In the half reaction

$$I_2 \rightarrow 2 \ I^-$$

the iodine is

(a) reduced
(b) oxidized
(c) neither of the above
Vitamin C is an "antioxidant". This is because it

(a) oxidizes readily
(b) is an oxidizing agent
(c) neither of the above
In which of the following is the oxidation number of iodine greatest?

(a) I₂  
(b) IO⁻  
(c) IO₂⁻  
(d) IO₂
If a reducing agent is to be used to generate the various oxidation states of vanadium, one should start with

(a) \( \text{VO}_3^- \) (yellow)
(b) \( \text{VO}^{2+} \) (green)
(c) \( \text{V}^{3+} \) (blue)
(d) \( \text{V}^{2+} \) (violet)
In the reaction

\[ 2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2 \]

oxygen is

(a) oxidized
(b) reduced
(c) neither oxidized or reduced
(d) both oxidized and reduced
When two of the following compounds are mixed, a redox reaction occurs in which the third is formed. Which is the product?

(a) $\text{SO}_2$  (b) $\text{S}$  (c) $\text{H}_2\text{S}$
Protein folding is often stabilized by the formation of disulfide bonds between cysteine side chains. In this reaction

\[ \text{SH} \rightarrow \text{SS} \]

the sulfur is

(a) reduced
(b) oxidized
(c) neither of the above
In balancing the oxidation of methanol to formic acid

$$\text{CH}_3\text{OH} \rightarrow \text{HCOOH} \quad \text{(skeletal)}$$

the number of electrons that must be added to the right side is

(a) 0 \quad (b) 2
(c) 4 \quad (d) 6
In balancing the half-reaction

\[ \text{CN}^- \rightarrow \text{CNO}^- \]  (skeletal)

the number of electrons that must be added is

(a) 0
(b) 2 on the left
(c) 2 on the right
In balancing the half reaction
\[ \text{S}_2\text{O}_3^{2-} \rightarrow \text{S(s)} \] (skeletal)
the number of electrons that must be added is

(a) 2 on the left
(b) 2 on the right
(c) 4 on the left
(d) 4 on the right
For the reaction between permanganate ion and oxalate ion in basic solution, the unbalanced equation is

\[ \text{MnO}_4^- + \text{C}_2\text{O}_4^{2-} \rightarrow \text{MnO}_2(\text{s}) + \text{CO}_3^{2-} \]

When this equation is balanced, the number of \( \text{OH}^- \) ions is

(a) 2 on the left
(b) 2 on the right
(c) 4 on the left
(d) 4 on the right
The line representation for a voltaic cell utilizing the reaction

\[2 \text{Cr(s)} + 3 \text{Cu}^{2+} \rightarrow 2 \text{Cr}^{3+} + 3 \text{Cu}(s)\]

is

(a) \(\text{Cr(s)} | \text{Cu}^{2+} || \text{Cr}^{3+} | \text{Cu(s)}\)

(b) \(\text{Cr(s)} | \text{Cr}^{3+} || \text{Cu}^{2+} | \text{Cu(s)}\)

(c) \(\text{Cu(s)} | \text{Cu}^{2+} || \text{Cr}^{3+} | \text{Cr(s)}\)

(d) \(\text{Cu(s)} | \text{Cr}^{3+} || \text{Cu}^{2+} | \text{Cr(s)}\)
The line representation for a voltaic cell utilizing the reaction

\[ 2 \text{Fe}^{2+} + \text{Cu}^{2+} \rightarrow 2 \text{Fe}^{3+} + \text{Cu} \ (s) \]

is

(a) \( \text{Fe}^{2+} \ | \ \text{Fe}^{3+} \ || \ \text{Cu}^{2+} \ | \ \text{Cu}(s) \)

(b) \( \text{Fe}^{3+} \ | \ \text{Fe}^{2+} \ || \ \text{Cu}^{2+} \ | \ \text{Cu}(s) \)

(c) \( \text{Cu}(s) \ | \ \text{Fe}^{3+}, \text{Cu}^{2+} \ || \ \text{Fe}^{2+} \ | \ \text{Cu}(s) \)

(d) \( \text{Pt}(s) \ | \ \text{Fe}^{3+}, \text{Fe}^{2+} \ || \ \text{Cu}^{2+} \ | \ \text{Cu}(s) \)
Consider the voltaic cell

\[ \text{Pt(s)} | \text{Sn}^{2+},\text{Sn}^{4+} || \text{Fe}^{2+},\text{Fe}^{3+} | \text{Pt(s)} \]

The anode reaction produces

(a) \( \text{Sn}^{2+} \)  (b) \( \text{Fe}^{2+} \)
(c) \( \text{Sn}^{4+} \)  (d) \( \text{Fe}^{3+} \)
Consider the voltaic cell
\[ \text{Zn(s)} \mid \text{Zn}^{2+}(\text{aq}) \parallel \text{Cl}^-(\text{aq}) \mid \text{Cl}_2(\text{g}) \mid \text{Pt(s)} \]

The cathode reaction produces
(a) \( \text{Zn}^{2+} \)    (b) \( \text{Cl}^- \)
(c) \( \text{Cl}_2 \)    (d) \( \text{Pt} \)
When a voltaic cell is running, cations in the salt bridge
(a) move into the cathode compartment
(b) move into the anode compartment
(c) stay put
\( \varepsilon_{H^+/H_2}^o \) is

(a) positive

(b) negative

(c) zero
$\varepsilon_{\text{Zn}^{2+}|\text{Zn}}^0$ is the EMF of the cell

(a) 
Zn(s)$|\text{Zn}^{2+}(1\ \text{M})||\text{H}^+(1\ \text{M})|\text{H}_2(1\ \text{atm})|\text{Pt}(s)$

(b) 
Pt(s)$|\text{H}_2(1\ \text{atm})|\text{H}^+(1\ \text{M})||\text{Zn}^{2+}(1\ \text{M})|\text{Zn}(s)$
For the cell

\[
\text{Zn}(s) \ | \ \text{Zn}^{2+}(1 \text{ M}) \ || \ \text{Cl}^{-}(1 \text{ M}) \ | \ \text{Cl}_2(\text{g}) \ | \ \text{Pt}(s)
\]

the EMF is

(a) \[ \varepsilon^o_{\text{Zn}^{2+}|\text{Zn}} - \varepsilon^o_{\text{Cl}_2|\text{Cl}^{-}} \]

(b) \[ \varepsilon^o_{\text{Zn}^{2+}|\text{Zn}} + \varepsilon^o_{\text{Cl}_2|\text{Cl}^{-}} \]

(c) \[ -\varepsilon^o_{\text{Zn}^{2+}|\text{Zn}} - \varepsilon^o_{\text{Cl}_2|\text{Cl}^{-}} \]

(d) \[ -\varepsilon^o_{\text{Zn}^{2+}|\text{Zn}} + \varepsilon^o_{\text{Cl}_2|\text{Cl}^{-}} \]
If the cells

\[ \text{Zn(s)} | \text{Zn}^{2+}(1 \text{ M}) || \text{Pb}^{2+}(1 \text{ M}) | \text{Pb(s)} \]

and

\[ \text{Pb(s)} | \text{Pb}^{2+}(1 \text{ M}) || \text{Cl}^-(1 \text{ M}) | \text{Cl}_2(\text{g}) | \text{Pt(s)} \]

are connected in series, the total EMF is

(a) \[ 2 \varepsilon^0_{\text{Pb}^{2+}\text{Pb}} - \varepsilon^0_{\text{Zn}^{2+}\text{Zn}} - \varepsilon^0_{\text{Cl}_2\text{Cl}^-} \]

(b) \[ + \varepsilon^0_{\text{Zn}^{2+}\text{Zn}} + \varepsilon^0_{\text{Cl}_2\text{Cl}^-} - 2 \varepsilon^0_{\text{Pb}^{2+}\text{Pb}} \]

(c) \[ + \varepsilon^0_{\text{Zn}^{2+}\text{Zn}} - \varepsilon^0_{\text{Cl}_2\text{Cl}^-} \]

(d) \[ - \varepsilon^0_{\text{Zn}^{2+}\text{Zn}} + \varepsilon^0_{\text{Cl}_2\text{Cl}^-} \]
If the cell
\[ \text{Zn}(s)|\text{Zn}^{2+}(1 \text{ M})||\text{H}^+(1 \text{ M})|\text{H}_2(1 \text{ atm})|\text{Pb}(s) \]
has an EMF of 0.763 V and the cell
\[ \text{Zn}(s)|\text{Zn}^{2+}(1 \text{ M})||\text{Tl}^+(1 \text{ M})|\text{Tl}(s) \]
has an EMF of 0.427 V, then \( \varepsilon_{\text{Tl}^+|\text{Tl}}^o = \)

(a) \( (+ 0.763 + 0.427) \text{ V} \)
(b) \( (- 0.763 + 0.427) \text{ V} \)
(c) \( (+ 0.763 - 0.427) \text{ V} \)
(d) \( (- 0.763 - 0.427) \text{ V} \)
Given that
\[ \varepsilon_{Ni^{2+} | Ni}^o = -0.23 \text{ V} \]
and
\[ \varepsilon_{Zn^{2+} | Zn}^o = -0.763 \text{ V} \]
it is expected that
(a) Ni will reduce Zn\(^{2+}\) to Zn
(b) Zn will reduce Ni\(^{2+}\) to Ni
(c) neither of the above
Given that
\[ \varepsilon_{\text{Cu}^{2+}\mid \text{Cu}}^o = +0.340 \text{ V} \]
and
\[ \varepsilon_{\text{Zn}^{2+}\mid \text{Zn}}^o = -0.763 \text{ V} \]
the cell
\[ \text{Cu(s) }|\text{ Cu}^{2+}(1 \text{ M}) || \text{ Zn}^{2+}(1 \text{ M}) | \text{ Zn(s)} \]
will run
(a) forward (b) backward
From the standard electrode potentials
\[ \varepsilon^{\circ}_{Fe^{3+}|Fe^{2+}} = +0.770 \text{ V} \]
and
\[ \varepsilon^{\circ}_{Fe^{3+}|Fe} = -0.036 \text{ V} \]
and
\[ \varepsilon^{\circ}_{Fe^{2+}|Fe} = -0.44 \text{ V} \]
it follows that the disproportionation of Fe\(^{2+}\)
(a) is (b) is not spontaneous under standard conditions.
From the standard electrode potentials

\[ \varepsilon_{Cu^{2+}|Cu^{+}}^{o} = +0.153 \text{ V} \]

and

\[ \varepsilon_{Cu^{2+}|Cu}^{o} = +0.340 \text{ V} \]

and

\[ \varepsilon_{Cu^{+}|Cu}^{o} = +0.521 \text{ V} \]

it follows that the disproportionation of Cu\(^+\) (a) is (b) is not spontaneous under standard conditions.
Which of the following statements about a galvanic cell is true?

(a) If $\Delta\varepsilon < 0$, then $\Delta G > 0$
(b) If $\Delta\varepsilon^\circ > 0$, then $\Delta G > 0$
(c) If $\Delta\varepsilon^\circ < 0$, then $K_{eq} > 1$
(d) If $\Delta\varepsilon > 0$, then $K_{eq} > 1$
A fuel cell involves the anode reaction

\[ \text{H}_2 \ (g) \rightarrow 2 \text{H}^+ \ (aq) + 2 \text{e}^- \]

and the cathode reaction

\[ 4 \text{e}^- + 4 \text{H}^+ \ (aq) + \text{O}_2 \ (g) \rightarrow 2 \text{H}_2\text{O} \ (\ell) \]

Since \( \Delta G_f^\circ(\text{H}_2\text{O} \ (\ell)) = -237.18 \text{ kJ/mol} \),

(a) \( \Delta \varepsilon^\circ = + \frac{237.18 \text{ kJ/mol}}{2} \)

(b) \( \Delta \varepsilon^\circ = + \frac{237.18 \text{ kJ/mol}}{4} \)

(c) \( \Delta \varepsilon^\circ = - \frac{237.18 \text{ kJ/mol}}{2} \)

(d) \( \Delta \varepsilon^\circ = - \frac{237.18 \text{ kJ/mol}}{4} \)
Consider the cell

\[ \text{Cu}(s) \mid \text{Cu}^{2+}(x \text{ M}) \parallel \text{Cu}^{2+}(y \text{ M}) \mid \text{Cu}(s) \]

If \( y \) is decreased, the EMF of the cell will

(a) increase
(b) decrease
(c) not change
When a strip of Cu and a strip of Zn are poked into a piece of fruit or vegetable (or suspended in a beverage) without direct contact, a wire connecting them is found to carry current. Given that

\[ \varepsilon_{Zn^{2+}|Zn}^o = -0.763 \text{ V} \quad \& \quad \varepsilon_{Cu^{2+}|Cu}^o = +0.340 \text{ V} \]

the correct representation of the cell is

(a) \( \text{Cu(s)} | \text{Cu}^{2+}(aq) || \text{Zn}^{2+}(aq) | \text{Zn(s)} \)
(b) \( \text{Zn(s)} | \text{Zn}^{2+}(aq) || \text{Cu}^{2+}(aq) | \text{Cu(s)} \)
(c) \( \text{Cu(s)} | \text{H}_2(g) | \text{H}^+(aq), \text{Zn}^{2+}(aq) | \text{Zn(s)} \)
(d) \( \text{Zn(s)} | \text{Zn}^{2+}(aq), \text{H}^+(aq) | \text{H}_2(g) | \text{Cu(s)} \)

A more acidic fruit, vegetable or beverage will

(a) enhance
(b) reduce
(c) have no effect on
the cell potential
As the \([\text{Zn}^{2+}]\) in the cell increases, the cell potential will

(a) increase  
(b) decrease  
(c) remain the same

If the size of the Zn electrode is increased, the cell potential will

(a) increase  
(b) decrease  
(c) remain the same
Which of the following commercial cells does not have a constant discharge voltage?

(a) \( \text{Cd(s)} | \text{Cd(OH)}_2 (s) | \text{OH}^- (\text{aq}) | \text{NiO(OH)}(s) | \text{Ni(OH)}_2(s) \)

(b) \( \text{Li}_y\text{C}_6(s) | \text{C}_6(s) | \text{Li}^+(\text{aq}) | \text{Li}_x\text{CoO}_2(s) | \text{Li}_{x+y}\text{CoO}_2(s) \)

(c) \( \text{Pb(s)} | \text{PbSO}_4(s) | \text{HSO}_4^- (\text{aq}) | \text{PbO}_2(s) | \text{PbSO}_4(s) \)

(d) \( \text{Zn(s)} | \text{Zn(OH)}_2(s) | \text{OH}^- (\text{aq}) | \text{HgO(s)} | \text{Hg(ℓ)} | \text{Fe(s)} \)
For the cell

\[ \text{Ni(s) | Ni(NO}_3\text{)}_2 (0.1 \text{ M}) \]
\[ \text{|| KCl (0.2 M) | Cl}_2(0.5 \text{ atm}) | \text{Pt(s)} \]

the value of the reaction quotient, \( Q \), is

(a) \( \frac{(0.5)(0.1)}{(0.2)^2} \)
(b) \( \frac{(0.1)(0.2)}{(0.5)^2} \)
(c) \( \frac{(0.5)(0.1)^2}{(0.2)} \)
(d) \( \frac{(0.1)(0.2)^2}{(0.5)} \)

and

(a) \( \Delta \varepsilon = \Delta \varepsilon^\circ + \frac{RT}{2F} \ln Q \)
(b) \( \Delta \varepsilon = \Delta \varepsilon^\circ - \frac{RT}{2F} \ln Q \)
(c) \( \Delta \varepsilon = \Delta \varepsilon^\circ + \frac{RT}{F} \ln Q \)
(d) \( \Delta \varepsilon = \Delta \varepsilon^\circ - \frac{RT}{F} \ln Q \)
A methanol fuel cell involves the anode reaction

\[ \text{H}_2\text{O} + \text{CH}_3\text{OH} \rightarrow \text{CO}_2 + 6 \text{ H}^+ + 6 \text{ e}^- \]

and the cathode reaction

\[ 4 \text{ e}^- + 4 \text{ H}^+ + \text{O}_2 \rightarrow 2 \text{ H}_2\text{O} \]

the voltage of this cell is

(a) \[ \Delta \varepsilon^\circ - \frac{RT}{6\mathcal{F}} \ln \left\{ \frac{p_{\text{CO}_2}}{p_{\text{O}_2} [\text{CH}_3\text{OH}]} \right\} \]

(b) \[ \Delta \varepsilon^\circ - \frac{RT}{4\mathcal{F}} \ln \left\{ \frac{p_{\text{CO}_2}}{p_{\text{O}_2} [\text{CH}_3\text{OH}]} \right\} \]

(c) \[ \Delta \varepsilon^\circ - \frac{RT}{12\mathcal{F}} \ln \left\{ \frac{p_{\text{CO}_2}^2}{p_{\text{O}_2}^3 [\text{CH}_3\text{OH}]^2} \right\} \]

(d) \[ \Delta \varepsilon^\circ - \frac{RT}{12\mathcal{F}} \ln \left\{ \frac{p_{\text{CO}_2}^3}{p_{\text{O}_2}^2 [\text{CH}_3\text{OH}]^3} \right\} \]
For the reaction

$$2 I^- + Cl_2 \rightarrow 2 Cl^- + I_2$$

the standard cell voltage is 0.82 V. The equilibrium constant for this reaction is given by

$$RT \ln K_{eq} =$$

(a) 1 $\mathcal{E}$ (0.82 V) \hspace{1cm} (b) $-1 \mathcal{E}$ (0.82 V)
(c) 2 $\mathcal{E}$ (0.82 V) \hspace{1cm} (d) $-2 \mathcal{E}$ (0.82 V)
Given that

\[ \varepsilon^0_{AgCl|Ag} = +0.2223 \text{ V} \]
\[ \varepsilon^0_{AgBr|Ag} = +0.0713 \text{ V} \]
\[ \varepsilon^0_{AgI|Ag} = -0.152 \text{ V} \]
\[ \varepsilon^0_{Ag^+|Ag} = +0.799 \text{ V} \]

which has the smallest \( K_{sp} \)?

(a) AgCl  (b) AgBr  (c) AgI

\( K_{sp}(AgBr) = \)

(a) \( \exp \left[ \frac{\varphi (-0.799 + 0.0713)}{RT} \right] \)
(b) \( \exp \left[ \frac{\varphi (-0.799 - 0.0713)}{RT} \right] \)
(c) \( \exp \left[ \frac{RT}{\varphi (-0.799 + 0.0713)} \right] \)
(d) \( \exp \left[ \frac{RT}{\varphi (-0.799 - 0.0713)} \right] \)
Thomas Edison's first electricity meter was based on changes in mass of two parallel Zn plates immersed in zinc sulfate solution. In this device, transfer of a mole of Zn from one plate to the other signifies passage of:

(a) 1 C
(b) 1 F
(c) 2 C
(d) 2 F
Given that the charge of a mole of electrons is $96,485 \, \text{C} = 1 \, \text{F}$, plating 1 mole of chromium from chromic acid ($\text{H}_2\text{CrO}_4$) using a 200 A current will take

(a) $\frac{3 \times 96,485}{200}$
(b) $\frac{200}{3 \times 96,485}$
(c) $\frac{6 \times 96,485}{200}$
(d) $\frac{200}{6 \times 96,485}$

seconds.
To plate Cr(s) from aqueous solution under standard conditions, one can start with

(a) Cr\(^{3+}\)
(b) Cr\(^{2+}\)
(c) either
(d) neither

given that \( \varepsilon^{0}_{Cr^{3+}|Cr} = -0.74 \text{ V} \)
\( \varepsilon^{0}_{Cr^{2+}|Cr} = -0.91 \text{ V} \)
\( \varepsilon^{0}_{H_{2}O|H_{2}} = -0.8277 \text{ V} \)
When a dilute solution of Li₂SO₄ is electrolyzed, the products formed at the anode and cathode respectively are

(a) S and Li
(b) O₂ and Li
(c) SO₂ and H₂
(d) O₂ and H₂

Possibly useful information:

\[ \varepsilon_{O_2|H_2O}^o = +1.229 \text{ V} \]
\[ \varepsilon_{H_2O|H_2}^o = -0.8277 \text{ V} \]
\[ \varepsilon_{Li^+|Li}^o = -3.405 \text{ V} \]
Electricity from a fuel cell that consumes H₂ and O₂ is used to drive the electrolysis of H₂C₂O₄ to CO₂ and H₂. Assuming that all the gases are held under the same conditions, the volume of O₂ consumed is

(a) one forth
(b) half
(c) the same as
(d) twice

the volume of CO₂ produced.