FORMULA SHEET (tear off)

1A	2A											3A	4A	5A	6A	7A	8A
1 H 1.01																	2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 181.0	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]	103 Lr [262]	104 Rf [261]	105 Db [262]	106 Sg [266]												

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [145]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0
89 Ac [227]	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np [237]	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]

$N_A = 6.022 \times 10^{23}$ $\quad$ °C = ($^5/_9$) (°F - 32) $\quad$ °F = ($^9/_5$)(°C) + 32

1 amu = 1.661×10^{-27} kg $\quad$ °C = K - 273.15 $\quad$ K = °C + 273.15

1 atm = 760 torr = 760 mm Hg $\quad$ 1 atm = 1.013 bar $\quad$ $pV = nRT$

R = 0.08206 L•atm/mol•K $\quad$ 1 L•atm = 101.3 J

R = 8.314 J/mol•K $\quad$ 1 J= 1 kg•m^2/s^2

$p_A = X_A\, p_A°$ $\quad$ $[B] = k\, p_B$ $\quad$ $\Delta p_A = X_B p_A°$

$\Delta T_b = K_b\, m_B$ $\quad$ $\Delta T_f = K_f\, m_B$ $\quad$ $\Pi = [B]RT$

$H = U + pV$ $\quad$ $G = H - TS$

$\Delta G_{rxn} = \Delta G°_{rxn} + RT \ln Q$ $\quad$ $\ln K = - \Delta G°_{rxn}/RT$ $\quad$ $K_p = K_C\, (RT)^{\Delta n}$

If $ax^2 + bx + c = 0$, then $x = \left(\frac{- b \pm [b^2 - 4ac]^{1/2}}{2a} \right)$

$K_a \bullet K_b = K_w = 1.0 \times 10^{-14}$ (at T = 25°C) $\quad$ $pH = pK_a + \log_{10}\{[\text{base}]/[\text{acid}]\}$

GENERAL CHEMISTRY 2
THIRD HOUR EXAM

Name ____

Panthersoft ID ____

Signature ____

Part 1 ________________ **(16 points)**

Part 2 ________________ **(24 points)**

Part 3 ________________ **(40 points)**

TOTAL ________________ **(80 points)**

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Do all of the following problems. Show your work.

Part 1. Multiple choice. Circle the letter corresponding to the correct answer. There is one and only one correct answer per problem. [4 points each]

1) From the substances HI, H_2S, and H_2Se

a) HI is the strongest acid and H_2Se is the weakest acid
b) HI is the strongest acid and H_2S is the weakest acid
B c) H_2S is the strongest acid and HI is the weakest acid
d) H_2S is the strongest acid and H_2Se is the weakest acid
e) H_2Se is the strongest acid and H_2S is the weakest acid

2) In the reaction

$$Al(H_2O)_6^{3+}(aq) + H_2O(\ell) \leftrightarrows Al(H_2O)_5OH^{2+}(aq) + H_3O^+(aq)$$

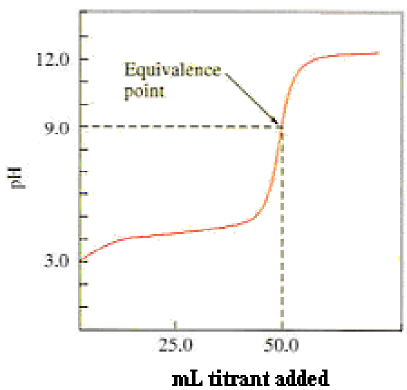
the $Al(H_2O)_6^{3+}$ ion functions as

a) the conjugate base of H_2O
b) the conjugate acid of H_2O
D c) a Bronsted base
d) a Bronsted acid
e) none of the above

3) A small amount of a strong acid is added to a buffer solution. What will happen to the pH of the solution?

a) The pH will increase by a large amount
b) The pH will decrease by a large amount
D c) The pH will increase by a small amount
d) The pH will decrease by a small amount
e) The pH will not change

4) A titration curve is given in the figure below. The titration is carried out at T = 25. °C.



Based on this curve, we may say that

a) a strong acid is being titrated with a strong base
b) a weak acid is being titrated with a strong base
B c) a strong base is being titrated with a strong acid
d) a weak base is being titrated with a strong acid
e) cannot tell from the information given

Part 2. Short answer.

1) Define the following terms [4 points each]

end point (for an acid/base titration) – The point in the titration where the change in the color of the indicator is observed.

polyprotic acid - An acid that contains two or more donatable protons.

2) Values for K_b for several weak bases are given below, at T = 25. °C.

NH_3	$K_b = 1.8 \times 10^{-5}$	$(C_2H_5)_2NH$	$K_b = 5.4 \times 10^{-4}$
C_5H_5N	$K_b = 1.7 \times 10^{-9}$	$C_6H_5NH_2$	$K_b = 3.8 \times 10^{-10}$

From the lists below circle the correct answer. There is one and only one correct answer per problem. [4 points each]

a) The strongest weak base

NH_3 **$(C_2H_5)_2NH$** C_5H_5N $C_6H_5NH_2$

b) The strongest conjugate acid

NH_4^+ $(C_2H_5)_2NH_2^+$ $C_5H_5NH^+$ **$C_6H_5NH_3^+$**

3) A buffer is formed by adding an equal number of moles of hypochlorous acid (HClO, $K_a = 3.5 \times 10^{-8}$) and potassium hypochlorite (KClO) to water, at T = 25. °C.

a) What is the pH of the buffer? [4 points]

From the Henderson equation, $pH = pK_a + \log_{10}\{[base]/[acid]\}$. But $[HClO] = [ClO^-]$, so

$pH = pK_a = -\log_{10}(3.5 \times 10^{-8}) = 7.46$

b) Give the balanced reaction that takes place when a small amount of potassium hydroxide (KOH) is added to the above buffer. [4 points]

$KOH(aq) + HClO(aq) \rightarrow K^+(aq) + ClO^-(aq) + H_2O(\ell)$

Part 3. Problems.

1) Hypochlorous acid (HOCl) is a weak acid, with $K_a = 3.5 \times 10^{-8}$ at T = 25. °C.

a) Give the conjugate base of HOCl (correct formula and charge) [4 points]

______OCl^-____________

b) What is the pH and the percent dissociation for a 0.00900 M aqueous solution of HOCl at T = 25. °C? [12 points]

Reaction is $HOCl(aq) + H_2O(\ell) \leftrightarrows H_3O^+(aq) + OCl^-(aq)$

$$K_a = \frac{[H_3O^+]\,[OCl^-]}{[HOCl]} = 3.5 \times 10^{-8}$$

	Initial	Change	Equilibrium
H_3O^+	0	x	x
OCl^-	0	x	x
HOCl	0.00900	- x	0.00900 - x

So $$\frac{(x)\,(x)}{(0.00900 - x)} = 3.5 \times 10^{-8}$$

If we assume x << 0.00900, then we get

$$\frac{x^2}{(0.00900)} = 3.5 \times 10^{-8} \qquad x^2 = (3.5 \times 10^{-8})\,(0.00900) = 3.15 \times 10^{-10}$$

$$x = (3.15 \times 10^{-10})^{1/2} = 1.78 \times 10^{-5}$$

$$pH = -\log_{10}(1.78 \times 10^{-5}) = 4.75$$

$$\%\ \text{ionization} = \frac{[OCl^-]_{eq}}{[HOCl]_{initial}} \times 100\% = \frac{(1.78 \times 10^{-5})}{(0.00900)} \times 100\ \% = 0.20\ \%$$

2) A 0.687 g sample of a weak monoprotic acid is titrated with a 0.1826 M solution of NaOH, a strong base. After 25.89 mL of the NaOH solution has been added the equivalence point for the titration is reached. What is the molecular mass of the weak monoprotic acid? [12 points]

Let HA = weak acid $\quad HA(aq) + NaOH(aq) \rightarrow NaA(aq) + H_2O(\ell)$

$$\text{moles HA} = 0.02589 \text{ L NaOH soln} \; \frac{0.1826 \text{ mol NaOH}}{\text{L soln}} \; \frac{1 \text{ mol HA}}{1 \text{ mol NaOH}} = 4.73 \times 10^{-3} \text{ mol HA}$$

$$\text{MW} = \frac{0.687 \text{ g HA}}{4.73 \times 10^{-3} \text{ mol HA}} = 145. \text{ g/mol}$$

3) A chemist prepares 1.000 L of a 0.0218 M solution of iodoacetic acid (CH_2ICOOH, MW = 185.9 g/mol), a weak monoprotic acid with $K_a = 7.6 \times 10^{-4}$ at T = 25. °C. How many grams of sodium iodoacetate ($NaCH_2ICOO$, MW = 207.9 g/mol) must be added to the solution to convert it into a pH = 3.00 buffer? [12 points]

From the Henderson equation, $\quad pH = pK_a + \log_{10}\{[\text{base}]/[\text{acid}]\}$

$\log_{10}\{[\text{base}]/[\text{acid}]\} = pH - pK_a \qquad pK_a = -\log_{10}(7.6 \times 10^{-4}) = 3.12$

$= 3.00 - 3.12 = -0.12$

Taking the inverse $\log_{10}$, we get $\quad \{[\text{base}]/[\text{acid}]\} = 10^{-0.12} = 0.759$

$[\text{base}] = 0.759 \, [\text{acid}] = 0.759 \, (0.0218 \text{ M}) = 0.01654 \text{ M}$

$$\text{So mass of } NaCH_2ICOO = 1.000 \text{ L} \; \frac{0.01654 \text{ mol}}{\text{L}} \; \frac{207.9 \text{ g}}{\text{mol}} = 3.44 \text{ g } NaCH_2ICOO$$