Chemistry 112, Fall 2006, Section 1 (Garman and Heuck)
Final Exam A (100 points)
19 Dec 2006

Name: KEY A

YOU MUST:
Put your **name** and **student ID** on the bubble sheet correctly.
Put the exam version on the bubble sheet on the upper left side above the word "NAME". **This is Final Exam A.**
Put **all** your answers on the bubble sheet.
Please sign the statement on the last page of the exam.

Please make sure your exam has **9 pages** (plus this one and 3 reference pages at the back).
Please keep your eyes on your own paper and your answers covered.
Use the exam as scratch paper. We will not grade anything on the exam itself.
Turn in both the exam and bubble sheet when you are done. **Good luck!**

Chem 112, Fall 06, Section 1
Final Exam A

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1) (4 points) If a person records a blood alcohol level of 0.0133 M (or 0.08% by volume), what was the person's blood alcohol level 2.5 hours before this measurement? The zero order rate constant for the oxidation of ethanol in the liver is 0.00425 M/hour.

A) 0.00268 M (= 0.0161% by volume)
B) 0.0106 M (= 0.0638% by volume)
C) 0.0134 M (= 0.0806% by volume)
D) 0.0216 M (= 0.130% by volume)
E) 0.0239 M (= 0.144% by volume)

$A_0 - A = kt$

$A_0 = kt + A$

$= (0.00425\,M/hr)(2.5\,hr) + 0.0133\,M$

$= 0.0239\,M$

2) (4 points) How much N_2 gas dissolves in the tissues of a diver who experiences 5.00 atm (=3800 mm Hg) of N_2 pressure during a dive? Assume the diver has 50L of fluid in her tissues.

A) 0.00320 g
B) 0.00589 g
C) 0.0896 g
D) 0.160 g
E) 4.48 g

$S_g = k_H P_g$

$= (8.42 \times 10^{-7}\,M/mm\,Hg)(3800\,mm\,Hg)$

$= 0.00320\,M$

$= 0.00320\,\frac{moles\,N_2}{L} \times 50L \times \frac{28.0\,g\,N_2}{mole\,N_2} = 4.48\,g$

3) (4 points) What is the boiling point of an ideal solution where 100g of $MgCl_2$ is dissolved in 0.250 kg of water, and the final volume of the solution is 265ml?

A) 6.45°C
B) 102.03°C
C) 102.15°C
D) 106.09°C
E) 106.45°C

$\Delta T = k \cdot m \cdot i$

$= (+0.512\,°C/m)(4.20\,m)(3)$

$= 6.45\,°C$

$BP_{APW} = 100°C + \Delta T$

$= 106.45°C$

$m = \frac{moles}{kg\,H_2O}$

$= \frac{1.05\,moles\,MgCl_2}{0.250\,kg\,H_2O}$

$= 4.20\,m$

$i = 3$ for

$MgCl_{2(s)} \rightarrow Mg^{2+}_{(g)} + 2Cl^-_{(g)}$

Mg = 24.31
2×Cl = 70.90
$MgCl_2$ 95.21 g/mole

$100g\,MgCl_2 \times \frac{1\,mole}{95.21\,g}$

$= 1.05\,moles\,MgCl_2$

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4) (4 points) Ethylene glycol ($HOCH_2CH_2OH$, molecular weight 62.1 g/mole) is a non-electrolyte commonly used in automobile radiators to prevent overheating. If 50.0 g of ethylene glycol is added to 50.0 g of water, what is the vapor pressure of the resulting solution at 100°C?

A) 0.225 mm Hg
B) 0.775 mm Hg
C) 171 mm Hg
D) 589 mm Hg
E) None of the above

$P_A = X_A P_A^o$

$X_{H_2O} = \frac{\text{moles } H_2O}{\text{moles } H_2O + \text{moles EG}}$

$= \frac{2.78}{2.78 + 0.805}$

$= 0.775$

$= (0.775)(760 \text{ mm Hg})$

$= 589 \text{ mm Hg}$

moles $H_2O = 50g \times \frac{1 \text{ mole}}{18.0g}$

$= 2.78$ moles

moles EG $= 50g \times \frac{1 \text{ mole}}{62.1g}$

$= 0.805$ moles

5) (4 points) Radioactive iodine, ^{125}I, is used to diagnose and cure thyroid problems in people. The half life for the first order radioactive decay of ^{125}I is 63 days. If you ingest 0.200 g of ^{125}I, how long will it take for the amount of ^{125}I to decay to 0.020 g?

A) 63 days
B) 189 days
C) 209 days
D) 252 days
E) 4090 days

$\ln N/N_0 = -kt$

$t = \frac{\ln N/N_0}{-k}$

$= \frac{\ln\left(\frac{0.020}{0.200}\right)}{-0.011 \text{ day}^{-1}}$

$= 209$ days

$t_{1/2} = \frac{.693}{k}$

$k = \frac{.693}{t_{1/2}}$

$= \frac{.693}{63d}$

$= 0.011 \text{ day}^{-1}$

6) (3 points) Which of the following plots do you expect to be linear for the first order reaction for the decomposition of SO_2Cl_2 according to the reaction:

$$SO_2Cl_2\ (g) \rightarrow SO_2\ (g) + Cl_2\ (g)$$

A) $[SO_2Cl_2]$ vs. time
B) ln $[SO_2Cl_2]$ vs. time
C) $1/[SO_2Cl_2]$ vs. time
D) $[SO_2Cl_2]$ vs. temperature
E) ln $[SO_2Cl_2]$ vs. temperature

0 order: linear in $[SO_2Cl_2]$ v. time
→ 1st order: linear in $\ln[SO_2Cl_2]$ v. time
2nd order: linear in $1/[SO_2Cl_2]$ v. time

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The next two problems refer to the following data, collected for the reaction of nitrogen and hydrogen to make ammonia: $N_2\,(g) + 3H_2\,(g) \rightarrow 2NH_3\,(g)$

Experiment	$[N_2]$	$[H_2]$	initial rate of appearance of NH_3
1	0.030 M	0.010 M	4.21×10^{-5} M/min
2	0.060 M	0.010 M	1.68×10^{-4} M/min
3	0.030 M	0.020 M	3.37×10^{-4} M/min

2x 8x 4x 2x

doubling $[N_2]$ increases rate 4x, so rate ∝ $[N_2]^2$

doubling $[H_2]$ increases rate 8x, so rate ∝ $[H_2]^3$

7) (4 points) From the above data, the rate equation for this reaction is:

A) rate = $k[N_2][H_2]^2$
B) rate = $k[N_2][H_2]^3$
C) rate = $k[N_2]^2[H_2]$
D) rate = $k[N_2]^2[H_2]^2$
E) rate = $k[N_2]^2[H_2]^3$

rate = $k[N_2]^2[H_2]^3$

8) (3 points) From the above data, the rate constant for this reaction is:

A) $k = 4.68\ M^{-2}\ min^{-1}$
B) $k = 14.0\ M^{-2}\ min^{-1}$
C) $k = 4.68 \times 10^{2}\ M^{-3}\ min^{-1}$
D) $k = 1.40 \times 10^{3}\ M^{-3}\ min^{-1}$
E) $k = 4.68 \times 10^{4}\ M^{-4}\ min^{-1}$

$$k = \frac{\text{rate}}{[N_2]^2[H_2]^3} = \frac{4.21 \times 10^{-5}\ M/min}{[0.030M]^2\,[0.010M]^3} = 4.68 \times 10^{4}\ M^{-4}\ min^{-1}$$

9) (5 points) What is the activation energy for a reaction if the rate constant k goes from 2.00×10^{1} to 1.60×10^{2} when the temperature is raised from 400K to 800K?

A) 4.32×10^{-5} kJ/mol
B) 5.32×10^{-2} kJ/mol
C) 0.137 kJ/mol
D) 13.8 kJ/mol
E) None of the above

$$\ln k_2/k_1 = \frac{-E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$E_a = \frac{-R \ln k_2/k_1}{\frac{1}{T_2} - \frac{1}{T_1}} = \frac{-(8.31\ J/mol\,K)\left(\ln \frac{160}{20}\right)}{\frac{1}{800K} - \frac{1}{400K}}$$

$= 13824\ J/mol$

$= 13.8\ kJ/mol$

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The next four problems refer to the following titration: A 24.8 mL sample of a 0.331 M aqueous acetic acid (HAcO) solution is titrated with a 0.415 M aqueous potassium hydroxide solution.
K_a (acetic acid) = 1.8 x 10^{-5}

10) (5 points) What is the pH at the start of the titration, before any potassium hydroxide (KOH) has been added?

A) 9.0
B) 2.6
C) 11.4
D) 4.7
E) cannot tell

$HOAc + H_2O \rightleftharpoons OAc^- + H_3O^+$

	HOAc	OAc^-	H_3O^+
I	.331M	—	—
C	$-x$	$+x$	$+x$
E	$.331-x$	x	x

$$K_a = \frac{[OAc^-][H_3O^+]}{[HOAc]} = \frac{(x)(x)}{(.331-x)} = 1.8\times10^{-5}$$

$x^2 = 5.96\times10^{-6}$

$x = 2.44\times10^{-3} = [H_3O^+]$

$pH = -\log[H_3O^+]$
$= 2.6$

11) (5 points) What is the pH at the half-point of the titration?

A) 9.0
B) 2.6
C) 11.4
D) 4.7
E) cannot tell

At the midpoint of a titration, pH = pKa

$pKa = -\log Ka$
$= -\log 1.8\times10^{-5}$
$= 4.7$

12) (3 points) What is the concentration of potassium ions (K^+) at the equivalence point?

A) 0.194 M
B) 0.174 M
C) 0.184 M
D) cannot tell

24.8 mL = 0.0248 L

$0.0248\,L \times \frac{0.331 \text{ moles}}{L} = 0.00821$ moles acid

At equivalence, moles KOH added = moles acid
= 0.00821 moles

Volume base added = $\frac{0.00821 \text{ moles}}{0.415 \text{ moles/L}} = 0.0198$ L

Total volume = volume acid + volume base added
= 0.0248 L + 0.0198 L
= 0.0446 L

$[K^+]$ = moles/L = $\frac{0.00821 \text{ moles}}{0.0446 \text{ L}} = 0.184$ M

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(continued from previous page)

13) (3 points) What is the pH at the equivalence point? K_b (acetate, AcO^-) = 5.56 x 10^{-10}

A) 9.0
B) 2.6
C) 11.4
D) 4.7
E) cannot tell

At equivalence, all of the HOAc has been neutralized by KOH

$OAc^- + H_2O \rightleftharpoons HOAc + OH^-$

	OAc^-	HOAc	OH^-
I	0.184M	—	—
C	$-x$	$+x$	$+x$
E	$0.184-x$	x	x

$k_b = \frac{[HOAc][OH^-]}{[OAc^-]} = \frac{(x)(x)}{(0.184-x)} = 5.56\times10^{-10}$

$= \frac{x^2}{0.184} = 5.56\times10^{-10}$

$x^2 = 1.02\times10^{-10}$

$x = 1.01\times10^{-5} = [OH^-]$

$pOH = -\log[OH^-]$
$= -\log 1.01\times10^{-5}$
$= 4.99$

$14 - pOH = pH = 9.01$

14) (3 points) For one mole at 298 K, which of the following compounds will have the higher entropy?

A) CH_4
B) CH_3CH_3
C) $CH_3CH_2CH_3$
D) $CH_3CH_2CH_2CH_3$
E) cannot tell

15) (3 points) The equilibrium constant expression for the solubility of Ag_2CO_3 is:

A) $K_{sp} = 2[Ag^+][CO_3^{2-}]$
B) $K_{sp} = [Ag^+]^3[CO_3^{2-}]^2$
C) $K_{sp} = [Ag^+]^2[CO_3^{2-}]$
D) $K_{sp} = [Ag^+][CO_3^{2-}]/[Ag\ CO_3]$
E) none of the above

$Ag_2CO_3\ (s) \rightleftharpoons 2Ag^+ + CO_3^{2-}$

$K_{sp} = [Ag^+]^2[CO_3^{2-}]$

16) (3 points) For a reversible reaction at the equilibrium

A) The concentration of reactants equals the concentration of products.
B) The forward and reverse reactions still occur.
C) The rates of the forward and reverse reactions are equal to zero.
D) The concentrations of products is always higher than the concentrations of reactants
E) None of the above.

17) (3 points) In the following reaction

$$HPO_4^{2-}(aq) + H_2O(l) \leftrightarrows PO_4^{3-}(aq) + H_3O^+(aq)$$

A) HPO_4^{2-} is an acid and H_2O is its conjugate base.
B) HPO_4^{2-} is an acid and PO_4^{3-} is its conjugate base.
C) H_3O^+ is an acid and HPO_4^{2-} is its conjugate base.
D) H_2O is an acid and PO_4^{3-} is its conjugate base.
E) H_3O^+ is an acid and PO_4^{3-} is its conjugate base.

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18) (3 points) If Q > K for the following reaction 2A + B ⇆ 3C, in order to reach equilibrium

A) more C will be produced
B) more A will be produced
C) the concentration of A will decrease by 1/2
D) the concentration of B will decrease by 3/2
E) none of the above

Q > K means reaction will shift to the left to reach equilibrium

19) (3 points) For the titration of a monoprotic acid with a strong base, which of the following statements is always true?

A) The pH at the equivalence point is equal to 7.0
B) The pH at the equivalence point depends on the initial concentration of acid
C) The pH at the equivalence point is lower than pH at the half point of the titration
D) The pH at the equivalence point is higher than pH at the half point of the titration
E) None of the above

20) (6 points) For the following reaction,

$$2\,SO_2\,(g) + O_2\,(g) \leftrightarrows 2\,SO_3\,(g)$$

the equilibrium constant, K_p, is 0.758 at 627 °C. What is the equilibrium constant at 627 °C for the reaction below?

$$SO_3\,(g) \leftrightarrows SO_2\,(g) + 1/2\,O_2\,(g)$$

A) 0.660
B) 0.871
C) 1.15
D) 1.32
E) none of the above

$$K_p = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

$$\sqrt{K_p} = \sqrt{\frac{[SO_3]^2}{[SO_2]^2[O_2]}} = \frac{[SO_3]}{[SO_2][O_2]^{1/2}}$$

$$\frac{1}{\sqrt{K_p}} = \frac{[SO_2][O_2]^{1/2}}{[SO_3]} = k \text{ for } 2^{nd} \text{ reaction}$$

$$\frac{1}{\sqrt{K_p}} = \frac{1}{\sqrt{0.758}} = 1.15$$

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Without doing any calculations, match the following thermodynamic properties with their appropriate numerical sign for the following exothermic reaction.

$$4NH_3\,(g) + 5O_2\,(g) \longrightarrow 4NO\,(g) + 6H_2O\,(g)$$

21) (3 points) ΔH_{rxn} B
22) (3 points) ΔS_{rxn} A
23) (2 points) ΔG_{rxn} B
24) (2 points) $\Delta S_{universe}$ A

A) > 0
B) < 0
C) > 0 low T, < 0 high T
D) < 0 low T, > 0 high T

- exothermic: ΔH is ⊖
- 9 moles → 10 moles means ΔS is ⊕
- if ΔH is ⊖ and ΔS is ⊕ ΔG will be ⊖ at all temperatures
- ΔS_{univ} is ⊕ for spontaneous reactions

25) (6 points) Balance the following redox reaction in a basic solution:

$$Zn\,(s) + Cr_2O_7^{2-}\,(aq) \rightarrow Zn^{2+}\,(aq) + Cr^{3+}\,(aq)$$

A) $14H^+ + Zn + Cr_2O_7^{2-} \rightarrow Zn^{2+} + 2Cr^{3+} + 7H_2O$
B) $14H^+ + 3Zn + Cr_2O_7^{2-} \rightarrow 3Zn^{2+} + 2Cr^{3+} + 7H_2O$
C) $7H_2O + Zn + Cr_2O_7^{2-} \rightarrow Zn^{2+} + 2Cr^{3+} + 14OH^-$
D) $7H_2O + 3Zn + Cr_2O_7^{2-} \rightarrow 3Zn^{2+} + Cr^{3+} + 14OH^-$
E) $7H_2O + 3Zn + Cr_2O_7^{2-} \rightarrow 3Zn^{2+} + 2Cr^{3+} + 14OH^-$

- Balance masses for half reactions:

$$Zn \longrightarrow Zn^{2+} + 2e^{\ominus}$$

$$14H^+ + Cr_2O_7^{2-} + 6e^{\ominus} \longrightarrow 2Cr^{3+} + 7H_2O$$

- Balance electrons:

$$3Zn \longrightarrow 3Zn^{2+} + 6e^{\ominus}$$

$$14H^+ + Cr_2O_7^{2-} + 6e^{\ominus} \longrightarrow 2Cr^{3+} + 7H_2O$$

- Add half reactions

$$14H^+ + 3Zn + Cr_2O_7^{2-} \longrightarrow 3Zn^{2+} + 2Cr^{3+} + 7H_2O$$

- Add $-OH$

$$+14OH^- \qquad\qquad +14OH^-$$

$$14H_2O + 3Zn + Cr_2O_7^{2-} \longrightarrow 3Zn^{2+} + 2Cr^{3+} + 7H_2O + 14OH^-$$

- remove $7H_2O$ from each side

$$7H_2O + 3Zn + Cr_2O_7^{2-} \longrightarrow 3Zn^{2+} + 2Cr^{3+} + 14OH^-$$

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The next **3 questions** refer to the following electrochemical cell:

A nickel electrode is put into a solution that contains 1.00 M Ni^{2+} ions, and a silver electrode is put into a solution that contains 1.00 M Ag^{+} ions. The electrodes are connected by a wire, and the solutions are connected by a salt bridge. The entire cell is placed at room temperature.

26) (3 points) What is the overall reaction that takes place?

A) $2Ag^{+}$ (aq) + 2Ag (s) ⇆ Ni^{2+} (aq) + Ni (s)
B) Ni^{2+} (aq) + Ni (s) ⇆ $2Ag^{+}$ (aq) + 2Ag (s)
C) Ni^{2+} (aq) + 2Ag (s) ⇆ $2Ag^{+}$ (aq) + Ni (s)
D) $2Ag^{+}$ (aq) + Ni (s) ⇆ Ni^{2+} (aq) + 2Ag (s)
E) None of these occurs

$2Ag^{+} + 2e^{-} \rightarrow 2Ag$ $E = 0.799\ V$
$Ni \rightarrow Ni^{2+} + 2e^{-}$ $E = -0.25\ V$
$2Ag^{+} + Ni \rightarrow Ni^{2+} + 2Ag$

27) (3 points) What is the voltage produced by this cell?

A) -1.049 V
B) -0.549 V
C) 0.549 V
D) 1.049 V
E) 1.848 V

$E^{\circ}_{cell} = E^{\circ}_{cathode} - E^{\circ}_{anode}$
$= 0.799\ V - (-0.25\ V)$
$= 1.049\ V$

28) (4 points) What is the voltage produced by this cell if the concentrations of the Ni^{2+} and Ag^{+} ions are each reduced to 0.0100 M?

A) 0.931 V
B) 0.990 V
C) 1.049 V
D) 1.108 V
E) None of these is correct

$E = E^{\circ} - \frac{.0257}{n} \ln Q$
$= 1.049 - \frac{.0257}{2} \ln 100$
$= 1.049 - 0.0592$
$= 0.990\ V$

$Q = \frac{[Ni^{2+}]}{[Ag^{+}]^2}$
$= \frac{[0.01]}{[0.01]^2}$
$= 100$

n = 2 for this reaction where 2 electrons are transferred

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Extra credit problems:

29) (5 points) 5.00 g of an unknown non-electrolyte compound is used to make 100ml of a solution. The solution exerts a pressure of 1250 mm Hg at room temperature. What is the molecular weight of the unknown compound?

A) 74.4 g/mole
B) 744 g/mole
C) 7.53 x 10^4 g/mole
D) 5.65 x 10^5 g/mole
E) None of these is correct

$\Pi = cRT$

$c = \frac{\Pi}{RT} = \frac{(250\text{ mm Hg})(1\text{ atm}/760\text{ mm Hg})}{(0.0821\ \frac{l\text{-atm}}{\text{mol K}})(298\text{ K})}$

$= 0.672$ moles/L

0.0672 moles/L $\times$ 0.100 L $= 0.00672$ moles

$\frac{5\text{ g}}{0.00672\text{ moles}} = 744$ g/mole

30) (5 points) For the reaction: $NH_4Cl\ (aq) \longrightarrow NH_3\ (g) + HCl\ (aq)$

$\Delta H° = 86.4$ kJ/mol and $\Delta S° = 79.1$ J/(mol. K) (Assume that $\Delta H°$ and $\Delta S°$ are independent of temperature.)

The equilibrium constant for this reaction at 299 K is:

A) 0.975
B) 5.57 x 10^{-26}
C) 1.79 x 10^{25}
D) 9.28 x 10^{10}
E) 1.09 x 10^{-11}

$\Delta G° = \Delta H° - T\Delta S°$

$= (86.4\text{ kJ/mole}) - (299\text{ K})(.0791\ \frac{\text{kJ}}{\text{mol K}})$

$= 62.7$ kJ/mole

$= 62700$ J/mole

$\Delta G = -RT \ln K$

$\ln K = \frac{\Delta G}{-RT} = \frac{62700\text{ J/mole}}{-(8.31\text{ J/mole K})(299\text{ K})}$

$= -25.25$

$K = 1.08 \times 10^{-11}$

Please sign the following statement at the completion of the exam:
I did not cheat on this exam. _____(name)

_____(signature)

PERIODIC TABLE OF THE ELEMENTS

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.939	4 Be 9.012											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 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	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 (99)	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	57 La 138.9	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 226.0	89 Ac 227.0	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

USEFUL INFORMATION:

Constants

1 atm = 760 mm Hg	T (°C) + 273 = T (K)	k_H for N_2 = 8.42 x 10^{-7} M/mm Hg
R = 0.0821 (L•atm)/(mol•K) = 8.31 J/(mol•K) = 8.31x10^{-3} kJ/(mol•K)	Room Temperature = 25°C = 298K	P° (H_2O, 100°C) = 760 mm Hg
K_{bp} for water: +0.512°C/m	K_{fp} for water: -1.86°C/m	
$K_w = 1 \times 10^{-14}$, 25 °C	ΔH_{vap} for water = 40.7 kJ/mol	F = 96,485 coulombs/mole e^- = 96,485 J/(V•mole)

Formulae:

PV = nRT	ln P = (-ΔH/RT) + c	ln (P_2/P_1) = (ΔH/R)($1/T_1$-$1/T_2$)
ΔT = Kmi	$P_A = X_A P_A^o$	Π = cRT
$S_g = k_H P_g$	Molarity (M) = moles/L solution	molality (m) = moles/kg H_2O
ln (A/A_0) = -kt	1/A-1/A_0 = kt	A_0-A = kt
$t_{1/2}$ = 0.693/k	ln (k_2/k_1) = (-E_a/R)($1/T_2$-$1/T_1$)	$k = Ae^{-E_a/RT}$
$ax^2+bx+c = 0$	x = [-b ± sqrt(b^2-4ac)]/(2a)	
pX = -log X	$pK_w = pK_a + pK_b$	pK_w = pH + pOH
pH = pK_a + log ([Conjugate Base]/[Acid])	pOH = pK_b + log ([Conjugate Acid]/[Base])	
$\Delta G°_{rxn} = \Delta H°_{rxn} - T\Delta S°_{rxn}$	ΔS = q_{rev}/T	$\Delta S_{sys} = \Delta S_{fus} = \Delta H_{fus}/T_{fus}$
$\Delta S_{surr} = -\Delta H_{sys}/T = -\Delta H_{rxn}/T$	$\Delta S_{sys} = \Delta S_{vap} = \Delta H_{vap}/T_{vap}$	$\Delta S_{univ} = \Delta S_{sys} + S_{surr}$
ΔG = ΔH - TΔS	ΔG° = -RT ln K	ΔG = ΔG° + RT ln Q
$E°_{cell} = E°_{cathode} - E°_{anode}$	E = E° – (0.0257/n) ln Q (at 25°C)	ln K_{eq} = nE°/0.0257 (at 25°C)
ΔG° = -nFE°	Current I (Amperes, A) = electric charge (coulombs, C) / time (sec)	

Table 20.1 Standard Reduction Potentials in Aqueous Solution at 25 °C*

Reduction Half-Reaction		$E°$ (V)
$F_2(g) + 2\ e^-$	$\longrightarrow 2\ F^-(aq)$	+2.87
$H_2O_2(aq) + 2\ H^+(aq) + 2\ e^-$	$\longrightarrow 2\ H_2O(\ell)$	+1.77
$PbO_2(s) + SO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$	$\longrightarrow PbSO_4(s) + 2\ H_2O(\ell)$	+1.685
$MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^-$	$\longrightarrow Mn^{2+}(aq) + 4\ H_2O(\ell)$	+1.51
$Au^{3+}(aq) + 3\ e^-$	$\longrightarrow Au(s)$	+1.50
$Cl_2(g) + 2\ e^-$	$\longrightarrow 2\ Cl^-(aq)$	+1.36
$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6\ e^-$	$\longrightarrow 2\ Cr^{3+}(aq) + 7\ H_2O\ (\ell)$	+1.33
$O_2(g) + 4\ H^+(aq) + 4\ e^-$	$\longrightarrow 2\ H_2O(\ell)$	+1.229
$Br_2(\ell) + 2\ e^-$	$\longrightarrow 2\ Br^-(aq)$	+1.08
$NO_3^-(aq) + 4\ H^+(aq) + 3\ e^-$	$\longrightarrow NO(g) + 2\ H_2O(\ell)$	+0.96
$OCl^-(aq) + H_2O(\ell) + 2\ e^-$	$\longrightarrow Cl^-(aq) + 2\ OH^-(aq)$	+0.89
$Hg^{2+}(aq) + 2\ e^-$	$\longrightarrow Hg(\ell)$	+0.855
$Ag^+(aq) + e^-$	$\longrightarrow Ag(s)$	+0.799
$Hg_2^{2+}(aq) + 2\ e^-$	$\longrightarrow 2\ Hg(\ell)$	+0.789
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	+0.771
$I_2(s) + 2\ e^-$	$\longrightarrow 2\ I^-(aq)$	+0.535
$O_2(g) + 2\ H_2O(\ell) + 4\ e^-$	$\longrightarrow 4\ OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2\ e^-$	$\longrightarrow Cu(s)$	+0.337
$Sn^{4+}(aq) + 2\ e^-$	$\longrightarrow Sn^{2+}(aq)$	+0.15
$2\ H^+(aq) + 2\ e^-$	$\longrightarrow H_2(g)$	0.00
$Sn^{2+}(aq) + 2\ e^-$	$\longrightarrow Sn(s)$	−0.14
$Ni^{2+}(aq) + 2\ e^-$	$\longrightarrow Ni(s)$	−0.25
$V^{3+}(aq) + e^-$	$\longrightarrow V^{2+}(aq)$	−0.255
$PbSO_4(s) + 2\ e^-$	$\longrightarrow Pb(s) + SO_4^{2-}(aq)$	−0.356
$Cd^{2+}(aq) + 2\ e^-$	$\longrightarrow Cd(s)$	−0.40
$Fe^{2+}(aq) + 2\ e^-$	$\longrightarrow Fe(s)$	−0.44
$Zn^{2+}(aq) + 2\ e^-$	$\longrightarrow Zn(s)$	−0.763
$2\ H_2O(\ell) + 2\ e^-$	$\longrightarrow H_2(g) + 2\ OH^-(aq)$	−0.8277
$Al^{3+}(aq) + 3\ e^-$	$\longrightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2\ e^-$	$\longrightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\longrightarrow Na(s)$	−2.714
$K^+(aq) + e^-$	$\longrightarrow K(s)$	−2.925
$Li^+(aq) + e^-$	$\longrightarrow Li(s)$	−3.045

* In volts (V) versus the standard hydrogen electrode.

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