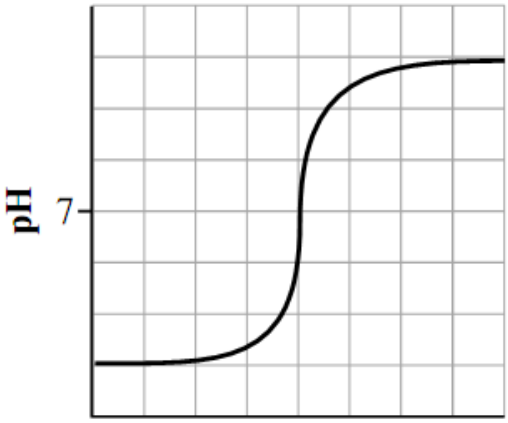
Weak polyprotic base titrated with a strong acid



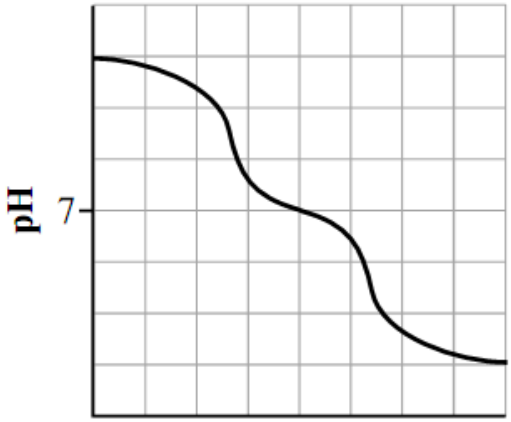
SUMMARY ***Titration Generalizations***

- Strong acid–strong base reactions are quantitative (100%) and have an equivalence point pH = 7.
- Strong acid–weak base quantitative reaction equivalence points have a pH <7.
- Weak acid–strong base quantitative reaction equivalence points have a pH >7.
- Polyprotic entity samples produce sequential reactions in titrations, each of which may or may not be quantitative.

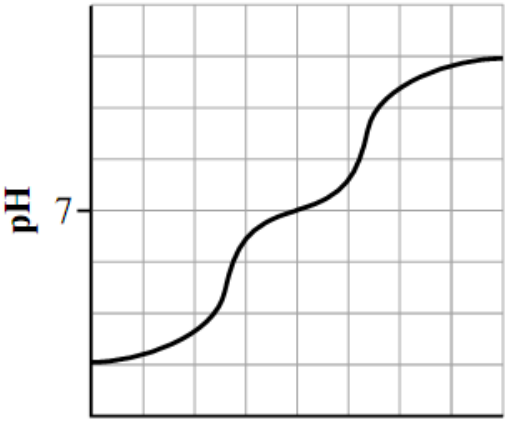
_____ _____ titrated with _____ _____



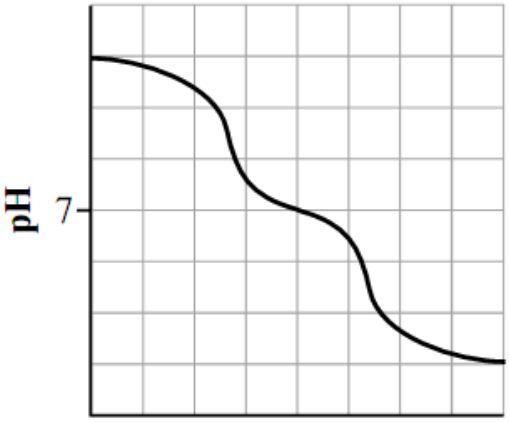
_____ _____ titrated with _____ _____



_____ _____ titrated with _____ _____

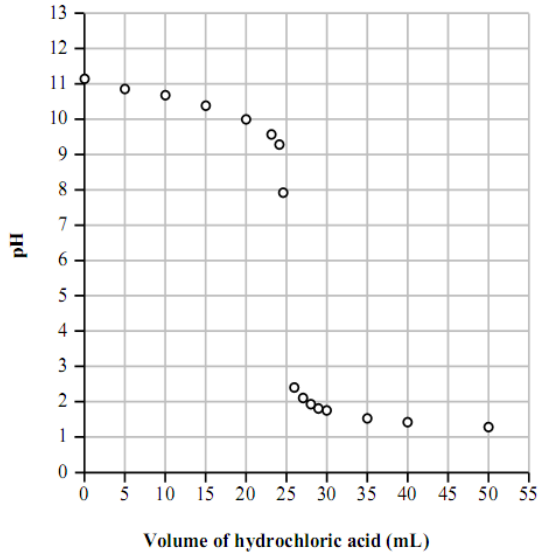


_____ _____ titrated with _____ _____



Use the following information to answer the next question.

Titration Plot for 25.0 mL of 0.100 mol/L $NH_{3(aq)}$ with 0.100 mol/L $HCl_{(aq)}$

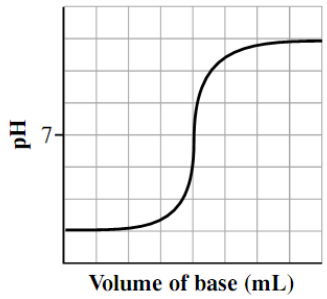


The most suitable indicator for the titration is

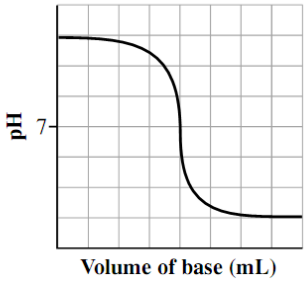
A. phenolphthalein
B. methyl violet
C. chlorophenol red
D. methyl orange

Which of the following diagrams represents the titration of a polyprotic acid with a strong base?

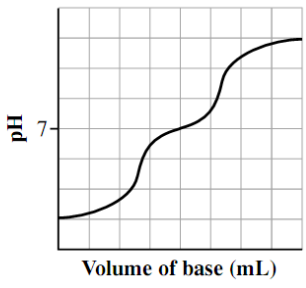
A.



B.



C.



D.