

BEARSO Chem Lab KEY

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Notes:

- The test is out of 162 points. Ties were broken in the following order: Lab score, Question 5 score, Question 4 score.
- Please don't feel discouraged if you feel you didn't do as well as you had hoped. This test was pretty difficult, and the average score was really low. That's what this tournament is: a learning opportunity for you!
- If you and your partner submitted different answers for the same question, we took the higher of the two scores. If you submitted different answers through Method 1 and Method 2, we took the score of whichever one we graded first. In the future, please choose one method and make sure to coordinate with your partner!
- For those of you who chose Method 1, the score indicated on Scilympiad is your total score for that question (e.g. your score for 1.1 reflects your score for the whole of Question 1). Unfortunately, we had already gotten through most of your tests before we were able to alter scores for individual sub-questions (since a blank Scilympiad test gave you a default 0).
- In the future, please remember to read the instructions thoroughly. There's a lot of important information in there, even if it is lengthy. It is worth the time spent reading it, even though you could be spending that time working on the test. Case in point: a lot of your emails bounced because you didn't write the correct email addresses.
- Hope you all had fun!

“Lab” (30 points)

Unfortunately, or maybe fortunately, you will not have to do some boring acid-base titration that they make you do at every tournament. Have fun!

Being the snoopiest chemist you are, you sneak into your teacher's chemistry closet and discover that there is an unlabeled dry waste container. What an irresponsible teacher indeed. But now you are obligated to determine what it was in order to protect the environment and other humans from irresponsible toxic waste disposal. Luckily, you checked the bottom of the bottle to find its manufacturing date, which eliminates many possibilities as you knew the lab schedule.

The waste can contain any combination of the following compounds (in appreciable amounts): Methyl Red (an indicator $pK_a = 4.95$ goes from yellow to red), Potassium Chromate, Silver Nitrate, Zinc Sulfate, and Lead Acetate.

1. Qual 1. The first thing you do is dissolve everything in distilled water. The solution remains colorless and no insolubles are observed. Based on this information what, if any, compound(s) can you conclude is not in the waste mixture and why?

+1 for potassium chromate

+1 methyl red

+1 for stating chromate is colored

+1 for stating methyl red is colored

Note: It was overlooked that $PbSO_4$ is insoluble so if you concluded that the two cannot be in solution together I will give you full credit for the 1,2,3

2. Qual 2. Next you add some dilute NaOH and a white precipitate forms, this eliminates silver nitrate as a possibility. Why are you not yet certain about the contents of the waste?

+2 for saying that both Zinc Sulfate and Lead Acetate form white precipitates

3. Qual 3. Next you add concentrated NaOH and some of the cloudiness disappears, but a precipitate still remains. What can you conclude about the contents of the waste and why does this step make certain what you could not determine in the previous step?

+2 for saying that Zinc Sulfate and Lead Acetate were in the waste.

+2 for mentioning amphotericity

Zinc Hydroxide is amphoteric and therefore will dissolve in concentrated base.

Wanting to know what other idiotic things your teacher has been doing, you go snooping around more and find that they made a solution of silver nitrate for no reason. They didn't even bother to label the concentration. So you must determine it yourself.

4. Tech 1. You decide to determine the concentration through a back titration using an excess of either NaOH and NH_3 and titrating the excess with HCl. Your options of titrants are NaOH or NH_3 , which one should you pick and why?

+1 For NaOH

+2 For explaining that Ag_2O is insoluble. Acceptable if they write AgOH

5. Tech 2. Write the net ionic reactions that occur in the first step and second step.

+2 for $2\text{Ag}^+_{(\text{aq})} + 2\text{OH}^-_{(\text{aq})} \rightarrow \text{Ag}_2\text{O}_{(\text{s})} + \text{H}_2\text{O}_{(\text{l})}$ Acceptable: $\text{Ag}^+_{(\text{aq})} + \text{OH}^-_{(\text{aq})} \rightarrow \text{AgOH}_{(\text{s})}$ Give only one if missing states

+2 for $\text{H}^+_{(\text{aq})} + \text{OH}^-_{(\text{aq})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$ Give only one if missing states

6. Tech 3. You want to prepare a 0.1 M solution of NaOH (MM = 40) but you only have solid crystals of it. Describe how to prepare 50 mL of this 0.1M solution using common general chemistry lab equipment.

+1 For stating that it should be done in a volumetric flask.

+2 For stating that 0.2 grams of NaOH are needed

+2 For stating that first pour the water to below the mark and stir until dissolved, and then topping it off (+1 if didn't mention first mix then top off)

7.Tech 4. Now you have to standardize your NaOH (MM = 40) solution against some KHP. Why do you have to standardize your NaOH solution?

+1 for saying that sodium hydroxide is hygroscopic, or any proper description of hygroscopy, or absorbs CO_2

+1 for saying to determine the actual concentration of NaOH

8.Quant 1. You titrated 3.01 g of KHP (Monoprotic, MM = 204) with 15.0 mL of your NaOH solution to a phenolphthalein endpoint. Determine the concentration of your NaOH solution.

$$0.015 * M = 3.01/204, M = 0.984M$$

+1 for calculations

+1 for answer

9.Quant 2. Now you are ready to do the titration. You add 5.00 mL of your NaOH solution to a 25 mL aliquot of the mystery AgNO_3 solution and titrate the mixture with 20.4 mL of your 0.1 M HCl solution to a methyl red endpoint. Determine the concentration of the silver nitrate.

$$\text{Amount of acid: } 0.0204 * 0.1 = 0.00204 \text{ mol HCl}$$

$$\text{Amount of reacted base: } 0.005 * 0.984 - 0.00204 = 0.00288 \text{ mol, this is also the moles } \text{Ag}^+$$

$$0.00288/0.025 = 0.115 \text{ M } \text{AgNO}_3$$

+1 for calculating moles acid

+2 for calculating moles Ag^+

+1 for molarity

Question 1 (15 pts)

You embark on this chemistry adventure we call a scioly test. But first thing you note is that you really need to go to the bathroom. Huh, someone must have slipped some $\text{Mg}(\text{OH})_2$ into your water, or maybe your careless self did on accident.

As you sit on the toilet seat you begin to ponder some of the properties of $\text{Mg}(\text{OH})_2$.

10. 1.1 Is $\text{Mg}(\text{OH})_2$ an acid or a base? Why?

+1 For saying base

+1 For saying that it increases $[\text{OH}^-]$ or it is a good proton acceptor

11. 1.2 $\text{Mg}(\text{OH})_2$ is strong, but if you stick your hand into a saturated solution of $\text{Mg}(\text{OH})_2$ it should not burn your hand. Why is this the case?

+2 for stating that its solubility is very low, and despite everything that dissolves dissociates, not much dissolves to begin with

*note: remember, dissolving and dissociating are different

12. 1.3 The solubility of $\text{Mg}(\text{OH})_2$ in neutral water is 1.71×10^{-4} mol/L. Calculate the K_{sp} of $\text{Mg}(\text{OH})_2$.

$$(1.71 \times 10^{-4})(1.71 \times 2 \times 10^{-4})^2 = 2 \times 10^{-11}$$

+1 For 2×10^{-11} No points if units are given

+1 For work

13. 1.4 What you just calculated in the previous problem is only an approximation. For $\text{Mg}(\text{OH})_2$ and other sparingly soluble/insoluble salts, the method you used is a rather good method, but still an approximation nonetheless. Why is it an approximation?

+2 For mentioning how activities are used to determine equilibrium constants and that concentrations are only approximations

+2 For mentioning that ionic attraction in more concentrated salt solutions can cause the activity to deviate significantly from the concentration approximation.

14. 1.5 Since the approximation is rather good, use the K_{sp} value you determined in 1.3 to determine the solubility of $\text{Mg}(\text{OH})_2$ (MM = 58.3) in g/L in a buffer solution whose pH is maintained at 10.

$$\text{Solubility} = K_{\text{sp}}/[\text{OH}^-]^2 = 2 \times 10^{-11}/(10^{-4})^2 = 0.002 \text{ M} = 0.117 \text{ g/L}$$

+2 for 0.117 g/L, no points without units

+1 for work

15. 1.6 If you tried to dissolve the $\text{Mg}(\text{OH})_2$ in a solution of MgCl_2 would you expect the solubility of $\text{Mg}(\text{OH})_2$ to be higher, the same, or lower? Why?

+1 For saying lower

+1 For saying common ion effect, or using Le Chatelier's principle

Question 2 (15 pts)

So now that you are relieved, it is time to tackle some more problems. If you did not start on the lab question, your adventure so far has been rather basic. Well it is about to get a whole lot more basic.

16. 2.1 What makes a compound more strongly basic? What does that say about the corresponding conjugate acid?

+1 For stating that a stronger base is a stronger proton acceptor or +1 for saying more strongly increases OH^- concentration or +1 for saying easier donation of lone pair

+1 For stating that it means the conjugate acid is weaker

17. 2.2 Your interest in bases has gotten your friends calling you basic. What they don't know is that you're a proton ripping SciOlyer. You aspire to deprotonate ethanol ($\text{pK}_a = 16$). But since you're extra, you pick one of the strongest bases you can easily find, sodium amide (NaNH_2 , pK_a of ammonia = 38). You make a 6M aqueous solution of the sodium amide and add some ethanol to the solution. Using spectroscopy you find that very little of your ethanol is actually deprotonated! You realize the reason is that water is not a suitable solvent; explain why that is the case.

+2 For leveling effect, or stating that in aqueous solution the strongest base is OH^-

+2 For stating that OH^- is not a strong enough base by showing that pK_a of water < pK_a of ethanol therefore the reaction favors ethanol and not ethoxide

18. 2.3 Now you have to pick a different solvent so you can actually deprotonate ethanol. You decide on DMSO ($pK_a = 35$, assume it dissolves in DMSO). Why is this a better choice of solvent for this purpose?

+1 For stating that DMSO is less acidic.

+2 For stating that deprotonated DMSO is a much stronger base than hydroxide by showing that pK_a of DMSO $>$ pK_a of ethanol hence the reaction favors ethoxide

19. 2.4 Estimate the percentage of amide molecules (assume they all dissolve) that are protonated in DMSO to 1 decimal place.

1 - $1/1000 = 0.999$, (pK_a difference is 3)

+2 for 99.9%

20. 2.5 Why would the procedure you used in 2.2 work if instead of ethanol you used 2,2,2-trifluoroethanol (CF_3CH_2OH)? Explain using concepts of acidity.

+2 For stating inductive effects of the fluorine pulls electron density from the oxygen, which increases stability of the conjugate acid

+1 For stating that 2,2,2-trifluoroethanol is a stronger acid than ethanol

+1 For stating that it can be deprotonated by OH^- in more considerable amounts

Question 3 (24 pts)

Mixing things can sometimes be oddly satisfying. Whether it looks like a colorful vortex, or stirring around beautiful crystals in suspension, there are things about the process of mixing that never gets old. However, as you probably know, the science mixing isn't always as pretty as it looks, so I won't bother asking you about the ugly stuff :).

21. 3.1 What drives ideal mixing? In other words, why is ideal mixing spontaneous?

+2 For saying entropy

+1 For saying that there is no enthalpy change in ideal mixing

(if they just write negative dG) +1 (must be specific for contributions to dG)

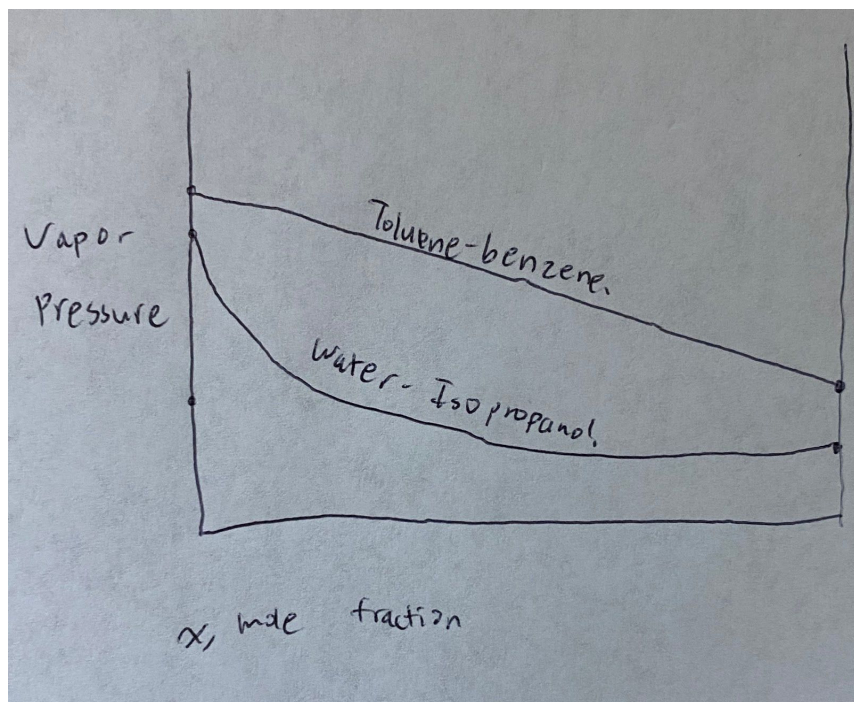
22. 3.2 Of these two mixtures, which one would be a more ideal solution:

Toluene($\text{CH}_3\text{C}_6\text{H}_5$)-Benzene(C_6H_6) or water-isopropanol($\text{CH}_3\text{CH}_2\text{OHCH}_3$) and why?

+2 For Toluene-Benzene

+2 For stating that the intermolecular attraction between toluene and benzene are very similar and hence there is a small enthalpy of mixing

23. 3.3 On the same graph, draw a pressure-composition diagram for both mixtures. No need to know exact vapor pressures, but you should know the relative vapor pressures (toluene and benzene, having weaker intermolecular attractions, have higher vapor pressure).



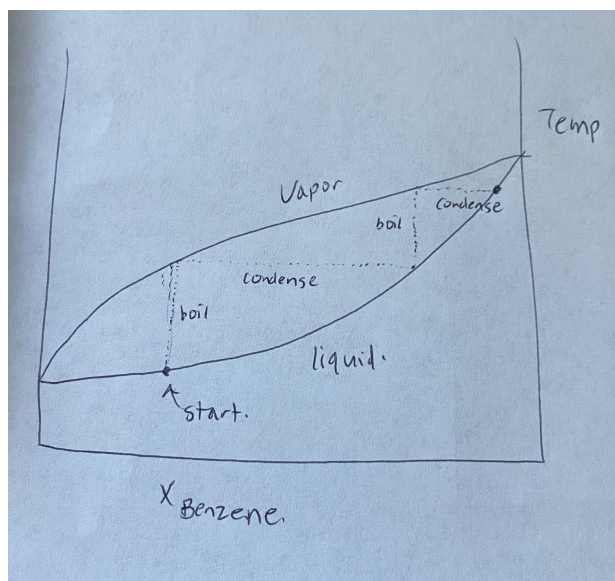
+1 For correctly labeled axes.

+2 for a straight line for toluene benzene

+2 for negative deviation in water isopropanol

The graph above starts at the more volatile substance first, so benzene and isopropanol respectively, this graph can be mirrored and will also be correct.

24. 3.4 On another graph, draw a rough temperature composition (include both liquid and vapor phase) diagram of the toluene-benzene mixture. Assuming the mixture begins at around 10% (in mole fraction) of benzene and is in liquid phase, label the starting point on the graph and draw how the mixture will change after at least 2 consecutive boiling and condensing cycles with the goal being toward purer benzene.



- +1 for correctly labeled axes (X_{toluene} works too, the graph would just be mirrored)
- +2 for rough vapor and liquid curves (since benzene-toluene is approximately ideal, there is no azeotrope)
- +2 for two cycles drawn correctly. The line for boiling should be vertical and condensation should be horizontal.
- *note: I graded this wrong. You may have lost 2 points, even if you drew it correctly

25. 3.5 The vapor pressure of water at 25°C is 22.8 mmHg and the vapor pressure at the same temperature of ethanol is 60.8 mmHg. Use Raoult's law to determine the vapor pressure of a 5 percent by mass aqueous solution of ethanol (MM = 46). Then explain why Raoult's law is a limiting law.

$$5/46 = 0.108 \text{ mol EtOH}, 95/18 = 5.28 \text{ mol H}_2\text{O}. x_{\text{EtOH}} = 0.108/(5.28 + 0.108) = 0.0200, x_{\text{H}_2\text{O}} = 0.980$$

+2 For converting percent to mole fraction

$$0.0200 * 60.8 + 0.980 * 22.8 = 23.6 \text{ mmHg}$$

+2 For using Raoult's law properly (remember, both will contribute to vapor pressure)

+1 for correct answer

+2 For explaining that Raoult's law works best at dilute concentrations hence it is a limiting law. It works the best at the limit ($x \rightarrow 0$)

Question 4 (29 pts)

Buffer solutions are like the safety net of chemistry. Unlike US oligarchs who care nothing about you and would allow minor downturns ruin your life, buffer solutions help maintain your body pH despite changes in your environment. Yes, buffers are very progressive :).

26. 4.1 Can you make a buffer solution from HNO_3 and NaNO_3 ? Why or why not?

+1 For saying no

+1 For stating that nitric acid is strong and hence it cannot form an effective buffer

27. 4.2 Explain why buffer solutions help maintain pH despite additions of small amounts of strong acid or base.

+2 for stating that both the conjugate acid and conjugate base are present, meaning small amounts of strong acid or base will not change the ratio of the two that drastically.

Or

+2 for using Henderson-Hasselbach equation and explains how the ratio changes slowly

28. 4.3 Let's say you have 100 mL of a 0.1M solution of sodium oxalate, $\text{Na}_2\text{C}_2\text{O}_4$. How many milliliters of a 10M HCl solution do you need to add to the solution to create a pH 4 buffer? ($\text{pK}_{a1} = 1.25$, $\text{pK}_{a2} = 3.81$)

$4 = 3.81 + \log((0.01 - x)/x)$ $x = 0.00392$ mol HCl. $0.00392/10 = 0.000392$ L HCl solution. This equals 0.392 mL.

+1 For Henderson Hasselbach equation, or equilibrium expression

+2 solving for the unknown

+1 for answer

29. 4.4 With the same starting materials as in 4.3, how many milliliters of the HCl solution would you need to add to create a pH 1 buffer?

$1 = 1.25 + \log((0.01 - x)/x)$ $x = 0.00640$. That means there is 0.00640 mol H_2Ox , since the concentration of HCl is very high, we can assume the volume change to be negligible.

From here, you can go straight to saying that $0.01 + 0.0064 + 0.01$ (because the hydrogen ion concentration is non negligible) mol HCl = 2.64 mL HCl

Or Charge balance to be more rigorous

$$[H_2Ox] = 0.0640 \text{ M. } [HOx^-] = 0.0360 \text{ M. } [H^+] = 0.1 \text{ M}$$

$$[Cl^-] + [HOx^-] = [H^+] + [Na^+]$$

$$[Cl^-] + 0.0360 = 0.1 + 0.2$$

$$[Cl^-] = 0.264 \text{ M}$$

This means 0.0264 mol HCl, which means 0.00264L or 2.64mL HCl

+1 For using the Henderson Hasselbach equation

+2 For solving for concentrations/moles of the conjugate acid or base.

+2 For realizing non negligible $[H^+]$

+1 For correct answer

30. 4.5 Draw the titration curve for adding HCl to sodium oxalate. Be sure to calculate the pH at important points and label them on the graph. (Initial, first half eq, you do not need to find first eq, second half eq, second eq)

+1 for initial pH + 1 for work, must be labeled on graph

$$pK_b = 14 - 3.81 = 10.19, pH = 14 + \log(\sqrt{10^{-pK_b} \times 0.1}) = 8.405$$

+1 for labeled half eq

+1 for labeled half eq

+1 for labeled approximate first eq (you can find it with a pretty nasty mass charge balance, but you don't have to)

+2 for pH at second equivalence +2 for using equilibrium constants +2 for mass balance, +2 for charge balance, point must be labeled on graph

$$K_{a1} = \frac{[H^+][HOx^-]}{[H_2Ox]}, K_{a2} = \frac{[H^+][Ox^{2-}]}{[HOx^-]} \quad 0.1 = [H_2Ox] + [HOx^-] + [Ox^{2-}], [H^+] = [HOx^-] + 2[Ox^{2-}] + [Cl^-]$$

$$[H^+] = 0.608 \text{ M}$$

$$pH = 0.216$$

This was calculated using $[\text{Cl}^-] = 0.2\text{M}$ which is not accurate for this situation, but as long as they use a reasonable $[\text{Cl}^-]$ and get a similar pH it will be accepted. The exact locations of the end points and the half eq points can be estimated in terms of how many mL HCl is added. Initial point is of course at zero, the first half eq point is approximately 0.5, first eq point around a region greater than 1, the second half eq is around somewhere near 2, and the second eq point is somewhere near 3.

+1 for graph with axes

+1 for reasonable slopes, (shallow around half eq, steep at eq)

Question 5 (22 pts)

Learning through osmosis really do be a thing. If your friends are legends a little will rub off onto you. If you are a legend then a little will rub off onto your friends. Well let's examine some osmosis in chemistry.

31. 5.1 In a very theoretical U-tube with water and in the middle there is a semipermeable membrane that only allows water to pass through, we dissolve 50 milligrams of an unknown monoprotic carboxylic acid. Each side is filled with about 100 ml of water/solution. Draw a diagram of the setup. Be sure to label which side has the dissolved acid, and be sure to identify which side is the water level higher.

+1 for drawing a reasonable drawing of a U-tube (water on one side, solution w/ acid on the other, semi-permeable membrane in between)

+1 for indicating that the water level of the side with the acid is higher

32. 5.2 One side of the **theoretical** tube is a whopping 625 mm higher than the other side. Assuming the density of the water and solution is 1 g/mL, calculate the molar mass of the carboxylic acid.

+1 for writing out $\rho gh = MRT$ or more explicitly $\text{molar mass} = \frac{cRT}{\rho gh}$ (M in units mol/L, c in units g/L).

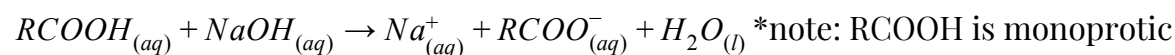
$$\rho = 1000 \text{ kg m}^{-3}, g = 9.8 \text{ m s}^{-2}, h = 0.625 \text{ m}, c = 0.5 \text{ mg mL}^{-1} = 500 \text{ g m}^{-3},$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} = 8.314 \text{ kg m}^2 \text{ s}^{-2} \text{ mol}^{-1} \text{ K}^{-1}, T = 298.15 \text{ K} \text{ *units are important!}$$

+1 for calculating that 0.5 mg/mL is equivalent to 500 g/m³

+2 for calculating the molar mass to be about 202.4 g/mol

33. 5.3 To corroborate your observations, you decide to perform a titration. You dissolve enough of the acid into water to have a total of 5 grams, and titrate it with 32.6 mL of 1.5M NaOH to a phenolphthalein endpoint. Determine the molar mass of the carboxylic acid.



$$(5 \text{ g RCOOH}) / (0.0489 \text{ mol NaOH}) * (1 \text{ mol RCOOH} / 1 \text{ mol NaOH}) = 102.1 \text{ g/mol}$$

+1 for $0.0326 \text{ L} * 1.5 \text{ M} = 0.0489 \text{ mol NaOH}$

+2 for calculating the molar mass to be 102.1 g/mol

34. 5.4 If you did it correctly, you should get two different answers for 5.2 and 5.3, can you explain why this is the case, and explain which one is the correct value if any?

+1 for 5.3, +1 for mentioning carboxylic acid dimerization would cause the apparent concentration of a solute to be lower, +1 for explaining that titration only looks for the acidic proton, and since it's given that it is monoprotic will give the correct molar mass.

35. 5.5 If you tried using boiling point elevation to calculate the molar mass would your answer be closer to that of 5.2 or 5.3, explain why.

+1 for 5.2, +2 for explaining that boiling point elevation is also a colligative property and will be affected by apparent lower concentrations of solute

36. 5.6 To determine the identity, you finally perform a combustion analysis. You burn 5 grams of the sample and collect 8.62 g of CO₂ and 2.64 g of H₂O. The molecule contains only C, H, and O. Determine the molecular formula using the information from this problem and previous problems. Then draw a plausible structure for the compound.

*note: the masses of H₂O and CO₂ in the test were 2.43g and 13.4 g (which were wrong). Points were assigned based on those values. The compound was cinnamic acid.

$$8.62 \text{ g CO}_2 / (44.01 \text{ g CO}_2 / 1 \text{ mol CO}_2) * (1 \text{ mol C} / 1 \text{ mol CO}_2) = 0.196 \text{ mol C} = 2.352 \text{ g C}$$

$2.64 \text{ g H}_2\text{O} / (18.02 \text{ g H}_2\text{O}/1 \text{ mol H}_2\text{O}) * (2 \text{ mol H}/1 \text{ mol H}_2\text{O}) = 0.293 \text{ mol H} = 0.293 \text{ g H}$
 $5 \text{ g} - 2.352 \text{ g C} - 0.293 \text{ g H} = 2.355 \text{ g O} / (16 \text{ g O}/1 \text{ mol O}) = 0.147 \text{ mol O}$

*remember, we don't know whether the oxygen in H_2O and CO_2 comes from the compound or the oxygen from combustion

Ratios: $0.196 \text{ mol C} / 0.147 \text{ mol O} = 1.3333 = 4/3$; $0.293 \text{ mol H} / 0.147 \text{ mol O} = 2$

Empirical formula = $\text{C}_4\text{H}_6\text{O}_3$ (mm = 102.1 g/mol)

Molecular formula = "empirical formula" * (molecular weight/empirical mass) =

$\text{C}_4\text{H}_6\text{O}_3 * (102.1 \text{ g/mol} / 102.1 \text{ g/mol}) = \text{C}_4\text{H}_6\text{O}_3$

+3 for calculating 0.196 mol C, 0.293 mol H, and 0.147 mol O

+2 for calculating empirical formula $\text{C}_4\text{H}_6\text{O}_3$ and molecular formula $\text{C}_4\text{H}_6\text{O}_3$

+2 for any reasonable drawing with a proper molecular formula, proper bonding/octets, one carboxylic acid group, and no alcohol groups (monoprotic)

***compound is acetoacetic acid (mm = 102.09 g/mol)**

Question 6 (14 pts)

Each human has their own complex personalities, and that is usually seen as a good thing. It is interesting to know each human's complexities. Complex ions and molecules in chemistry also have very complex properties and personalities. Careful manipulation of ligands often drastically changes the properties of the molecule. Although we will not be looking at properties of complex ions, we will be answering some questions about their formation.

37. 6.1 The K_{sp} of FeS (MM = 87.92) is 4×10^{-19} . Calculate in ppm (use $\mu\text{g/L}$) the solubility of FeS in neutral distilled water.

Solubility = $\sqrt{4 \times 10^{-19}} = 6.325 \times 10^{-10} \text{ M}$, $5.56 \times 10^{-8} \text{ g/L} \rightarrow 0.0556 \text{ ppm}$

+1 for solubility calculation

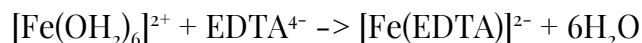
+1 for ppm answer

+1 for work

As you can see the solubility of FeS in water is very low, we can increase the solubility of FeS by adding a chelating agent, in this case we will use EDTA, which is a hexadentate ion usually with a charge of 4-. A simplified reaction is given below



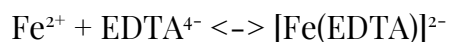
38. 6.2 $[\text{Fe}(\text{EDTA})]^{2-}$ is soluble in water and, as you can see from the formation constant, is very stable. Using your knowledge of free energy and solubility (think about hydration complexes), explain why a chelating agent like EDTA creates very stable complexes.



+2 for either writing the reaction or stating that chelation has favorable entropy change

+1 for stating that this decreases (make more negative) free energy change of chelation increasing its stability

39. 6.3 Ignoring effects of pH (assume neutral solution), determine the $[\text{EDTA}^{4-}]$ needed to completely dissolve 0.1g of FeS in 1 L of water.



$$[\text{S}^{2-}][[\text{Fe}(\text{EDTA})]^{2-}]/[\text{EDTA}^{2-}] = K_{\text{sp}} \times K_f$$

Full dissolution occurs at $[\text{S}^{2-}] = [\text{Fe}(\text{EDTA})]^{2-} = 0.1/87.92 = 0.00114\text{M}$

$$0.00114^2/[\text{EDTA}^{2-}] = 4 \times 10^{-19} \times 2.1 \times 10^{14}$$

$$[\text{EDTA}^{2-}] = 0.0155 \text{ M}$$

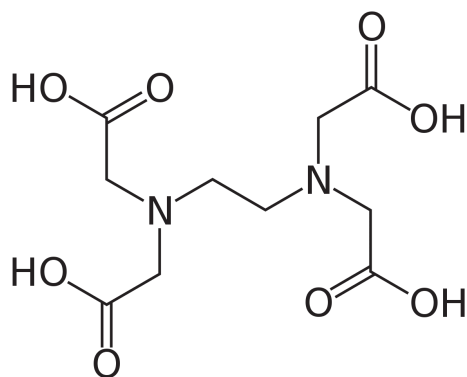
+2 for writing equilibrium expression

+1 for realizing what to plug in for $[\text{S}^{2-}]$ or $[\text{Fe}(\text{EDTA})]^{2-}$

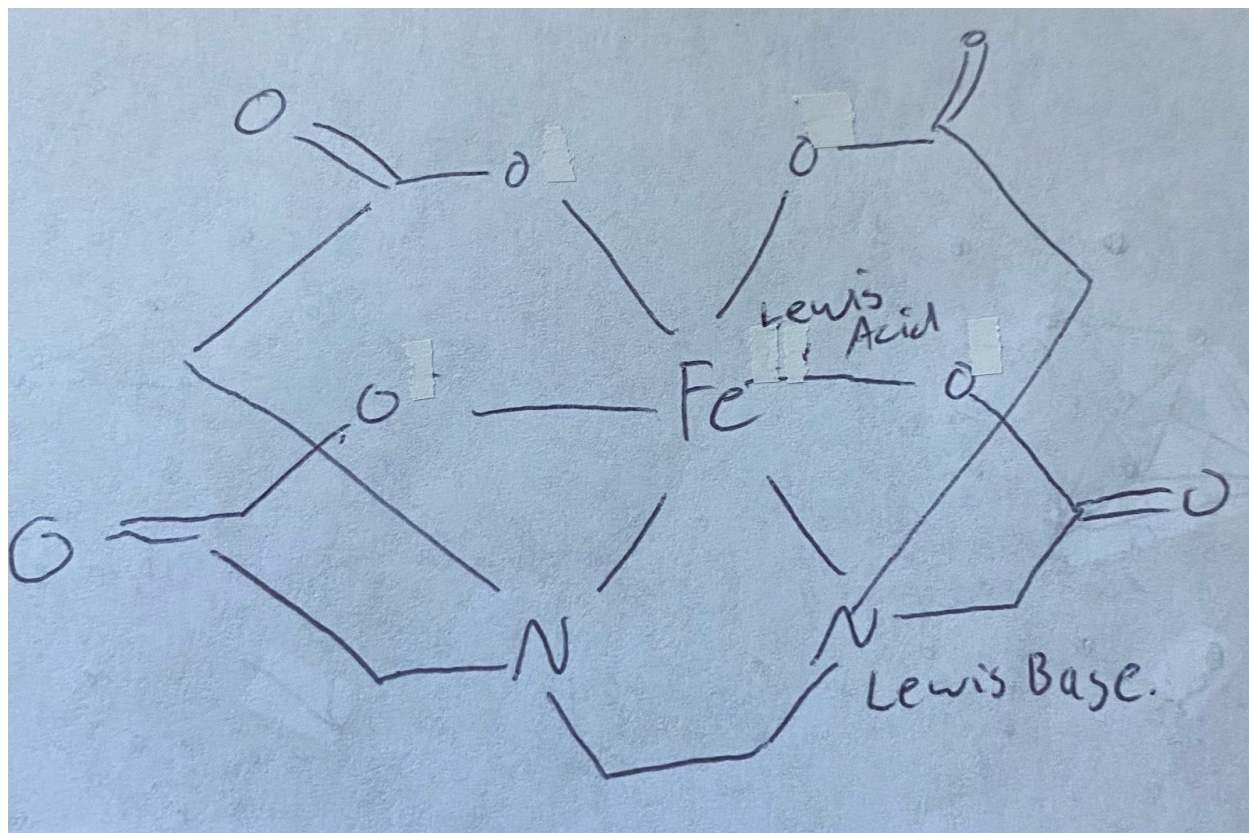
+1 for answer

0.0166 is acceptable due to vague wording, it was intended to be what concentration needs to be maintained.

40. 6.4



Here's EDTA in its acid form. Often, complex formation is regarded as a lewis acid-lewis base reaction. Draw $\text{Fe}(\text{EDTA})^{2-}$. Do not worry about orientation or how it looks, I just want to see that you identified correctly which atoms bond to the iron. Also be sure to label which is the lewis acid and which is the lewis base.



+2 For drawing correctly

+1 For Fe being lewis acid, + 1 for nitrogen or oxygen or both being identified as lewis base (they both are)

Question 7 (14 pts)

Welcome to the last question! In the previous question, we worked with metal ions. We will end our little chemistry excursion with a problem regarding metal.

41. 7.1 You have a 5.5 g sample of mixed metal shavings containing silver, gold, and aluminum. You prepare a concentrated solution of sodium hydroxide and pour it into the mixture of metal and collect the gas released. Please write the significant reaction(s) that occurred, and why the (or none of) the other metals didn't react.

+1 for writing out $Al_{(s)} + NaOH_{(aq)} \rightarrow NaAlO_{2(aq)} + H_{2(g)}$

$2Al_{(s)} + 2NaOH_{(aq)} + 2H_2O_{(l)} \rightarrow 2NaAlO_{2(aq)} + 3H_{2(g)}$

$2Al_{(s)} + 2NaOH_{(aq)} + 6H_2O_{(l)} \rightarrow 2NaAl(OH)_4(aq) + 3H_{2(g)}$

+1 for indicating that only Al reacts/Ag and Au don't react

+1 for stating that NaOH cannot oxidize Ag and Au

42. 7.2 Assuming this gas is pure, you combust this gas and collected 1.483 g of a liquid. Assuming the combustion process is 80% efficient and gas collection is 100% efficient, how many moles of gas was collected in the process performed in the previous question.

The gas is H_2 the liquid is water. 1.48g water at 80% efficiency (1.48g collected from 80% of the H_2 gas combusting) means 1.854 g water = 0.103 mol water = 0.103 mol H_2

+1 for realizing liquid is water.

+1 for calculation

+1 for answer

43. 7.3 You now treat this solution with hot, concentrated nitric acid. (You performed this in a fume hood of course) You stir and filter away the liquid. Write the significant reaction(s) that occurred and why the (or none of) the other metals didn't react?

+ 2 for $Ag_{(s)} + HNO_{3(aq)} \rightarrow AgNO_{3(aq)} + NO_{2(g)} + H_2O_{(l)}$

+2 For saying that nitric acid is not a strong enough oxidizer to oxidize gold.

44. 7.4 You dry and weigh whatever is left, and find that you are left with 0.99 g of stuff. What compound remains, and calculate the percent composition of aluminum, silver, and gold in the original mixture.

$$0.103 \text{ mol H}_2 * \frac{2}{3} = 0.0687 \text{ mol Al} = 1.853 \text{ g Al} = 34\% \text{ Al}$$

$$0.99\text{g}/5.5 = 18\%$$

The rest is then 48%

What is left is gold

+1 for Al calculation, +1 for Al composition

+1 for silver composition

+1 for gold composition.

*percentages are 34% Al, 48% Ag, 18% Au