Chapter 19 Pool Questions

1. When balancing oxidation–reduction reactions in acidic solution by the half-reaction method, oxygen is balanced by adding
   a) O.
   b) O_2.
   c) OH^-.
   d) H_2O.
   e) none of these

2. When the following oxidation–reduction reaction in acidic solution is balanced such that all coefficients are integers, what is the lowest whole-number coefficient for H^+, and on which side of the balanced equation should it appear?
   $MnO_4^-(aq) + Br^-(aq) \rightarrow Mn^{2+}(aq) + Br_2(l)$
   a) 1, reactant side
   b) 2, product side
   c) 4, product side
   d) 8, reactant side
   e) 16, reactant side

3. A strip of iron is placed in a 1 *M* solution of iron(II) sulfate, and a strip of copper is placed in a 1 *M* solution of copper(II) chloride. The two solutions are connected with a salt bridge, and the two metals are connected to a voltmeter. With the two electrodes connected together, how do the Cl^- ions move?

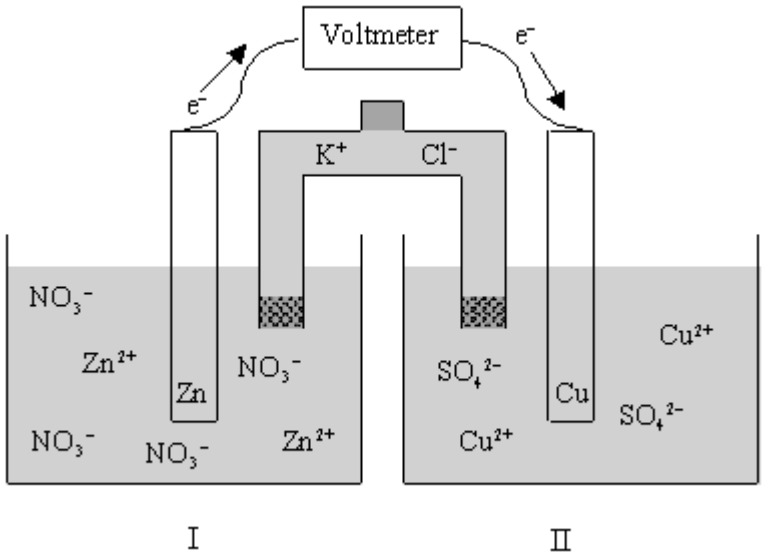
Reduction Half-Reaction	$E°$ (V)
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.41
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	0.34

   a) through the external circuit from Cu to Fe
   b) through the salt bridge from the Cu half-cell to the Fe half-cell
   c) in random fashion
   d) in the direction opposite to the movement of the sulfate ions
   e) together with the Cu^{2+} ions to form an insoluble precipitate

4. Which statement is <u>always</u> true of the cathode in an electrochemical cell?
   a) It is considered the "negative" electrode.
   b) It is considered the "positive" electrode.
   c) Reduction occurs here.
   d) Metal is plated out here.
   e) Negative ions flow toward the cathode.

5. Which reaction would be most likely to occur at the anode of a voltaic cell?
   a) $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$
   b) $PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$
   c) $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
   d) $PbSO_4(s) \rightarrow Pb^{2+}(aq) + SO_4^{2-}(aq)$
   e) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

6. Which of the following statements is true concerning half-cell I of the voltaic cell shown below?



a) Zn^{2+} and NO_3^- increase with time.
b) Zn^{2+} and Cl^- increase with time.
c) Zn^{2+} and NO_3^- decrease with time.
d) Zn^{2+} and Cl^- decrease with time.
e) Zn^{2+} decreases with time, and Cl^- increases with time.

7. In the following electrochemical cell, what is the oxidizing agent?
$Mg(s) \mid Mg^{2+}(aq) \parallel Fe^{3+}(aq), Fe^{2+}(aq) \mid Pt(s)$

a) Pt
b) Mg
c) Mg^{2+}
d) Fe^{2+}
e) Fe^{3+}

8. A zinc–copper voltaic cell is represented as follows:
$Zn(s) \mid Zn^{2+}(1.0\ M) \parallel Cu^{2+}(1.0\ M) \mid Cu(s)$

Which of the following statements is <u>false</u>?

a) The mass of the zinc electrode decreases during discharge.
b) The copper electrode is the anode.
c) Electrons flow through the external circuit from the zinc electrode to the copper electrode.
d) Reduction occurs at the copper electrode during discharge.
e) The concentration of Cu^{2+} decreases during discharge.

9. What is the cell reaction for the following electrochemical cell?
$Mg \mid Mg^{2+}(aq) \parallel Al^{3+}(aq) \mid Al$

a) $Mg(s) + Mg^{2+}(aq) \rightarrow Al(s) + Al^{3+}(aq)$
b) $Mg(s) + Al^{3+}(aq) \rightarrow Al(s) + Mg^{2+}(aq)$
c) $2Al(s) + 3Mg^{2+}(aq) \rightarrow 3Mg(s) + 2Al^{3+}(aq)$
d) $3Mg(s) + 2Al^{3+}(aq) \rightarrow 2Al(s) + 3Mg^{2+}(aq)$
e) $Al(s) + Mg^{2+}(aq) \rightarrow Mg(s) + Al^{3+}(aq)$

10. In a table of standard reduction potentials, the strongest oxidizing agents are the _____ species in the half-reactions with the _____ $E°$ values.
a) oxidized, most negative
b) reduced, most negative
c) oxidized, most positive
d) reduced, most positive
e) none of these

11. Given:

$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$; $E° = -1.18$ V

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$; $E° = 0.34$ V

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$; $E° = 1.33$ V

Which of the following species is the strongest reducing agent?

a) Mn^{2+}
b) Mn
c) Cu
d) $Cr_2O_7^{2-}$
e) Cr^{3+}

12. Given:

$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$; $E° = 0.80$ V

$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$; $E° = -0.13$ V

$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$; $E° = -0.23$ V

$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$; $E° = -0.40$ V

$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$; $E° = -0.76$ V

$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$; $E° = -1.66$ V

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$; $E° = -2.38$ V

Under standard-state conditions, which of the following metals will reduce Ag^+ to Ag but will not reduce Ni^{2+} to Ni?

a) Zn
b) Pb
c) Mg
d) Cd
e) Al

13. Which of the following statements is true about a voltaic cell for which $E°_{cell} = 1.00$ V?
a) It has $\Delta G° > 0$.
b) The system is at equilibrium.
c) It has $K = 1$.
d) The cathode must be made of the same material as the anode.
e) The reaction is spontaneous.

14. Consider the following standard reduction potentials:
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$; $E° = -2.38$ V

$V^{2+}(aq) + 2e^- \rightleftharpoons V(s)$; $E° = -1.18$ V

$Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$; $E° = 0.15$ V

Which of the following reactions will proceed spontaneously from left to right under standard-state conditions?

a) $Mg^{2+}(aq) + V(s) \rightarrow V^{2+}(aq) + Mg(s)$
b) $Mg^{2+}(aq) + 2Cu^+(aq) \rightarrow 2Cu^{2+}(aq) + Mg(s)$
c) $V^{2+}(aq) + 2Cu^+(aq) \rightarrow V(s) + 2Cu^{2+}(aq)$
d) $Mg(s) + 2Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + 2Cu^+(aq)$
e) $2Cu^{2+}(aq) + 2Cu^+(aq) \rightarrow Mg^{2+}(aq) + Mg(s)$

15. What is $E°_{cell}$ for the cell reaction $2Cr(s) + 3Sn^{4+}(aq) \rightarrow 3Sn^{2+}(aq) + 2Cr^{3+}(aq)$ given the following:

$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$; $E° = -0.74$ V

$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$; $E° = 0.15$ V

a) 1.93 V
b) 0.89 V
c) 0.59 V
d) 0.45 V
e) –0.59 V

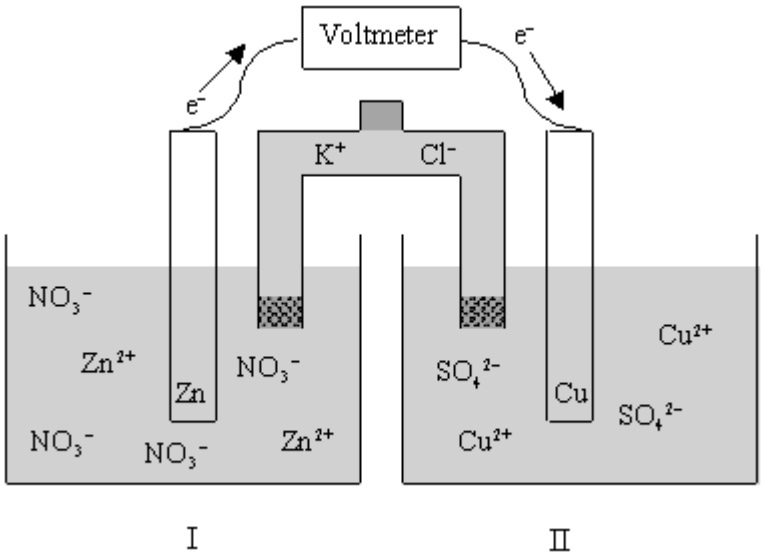
16. Which of the following statements is true concerning the electrochemical cell depicted below?
Mg | $Mg^{2+}(aq)$ || $Cu^{2+}(aq)$ | Cu

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$; $E° = -2.38$ V

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$; $E° = 0.34$ V

a) The cell reaction is spontaneous with a standard cell potential of 2.72 V.
b) The cell reaction is spontaneous with a standard cell potential of 2.04 V.
c) The cell reaction is nonspontaneous with a standard cell potential of –2.72 V.
d) The cell reaction is nonspontaneous with a standard cell potential of –2.04 V.
e) The cell is at equilibrium.

17. If the cell is initially at standard-state conditions, which of the following statements is true?



$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$; $E° = -0.76$ V

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$; $E° = 0.34$ V

a) Initially $\Delta G = -212$ kJ, and it will become more negative with time.
b) Initially $\Delta G = 212$ kJ, and it will become more negative with time.
c) Initially $\Delta G = -212$ kJ, and it will become more positive with time.
d) Initially $\Delta G = 212$ kJ, and it will become more positive with time.
e) Initially $\Delta G = -212$ kJ, and it will not change with time.

18. Given:
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$; $E° = -1.66$ V

$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$; $E° = 0.54$ V

What is $\Delta G°$ for the following cell reaction?

$2AlI_3(aq) \rightleftharpoons 2Al(s) + 3I_2(s)$

a) 4.2×10^5 J
b) -6.5×10^5 J
c) -1.3×10^6 J
d) 1.3×10^6 J
e) -4.2×10^5 J

19. For a reaction in a voltaic cell, both $\Delta H°$ and $\Delta S°$ are positive. Which of the following statements is true?
a) $E°_{cell}$ will increase with an increase in temperature.
b) $E°_{cell}$ will decrease with an increase in temperature.
c) $E°_{cell}$ will not change when the temperature increases.
d) $\Delta G° > 0$ for all temperatures.
e) None of the above statements is true.

20. The standard free energies of formation of several species are as follows:

	kJ/mol
$H^+(aq)$	0
$H_2O(l)$	–237.0
$CH_3OH(aq)$	–163.0
$HCOOH(aq)$	–350.9
e^-	0

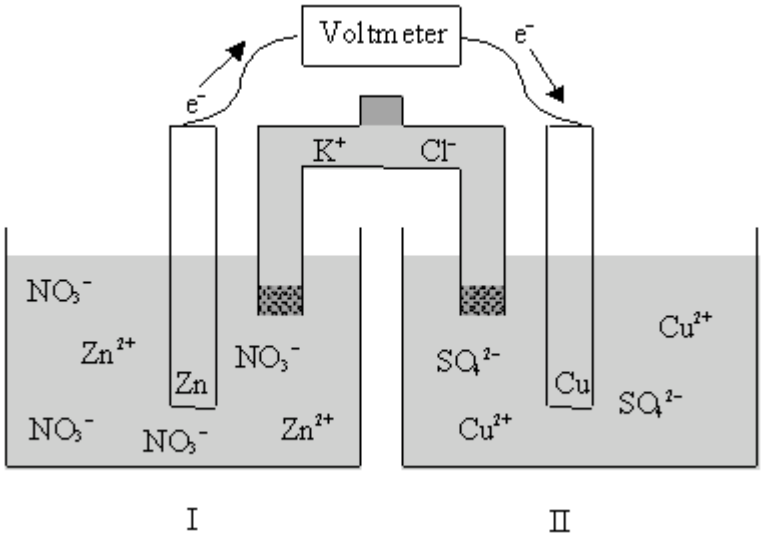
What is the standard reduction potential of formic acid in aqueous solution (that is, for $HCOOH + 4H^+ + 4e^- \rightarrow CH_3OH + H_2O$)?

a) 0.127 V
b) 0.509 V
c) –0.717 V
d) –0.127 V
e) 1.946 V

21. What is E of the following cell reaction at 25°C? $E°_{cell} = 0.460$ V.
$Cu(s) \mid Cu^{2+}(0.012\ M) \parallel Ag^+(0.11\ M) \mid Ag(s)$

a) 0.282 V
b) 0.465 V
c) 0.470 V
d) 0.460 V
e) 0.488 V

22. If the cell is initially at standard-state conditions, which of the following statements is true?



$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$; $E° = -0.76$ V

$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$; $E° = 0.34$ V

a) Initially $K_c = 1.5 \times 10^{37}$, and it decreases with time.
b) Initially $K_c = 1.5 \times 10^{-37}$, and it decreases with time.
c) Initially $K_c = 1.5 \times 10^{37}$, and it increases with time.
d) Initially $K_c = 1.5 \times 10^{-37}$, and it increases with time.
e) Initially $K_c = 1.5 \times 10^{37}$, and it does not change with time.

23. For the cell reaction
$2MnO_4^-(aq) + 5H_2SO_3(aq) \rightarrow 2Mn^{2+}(aq) + 5SO_4^{2-}(aq) + 4H^+(aq) + 3H_2O(l)$

the standard cell potential is 1.34 V. Which change(s) will result in an increase in the cell potential?

1. increasing the permanganate-ion concentration

2. increasing the manganese(II)-ion concentration

3. increasing the amount of H_2SO_3

a) 1 only
b) 2 only
c) 3 only
d) 1 and 2 only
e) 1 and 3 only

24. What is the copper(II)-ion concentration at 25°C in the cell $Zn(s) \mid Zn^{2+}(1.0\ M) \parallel Cu^{2+}(aq) \mid Cu(s)$ if the measured cell potential is 1.04 V? The standard cell potential is 1.10 V.
    a) 0.996 *M*
    b) 0.00940 *M*
    c) 0.0969 *M*
    d) 0.992 *M*
    e) 1.00 *M*

25. Cathodic protection results when
    a) iron is attached to a more active metal.
    b) iron is amalgamated with mercury.
    c) iron is tin-plated for use as a tin can.
    d) iron is painted to protect it from corrosion.
    e) iron is made amphoteric.

26. What half-reaction occurs at the cathode during the electrolysis of molten potassium bromide?
    a) $2Br^-(l) \rightarrow Br_2(l) + 2e^-$
    b) $Br_2(l) + 2e^- \rightarrow 2Br^-(l)$
    c) $K^+(l) + e^- \rightarrow K(s)$
    d) $K(s) \rightarrow K^+(l) + e^-$
    e) $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(l)$

27. What is the half-reaction that occurs at the cathode during electrolysis of an aqueous potassium iodide solution?

Reduction Half-Reaction	$E°$ (V)
$K^+(aq) + e^- \rightleftharpoons K(s)$	–2.93
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	–0.83
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	0.54
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	1.23

    a) $K^+(aq) + e^- \rightarrow K(s)$
    b) $K(s) \rightarrow K^+ + e^-$
    c) $I_2(aq) + 2e^- \rightarrow 2I^-(aq)$
    d) $H_2O(l) \rightarrow \frac{1}{2}O_2(g) + 2H^+(aq) + 2e^-$
    e) $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

28. Which of the following statements is true concerning the electrolysis of a 1.0 *M* aqueous solution of NaI?

Reduction Half-Reaction	$E°$ (V)
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	–2.71
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	–0.83
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	0.54
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	1.23

a) The solution becomes more basic.
b) Sodium is deposited at the cathode.
c) Hydrogen is evolved at the anode.
d) Oxygen is evolved at the anode.
e) Iodine is formed at the cathode.

29. When Au is obtained by electrolysis from $NaAu(CN)_2$, what is the minimum number of coulombs required to produce 1.42 mol of gold?
a) 6.85×10^4 C
b) 1.37×10^5 C
c) 2.74×10^5 C
d) 4.11×10^5 C
e) 5.48×10^5 C

30. How many faradays are required to convert a mole of NO_3^- ions to NH_4^+ ions?
a) 4
b) 5
c) 6
d) 7
e) 8

ANSWERS

Question	Answer
1	d
2	e
3	b
4	c
5	e
6	b
7	e
8	b
9	d
10	c
11	b
12	b
13	e
14	d
15	b
16	a
17	c
18	d
19	a
20	a
21	d
22	e
23	e
24	b
25	a
26	c
27	e
28	a
29	b
30	e