CHMG 152 Exam #2 Name:_____

Please SHOW ALL WORK!!!!

$$R = 0.082058 \frac{L\ atm}{mol\ K} = 8.314 \frac{J}{mol\ K}$$

Dissociation constants of acids:

HOAc $K_a=1.78x10^{-5}$
H_2SO_4 $K_{a1}=1x10^{7}$ $K_{a2}=1.0x10^{-2}$
HCNO $K_a=2x10^{-4}$
H_2CO_3 $K_{a1}=4.3x10^{-7}$ $K_{a2}=5.6x10^{-11}$

H_2O $K_w=1.0x10^{-14}$
HIO $K_a=2.3x10^{-11}$
HIO_3 $K_a = 1.7x10^{-4}$
HCl $K_a=1x10^{8}$
HNO_3 $K_a=1x10^{6}$
HF $K_a = 3.5x10^{-4}$
$H_2C_2O_4$ $K_{a1} = 6.0x10^{-2}$ $K_{a2} = 6.1x10^{-5}$

Strong Acids	Strong Bases
HCl	KOH
HNO_3	NaOH
H_2SO_4 (K_{a1})	$Ba(OH)_2$
$HClO_4$	$Ca(OH)_2$
HBr	$Sr(OH)_2$
HI	LiOH

Dissociation constants of bases:

NH_3 $K_b=1.76x10^{-5}$
CH_3NH_2 $K_b=4.4x10^{-4}$
$HONH_2$ $K_b=1.1x10^{-8}$

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

1. (20 pt.) What is the pH of 0.100 M CH_3NH_2?

Hey, it's an equilibrium problem! It has THREE PARTS!

	CH_3NH_2 (aq) +	H_2O (l)	→	OH^- (aq) +	$CH_3NH_3^+$ (aq)
I	0.100			0	0
C	-x	-		+x	+x
E	0.100-x			x	x

$$K_b = 4.4 \times 10^{-4} = \frac{(x)(x)}{(0.10 - x)}$$

Assume x<<0.325

$$4.4 \times 10^{-4} \approx \frac{(x)(x)}{(0.10)}$$

$$x = 6.63 \times 10^{-3}, good\ assumption$$

pOH=-log(0.00663) = 2.18
pH=14-pOH = 11.82

2. (20 pt.) Vanadium can be obtained by the reduction of vanadium salts (VO^+) by chloride ion at 298 K:

$VO^+_{(aq)} + Cl^-_{(aq)} \leftrightarrow V_{(s)} + OCl_{(aq)}$ $\quad\quad$ $K_c = 1.70$

150 mL of 0.250 M VO^+ is mixed with 150 mL of 0.100 M Cl^- at 298 K. How many grams of Vanadium metal would I expect to make?

Hey, there's a K! It's an equilibrium problem. It must have 3 parts!

Don't forget the dilution!

(0.250 M VO^+)(150 mL) = M_2 (300 mL total)

M_2 = 0.125 M Sn^{2+}

(0.100 M Cl^-)(150 mL) = M_2 (300 mL total)

M_2 = 0.05 M Co^{2+}

	$VO^+(aq)$	$+ Cl^-(aq)$	$\leftrightarrow$	$V(s)$	$+ OCl^-(aq)$
I	0.125	$0.05\ M$		0	0
C	$-x$	$-x$		$+x$	$+x$
E	$0.125-x$	$0.05-x$		X	X

Solids have an activity of 1, so it doesn't appear in K

$$K = 1.7 = \frac{(x)}{(0.125 - x)(0.05 - x)}$$

$$x = 0.0088\ M\ or\ 0.709\ M$$

Only the 1st root makes sense, 0.709 M is way too big in the ICE chart.

$$\frac{0.0088\ mol}{L}\,0.300\ L = 0.00264\ mol\,\frac{50.94\ g}{mol} = 0.135\ g$$

3. (20 pt.) 0.3 moles of $CO_{(g)}$ and 0.3 moles of chlorine gas are mixed in an otherwise evacuated 2 Liter flask at 298 K. Carbon monoxide and chlorine will combine to form $COCl_{2\,(g)}$ at 298 K. When equilibrium has been established, the total pressure in the flask is found to be 4.24 atm. What is the K_p of this reaction.

PV=nRT

$$P = \frac{nRT}{V} = \frac{(0.3\ mol)(0.082058\frac{Latm}{molK})(298\ K)}{2\ L} = 3.668\ atm$$

	$CO(g) + Cl_2\ (g) \leftrightarrow COCl_2(g)$		
I	3.668 atm	3.668 atm	0 atm
C	-x	-x	+x
E	3.668-x	3.668-x	x

P_{tot} = 4.24 atm = $P_{cO} + P_{Cl2} + P_{COCl2}$ = 3.668-x + 3.668-x + x
X = 3.096

$$K_p = \frac{P_{cocl_2}}{P_{CO}P_{cl_2}} = \frac{3.096}{(3.668-3.096)(3.668-3.096)} = 9.46$$

4. (20 pt) 10.00 mL of 0.250 M NH_3 (K_b=1.8x10^{-5}) is titrated with a 0.100 M solution of HCl. What is the pH of the solution after 20.00 mL of HCl has been added?
0.250 M NH_3 * 0.010 L = 0.0025 mol NH_3
0.100 M HCl * 0.020 L = 0.002 mol HCl

Neutralization:

	NH_3 + HCl →	NH_4^+ +	Cl^-
I	0.0025 0.002	0	0
C	-x -x	+x	+x
E	0.0025-x 0	x	x

0.002-x=0
X=0.002

	NH_3 + HCl →	NH_4^+ +	Cl^-
I	0.0025 0.002	0	0
C	-0.002 -0.002	+0.002	+0.002
E	0.0005 0	0.002	0.002

It's a buffer!

	NH_3 + H_2O ↔	NH_4^+ +	OH^-
I			
C			
E			

$pH = pK_a + \log[NH_3]/[NH_4^+]$
pH = 9.26 + log (0.0005/0.002)
pH = 8.66

5. (20 pt.) A 3.2 M aqueous solution of caproic acid ($HC_6H_{11}O_2$) has a pH of 2.94. What is the K_a of the acid?

$$HC_6H_{11}O_{2\,(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + C_6H_{11}O_2^-{}_{(aq)}$$

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$$HC_6H_{11}O_{2\,(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + C_6H_{11}O_2^-{}_{(aq)}$$

I	3.2 M	0	0
C	-x	+x	+x
E	3.2-x	x	x

$pH = - \log [H_3O^+]$
$2.94 = - \log [H_3O^+]$
$[H_3O^+ = 10^{-2.94} = 1.15x10^{-3}$

$K_a = (x*x)/3.2-x = (1.15x10^{-3})^2/(3.2-1.15x10^{-3})$
$K_a = 4.12x10^{-7}$

The Periodic Table of the Elements

1 **H** Hydrogen 1.00794																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012182											5 **B** Boron 10.811	6 **C** Carbon 12.0107	7 **N** Nitrogen 14.00674	8 **O** Oxygen 15.9994	9 **F** Fluorine 18.9984032	10 **Ne** Neon 20.1797
11 **Na** Sodium 22.989770	12 **Mg** Magnesium 24.3050											13 **Al** Aluminum 26.981538	14 **Si** Silicon 28.0855	15 **P** Phosphorus 30.973761	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.4527	18 **Ar** Argon 39.948
19 **K** Potassium 39.0983	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.955910	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.9415	24 **Cr** Chromium 51.9961	25 **Mn** Manganese 54.938049	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933200	28 **Ni** Nickel 58.6934	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92160	34 **Se** Selenium 78.96	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.4678	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.90585	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.90638	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.90550	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.8682	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.710	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90447	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.90545	56 **Ba** Barium 137.327	57 **La** Lanthanum 138.9055	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.9479	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.078	79 **Au** Gold 196.96655	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.3833	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98038	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (263)	107 **Bh** Bohrium (262)	108 **Hs** Hassium (265)	109 **Mt** Meitnerium (266)	110 (269)	111 (272)	112 (277)	113	114				

58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.90765	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.92534	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93032	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93421	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
90 **Th** Thorium 232.0381	91 **Pa** Protactinium 231.03588	92 **U** Uranium 238.0289	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)