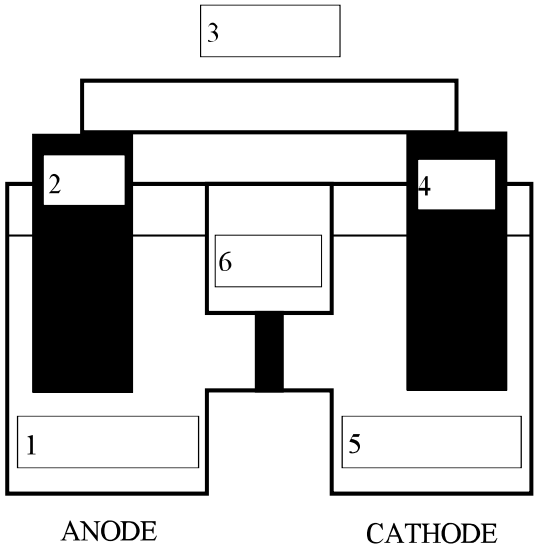
For many of these questions you will need to use E° Values. A table of these values along with the electrochemical equations is given at the end of this document.

Consider the following electrochemical cell for the next three questions: [S 00, ex 3]

Ag / AgBr(s), NaBr (aq, 1.0 M) // NaBr (aq, 1.0 M), Br_2(l) / Pt

1. Use the adjacent diagram to show what the cell would look like.



Label as follows:
1. compound(s) in anode compartment
2. anode material
3. direction of e- flow through external wire
4. cathode material
5. compound(s) in cathode compartment
6. identity and direction of ion flow through solution.

The answers in order are:

(a) AgBr(s) + NaBr(aq), Pt, e-→, Ag, NaBr(aq) + Br_2(l), Br^-→
(b) NaBr(aq) + Br_2(l), Ag, ←e-, Pt, AgBr(s) + NaBr(aq), Br^-→
(c) AgBr(s) + NaBr(aq), Ag, e-→, Pt, NaBr(aq) + Br_2(l), ←Br^-
(d) AgBr(s) + NaBr(aq), Ag, ←e-, Pt, NaBr(aq) + Br_2(l), Br^-→
(e) NaBr(aq) + Br_2(l), Pt, e-→, Ag, AgBr(s) + NaBr(aq), ←Br^-

2. What is the overall reaction occurring in the cell?

(a) Br_2(l) + 2 Na^+ → 2 NaBr (aq)
(b) Ag(s) + Br_2(l) → AgBr(s)
(c) 2 AgBr(s) → 2 Ag(s) + Br_2(l)
(d) 2 Ag(s) + Br_2(l) → 2 AgBr(s)
(e) Ag(s) + AgBr(s) → Pt(s) + Br_2(l)

3. What is E_{cell} after the overall cell reaction has reached <u>equilibrium</u>?

(a) −1.02 V (b) 1.02 V (c) 0.00 V
(d) 1.16 V (e) −1.16 V

4. Fill in the blanks for the following statements regarding electrochemical cells. [S 01, ex3]

The electrode where the oxidation occurs is called the _____.

The electrode where the reduction occurs is called the _____.

When current flows, electrons move through the external circuit from the _____ to the _____, and ions move in solution to give a net flow of negative charge from the _____ compartment to the _____ compartment.

The answers in order are

(a) anode, cathode, anode, cathode, anode, cathode
(b) anode, cathode, cathode, anode, cathode, anode
(c) anode, cathode, anode, cathode, cathode, anode
(d) cathode, anode, anode, cathode, cathode, anode
(e) cathode, anode, cathode, anode, anode, cathode

Consider the following oxidation-reduction reaction for the next <u>two</u> problems: [S 02, ex3]

$$Ni(s) + Br_2(l) \rightarrow Ni^{2+}(aq) + 2\,Br^-(aq)$$

5. In which one of the following electrochemical cells does the above reaction occur?

(a) Ni / Br_2 (l) // Ni^{2+}(aq), Br^-(aq) / Pt
(b) Pt / Br^-(aq), Br_2(l) // Ni^{2+}(aq) / Ni
(c) Pt / Ni^{2+}(aq) // Br^-(aq), Br_2(l) / Ni
(d) Ni / Ni^{2+}(aq) // Br^-(aq), Br_2(l) / Pt
(e) Ni / Br^-(aq), Br_2(l) // Ni^{2+}(aq) / Pt

6. What is $E°_{cell}$ for the electrochemical cell in which this reaction occurs? Will the cell produce electrical power or consume it?

(a) 1.35 V; produces power
(b) −1.35 V; consumes power
(c) 0.83 V; consumes power
(d) −0.83 V; produces power
(e) 1.81 V; consumes power
(ab) −1.81 V; consumes power

Consider the following electrochemical cell for the next 3 questions. [S 01, ex 3]

$$Ni / NiSO_4(aq, 1\ M) // Na_2SO_4\ (aq, 1\ M), Na_2S_2O_8\ (aq, 1\ M) / Pt$$

7. What is $E°_{cell}$?

(a) −2.27 V (b) 2.27 V (c) −1.75 V (d) 1.75 V (e) −2.01 V (ab) 2.01 V

8. What is the overall reaction occurring in the cell?

(a) $NiSO_4(aq) + Ni(s) \rightarrow Na_2SO_4(aq) + Na_2S_2O_8(aq)$
(b) $NiSO_4(aq) + Na_2SO_4(aq) \rightarrow Na_2S_2O_8(aq) + Ni(s)$
(c) $Na_2SO_4(aq) + Na_2S_2O_8(aq) \rightarrow NiSO_4(aq) + Ni(s)$
(d) $Na_2S_2O_8(aq) + Ni(s) \rightarrow NiSO_4(aq) + Na_2SO_4(aq)$
(e) $Ni(s) + Na_2SO_4(aq) \rightarrow NiSO_4(aq) + Na_2S_2O_8(aq)$

9. What is $\Delta G°$ for the overall reaction occurring in the cell?

(a) −438 kJ/mol (b) 438 kJ/mol (c) −219 kJ/mol
(d) 219 kJ/mol (e) −201 kJ/mol (ab) 201 kJ/mol

Consider the following oxidation-reduction reaction for the next two problems: [F 01, ex 3]

$$Sn^{2+}(aq) + Cu^{2+}(aq) \rightarrow Sn^{4+}(aq) + Cu(s)$$

10. In which one of the following electrochemical cells does the above reaction occur?

(a) $Cu / Cu^{2+}(aq) // Sn^{2+}(aq) / Sn$
(b) $Cu / Cu^{2+}(aq) // Sn^{2+}(aq), Sn^{4+}(aq) / Pt$
(c) $Cu / Sn^{2+}(aq), Sn^{4+}(aq) // Cu^{2+}(aq) / Pt$
(d) $Sn / Sn^{2+}(aq) // Cu^{2+}(aq) / Cu$
(e) $Pt / Sn^{2+}(aq), Sn^{4+}(aq) // Cu^{2+}(aq) / Cu$

11. Use E° values to calculate K for the reaction at 25°C.

(a) 2×10^{3} (b) 3×10^{-7} (c) 3×10^{6} (d) 1.5 (e) 6×10^{-3}

Consider the following electrochemical cell for the next four questions. [F 02, ex 3]

$$Pt / Sn(NO_3)_4(aq),\ Sn(NO_3)_2(aq) // Sn(NO_3)_2(aq) / Sn$$

12. What are the names of the ionic compounds in the cell?

(a) sodium nitrite, sodium nitrate
(b) tin nitrate, tin nitrite
(c) selenium(IV) nitrogen trioxide, selenium(II) nitrogen trioxide
(d) tin(IV) nitrate, tin(II) nitrate
(e) selenium(VIII) nitrate, selenium(IV) nitrate

13. What is the overall reaction occurring in the cell?

(a) $Sn(NO_3)_4 + Sn \rightarrow 2\ Sn(NO_3)_2$
(b) $Sn(NO_3)_2 + 2\ Pt \rightarrow Sn + 2\ PtNO_3$
(c) $Sn + Sn(NO_3)_2 \rightarrow Sn(NO_3)_4 + Sn(NO_3)_2$
(d) $Sn(NO_3)_4 \rightarrow Sn(NO_3)_2 + 2\ NO_3^-$
(e) $2\ Sn(NO_3)_2 \rightarrow Sn(NO_3)_4 + Sn$

14. What is $E°_{cell}$?

(a) 0.29 V (b) 0.15 V (c) 0.01 V (d) −0.14 V (e) −0.29 V

15. Lets say the cell was set up with the compartment on the left containing 1.00 M $Sn(NO_3)_4$ and 1.00 M $Sn(NO_3)_2$. If $E_{cell} = -0.425$, what is the concentration of $Sn(NO_3)_2$ in the compartment on the right?

(a) 2.7×10^{-5} M (b) 4.4×10^{-15} M (c) 3.6×10^{4} M
(d) 1.4×10^{-3} M (e) 0.055 M

16. What is E_{cell} of the following electrochemical cell? [S 02, ex 3]

$$Ag / AgClO_4(aq, 0.010\ M) // MgSO_4(aq, 1.0\times10^{-3}\ M) / Mg$$

(a) −3.14 V (b) −1.78 V (c) 3.22 V (d) −3.17 V (e) 1.78 V

17. Calculate E°cell for the following electrochemical cell. Will the cell produce electric power or consume power? [F 01, ex3]

$$Pt / H_2O_2 (aq, 1M), HCl (aq, 1 M) // ZnCl_2 (aq, 1 M) / Zn$$

(a) −1.02 V, consumes power (b) −1.02 V, produces power
(c) 2.54 V, consumes power (d) 2.54 V, produces power
(e) 1.02 V, consumes power (ab) 1.02 V, produces power
(ac) −2.54 V, consumes power (ad) −2.54 V, produces power

18. An electrochemical cell to measure Ni^{2+} is constructed by placing a Ni wire in a 1.00 M $NiSO_4$ solution in one compartment of the cell. The solution with the unknown $[Ni^{2+}]$ is placed in the other compartment along with another Ni wire. The potential of the Ni wire in the compartment containing the unknown $[Ni^{2+}]$ was found to be −0.1285 V vs the Ni wire in the compartment containing 1.00 M $NiSO_4$. What is the $[Ni^{2+}]$ in the unknown solution? [S 01, ex3]

(a) 8.5×10^{-7} M (b) 9.5×10^{-14} M (c) 6.8×10^{-3} M
(d) 2.9×10^{-7} M (e) 4.6×10^{-5} M

19. An electrochemical cell to measure $[Cl^-]$ was constructed by placing a AgCl(s)-coated Ag wire in a 1.00 M KCl solution in one compartment of the cell. The unknown Cl^- solution is placed in the other compartment along with another AgCl(s)-coated Ag wire. The potential difference between the Ag wires was then measured with a voltmeter. The potential of the Ag wire in the compartment containing the unknown Cl^- was found to be +0.1445 V vs. the other Ag wire. What is the $[Cl^-]$ of the unknown solution? [S 00, ex 3]

(a)0.022 M (b) 3.6×10^{-3} M (c) 0.017 M (d) 0.41 M (e) 8.5×10^{-2} M

20. Which one of the following statements best explains how fuel cells differ from batteries? [F 02, ex3]

(a) A battery contains an anode and a cathode, but a fuel cell contains only an anode.
(b) A battery is an example of a voltaic cell and a fuel cell is an example of a electrolytic cell.
(c) In a fuel cell the reactants are continuously added and the products removed.
(d) Fuel cells are being developed for used in automobiles.
(e) A fuel cell produces fuel.

Answers: 1 c, 2 d, 3 c, 4 c, 5 d, 6 a, 7 b, 8 e, 9 a, 10e, 11 c, 1 2d, 13 e, 14 e, 15 a, 16 a, 17 ac, 18 e, 19 b, 20 c.

EQUATIONS and ADDITIONAL INFO

$$oO + ne^- \rightleftarrows rR$$

$$E_{cell} = E_{cat} - E_{an}$$

$$\Delta G^\circ = -nFE^\circ_{rxn}$$

$$E = E^\circ - \frac{0.0592V}{n}\log\frac{[R]^r}{[O]^o} \quad at\ 25^\circ C$$

$$K = e^{\frac{nF\Delta E^\circ}{RT}} \quad or \quad K = 10^{\frac{n\Delta E^\circ}{0.0592}}\ at\ 25^\circ C$$

F = 96485 coul/mol R = 8.314 J/(mol·K) Volt = Joule/coul 0° C = 273.15 K

Standard Electrode Potentials

Half Reaction	E° (V)
$Ag^+(aq) + e^- \rightleftarrows Ag(s)$	+0.80 V
$AgCl(s) + e^- \rightleftarrows Ag(s) + Cl^-(aq)$	+0.2223 V
$AgBr(s) + e^- \rightleftarrows Ag(s) + Br^-(aq)$	+0.07 V
$AgI(s) + e^- \rightleftarrows Ag(s) + I^-(aq)$	−0.152 V
$Br_2(l) + 2\ e^- \rightleftarrows 2\ Br^-(aq)$	+1.09 V
$Cd^{2+}(aq) + 2\ e\text{-} \rightleftarrows Cd(s)$	−0.40 V
$Cl_2(g) + 2\ e\text{-} \rightleftarrows 2\ Cl^-(aq)$	+1.36
$Cu^+(aq) + e^- \rightleftarrows Cu(s)$	+0.52 V
$Cu^{2+}(aq) + 2\ e\text{-} \rightleftarrows Cu(s)$	+0.34 V
$Fe^{2+}(aq) + 2\ e\text{-} \rightleftarrows Fe(s)$	−0.45 V
$Fe^{3+}(aq) + e^- \rightleftarrows Fe^{2+}(aq)$	+0.77 V
$2\ H^+(aq) + 2\ e\text{-} \rightleftarrows H_2(g)$	0.000V
$H_2O_2(aq) + 2\ H^+(aq) + 2\ e\text{-} \rightleftarrows 2\ H_2O(l)$	+1.78 V
$2\ Hg^{2+}(aq) + 2\ e\text{-} \rightleftarrows 2\ Hg_2^{2+}$	0.905 V
$Hg_2^{2+}(aq) + 2\ e\text{-} \rightleftarrows 2\ Hg(l)$	0.7961 V
$Hg_2SO_4(s) + 2\ e\text{-} \rightleftarrows 2\ Hg(l) + SO_4^{2-}$	0.6158 V
$I_2(s) + 2\ e\text{-} \rightleftarrows 2\ I^-(aq)$	+0.54 V
$Mg^{2+}(aq) + 2\ e\text{-} \rightleftarrows Mg(s)$	−2.37 V
$Ni^{2+}(aq) + 2\ e^- \rightleftarrows Ni(s)$	−0.257 V
$Ni(OH)_2(s) + 2\ e\text{-} \rightleftarrows Ni(s) + 2\ OH^-(aq)$	−0.72 V
$PbO_2(s) + 3\ H^+(aq) + HSO_4^-(aq) + 2\ e\text{-} \rightleftarrows PbSO_4(s) + 2\ H_2O(l)$	+1.628 V
$PbSO_4(s) + H^+ + 2\ e\text{-} \rightleftarrows Pb(s) + HSO_4^-$	−0.296 V
$S_2O_8^{2-}(aq) + 2\ e^- \rightleftarrows 2\ SO_4^{2-}(aq)$	+2.01 V
$Sn^{4+}(aq) + 2\ e^- \rightleftarrows Sn^{2+}$	+0.15 V
$Sn^{2+}(aq) + 2\ e^- \rightleftarrows Sn(s)$	−0.14 V
$Zn^{2+}(aq) + 2\ e^- \rightleftarrows Zn(s)$	−0.76 V