

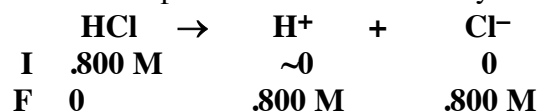
During Class Invention  
 Titration Between a Strong Acid and A Strong Base

Name \_\_\_\_\_

1. Qualitatively, describe how the pH of a solution of a strong acid changes when a solution of strong base is added to it.

**The pH of a solution of a strong acid will increase when a solution containing a strong base is added to it.**

- a. A titration is performed by adding 0.600 M KOH to 40.0 mL of 0.800 M HCl.
- i) Calculate the pH before addition of any KOH.



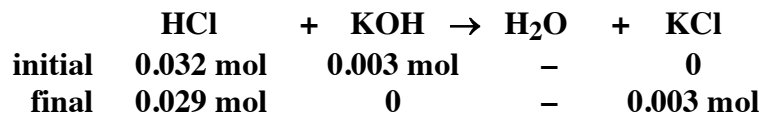
**HCl is a strong acid and completely dissociates in water. Therefore, [H<sup>+</sup>] = 0.800 M and pH = 0.097**

- ii) Calculate the pH after the addition of 5.0 mL of the base.

**Add 5.0 mL of 0.600 M KOH.**

$$5.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.600 \text{ mol}}{1 \text{ L}} \right) = 0.0030 \text{ mol KOH}$$

$$40.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.800 \text{ mol}}{1 \text{ L}} \right) = 0.032 \text{ mol HCl}$$



$$[\text{HCl}] = \frac{0.029 \text{ mol}}{0.045 \text{ L}} = 0.644 \text{ M}$$

$$\text{pH} = 0.191$$

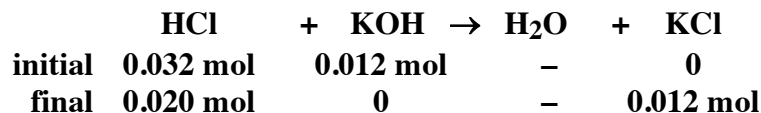
ii) (Continued)

Calculate the pH after the addition of 20.0 mL of the base.

**Add 20.0 mL of 0.600 M KOH**

$$20.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.600 \text{ mol}}{1 \text{ L}} \right) = 0.0120 \text{ mol KOH}$$

$$40.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.800 \text{ mol}}{1 \text{ L}} \right) = 0.0320 \text{ mol HCl}$$



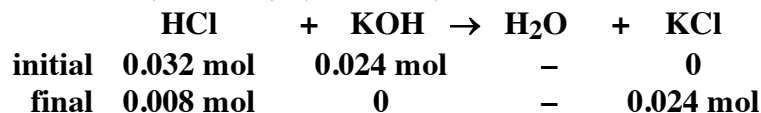
$$[\text{HCl}] = \frac{0.020 \text{ mol}}{0.060 \text{ L}} = 0.333 \text{ M}$$

$$\text{pH} = 0.478$$

Calculate the pH after the addition of 40.0 mL of the base.

**Add 40.0 mL of 0.600 M KOH**

$$40.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.600 \text{ mol}}{1 \text{ L}} \right) = 0.0240 \text{ mol KOH}$$



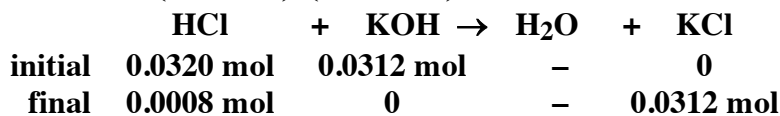
$$[\text{HCl}] = \frac{0.008 \text{ mol}}{0.080 \text{ L}} = 0.100 \text{ M}$$

$$\text{pH} = 1.00$$

Calculate the pH after the addition of 52.0 mL of the base.

**Add 52.0 mL of 0.600 M KOH**

$$52.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.600 \text{ mol}}{1 \text{ L}} \right) = 0.0312 \text{ mol KOH}$$



$$[\text{HCl}] = \frac{0.0008 \text{ mol}}{0.092 \text{ L}} = 8.7 \times 10^{-3} \text{ M}$$

$$\text{pH} = 2.06$$

Calculate the pH after the addition of 53.0 mL of the base.

**Add 53.0 mL of 0.600 M KOH**

$$53.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.600 \text{ mol}}{1 \text{ L}} \right) = 0.0318 \text{ mol KOH}$$

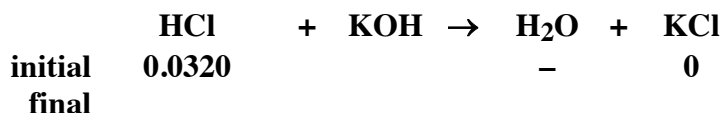


$$[\text{HCl}] = \frac{0.0002 \text{ mol}}{0.093 \text{ L}} = 2.2 \times 10^{-3} \text{ M}$$

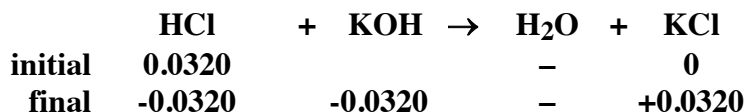
$$\text{pH} = 2.67$$

iii) Calculate the volume of base needed to reach the equivalence point.

$$40.0 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.800 \text{ mol}}{1 \text{ L}} \right) = 0.032 \text{ mol HCl}$$



At the equivalence point the moles of the acid reacted equals the moles of base reacted.

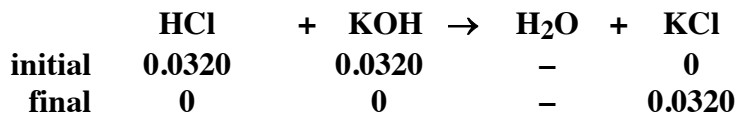


$$0.032 \text{ mol HCl} \left( \frac{1 \text{ mol KOH}}{1 \text{ mol HCl}} \right) = 0.032 \text{ mol KOH}$$

$$0.032 \text{ mol KOH} \left( \frac{1 \text{ L}}{0.600 \text{ mol}} \right) = 0.0533 \text{ L (53.3 mL)}$$

iv) What is the pH at the equivalence point?

Add 53.3 mL of 0.600 M KOH

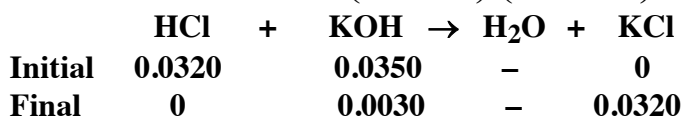


KCl is the salt of a strong acid and strong base, so the pH = 7.00 at the equivalence point.

v) Calculate the pH after adding 5.00 mL of NaOH past the equivalence point.

Add 58.3 mL of 0.600 M KOH

$$58.3 \text{ mL} \left( \frac{1 \text{ L}}{1000 \text{ mL}} \right) \left( \frac{0.600 \text{ mol}}{1 \text{ L}} \right) = 0.0350 \text{ mol KOH}$$



$$[\text{KOH}] = \frac{0.0030 \text{ mol}}{0.0983 \text{ L}} = 3.05 \times 10^{-2} \text{ M}$$

$$\text{pOH} = 1.52 \quad \text{pH} = 12.48$$

2. Using the designated space below sketch the titration curve for each of the following cases.

a) 50.0 mL of 0.100 M HCl and 0.100 M NaOH

b) 50.0 mL of 0.00100 M HCl and 0.00100 M NaOH

