November, 2019

New Trier Tryout

H_2SO_4: 2
Asher and Eric: 0

Chem Lab C

Written by: Asher Noel

Individual Grade: _____
Individual Name: _____

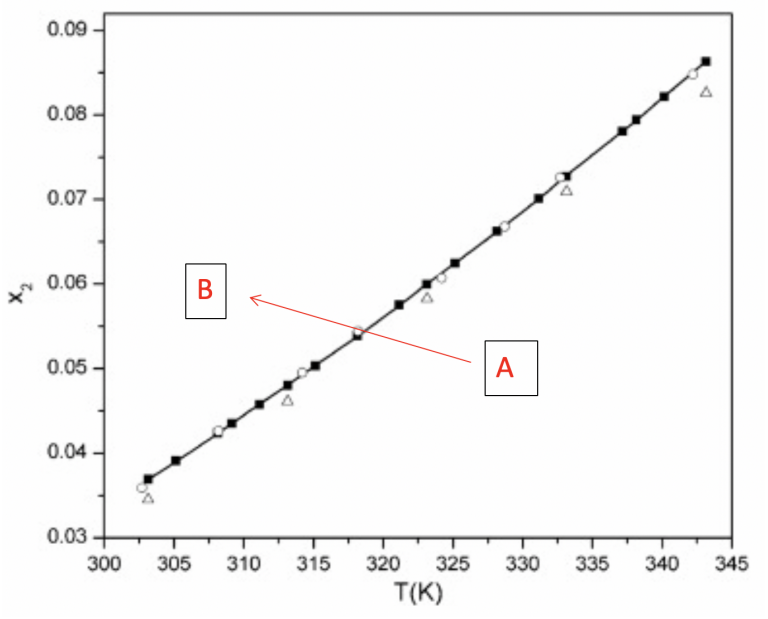
Score: _____/100
Rank: _____

Directions:
Each question is worth one point. Some questions are sourced from Atkin's *Physical Chemistry* and the Internet. Only the answer sheet will be scored.
Questions? Email me at ashernoel@college.harvard.edu!

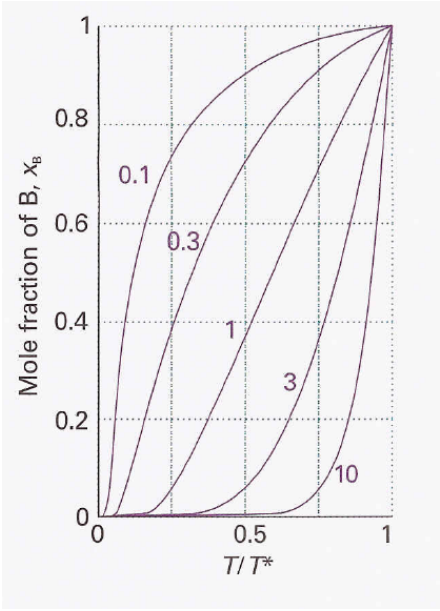
Good Luck!

Contents

Section 1: Solubility



(a) Solubility Curve



(b) Mole Fraction of an Ideal Solution

1. A clear solution transitions from A to B and remains clear as shown in Figure 1a. Describe its type of saturation.
2. (2 points) Give the equation of the molar solubility s (mol dm^{-3}) of $Th(IO_3)_4$ as a function of the solubility product K_{sp}.
3. (2 points) Broadly speaking, what is a colligative property? Why is solubility not one? colligative: depend only on the solute, not the identity. Solubility varies with identity.
4. (2 points) Explain why the solubility of gases decreases with increasing temperature.
5. (2 points) With reference to Figure 1b, what does T^* signify?
6. (2 points) The enthalpy of fusion of anthracene is 28.8 k] mol-1 and its melting point is 217C. Calculate its ideal solubility in benzene at 25C in grams.
7. (2 points) Use Henry's law and K/(kPa kg mol-1) = 3,010 for CO_2 in water to calculate the solubility (as a molality) of CO_2 in water at 25C when its partial pressure is (a) 0.10 atm and (b) 1.00 atm.

x_{HCL}	0.005	0.012	0.019
p_{HCL}/kPa	32.0	76.9	121.8

Table 1: Data for Questions 9 and 10

8. (2 points) At 300 K, the partial vapour pressures of HCI (that is, the partial pressure of the HCI vapour) in liquid $GeCl_4$ are as shown in Table 1. Calculate Henry's law constant at 300K.
9. (2 points) Use Table 1 to predict the partial vapor pressure of HCL above it's solution in liquid germanium tetrachloride of molality 0.10 mol kg-1.

Section 2: Basics

1. The addition of 100 g of a compound to 750 g of CCl_4 lowered the freezing point of the solvent by 10.5 K. Calculate the molar mass of the compound.
2. The osmotic pressure of an aqueous solution at 300 K is 120 kPa. Calculate the freezing point of the solution. -0.077C
3. At 20C, the density of a 20 per cent by mass ethanol-water solution is 968.7 kg m-3. Given that the partial molar volume of ethanol in the solution is 52.2 cm' mol'", calculate the partial molar volume of the water.
4. (2 points) What is the color of Be^{3+}? V^{3+}? Chromium solution reacted with excess ammonia?
5. What is an aqueous solution?
6. What is the absorbance of a solution that transmits 1% of radiation?
7. What is absorbance equal to in Beer-Lambert's law? Define your use of symbols.

   Use the following information to answer Questions 6-8: Metal aquo-complexes are coordination compounds that have the general stoichiometry $[Me(H_2O)_n]^{z+}$
8. What is the formula of the metal aquo-complex of aqueous nickel?
9. What is the ligand in the above equation?
10. What is the VSEPR molecular structure of the aquo-complex of aqueous nickel?

    Use the following information to answer Questions 9-12: A 5L aqueous solution EricLiu (or ericlepanda) is prepared with KNO_3 to have a molality of 0.0015 m.
11. Calculate the molarity of EricLiu.
12. Calculate the mass percentage of EricLiu.
13. Calculate the mass fraction of EricLiu.
14. Calculate the parts per billion of EricLiu.

Section 3: Fun Mixtures

1. (2 points) What proportions of hexane and heptane should be mixed (a) by mole fraction, (b) by mass in order to achieve the greatest entropy of mixing?
2. Calculate the ionic strength of a solution that is 0.10 mol kg-I in KCl(aq) and 0.20 mol kg-I in $CuSO_4$(aq).
3. What is a eutectic system?
4. (2 points) Is milk a colloid, suspension, or solution? Why?

   Write net equations for each of the reactions below. Use appropriate ionic and molecular formulas and omit formulas for all ions or molecules that do not take part in a reaction. You need not balance the equations.

5. (2 points) Phosphorous tribromide and water are mixed.
6. (2 points) Hydrogen sulfide gas is passed into a solution of nickel(II) perchlorate.
7. (2 points) Solutions of sodium sulfate and lead(II) nitrate are mixed.
8. (2 points) Lead(II) carbonate is added to hydrobromic acid.
9. (2 points) Freshly precipitated manganese(IV) oxide acts as a catalyst when added to a solution of hydrogen peroxide.
10. (2 points) Dilute solutions of cesium bromide and silver nitrate are combined.
11. (2 points) Aqueous silver acetate is mixed with aqueous sodium chromate.
12. (2 points) A small piece of potassium is added to water.
13. (2 points) Solutions of hydrochloric acid and silver acetate are mixed.

Section 4: Buffers

1. What is the pH of a solution containing 0.02 M HA and 0.01 M A-? pKb of HA = 9.0.
2. What is the pH of a solution containing 0.0001 M HA and 0.0002 M A-? pKa of HA = 3.0.
3. Consider a solution initially containing 0.400 mol fluoride anion and 0.300 mol of hydrogen fluoride (HF). How many moles of hydrogen fluoride are present after addition of 70.0 mL of 0.600M HCl to this solution?
4. Consider a solution initially containing 0.50 mol ammonia (NH_3) and 0.30 mol of ammonium ion (NH_4^+). What is the pH after addition of 0.20 mol of HCl to this solution? (NH_4^+, Ka = 5.6×10^{-10})?
5. Calculate the pH in a solution prepared by dissolving 0.050 mol of acetic acid (CH_3COOH) and 0.20 mol of sodium acetate ($NaCH_3COO$) in water and adjusting the volume to 500 mL. The pKa for acetic acid (CH_3COOH) is 4.75.
6. Suppose 0.010 mol of NaOH is added to the buffer from the previous question. Calculate the pH of the solution that results.
7. Eric wants you to make a buffer solution with an equal number of moles of acetic acid (CH_3COOH) and acetate (CH_3COO^-). Calculate to one significant figure the minimum number of moles of each that you must use to prevent a change in the pH of more than 0.20 pH units after the addition of 1.0 mL of 5.00 M HCl (aq) to 100.0 mL of the buffer solution, generating 101.0 mL of solution. The Ka of acetic acid is 1.8 x 10-5.

Indicate whether each of the following solution mixtures will make a buffer solution (0.5 points each):

8. 50.0 mL of 0.20 M CH_3CO_2H + 50.0 mL of 0.20 M $NaCH_3CO_2$
9. 50.0 mL of 0.20 M $HC_2H_3O_2$ + 50.0 mL of 0.10 M NaOH
10. 50.0 mL of 0.20 M $HC_2H_3O_2$ + 50.0 mL of 0.20 M NaOH
11. 50.0 mL of 0.20 M $NaC_2H_3O_2$ + 50.0 mL of 0.20 M HCl

Use the following information to answer Questions 10-13: A buffer solution is prepared from 1.00 L of 0.0500 M CH_3COOH (Ka = 1.8 x 10^{-5}) and 2.50 g sodium acetate, $Na(CH_3COO)$.

12. What is the pH of this solution?
13. 1.00 mL of a 1.00 M solution of hydrochloric acid is added to the buffer. Calculate the pH after addition.
14. Calculate the mass of sodium hydroxide that would need to be added to 1.00 L of 0.050 M CH_3COOH to produce a solution with the same pH as the original buffer.

Section 5: Titrations

1. (2 points for 2:0 acid:asher/eric) A solution of sulfuric acid (H_2SO_4, 25.00 mL) was titrated to the second equivalence point (both protons were removed) with 34.55 mL of 0.1020 M sodium hydroxide. What was the concentration of the sulfuric acid?

2. Glycolic acid, which is a monoprotic acid and a constituent in sugar cane, has a pKa of 3.9. A 25.0 mL solution of glycolic acid is titrated to the equivalence point with 35.8 mL of 0.020 M sodium hydroxide solution. What is the pH of the resulting solution at the equivalence point?

3. Quinine is a weak base, with pKb = 5.10. What is the pH if a 25.0 mL solution originally containing 0.125 moles of quinine is titrated with HCl to the equivalence point, and if the combined total volume at the end is 56.0 mL?

4. If you start with 80.0 mL of 0.40 M HNO_3, calculate the [H+] concentration following addition of 40.0 mL of 0.60 M KOH.

5. A 10.0 mL sample of 0.20 M HNO_2 solution is titrated with 0.10 M NaOH. (Ka of HNO_2 is 4.3 x 10^{-4}). Calculate the pH at the equivalence point.

6. Calculate the pH with 2.00 mL of NaOH added past the equivalence point in 5.

   For a monoprotic weak acid strong base titration:

7. (2 points) Derive pH(Ka, [A]) before the titration

8. (2 points) Derive pH(Ka, [A], Va, [B], Vb) for a titration

9. (5 points) Derive pH(Kw, Ka, [A], [B]) at the equivalence point

10. (3 points) Derive pH(Va, Vb, [A], [B]) after the equivalence point

Section 6: Acid-Base Fun

1. Edward dissolves 69.9 micrograms of K(Eric) (molar mass = 420.4g) in deionized water to make 1.00L of solution. What is the pH of this solution?

2. Estimate the pH of a solution that is 0.10M in acetic acid (Ka=1.810–5) and 0.01M in formic acid (Ka=1.710–4).

3. A 1 mL sample of a 0.1 M solution of a divalent metal ion is pale pink. To it is added 1 mL of concentrated HCl, which causes a color change to bright blue. What is the metal ion?

4. (2 points) Classify the following as lewis acids or bases: H3As, HI, CH4, F-.

5. Identify the Lewis acid in $BH_3 + (CH_3)_2S \longrightarrow H_3B\,S(CH_3)_2$.

6. What is the normality of a 1 M solution of H_2SO_4?

7. (2 points)An unknown student takes an unknown weight of an unknown weak monoprotic acid, dissolves it in an unknown volume of distilled water, and titrates it with an unknown strong base of an unknown concentration. After adding 10.00ml of base, he or she notices that the pH of the solution is 5.0. If it takes 32.22 ml of base to reach the equivalence point, what is the Ka of the acid? Credit: Mr. Forbes.

Answer Sheet A: Section 1-3

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Answer Sheet B: Sections 4-6

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