

American University of Beirut
Chem.206 - Final Exam

H.Ubayd

Time: 75min.

Jan., 11, 2001

Lab Final

Name: (family first) _____

Student Number: _____

Section: _____

Grades

I : _____ / 24

II : _____ / 18

III : _____ / 20

IV : _____ / 18

V : _____ / 20

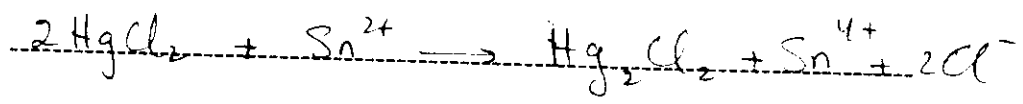
Sum : _____ out of 100

24

I. (24%) Complete the following statements with the appropriate words, equations or calculations.

- (2) a- Boiled water is used in acid-base titration in order to expel CO₂ from solution.
- (2) b- A device in which a small electric current causes a mechanical system to return to its null position is called a servo system.
- (2) c- The kind of error that results from measurements using an uncalibrated apparatus is systematic or determinate error (poor accuracy).
- (2) d- A reliable analytical method for the determination of the concentration of a metallic cation like Zn²⁺ or Ca²⁺ in solution is: complexometric titration with EDTA using a suitable indicator.

(4) e- In the redox titration of Fe²⁺ against K₂Cr₂O₇ solution, the reagent used just before titration to avoid the presence of traces of Sn²⁺ is HgCl₂. This reagent oxidizes Sn²⁺ according to the following reaction:



(4) f- The percent transmittance of a 2.40x10⁻³ M solution of molar absorptivity 2.00x10² M⁻¹cm⁻¹ in a cell of a 2.00-cm pathlength is: (Show method)

$$A = \epsilon c l = 9.60 \times 10^{-1}$$

$$T = 10^{-A} = 10^{-0.960} = 0.110$$

$$\% T = 11.0 \%$$

(4) g- In the above exercise, if the molar absorptivity of the solution is doubled, the transmittance will not be doubled (only A is doubled) because absorbance and transmittance vary in such a way that A is directly proportional to ϵ (and $c \times l$) but T is not linearly related to A, it is an exponential function of A.

(4) h- In order to insure that the ligand EDTA is completely dissociated, we should use a basic buffer (pH: 9-10).

The number of donor atoms in this case is six (4 oxygens x 2 nitrogen).

- II. (18%) a. A sodium hydroxide solution was 0.1019M immediately after standardization. Exactly 500.0ml of the reagent were left exposed to air for several days and absorbed 0.652g of CO_2 ($\text{CO}_2 = 44.01 \text{ g/mole}$) Calculate the relative error in determining the concentration of an acetic acid solution (if it is the same as the relative error in the molarity of NaOH).

6. millimoles of NaOH left = $n_i - n_{\text{reacted}}$

$$= (500.0)(0.1019) - \frac{0.652}{0.04401}$$

$$= 36.135 \text{ millimoles}$$

$$[\text{NaOH}] = \frac{n}{V} = \frac{36.135}{500.0} = 0.07227 \text{ M}$$

$$\text{Relative Error in } M = \frac{0.07227 - 0.1019}{0.1019} \times 100$$

$$= 29\%$$

- b. Analysis of Cadmium, Cd, in water gave a value of 1.20 ppb (w/v). What mass of Cd is contained in 2.00L of water? ($1\text{b} = 10^9$)

6.
$$\text{ppb } \frac{w}{V} = \frac{m(\text{g})}{V(\text{ml})} \times 10^9$$

$$m = (1.20)(2.00 \times 10^3) \times 10^{-9}$$

$$= 2.40 \times 10^{-6} \text{ g} = 2.40 \text{ } \mu\text{g}$$

- c. Calculate the electrode potential of a platinum electrode immersed in a solution buffered to a pH of 5.5 and saturated with $\text{H}_2(\text{g})$ at 1.00atm.

6.
$$\text{pH} = 5.5 \Rightarrow [\text{H}^+] = 10^{-5.5} = 3.16 \times 10^{-6} \text{ M}$$

$$E_{\text{Pt}} = E^\circ - \frac{0.0592}{2} \log \frac{P_{\text{H}_2}}{[\text{H}^+]^2}$$

$$= -0.326 \text{ V}$$

- IV. (15%) In order to measure the concentration of nitrite, NO_2^- , in an aquarium, a spectrophotometric analysis of a red-purple nitrite product is carried out, and the following tabulated results are obtained:

Aquarium nitrite analysis

Sample	Absorbance (blank subtracted)
Blank	0.000
Standards	
0.4575 ppm	0.082
0.9150 ppm	0.164
1.830 ppm	0.325
Unknown	0.278
Unknown	0.274

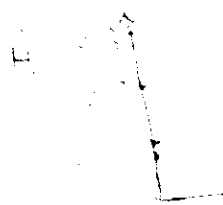
a- Plot the calibration curve on the graph paper provided and deduce the average concentration in ppm of the unknown if the dilution factor is 100.0 ml to 5.00 ml sample.

b- Calculate the molarity of nitrite in the aquarium. (N= 14.007)

Handwritten note: 20000 ppm

Handwritten note: 10000 ppm

Handwritten calculation: 31.00×10^{-6}

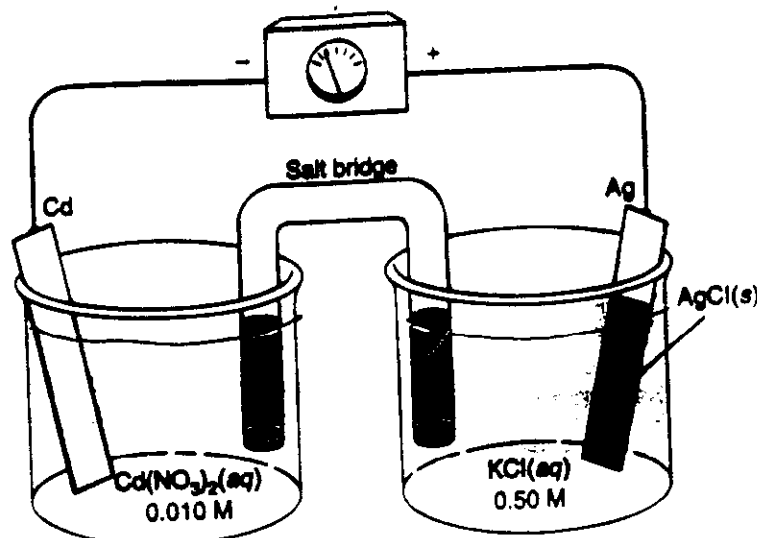


$$M = \frac{m}{V} \times 10^3$$

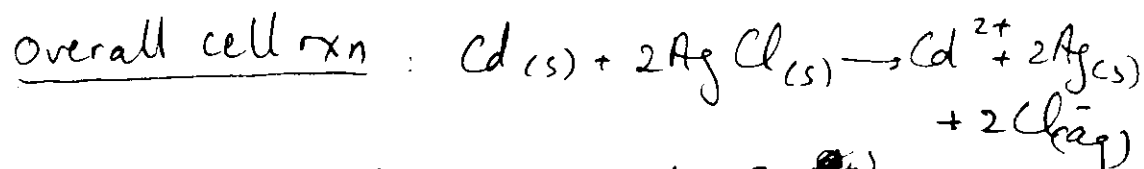
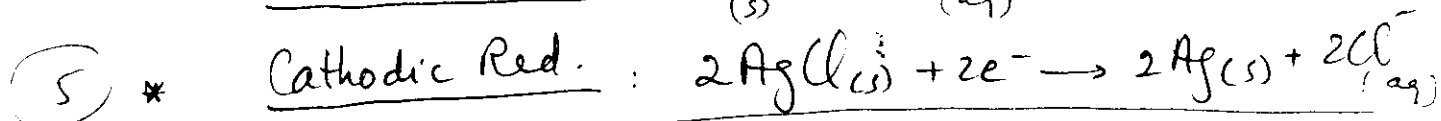
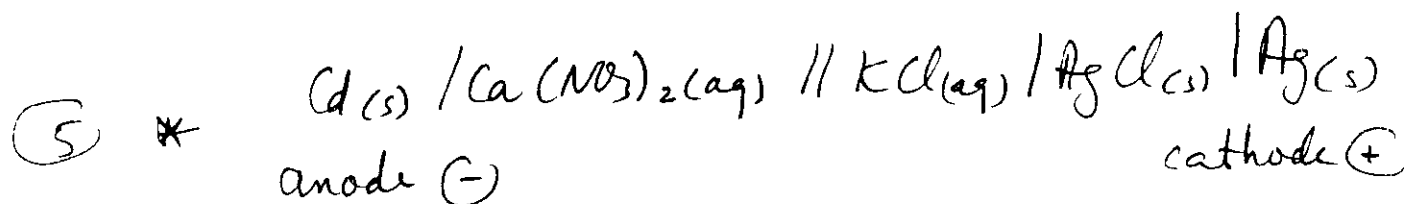
$$m_{\text{NO}_2} = \frac{31.00 \times 10^{-6}}{10^{-3}} = 31.00 \times 10^{-3} \text{ g/L}$$

$$M = \frac{n}{V} = \frac{31.00 \times 10^{-3}}{14.007} = 2.213 \times 10^{-3} \text{ M}$$

III. (20%) I



- a- Write the short hand representation for the cell given in Fig. 1. Give its anode half-reaction, cathode half-reaction and the overall cell reaction. Given that: $E^\circ(\text{Cd}^{2+}/\text{Cd}) = -0.402\text{V}$, $E^\circ(\text{AgCl}/\text{Ag}) = +0.222\text{V}$
 b- Calculate emf of the above cell under the given conditions.



(10) *
$$E_{\text{Cd}^{2+}/\text{Cd}} = E^\circ_{\text{Cd}^{2+}} - \frac{0.0592}{2} \log \frac{[\text{Cd}^{2+}]}{[\text{Cd}]} = E^\circ_{\text{Cd}^{2+}} - \frac{0.0592}{2} \log(0.010) = -0.402 - 0.0592 = -0.461\text{V}$$

$$E_{\text{AgCl}/\text{Ag}} = E^\circ_{\text{AgCl}} - \frac{0.0592}{1} \log[\text{Cl}^-]_{0.50} = +0.222 + 0.0178 = 0.240\text{V}$$

$$E_{\text{cell}} = E_{\text{cathode}} - E_{\text{anode}}$$

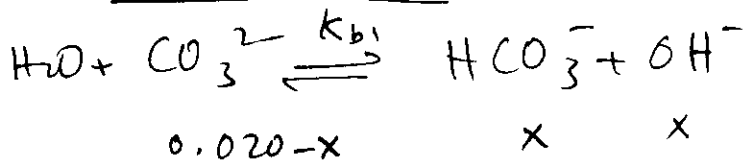
$$= 0.240 + 0.461 = 0.701\text{V}$$

- V. (20%) Refer to Fig. 2, the titration curve of 50.00 ml of 0.0200 M sodium carbonate, Na_2CO_3 against 0.100 M hydrochloric acid to answer the following question.
 (Na_2CO_3 : $\text{p}K_{a1} = 6.352$ $\text{p}K_{a2} = 10.329$)

Use the graph and the equilibrium constants to calculate the exact values of pH at points A, B, C, D and E. The approximate values are shown in the figure.

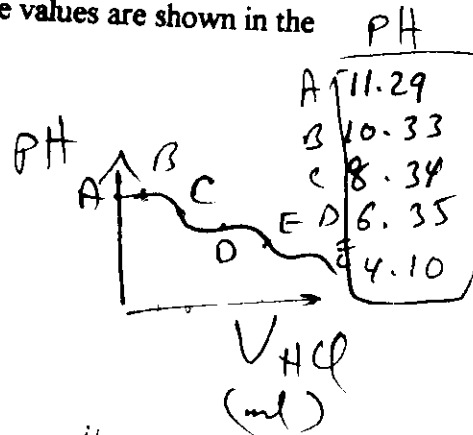
* At pt A:

Pure Na_2CO_3 :



$$K_b = \frac{K_w}{K_{a2}} = \frac{x^2}{0.020 - x} = 2.13 \times 10^{-4}$$

$$\Rightarrow x = 1.96 \times 10^{-3} \text{ M} = [\text{OH}^-] \Rightarrow \text{pH} = \boxed{11.29}$$



* At pt B: Half equivalence: $\frac{10.90}{2} = 5.00 \text{ ml}$

$$\text{pH} = \text{p}K_{a2} + \log \left[\frac{[\text{CO}_3^{2-}]}{[\text{HCO}_3^-]} \right] = \boxed{10.33} \text{ (Buffer)}$$

* At pt C: 1st equivalence pt:

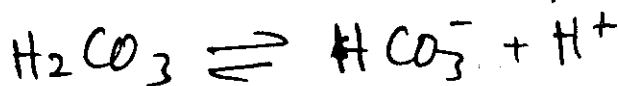
$$\text{pH} = \frac{1}{2}(\text{p}K_{a1} + \text{p}K_{a2}) = \frac{1}{2}(6.352 + 10.329) = \boxed{8.34}$$

* At pt D: Half equivalence: (Buffer)

$$\text{pH} = \text{p}K_{a1} + \log \left[\frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} \right] = \text{p}K_{a1} = \boxed{6.35}$$

* At pt E: Dilution factor 50.00 \rightarrow 70.00 ml
 all $\text{CO}_3^{2-} \rightarrow \text{H}_2\text{CO}_3$

$$[\text{H}_2\text{CO}_3] = \frac{n}{V_T} = \frac{50.00 \times 0.020}{70.00} = 0.0143$$



$$10^{-6.352} K_1 = \frac{x^2}{0.0143 - x} \Rightarrow x = 7.98 \times 10^{-5} \text{ M} = [\text{H}^+] \Rightarrow \text{pH} = \boxed{4.10}$$