MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) The gain of electrons by an element is called ________.
   A) reduction
   B) disproportionation
   C) fractionation
   D) oxidation
   E) sublimation
   Page Ref: Sec. 20.1
   Topic:

2) ________ is the oxidizing agent in the reaction below.
   \[ \text{Cr}_2\text{O}_7^{2-} + 6\text{H}_2\text{O} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 8\text{H}_2\text{O} + 7\text{H}_2\text{O} \]
   A) \text{Cr}_2\text{O}_7^{2-}
   B) \text{Cr}^{3+}
   C) \text{S}_2\text{O}_5^{2-}
   D) \text{S}_2\text{O}_3^{2-}
   E) \text{H}^+
   Page Ref: Sec. 20.1
   Topic:

3) Which substance is the reducing agent in the reaction below?
   \[ \text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{PbSO}_4 + 2\text{H}_2\text{O} \]
   A) \text{H}_2\text{SO}_4
   B) \text{PbSO}_4
   C) \text{H}_2\text{O}
   D) \text{Pb}
   E) \text{PbO}_2
   Page Ref: Sec. 20.1
   Topic:

4) What is the oxidation number of manganese in the permanganate ion?
   A) +1
   B) +4
   C) +7
   D) +5
   E) +2
   Page Ref: Sec. 20.1
   Topic:

5) ________ electrons appear in the following half-reaction when it is balanced.
   \[ \text{S}_4\text{O}_6^{2-} \rightarrow 2\text{S}_2\text{O}_3^{2-} \]
   A) 1
   B) 3
   C) 2
   D) 4
   E) 6
   Page Ref: Sec. 20.2
   Topic:

6) What is the coefficient of the hypochlorite ion when the following equation is balanced?
   \[ \text{ClO}^- + \text{S}_2\text{O}_3^{2-} \rightarrow \text{Cl}^- + \text{SO}_4^{2-} \]  (basic solution)
   A) 1
   B) 2
   C) 3
   D) 4
   E) 5
   Page Ref: Sec. 20.2
   Topic:
7) What is the coefficient of iodide when the following equation is balanced?

\[ \text{MnO}_4^- + I^- \rightarrow \text{Mn}^{2+} + I_2 \]  
(acidic solution) 

A) 3  
B) 5  
C) 1  
D) 2  
E) 4

Page Ref: Sec. 20.2  
Topic:  

8) The electrode at which oxidation occurs is called the 
A) cathode  
B) anode  
C) voltaic cell  
D) reducing agent  
E) oxidizing agent

Page Ref: Sec. 20.3  
Topic:  

9) The purpose of the salt bridge in an electrochemical cell is to 
A) provide a means for electrons to travel from the cathode to the anode.  
B) maintain electrical neutrality in the half-cells via migration of ions.  
C) provide a source of ions to react at the anode and cathode.  
D) provide a means for electrons to travel from the anode to the cathode.  
E) provide oxygen to facilitate oxidation at the anode.

Page Ref: Sec. 20.3  
Topic:  

10) In a voltaic cell, electrons flow from the ________ to the ________.
A) anode, salt bridge  
B) anode, cathode  
C) salt bridge, anode  
D) salt bridge, cathode  
E) cathode, anode

Page Ref: Sec. 20.3  
Topic:  

11) The reduction half reaction occurring in the standard hydrogen electrode is ________
A) \( \text{O}_2 (g) + 4\text{H}^+ (aq) + 4e^- \rightarrow 2\text{H}_2\text{O} (l) \)  
B) \( \text{H}_2 (g, 1 \text{ atm}) \rightarrow 2\text{H}^+ (aq, 1\text{M}) + 2e^- \)  
C) \( 2\text{H}^+ (aq, 1\text{M}) + \text{Cl}_2 (aq) \rightarrow 2\text{HCl} (aq) \)  
D) \( 2\text{H}^+ (aq, 1\text{M}) + 2e^- \rightarrow \text{H}_2 (g, 1 \text{ atm}) \)  
E) \( 2\text{H}^+ (aq) + 2\text{OH}^- \rightarrow \text{H}_2\text{O} (l) \)

Page Ref: Sec. 20.4  
Topic:  

12) \( 1\text{V} = \) ________.
A) 1 amp • s  
B) 96485 C  
C) 11 J/C  
D) 11 J/s  
E) 1 C/J

Page Ref: Sec. 20.4  
Topic:  

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<table>
<thead>
<tr>
<th>Half Reaction</th>
<th>E' (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{I}_2 (g) + 2e^- \rightarrow 2\text{I}^- ) (aq)</td>
<td>+2.87</td>
</tr>
<tr>
<td>( \text{Cl}_2 (g) + 2e^- \rightarrow 2\text{Cl}^- ) (aq)</td>
<td>+1.359</td>
</tr>
<tr>
<td>( \text{Br}_2 (l) + 2e^- \rightarrow 2\text{Br}^- ) (aq)</td>
<td>+1.065</td>
</tr>
<tr>
<td>( \text{O}_2 (g) + 4\text{H}^+ ) (aq) + 4e(^-) \rightarrow 2\text{H}_2\text{O} (l)</td>
<td>+1.23</td>
</tr>
<tr>
<td>( \text{Ag}^+ + e^- \rightarrow \text{Ag} (s) )</td>
<td>+0.799</td>
</tr>
<tr>
<td>( \text{Fe}^{3+} ) (aq) + e(^-) \rightarrow \text{Fe}^{2+} ) (aq)</td>
<td>+0.771</td>
</tr>
<tr>
<td>( \text{I}_2 (s) + 2e^- \rightarrow 2\text{I}^- ) (aq)</td>
<td>+0.536</td>
</tr>
<tr>
<td>( \text{Cu}^{2+} + 2e^- \rightarrow \text{Cu} (s) )</td>
<td>+0.34</td>
</tr>
<tr>
<td>( 2\text{H}^+ + 2e^- \rightarrow \text{H}_2 (g) )</td>
<td>0</td>
</tr>
<tr>
<td>( \text{Pb}^{2+} + 2e^- \rightarrow \text{Pb} (s) )</td>
<td>-0.126</td>
</tr>
<tr>
<td>( \text{Ni}^{2+} + 2e^- \rightarrow \text{Ni} (s) )</td>
<td>-0.28</td>
</tr>
<tr>
<td>( \text{Li}^+ + e^- \rightarrow \text{Li} (s) )</td>
<td>-3.05</td>
</tr>
</tbody>
</table>

13) Which of the halogens in Table 20.1 is the strongest oxidizing agent?
A) Br\(_2\)
B) F\(_2\)
C) I\(_2\)
D) Cl\(_2\)
E) All of the halogens have equal strength as oxidizing agents.

Page Ref: Sec. 20.4

Topic:

14) Using Table 20.1, which substance can be oxidized by \( \text{O}_2 (g) \) in acidic aqueous solution?
A) Ag (s)
B) Br\(_2\) (l)
C) Br\(^-\) (aq)
D) Cu\(^{2+}\) (aq)
E) Ni\(^{2+}\) (aq)

Page Ref: Sec. 20.4

Topic:

15) Using Table 20.1, which substance can oxidize \( \Gamma^- \) (aq) to \( \text{I}_2 \) (s)?
A) Cu\(^{2+}\) (aq)
B) Ni\(^{2+}\) (aq)
C) Br\(^-\) (aq)
D) Ag (s)
E) Br\(_2\) (l)

Page Ref: Sec. 20.4

Topic:

16) The more ________ the value of \( E'_{\text{red}} \) the greater the driving force for reduction.
A) positive
B) extensive
C) exothermic
D) endothermic
E) negative

Page Ref: Sec. 20.4

Topic:
Table 20.2

<table>
<thead>
<tr>
<th>Half-reaction</th>
<th>E' (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr$^{3+}$ (aq) + 3e$^-$ → Cr (s)</td>
<td>-0.74</td>
</tr>
<tr>
<td>Fe$^{2+}$ (aq) + 2e$^-$ → Fe (s)</td>
<td>-0.440</td>
</tr>
<tr>
<td>Fe$^{3+}$ (aq) + e$^-$ → Fe$^{2+}$ (aq)</td>
<td>-0.771</td>
</tr>
<tr>
<td>Sn$^{4+}$ (aq) + 2e$^-$ → Sn$^{2+}$ (aq)</td>
<td>+0.154</td>
</tr>
</tbody>
</table>

17) The standard cell potential (E<sub>cell</sub>) for the voltaic cell based on the reaction below is _______ V.

Sn$^{2+}$ (aq) + 2Fe$^{3+}$ (aq) → 2Fe$^{2+}$ (aq) + Sn$^{4+}$ (aq)

A) -0.46  B) +1.39  C) +1.21  D) +0.617  E) +0.46

Page Ref: Sec. 20.4

18) The standard cell potential (E<sub>cell</sub>) for the voltaic cell based on the reaction below is _______ V.

2Cr (s) + 3Fe$^{2+}$ (aq) → 3Fe (s) + 2Cr$^{3+}$ (aq)

A) +3.10  B) -0.16  C) +0.30  D) +2.80  E) +0.83

Page Ref: Sec. 20.4

19) Which of the following reactions will occur spontaneously as written?

A) Sr$^{2+}$ (aq) + Fe$^{3+}$ (aq) → Sn$^{2+}$ (aq) + Fe$^{2+}$ (aq)
B) 3Fe$^{2+}$ (aq) → Fe (s) + 2Fe$^{3+}$ (aq)
C) 3Sn$^{4+}$ (aq) + 2Cr (s) → 2Cr$^{3+}$ (aq) + 3Sn$^{2+}$ (aq)
D) Sn$^{4+}$ (aq) + Fe$^{2+}$ (aq) → Sn$^{2+}$ (aq) + Fe (s)
E) 3Fe (s) + 2Cr$^{3+}$ (aq) → 2Cr (s) + 3Fe$^{2+}$ (aq)

Page Ref: Sec. 20.5

20) What is the anode in an alkaline battery?

A) Zn powder  B) Pt  C) KOH  D) Mn$_2$O$_3$  E) MnO$_2$

Page Ref: Sec. 20.7

21) The lead-containing reactant(s) consumed during recharging of a lead-acid battery is/are ________.

A) PbSO$_4$ (s) only
B) Pb (s) only
C) PbO$_2$ (s) only
D) both PbO$_2$ (s) and PbSO$_4$ (s)
E) both Pb (s) and PbO$_2$ (s)

Page Ref: Sec. 20.7
22) In a lead-acid battery, the electrodes are consumed. In this battery,
   A) the anode is PbO2.
   B) the cathode is PbSO4.
   C) the cathode is Pb.
   D) the anode is PbSO4.
   E) the anode is Pb.

23) Galvanized iron is iron coated with

24) Cathodic protection of a metal pipe against corrosion usually entails:
   A) attaching a dry cell to reduce any metal ions which might be formed.
   B) coating the pipe with a fluoropolymer to act as a source of fluoride ion (since the latter is so hard to oxidize).
   C) coating the pipe with another metal whose standard reduction potential is less negative than that of the pipe.
   D) attaching an active metal to make the pipe the cathode in an electrochemical cell.
   E) attaching an active metal to make the pipe the anode in an electrochemical cell.

25) Corrosion of iron is retarded by
   A) high pH conditions
   B) low pH conditions
   C) the presence of salts
   D) both the presence of salts and high pH conditions
   E) both the presence of salts and low pH conditions

26) One of the differences between a voltaic cell and an electrolytic cell is that in an electrolytic cell
   A) a nonspontaneous reaction is forced to occur
   B) an electric current is produced by a chemical reaction
   C) electrons flow toward the anode
   D) O₂ gas is produced at the cathode
   E) oxidation occurs at the cathode
22) In a lead-acid battery, the electrodes are consumed. In this battery,
   A) the anode is PbO₂.
   B) the cathode is PbSO₄.
   C) the cathode is Pb.
   D) the anode is PbSO₄.
   E) the anode is Pb.
   Page Ref: Sec. 20.7
   Topic: 

23) Galvanized iron is iron coated with
   A) magnesium.
   B) iron oxide.
   C) zinc.
   D) chromium.
   E) phosphate.
   Page Ref: Sec. 20.8
   Topic: 

24) Cathodic protection of a metal pipe against corrosion usually entails
   A) attaching a dry cell to reduce any metal ions which might be formed.
   B) coating the pipe with a fluoropolymer to act as a source of fluoride ion (since the latter is so hard to
       oxidize).
   C) coating the pipe with another metal whose standard reduction potential is less negative than that of
       the pipe.
   D) attaching an active metal to make the pipe the cathode in an electrochemical cell.
   E) attaching an active metal to make the pipe the anode in an electrochemical cell.
   Page Ref: Sec. 20.8
   Topic: 

25) Corrosion of iron is retarded by ________.
   A) high pH conditions
   B) low pH conditions
   C) the presence of salts
   D) both the presence of salts and high pH conditions
   E) both the presence of salts and low pH conditions
   Page Ref: Sec. 20.8
   Topic: 

26) One of the differences between a voltaic cell and an electrolytic cell is that in an electrolytic cell
   ________.
   A) a nonspontaneous reaction is forced to occur
   B) an electric current is produced by a chemical reaction
   C) electrons flow toward the anode
   D) O₂ gas is produced at the cathode
   E) oxidation occurs at the cathode
   Page Ref: Sec. 20.9
   Topic: 

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