Table 15.6-1 Redox Reactions in Chemolithotrophic Bacteria

Reductant	Redox Couple*	E'_0 [mV]	Reactions	$\Delta G'_0$ [kJ*mol^{-1}]**	Enzymes; Cofactors	Organisms
Carbon monoxide	CO_2/CO	−540	$CO + H_2O \rightarrow CO_2 + 2\,H^+ + 2\,e^-$		carbon monoxide dehydrogenase	'Carboxidobacteria', e.g. *Pseudomonas*
	O_2 (0.21 atm)/H_2O	+816	$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
			$\Sigma = CO + ½\,O_2 \rightarrow CO_2$	−261		
Hydrogen	$2\,H^+/H_2$	−410	$H_2 \rightarrow 2\,H^+ + 2\,e^-$		hydrogenase, [NiFe] or [Fe]	'Knallgas' bacteria
			$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
			$\Sigma = H_2 + ½\,O_2 \rightarrow H_2O$	−237		
Sulfide	S_0/HS^-	−260	$HS^- \rightarrow S_0 + H^+ + 2\,e^-$		'sulfide oxidase'	*Thiobacillus; Beggiatoa; Wolinella succinogenes* (uses fumarate as el.acc.)
			$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
			$\Sigma = HS^- + ½\,O_2 + H^+ \rightarrow S_0 + H_2O$	−207		
	HSO_3^-/HS^-	−110	$HS^- + 3\,H_2O \rightarrow HSO_3^- + 6\,H^+ + 6\,e^-$		sulfite reductase; siroheme, FeS	*Thiobacillus; Sulfolobus*
			$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
			$\Sigma = HS^- + 1½\,O_2 \rightarrow HSO_3^-$	−536		
Sulfur	HSO_3^-/S_0	−45	$S_0 + O_2 + H_2O \rightarrow S_{n-1} + HSO_3^- + H^+$	−332	'sulfur dioxygenase'; FeS	*Thiobacillus*
Sulfite	SO_4^{2-}/HSO_3^-	−520	$HSO_3^- + H_2O \rightarrow SO_4^{2-} + 3\,H^+ + 2\,e^-$		sulfite: cytochrome c oxidoreductase; heme-Fe, Mo^{++}	*Thiobacillus (T. denitrificans* uses NO_3^- as electron accept.anaerobically)
			$½\,O_2 + 2\,e^- + 2H^+ \rightarrow H_2O$			
			$\Sigma = HSO_3^- + ½\,O_2 \rightarrow SO_4^{2-} + H^+$	−258		
	APS/HSO_3^-	−60	a) $HSO_3^- + AMP \rightarrow APS + 2\,e^-$		a) adenosine phosphosulfate reductase; FAD, FeS, b) sulfate adenylyl transferase; Mg^{++}, c) adenylate kinase, Mg^{++}	*Thiobacillus*
			b) $APS + P_i \rightarrow SO_4^{2-} + ADP + H^+$			
			c) $ADP \rightarrow ½\,AMP + ½\,ATP$			
			$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
			$\Sigma = HSO_3^- + ½\,O_2 + P_i + ½\,AMP + H^+ \rightarrow SO_4^{2-} + ½\,ATP + H_2O$	~ −227		
Ammonia	NH_2OH/NH_3	+900	a) $NH_3 + O_2 + 2\,H^+ + 2\,e^- \rightarrow NH_2OH + H_2O$		a) NH_3 monooxygenase; Cu, b) hydroxylamine: cytochrome c_{554} oxidoreductase, heme-Fe, Mo^{++}	nitrosofying bacteria, e.g. *Nitrosomonas*
	NO_2^-/NH_2OH	+60	b) $NH_2OH + H_2O \rightarrow NO_2^- + 5\,H^+ + 4\,e^-$			
			$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
	$\Sigma = NO_2^-/NH_3$	+340	$\Sigma = NH_3 + 1½\,O_2 \rightarrow NO_2^- + H_2O + H^+$	−276		
Nitrite	NO_3^-/NO_2^-	+430	$NO_2^- + H_2O \rightarrow NO_3^- + 2\,H^+ + 2\,e^-$		nitrite: cytochrome c_{550} oxidoreductase; heme-Fe, Mo^{++}	nitrifying bacteria: e.g., *Nitrobacter*
			$½\,O_2 + 2\,e^- + 2\,H^+ \rightarrow H_2O$			
			$\Sigma = NO_2^- + ½\,O_2 \rightarrow NO_3^-$	−75		
Fe^{2+} at low pH (ca.2.0)	Fe^{3+}/Fe^{2+}	+770	$Fe^{2+} \rightarrow Fe^{3+}$		rusticyanin; Cu	*Thiobacillus ferrooxidans, Sulfolobus*
	O_2 (0.21 atm)/H_2O	+1100	$¼\,O_2 + e^- + H^+ \rightarrow ½\,H_2O$			
			$\Sigma = Fe^{2+} + ¼\,O_2 + H^+ \rightarrow Fe^{3+} + ½\,H_2O$	~ −32		
Fe^{2+} at ca. neutral pH	$Fe(OH)_3$ (sat.)/Fe^{2+} (10 µmol/l)	− 150	$Fe^{2+} + ¼\,O_2 + 2½\,H_2O \rightarrow Fe(OH)_3 + 2\,H^+$	?	?	*Gallionella*
Mn^{2+} at ca. neutral pH	MnO_2/Mn^{2+}	?	unknown	?	?	marine *Pseudomonas*

* These reactions proceed from reduced to oxidized state

** Calculated from $\Delta E'_0$ or from free energies of formation per mole of substrate oxidized