Redox and Galvanic Cells Review **Key**

1. Assign oxidation numbers to each atom in the following molecules.

HNO_3 (+1, +5, −2) $MgSO_4$ (+2, +6, −2) $Na_2C_2O_4$ (+1, +3, −2) CO_2 (+4, −2)

$CuCl_2$ (+2, −1) Ag (0) Cr_2O_3 (+3, −2) O_2 (0)

2. For the following redox reactions, indicate the species getting oxidized (~~the reducing agent~~) and the species getting reduced (~~the oxidizing agent~~).

a. $\overset{-4}{C}H_4\,(g) + H_2\overset{+1}{O}\,(g) \rightarrow \overset{+2}{C}\overset{-2}{O}\,(g) + 3\,H_2\,(g)$

H gets reduced

C gets oxidized

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

Cu gets oxidized

Ag gets reduced

3. Complete the following half reactions and identify as being oxidation or reduction

a. $Fe \rightarrow Fe^{2+} + 2e^-$ (oxid)

b. $Li^+ + 1e^- \rightarrow Li$ (red.)

c. $Ba^{2+} + 2e^- \rightarrow Ba$ (red.)

d. $2I^- \rightarrow I_2 + 2e^-$ (oxid)

4. Balance the following equations by the half-reaction method.

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

$Cr \rightarrow Cr^{3+} + 3e^-$

$3e^- + 4H^+ + NO_3^- \rightarrow NO + 2H_2O$

$Cr + 4H^+ + NO_3^- \rightarrow Cr^{3+} + NO + 2H_2O$

b. $Al\,(s) + MnO_4^-\,(aq) \rightarrow Al^{3+}\,(aq) + Mn^{2+}\,(aq)$

$5(Al \rightarrow Al^{3+} + 3e^-)$

$3(MnO_4^- + 8H^+ \xrightarrow{+5e^-} Mn^{2+} + 4H_2O)$

$5Al \rightarrow 5Al^{3+} + 15e^-$

$3MnO_4^- + 24H^+ + 15e^- \rightarrow 3Mn^{2+} + 12H_2O$

$5Al + 3MnO_4^- + 24H^+ \rightarrow 5Al^{3+} + 3Mn^{2+} + 12H_2O$

c. $CH_3OH\,(aq) + Ce^{4+}\,(aq) \rightarrow CO_2\,(aq) + Ce^{3+}\,(aq)$

$6e^- + 6Ce^{4+} \rightarrow 6Ce^{3+}$

$H_2O + CH_3OH \rightarrow CO_2 + 6H^+ + 6e^-$

$H_2O + CH_3OH + 6Ce^{4+} \rightarrow 6Ce^{3+} + CO_2 + 6H^+$

5. Sketch the galvanic cell from the following net reaction. Show the direction of electron flow and identify the anode and the cathode.

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

reduced = cathode

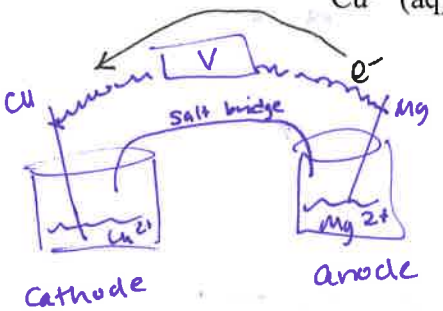

TABLE 18.1 Standard Reduction Potentials at 25 °C

Reduction half-reaction		$E°$(V)
$F_2(g) + 2e^-$	$\rightarrow 2F^-(aq)$	2.87
$Ce^{4+}(aq) + e^-$	$\rightarrow Ce^{3+}(aq)$	1.61
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$	1.51
$Cl_2(g) + 2e^-$	$\rightarrow 2Cl^-(aq)$	1.36
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow 2H_2O(\ell)$	1.23
$Br_2(\ell) + 2e^-$	$\rightarrow 2Br^-(aq)$	1.06
$NO_3^-(aq) + 4H^+(aq) + 3e^-$	$\rightarrow NO(g) + 2H_2O(\ell)$	0.96
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	0.80
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	0.77
$I_2(s) + 2e^-$	$\rightarrow 2I^-(aq)$	0.54
$Cu^{2+}(aq) + 2e^-$	$\rightarrow Cu(s)$	0.34
$AgCl(s) + e^-$	$\rightarrow Ag(s) + Cl^-(aq)$	0.222
$Sn^{4+}(aq) + 2e^-$	$\rightarrow Sn^{2+}(aq)$	0.15
$2H^+(aq) + 2e^-$	$\rightarrow H_2(g)$	0.000
$Pb^{2+}(aq) + 2e^-$	$\rightarrow Pb(s)$	−0.126
$Ni^{2+}(aq) + 2e^-$	$\rightarrow Ni(s)$	−0.25
$Cr^{3+}(aq) + e^-$	$\rightarrow Cr^{2+}(aq)$	−0.41
$Fe^{2+}(aq) + 2e^-$	$\rightarrow Fe(s)$	−0.44
$Zn^{2+}(aq) + 2e^-$	$\rightarrow Zn(s)$	−0.76
$Ba^{2+}(aq) + 2e^-$	$\rightarrow Ba(s)$	−1.57
$Al^{3+}(aq) + 3e^-$	$\rightarrow Al(s)$	−1.66
$Mg^{2+}(aq) + 2e^-$	$\rightarrow Mg(s)$	−2.37
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	−2.714
$Li^+(aq) + e^-$	$\rightarrow Li(s)$	−3.045

6. What is the overall cell potential, $E_{cell}°$, in V for this galvanic cell?

$E°_{cell} = E°_{cath} - E°_{anode}$

$= 0.34\,V - (-2.37V) = 2.71\,V$

⊕ spont galvanic

7. What is the overall Gibbs Free Energy, $\Delta G°$, for the reaction?

$\Delta G° = -nFE° = -2\,F\,(2.71V)$

$\Delta G = -522949\,J$

$= -523\,kJ$ (3 SF's)

8. If you constructed a galvanic cell using Zn and Ag, which species would make a better anode and why?

Zn/Zn^{2+} −0.76V

Ag/Ag^+ 0.80V

bc Zn more ⊖ easier to oxidize - better anode.