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 $= 6.022 \times 10^{23}$ $^{units}/_{mol}$

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

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

$P_1 = X_1 P_1^{o}$

$P = cRTi$

$C_1 V_1 = C_2 V_2$

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

Name: _____

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?
9.167×10^{-12}	**1.091×10^{-3}**	**11.0378**	**2.9622**	**Basic**
2.28×10^{-2}	**4.39×10^{-13}**	1.642	**12.358**	**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)

$$0.38\text{mol } HClO_4(aq) + 0.38\text{mol } NaOH(aq)$$

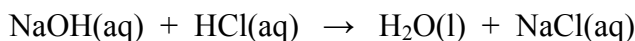**This is a strong acid/strong base combination. Not a buffer.**

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

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 0.824 M NaOH(aq) must be added to 25.00mL of 0.993 M HCl(aq) to reach the equivalence point? What is the pH of this solution at the equivalence point? (14pts)

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

$$\left(0.993 \tfrac{\text{mols HCl}}{\text{L HCl sol'n}}\right)\left(0.02500\text{L HCl sol'n}\right)\left(\frac{1\text{mol NaOH}}{1\text{mol HCl}}\right)\left(\frac{1\text{L NaOH sol'n}}{0.824\text{mol NaOH}}\right) = 0.0301\text{L NaOH(aq)}$$
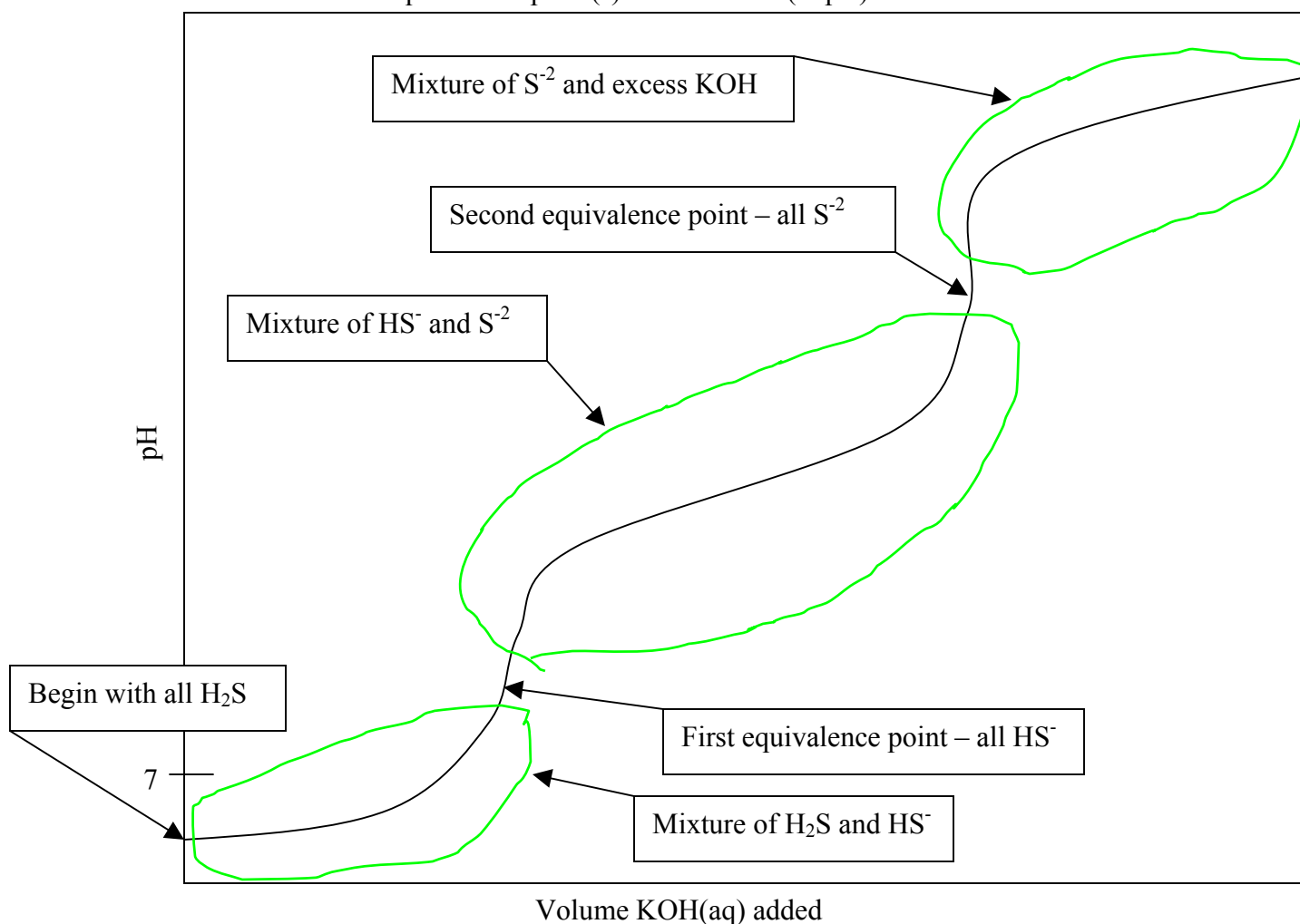
Since this a strong acid/strong base titration, the pH at the equivalence point should be 7.

Score

4. You have prepared a buffer solution by combining 0.237mols of hypochorous acid (HClO, $K_a = 3.5x10^{-8}$) and 0.186mols of sodium hypochlorite in enough water to make 500.0mL of solution. What is the pH of this buffer solution? (16pts)

Plugging in to the Henderson-Hasselbalch equation:

$$pH = pK_a + \log\frac{[conj.base]}{[conj.acid]} = -\log(3.5x10^{-8}) + \log\frac{0.186}{0.237} = 7.35$$

5. Sketch the titration curve (pH vs. volume added) for the titration of 1 M hydrosulfuric acid (H_2S, $K_{a1}=1x10^{-7}$) 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 500.0mL of a solution containing 0.153 mol of the base and 0.191 mol of its conjugate acid has a pH of 6.114? Over what pH range would this conjugate acid/ conjugate base pair make an effective buffer? (18pts)

> Plugging in to the Henderson-Hasselbalch equation:
> $$6.114 = pK_a + \log\frac{(0.153)}{(0.191)}$$
> Solving:
> pK_a for the conjugate acid $=$ 6.210
> K_a for the conjugate acid $=$ 6.16×10^{-7}
> K_b for the conjugate base $=$ 1.62×10^{-8}
>
> This system would be a good buffer over the pH range 5.210 to 7.210

7. You have titrated 35.00mL of a monoprotic acid ($K_a = 3.4 \times 10^{-6}$) with 0.891 M NaOH(aq). If o-Cresolphthalein (endpoint 8.3-9.8) 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 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)

> $$\left(0.891 \tfrac{\text{mol NaOH}}{\text{L NaOH sol'n}}\right)\left(0.03137\text{L NaOH}\right)\left(\frac{1\text{mol HA}}{1\text{mol NaOH}}\right)\left(\frac{1}{0.03500\text{L HA sol'n}}\right) = 0.799\text{M HA(aq)}$$
>
> 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