# Chem 462
# Exam 2 - Fall 2002

| Scores | |
|---|---|
| 1 | /16 |
| 2 | /8 |
| 3 | /6 |
| 4 | /14 |
| 5 | /12 |
| 6 | /6 |
| 7 | /6 |
| 8 | /18 |
| 9 | /14 |
| Tot. | /100 |

Name ________________________________

I.D. # ____________________

## PHYSICAL CONSTANTS/CONVERSION FACTORS

**Speed of light = $3.00 \times 10^{8}$ m/s**
**Planck's const. = $6.63 \times 10^{-34}$ J•s**
**Avagadro's Number = $6.02 \times 10^{23}$**
**Electron charge = $1.602 \times 10^{-19}$ C**
**Faraday's const. = 96487 C $mol^{-1}$ ($e^{-}$)**
**Gas const.(R) = 0.0821 L atm $mol^{-1}$ $K^{-1}$**
**= 62.4 L torr $mol^{-1}$ $K^{-1}$**
**= 8.314 J $mol^{-1}$ $K^{-1}$**
**= 1.987 cal $mol^{-1}$ $K^{-1}$**
**Mass of e = 0.00055 amu**
**= $9.1094 \times 10^{-31}$ kg**

**0 ˚C = 273 K**
**1.00 atm = 760 torr**
**1 inch = 2.54 cm**
**1.00 lb = 454 g**
**1 Å = $1.0 \times 10^{-8}$ cm**
**1 eV = $1.602 \times 10^{-19}$ J**
**1.0 cal = 4.184 J (exact)**
**Mass of p = 1.0073 amu**
**= $1.6726 \times 10^{-27}$ kg**
**Mass of p = 1.0087 amu**
**= $1.6749 \times 10^{-27}$ kg**

Pauling Electronegativity → 2.1 1 H 1.008 ← Atomic molar mass (Atomic weight)

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1 1 H 1.008 | | | | | | | | | | | | | | | | | 2 He 4.003 |
| 1.0 3 Li 6.941 | 1.5 4 Be 9.012 | | | | | | | | | | | 2.0 5 B 10.81 | 2.5 6 C 12.01 | 3.0 7 N 14.01 | 3.5 8 O 16.00 | 4.0 9 F 19.00 | 10 Ne 20.18 |
| 1.0 11 Na 22.99 | 1.2 12 Mg 24.30 | | | | | | | | | | | 1.5 13 Al 26.98 | 1.8 14 Si 28.09 | 2.1 15 P 30.97 | 2.5 16 S 32.07 | 3.0 17 Cl 35.45 | 18 Ar 39.95 |
| 0.9 19 K 39.10 | 1.0 20 Ca 40.08 | 1.3 21 Sc 44.96 | 1.4 22 Ti 47.88 | 1.5 23 V 50.94 | 1.6 24 Cr 52.00 | 1.6 25 Mn 54.94 | 1.7 26 Fe 55.85 | 1.7 27 Co 58.93 | 1.8 28 Ni 58.69 | 1.8 29 Cu 63.55 | 1.6 30 Zn 65.39 | 1.7 31 Ga 69.72 | 1.9 32 Ge 72.61 | 2.1 33 As 74.92 | 2.4 34 Se 78.96 | 2.8 35 Br 79.90 | 36 Kr 83.80 |
| 0.9 37 Rb 85.47 | 1.0 38 Sr 87.62 | 1.2 39 Y 88.91 | 1.3 40 Zr 91.22 | 1.5 41 Nb 92.91 | 1.6 42 Mo 95.94 | 1.7 43 Tc (98) | 1.8 44 Ru 101.1 | 1.8 45 Rh 102.9 | 1.8 46 Pd 106.4 | 1.6 47 Ag 107.9 | 1.6 48 Cd 112.4 | 1.6 49 In 114.8 | 1.8 50 Sn 118.7 | 1.9 51 Sb 121.8 | 2.1 52 Te 127.6 | 2.5 53 I 126.9 | 54 Xe 131.3 |
| 0.8 55 Cs 132.9 | 1.0 56 Ba 137.3 | 1.1 57 ★La 138.9 | 1.3 72 Hf 178.5 | 1.4 73 Ta 180.9 | 1.5 74 W 183.8 | 1.7 75 Re 186.2 | 1.9 76 Os 190.2 | 1.9 77 Ir 192.2 | 1.8 78 Pt 195.1 | 1.9 79 Au 197.0 | 1.7 80 Hg 200.6 | 1.6 81 Tl 204.4 | 1.7 82 Pb 207.2 | 1.8 83 Bi 209.0 | 1.9 84 Po (209) | 2.1 85 At (210) | 86 Rn (222) |
| 0.8 87 Fr (223) | 1.0 88 Ra (226) | 1.1 89 ▼Ac (227) | 104 Unq (261) | 2.1 105 Unp (262) | 106 Unh (263) | 107 Uns (262) | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ★ Lanthanide series | 1.1 58 Ce 140.1 | 1.1 59 Pr 140.9 | 1.1 60 Nd 144.2 | 1.1 61 Pm (145) | 1.1 62 Sm 150.4 | 1.1 63 Eu 152.0 | 1.1 64 Gd 157.2 | 1.1 65 Tb 158.9 | 1.1 66 Dy 162.5 | 1.1 67 Ho 164.9 | 1.1 68 Er 167.3 | 1.1 69 Tm 168.9 | 1.0 70 Yb 173.0 | 1.2 71 Lu 175.0 |
| ▼ Actinide series | 1.2 90 Th 232.0 | 1.3 91 Pa 231.0 | 1.5 92 U 238.0 | 1.3 93 Np (237) | 1.3 94 Pu (244) | 1.3 95 Am (243) | 1.3 96 Cm (247) | 1.3 97 Bk (247) | 1.3 98 Cf (251) | 1.3 99 Es (252) | 1.3 100 Fm (257) | 1.3 101 Md (258) | 1.3 102 No (259) | 1.5 103 Lr (260) |

## Read questions carefully & give answers in the blanks provided

(**1**) (16 points) Give products for all the reactions below. If no reaction occurs, write “NR” — do not leave it blank.

(a) 2 HF(*l*) + $PF_5$ □ (write the species present in this acid-base equilibrium)

(b) $N_2O_5$(g) + excess $H_2O$ □

(c) $Li_3N$ is added to an acetic acid solution in $NH_3$(*l*) □

(d) $Cu^{2+}$(aq) + Ag(s) □

(e) $Cu_2S$(s) + $O_2$ (air) □ (roasting at high temperature)

(f) $SO_3$ + excess $H_2O$ □

(g) NOF + $ClF_5$ □ (write the species present in this acid-base equilibrium)

(h) $Al(OH)_3$ (hydrous) + excess $OH^-$ □

(**2**) (8 points) Using hard-soft concepts, predict which of the following should have an equilibrium constant greater than 1. Unless otherwise stated, assume these are measured at 25 ˚C in the gas phase or hydrocarbon solutions.

(a) $Et_3PBBr_3$ + $Et_3PBF_3$ □ $Et_3PBF_3$ + $Et_3PBBr_3$

(b) $SO_2$ + $(C_6H_5)_3P{:}HOC(CH_3)_3$ □ $(C_6H_5)_3P{:}SO_2$ + $HOC(CH_3)_3$

(c) $CH_3HgI$ + HCl □ $CH_3HgCl$ + HI

(d) $[AgCl_2]^-$(aq) + 2 $CN^-$(aq) □ $[Ag(CN)_2]^-$(aq) + 2 $Cl^-$(aq)

(**3**) (6 points) For each the following sets, put the compounds in order.

(a) $HSO_4^-$, $H_3O^+$, $H_4SiO_4$, $NH_3$, $HSO_3F$ increasing Brønsted acidity in water.

(b) $S^{2-}$, $O^{2-}$, $F^-$, $Cl^-$, $I^-$ increasing Brønsted basicity in water.

(**4**) (a) (14 pts) Dilute hydrogen peroxide ($H_2O_2$) solutions are used to kill anaerobic bacteria in fresh wounds. The iron in blood acts as a catalyst to produce the characteristic gas evolution ("fizzing") that occurs in this process. Write an equation for the reaction that takes place and compute $\Delta G^\circ$ for that reaction.

(**5**) (12 pts) Phosphorous and boric acids have analogous compositions: $H_3EO_3$ (E = B, P). However, boric acid is monobasic with p$K_a$ = 9.1. Phosphorous acid is dibasic with p$K_{a1}$ = 1.8 and p$K_{a2}$ = 6.6.

(a) With appropriate equations, show how boric acid, $B(OH)_3$, acts as a Lewis acid and show what species acts as a Brønsted acid (p$K_a$ = 9.1) in aqueous boric acid solutions. Show the structures of all relevant species in your equations.

(b) Show how the measured p$K_a$ values of phosphorous acid are consistent with its structure. (The Pauling/Bell equation is: $pK_a \approx 8 - 5p$).

(**6**) (6 pts) Give a brief, but informative, explanation for the fact that $FeCl_4^-$ is formed when $FeCl_3$ is dissolved in $OP(OCH_2CH_3)_3$.

(**7**) (6 pts) The heats of reaction of $B(CH_3)_3$ with $NH_3$, $CH_3NH_2$, $(CH_3)_2NH$, and $(CH_3)_3N$ are –57.7, –73.6, –80.8, –73.6 kJ/mol, respectively. Explain the trend(s) in this data.

**(8)** (18 pts) (a) Gold is a noble metal that is oxidized only with difficulty (which is why gold is a practical coinage metal). Cyanide is used in gold extraction from ores. Given the standard potentials for $Au^{I}$ reduction,

$$Au^{+} + e^{-} \rightarrow Au \qquad E^{\circ} = +1.68\ V$$
$$[Au(CN)_2]^{-}(aq) + e^{-} \rightarrow Au + 2CN^{-}(aq) \qquad E^{\circ} = -0.6\ V$$

Compute the complex formation constant for the reaction:

$$Au^{+}(aq) + 2CN^{-}(aq) \rightleftharpoons [Au(CN)_2]^{-}(aq)$$

(**9**) (14 points) In class, the rates of outer sphere electron transfer reactions were discussed. One of the degenerate (self-exchange) reactions,

$$[Co(H_2O)_6]^{3+} + [Co(H_2O)_6]^{2+} \rightleftharpoons [Co(H_2O)_6]^{2+} + [Co(H_2O)_6]^{3+}$$

is fairly fast (~5 $M^{-1}$ $s^{-1}$), even though the $Co^{III}$ complex is low-spin and the $Co^{II}$ complex is high-spin. Furthermore, the difference between the $Co^{III}$–O and the $Co^{II}$–O bond lengths is large (~ 0.15 Å). Try to provide an explanation for this seemingly anomalous behavior! *Hints: (1) $H_2O$ is a weak field ligand, so the low-spin state for $[Co(H_2O)_6]^{3+}$ is itself somewhat "anomalous". (2) The reaction pathway in this case is thought to be a little more complicated than the cases discussed in class.*

# Standard Reduction Potentials, 298K

The concentration of each aqueous solution is 1 mol dm$^{-3}$ and the pressure of a gaseous component is 1 bar ($10^5$ Pa). (Changing the standard pressure to 1 atm (101 300 Pa) makes no difference to the values of $E^o$ at this level of accuracy.) Each half-cell listed contains the specified solution species at a concentration of 1 mol dm$^{-3}$; where the half-cell contains $[OH]^-$, the value of $E^o$ refers to $[OH^-] = 1$ mol dm$^{-3}$, hence the notation $E^o_{[OH^-]=1}$ (see Box 7.1).

| **Reduction half-equation** | $E^o$ **or** $E^o_{[OH^-]=1}$ **/ V** |
|---|---|
| $Li^+(aq) + e^- \rightleftharpoons Li(s)$ | −3.04 |
| $Cs^+(aq) + e^- \rightleftharpoons Cs(s)$ | −3.03 |
| $Rb^+(aq) + e^- \rightleftharpoons Rb(s)$ | −2.98 |
| $K^+(aq) + e^- \rightleftharpoons K(s)$ | −2.93 |
| $Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)$ | −2.87 |
| $Na^+(aq) + e^- \rightleftharpoons Na(s)$ | −2.71 |
| $La^{3+}(aq) + 3e^- \rightleftharpoons La(s)$ | −2.38 |
| $Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$ | −2.37 |
| $Y^{3+}(aq) + 3e^- \rightleftharpoons Y(s)$ | −2.37 |
| $Sc^{3+}(aq) + 3e^- \rightleftharpoons Sc(s)$ | −2.03 |
| $Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$ | −1.66 |
| $[HPO_3]^{2-} + 2H_2O + 2e^- \rightleftharpoons [H_2PO_2]^- + 3[OH]^-$ | −1.65 |
| $Ti^{2+}(aq) + 2e^- \rightleftharpoons Ti(s)$ | −1.63 |
| $Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$ | −1.19 |
| $V^{2+}(aq) + 2e^- \rightleftharpoons V(s)$ | −1.18 |
| $Te(s) + 2e^- \rightleftharpoons Te^{2-}(aq)$ | −1.14 |
| $2[SO_3]^{2-} + 2H_2O + 2e^- \rightleftharpoons 4[OH]^- + [S_2O_4]^{2-}$ | −1.12 |
| $[SO_4]^{2-}(aq) + H_2O(l) + 2e^- \rightleftharpoons [SO_3]^{2-}(aq) + 2[OH]^-(aq)$ | −0.93 |
| $Se(s) + 2e^- \rightleftharpoons Se^{2-}(aq)$ | −0.92 |
| $Cr^{2+}(aq) + 2e^- \rightleftharpoons Cr(s)$ | −0.91 |
| $2[NO_3]^-(aq) + 2H_2O(l) + 2e^- \rightleftharpoons N_2O_4(g) + 4[OH]^-(aq)$ | −0.85 |
| $2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2[OH]^-(aq)$ | −0.82 |
| $Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$ | −0.76 |
| $Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$ | −0.74 |
| $S(s) + 2e^- \rightleftharpoons S^{2-}(aq)$ | −0.48 |
| $[NO_2]^-(aq) + H_2O(l) + e^- \rightleftharpoons NO(g) + 2[OH]^-(aq)$ | −0.46 |
| $Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$ | −0.44 |
| $Cr^{3+}(aq) + e^- \rightleftharpoons Cr^{2+}(aq)$ | −0.41 |
| $Ti^{3+}(aq) + e^- \rightleftharpoons Ti^{2+}(aq)$ | −0.37 |
| $PbSO_4(s) + 2e^- \rightleftharpoons Pb(s) + [SO_4]^{2-}(aq)$ | −0.36 |
| $Tl^+(aq) + e^- \rightleftharpoons Tl(s)$ | −0.34 |
| $Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$ | −0.28 |
| $H_3PO_4(aq) + 2H^+(aq) + 2e^- \rightleftharpoons H_3PO_3(aq) + H_2O(l)$ | −0.28 |
| $V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$ | −0.26 |
| $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$ | −0.25 |
| $2[SO_4]^{2-} + 4H^+ + 2e^- \rightleftharpoons [S_2O_6]^{2-} + 2H_2O$ | −0.22 |

| Reduction half-equation | $E^o$ or $E^o_{[OH^-]=1}$ / V |
|---|---|
| $O_2 + 2H_2O + 2e^- \rightleftharpoons H_2O_2 + 2[OH]^-$ | −0.15 |
| $Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$ | −0.14 |
| $Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$ | −0.13 |
| $Fe^{3+}(aq) + 3e^- \rightleftharpoons Fe(s)$ | −0.04 |
| $2H^+(aq, 1\,mol\,dm^{-3}) + 2e^- \rightleftharpoons H_2(g, 1\,bar)$ | 0 |
| $[NO_3]^-(aq) + H_2O(l) + 2e^- \rightleftharpoons [NO_2]^-(aq) + 2[OH]^-(aq)$ | +0.01 |
| $[S_4O_6]^{2-}(aq) + 2e^- \rightleftharpoons 2[S_2O_3]^{2-}(aq)$ | +0.08 |
| $S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(aq)$ | +0.14 |
| $2[NO_2]^-(aq) + 3H_2O(l) + 4e^- \rightleftharpoons N_2O(g) + 6[OH]^-(aq)$ | +0.15 |
| $Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$ | +0.15 |
| $Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$ | +0.15 |
| $[SO_4]^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons H_2SO_3(aq) + H_2O(l)$ | +0.17 |
| $AgCl(s) + e^- \rightleftharpoons Ag(s) + Cl^-(aq)$ | +0.22 |
| $Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ | +0.34 |
| $[VO]^{2+}(aq) + 2H^+(aq) + e^- \rightleftharpoons V^{3+}(aq) + H_2O(l)$ | +0.34 |
| $[ClO_4]^-(aq) + H_2O(l) + 2e^- \rightleftharpoons [ClO_3]^-(aq) + 2[OH]^-(aq)$ | +0.36 |
| $[Fe(CN)_6]^{3-}(aq) + e^- \rightleftharpoons [Fe(CN)_6]^{4-}(aq)$ | +0.36 |
| $O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4[OH]^-(aq)$ | +0.40 |
| $Cu^+(aq) + e^- \rightleftharpoons Cu(s)$ | +0.52 |
| $I_2(aq) + 2e^- \rightleftharpoons 2I^-(aq)$ | +0.54 |
| $H_3AsO_4(aq) + 2H^+(aq) + 2e^- \rightleftharpoons HAsO_2(aq) + 2H_2O(l)$ | +0.56 |
| $[MnO_4]^-(aq) + e^- \rightleftharpoons [MnO_4]^{2-}(aq)$ | +0.56 |
| $[MnO_4]^-(aq) + 2H_2O(aq) + 3e^- \rightleftharpoons MnO_2(s) + 4[OH]^-(aq)$ | +0.59 |
| $[BrO_3]^-(aq) + 3H_2O(l) + 6e^- \rightleftharpoons Br^-(aq) + 6[OH]^-(aq)$ | +0.61 |
| $O_2(g) + 2H^+(aq) + 2e^- \rightleftharpoons H_2O_2(aq)$ | +0.70 |
| $[BrO]^-(aq) + H_2O(l) + 2e^- \rightleftharpoons Br^-(aq) + 2[OH]^-(aq)$ | +0.76 |
| $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ | +0.77 |
| $Ag^+(aq) + e^- \rightleftharpoons Ag(s)$ | +0.80 |
| $[ClO]^-(aq) + H_2O(l) + 2e^- \rightleftharpoons Cl^-(aq) + 2[OH]^-(aq)$ | +0.84 |
| $2HNO_2(aq) + 4H^+(aq) + 4e^- \rightleftharpoons H_2N_2O_2(aq) + 2H_2O(l)$ | +0.86 |
| $[NO_3]^-(aq) + 3H^+(aq) + 2e^- \rightleftharpoons HNO_2(aq) + H_2O(l)$ | +0.93 |
| $Pd^{2+} + 2e^- \rightleftharpoons Pd$ | +0.95 |
| $[NO_3]^-(aq) + 4H^+(aq) + 3e^- \rightleftharpoons NO(g) + 2H_2O(l)$ | +0.96 |
| $HNO_2(aq) + H^+(aq) + e^- \rightleftharpoons NO(g) + H_2O(l)$ | +0.98 |
| $[VO_2]^+(aq) + 2H^+(aq) + e^- \rightleftharpoons [VO]^{2+}(aq) + H_2O(l)$ | +0.99 |
| $[Fe(bpy)_3]^{3+}(aq) + e^- \rightleftharpoons [Fe(bpy)_3]^{2+}(aq)$ | +1.03 |
| $[IO_3]^-(aq) + 6H^+(aq) + 6e^- \rightleftharpoons I^-(aq) + 3H_2O(l)$ | +1.09 |
| $Br_2(aq) + 2e^- \rightleftharpoons 2Br^-(aq)$ | +1.09 |
| $[Fe(phen)_3]^{3+}(aq) + e^- \rightleftharpoons [Fe(phen)_3]^{2+}(aq)$ | +1.12 |
| $Pt^{2+} + 2e^- \rightleftharpoons Pt$ | +1.18 |
| $2[IO_3]^-(aq) + 12H^+(aq) + 10e^- \rightleftharpoons I_2(aq) + 6H_2O(l)$ | +1.20 |
| $O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$ | +1.23 |
| $MnO_2(s) + 4H^+(aq) + 2e^- \rightleftharpoons Mn^{2+}(aq) + 2H_2O$ | +1.23 |
| $Tl^{3+}(aq) + 2e^- \rightleftharpoons Tl^+(aq)$ | +1.25 |
| $2HNO_2(aq) + 4H^+(aq) + 4e^- \rightleftharpoons N_2O(g) + 3H_2O(l)$ | +1.30 |
| $[Cr_2O_7]^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$ | +1.33 |
| $Cl_2(aq) + 2e^- \rightleftharpoons 2Cl^-(aq)$ | +1.36 |
| $2[ClO_4]^-(aq) + 16H^+(aq) + 14e^- \rightleftharpoons Cl_2(aq) + 8H_2O(l)$ | +1.39 |
| $[ClO_4]^-(aq) + 8H^+(aq) + 8e^- \rightleftharpoons Cl^-(aq) + 4H_2O(l)$ | +1.39 |
| $[BrO_3]^-(aq) + 6H^+(aq) + 6e^- \rightleftharpoons Br^-(aq) + 3H_2O(l)$ | +1.42 |
| $[ClO_3]^-(aq) + 6H^+(aq) + 6e^- \rightleftharpoons Cl^-(aq) + 3H_2O(l)$ | +1.45 |
| $2[ClO_3]^-(aq) + 12H^+(aq) + 10e^- \rightleftharpoons Cl_2(aq) + 6H_2O(l)$ | +1.47 |

| Reduction half-equation | $E^{\circ}$ or $E^{\circ}_{[OH^-]=1}$ / V |
|---|---|
| $2[BrO_3]^-(aq) + 12H^+(aq) + 10e^- \rightleftharpoons Br_2(aq) + 6H_2O(l)$ | +1.48 |
| $HOCl(aq) + H^+(aq) + 2e^- \rightleftharpoons Cl^-(aq) + H_2O(l)$ | +1.48 |
| $[MnO_4]^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ | +1.51 |
| $Mn^{3+}(aq) + e^- \rightleftharpoons Mn^{2+}(aq)$ | +1.54 |
| $2HOCl(aq) + 2H^+(aq) + 2e^- \rightleftharpoons Cl_2(aq) + 2H_2O(l)$ | +1.61 |
| $[MnO_4]^-(aq) + 4H^+(aq) + 3e^- \rightleftharpoons MnO_2(s) + 2H_2O(l)$ | +1.69 |
| $PbO_2(s) + 4H^+(aq) + [SO_4]^{2-}(aq) + 2e^- \rightleftharpoons PbSO_4(s) + 2H_2O(l)$ | +1.69 |
| $Ce^{4+}(aq) + e^- \rightleftharpoons Ce^{3+}(aq)$ | +1.72 |
| $H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$ | +1.78 |
| $Co^{3+}(aq) + e^- \rightleftharpoons Co^{2+}(aq)$ | +1.92 |
| $[S_2O_8]^{2-}(aq) + 2e^- \rightleftharpoons 2[SO_4]^{2-}(aq)$ | +2.01 |
| $XeO_3(aq) + 6H^+(aq) + 6e^- \rightleftharpoons Xe(g) + 3H_2O(l)$ | +2.10 |
| $[FeO_4]^{2-} + 8H^+ + 3e^- \rightleftharpoons Fe^{3+} + 4H_2O$ | +2.20 |
| $H_4XeO_6(aq) + 2H^+(aq) + 2e^- \rightleftharpoons XeO_3(aq) + 3H_2O(l)$ | +2.42 |
| $F_2(aq) + 2e^- \rightleftharpoons 2F^-(aq)$ | +2.87 |