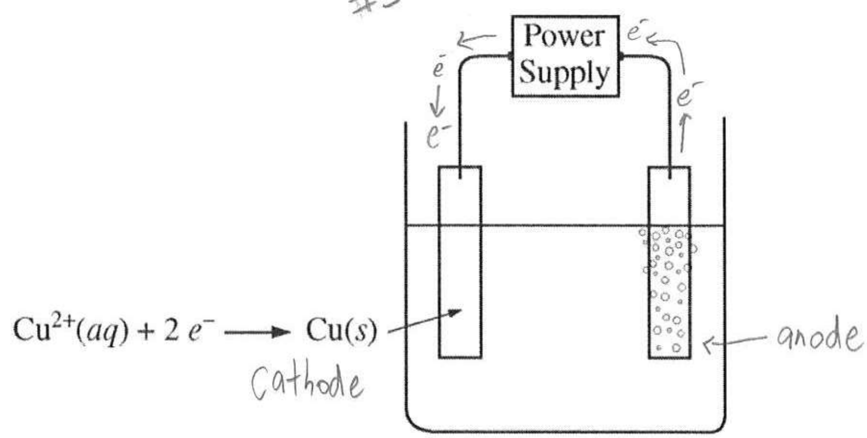
~~52~~ 55

Unit 3: AP Free Response Practice ~~#3~~ #5 (2007 FR #3, modified) [10 points]



3. An external direct-current power supply is connected to two platinum electrodes immersed in a beaker containing 1.0 M $CuSO_4(aq)$ at 25°C, as shown in the diagram above. As the cell operates, copper metal is deposited onto one electrode and $O_2(g)$ is produced at the other electrode. The two reduction half-reactions for the overall reaction that occurs in the cell are shown in the table below.

Half-Reaction	$E°$(V)	
$O_2(g) + 4\,H^+(aq) + 4\,e^- \rightarrow 2\,H_2O(l)$	+1.23	$\Rightarrow E°_{ox} = -1.23\,V$
$Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$	+0.34	$= E°_{red}$

a. On the diagram, indicate the direction of electron flow in the wire. [*1 point*]

b. Write the balanced net ionic equation for the electrolysis reaction that occurs in the cell. [*2 points]*

c. Predict the algebraic sign of ΔG° for the reaction. Justify your prediction. [*1 point*]

d. Calculate the value of ΔG° for the reaction. [*2 points*]

An electric current of 1.50 amps passes through the cell for 40.0 minutes.

e. Calculate the mass, in grams, of the Cu(s) that is deposited on the electrode. [*2 points*]

f. Calculate the dry volume, in liters measured at 25°C ad 1.16 atm, of the $O_2(g)$ that is produced. [*2 points*]

b.) $2 \times (Cu^{2+} + 2e^- \rightarrow Cu)$

$+ \quad 2H_2O \rightarrow O_2 + 4H^+ + 4e^- \quad +$

$2Cu^{2+}(aq) + 2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 2Cu(s)$

c.) $+\Delta G$, b/c this rxn is not thermodynamically favorable (b/c an external power source was required)

d.) $E°_{cell} = E°_{ox} + E°_{red} = -1.23 + 0.34 = -0.89\,V$

$\Delta G° = -nFE°_{cell} = -(4\text{ mol }e^-)(96{,}485\,\frac{C}{mole^-})(-0.89\,J/C)$

$= \boxed{+340{,}000\,J/mol_{rxn} = +340\,kJ/mol_{rxn}}$

e.) $40.0\text{ min} \times \frac{60\text{ sec}}{1\text{ min}} \times \frac{1.50\text{ C}}{1\text{ sec}} \times \frac{1\text{ mol } e^-}{96{,}485\text{ C}} \times \frac{1\text{ mol Cu}}{2\text{ mol } e^-} \times \frac{63.55\text{ g}}{1\text{ mol Cu}}$

$= \boxed{1.19\text{ g Cu}}$

f.) $1.19\text{ g Cu} \times \frac{1\text{ mol Cu}}{63.55\text{ g Cu}} \times \frac{1\text{ mol } O_2}{2\text{ mol Cu}} = 0.00936\text{ mol } O_2$

$V = \frac{nRT}{P} = \frac{(0.00936)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298K)}{1.16\text{ atm}} = \boxed{0.197\text{ L } O_2}$