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 = 6.022×10^{23} $^{units}/_{mol}$

$32.00^oF = 0.000^oC = 273.15K$

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

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

$PV = nRT$

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

For water, $k_{fp} = -1.86$ $^{^oC}/_m$; $k_{bp} = 0.52$ $^{^oC}/_m$

$P_1 = X_1 P_1^o$

$P = cRTi$

$C_1 V_1 = C_2 V_2$

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?
3.648×10^{-9}	2.741×10^{-6}	8.4379	5.5621	Basic
1.31×10^{-4}	7.62×10^{-11}	3.882	10.118	Acidic

Conjugate Acid	K_a @25ºC	Conjugate Base	K_b @25ºC
H_2SO_3	1.2×10^{-2}	HSO_3^-	8.3×10^{-13}
$H_2PO_4^-$	6.2×10^{-8}	HPO_4^{2-}	1.6×10^{-7}

2. Explain why each of the following *does not* result in an effective buffer? (15pts)
$$0.38\text{mol } HClO_4(aq) + 0.38\text{mol } NaOH(aq)$$

This is a strong acid/strong base combination. Not a buffer.

$$1.28\text{mol } H_2CO_3(aq) + 0.64\text{mol } HCl(aq)$$

This is an acid/acid combination. Not a buffer.

$$1.24\text{mol } HNO_2(aq) + 0.03\text{mol } NaNO_2(aq)$$

This is a weak acid/weak conjugate base combination, but the concentrations are too far apart to be an effective buffer

3. How much 1.156 M NaOH(aq) must be added to 45.00mL of 1.031 M HCl(aq) to reach the equivalence point? What is the pH of this solution at the equivalence point? (14pts)

$$NaOH(aq) + HCl(aq) \rightarrow H_2O(l) + NaCl(aq)$$
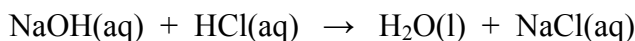
$$\left(1.031 \tfrac{\text{mols HCl}}{\text{L HCl sol'n}}\right)(0.04500\text{L HCl sol'n})\left(\frac{1\text{mol NaOH}}{1\text{mol HCl}}\right)\left(\frac{1\text{L NaOH sol'n}}{1.156\text{mol NaOH}}\right) = 0.04013\text{L NaOH(aq)}$$

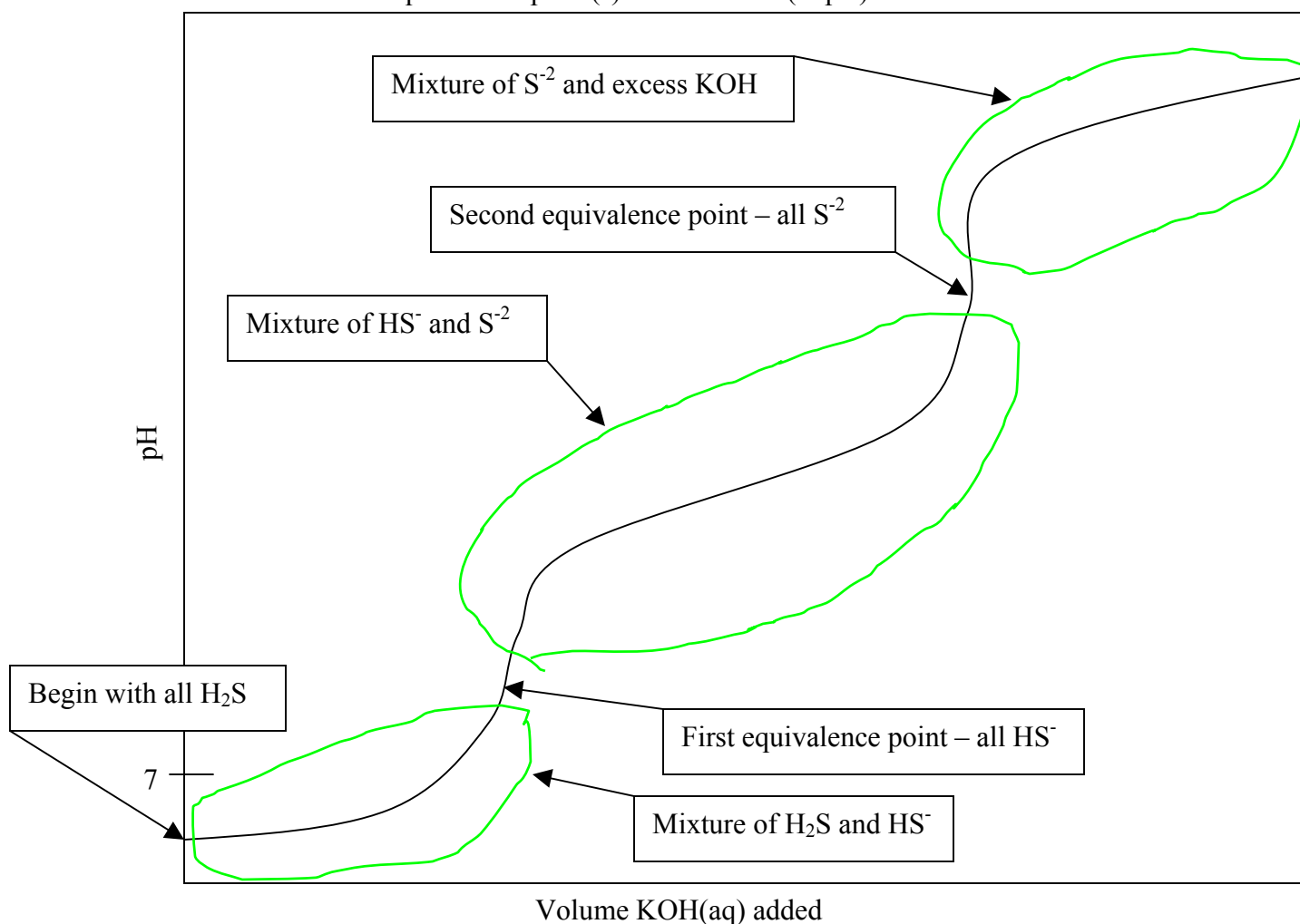Since this a strong acid/strong base titration, the pH at the equivalence point should be 7.

Score

4. You have prepared a buffer solution by combining 0.436mols of hypochorous acid (HClO,
    $K_a = 3.5 \times 10^{-8}$) and 0.382mols of sodium hypochlorite in enough water to make 600.0mL of
    solution. What is the pH of this buffer solution? (16pts)

Plugging in to the Henderson-Hasselbalch equation:
$$pH = pK_a + \log\frac{[conj.base]}{[conj.acid]} = -\log(3.5x10^{-8}) + \log\frac{0.382}{0.436} = 7.40$$

5. Sketch the titration curve (pH vs. volume added) for the titration of 1 M hydrosulfuric acid
    (H_2S, $K_{a1}=1\times10^{-7}$) and 1 M KOH(aq). Label all the axes (including approximately accurate
    numbers) and the major sulfur-based species present in solution at each point in the titration
    curve. Indicate the equivalence point(s) on the curve. (18pts)

Mixture of S^{-2} and excess KOH

Second equivalence point – all S^{-2}

Mixture of HS^- and S^{-2}

pH

Begin with all H_2S

7

First equivalence point – all HS^-

Mixture of H_2S and HS^-

Volume KOH(aq) added

Score

6. What is the K_b of a base if 300.0mL of a solution containing 0.442 mol of the base and 0.496 mol of its conjugate acid has a pH of 5.612? Over what pH range would this conjugate acid/ conjugate base pair make an effective buffer? (18pts)

Plugging in to the Henderson-Hasselbalch equation:
$$5.612 = pK_a + \log\frac{(0.442)}{(0.496)}$$
Solving:
pK_a for the conjugate acid $=$ 5.662
K_a for the conjugate acid $=$ 2.18x10^{-6}
K_b for the conjugate base $=$ 4.59x10^{-9}

This system would be a good buffer over the pH range 4.662 to 6.662

7. You have titrated 15.00mL of a monoprotic acid (K_a = 3.4x10^{-6}) with 0.264 M NaOH(aq). If o-Cresolphthalein (endpoint 8.3-9.8) is used as an indicator, you reach the endpoint when 28.61mL of base is added. Based on this data, what is the concentration of the acid? Would your result change if Bromoeresol Green (endpoint 3.9-5.4) was used as an indicator? If so, how? Which indicator (o-Cresolphthalein or Bromoeresol Green) more correctly indicates the equivalence point in this titration? (Explain your answers!) (21pts)

$$\left(0.264 \tfrac{\text{mol NaOH}}{\text{L NaOH sol'n}}\right)\left(0.02861\text{L NaOH}\right)\left(\frac{1\text{mol HA}}{1\text{mol NaOH}}\right)\left(\frac{1}{0.01500\text{L HA sol'n}}\right) = 0.504\text{M HA(aq)}$$

This is the titration of a weak acid with a strong base, so base should be added to the acid and the pH at the equivalence point should be basic. Therefore, if Bromoeresol Green is used as the indicator, it will change color when *less* base has been added. That would make the calculated concentration of HA *lower* than the concentration determined using o-Cresolphthalein.

Because the equivalence point should be basic, the indicator used in this titration should have an endpoint that is basic. o-Cresolphthalein is the more correct indicator for this titration.

Score