

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

$32.00^\circ\text{F} = 0.000^\circ\text{C} = 273.15\text{K}$

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

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

$1\text{atm} = 760\text{torr} = 760\text{mmHg} = 101.325\text{kPa}$

$PV = nRT$

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

For water: $k_{\text{fp}} = -1.86^\circ\text{C}/m$
 $k_{\text{bp}} = 0.512^\circ\text{C}/m$

$P_1 = X_1 P_1^\circ$

$\Pi = MRTi$

$C_1 V_1 = C_2 V_2$

Integrated Rate Laws:

0th $[A]_t = -kt + [A]_o$

1st $\ln[A]_t = -kt + \ln[A]_o$

2nd $1/[A]_t = kt + 1/[A]_o$

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

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

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

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

$E_{\text{cell}} = E_{\text{cell}}^\circ - \frac{RT}{nF} \ln Q$

$E_{\text{cell}}^\circ = \frac{RT}{nF} \ln K^\circ$

$K^\circ = e^{(nF/RT) E_{\text{cell}}^\circ}$

$F = 96485 \text{ J}/\text{V}\cdot\text{mol of electrons}$

$\Delta G^\circ = \Delta H^\circ_{\text{system}} - T\Delta S^\circ_{\text{system}}$

$\Delta G^\circ = -nFE_{\text{cell}}^\circ = -RT \ln K^\circ$

$\Delta G = \Delta G^\circ + RT \ln Q$

$F = 96485 \text{ C}/\text{mol electrons}$

$1A = 1 \text{ C} / \text{sec}$

Quadratic formula:

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

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	71 Lu 174.97	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	103 Lr (260)	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							

57 La 138.91	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
89 Ac 227.03	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)

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

$[\text{H}_3\text{O}^+]$	$[\text{OH}^-]$	pH	pOH	Acidic, Basic or Neutral?
1.39×10^{-9}				
			11.382	

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

Conjugate Acid	K_a @25°C	Conjugate Base	K_b @25°C
HNO_2			2.493×10^{-11}
	1.586×10^{-7}	HPO_4^{2-}	

3. A labmate has prepared a lactate/lactic acid buffer solution $\{\text{C}_3\text{H}_5\text{O}_3^{-1}(\text{aq}) / \text{HC}_3\text{H}_5\text{O}_3(\text{aq})\}$ at pH=4.05, but does not write much information down in a lab notebook. You know that the concentration of the buffer is 0.995M and $\text{p}K_b=10.140$ for $\text{C}_3\text{H}_5\text{O}_3^{-1}(\text{aq})$. Is the concentration of conjugate acid higher in this buffer or is the concentration of conjugate base in this buffer higher? Over what pH range would lactate/lactic acid make an effective buffer? Explain your answers. (10pts)
4. How many milliliters of 0.439M $\text{HClO}_4(\text{aq})$ must be added to 25.00mL of 0.396M $\text{Mg}(\text{OH})_2(\text{aq})$ to reach the equivalence point? What is the pH of this solution at the equivalence point? Explain any assumptions. (10pts)

5. What is the expected pH of a 0.834M aqueous solution of hypochlorous acid? $\{K_a(\text{HClO}) = 3.462 \times 10^{-8}\}$ (10pts)
6. What is the expected pH of a 0.337M aqueous solution of potassium cyanide? $\{K_b(\text{CN}^-) = 3.0 \times 10^{-5}\}$ (10pts)
7. You have prepared a buffer solution by combining 0.537mols of benzoic acid ($\text{HC}_7\text{H}_5\text{O}_2$, $K_a = 6.4 \times 10^{-5}$) and 0.394mols of sodium benzoate in enough water to make 600.0mL of solution. What is the pH of this buffer solution? (10pts)
8. What is the K_b of a weak base if 500.0mL of a solution containing 0.218mol of the base and 0.243mol of its conjugate acid has a pH of 6.837? Over what pH range would this conjugate acid/ conjugate base pair make an effective buffer? (12pts)

9. You have titrated 25.00mL of 0.413M sulfurous acid solution with an unknown sodium hydroxide solution. You reach the second equivalence point when 39.62mL of base is added. What is the concentration of the original stock sodium hydroxide solution? $\{K_{a1}(\text{H}_2\text{SO}_3) = 1.54 \times 10^{-2}, K_{a2} = 1.02 \times 10^{-7}\}$ (12pts)
10. You have titrated 20.00mL of an unknown arsenic acid $\{\text{H}_3\text{AsO}_4(\text{aq}), pK_{a1}=2.30, pK_{a2}=7.10, pK_{a3}=11.53\}$ solution to the second equivalence point with 41.63mL of 0.387M potassium hydroxide. Write out balanced chemical equations for the step-wise deprotonation of arsenic acid. Sketch the titration curve and label all equivalence points and all arsenic acid-based species in solution in all portions of the curve. What is the concentration of the unknown arsenic acid solution? How many milliliters were required to reach the *first* equivalence point in this titration? (18pts)
11. You need to determine the exact concentration of a freshly prepared solution of propanoic acid ($\text{C}_2\text{H}_5\text{COOH}(\text{aq}), K_a = 1.34 \times 10^{-5}$) that is approximately 0.5M, but your pH probe is not working. You have found the following visual pH indicators in your lab: Methyl Red (MR, endpoint = 4.4-6.2), Phenol Red (PR, endpoint = 6.4-7.7), Cresol Red (CR, endpoint = 7.2-8.8). If you are titrating with a 0.429M NaOH(aq) solution, which indicator(s) would you choose for this titration? Explain your answer. (10pts)