Surname (last name):______________________________

Given name (first name):______________________________

Student number:_____________________

Course: 1311 C

Chemistry 1311C
Midterm 2
Nov. 24th, 2011

Please keep your work covered and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the University.

A periodic table, formula sheet are provided. You may rip these 2 pages off of the exam and use them to cover your work.

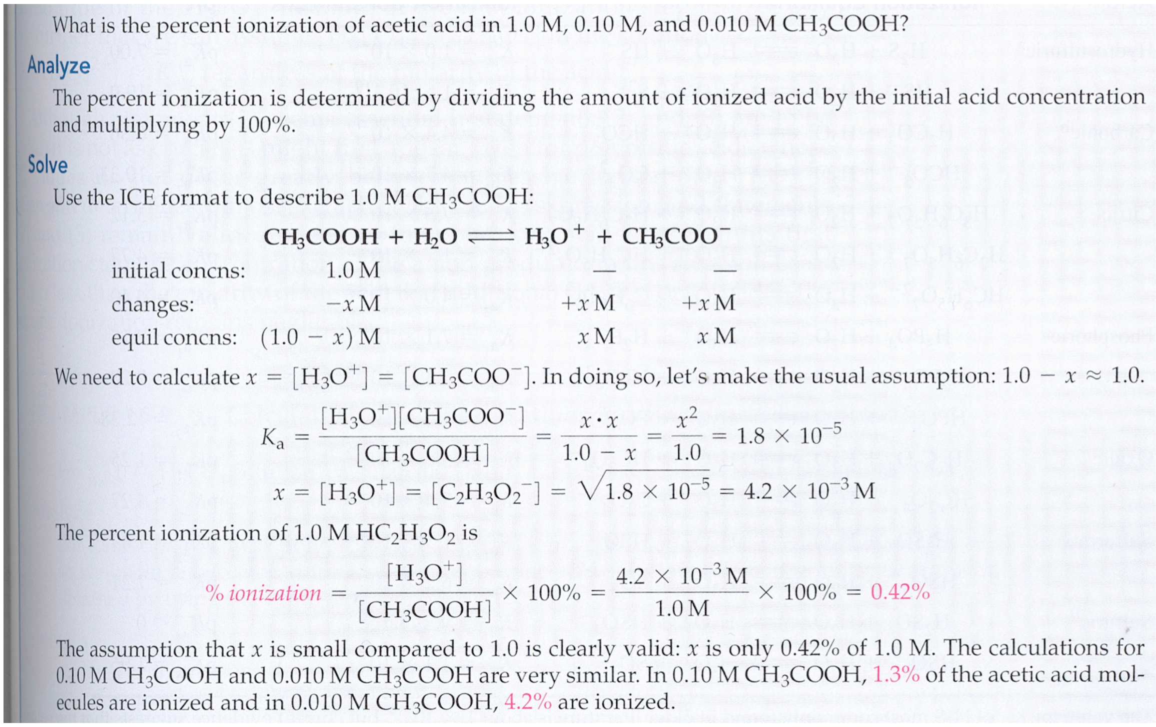
You have 80 minutes to complete the exam.

For each question, please write your final answer in the space provided.

Question	1	2	3	4	5	6
Points	5	5	5	5	5	5
Note						

Totale
30

1. Acetic acid is a weak acid with K_a=1.8 x 10^{-5}. What is the percent ionization of acetic acid in **a**) 1.0 M, **b**) 0.10 M and **c**) 0.010 M CH_3COOH?



What is the percent ionization of acetic acid in 1.0 M, 0.10 M, and 0.010 M CH_3COOH?

Analyze

The percent ionization is determined by dividing the amount of ionized acid by the initial acid concentration and multiplying by 100%.

Solve

Use the ICE format to describe 1.0 M CH_3COOH:

$$\mathbf{CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-}$$

initial concns:	1.0 M	—	—
changes:	$-x$ M	$+x$ M	$+x$ M
equil concns:	$(1.0 - x)$ M	x M	x M

We need to calculate $x = [H_3O^+] = [CH_3COO^-]$. In doing so, let's make the usual assumption: $1.0 - x \approx 1.0$.

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]} = \frac{x \cdot x}{1.0 - x} = \frac{x^2}{1.0} = 1.8 \times 10^{-5}$$

$$x = [H_3O^+] = [C_2H_3O_2^-] = \sqrt{1.8 \times 10^{-5}} = 4.2 \times 10^{-3}\,\text{M}$$

The percent ionization of 1.0 M $HC_2H_3O_2$ is

$$\%\ \textit{ionization} = \frac{[H_3O^+]}{[CH_3COOH]} \times 100\% = \frac{4.2 \times 10^{-3}\,\text{M}}{1.0\,\text{M}} \times 100\% = 0.42\%$$

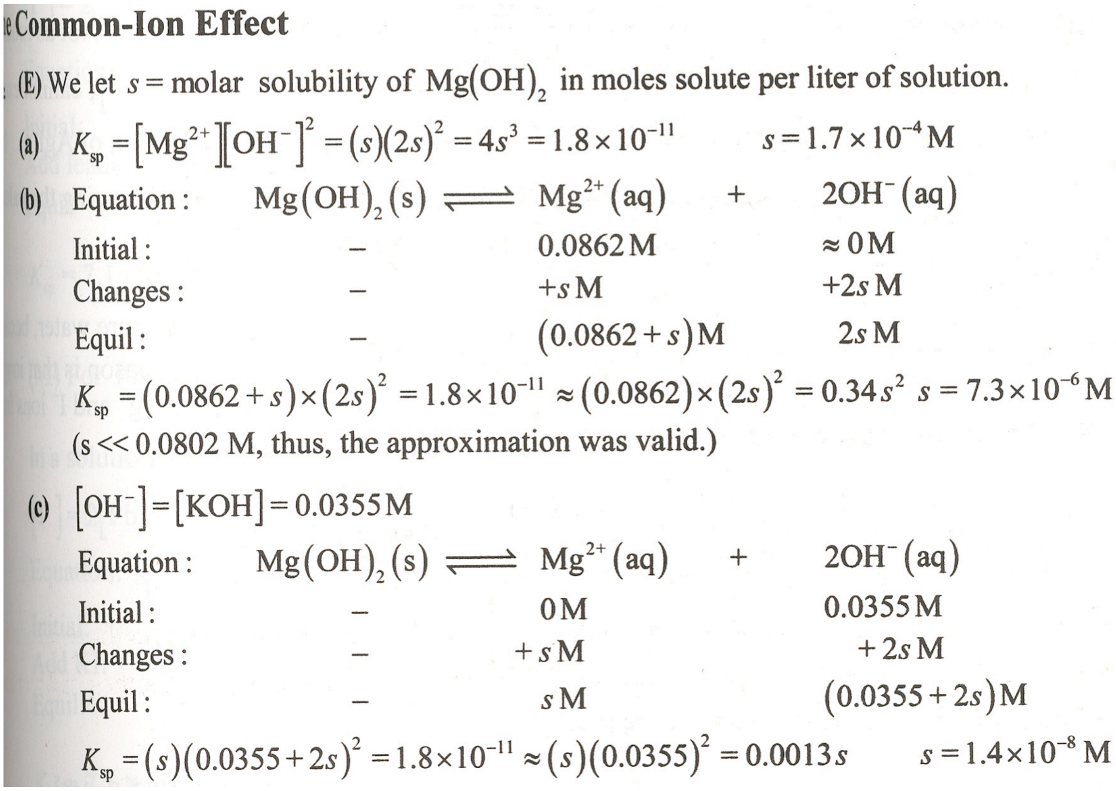
The assumption that x is small compared to 1.0 is clearly valid: x is only 0.42% of 1.0 M. The calculations for 0.10 M CH_3COOH and 0.010 M CH_3COOH are very similar. In 0.10 M CH_3COOH, 1.3% of the acetic acid molecules are ionized and in 0.010 M CH_3COOH, 4.2% are ionized.

2. Common ion effect: Calculate the molar solubility of Mg(OH)$_2$ (K_{sp}= 1.8 x 10^{-11}) in:

a) Pure water

b) 0.0862 M MgCl$_2$

c) 0.0355 M KOH (aq)



Common-Ion Effect

(E) We let s = molar solubility of $\mathrm{Mg(OH)_2}$ in moles solute per liter of solution.

(a) $K_{sp} = [\mathrm{Mg^{2+}}][\mathrm{OH^-}]^2 = (s)(2s)^2 = 4s^3 = 1.8 \times 10^{-11}$ $\quad s = 1.7 \times 10^{-4}\,\mathrm{M}$

(b)

Equation :	$\mathrm{Mg(OH)_2(s)} \rightleftharpoons$	$\mathrm{Mg^{2+}(aq)}$	+	$\mathrm{2OH^-(aq)}$
Initial :	–	0.0862 M		≈ 0 M
Changes :	–	$+s$ M		$+2s$ M
Equil :	–	$(0.0862 + s)$M		$2s$ M

$K_{sp} = (0.0862 + s) \times (2s)^2 = 1.8 \times 10^{-11} \approx (0.0862) \times (2s)^2 = 0.34s^2$ $\quad s = 7.3 \times 10^{-6}\,\mathrm{M}$

(s << 0.0802 M, thus, the approximation was valid.)

(c) $[\mathrm{OH^-}] = [\mathrm{KOH}] = 0.0355\,\mathrm{M}$

Equation :	$\mathrm{Mg(OH)_2(s)} \rightleftharpoons$	$\mathrm{Mg^{2+}(aq)}$	+	$\mathrm{2OH^-(aq)}$
Initial :	–	0 M		0.0355 M
Changes :	–	$+s$ M		$+2s$ M
Equil :	–	s M		$(0.0355 + 2s)$M

$K_{sp} = (s)(0.0355 + 2s)^2 = 1.8 \times 10^{-11} \approx (s)(0.0355)^2 = 0.0013s$ $\quad s = 1.4 \times 10^{-8}\,\mathrm{M}$

3. You are given a 0.500L of a 0.660M solution of HOBr (Ka= 2.10×10^{-9})

(a) What is the pH of this solution?

Answer:

$HOBr \longrightarrow H^+ \quad OBr^-$

$0.660 \quad - \quad -$

$0.660-x \quad x \quad x$

$x^2/0.660-x = 2.10x\ 10^{-9}$

Since $0.66>>2.1x10^{-9}$ *we will use the "assumption" and* $0.66-x = 0.66$

$x^2 = 2.10x10^{-9}\ x\ 0.660 = 1.39x10^{-9}$

$x = 3.72\ x\ 10^{-5}$

This is the $[H^+]$ *so* $pH = 4.43$

(b) You now add 18.51g of KOH to this solution.
What is the pH of this solution?

Answer:

Moles of HOBr = 0.500L x 0.660M = 0.330 moles HOBr

18.5 g x (1 mole/56.11g) = 0.3297 = 0.330 moles

Added 0.330 moles of KOH

The reaction is 1:1

$KOH + HOBr \rightarrow K^+ + H_2O + OBr^-$

This solution now contains 0.330 mole/0.5L or 0.660M OBr^-

This species is a base

$OBr^- + H_2O \rightarrow HOBr + OH^-$ *and* $Kb = Kw/Ka = 10^{-14}/2.10x10^{-9} = 0.476\ x\ 10^{-5}$

$OBr^- + H_2O \qquad HOBr + \qquad OH^-$

0.660

$0.660-x \quad x \quad x$

$x^2/(0.660-x) = 4.76x10^{-6}$

Since $0.660>>4.76x10^{-6}$ *we will use the "assumption" and* $0.66-x = 0.66$

$x^2 = 0.660\ x\ 4.76x10^{-6} \qquad x^2 = [OH^-] = 3.14\ x\ 10^{-6} \qquad pOH = 2.75$ *and* $pH = 11.24$

4. (a) What is the minimum value of n for the following *l* values?

l = 3

minimum n = 4

l = 2

minimum n = 3

(b) Circle (neatly!) the best **single** answer to the following question.

An atomic wavefunction represents:

i. the region of high probability for an electron around the nucleus of an atom

ii. the exact location of the electron

iii. the repulsion of all the electrons among themselves

iv. the region of high electron density for a covalent bond

v. an orbit that an electron follows around the nucleus of an atom

(c) How many orbitals are available with the following sets of quantum numbers?

n = 4, *l* = 2, m_l = 1

There is only one orbital (2 electrons)

n = 3, *l* = 3, m_l = -1, m_s= -1/2

zero orbitals, for n = 3 l cannot equal 3

n = 4, *l* = 3

m_l =-3, -2, -1, 0, 1, 2, 3. There are 7 orbitals (they can hold 14 electrons)

5. What is the electron configuration for the following metal ions and how many unpaired electrons do they have? Diamagnetic or paramagnetic?

a) Fe(III)

Electron configuration: d^5
Number of unpaired electrons: 5
Diamagnetic or Paramagnetic: para

b) Co(II)

Electron configuration: d^7
Number of unpaired electrons: 3
Diamagnetic or Paramagnetic: para

c) Zn(II)

Electron configuration: d^{10}
Number of unpaired electrons: 0
Diamagnetic or Paramagnetic: dia

6) a) For a hydrogen atom, if an electron drops from the excited state where n = 3 to the ground state, what energy of light is emitted?

$$\Delta E = R_H\left(\frac{1}{n_l^2} - \frac{1}{n_h^2}\right)$$

$$\Delta E = 2.18 \times 10^{-18}\ \text{J}\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$$

$= 1.94 \times 10^{-18}$ J
The energy of light emitted is $=1.94 \times 10^{-18}$ J

b) what *wavelength* of light is emitted in nm?

E= 1.94 x 10^{-18} J;

λ = hc/E

λ = (6.626 x 10^{-34} J.S)(3.00 x 10^{8} m/s)/(1. 1.94 x 10^{-18} J)=1.025 x 10^{-7} m = 102.5 nm

EQUATIONS SHEET

$\Delta H^o_{rxn} = \Sigma n\Delta H^o_f$ (products) – $\Sigma m\Delta H^o_f$ (reactants)

$\Delta S^o_{rxn} = \Sigma nS^o$ (products) – ΣmS^o (reactants)

$PV = nRT$ $\quad$ $\Delta G = \Delta H - T\Delta S$ $\quad$ $\Delta G^o = -RT\ln K$

$\upsilon_{rms} = (3RT/MM)^{1/2}$ $\quad$ $\Delta E = q + w$ $\quad$ $\Delta G = \Delta G^o + RT\ln Q$

$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$ $\quad$ $q = ms\Delta T$ $\quad$ $q = C\Delta T$

$w = -P\Delta V$ $\quad$ $[A] = -kt + [A]_o$ $\quad$ $t_{1/2} = 0.693/k$

$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ $\quad$ $1/[A] = kt + 1/[A]_o$ $\quad$ $\ln[A] = -kt + \ln[A]_o$

$P_A = X_A P_A^o$ $\quad$ $P_A = X_A P_{Total}$ $\quad$ $P_{total} = P_1 + P_2 + \ldots$ $\quad$ $K_P = K_C(RT)^{\Delta n}$

Solubility = $k_H P_{gas}$ $\quad$ $KE = (3/2)\ RT$ $\quad$ $d = [P(MM)/RT]$

$pH = -\log[H_3O^+]$ $\quad$ $pOH = -\log[OH^-]$ $\quad$ $pH + pOH = 14$

$K_w = K_a \times K_b$ $\quad$ $pH = pKa + \log\frac{[\text{conjugate base}]}{[\text{acid}]}$

$E^o_{cell} = E^o_{reduction} + E^o_{oxidation}$ $\quad$ Charge (C) = current (A) x time (s)

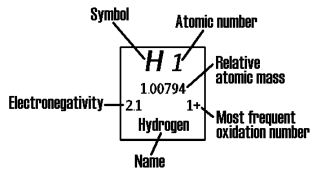
$E^o = (0.0257/n)\ln K$ $\quad$ $E = E^o - (0.0257/n)\ln Q$ $\quad$ $\Delta G = -nFE_{cell}$

$E = hc/\lambda$ $\quad$ $E = h\nu$ $\quad$ $c = \lambda\nu$

$$\Delta E = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

Constants:		Conversion Factors :
Avogadro's Number (N_A)	6.02×10^{23}	$1\ A = 1\ C\ s^{-1}$
Faraday's constant (F)	96,500 C/mol e^-	$1\ C = 1\ J\ V^{-1}\ mol^{-1}$
Universal Gas Constant (R)	$8.314\ J\ mol^{-1}\ K^{-1}$ $8.314\ kg\ m^2\ mol^{-1}\ K^{-1}\ s^{-2}$ $0.08206\ L\ atm\ mol^{-1}\ K^{-1}$	
Planck's constant (h)	6.626×10^{-34} J s	1 atm = 760 torr
Rydberg Constant (R_H)	2.18×10^{-18} J	= 760 mm Hg
Speed of light(c)	3.00×10^8 m/s	= 101.3 kPa

$ax^2+bx+c=0$; $\quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$



	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	*H 1* 1.00794 2.1 1+ Hydrogen																	*He 2* 4.002602 - - Helium
2	**Li 3** 6.941 1.0 1+ Lithium	**Be 4** 9.012182 1.5 2+ Beryllium											**B 5** 10.811 2.0 3+ Boron	**C 6** 12.011 2.5 4+,4- Carbon	*N 7* 14.00674 3.0 3+,3- Nitrogen	*O 8* 15.9994 3.5 2- Oxygen	*F 9* 18.9984032 4.0 1- Fluorine	*Ne 10* 20.1797 - - Neon
3	**Na 11** 22.989768 0.9 1+ Sodium	**Mg 12** 24.3050 1.2 2+ Magnesium											**Al 13** 26.981539 1.5 3+ Aluminum	**Si 14** 28.0855 1.8 4+ Silicon	**P 15** 30.973762 2.1 5+ Phosphorus	**S 16** 32.066 1.8 4+ Sulfur	*Cl 17* 35.4527 3.0 1- Chlorine	*Ar 18* 39.948 - - Argon
4	**K 19** 39.0983 0.8 1+ Potassium	**Ca 20** 40.078 1.0 2+ Calcium	**Sc 21** 44.955910 1.3 3+ Scandium	**Ti 22** 47.88 1.5 4+ Titanium	**V 23** 50.9415 1.6 5+ Vanadium	**Cr 24** 51.9961 1.6 3+ Chromium	**Mn 25** 54.93805 1.5 2+ Manganese	**Fe 26** 55.847 1.8 3+ Iron	**Co 27** 58.9332 1.8 2+ Cobalt	**Ni 28** 58.6934 1.8 2+ Nickel	**Cu 29** 63.546 1.9 2+ Copper	**Zn 30** 65.39 1.6 2+ Zinc	***Ga 31*** 69.723 1.6 3+ Gallium	**Ge 32** 72.61 1.6 4+ Germanium	**As 33** 74.92159 2.0 3+,3- Arsenic	**Se 34** 78.96 2.4 4+ Selenium	***Br 35*** 79.904 2.8 1- Bromine	*Kr 36* 83.80 - - Krypton
5	**Rb 37** 85.4678 0.8 1+ Rubidium	**Sr 38** 87.62 1.0 2+ Strontium	**Y 39** 88.90585 1.3 3+ Yttrium	**Zr 40** 91.224 1.4 4+ Zirconium	**Nb 41** 92.90638 1.6 5+ Niobium	**Mo 42** 95.94 1.8 6+ Molybdenum	Tc 43 98.9063 1.9 7+ Technetium	**Ru 44** 101.57 2.2 3+,4+ Ruthenium	**Rh 45** 102.9055 2.2 3+ Rhodium	**Pd 46** 106.42 2.2 2+ Palladium	**Ag 47** 107.8682 1.9 1+ Silver	**Cd 48** 112.411 1.7 2+ Cadmium	**In 49** 114.82 1.7 3+ Indium	**Sn 50** 118.71 1.8 4+ Tin	**Sb 51** 121.757 1.9 3+,3- Antimony	**Te 52** 127.60 2.1 4+ Tellurium	**I 53** 126.90447 2.5 1- Iodine	*Xe 54* 131.29 - - Xenon
6	***Cs 55*** 132.90543 0.7 1+ Cesium	**Ba 56** 137.327 0.9 2+ Barium	**La 57** 138.9055 1.1 3+ Lanthanum	**Hf 72** 178.49 1.3 4+ Hafnium	**Ta 73** 180.9479 1.5 5+ Tantalum	**W 74** 183.85 1.7 6+ Tungsten	**Re 75** 186.207 1.9 7+ Rhenium	**Os 76** 190.2 2.2 4+ Osmium	**Ir 77** 192.22 2.2 4+ Iridium	**Pt 78** 195.08 2.2 4+ Platinum	**Au 79** 196.96654 2.4 3+ Gold	***Hg 80*** 200.59 1.9 2+ Mercury	**Tl 81** 204.3833 1.8 1+ Thallium	**Pb 82** 207.2 1.8 2+ Lead	**Bi 83** 208.98037 1.9 3+ Bismuth	**Po 84** 208.9824 2.0 2+ Polonium	**At 85** 209.9871 2.2 1- Astatine	*Rn 86* 222.0176 - - Radon
7	***Fr 87*** 223.0197 0.7 1+ Francium	**Ra 88** 226.0254 0.9 2+ Radium	**Ac 89** 227.0278 1.1 3+ Actinium	Rf 104 261.11 - - Rutherfordium	Db 105 262.11 - - Dubnium	Sg 106 263.12 - - Seaborgium	Bh 107 262.12 - - Bohrium	Hs 108 264 - - Hassium	Mt 109 266.1378 - - Meitnerium	Uun 110 269 - - Ununnilium	Uuu 111 272 - - Unununium	Uu 112 277 - - Ununbium		Uuq 114 289 - - Ununquadium		Uuh 116 289 - - Ununhexium		Uuo 118 293 - - Ununoctium

6	**Ce 58** 140.115 1.1 3+ Cerium	**Pr 59** 140.90765 1.1 3+ Praseodymium	**Nd 60** 144.24 1.1 3+ Neodymium	Pm 61 144.9127 1.1 3+ Promethium	**Sm 62** 150.36 1.2 3+ Samarium	**Eu 63** 151.965 1.2 3+ Europium	**Gd 64** 157.25 1.2 3+ Gadolinium	**Tb 65** 168.92534 1.2 3+ Terbium	**Dy 66** 162.50 1.2 3+ Dysposium	**Ho 67** 164.93032 1.2 3+ Holmium	**Er 68** 167.26 1.2 3+ Erbium	**Tm 69** 168.93421 1.2 3+ Thulium	**Yb 70** 173.04 1.1 3+ Ytterbium	**Lu 71** 174.967 1.2 3+ Lutetium
7	**Th 90** 232.0381 1.3 4+ Thorium	**Pa 91** 231.03588 1.5 5+ Protactinium	**U 92** 238.0289 1.4 6+ Uranium	Np 93 237.082 1.3 5+ Neptunium	Pu 94 244.0642 1.3 4+ Plutonium	Am 95 243.0614 1.3 3+ Americium	Cm 96 247 1.3 3+ Curium	Bk 97 247.0703 1.3 3+ Berkelium	Cf 98 251.0796 1.3 3+ Californium	Es 99 252.03 1.3 - Einsteinium	Fm 100 257.0951 1.3 - Fermium	Md 101 258.01 1.3 - Mendelevium	No 102 259.1009 1.3 - Nobelium	Lr 103 260.1053 - - Lawrencium

Under normal conditions, bold symbols correspond to solid state, bold italic correspond to liquid state, italic correspond to gaseous state and normal correspond to synthetic elements.