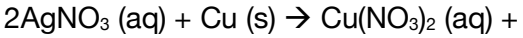
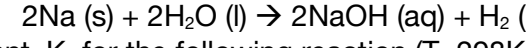
1. For the following reaction, draw a galvanic cell and label ALL parts (make sure to include where oxidation and reduction are happening, and how all species flow through the system, including electrons).



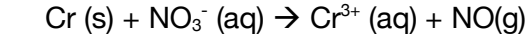
$$2AgNO_3\ (aq) + Cu\ (s) \rightarrow Cu(NO_3)_2\ (aq) + 2Ag\ (s)$$

2. Calculate the standard emf for a galvanic cell based on the following rxn:



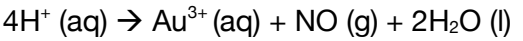
$$2Na\ (s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2\ (g)$$

3. Calculate the eq. constant, K, for the following reaction (T=298K, acidic conditions):



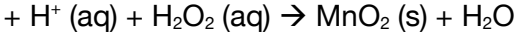
$$Cr\ (s) + NO_3^-\ (aq) \rightarrow Cr^{3+}\ (aq) + NO(g)$$

4. Calculate E°_{ox} for the reaction below:



$$Au(s) + NO_3^-\ (aq) + 4H^+\ (aq) \rightarrow Au^{3+}\ (aq) + NO\ (g) + 2H_2O\ (l) \qquad E^\circ_{cell} = -0.54$$

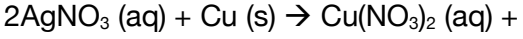
5. Rank the following in order of increasing strength as oxidizing/reducing agents:
   a. Ag, Cr^{3+}, Li, F^-, H_2 – reducing agents
   b. F_2, Cr^{3+}, I_2, MnO_4^- – oxidizing agents
   c. Cu^+, Ni, Cd, Cr – reducing agents
6. Calculate the standard E° for the electrochemical cell below:
   a. $Al\ (s) \mid Al^{3+}\ (aq) \parallel Mg^{2+}\ (aq) \mid Mg\ (s)$
   b. $Zn\ (s) \mid Zn^{2+}\ (aq) \parallel SO_4^{2-}\ (aq) \mid H_2SO_3\ (aq) \mid Pt(s)$
7. Calculate □G° and K for the following reaction. Is this reaction spontaneous?



$$MnO_4^-\ (s) + H^+\ (aq) + H_2O_2\ (aq) \rightarrow MnO_2\ (s) + H_2O\ (l) + O_2\ (g)$$

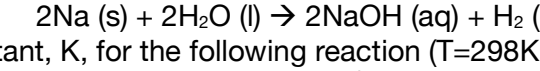
8. A number of chemical species can behave as both an oxidizing reagent and a reducing reagent. In the following situations, what reaction would predominate?
   a. Chamber containing Mn^{2+} (aq), PbO_2 (s), and Ag (s)
   b. Chamber containing I_2 (s), Zn^{2+} (aq) and Cl_2 (g)
   c. Chamber containing Cr^{3+} (aq), ClO_2^- (aq), and Au (s)

1. For the following reaction, draw a galvanic cell and label ALL parts (make sure to include where oxidation and reduction are happening, and how all species flow through the system, including electrons).



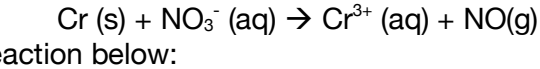
$$2AgNO_3\ (aq) + Cu\ (s) \rightarrow Cu(NO_3)_2\ (aq) + 2Ag\ (s)$$

2. Calculate the standard emf for a galvanic cell based on the following rxn:



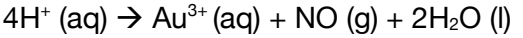
$$2Na\ (s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2\ (g)$$

3. Calculate the eq. constant, K, for the following reaction (T=298K, acidic conditions):



$$Cr\ (s) + NO_3^-\ (aq) \rightarrow Cr^{3+}\ (aq) + NO(g)$$

4. Calculate E°_{ox} for the reaction below:



$$Au(s) + NO_3^-\ (aq) + 4H^+\ (aq) \rightarrow Au^{3+}\ (aq) + NO\ (g) + 2H_2O\ (l) \qquad E^\circ_{cell} = -0.54$$

5. Rank the following in order of increasing strength as oxidizing/reducing agents:
   a. Ag, Cr^{3+}, Li, F^-, H_2 – reducing agents
   b. F_2, Cr^{3+}, I_2, MnO_4^- – oxidizing agents
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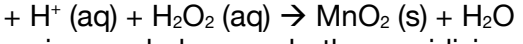
6. Calculate the standard E° for the electrochemical cell below:
   a. $Al\ (s) \mid Al^{3+}\ (aq) \parallel Mg^{2+}\ (aq) \mid Mg\ (s)$
   b. $Zn\ (s) \mid Zn^{2+}\ (aq) \parallel SO_4^{2-}\ (aq) \mid H_2SO_3\ (aq) \mid Pt(s)$
7. Calculate □G° and K for the following reaction. Is this reaction spontaneous?



$$MnO_4^-\ (s) + H^+\ (aq) + H_2O_2\ (aq) \rightarrow MnO_2\ (s) + H_2O\ (l) + O_2\ (g)$$

8. A number of chemical species can behave as both an oxidizing reagent and a reducing reagent. In the following situations, what reaction would predominate?
   a. Chamber containing Mn^{2+} (aq), PbO_2 (s), and Ag (s)
   b. Chamber containing I_2 (s), Zn^{2+} (aq) and Cl_2 (g)
   c. Chamber containing Cr^{3+} (aq), ClO_2^- (aq), and Au (s)

USEFUL INFORMATION:

F = 1F = 96485 C/mol = 96485 J/V·mol R = 8.314 J/mol·K

Standard Reduction Potentials at 25°C (298 K) for Many Common Half-reactions

Half-reaction	$\mathscr{E}°$ (V)	Half-reaction	$\mathscr{E}°$ (V)
$F_2 + 2e^- \rightarrow 2F^-$	2.87	$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	0.40
$Ag^{2+} + e^- \rightarrow Ag^+$	1.99	$Cu^{2+} + 2e^- \rightarrow Cu$	0.34
$Co^{3+} + e^- \rightarrow Co^{2+}$	1.82	$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	0.27
$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$	1.78	$SO_4^{2-} + 4H^+ + 2e^- \rightarrow H_2SO_3 + H_2O$	0.20
$Ce^{4+} + e^- \rightarrow Ce^{3+}$	1.70	$Cu^{2+} + e^- \rightarrow Cu^+$	0.16
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$	1.69	$2H^+ + 2e^- \rightarrow H_2$	0.00
$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$	1.68	$Fe^{3+} + 3e^- \rightarrow Fe$	−0.036
$IO_4^- + 2H^+ + 2e^- \rightarrow IO_3^- + H_2O$	1.60	$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	1.51	$Sn^{2+} + 2e^- \rightarrow Sn$	−0.14
$Au^{3+} + 3e^- \rightarrow Au$	1.50	$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23
$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O$	1.46	$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$	−0.35
$Cl_2 + 2e^- \rightarrow 2Cl^-$	1.36	$Cd^{2+} + 2e^- \rightarrow Cd$	−0.40
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	1.33	$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	1.23	$Cr^{3+} + e^- \rightarrow Cr^{2+}$	−0.50
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	1.21	$Cr^{3+} + 3e^- \rightarrow Cr$	−0.73
$IO_3^- + 6H^+ + 5e^- \rightarrow \frac{1}{2}I_2 + 3H_2O$	1.20	$Zn^{2+} + 2e^- \rightarrow Zn$	−0.76
$Br_2 + 2e^- \rightarrow 2Br^-$	1.09	$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	−0.83
$AuCl_4^- + 3e^- \rightarrow Au + 4Cl^-$	0.99	$Mn^{2+} + 2e^- \rightarrow Mn$	−1.18
$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$	0.96	$Al^{3+} + 3e^- \rightarrow Al$	−1.66
$ClO_2 + e^- \rightarrow ClO_2^-$	0.954	$H_2 + 2e^- \rightarrow 2H^-$	−2.23
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	0.91	$Mg^{2+} + 2e^- \rightarrow Mg$	−2.37
$Ag^+ + e^- \rightarrow Ag$	0.80	$La^{3+} + 3e^- \rightarrow La$	−2.37
$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	0.80	$Na^+ + e^- \rightarrow Na$	−2.71
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.77	$Ca^{2+} + 2e^- \rightarrow Ca$	−2.76
$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$	0.68	$Ba^{2+} + 2e^- \rightarrow Ba$	−2.90
$MnO_4^- + e^- \rightarrow MnO_4^{2-}$	0.56	$K^+ + e^- \rightarrow K$	−2.92
$I_2 + 2e^- \rightarrow 2I^-$	0.54	$Li^+ + e^- \rightarrow Li$	−3.05

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