1. Which of the following represents a redox reaction?
   
   A. CaCO₃ → CaO + CO₂  
   B. SiCl₄ + 2Mg → Si + 2MgCl₂  
   C. 2NaOH + H₂SO₄ → 2H₂O + Na₂SO₄  
   D. AgBr + 2S₂O₃²⁻ → Ag(S₂O₃)₂³⁻ + Br⁻

2. Consider the following reaction:
   
   TiCl₄ + O₂ → TiO₂ + 2Cl₂

   Each oxygen atom is
   
   A. reduced and loses 2e⁻  
   B. reduced and gains 2e⁻  
   C. oxidized and loses 2e⁻  
   D. oxidized and gains 2e⁻

3. When NO₂ acts as a reducing agent, a possible product is
   
   A. NO  
   B. N₂O  
   C. N₂O₄  
   D. N₂O₅

4. Which of the following 1.0 M solutions will react spontaneously with lead?
   
   A. KCl  
   B. CuCl₂  
   C. ZnCl₂  
   D. MgCl₂

5. Consider the following redox reaction:
   
   I₂ + 2S₂O₃²⁻ → S₄O₆²⁻ + 2I⁻

   In a titration, 40.00 mL of Na₂S₂O₃ is needed to react completely with 4.0 × 10⁻³ mol I₂. 
   What is the concentration of Na₂S₂O₃ ?
   
   A. 0.10 M  
   B. 0.16 M  
   C. 0.20 M  
   D. 0.32 M

6. In an operating electrochemical cell the function of a salt bridge is to
   
   A. allow hydrolysis to occur.  
   B. allow a non-spontaneous reaction to occur.  
   C. permit the migration of ions within the cell.  
   D. transfer electrons from the cathode to the anode.

7. As the cell operates, electrons flow toward
   
   A. the Pb electrode, where Pb is oxidized.  
   B. the Cd electrode, where Cd is oxidized.  
   C. the Pb electrode, where Pb²⁺ is reduced.  
   D. the Cd electrode, where Cd²⁺ is reduced.
8. The $E^\circ$ value for the reduction of $\text{Cd}^{2+}$ is
   A. $-0.40 \ \text{V}$ \quad C. $+0.14 \ \text{V}$
   B. $-0.27 \ \text{V}$ \quad D. $+0.40 \ \text{V}$

9. The following reaction occurs in an electrochemical cell:
   \[ 3\text{Cu}^{2+} + 2\text{Cr} \rightarrow 2\text{Cr}^{3+} + 3\text{Cu} \]
   The $E^\circ$ for the cell is
   A. 0.40 V \quad C. 1.08 V
   B. 0.75 V \quad D. 2.50 V

10. During the corrosion of magnesium, the anode reaction is
    A. $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$
    B. $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$
    C. $4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^-$
    D. $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$

11. A molten binary salt, $\text{ZnCl}_2$, undergoes electrolysis. The cathode reaction is
    A. $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$ \quad C. $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$
    B. $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ \quad D. $\text{Zn}^{2+} + 2\text{e}^- \rightarrow \text{Zn}$
12. Manganese has an oxidation number of +4 in
   A. MnO
   B. MnO₂
   C. Mn₂O₃
   D. Mn₂O₇

13. In which reaction is nitrogen reduced?
   A. 2NO + O₂ → 2NO₂
   B. 4NH₃ + 5O₂ → 4NO + 6H₂O
   C. Cu²⁺ + 2NO₂ + 2H₂O → Cu⁺ + 4H⁺ + 2NO₃⁻
   D. 4Zn + 10H⁺ + NO₃⁻ → 4Zn²⁺ + NH₄⁺ + 3H₂O

14. An oxidizing agent will cause which of the following changes?
   A. PtO₂ → PtO
   B. PtO₃ → PtO₂
   C. Pt(OH)₂ → Pt
   D. Pt(OH)₂²⁺ → PtO₃

15. Consider the overall reaction of the rechargeable nickel-cadmium battery:
    \[ \text{NiO}_2(\text{s}) + \text{Cd}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{Ni(OH)}_2(\text{s}) + \text{Cd(OH)}_2(\text{s}) \]
    Which of the following occurs at the anode as the reaction proceeds?
    A. Cd loses 2e⁻ and forms Cd(OH)₂(\text{s})
    B. Cd gains 2e⁻ and forms Cd(OH)₂(\text{s})
    C. NiO₂ loses 2e⁻ and forms Ni(OH)₂(\text{s})
    D. NiO₂ gains 2e⁻ and forms Ni(OH)₂(\text{s})

16. Which of the following will oxidize Fe²⁺?
   A. I₂(\text{s})
   B. Ni(\text{s})
   C. Zn(\text{s})
   D. Br₂(\text{l})

17. Consider the following half-reaction in a basic solution:
    \[ \text{Ag}_2\text{O}_3 \rightarrow \text{AgO} \quad \text{(basic)} \]
    The balanced half-reaction is
    A. \[ \text{Ag}_2\text{O}_3 + 4\text{H}^+ + 4\text{e}^- \rightarrow \text{AgO} + 2\text{H}_2\text{O} \]
    B. \[ \text{Ag}_2\text{O}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{AgO} + \text{H}_2\text{O} \]
    C. \[ \text{Ag}_2\text{O}_3 + \text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{AgO} + 2\text{OH}^- \]
    D. \[ \text{Ag}_2\text{O}_3 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow \text{AgO} + 4\text{OH}^- \]
18. The concentration of $\text{Fe}^{2+}$ can be determined by a redox titration using

A. $\text{KBr}$  
B. $\text{SnCl}_2$  
C. $\text{KMnO}_4$ (basic)  
D. $\text{KBrO}_3$ (acidic)

19. Consider the following electrochemical cell:

Which of the following occurs as the cell operates?

A. Zinc electrode is reduced and increases in mass.  
B. Zinc electrode is reduced and decreases in mass.  
C. Zinc electrode is oxidized and increases in mass.  
D. Zinc electrode is oxidized and decreases in mass.

20. Which of the following reactants would produce an $E^\circ$ of $+0.63 \text{ V}$?

A. $\text{Ag}^+ + \text{I}_2$  
B. $\text{Pb}^{2+} + \text{Zn}$  
C. $\text{Mg}^{2+} + \text{Ca}$  
D. $\text{Zn}^{2+} + \text{Mn}$

21. The process of applying an electric current through a cell to produce a chemical change is called

A. corrosion.  
B. ionization.  
C. hydrolysis.  
D. electrolysis.

22. Consider the following electrolytic cell:

The cathode reaction is

A. $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$  
B. $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$  
C. $\text{H}_2\text{O} \rightarrow \frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$  
D. $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$
23. A chemical process involving the loss of electrons is a definition of
   A. oxidation.  C. galvanization.

24. Which of the following is not a redox reaction?
   A. $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$  
   C. $\text{CuS} + 2\text{O}_2 + \text{C} \rightarrow \text{Cu} + \text{SO}_2 + \text{CO}_2$
   B. $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{S}_2\text{O}_7$
   D. $4\text{Ag} + 2\text{H}_2\text{S} + \text{O}_2 \rightarrow 2\text{Ag}_2\text{S} + 2\text{H}_2\text{O}$

25. A reducing agent will cause which of the following changes?
   A. $\text{ClO}_3^- \rightarrow \text{ClO}_2$
   C. $\text{H}_3\text{PO}_3 \rightarrow \text{H}_3\text{PO}_4$
   B. $\text{NO}_2^- \rightarrow \text{N}_2\text{O}_4$
   D. $\text{HS}_2\text{O}_4^- \rightarrow \text{H}_2\text{SO}_3$

26. The oxidation number of zinc in a reaction increases by 2. This indicates that
   A. zinc is reduced and loses 2 electrons.
   C. zinc is oxidized and loses 2 electrons.
   B. zinc is reduced and gains 2 electrons.
   D. zinc is oxidized and gains 2 electrons.

27. Which metal will react spontaneously with water?
   A. Ca
   B. Ni
   C. Pb
   D. Hg

28. Consider the following redox reaction which occurs in a lead-acid storage cell:
   $$\text{PbO}_2(s) + \text{Pb}(s) + 2\text{H}_2\text{SO}_4(aq) \rightarrow 2\text{PbSO}_4(aq) + 2\text{H}_2\text{O}(l)$$

   The balanced reduction half-reaction is
   A. $\text{Pb} \rightarrow \text{Pb}^{2+} + 2e^-$
   B. $\text{Pb} + \text{SO}_4^{2-} \rightarrow \text{PbSO}_4 + 2e^-$
   C. $2\text{H}_2\text{SO}_4 + 2\text{Pb} + 2e^- \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O}$
   D. $\text{PbO}_2 + 4\text{H}^+ + \text{SO}_4^{2-} + 2e^- \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$

29. Consider the following redox reactions:
   $$\text{HClO} + \text{I}^- \rightarrow \text{HIO} + \text{Cl}^- \quad E^o = +0.49 \text{ V}$$
   $$\text{HClO} + \text{Br}^- \rightarrow \text{HBrO} + \text{Cl}^- \quad E^o = +0.15 \text{ V}$$

   The relative strength of the oxidizing agents from strongest to weakest is
   A. HIO > HBrO > HClO
   B. HClO > HIO > HBrO
   C. HBrO > HIO > HClO
   D. HClO > HBrO > HIO
30. Consider the following diagram of a fuel cell in which \( \text{H}_2 \) and \( \text{O}_2 \) combine to produce \( \text{H}_2\text{O} \) under basic conditions:

The reaction at the anode is

- A. \( 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2 \)
- B. \( \frac{1}{2} \text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O} \)
- C. \( 4\text{OH}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \)
- D. \( \text{H}_2 + 2\text{OH}^- \rightarrow 2\text{H}_2\text{O} + 2\text{e}^- \)

31. As the cell operates, observations include

<table>
<thead>
<tr>
<th>Mass of Nickel Electrode</th>
<th>Concentration of Copper Ions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. decreases</td>
<td>increases</td>
</tr>
<tr>
<td>B. decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>C. increases</td>
<td>increases</td>
</tr>
<tr>
<td>D. increases</td>
<td>decreases</td>
</tr>
</tbody>
</table>

32. What is the cell potential, \( E^\circ \), for this cell?

- A. 0.08 V
- B. 0.26 V
- C. 0.60 V
- D. 0.78 V

33. Consider the following electrolytic cell:

- A. \( \text{I}^- \) migrates to the anode and gains electrons.
- B. \( \text{I}^- \) migrates to the cathode and loses electrons.
- C. \( \text{Na}^+ \) migrates to the anode and loses electrons.
- D. \( \text{Na}^+ \) migrates to the cathode and gains electrons.

3Y. Which of the following are necessary for electroplating to occur using an electrolytic cell?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Two electrodes</td>
</tr>
<tr>
<td>II.</td>
<td>A metal ion being reduced</td>
</tr>
<tr>
<td>III.</td>
<td>A direct current power source</td>
</tr>
</tbody>
</table>

- A. I and II only.
- B. I and III only.
- C. II and III only.
- D. I, II, and III.
35. The pH of acid rain could be
   A. 5.0        C. 9.0       (1 mark)
   B. 7.0        D. 11.0

36. Consider the following reaction:
   \[ \text{Zn}_{(s)} + 2\text{H}^+_{(aq)} \rightarrow \text{Zn}^{2+}_{(aq)} + \text{H}_2_{(g)} \]
   The species being oxidized is
   A. \(\text{H}_2\)       C. \(\text{Zn}\)       (1 mark)
   B. \(\text{H}^+\)       D. \(\text{Zn}^{2+}\)

37. When \(\text{SO}_4^{2-}\) reacts to form \(\text{S}_2\text{O}_6^{2-}\), the sulphur atoms
   A. lose electrons and are reduced.       (2 marks)
   B. gain electrons and are reduced.
   C. lose electrons and are oxidized.
   D. gain electrons and are oxidized.

38. Which of the following is a list of metals in order from strongest to weakest
    reducing agents?
   A. \(\text{Au} > \text{Ni} > \text{Rb}\)       (1 mark)
   B. \(\text{Ni} > \text{Au} > \text{Rb}\)
   C. \(\text{Ni} > \text{Rb} > \text{Au}\)
   D. \(\text{Rb} > \text{Ni} > \text{Au}\)

39. Consider the following spontaneous reaction:
   \[ \text{Mg}_{(s)} + 2\text{HCl}_{(aq)} \rightarrow \text{MgCl}_2_{(aq)} + \text{H}_2_{(g)} \]
   Which of the following statements is correct?       (1 mark)
   A. \(\text{Mg}\) is a weaker reducing agent than \(\text{H}_2\)
   B. \(\text{Mg}\) is a weaker reducing agent than \(\text{H}^+\)
   C. \(\text{Mg}\) is a stronger reducing agent than \(\text{H}_2\)
   D. \(\text{Mg}\) is a stronger reducing agent than \(\text{H}^+\)

40. Which of the following will not react spontaneously with \(\text{H}_2\text{O}\)
    at standard conditions?               (1 mark)
   A. \(\text{F}_2\)       C. \(\text{Na}\)
   B. \(\text{Ca}\)       D. \(\text{Sn}\)

41. When a piece of \(\text{Cu}\) is placed in 1.0 M \(\text{AgNO}_3\),
   A. the \([\text{Ag}^+]\) increases.       (1 mark)
   B. the \([\text{Cu}^{2+}]\) increases.
   C. the \([\text{NO}_3^-]\) decreases.
   D. no change occurs.
42. Which of the following diagrams represents the relationship between \([\text{Ni}^{2+}]\) and the mass of the Cu electrode as the cell above is in operation?

(1 mark)

43. The \(E^0\) for the above cell is

A. \(-0.04\) volts  
B. \(-0.60\) volts  
C. \(+0.04\) volts  
D. \(+0.60\) volts

(1 mark)

44. Which of the following describes an electrochemical cell?

(2 marks)

<table>
<thead>
<tr>
<th>(E_{cell}^0)</th>
<th>Type of reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>positive</td>
<td>spontaneous</td>
</tr>
<tr>
<td>positive</td>
<td>non-spontaneous</td>
</tr>
<tr>
<td>negative</td>
<td>spontaneous</td>
</tr>
<tr>
<td>negative</td>
<td>non-spontaneous</td>
</tr>
</tbody>
</table>

45. Which of the following aqueous solutions should not be used as an electrolyte in an electrolytic cell?

(1 mark)

A. 1.0 M KOH  
B. 1.0 M \(\text{H}_2\text{SO}_4\)  
C. 1.0 M \(\text{CuSO}_4\)  
D. 1.0 M \(\text{C}_6\text{H}_2\text{O}_6\)

46. When 1.0 M \(\text{Na}_2\text{SO}_4\) is electrolyzed, the solution near the anode becomes

(2 marks)

A. basic and bubbles form.  
B. acidic and bubbles form.  
C. basic and no bubbles form.  
D. acidic and no bubbles form.
47. Consider the following spontaneous reaction:

\[ 2\text{Al}_{(s)} + 3\text{Cu}^{2+}_{(aq)} \rightarrow 2\text{Al}^{3+}_{(aq)} + 3\text{Cu}_{(s)} \]  

In this reaction, the oxidizing agent is

A. Al  C. Al^{3+}  
B. Cu  D. Cu^{2+}

48. Bromine has an oxidation number of +3 in

A. KBrO  C. KBrO_3  
B. KBrO_2  D. KBrO_4

49. In an experiment, Te reacts spontaneously with Ag^+ but not with Ti^{2+}.

The relative strength of oxidizing agents from strongest to weakest is

A. Ag^+ > Te^{4+} > Ti^{2+}  
B. Ag^+ > Ti^{2+} > Te^{4+}  
C. Te^{4+} > Ti^{2+} > Ag^+  
D. Ti^{2+} > Te^{4+} > Ag^+

50. A piece of Au does not react spontaneously with 1.0 M HCl.

Which of the following statements is true?

A. Au is a weaker reducing agent than H_2  
B. Au is a stronger reducing agent than H_2  
C. Au is a weaker oxidizing agent than H^+  
D. Au is a stronger oxidizing agent than H^+

51. Which two species will react spontaneously with each other at standard conditions?

A. Cl_2 and Br^-  
B. Zn and Al^{3+}  
C. Au and Sn^{2+}  
D. I_2 and SO_4^{2-}

52. What occurs when a piece of Zn is placed in 1.0 M Cu(NO_3)_2 ?

A. [Cu^{2+}] decreases  
B. [Zn^{2+}] decreases  
C. [NO_3^-] increases  
D. no change occurs
53. Which of the following diagrams represents the relationship between \([\text{Zn}^{2+}]\) and \([\text{Ni}^{2+}]\) as the cell is in operation? (1 mark)

A.  
\[
\begin{array}{c}
\text{[Ni}^{2+}] \\
\text{[Zn}^{2+}] \\
\end{array}
\]

B.  
\[
\begin{array}{c}
\text{[Zn}^{2+}] \\
\text{[Ni}^{2+}] \\
\end{array}
\]

C.  
\[
\begin{array}{c}
\text{[Ni}^{2+}] \\
\text{[Zn}^{2+}] \\
\end{array}
\]

D.  
\[
\begin{array}{c}
\text{[Zn}^{2+}] \\
\text{[Ni}^{2+}] \\
\end{array}
\]

54. The \(E^0\) for the cell in the diagram is (1 mark)

A.  
\(-1.02\) Volts

B.  
\(-0.50\) Volts

C.  
\(+0.50\) Volts

D.  
\(+1.02\) Volts

55. Which of the following does not affect the cell potential? (1 mark)

A.  
\([\text{Ni}^{2+}]\)

B.  
\([\text{Zn}^{2+}]\)

C.  
temperature

D.  
surface area of the electrodes

56. What type of ions move toward each electrode in an electrolytic cell? (2 marks)

<table>
<thead>
<tr>
<th>Anode</th>
<th>Cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. anions</td>
<td>cations</td>
</tr>
<tr>
<td>B. cations</td>
<td>anions</td>
</tr>
<tr>
<td>C. anions</td>
<td>anions</td>
</tr>
<tr>
<td>D. cations</td>
<td>cations</td>
</tr>
</tbody>
</table>

57. The electrolysis of 1.0 M NaI using inert electrodes will produce (2 marks)

A. sodium and iodine.

B. sodium and oxygen.

C. hydrogen and iodine.

D. hydrogen and oxygen.
58. Which of the following describes a strong oxidizing agent? (1 mark)
   A. a substance which loses electrons readily
   B. a substance which gains electrons readily
   C. a substance which has a large increase in oxidation number
   D. a substance which has a small increase in oxidation number

59. Consider the following unbalanced redox reaction: (2 marks)
   \[ \text{Sn}^{2+} + \text{MnO}_4^- \rightarrow \text{Sn}^{4+} + \text{Mn}^{2+} \]

   Which of the following describes the change in Sn^{2+} ?
   A. loses electrons and is reduced
   B. gains electrons and is reduced
   C. loses electrons and is oxidized
   D. gains electrons and is oxidized

60. A solution containing Pd^{2+} reacts spontaneously with Ga to produce Pd and Ga^{3+}. However, a solution containing Pd^{2+} does not react with Pt. The metals, in order of increasing strength as reducing agents, are (1 mark)
   A. Pt < Pd < Ga
   B. Pt < Ga < Pd
   C. Ga < Pt < Pd
   D. Ga < Pd < Pt

61. Which of the following can act as an oxidizing agent, but not as a reducing agent? (1 mark)
   A. Cr
   B. Cl^-
   C. Cu^+
   D. Na^+

62. Solid copper forms spontaneously in the following reaction: (1 mark)
   \[ \text{V} + \text{Cu}^{2+} \rightarrow \text{Cu} + \text{V}^{2+} \]

   Based on this observation, Cu^{2+} is a
   A. weaker reducing agent than V^{2+}
   B. weaker oxidizing agent than V^{2+}
   C. stronger reducing agent than V^{2+}
   D. stronger oxidizing agent than V^{2+}

63. Which of the following could be used to determine the [Fe^{2+}] by a redox titration? (1 mark)
   A. I_2
   B. Cl^-
   C. Cu^{2+}
   D. MnO_4^- (acidified)
64. What happens to the lead electrode?
   A. It loses mass as it is reduced.
   B. It gains mass as it is reduced.
   C. It loses mass as it is oxidized.
   D. It gains mass as it is oxidized.

65. As the cell operates, what happens to the ions in the salt bridge?
   A. K⁺ and NO₃⁻ will both migrate toward the Pb half-cell.
   B. K⁺ and NO₃⁻ will both migrate toward the Cu half-cell.
   C. K⁺ will migrate toward the Cu half-cell and NO₃⁻ will migrate toward the Pb half-cell.
   D. K⁺ will migrate toward the Pb half-cell and NO₃⁻ will migrate toward the Cu half-cell.

66. What is the initial cell voltage? (1 mark)
   A. +0.02 V
   B. +0.21 V
   C. +0.28 V
   D. +0.47 V

67. Consider the following: (2 marks)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>electrolysis of water</td>
</tr>
<tr>
<td>II</td>
<td>electroplating of copper</td>
</tr>
<tr>
<td>III</td>
<td>rusting of iron</td>
</tr>
</tbody>
</table>

Which of the above involve non-spontaneous redox reactions?
   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III

68. A copper spoon was electroplated with silver. Which of the following reactions occurred at the cathode during electroplating? (1 mark)
   A. Ag → Ag⁺ + e⁻
   B. Ag⁺ + e⁻ → Ag
   C. Cu → Cu²⁺ + 2e⁻
   D. Cu²⁺ + 2e⁻ → Cu
69. An oxidizing agent is
A. reduced as it loses electrons.
B. reduced as it gains electrons.
C. oxidized as it loses electrons.
D. oxidized as it gains electrons.

70. Consider the following spontaneous reaction:

\[ \text{Ga}^{3+} + 3\text{Rb} \rightarrow 3\text{Rb}^+ + \text{Ga} \]

What happens in this reaction?
A. Rb is reduced.
B. Rb gains electrons.
C. \(\text{Ga}^{3+}\) loses electrons.
D. \(\text{Ga}^{3+}\) acts as an oxidizing agent.

71. What is the oxidation number of S in \(\text{S}_2\text{O}_6^{2-}\)?
A. +3
B. +5
C. +6
D. +7

72. Which of the following is the weakest oxidizing agent?
A. \(\text{Cl}_2\)
B. \(\text{Al}^{3+}\)
C. \(\text{Sn}^{2+}\)
D. acidified \(\text{Cr}_2\text{O}_7^{2-}\)

73. Which of the following could react spontaneously with Ag metal?
A. \(\text{Cl}^-\)
B. \(\text{Fe}^{2+}\)
C. acidified \(\text{SO}_4^{2-}\)
D. acidified \(\text{NO}_3^-\)

74. Which of the following could be titrated using acidified \(\text{MnO}_4^-\) ions?
A. \(\text{Na}^+\)
B. \(\text{IO}_3^-\)
C. \(\text{SO}_4^{2-}\)
D. \(\text{H}_2\text{O}_2\)
75. What happens to the zinc electrode?
   A. Mass increases as it is reduced.
   B. Mass decreases as it is reduced.
   C. Mass increases as it is oxidized.
   D. Mass decreases as it is oxidized.

76. Calculate the $E^0$ for the above cell.
   A. $-0.42 \text{ V}$
   B. $0.91 \text{ V}$
   C. $1.10 \text{ V}$
   D. $1.30 \text{ V}$

77. What happens to iron as it corrodes?
   A. It loses electrons and is reduced.
   B. It gains electrons and is reduced.
   C. It loses electrons and is oxidized.
   D. It gains electrons and is oxidized.

78. What reaction occurs at the cathode?
   A. $2I^- \rightarrow I_2 + 2e^-$
   B. $Cu^{2+} + 2e^- \rightarrow Cu$
   C. $H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$
   D. $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

79. What happens to the $[I^-]$ in the operating cell?
   A. $[I^-]$ increases overall.
   B. $[I^-]$ decreases overall.
   C. $[I^-]$ remains constant overall.
   D. $[I^-]$ decreases near the anode and increases near the cathode.
80. The equation for the decomposition of nitrous acid is

\[ 3\text{HNO}_2 \rightarrow 2\text{NO} + \text{HNO}_3 + \text{H}_2\text{O} \]

Which of the following is correct? (1 mark)

A. This is a redox reaction.  
B. This is an acid-base reaction.  
C. This is a reduction half equation.  
D. This is an oxidation half equation.

81. An equation for the rusting of iron is shown below:

\[ 4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3 \]

Which of the following is false? (1 mark)

A. This is a redox reaction.  
B. \( \text{O}_2 \) is the oxidizing agent.  
C. Metallic iron is reduced to \( \text{Fe}^{3+} \).  
D. Metallic iron is the reducing agent.

82. In which of the following chemical changes will there be an oxidation number change of +3? (1 mark)

A. \( \text{Cr}^{3+} \rightarrow \text{Cr}^{2+} \)  
B. \( \text{ClO}^- \rightarrow \text{ClO}_2^- \)  
C. \( \text{Cr}^{3+} \rightarrow \text{Cr}_2\text{O}_7^{2-} \)  
D. \( \text{Mn}^{2+} \rightarrow \text{MnO}_4^- \)

83. Which of the following ions can be reduced by \( \text{Pb}_{(s)} \) under standard conditions? (1 mark)

A. \( \text{Cu}^+ \)  
B. \( \text{Cr}^{3+} \)  
C. \( \text{Sn}^{2+} \)  
D. \( \text{Ca}^{2+} \)

84. Consider the following equation for the combustion of ethane:

\[ 2\text{C}_2\text{H}_6 + 7\text{O}_2 \rightarrow 4\text{CO}_2 + 6\text{H}_2\text{O} \]

The change in oxidation number for carbon is equivalent to (1 mark)

A. 1 electron lost.  
B. 7 electrons lost.  
C. 1 electron gained.  
D. 7 electrons gained.

85. Consider the diagram

Identify the cathode half reaction. (2 marks)

A. \( \text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^- \)  
B. \( 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2 \)  
C. \( \text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au} \)  
D. \( \text{Co}^{2+} + 2\text{e}^- \rightarrow \text{Co} \)
86. As a standard Zn / Ag electrochemical cell operates, in which direction do anions move and how does the mass of the cathode change? (2 marks)

<table>
<thead>
<tr>
<th>Anion Direction</th>
<th>Mass of Cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. towards Zn electrode</td>
<td>increases</td>
</tr>
<tr>
<td>B. towards Ag electrode</td>
<td>increases</td>
</tr>
<tr>
<td>C. towards Zn electrode</td>
<td>decreases</td>
</tr>
<tr>
<td>D. towards Ag electrode</td>
<td>decreases</td>
</tr>
</tbody>
</table>

87. What is the standard cell potential for the following reaction: (1 mark)

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

A. -1.08 V  
B. +0.40 V  
C. +1.08 V  
D. +2.50 V

88. Consider the following:

\[ 2Cr^{2+} + Ti^{3+} \rightarrow 2Cr^{3+} + Ti^{+} \]

\[ E^0 = +1.19 \text{ V} \]

Identify the standard potential for the half-cell reaction: (1 mark)

\[ Ti^{+} \rightarrow Ti^{3+} + 2e^- \]

A. -0.78 V  
B. +1.60 V  
C. +0.78 V  
D. +1.19 V

89. The electrolysis of aqueous Rb₂SO₄ solution using carbon electrodes produces changes in the solution around the electrodes. How will the pH change around the anode and the cathode? (2 marks)

<table>
<thead>
<tr>
<th>pH around the Anode</th>
<th>pH around the Cathode</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. increase</td>
<td>increase</td>
</tr>
<tr>
<td>B. decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>C. increase</td>
<td>decrease</td>
</tr>
<tr>
<td>D. decrease</td>
<td>increase</td>
</tr>
</tbody>
</table>

90. The same amount of electricity (same number of moles of electrons) is used to carry out the electrolysis of PdCl₂(aq) and AgNO₃(aq) solutions in separate cells. The masses of Pd and Ag produced were measured and compared. Which of the following is true about the mass of Pd produced? (1 mark)

A. The mass of Pd produced is not related to the mass of Ag.  
B. The mass of Pd produced is approximately half that of Ag.  
C. The mass of Pd produced is approximately twice that of Ag.  
D. The mass of Pd produced is approximately the same as that of Ag.
91. Which equation represents a redox reaction? (1 mark)

A. \(\text{C} + \text{O}_2 \rightarrow \text{CO}_2\)
B. \(\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}\)
C. \(2\text{CrO}_4^{2-} + 2\text{H}^+ \rightarrow \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}\)
D. \(\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2 + \text{H}_2\text{O}\)

92. What is a typical characteristic of a strong oxidizing agent? (1 mark)

A. It is readily oxidized.
B. It easily loses electrons.
C. It has a negative oxidation number.
D. It has a positive reduction potential.

93. When \(\text{U}_3\text{O}_8\) (pitchblende) is dissolved in nitric acid, it changes into \(\text{UO}_2\)(\(\text{NO}_3\))\(_2\) (uranyl nitrate). What is the change in oxidation number for uranium? (1 mark)

A. \(+2\frac{2}{3}\)
B. \(+\frac{8}{3}\)
C. \(-3\frac{1}{3}\)
D. \(-10\)

94. The metals \(\text{Hg}\), \(\text{Cd}\), \(\text{Ga}\) and \(\text{Pd}\) react as follows:

\[
3\text{Pd}^{2+} + 2\text{Ga} \rightarrow 2\text{Ga}^{3+} + 3\text{Pd}
\]

\[
\text{Cd} + \text{Ga}^{3+} \rightarrow \text{no reaction}
\]

\[
\text{Hg}^{2+} + \text{Pd} \rightarrow \text{Pd}^{2+} + \text{Hg}
\]

Which of the following metals is the strongest reducing agent? (2 marks)

A. \(\text{Pd}\)
B. \(\text{Ga}\)
C. \(\text{Cd}\)
D. \(\text{Hg}\)

95. Which of the following metals can be oxidized by 1.0 M \(\text{Fe}^{2+}\)? (1 mark)

A. \(\text{Sn}\)
B. \(\text{Co}\)
C. \(\text{Cr}\)
D. \(\text{Ag}\)

96. What is the equation for the half-reaction that occurs at the cathode? (1 mark)

A. \(\text{Ag} \rightarrow \text{Ag}^+ + e^-\)
B. \(\text{Ag}^+ + e^- \rightarrow \text{Ag}\)
C. \(\text{Zn} \rightarrow \text{Zn}^{2+} + 2e^-\)
D. \(\text{Zn}^{2+} + 2e^- \rightarrow \text{Zn}\)