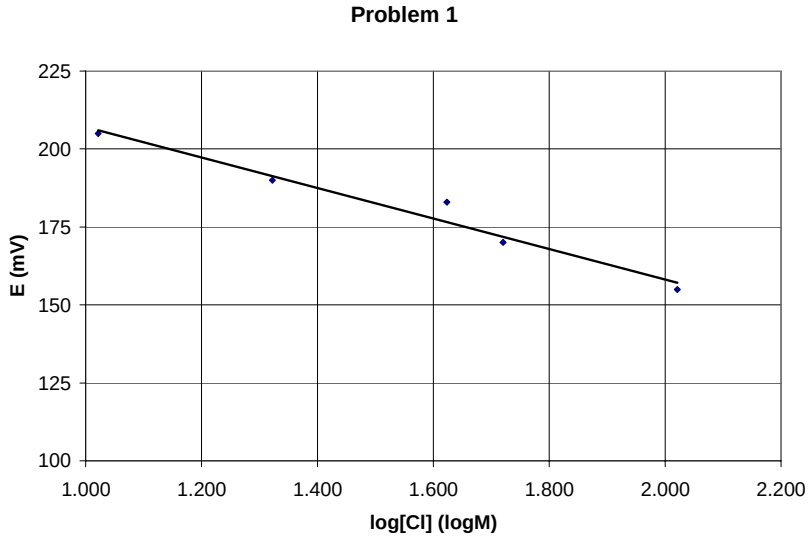
Potentiometry Additional Problems

1. Graph the following potentiometric data. What is the equation of the line with error? Stock solution used is 210.0 ppm $Cl^-$. Total volume of each calibration standard is 100.0 mL.

| volume stock soln (mL) | Potential (mV) | *conc (ppm)* | *log conc* |
|---|---|---|---|
| 5.00 | 205 | *=(5.00)(210)/(100) =10.5* | *1.021* |
| 10.00 | 190 | *21.00* | *1.3222* |
| 20.00 | 183 | *42.00* | *1.6232* |
| 25.00 | 170 | *52.50* | *1.7202* |
| 50.00 | 155 | *105.0* | *2.0212* |

*Graph log concentration versus potential for a linear graph.*




*The equation of the line is*

$$E = -(48.9 \pm 5.4)\log[Cl] + (256 \pm 8)$$

*slope has 3 sf since it came from Δy/Δx and y only had 3 sf.*

2. Using the data above, what is the concentration of chloride ion in a solution with a potential of 174 mV? with error?

*174 = -48.9log[Cl] + 256*
*-82 = -48.9log[Cl]*
*1.7= log[Cl]*
*47.5 ppm = [Cl] = 50 with strict sf, but there are arguments for 2 or 3 as well. See the end of this problem.*

$$\frac{e_x}{47.5} = \sqrt{\left(\frac{5.4}{48.9}\right)^2 + \left(\frac{8}{82}\right)^2} = \sqrt{0.012194 + 0.009518} = 0.021712$$

*$e_x$ = (47.5)(0.021712) = 1.0*
*Answer = 47±1 ppm (sf based on error)*

*one sf...when you subtract, you go down to two. When you reverse a log, the decimal places become the sf, so that argues for one sf in the final answer.*

*two sf....based on the error calculation, the uncertain digit is the second.*

*three sf...all the numbers, both in the graph and the data used have 3 sf.*

*I will accept any of these three answers. I kind of lean toward the middle one as the best in this situation.*

3. A solution was made by dissolving 1.547 g sample in 100.0 mL. A 10.00 mL aliquot of this solution was diluted to 100.0 mL. The potential of the diluted sample was 185 mV. What is the %Cl in the sample? with error?

*185 = -48.9log[Cl] + 256*
*-71 = -48.9log[Cl]*
*1.452 = log[Cl]*
*28.3 ppm = [Cl] in the diluted solution*

*MV = MV*
*(28.3 ppm)(100.0 mL) = M(10.00 mL)*
*283 ppm = M = concentration in original solution*

*283 mg/L (0.1000 L) = 28.3 mg Cl in original sample*

*%Cl = 28.3 mg Cl/1547 mg sample x 100 = 1.83%*

*Error: Assuming the largest errors are accounted for in the equation of the line*

$$\frac{e_x}{1.83} = \sqrt{\left(\frac{5.4}{48.9}\right)^2 + \left(\frac{8}{71}\right)^2} = \sqrt{0.012194 + 0.012696} = 0.02488$$

*$e_x$ = (1.83)(0.02488) = 0.04*

*Final answer = 1.83±0.04%*

4. A series of nitrate standards were measured with potentiometry and graphed appropriately. Using molarity as the concentration unit, the equation of the line was

E = (69.9±0.8)$pNO_3$ + 299±8

If a 1.581 g sample dissolved to make 250.0 mL of solution had a potential of 385 mV, what is the concentration of nitrate in the sample? With error?

*385 = 69.9$pNO_3$ + 299*
*86 = 69.9 $pNO_3$*
*1.2303 = $pNO_3$ = -log[$NO_3^-$]*
*0.0588 M = [$NO_3^-$]*

*0.0588 mol $NO_3^-$/L (0.250 L) = 0.0147 mol x (62.01 g/1 mol) = 0.9115 g*

*%nitrate = 0.9115/1.581 x 100 = 57.7%*

$$\frac{e_x}{x} = \sqrt{\left(\frac{e_m}{m}\right)^2 + \left(\frac{e_b}{y-b}\right)^2} = \sqrt{\left(\frac{0.8}{69.9}\right)^2 + \left(\frac{8}{86}\right)^2} = \sqrt{0.00013098 + 0.0086533} = \sqrt{0.00878} = 0.09372$$

*$e_x$ = (57.7)(0.09372) = 5.4*

*final answer = 57.7±5.4% nitrate*

5. A series of copper(II) standards were measured potentiometrically and the results, using ppb as the concentration unit, were appropriately graphed to make the following line

E = (48.5±1.5)logCu + 859±39

What is the concentration of copper(II) ion in a solution with a potential of 945 mV? With error?

*945 = 48.5logCu + 859*
*86 = 48.5logCu*
*1.77 = logCu*
*59.3 ppb = [Cu]*

$$\frac{e_x}{x} = \sqrt{\left(\frac{e_m}{m}\right)^2 + \left(\frac{e_b}{y-b}\right)^2} = \sqrt{\left(\frac{1.5}{48.5}\right)^2 + \left(\frac{39}{86}\right)^2} = \sqrt{9.565x10^{-4} + 0.2056} = 0.4545$$

*$e_x$ = (0.4545)(59.3) = 26.9*

*final answer = 59.3±26.9 ppb*