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ANSWERS

1. (a) $Co(s) \rightarrow Co^{2+}(aq) + 2\,e^-$ This is the oxidation half-reaction. Co(s) is the reducing agent.

$Cu^{2+}(aq) + 2\,e^- \rightarrow Cu(s)$ This is the reduction half-reaction. $Cu^{2+}(aq)$ is the oxidizing agent.

The reducing agent [Co(s)] is lower in the redox table than the oxidizing agent [$Cu^{2+}(aq)$]. Therefore, the reaction is spontaneous.

(b) $Br_2(l) + 2\,e^- \rightarrow 2\,Br^-(aq)$ This is the reduction half-reaction. $Br_2(l)$ is the oxidizing agent.

$2\,I^-(aq) \rightarrow I_2(s) + 2\,e^-$ This is the oxidation half-reaction. $I^-(aq)$ is the reducing agent.

The reducing agent [$I^-(aq)$] is lower in the redox table than the oxidizing agent [$Br_2(l)$]. Therefore, the reaction is spontaneous.

(c) $Ni(s) \rightarrow Ni^{2+}(aq) + 2\,e^-$ This is the oxidation half-reaction. Ni(s) is the reducing agent.

$Zn^{2+}(aq) + 2\,e^- \rightarrow Zn(s)$ This is the reduction half-reaction. $Zn^{2+}(aq)$ is the oxidizing agent.

The reducing agent [Ni(s)] is higher in the redox table than the oxidizing agent [$Cu^{2+}(aq)$]. Therefore, the reaction is not spontaneous.

2. The species present are Cu(s) , $H^+(aq)$, $Cl^-(aq)$, $H_2O(l)$.

The strongest oxidizing agent is $H^+(aq)$.

The strongest reducing agent is Cu(s).

The reaction is not spontaneous [Cu(s) is higher than $H^+(aq)$ in the redox table].

3. The species present are $Ca(s)$, $H_2O(l)$.

The strongest oxidizing agent is $H_2O(l)$.

The strongest reducing agent is $Ca(s)$.

The reaction is spontaneous [$Ca(s)$ is lower than $H_2O(l)$ in the redox table].

SOA: $2\ H_2O(l) + \cancel{2\ e^-} \rightarrow H_2(g) + 2\ OH^-(aq)$

SRA: $Ca(s) \rightarrow Ca^{2+}(aq) + \cancel{2\ e^-}$ The calcium is oxidized.

$$2\ H_2O(l) + Ca(s) \rightarrow H_2(g) + 2\ OH^-(aq) + Ca^{2+}(aq)$$

4. The species present are $K^+(aq)$, $MnO_4^-(aq)$, $Cr^{2+}(aq)$, $SO_4^{2-}(aq)$, $H_2O(l)$, $H^+(aq)$.

The strongest oxidizing agent is $MnO_4^-(aq) + H^+(aq)$. "under acidic conditions"

The strongest reducing agent is $Cr^{2+}(aq)$.

The reaction is spontaneous [$Cr^{2+}(aq)$ is lower than $MnO_4^-(aq) + H^+(aq)$ in the redox table].

SOA: $MnO_4^-(aq) + 8\ H^+(aq) + 5\ e^- \rightarrow Mn^{2+}(aq) + 4\ H_2O(l)$

SRA: $Cr^{2+}(aq) \rightarrow Cr^{3+}(aq) + e^-$

Balance the charge transfer.

SOA × 1 = $MnO_4^-(aq) + 8\ H^+(aq) + \cancel{5\ e^-} \rightarrow Mn^{2+}(aq) + 4\ H_2O(l)$

SRA × 5 = $5\ Cr^{2+}(aq) \rightarrow 5\ Cr^{3+}(aq) + \cancel{5\ e^-}$

$$MnO_4^-(aq) + 8\ H^+(aq) + 5\ Cr^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + 5\ Cr^{3+}(aq)$$