

# Nernst Equation

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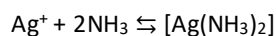
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## Purpose:

- Determine equilibrium constant for two equilibrium reactions  $\text{Ag}^+ + 2\text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]$  and  $\text{Ag}^+ + 2\text{S}_2\text{O}_3^{2-} \rightleftharpoons [\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$
- Evaluate accuracy of determine constants with percent error
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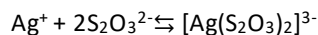
**Reference:** Kateley, L. J., *Introduction to Chemistry in the Laboratory*, 20<sup>th</sup> Ed., Lake Forest College, **2021**, Experiment xx, Appendix xx.

## Equilibrium One



- $K_f = [\text{Ag}(\text{NH}_3)_2] / [\text{Ag}^+][\text{NH}_3]^2 =$
- Assume:
  - o The reaction shifts almost completely to the right and has a large  $K_f$
  - o The reaction reaches equilibrium quickly
  - o The limiting reagent is  $\text{Ag}^+$  and there is a large excess of  $\text{NH}_3$  ligand

## Equilibrium Two



- $K_f = [\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-} / [\text{Ag}^+][\text{S}_2\text{O}_3]^{2-}$
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## Standardization of pH Meter as voltmeter

- Probe calibrated using a 1.61  $\pm$  0.05V
- Battery registered as 1.56 V which is within the range noted on the battery

## Set Up and Validation of a Voltic Cell

- Glassware cleaned to prevent source of error
  - Seven strips of filter paper soaked in 1M  $\text{KNO}_3$  to form salt bridge
  - Black and red clamps each attached to silver wire
- a)
- 10mL of 10.0mM  $\text{Ag}^+$  placed in 20mL beaker for cathode
  - 5mL of 10.0mM  $\text{Ag}^+$  placed in 30mL beaker for anode
  - Wire attached to black clamp placed in anode and wire attached to red clamp placed in cathode
  - Meter read 0.002V
- b)
- Silver wires washed with deionized water
  - Anode replaced with a solution of 1.00mL 10.0mM  $\text{Ag}^+$  and 4.00mL of deionized water
  - Salt bridge replaced with fresh 1M  $\text{KNO}_3$  soaked strip of filter paper
  - Meter read 0.036V
- c)
- Silver wires washed with deionized water
  - Anode replaced with a solution of 0.500mL of 10.0mM  $\text{Ag}^+$  and 4.500mL of deionized water
  - Salt bridge replaced with fresh 1.0M  $\text{KNO}_3$  soaked strip of filter paper
  - Meter reads 0.050V

**TABLE 1: VALIDATION OF THE NERNST EQUATION**

Cathode (red) vol 10.0 mM Ag <sup>+</sup>	Anode (black) vol 10.0 mM Ag <sup>+</sup>	Anode (black) H <sub>2</sub> O	mM conc Ag <sup>+</sup> anode	mM conc Ag <sup>+</sup> cathode	Conc ratio: [Ag <sup>+</sup> <sub>dil</sub> ] ÷ [Ag <sup>+</sup> <sub>conc</sub> ]	Theoretic al voltage (E <sub>cell</sub> )	Observed voltage (E <sub>cell</sub> )
10 mL	5 mL	0	10.0	10.0	1.00		
10 mL	1000 µL	4000 µL	2.00	10.0	0.200		
10 mL	500 µL	4500 µL	1.00	10.0	0.100		

### Determine Formation Constants Using Nernst Equation

- Cathode of 10mL of 10.0mM Ag<sup>+</sup> solution

**TABLE 2. ANODE CELL VOLUMES AND MILLIMOLES**

ligand	volume 10.0 mM Ag <sup>+</sup>	volume 100 mM ligand	total volume (mL)	mmol Ag <sup>+</sup> initially	mmol ligand initially	mmol complex at equilibrium	mmol ligand at equilibrium
NH <sub>3</sub>	5000 µL	5000 µL	10.00	0.0500	0.500	0.0500	0.400
NH <sub>3</sub>	7500 µL	2500 µL	10.00	0.0750	0.250	0.0750	0.100
S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	5000 µL	5000 µL	10.00	0.0500	0.500	0.050	0.400
S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	7500 µL	2500 µL	10.00	0.0750	0.250	0.0750	0.100

**TABLE 3: DETERMINATION OF FORMATION CONSTANTS USING THE NERNST EQUATION**

ligand	M <sub>complex</sub>	M <sub>ligand</sub>	M <sub>Ag+dilute</sub>	E <sub>cell</sub> volts	K <sub>f</sub>
NH <sub>3</sub>	0.00500	0.0400		0.099	
NH <sub>3</sub>	0.00750	0.0100		0.220	
S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	0.0050	0.040		0.606	
S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	0.00500	0.0100		0.654	

### Conclusion:

- Silver ion is very low and hard to measure in moles per liter
- True values:  $1.7 \times 10^7$  and  $2.9 \times 10^{13}$
- Possible source of error from touching the filter paper
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