

Name: KEY

Chemistry 111
Test 4
December 18, 2004

Instructions before starting the test:

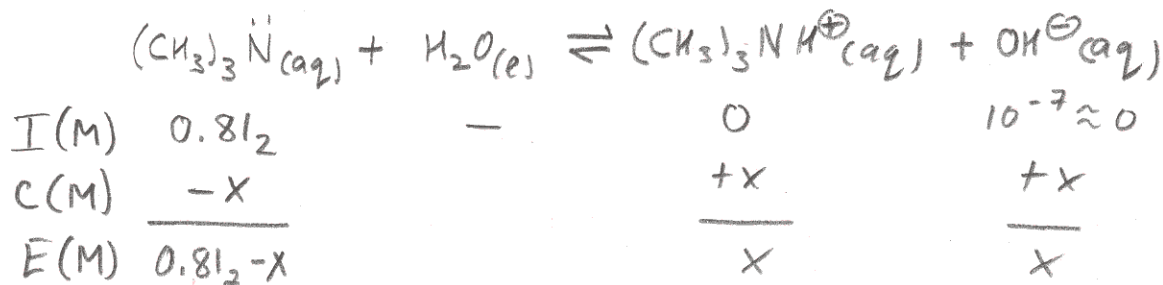
1. Write your name in the space above and on the backs of Pages 2-4.
2. Your exam booklet should have **five** pages total, with questions on Pages 2-4, and a periodic table and other reference data on Page 5. Check to see you have five pages now. If you do not, ask for another copy of the exam.
3. You may tear off Page 5 if you wish, but be careful not to remove the staple.
4. You may use programmable calculators, but chemical data should not be stored in them.
5. You may use as a reference a single sheet of 8.5"x 11" paper that you have filled (front and back) with information.
6. You have **2 hours and 15 minutes** to work on both this test and the final examination. Do not start until you are instructed to.

<u>(Possible Points)</u>	<u>Your Score</u>
Question 1 (35)	
Question 2 (10)	
Question 3 (15)	
Question 4 (40)	
Total (100)	

mean 71

1. (35 points) $(\text{CH}_3)_3\text{N}$ (trimethylamine) is a useful base in organic reactions. Its K_b is 6.3×10^{-5} at 25°C . Calculate the pH of a solution in which 12 g of $(\text{CH}_3)_3\text{N}$ are dissolved in water to make a 250-mL solution.

$$12 \text{ g } (\text{CH}_3)_3\text{N} \left(\frac{\text{mol}}{59.11 \text{ g}} \right) \left(\frac{1}{0.250 \text{ L}} \right) = 0.812 \text{ M}$$



$$K_b = \frac{[(\text{CH}_3)_3\text{NH}^+][\text{OH}^-]}{[(\text{CH}_3)_3\text{N}]} = \frac{x^2}{0.812 - x} = 6.3 \times 10^{-5}$$

$$0.812 > 10^4 K_b, \text{ so } x \ll 0.812$$

$$\frac{x^2}{0.812} = 6.3 \times 10^{-5} \Rightarrow x = \sqrt{(0.812)(6.3 \times 10^{-5})} = 0.00715 \text{ M} = [\text{OH}^-]$$

$$\text{pOH} = -\log(0.00715) = 2.15 \Rightarrow \text{pH} = 14.00 - \text{pOH} = \boxed{11.85}$$

-2 sig fig

-4 math

-6 miscalculated molarity (bad dimensional analysis)

-10 used K_a

-12 wrong chemical rxn

-12 confused pH and pK_a (or pOH and pK_b)

-8 confused pH and pOH (said $x = [\text{H}_3\text{O}^+]$)

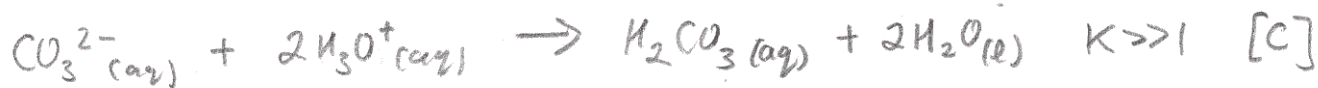
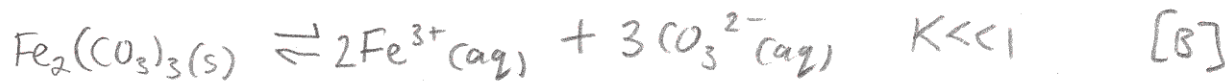
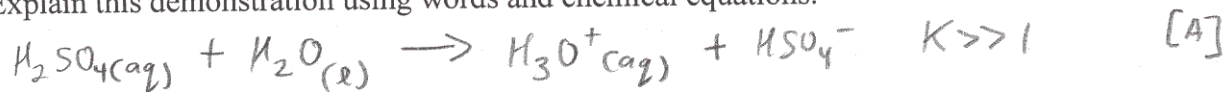
2. (10 points) Would you expect an aqueous solution of LiBr to be acidic, neutral or basic? Explain.

Li^{\oplus} has no H^{\oplus} 's to donate.

Br^{\ominus} is the conjugate base of a strong acid, so Br^{\ominus} 's desire for H^{\oplus} is negligible (i.e. less than H_2O 's desire).

- 5 'neutral', but no discussion of Br^{\ominus} 's negligible rxn with H_2O
- 3 ~~4~~ Br^{\ominus} not described as the conj. base of a strong acid
- 7 Basic because Br^{\ominus} pulls H^{\oplus} off H_2O
- 10 Basic for no plausible reason
- 10 LiBr intact in water
- 10 Acidic

3. (15 points) On the last day of class, I dissolved solid $\text{Fe}_2(\text{CO}_3)_3$ by the addition of $\text{H}_2\text{SO}_4(\text{aq})$. Explain this demonstration using words and chemical equations.



- 2 no mention of CO_2 loss
- 4 ^{per} incorrect chemical formula (or unbalanced chem eqn) } ~~no more than 3 for total~~ ← up to -3
- 5 no mention of LeChatelier or basicity of CO_3^{2-}
- 2 The entire compound $\text{Fe}_2(\text{CO}_3)_3$ is a base
- 12 Begging question / no chemical equations
- 8 Egregious chemical equations / implausible chemistry
- 6 only balanced overall equation (no explanation)

4. (a) (30 points) A biochemist weighs out 0.18 mol of acrylic acid (C_2H_3COOH) and dissolves it in 250 mL of water. She then adds 350 mL of 0.16 M $NaOH(aq)$. Calculate the pH of the resulting solution. (The K_a of acrylic acid is 5.6×10^{-5} .)

$$0.350 \cancel{L} \left(\frac{0.16 \text{ mol } OH^-}{\cancel{L}} \right) = 0.056 \text{ mol } OH^-$$



i (mol)	0.18	0.056	0	-
c (mol)	-0.056	-0.056	+0.056	
f (mol)	0.124	0	0.056	

$$pK_a(C_2H_3COOH) = -\log(5.6 \times 10^{-5}) = 4.25_2$$

$$pH = pK_a(C_2H_3COOH) + \log \frac{[C_2H_3COO^-]}{[C_2H_3COOH]} = 4.25_2 + \log \frac{0.056}{0.124} = \boxed{3.91}$$

-2 sig figs (only if not -17 or lower)

-5 treated hydrolysis of C_2H_3COOH , but neglected $n_{H_3O^+}$, $C_2H_3COO^-$, or $n_{C_2H_5COOH}$ in stoichiometry calc

~~mol OH = mol~~

-12 Error in calculating pK_a (conceptual)

-12 no treatment of stoichiometric reaction

take off for only 1 of these

-5 unit error

-5 no dilution factor

-12 Just hydrolysis

-12 wrong chemical eqn

-12 mol $OH^- =$ mol weak base

-12 no rxn of weak acid w/ strong base

-12 K_a for stoichiometric rxn

-5 wrong volumes

-5 no final answer

+6 SOME CORRECT WORK

(b) (10 points). Would the solution prepared in part (a) be better equipped to resist increases or decreases in pH? Explain.

Harder to increase pH since there are more moles of the weak acid C_2H_3COOH than $C_2H_3COO^-$ (the weak base)

-4 correct but vague

-7 harder to decrease pH since pH already acidic (or harder to increase since pH already > 7)

-4 harder to increase pH " " " (but no more)

-5 doesn't say in which direction pH is harder to change

-4 answer in (b) doesn't match answer in (a)

-6 right answer, but no explanation (or wrong explanation)

-9 something

-6 wrong answer, but valid reason

Possibly Useful Information

$$K_a K_b = [\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14} \quad pK_a + pK_b = \text{pH} + \text{pOH} = 14.00$$

$$N_A = 6.022 \times 10^{23} \text{ particle mol}^{-1} \quad 1 \text{ L} = 1000 \text{ mL} = 1000 \text{ cm}^3 \quad T(\text{K}) = T(^{\circ}\text{C}) + 273.15$$

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 *La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 †Ac 227.03															

* 58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
† 90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)