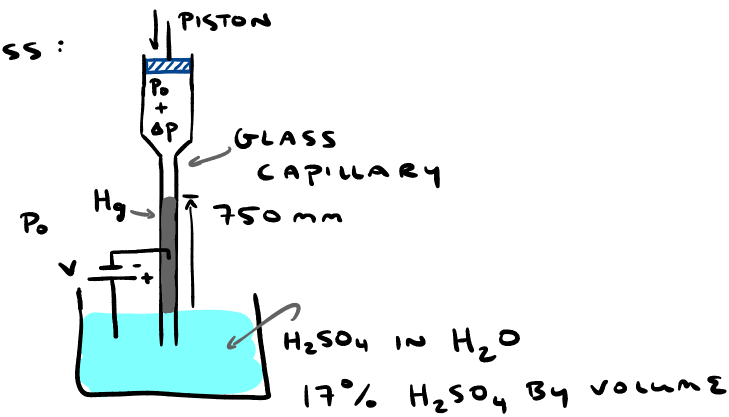
EXERCISES WEEK 5:

1: LIPPMANN'S Δp VS. e CURVE.

- HERE IS A SIMPLIFIED VIEW OF THE SECOND APPARATUS DESCRIBED IN LIPPMANN'S ARTICLE DISCUSSED IN CLASS:



@ $V = 0$, IT IS FOUND THAT NO EXTRA PRESSURE Δp IS REQUIRED TO KEEP THE MENISCUS @ THE SAME LEVEL AS THE AIR-WATER INTERFACE.

a) WHAT IS THE PRESSURE DIFFERENCE @ THE Hg/H_2O MENISCUS?

b) DRAW A PICTURE SHOWING THE SHAPE OF THE MENISCUS. ASSUME THE ACIDIC SOLUTION "PERFECTLY WETS" THE CAPILLARY SO THAT THE RADIUS OF CURVATURE OF THE MENISCUS HAS THE SAME MAGNITUDE AS THE RADIUS OF THE CAPILLARY.

c) GIVEN THAT THE Hg/H_2O SURFACE TENSION IS $415 \frac{mN}{METER}$, ESTIMATE THE RADIUS OF THE CAPILLARY. IGNORE THE EFFECT OF THE DISSOLVED ACID ON THE VALUE OF γ.

- WHEN LIPPMANN BEGINS APPLYING VOLTAGE $V = V_{H_2O} - V_{Hg} > 0$ BETWEEN THE ACID SOLUTION AND THE Hg COLUMN, HE FINDS THAT AN ADDITIONAL PRESSURE

Δp > 0 IS NECESSARY TO RESTORE THE MENISCUS TO THE LEVEL OF THE AIR / WATER INTERFACE.

HERE IS HIS TABLE OF Δp VS. V :

V IN UNITS OF "DANIELL" 1 DANIELL = 1.1 VOLTS

e.	Δp.	e.	Δp.
	mm		mm
0,016	15	0,588	314
0,024	21,5	0,833	356,5
0,040	40	0,900	358,5
0,109	89	0,909	358,5
0,140	111	1,000	353
0,170	131	1,261	301
0,197	148	1,333	279
0,269	188,5	1,444	239
0,364	235	1,713	128
0,450	270,5	1,833	110
0,500	288	1,888	104
		2,000	94

Δp IN UNITS OF mmHg, WHERE 1 mmHg = "HYDROSTATIC PRESSURE OF A COLUMN OF MERCURY 1 mm IN HEIGHT."

d) ESTIMATE THE SURFACE TENSION @ V = 0.140 DANIELL.

e) ESTIMATE THE SIGN AND MAGNITUDE OF THE SURFACE CHARGE DENSITY ON THE MERCURY SIDE OF THE ELECTRIC DOUBLE LAYER @ V = 0.140 DANIELL

f) ESTIMATE THE VOLTAGE V_{pzc} WHERE THE SURFACE CHARGE GOES TO ZERO.

g) ESTIMATE THE CAPACITANCE C_A OF THE DOUBLE LAYER NEAR V_{pzc} FROM THE Δp VS. V DATA.

h) ESTIMATE THE EXPECTED CAPACITANCE C_A BASED ON GOUY-CHAPMAN THEORY OF THE DIFFUSE LAYER. ASSUME ALL THE H_2SO_4 IS SINGLY-DISSOCIATED, I.E.

$H_2SO_4 \rightarrow H^+ + HSO_4^-$ [NOT A BAD ASSUMPTION SINCE $K_a = 10^2$ MOLAR]

- DENSITY OF $H_2SO_{4(\ell)}$: $1.83 \frac{g}{cm^3}$
- MOLAR MASS OF H_2SO_4: $98 g/mol$
- PERMITTIVITY OF H_2O: $\varepsilon_r \simeq 80$

COMPARE W/ PART g)

i) ESTIMATE PEAK CONCENTRATION DIFFERENCE ΔC_o @ $V = 0.140$ DANIELL. DO WE SATISFY THE REQUIREMENT $|\Delta C_o| \ll C_o$ THAT JUSTIFIES APPLICATION OF THE "LINEARIZED" POISSON - BOLTZMANN EQUATION INTRODUCED IN LECTURE?