CH 302 Worksheet 11 Answer Key Balancing Redox Reactions

Half-reaction	ΔE_r^0 (V)
$Li^+(aq) + e^- \rightarrow Li(s)$	-3.05
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.68
$TiO(s) + 2H^+ + 2e^- \rightarrow Ti(s) + H_2O$	-1.31
$Ti^{3+}(aq) + 3e^- \rightarrow Ti(s)$	-1.21
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	-0.25
$CO_2(g) + 2H^+ + 2e^- \rightarrow HCOOH(aq)$	-0.11
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0
$SO_4^{2-}(aq) + 4H^+ + 2e^- \rightarrow 2H_2O(l) + SO_2(aq)$	+0.17
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$NO_3^-(aq) + 2H^+(aq) + e^- \rightarrow NO_2(g) + H_2O(l)$	+0.80
$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	+1.52
$Ag_2O_3(s) + 6H^+ + 4e^- \rightarrow 2Ag^+(aq) + 3H_2O$	+1.67
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87

For questions 1-5, determine whether, as written, the reaction is a battery ("galvanic") or electrolytic. Balance the reaction and then indicate which species is receiving the electrons and the sign of the cell for that electrode.

Note: These problems are harder than the problems on the next page. It was just convenient to put them here.

1. $TiO(s) + Au(s) \rightarrow Au^{3+}(aq) + Ti(s)$ *in acid*

   Answer: Electrolytic and electrons flow to TiO at cathode which is negative

   $6H^+(aq) + 3TiO(s) + 2Au(s) \rightarrow 2Au^{3+}(aq) + 3Ti(s) + 3H_2O$

2. $TiO(s) + Au(s) \rightarrow Au^{3+}(aq) + Ti(s)$ *in base*

   Answer: Electrolytic and electrons flow to TiO at cathode which is negative

   $3H_2O + 3TiO(s) + 2Au(s) \rightarrow 2Au^{3+}(aq) + 3Ti(s) + 6OH^-(aq)$

3. $Ag^+(aq) + F_2(g) \rightarrow F^-(aq) + Ag_2O_3(s)$ *in base*

   Answer: Battery and electrons flow to F_2 at cathode which is positive

   $6OH^-(aq) + 2Ag^+(aq) + 2F_2(g) \rightarrow 4F^-(aq) + Ag_2O_3 + 3H_2O$

4. $SO_4^{2-}(aq) + Al(s) \rightarrow Al^{3+}(aq) + SO_2(aq)$ *in acid*

   Answer: Battery and electrons flow to sulfate at cahode which is postive

   $12H^+(aq) + 3SO_4^{2-}(aq) + 2Al(s) \rightarrow 2Al^{3+} + 3SO_2(aq) + 6H_2O$

5. $NO_3^- + Ag^+(aq) \rightarrow Ag_2O_3(s) + NO_2(g)$ *in acid*

   Answer: Electrolyticand electrons flow to nitrate which is negative

   $2H^+(aq) + 4NO_3^-(aq) + 2Ag^+(aq) \rightarrow Ag_2O_3(s) + 4NO_2(g) + H_2O$

For the table on the following page, fill in the requested information for a *battery* made from the two indicated half-reactions

Half-reaction 1	Half-reaction 2	Cathode	Anode	Balanced Reaction	ΔE	Strongest oxidizing agent	Strongest reducing agent
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	$2H^+(aq) + 2e^- \rightarrow H_2(g)$	2	1	$2H^+(aq) + Ni(s) \rightarrow Ni^{2+}(aq) + H_2(g)$	+0.25	H^+	Ni
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	$Li^+(aq) + e^- \rightarrow Li(s)$	1	2	$F_2(g) + 2Li(s) \rightarrow 2F^-(aq) + 2Li^+(aq)$	+5.86	F_2	Li
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	$Ti^{3+}(aq) + 3e^- \rightarrow Ti(s)$	2	1	$Ti^{3+}(aq) + Al(s) \rightarrow Al^{3+}(aq) + Ti(s)$	+0.47	Ti^{3+}	Al
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	$2H^+(aq) + 2e^- \rightarrow H_2(g)$	1	2	$F_2(g) + H_2(g) \rightarrow 2F^-(aq) + 2H^+(aq)$	+2.87	F_2	H_2
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	2	1	$2Fe^{3+}(aq) + H_2(g) \rightarrow 2H^+(aq) + 2\ Fe^{2+}(aq)$	+0.77	Fe^{3+}	H_2
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	1	2	$2Fe^{3+}(aq) + Ni(s) \rightarrow Ni^{2+}(aq) + 2\ Fe^{2+}(aq)$	+1.02	Fe^{3+}	Ni
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	$Au^{3+}(aq) + 3e^- \rightarrow Au(s)$	2	1	$2Au^{3+}(aq) + 3Cu(s) \rightarrow 3Cu^{2+}(aq) + 2Au(s)$	+1.18	Au^{3+}	Cu
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	$Li^+(aq) + e^- \rightarrow Li(s)$	1	2	$Fe^{3+}(aq) + Li(s) \rightarrow Li^+(aq) + Fe^{2+}(aq)$	+3.82	Fe^{3+}	Li
$Ti^{3+}(aq) + 3e^- \rightarrow Ti(s)$	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	2	1	$3Cu^{2+}(aq) + 2Ti(s) \rightarrow 2Ti^{3+}(aq) + 3Cu(s)$	+1.55	Cu^{2+}	Ti
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	2	1	$F_2(g) + 2Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + 2F^-(aq)$	+2.10	F_2	Fe^{2+}