Chemistry CHM 1311C Test 2
November 26, 2013
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Name:____
Student Number:_______________________________________
Laboratory Day (circle one):

Tuesday 2:30 Tuesday 6:30

Wednesday 10:00 Thursday 2:30

Thursday 6:30 Friday 2:30

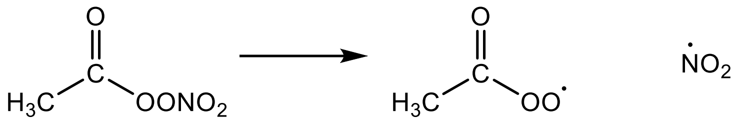
*Laboratory TA:*____

DO NOT TURN THE PAGE OR START THE EXAM UNTIL YOU ARE NOTIFIED.
You will have 80 minutes for the exam.
There are data and a periodic table on the last two pages.
Feel free to remove these and use them.

Question	Mark
1	**/ 5**
2	**/ 5**
3	**/ 5**
4	**/ 5**
5	**/ 5**
6	**/ 5**
Total	/30

Good Luck.

1. Peroxyacetyl nitrate (PAN) is an air pollutant produced during photochemical smog events. PAN is unstable and dissociates into peroxyacetyl radicals and nitrogen dioxide.



PAN

Trial	Initial [PAN] (M)	Initial Rate (M/min)
1	**1.02×10^{-3}**	**2.36×10^{-5}**
2	**2.04×10^{-3}**	**4.72×10^{-5}**
3	**4.09×10^{-3}**	**9.44×10^{-5}**

a) Using the data in the table, derive a rate law and a value for the rate constant (with units) for the decomposition of PAN at 298K.

b) The decomposition of PAN has a half-life of 35.0 hr at 273K. What is the rate constant for this reaction at this temperature? Use the same units as part (a).

c) What is the activation energy for this reaction?

2. Nitrosyl chloride decomposes to form nitrogen monoxide gas and chlorine gas, according to the following equation:

$2NOCl(g) \rightleftarrows 2NO(g) + Cl_2(g)$

At a 300 K, the equilibrium constant (K_p) is 1.60×10^{-6} . Calculate the equilibrium pressures of **all** gases if 2.0 moles of NOCl are placed in a 2.00L container and equilibrium is established.

3. A 1.82 g sample of a basic anion symbolized by B^-, with a molar mass of 26.02 g/mol, was dissolved in water to produce 100.0 ml of solution with a pH = 11.53. Write the equation for the reaction of B in water and calculate the ionization constant (K_b) for this base.

(b) What is the numerical value of the equilibrium constant for the following reaction?

$$BH + H_2O \rightleftarrows B^- + H_3O^+$$

4. You are given 0.500L of a 0.660M solution of HOBr (K_a= 2.00x10^{-9})

(a) What is the pH of this solution?

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

5. Metal hydroxide salts are commonly listed among the insoluble ionic compounds. The K_{sp} values of two of these salts are listed below.

$Mg(OH)_2$ $K_{sp} = 6.3x10^{-10}$
$Ca(OH)_2$ $K_{sp} = 6.5x10^{-6}$

You are given a solution that contains1.0M Ca^{2+} and 1.0M Mg^{2+}. At what pH will the first precipitation begin?

What will be the concentrations of Ca^{2+} and Mg^{2+} when the pH is 11?

6. Short answers:

Using the following information:

$SO_2(g) + ½\ O_2(g) \leftrightarrows SO_3(g)$ K= 2.30×10^4
$SO_2Cl_2(g) \leftrightarrows SO_2(g) + Cl_2(g)$ K= 2.9×10^{-2}

What is the equilibrium constant for the following reaction?

$SO_2Cl_2(g) + ½\ O_2(g) \rightleftharpoons SO_3(g) + Cl_2(g)$ K = ______________________

For the reaction

$SO_2 + ½\ O_2 \rightleftarrows SO_3$ $K_p = 3.4$ at 1000K

What is the value of K_p for the following reaction (also at 1000K)?

$½\ SO_3 \rightleftarrows ½\ SO_2 + 1/4\ O_2$ K_p = ______________________

Given that K_a of lactic acid, $CH_3CH(OH)\ CO_2H$, is 1.38×10^{-4} what is the K_b for the anion $CH_3CH(OH)\ CO_2^-$?

K_b = ______________________

If the rate law for the decomposition of hydrogen peroxide (H_2O_2) if given by rate = $7.3 \times 10^{-4} sec^{-1}[H_2O_2]$. What is the half-life for the decomposition?

$t_{1/2}$ = ______________________

For the following reaction,

$C(s) + H_2O(g) \rightleftarrows CO(g) + H_2(g)$ $\Delta H = 131$ kJ/mole

Will the amount of product **increase, decrease, or remain the same** if the volume is decreased while all other factors remain constant?

Work = mass x acceleration x height

Gas Law

$PV = nRT$

$P_{Total} = P_1 + P_2 + P_3 + \ldots$

$d = m/V = P(MW)/RT$

$KE = (1/2)mv_{av}^2$

$$\sqrt{\bar{v}^2} = \sqrt{\frac{3RT}{M}}$$

$$\frac{RateA}{RateB} = \sqrt{\frac{M_b}{M_a}}$$

$$P + \frac{n^2 a}{V^2}(V - nb) = nRT$$

Acid/Base

$pOH = -\log [OH^-]$

$pH = -\log[H^+]$

$pH + pOH = 14$

$K_a \times K_b = K_w$

$pH = pK_a + \log [A^-]/[HA]$

$$pH = \frac{pK_{a1} + pK_{a2}}{2}$$

Kinetics

$\ln[B]_t = -kt + \ln[B]_o$

$[B]_t = -kt + [B]_o$

$1/[B]_t = kt + 1/[B]_o$

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

$\ln(k_2/k_1) = -(E_a/R)(1/T_2 - 1/T_1)$

$k = \ln 2/t_{1/2}$

Thermodynamics

$\Delta U = q + w$

$w_{system} = -P\Delta V$

$\Delta H = \Delta U + P\Delta V$

$q_P = \Delta U + P\Delta V$

$C_p = C_v + R$

$\Delta H_{rxn}° = \Sigma n_p \Delta H_f°(\text{products}) - \Sigma n_r \Delta H_f°(\text{reactants})$

$S° = \Sigma n_p S°(\text{products}) - \Sigma n_r S°(\text{reactants})$

$\Delta G_{rxn}° = \Sigma n_p \Delta G°(\text{products}) - \Sigma n_r \Delta G°(\text{reactants})$

$q_{rev} = -w_{max} = nRT \ln (V_2/V_1)$

$\Delta S = q_{rev} / T$

$\Delta S_{T1-T2} = nC_p \ln(T_2/T_1)$

$\Delta S_{T1-T2} = nC_v \ln(T_2/T_1)$

$$\Delta S^0_{surroundings} = \frac{q_{surroundings}}{T} = \frac{-\Delta H_{sys}}{T}$$

$\Delta G^o = \Delta H^o - T\Delta S^o$

$\Delta G = \Delta G^o + RT \ln(Q)$

$\Delta G^o = -RT \ln(K)$

$\ln(K_2/K_1) = -\Delta H^o/R\ (1/T_2 - 1/T_1)$

Electrochemistry

$\Delta G = -nFE_{cell}$
$E_{cell} = E^o_{cell} - (RT/nF)\log Q$
$E_{cell} = E^o_{cell} - (0.0592/n)\log Q$

General

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

f.c. = valence-1/2 bonding pairs-lone pairs

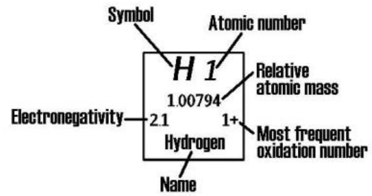
Data For Water

Density ρ = 1.00 g/mL (25°C)
C = 2.13 J g^- K^- (solid)
C = 4.18 J g^- K^- (liquid) $\Delta H°_{fus}$ = 6.02 kJ mol^-
C_p = 2.01 J g^- K^- (gas) $\Delta H°_{vap}$ = 40.7 kJ mol^-

Constants

Avogadro's Number	*N*	$6.022 x 10^{23}$	mol^{-1}
Boltzmann's constant	*k*	$1.30866 x 10^{-23}$	$J·K^{-1}$
Faraday's constant	*F*	96,485	$C·mol^{-1}$
Gas constant	*R*	8.314	$J·K^{-1}·mol^{-1}$
	R	8.314	kPa·L/(mol·K)
	R	0.08206	$atm·L·K^{-1}·mol^{-1}$
Planck's constant	*h*	$6.62608 x 10^{-34}$	J·s
Speed of Light	*c*	$2.99792458 x 10^{8}$	$m·s^{-1}$

Mokeur's Periodic table of the elements



	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	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.