Last Name: ______________________________

First name: ______________________________

Student Number: ______________________________

CHM 1311 A
Final Exam
Fall 2011

Professor: Dr. Fox

DO NOT WRITE THIS EXAM IF DR. FOX WAS NOT YOUR PROFESSOR! YES, I MEAN IT!

Please keep your work covered at all times 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.

There are 15 pages in this test. A periodic table, data tables, and a formula sheet are provided at the end. You may rip these pages off of the exam and use them to cover your work. Any scratch work should be done on the back of these pages.

Please show all work to receive partial credit.

You have 180 minutes to complete the exam.

Question	**Points Possible**	**Points Earned**	**TA Initial**
1	**20**		
2	**10**		
3	**10**		
4	**10**		
5	**10**		
6	**10**		
7	**10**		
8	**10**		
9	**10**		
TOTAL	**100**		

#1. (20 points) Short Answer Questions.

a) The *spdf* electron configuration of gallium is: __$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^1$_____

b) Which of the following ions is the strongest base? F^- HO_2^- N_3^- NO_2^-

c) Name the following compounds:

i. CrO_3 ____chromium (VI) oxide__________________

ii. $CaSO_4{\bullet}4H_2O$ __calcium sulfate tetrahydrate______________

d) The solubility of magnesium carbonate is highest in a buffer solution with a pH of

3.5 8.5 6.5 10.5

e) For a second order reaction, the plot of ____1/[A]_____ versus ___t______ will yield a straight line, where the slope is equal to _______k_________________.

f) A buffer solution is prepared from 0.450 M HCN and 0.450 M NaCN. The pH of this solution is _______9.21________.

g) In the following reaction, circle the oxidizing agent:

$$Fe_2O_3 + 3\ C \leftrightarrows 3\ CO + 2\ Fe$$

h) As the activation energy of a reaction increases, the reaction rate

INCREASES DECREASES STAYS CONSTANT

i) For an ideal gas, a graph of PV versus T will be a linear relationship with a slope that is directly proportional to the gas's:

KINETIC ENERGY MOLAR MASS ENTHALPY MASS

j) The concentration of lead (II) ions in a saturated solution of lead (II) chloride is ____0.017 mol/L________.

k) A one litre balloon is filled with neon gas. A hole is made in the balloon and the gas effuses at a rate of 0.0106 mol/hr. If the same balloon is refilled with argon at the same pressure and temperature, its rate of effusion would be _____0.0075 mol/hr_________.

l) Write the equilibrium constant expression for the following reaction, and choose the best means by which you could encourage the formation of hydrogen gas.

$CH_4(g) + H_2O(g) \leftrightarrows CO(g) + 3H_2(g)$ $\Delta H^o = 118$ kJ

- [✓ **i) Increase volume and add heat**]
- **ii) Add steam and remove heat**
- **iii) Remove carbon monoxide and decrease volume**
- **iv) Add hydrogen gas and increase volume**

$$K = \frac{(P_{CO})(P_{H2})^3}{(P_{CH4})(P_{H2O})}$$

m) An orbital is a spherical region of space in which there is a high probability of finding an electron. **TRUE** [✓ **FALSE**]

n) The standard heat of formation of solid $Fe(OH)_3$ is -824 kJ/mol. Write the chemical equation for the reaction to which this value applies.

$$Fe\,(s) + 3/2\ O_2\,(g) + 3/2\ H_2(g) \rightarrow Fe(OH)_3\,(s)$$

o) Which of the following would NOT produce a buffer? (HA = a weak acid)

[✓ **NaA + NaOH**] **HA + NaA** **NaA + HCl** **HA + NaOH**

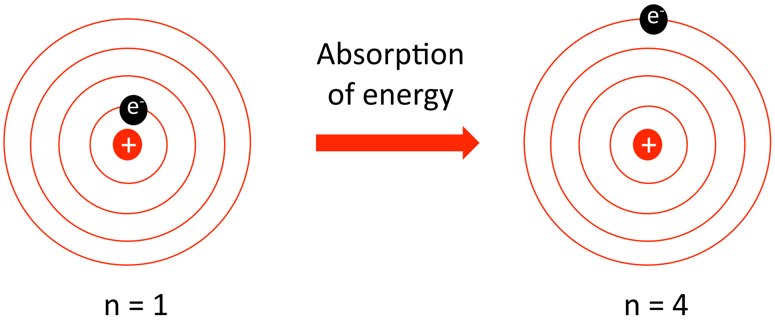
p) If the equilibrium constant for the reaction $HA + H_2O \rightleftarrows H_3O^+ + A^-$ is K_a, then the equilibrium constant for the reaction $A^- + H_2O \rightleftarrows HA + OH^-$ would be

K_a [✓ K_w/K_a] $1/K_a$ [✓ K_b]

q) The maximum number of electrons with quantum numbers n = 2 and ℓ = 1 is: _6____.

#2. (10 points)

(a) Draw a diagram of Bohr's model of the hydrogen atom showing the transition of an electron from the ground state to the *n* = 4 level.



(b) What is the change in energy (in J) of this transition?

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

$$= -2.179 \times 10^{-18} J \bullet \left(\frac{1}{4^2} - \frac{1}{1^2}\right)$$

$$= +2.043 \times 10^{-18} J$$

Answer : _______+2.043 x 10^{-18} J ___________

(c) What is the significance of the sign in your answer for part (b)?

The value of energy is positive, indicating that the atom *absorbed* energy.

(d) Calculate the wavelength (in nm) that corresponds to this energy.

$$E = h\nu = \frac{hc}{\lambda}$$

$$\therefore \lambda = \frac{hc}{E} = \frac{(6.626 \times 10^{-34} J \cdot s)(2.998 \times 10^{8} m/s)}{2.043 \times 10^{-18} J} = 9.72 \times 10^{-8} m = 97.2\ nm$$

Answer : __________97.2 nm_______________

#3. (10 points). You are given 200.0 mL of an aqueous solution that contains 0.250 M each of Ag^+, Pb^{2+}, and Ba^{2+}. You wish to precipitate these cations sequentially by adding chromate to the solution.

(a) In what order will the solids precipitate as chromate is added to the above solution?
What are the concentrations of CrO_4^{2-} needed to precipitate each cation? Whichever requires the least amount will precipitate first…

For Ag_2CrO_4: $Ag_2CrO_4\ (s) \leftrightarrows 2Ag^+(aq) + CrO_4^{2-}$

$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$

$\therefore\ [CrO_4^{2-}] = K_{sp}/[Ag^+]^2 = 1.9 \times 10^{-12}/(0.250)^2 = 3.04 \times 10^{-11}$ M

For $PbCrO_4$: $PbCrO_4\ (s) \leftrightarrows Pb^{2+}(aq) + CrO_4^{2-}$

$K_{sp} = [Pb^{2+}][CrO_4^{2-}]$

$\therefore\ [CrO_4^{2-}] = K_{sp}/[Pb^{2+}] = 1.8 \times 10^{-14}/(0.250) = 7.2 \times 10^{-14}$ M

For $BaCrO_4$: $BaCrO_4\ (s) \leftrightarrows Ba^{2+}(aq) + CrO_4^{2-}$

$K_{sp} = [Ba^{2+}][CrO_4^{2-}]$

$\therefore\ [CrO_4^{2-}] = K_{sp}/[Ba^{2+}] = 2.1 \times 10^{-10}/(0.25) = 8.4 \times 10^{-10}$

First = $PbCrO_4$ Second = Ag_2CrO_4 Third = $BaCrO_4$

(b) What concentration of chromate will cause the first precipitation?

From part (a), the concentration at which precipitation of $PbCrO_4$ begins is 7.2×10^{-14} M.

Answer: ______7.2×10^{-14} M________________

(c) At the point just before $BaCrO_4$ begins to precipitate, what will be the concentration of all of the ions in solution?

$BaCrO_4$ begins to precipitate when the $[CrO_4^-] = 8.4 \times 10^{-10}$ M. At this concentration, both Ag_2CrO_4 and $PbCrO_4$ have precipitated. So, what are the concentrations of each ion when $[CrO_4^-] = 8.4 \times 10^{-10}$ M?

$[Ba^{2+}]$ 0.250 M (still not precipitated)

$[Ag^+]$ $K_{sp} = [Ag^+]^2[CrO_4^{2-}]$

$\therefore [Ag^+] = \{K_{sp}/[CrO_4^{2-}]\}^{1/2} = \{1.9 \times 10^{-12}/(8.4 \times 10^{-10})\}^{1/2} = 0.0476$ M

$[Pb^{+2}]$ $K_{sp} = [Pb^{2+}][CrO_4^{2-}]$

$\therefore [Pb^{2+}] = K_{sp}/[CrO_4^{2-}] = 1.8 \times 10^{-14}/(8.4 \times 10^{-10}) = 2.14 \times 10^{-5}$ M

$[Ag^+]$ = 0.0476 M $[Pb^{2+}]$ = 2.14×10^{-5} M $[Ba^{2+}]$ = 0.250 M

#4. (10 points) Combustion of 1.110 g of a gaseous hydrocarbon yields 3.613 g of carbon dioxide and 1.109 g of water (and no other products).

a) What is the empirical formula of the hydrocarbon?

$$? \text{ mol C} = 3.613 \text{ g } CO_2 \times \frac{\text{mol } CO_2}{44.01 \text{ g } CO_2} \times \frac{1 \text{ mol C}}{1 \text{ mol } CO_2} = 0.0821 \text{ mol C}$$

$$? \text{ mol H} = 1.109 \text{ g } H_2O \times \frac{\text{mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{2 \text{ mol H}}{1 \text{ mol } H_2O} = 0.123 \text{ mol H}$$

$$\therefore C_{\frac{0.0821}{0.0821}}H_{\frac{0.123}{0.123}} \Rightarrow C_1H_{1.5} \Rightarrow C_2H_3$$

Answer: ____C_2H_3___________

b) A 0.288 g sample of the same hydrocarbon occupies a volume of 121 mL at 24.8°C and 753 mmHg. What is the molecular formula of the hydrocarbon?

$$n = \frac{PV}{RT} = 0.00490mol$$

$$\text{MM} = \frac{\text{m}}{\text{n}} = \frac{0.288\text{g}}{0.00490\text{mol}} = 58.7\text{g/mol}$$

EF mass = 27g/mol

$\therefore$ MF mass ≈ 2 x EFmass

$\therefore$ MF is 2 x the EF = C_4H_6

Answer: _____C_4H_6___________

c) Write a balanced chemical equation for the combustion of the hydrocarbon.

$$2\, C_4H_6 + 11\, O_2 \rightarrow 8\, CO_2 + 6\, H_2O$$

#5. (10 points) In an environmental analysis for copper in soils, the copper must first be oxidized to copper(II) ions using permanganate ions in acidic solution, with the following half-reactions.

$$\mathbf{MnO_4^- \rightarrow Mn^{2+}}$$

$$\mathbf{Cu \rightarrow Cu^{2+}}$$

a) Determine the overall balanced redox reaction equation.

① $5\,e^- + 8\,H^+ + MnO_4^- \rightarrow Mn^{2+} + 4\,H_2O$

② $Cu \rightarrow Cu^{2+} + 2\,e^-$

2 x ① $10\,e^- + 16\,H^+ + 2\,MnO_4^- \rightarrow 2\,Mn^{2+} + 8\,H_2O$

5 x ② $5\,Cu \rightarrow 5\,Cu^{2+} + 10\,e^-$

OVERALL:

$$5\,Cu + 16\,H^+ + 2\,MnO_4^- \rightarrow 2\,Mn^{2+} + 8\,H_2O + 5\,Cu^{2+}$$

b) A 55.0 g sample of soil was found to react with 12.76 mL of a 0.280 M $KMnO_4$ solution. What was the percent composition by mass of copper in the soil sample?

$$?\text{ g Cu} = 0.01276\text{ L KMnO}_4 \times \frac{0.280\text{ mol KMnO}_4}{\text{L}} \times \frac{5\text{ mol Cu}}{2\text{ mol MnO4}^-} \times \frac{63.546\text{ g Cu}}{\text{mol Cu}}$$

$$= 0.567\text{g}$$

$$\%\text{Cu} = \frac{0.567\text{ g Cu}}{55.0\text{ g soil}} \times 100\% = 1.03\%$$

Answer: 1.03%

#6. (10 points) You wish to prepare a buffer solution with pH = 9.45.

a) How many grams of $(NH_4)_2SO_4$ would you add to 425 mL of 0.258 M NH_3 to do this? You may assume that the solution's volume remains constant. K_b of $NH_3 = 1.8x10^{-5}$

$$K_a = \frac{K_W}{K_b} = \frac{1.0x10^{-14}}{1.8x10^{-5}} = 5.5x10^{-10}$$

$$pH = pK_a - \log\left(\frac{[NH_3]}{[NH_4^+]}\right) \quad \Rightarrow \quad 9.45 = -\log(5.5x10^{-10}) - \log\left(\frac{[NH_3]}{[NH_4^+]}\right)$$

$$\log\left(\frac{[NH_3]}{[NH_4^+]}\right) = 9.45 - 9.26 = 0.19 \quad \Rightarrow \quad \frac{[NH_3]}{[NH_4^+]} = 10^{0.19} = 1.55$$

$$\therefore [NH_4^+] = 1.55 \times [NH_3] = 1.55 \times 0.258M = 0.17M$$

$$? \text{ g } (NH_4)_2SO_4 = 0.425 \text{ L} \times \frac{0.17 \text{ mol } NH_4^+}{\text{L}} \times \frac{1 \text{ mol } (NH_4)_2SO_4}{2 \text{ mol } NH_4^+} \times \frac{132.1 \text{ g}}{\text{mol}} = 4.8 \text{ g}$$

Answer: ____________4.8 g_________

b) Which buffer component, and how much (in grams) would you add to 0.100 L of the buffer in part (a) to change its pH to 9.30? You may assume that the solution's volume remains constant.

$$pH = pK_a - \log\left(\frac{[NH_3]}{[NH_4^+]}\right)$$

$$9.30 = 9.26 - \log\left(\frac{[NH_3]}{[NH_4^+]}\right)$$

$$\log\left(\frac{[NH_3]}{[NH_4^+]}\right) = 9.30 - 9.26 = 0.04 \quad \Rightarrow \quad \frac{[NH_3]}{[NH_4^+]} = 10^{0.04} = 1.1$$

So, to lower the pH to 9.30, we'll need to add some acid. But how much?

$$[NH_3] = 0.258 \text{ M} \quad \text{and} \quad [NH_4^+] = 0.17 \text{ M} + x$$

$$\therefore \frac{[NH_3]}{[NH_4^+]} = \frac{0.258}{0.17 + x} = 1.1 \quad \Rightarrow \quad x = 0.062 \text{ M}$$

$$? \text{ g } (NH_4)_2SO_4 = 0.100 \text{ L} \times \frac{0.062 \text{ mol } NH_4^+}{\text{L}} \times \frac{1 \text{ mol } (NH_4)_2SO_4}{2 \text{ mol } NH_4^+} \times \frac{132.1 \text{ g}}{\text{mol}} = 0.41 \text{ g}$$

Answer:_________0.41 g of $[NH_4]_2SO_4$_________

#7. (10 points) In the titration of 40.00 mL of 0.200 M HOCl by 0.500 M NaOH:
(a) Calculate the initial pH (before any addition of NaOH).

HOCl is a weak acid:

	$HOCl(aq)$ ⇆	**$H^+(aq)$ +**	**$OCl^-(aq)$**
Initial	**0.200**	**0**	**0**
Change	**-x**	**+x**	**+x**
Equilibrium	**0.200-x**	**x**	**x**

$$K_a = \frac{[H^+][OCl^-]}{[HOCl]}$$

Assuming that $x << 0.200$:

$$2.9 \times 10^{-8} = \frac{(x)(x)}{(0.200 - x)}$$

$$x = \sqrt{(0.200)(2.9 \times 10^{-8})} = 7.6 \times 10^{-5}$$

pH = -log(H^+) = -log(x) = -log(7.6 x 10^{-5}) = 4.12

Answer: _____4.12__________

(b) What is the volume of NaOH needed to attain the equivalence point? Calculate the pH at the equivalence point.

At the equivalence point: number of moles of acid = number of moles of base
mol HOCl = C•V = (0.200 L)(0.040 mol/L) = 0.00800 mol
∴ mol NaOH = 0.00800 mol and V = 0.00800 mol/0.500 mol/L = 0.0160 L = 16.0 mL

For the neutralization:

	$HOCl(aq)$ +	**$OH^-(aq)$ →**	**$H_2O(l)$ +**	**$OCl^-(aq)$**
Before	**0.00800**	**0.00800**	**-**	**0**
Change	**-0.00800**	**-0.00800**	**-**	**+0.00800**
After	**0**	**0**	**-**	**0.00800**

new [OCl^-] = n/V = 0.00800 mol/ (0.0400L + 0.0160L) = 0.143 mol/L
OCl^- is a base and will hydrolyze in water:

	OCl^- (aq) +	**$H_2O(aq)$ →**	**$HOCl(aq)$ +**	**$OH^-(aq)$**
Initial	**0.143**	**-**	**0**	**0**
Change	**-x**	**-**	**+x**	**+x**
Equilibrium	**0.143-x**	**-**	**x**	**x**

$$K_b = \frac{K_w}{K_a} = \frac{[H^+][OCl^-]}{[HOCl]}$$

Assuming that $x << 0.143$:

$$\frac{1.0 \times 10^{-14}}{2.9 \times 10^{-8}} = \frac{(x)(x)}{(0.143 - x)}$$

$$x = \sqrt{(0.143)(3.4 \times 10^{-7})} = 2.2 \times 10^{-4}$$

pOH = -log(OH^-) = -log(x) = -log(2.2 x 10^{-4}) = 3.65
pH = 14 – pOH = 14 – 3.65 = 10.35

Volume of NaOH: ______16.0 mL________

pH: ______10.35___________

#8. (10 points). Steel is an alloy of iron and carbon, with iron being the major component. A steel ball bearing has a radius of 5.85 mm and a density of 7.75 g/cm^3. If the ball bearing contains 0.25% carbon (by mass) and that the percent natural abundance of ^{13}C is 1.108%, how many ^{13}C atoms are present in the ball bearing?

Recall: volume of a sphere = (4πr^3)/3

$$\text{? radius of ball, in cm} = 5.85\ \text{mm} \times \frac{1\ \text{cm}}{10\ \text{mm}} = 0.585\ \text{cm}$$

$$\text{? volume of ball, in cm}^3 = \frac{4}{3} \times \pi \times (0.585\ \text{cm})^3 = 0.839\ \text{cm}^3$$

$$\text{? mass of ball, in g} = 0.839\ \text{cm}^3 \times \frac{7.75\ \text{g steel}}{\text{cm}^3} = 6.50\ \text{g steel}$$

$$\text{? mass of C, in g} = 6.50\ \text{g steel} \times \frac{0.25\ \text{g C}}{100\ \text{g steel}} = 0.0162\ \text{g C}$$

$$\text{? mol of C} = 0.0162\ \text{g C} \times \frac{\text{mol C}}{12.011\ \text{g C}} = 0.00135\ \text{mol C}$$

$$\text{? mol }^{13}\text{C} = 0.00135\ \text{mol C} \times \frac{1.108\ \text{mol }^{13}\text{C}}{100\ \text{mol C}} = 1.50\text{x}10^{-5}\ \text{mol }^{13}\text{C}$$

$$\text{? atoms }^{13}\text{C} = 1.50\text{x}10^{-5}\ \text{mol }^{13}\text{C} \times \frac{6.022\text{x}10^{23}\ \text{atoms }^{13}\text{C}}{\text{mol }^{13}\text{C}} = 9.03\text{x}10^{18}\ \text{atoms}$$

Answer: **9.03x10^{18} atoms**

#9. (10 points) A 0.3268 g sample of caffeine ($C_8H_{10}O_2N_4$, heat of combustion = $-4.243\text{x}10^3$ kJ/mol) undergoes complete combustion in a bomb calorimeter. The bomb calorimeter assembly has a heat capacity of 5.136 kJ/ºC.

(a) What mass of oxygen is required for the complete combustion of the sample?

$$\_\_\_\ C_8H_{10}O_2N_4 + \_13.5\_\ O_2 \rightarrow \_8\_\ CO_2 + \_5\_\ H_2O + \_4\_\ NO_2$$

$$m_{O_2} = 0.3268\text{ g caffeine} \bullet \frac{\text{mol caffeine}}{194.19\text{ g caffeine}} \bullet \frac{13.5\text{ mol }O_2}{1\text{ mol caffeine}} \bullet \frac{32.00\text{ g }O_2}{\text{mol }O_2} = 0.7270\text{ g}$$

Answer: ________0.7270 g__________

(b) What will be the final temperature of the assembly if the initial temperature is 22.43ºC?

First, we find the amount of heat released in the combustion of the caffeine sample:

$$q_{\text{combustion}} = \Delta H^{o}_{\text{comb}} \times \text{mol caffeine} = (-4.243 \times 10^3\text{ kJ/mol})(0.001683\text{ mol}) = -7.140\text{ kJ}$$

The amount of heat released in the reaction is equal to the amount of heat absorbed by the calorimeter, or:

$$
\begin{aligned}
-\,q_{\text{comb}} &= q_{\text{cal}} \\
-\,q_{\text{comb}} &= C_{\text{cal}}(T_2 - T_1) \\
T_2 &= \frac{-q_{\text{comb}}}{C_{\text{cal}}} + T_1 \\
&= \frac{-(-7.140\text{ kJ})}{5.136\text{ kJ/°C}} + 22.43°\text{C} \\
&= 23.82°\text{C}
\end{aligned}
$$

Answer: _____23.82ºC__________

(c) What is the change in internal energy for the reaction?

$\Delta U = q + w$

This is a constant volume calorimeter, so w = 0, thus:

$\Delta U = q = -7.140$ kJ

Answer: _______-7.140 kJ__________

Gas Laws

$PV = nRT$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$P_T = P_1 + P_2 + P_3 + \ldots$

$P_A = \chi_A P_T$

$$d = \frac{m}{V} = \frac{P \cdot MM}{RT}$$

$$E_K = \frac{1}{2} m v^2$$

$$u_{rms} = \sqrt{\frac{3RT}{MM}}$$

$$\frac{Rate\ A}{Rate\ B} = \sqrt{\frac{MM_B}{MM_A}}$$

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

Equilibrium

$K_P = K_C(RT^{)\Delta n}$

Acid/Base

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

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

$pH + pOH = 14$

$K_a \times K_b = K_W$

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

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

Thermochemistry

$\Delta U = q + W$

$W_{system} = -P\Delta V = -\Delta nRT$

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

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

$q = ms\Delta T$

$q = n\Delta H$

$\Delta H_{rxn}° = \sum n\Delta H_f°(pdts) - \sum n\Delta H_f°(rxts)$

The atom

$E = h\nu$

$c = \nu\lambda$

$E = -B/n^2$

Kinetics

$[A]_t = [A]_o - kt$

$\ln[A]_t = \ln[A]_o - kt$

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

$k = Ae^{(-Ea/RT)}$

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

Other

$n = m/MM$

$C = n/V$

$$\%yield = \frac{actual\ yield}{theoretical\ yield} \times 100\%$$

$$\chi_A = \frac{n_A}{n_T}$$

Data For Water

Density = 1.00 g/mL (at 25°C)
s = 2.13 J g^{-1} K^{-1} (solid)
s = 4.184 J g^{-1} K^{-1} (liquid) $\Delta H^\circ_{fus} = 6.02$ kJ mol^{-1}
s = 2.01 J g^{-1} K^{-1} (gas) $\Delta H^\circ_{vap} = 40.7$ kJ mol^{-1}

Constants and Conversion Factors

1 mmHg = 1 torr 760 mmHg = 1 atm 1 atm = 101.325 kPa 1 atm = 1.013125 bar
1 cm^3 = 1 mL 1000 mL = 1 L 1000 L = 1 m^3

Avogadro's Number	*N*	$6.022\text{x}10^{23}$ mol^{-1}	
Boltzmann's constant	*k*	$1.30866\text{x}10^{-23}$ $J{\cdot}K^{-1}$	
Faraday's constant	*F*	96,485 $C{\cdot}mol^{-1}$	
Gas constant	*R*	8.31451 $J{\cdot}K^{-1}{\cdot}mol^{-1}$	
	R	0.08206 $atm{\cdot}L{\cdot}K^{-1}{\cdot}mol^{-1}$	
	R	8.31451 $m^3Pa{\cdot}K^{-1}{\cdot}mol^{-1}$	
	R	0.0831451 bar $L{\cdot}K^{-1}{\cdot}mol^{-1}$	
Planck's constant	*h*	$6.62608\text{x}10^{-34}$	J·s
Speed of Light	*c*	$2.99792458\text{x}10^{8}$	$m{\cdot}s^{-1}$

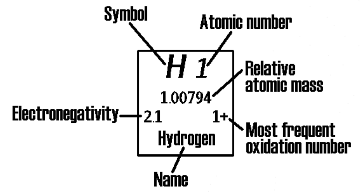
Table of Ionization Constants

Acid		K_a =
Iodic acid	$HIO_3 + H_2O \rightleftharpoons H_3O^+ + IO_3^-$	1.6×10^{-1}
Chlorous acid	$HClO_2 + H_2O \rightleftharpoons H_3O^+ + ClO_2^-$	1.1×10^{-2}
Chloroacetic acid	$HC_2H_2ClO_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_2ClO_2^-$	1.4×10^{-3}
Nitrous acid	$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$	7.2×10^{-4}
Hydrofluoric acid	$HF + H_2O \rightleftharpoons H_3O^+ + F^-$	6.6×10^{-4}
Formic acid	$HCHO_2 + H_2O \rightleftharpoons H_3O^+ + CHO_2^-$	1.8×10^{-4}
Benzoic acid	$HC_7H_5O_2 + H_2O \rightleftharpoons H_3O^+ + C_7H_5O_2^-$	6.3×10^{-5}
Hydrazoic acid	$HN_3 + H_2O \rightleftharpoons H_3O^+ + N_3^-$	1.9×10^{-5}
Acetic acid	$HC_2H_3O_2 + H_2O \rightleftharpoons H_3O^+ + C_2H_3O_2^-$	1.8×10^{-5}
Hypochlorous acid	$HOCl + H_2O \rightleftharpoons H_3O^+ + OCl^-$	2.9×10^{-8}
Hydrocyanic acid	$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$	6.2×10^{-10}
Phenol	$HOC_6H_5 + H_2O \rightleftharpoons H_3O^+ + C_6H_5O^-$	1.0×10^{-10}
Hydrogen peroxide	$H_2O_2 + H_2O \rightleftharpoons H_3O^+ + HO_2^-$	1.8×10^{-12}

Table of Solubility Product Constants

Compound	K_{sp}	Compound	K_{sp}
$Mg(OH)_2$	1.2 x 10^{-11}	Ag_2CrO_4	1.9 x 10^{-12}
AgCl	1.8 x 10^{-10}	$PbCrO_4$	1.8 x 10^{-14}
$CaSO_4$	9.1 x 10^{-6}	$BaCrO_4$	2.1 x 10^{-10}
AgI	1.5 x 10^{-16}	Hg_2Cl_2	1.3 x 10^{-18}
PbI_2	8.7 x 10^{-9}	$BaSO_4$	1.1 x 10^{-10}
$PbCl_2$	1.9 x 10^{-5}	Ag_2CO_3	8.5 x 10^{-12}

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.