Name: ____

Chemistry 210 Exam 3

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = $6.022\text{x}10^{23}\ {}^{\text{units}}/_{\text{mol}}$

$32.00^{o}F = 0.000^{o}C = 273.15K$

Density of Water = $1.000\ {}^{g}/_{mL}$

$R = 0.08206\ {}^{L\bullet atm}/_{mol\bullet K} = 8.314\ {}^{J}/_{mol\bullet K}$

PV=nRT

$\Delta T_{fp/bp} = k_{fp/bp}\bullet m\bullet i$

For water, $k_{fp} = -1.86\ {}^{^{o}C}/_{m}$; $k_{bp} = 0.52\ {}^{^{o}C}/_{m}$

$P_1 = X_1 P_1^{o}$

P = cRTi

$C_1V_1 = C_2V_2$

Quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Integrated Rate Laws:

$\ln[A]_t = -kt + \ln[A]_o$

$1/[A]_t = kt + 1/[A]_o$

$[A]_t = -kt + [A]_o$

$$k = Ae^{-Ea/RT}$$

$$\ln(k) = \left(\frac{-E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{conjugate acid}]}\right)$$

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	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** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	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** 91.224	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** 118.71	51 **Sb** 121.76	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** 183.84	75 **Re** 186.21	76 **Os** 190.23	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	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)		114		116		

58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.94	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** (258)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Score

1. Complete each row of the following tables for aqueous solutions at 25ºC (4pts per box):

$[H_3O^+]$	$[OH^-]$	pH	pOH	Acidic, Basic or Neutral?
3.19×10^{-4}	**3.13×10^{-11}**	**3.496**	**10.504**	**Acidic**
4.80×10^{-5}	**2.08×10^{-10}**	4.319	**9.681**	**Acidic**

Conjugate Acid	K_a @25ºC	Conjugate Base	K_b @25ºC
H_2CO_3	**4.2×10^{-7}**	**HCO_3^{-1}**	2.4×10^{-8}
HSO_4^{-1}	1.2×10^{-2}	SO_4^{2-}	**8.3×10^{-13}**

2. Does the combination listed result in an effective buffer solution? (4pts each)

Yes [*No*] 0.38mol HCl(aq) + 0.38mol NaOH(aq)

[*Yes*] *No* 0.90mol Na_3PO_4(aq) + 1.35mol HNO_3(aq)

[*Yes*] *No* 1.28mol Na_2CO_3(aq) + 0.64mol HCl(aq)

[*Yes*] *No* 2.14mol CH_3COOH(aq) + 1.96mol CH_3COOK(aq)

Yes [*No*] 0.06mol HCN(aq) + 0.98mol LiCN(aq)

3. How much 1.131 M NaOH(aq) must be added to 45.00mL of 0.984 M HCl(aq) to reach the equivalence point? What is the pH of this solution at the equivalence point? (12pts)

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

$$\frac{(0.04500\ \text{L HCl(aq)})\left(0.984\ \frac{\text{mol HCl}}{\text{L HCl(aq)}}\right)\left(\frac{1\ \text{mol NaOH}}{1\ \text{mol HCl}}\right)}{1.131\ \frac{\text{mols NaOH}}{\text{L sol'n}}} = 0.0392\ \text{L NaOH(aq)} = 39.2\ \text{mL NaOH(aq)}$$

Since this is a strong acid/strong base titration, the equivalence point should be at pH = 7.

Score

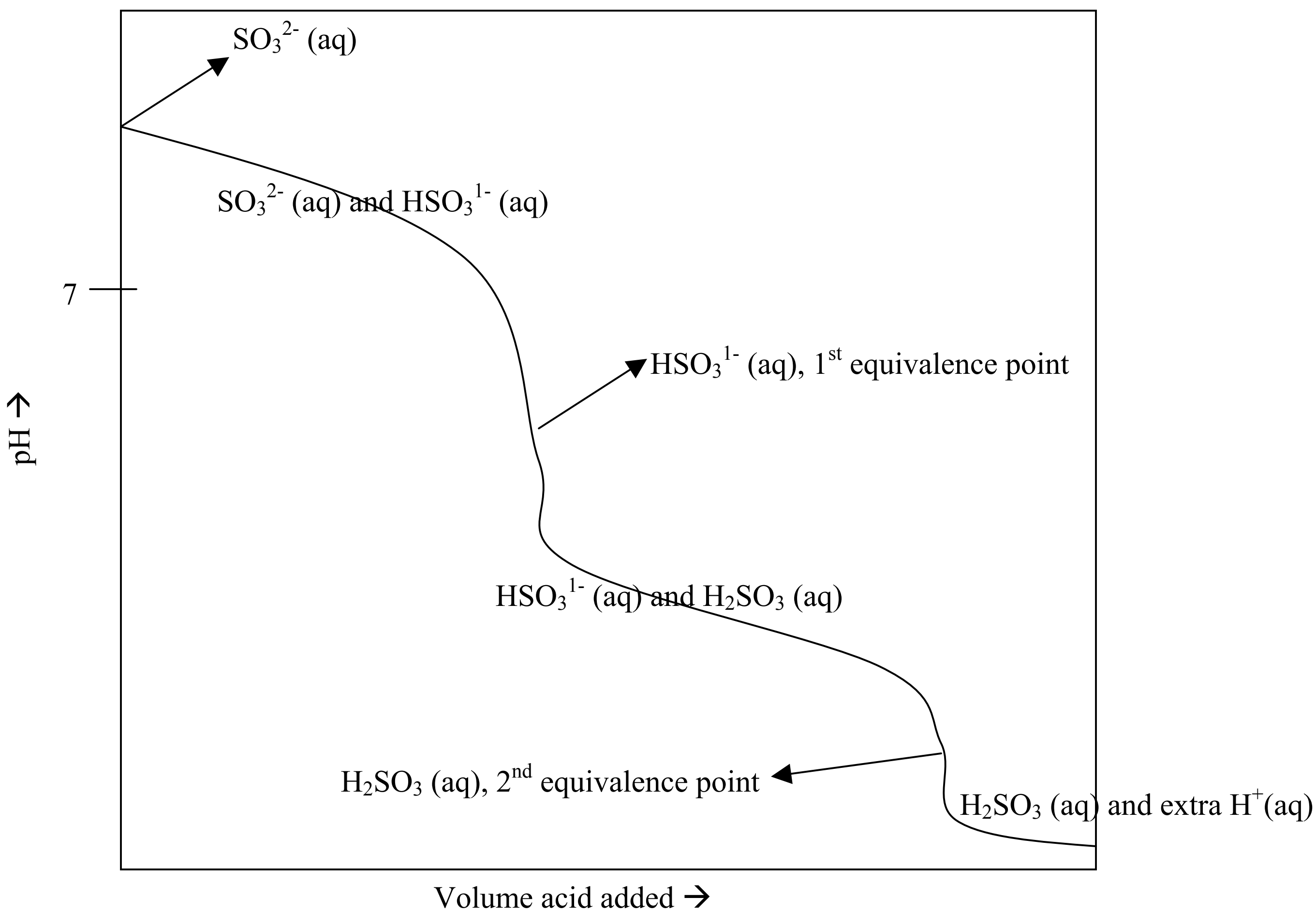
4. You have prepared a buffer solution by combining 0.164mols of nitrous acid (HNO_2, K_a = $4.5x10^{-4}$) and 0.186mols of sodium nitrite in enough water to make 500.0mL of solution. What is the pH of this buffer solution? (12pts)

Plugging into the Henderson-Hasselbalch equation:

$$pH = 3.35 + \log\left(\frac{0.186\text{mols}/0.5000\text{L}}{0.164\text{mols}/0.5000\text{L}}\right) = 3.40$$

NOTE: The H-H equation technically uses the *concentrations* of conjugate acid and conjugate base, but since they are both dissolved in the same volume of water, the volume cancels out.

5. Sketch the titration curve (pH vs. volume added) for the titration of 1 M potassium sulfite (K_2SO_3, K_{b1}=$1.6x10^{-7}$) and 1 M $HClO_4$(aq). Label all the axes (including approximately accurate numbers) and the major sulfite-based species present in solution at each point in the titration curve. Indicate the equivalence point(s) on the curve. (17pts)



Score

6. What is the K_b of a base if 750.0mL of a solution containing 0.153 mol of the base and 0.141 mol of its conjugate acid has a pH of 4.165? Over what pH range would this conjugate acid/ conjugate base pair make an effective buffer? (16pts)

Plugging into the Henderson-Hasselbalch equation:

$$4.165 = pK_a + \log\left(\frac{0.153\text{mols}/0.7500\text{L}}{0.141\text{mols}/0.7500\text{L}}\right)$$

$$pK_a = 4.130$$
$$K_a = 7.42\text{x}10^{-5}$$
$$K_b = 1.35\text{x}10^{-10}$$

This system would make an effective buffer over the range 3.130 → 5.130

7. You have titrated 25.00mL of a monoprotic acid ($K_a = 3.4\text{x}10^{-5}$) with 0.613 M KOH(aq). If thymol blue (endpoint 7.8-9.5) is used as an indicator, you reach the endpoint when 31.37mL of base is added. Based on this data, what is the concentration of the acid? Would your result change if ethyl red (endpoint 4.0-5.8) was used as an indicator? If so, how? Which indicator (thymol blue or ethyl red) more correctly indicates the equivalence point in this titration? (Explain your answers!) (25pts)

$$KOH(aq) + HA(aq) \rightarrow KA(aq) + H_2O(l)$$

$$\frac{(0.03137\text{ L KOH(aq)})\left(0.613\frac{\text{mol KOH}}{\text{L KOH(aq)}}\right)\left(\frac{1\text{ mol HA}}{1\text{ mol KOH}}\right)}{0.02500\text{ L HA(aq)}} = 0.769\text{ M HA(aq)}$$

Since this is a weak acid/strong base titration, the equivalence point should be basic. Therefore, the proper indicator to use will have an endpoint that is basic. Thymol blue is an appropriate indicator.

If ethyl red is used as an indicator in this reaction, it will reach its endpoint *before* the titration reaches its equivalence point. This would result in a *calculated concentration* that is too low.

NOTE: A slight language note here. Some people said that if ethyl red was used, the concentration of the acid would be lower. The concentration of the acid is the same regardless of the indicator used, but the concentration that is calculated would be lower than the actual concentration.

Score