

# POLYPROTIC ACID-BASE TITRATIONS

CHEM 25 | SDSU

# POLYPROTIC ACIDS/BASES

- As the polyprotic acids and bases are all weak acids or bases, they can be treated similarly when it comes to pH titrations.
- The key variation is the increase in equivalence points and how the pH is determined at those points.

# SAMPLE PROBLEM

Plot the titration curve for the titration of 12.0 mL of 22.0 mM potassium carbonate with 30.0 mM  $\text{HNO}_3$ .

Determine the pH after the following volumes of titrant have been added:

- A) 2.00 mL of titrant**
- B) 5.00 mL of titrant**
- C) 8.80 mL of titrant
- D) 10.00 mL of titrant
- E) 13.00 mL of titrant
- F) 17.60 mL of titrant

# PH BEFORE THE $V_{EQ}$

- Before any titrant is added the pH is determined by the  $K_a$ .
- Before the equivalence point the analyte will be in excess (dominant species).
- As titrant is added the concentration of the conjugate to the analyte is increased.
- This results in a buffer being formed - Henderson-Hasselbach equation.

# SAMPLE PROBLEM

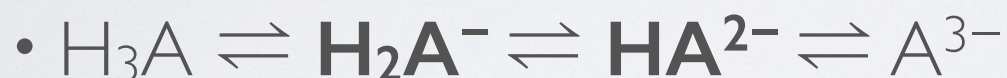
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# PH AT INTERMEDIATE EQUIVALENCE POINTS

- At the **intermediate equivalence points** the moles all of the weak polyprotic acid has been converted into a single form, between two equilibria.



- We must incorporate the two  $K_a$  values into the calculation of the pH.

$$[H^+] = \sqrt{\frac{K_{a_1}K_{a_2}F + K_{a_1}K_w}{K_{a_1} + F}}$$

For  $H_2A^-$

$$[H^+] = \sqrt{\frac{K_{a_2}K_{a_3}F + K_{a_2}K_w}{K_{a_2} + F}}$$

For  $HA^{2-}$

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# PH BETWEEN EQUIVALENCE POINTS

- At this stage the polyprotic acid (or base) begins to act as a buffer once again.
- The Henderson-Hasselbach trick of using volumes can apply, but with a little twist.
- You must account for the volume of titrant that went into getting to the prior equivalence point(s).



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# PH AT THE FINAL EQUIVALENCE POINT

- At the final equivalence point the weak acid (base) has been fully (de)protonated.
- It can be treated as a simple monoprotic weak acid (base) by using  $K_{a1}$  ( $K_{b1}$ ).
- You must remember to account for the dilution of the acid (find the new formal concentration).

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