Electrochemistry review

____ 1. When a substance undergoes oxidation, it always

a. loses electrons.
b. decreases its oxidation number
c. becomes positively charged
d. attains a zero charge

Use the following equation to answer this question.

$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 3\ Sn^{2+}(aq) \rightarrow 3\ Sn^{4+}(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$

____ 2. The species reduced in this reaction is

a. $Cr_2O_7^{2-}(aq)$
b. $Cr^{3+}(aq)$
c. $Sn^{2+}(aq)$
d. $Sn^{4+}(aq)$

____ 3. For the reaction,

$2\ Sn^{2+}(aq) \rightarrow Sn(s) + Sn^{4+}(aq)$
a correct statement is that the

a. reaction is spontaneous.
b. reaction involves a decrease in potential energy.
c. $Sn^{2+}(aq)$ is both the oxidizing and reducing agent.
d. Sn(s) is the oxidizing agent in this nonspontaneous reaction.

____ 4. A solution of acidified potassium permanganate is stored in an iron container. The net ionic equation for a reaction that occurs is

a. $MnO_4^-(aq) + 8\ H^+(aq) + 5\ K(s) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + 5\ K^+(aq)$
b. $2\ MnO_4^-(aq) + 16\ H^+(aq) + 5\ Fe(s) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 5\ Fe^{2+}(aq)$
c. $MnO_4^-(aq) + 8\ H^+(aq) + Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + Fe^{3+}(aq)$
d. $MnO_4^-(aq) + 8\ H^+(aq) + Fe(s) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + Fe^{2+}(aq)$

____ 5. In the compound $Sb_4O_6(s)$, antimony has an oxidation state of

a. 0
b. +3
c. +4
d. +6

____ 6. In the methane-oxygen fuel cell reaction

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g) \quad E°_{net} = +1.05\ V$

oxidation numbers show that

a. oxygen atoms lose electrons.
b. hydrogen atoms gain electrons.
c. $O_2(g)$ is the reducing agent.
d. carbon atoms lose electrons.

Use the following information to answer the next question.

Statement	Explanation
$F_2(g)$ is a strong reducing agent.	$F_2(g)$ has strong attraction for electrons.

____ 7. Based on this information, one should determine that

a. both the statement and the explanation are true, and that the explantion is correct for the statement.
b. both the statement and the explanation are true, but the explanation is not correct for the statement.
c. the statement is true, but the explanation is false.
d. the statement is false, but the explanation is true.

____ 8. The spontaneous reaction will occur when ___*i*____ is mixed with ___*ii*___.

	i	*ii*
A.	$Fe^{2+}(aq)$	$Pb^{2+}(aq)$
B.	$Cr^{2+}(aq)$	$Sn^{2+}(aq)$
C.	$Sn^{2+}(aq)$	$I_2(s)$
D.	$Na^{+}(aq)$	$Pb(s)$

Use the following chemical equations to answer the next question.

I. $H_2O(l) + H_2SeO_3(aq) \rightarrow SeO_4^{2-}(aq) + 4\ H^+(aq) + 2\ e^-$
II. $2\ H^+(aq) + N_2O(g) + 2\ e^- \rightarrow N_2(g) + H_2O(l)$
III. $H_2(g) + N_2O(g) + 2e^- \rightarrow N_2(g) + H_2O(l)$
IV. $H_2SeO_3(aq) + 4\ H^+(aq) + 2\ O_2(g) + 6\ e^- \rightarrow\ SeO_4^{2-}(aq) + 3\ H_2O(l)$

____ 9. The two chemical equations for the half-reactions that would occur in the net redox reaction $N_2O(g) + H_2SeO_3(aq) \rightarrow N_2(g) + SeO_4^{2-}(aq) + 2\ H^+(aq)$ are

a. I and II
b. I and III
c. II and III
d. II and IV

____ 10. An oxidation-reduction reaction that occurs in the human body is

a. $H_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l)$
b. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$
c. $C_{12}H_{22}O_{11}(s) + 12\ O_2(g) \rightarrow 12\ CO_2(g) + 11\ H_2O(g)$
d. $C_6H_{12}O_6(aq) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l)$

____ 11. In balancing redox reactions, the coefficients assigned to the oxidizing agents and reducing agents make the equation consistent with which of the following statements?

a. Electron gain equals electron loss.
b. Moles of reactants equal moles of products.
c. Energy change of products equals energy change of reactants.
d. Number of reactant molecules equals number of product molecules.

Use the following information to answer the next _ questions.

An iron ore sample was crushed and teated in order to convert all the iron to $Fe^{2+}(aq)$. This solution was then titrated with $KMnO_4(aq)$. The **unbalanced** redox equation for this reaction is

__$MnO_4^{2-}(aq)$ + __$H^+(aq)$ + __$Fe^{2+}(aq)$ → __$Mn^{2+}(aq)$ + __$H_2O(l)$ + __ $Fe^{3+}(aq)$

____ 12. The lowest whole number coefficients for the reactants in the balanced equation, in the order given, are

a. 1, 8, 1
b. 1, 8, 5
c. 2, 16, 5
d. 5, 16, 2

____ 13. The titration required 55.0 mL of 0.100 mol/L $KMnO_4(aq)$ to react completely with the $Fe^{2+}(aq)$. The mass of iron in the ore sample was

a. 0.123 g
b. 0.307 g
c. 0.768 g
d. 1.54 g

____ 14. During the titration,

a. the pH increases.
b. $Fe^{2+}(aq)$ gains electrons.
c. $Fe^{2+}(aq)$ acts as an oxidizing agent.
d. the acidified $MnO_4^-(aq)$ acts as a reducing agent.

____ 15. An equation that represents a redox reaction is

a. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$
b. $AgNO_3(aq) + KI(aq) \rightarrow AgI(s) + KNO_3(aq)$
c. $Mg(OH)_2(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + 2\ H_2O(l)$
d. $Cu(s) + 4\ HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ NO_2(g) + 2\ H_2O(l)$

____ 16. A spontaneous reaction would occur between 1.0 mol/L $Fe^{3+}(aq)$ solution and

a. $I_2(s)$
b. $Zn(s)$
c. $Hg(l)$
d. 1.0 mol/L $Fe^{2+}(aq)$

Use the following information to answer the next question.

Metals E(s), Q(s), R(s), and P(s) react with metallic ions to produce the following results:

$$Q^{2+}(aq) + 2\,R(s) \rightarrow Q(s) + 2\,R^{+}(aq)$$
$$Q^{2+}(aq) + E(s) \rightarrow \text{no reaction}$$
$$2\,P^{+}(aq) + E(s) \rightarrow 2\,P(s) + E^{2+}(aq)$$

____ 17. The strongest oxidizing agent is

a. $R^{+}(aq)$
b. $Q^{2+}(aq)$
c. $E^{2+}(aq)$
d. $P^{+}(aq)$

Use the following information to answer the next _ questions.

A student titrated samples of sulfurous acid with a potassium permanganate solution. He obtained the following results:

Table 1. Volumes of 0.0310 mol/L $KMnO_4(aq)$ required to completely react with 100.0 mL samples of sulfurous acid.

Trial	1	2	3	4
Final buret reading (mL)	9.50	18.15	26.75	34.75
Initial buret reading (mL)	1.00	9.50	18.15	26.75
Final colour of mixture	pink	pink	pink	colorless

____ 18. The balanced net ionic equation for the titration is

a. $2\,MnO_4^{-}(aq) + 5\,H_2SO_3(aq) + 6\,H^{+}(aq) \rightarrow 2\,Mn^{2+}(aq) + 5\,SO_4^{2-}(aq) + 3\,H_2O(l)$
b. $2\,MnO_4^{-}(aq) + 5\,H_2SO_3(aq) \rightarrow 2\,Mn^{2+}(aq) + 5\,SO_4^{2-}(aq) + 4\,H^{+}(aq) + 3\,H_2O(l)$
c. $2\,MnO_4^{-}(aq) + 5\,H_2SO_3(aq) + 16\,H^{+}(aq) \rightarrow 2\,Mn^{2+}(aq) + 5\,SO_4^{2-}(aq) + 20\,H^{+}(aq) + 3\,H_2O(l)$
d. $2\,MnO_4^{-}(aq) + 5\,SO_4^{2-}(aq) + 36\,H^{+}(aq) \rightarrow 2\,Mn^{2+}(aq) + 5\,H_2SO_3(aq) + 13\,H_2O(l)$

____ 19. The oxidation numbers for the metals in the oxides of $TiO_2(s)$, $MoO_3(s)$, $W_4O_{12}(s)$, and $W_2O_5(s)$ are, respectively,

a. 4, 6, 24, and 10
b. 2, 3, 3, and $\frac{5}{2}$
c. 4, 6, 6, and 5
d. 2, 3, 24, and $\frac{5}{2}$

____ 20. In the reaction

$$4\,Zn(s) + 10\,H^{+}(aq) + NO_3^{-}(aq) \rightarrow NH_4^{+}(aq) + 4\,Zn^{2+}(aq) + 3\,H_2O(l)$$

the reducing agent is

a. Zn(s)
b. $H^{+}(aq)$
c. $Zn^{2+}(aq)$
d. $NO_3^{-}(aq)$

Use the following information to answer the next question.

A student observed the reactions between four different metals and the solutions of their ions, and recorded these "spontaneous" reactions.

I. $W(s) + X^+(aq) \rightarrow W^+(aq) + X(s)$
II. $X(s) + Y^+(aq) \rightarrow X^+(aq) + Y(s)$
III. $Y(s) + Z^+(aq) \rightarrow Y^+(aq) + Z(s)$
IV. $Z(aq) + W^+(aq) \rightarrow Z^+(aq) + W(s)$
V. $X(s) + Z^+(aq) \rightarrow X^+(aq) + Z(s)$

____ 21. If equation I is correct, which equation did the student record incorrectly?

a. II
b. III
c. IV
d. V

Use the following reactions to answer the next question.

$Ir(s) + Tl^+(aq) \rightarrow$ no reaction
$Ir^{3+}(aq) + Re(s) \rightarrow$ no reaction
$3\ Tl^+(aq) + Y(s) \rightarrow 3\ Tl(s) + Y^{3+}(aq)$

___ 22. In these reactions, the strongest oxidizing agent is

a. $Tl^+(aq)$
b. $Y^{3+}(aq)$
c. $Ir^{3+}(aq)$
d. $Re^{3+}(aq)$

____ 23. The compound that has an oxidation number for iodine that differs from that of the other three compounds is

a. $H_4I_2O_9$
b. H_5IO_6
c. HIO_4
d. HIO_3

Use the following information to answer the next question.

Four reducing agents listed in order of decreasing strength are W, Z, Y, and X. Four statements about the reaction between the reducing agents and their respective oxidizing agents are:

I. $W(s) + X^{2+}(aq) \rightarrow W^{2+}(aq) + X(s)$
II. $Y(s) + X^{2+}(aq) \rightarrow Y^{2+}(aq) + X(s)$
III. $W(s) + Z^{2+}(aq) \rightarrow$ no reaction
IV. $Y(s) + Z^{2+}(aq) \rightarrow Y^{2+}(aq) + Z(s)$

____ 24. The statement(s) inconsistent with the correct order of reducing agents is(are)

a. IV only
b. III only
c. I and II
d. III and IV

____ 25. A redox reaction in which carbon is reduced is

a. $6\ H_2O(l) + 6\ CO_2(g) \rightarrow C_6H_{12}O_6(aq) + 6\ O_2(g)$
b. $HCO_3^-(aq) + H_3O^+(aq) \rightarrow H_2CO_3(aq) + H_2O(l)$
c. $CH_4(aq) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$
d. $C_6H_{12}O_6(aq) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l)$

____ 26. An example of a disproportionation reaction is

a. $2\ NH_3(aq) + NaOCl(aq) \rightarrow N_2H_4(aq) + NaCl(aq) + H_2O(l)$
b. $Cl_2(aq) + H_2O(l) \rightarrow HOCl(aq) + H^+(aq) + Cl^-(aq)$
c. $2\ F_2(g) + O_2(g) \rightarrow 2\ OF_2(g)$
d. $2\ Na(s) + I_2(s) \rightarrow 2\ NaI(s)$

____ 27. Iodine solutions, which contain a suspension of $I_2(s)$, have a brown colour. Which of the following metals will **not** cause an iodine solution to change colour?

a. Ni(s)
b. Cu(s)
c. Ag(s)
d. Mg(s)

Use the following information to answer the next question.

A sample of $Na_2S_2O_3(aq)$ is titrated with acidified $KMnO_4(aq)$ to a pink endpoint. One product of this redox reaction is $SO_4^{2-}(aq)$.

____ 28. A product of the reduction half-reaction is

a. $H^+(aq)$
b. $Mn^{2+}(aq)$
c. $SO_4^{2-}(aq)$
d. $S_2O_3^{2-}(aq)$

Use the following information to answer the next question.

The reactions below involve hypothetical metals and metallic ions.

Reaction	Observation
$Z^{3+}(aq) + X(s)$	no evidence of reaction
$X^{2+}(aq) + D(s)$	evidence of reaction
$D^+(aq) + A(s)$	evidence of reaction
$Z^{3+}(aq) + D(s)$	no evidence of reaction
$A^{2+}(aq) + Z(s)$	no evidence of reaction

____ 29. The order of oxidizing agents, from strongest to weakest, is

a. $X^{2+}(aq), Z^{3+}(aq), A^{2+}(aq), D^+(aq)$
b. $A^{2+}(aq), Z^{3+}(aq), D^+(aq), X^{2+}(aq)$
c. $Z^{3+}(aq), X^{2+}(aq), A^{2+}(aq), D^+(aq)$
d. $X^{2+}(aq), D^+(aq), Z^{3+}(aq), A^{2+}(aq)$

Use the following information to answer the next _ questions.

Titration of 20.0 mL Samples of Acidified $H_2O_2(l)$ with 0.15 mL $KMnO_4(aq)$				
Trial	**I**	**II**	**III**	**IV**
Final Buret volume (mL)	18.3	34.6	17.4	33.8
Initial Buret volume (mL)	0.4	18.3	0.9	17.4
Colour at endpoint	purple	pink	pink	pink

____ 30. The balanced equation for the titration is

a. $2\ MnO_4^-(aq) + 16\ H^+(aq) + 5\ H_2O_2(l) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 5\ O_2(g)$
b. $2\ MnO_4^-(aq) + 6\ H^+(aq) + 5\ H_2O_2(l) \rightarrow 2\ Mn^{2+}(aq) + 4\ H_2O(l) + O_2(g)$
c. $2\ MnO_4^-(aq) + 6\ H^+(aq) + 5\ H_2O_2(l) \rightarrow 2\ Mn^{2+}(aq) + 3\ H_2O(l) + 5\ O_2(g)$
d. $2\ MnO_4^-(aq) + 6\ H^+(aq) + 5\ H_2O_2(l) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 5\ O_2(g)$

Use the following information to answer the next question.

Ethanol reacts with acidified permanganate ion, as represented by the equation

$$5\ C_2H_5OH(l) + 4\ MnO_4^-(aq) + 12\ H^+(aq) \rightarrow 5\ CH_3COOH(aq) + 4\ Mn^{2+}(a) + 11\ H_2O(l)$$

____ 31. In this reaction, the oxidation number for the oxidizing agent changes from

a. +7 to +2
b. +28 to +8
c. +2 to 0
d. +10 to 0

Use the following information to answer the next _ questions.

In order to "hide" gold during the Second World War, Nobel Prize winner Neils Bohr "dissolved" the gold, stored it in a solution, and recovered it at the end of the war. One way to "dissolve" gold is to react it with *Aqua-Regia*, a mixture of nitric and hydrochloric acids. The **unbalanced** equation for this reaction is

$$Au(s) + HNO_3(aq) + HCl(aq) \rightarrow HAuCl_4(aq) + H_2O(l) + NO_2(g)$$

____ 32. The atom that undergoes reduction in this reaction is

a. Au
b. H
c. N
d. Cl

____ 33. When this equation is balanced using lowest whole number coefficients, the coefficient for nitric acid is

a. 2
b. 3
c. 4
d. 5

Use the following information to answer the next question.

Over 100 years ago, Gustave Eiffel designed the support structure for the Statue of Liberty. An iron framework was constructed and overlaid with copper sheets in such a way that the copper did not come into direct contact with the iron.

____ 34. The Statue of Liberty's blue-green colour, which has developed over time, can be attributed to the

a. oxidation of solid iron into iron(II) ions
b. oxidation of solid copper into copper(II) ions
c. reduction of solid iron and solid copper into cations
d. reduction of oxygen gas and liquid water into hydroxide ions

____ 35. The Statue of Liberty's blue-green colour, which has developed over time, can be attributed to the

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d. reduction of oxygen gas and liquid water into hydroxide ions

____ 36. A student was given three metal strips and was asked to identify each strip as lead, iron, or magnesium. The student labelled the strips X, Y, and Z and tested each strip in a $Zn(NO_3)_2(aq)$ solution and a $Ni(NO_3)_2(aq)$ solution. The student's observations are shown below.

Evidence of Reaction

	$Zn(NO_3)_2(aq)$	**$Ni(NO_3)_2(aq)$**
X	no reaction	black precipitate
Y	black precipitate	black precipitate
Z	no reaction	no reaction

The metals X, Y, and Z are, respectively,

a. lead, iron, and magnesium
b. lead, magnesium, and iron
c. iron, lead, and magnesium
d. iron, magnesium, and lead

Use the following information to answer the next _ questions.

Photochromic glass can be made by trapping silver chloride crystals and copper(I) ions in a glass matrix as the glass solidifies. When this type of glass is exposed to sunlight, the silver ions are converted into silver atoms, which cause the glass to darken. The two steps that occur in this chemical reaction are represented below.

light

Step I $Ag^{+} + Cl^{-} \leftrightarrow Ag + Cl$

Step II $Cl + Cu^{+} \leftrightarrow Cu^{2+} + Cl^{-}$

The reaction in the second step prevents the chlorine atoms from escaping from the glass.

____ 37. In step II, the Cu^{+} ion acts as the

a. reducing agent and loses one electron
b. oxidizing agent and gains one electron
c. reducing agent and decreases in oxidation number
d. oxidizing agent and increases in oxidation number

____ 38. The half-reaction that causes the darkening of the glass is represented by the equation

a. $Ag^{+} + e^{-} \rightarrow Ag$
b. $Ag \rightarrow Ag^{+} + e^{-}$
c. $Cl^{-} \rightarrow Cl + e^{-}$
d. $Cl + e^{-} \rightarrow Cl^{-}$

Use the following information to answer the next _ questions.

To determine the concentration of $Sn^{2+}(aq)$ solution, a student titrated a 50.00 mL sample of acidified $Sn^{2+}(aq)$ with 1.44 mmol/L $KMnO_4(aq)$. The titration required 24.83 mL of $KMnO_4(aq)$ in order to reach a pale pink endpoint.

____ 39. The balanced net ionic equation for this titration is

a. $2\ MnO_4^{-}(aq) + 16\ H^{+}(aq) + 5\ Sn^{2+}(aq) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 5\ Sn^{4+}(aq)$
b. $2\ MnO_4^{-}(aq) + 16\ H^{+}(aq) + 5\ Sn^{2+}(aq) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 5\ Sn(s)$
c. $MnO_4^{-}(aq) + 8\ H^{+}(aq) + Sn^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + Sn^{4+}(aq)$
d. $MnO_4^{-}(aq) + 8\ H^{+}(aq) + Sn^{2+}(aq) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + Sn(s)$

Use the following information to answer the next _ questions.

The beautiful patterns of butterfly wings, the stripes on zebra pelts and the myriad of colours of tropical fish all result from oscillating chemical reactions. These chemical reactions can be studied in a much simpler form in the laboratory. In 1958, the Russian chemist B.P. Belousoz discovered a complete reaction sequence in which the concentration of reactants and products oscillated over time.

Unbalanced Reaction Equations

I $\_\_H^+(aq) + \_\_BrO_2^-(aq) + \_\_\ BrO_3^-(aq) \leftrightarrow \_\_BrO_2(aq) + \_\_H_2O(l)$

II $\_\_Ce^{3+}(aq) + \_\_BrO_2(aq) \leftrightarrow \_\_\ Ce^{4+}(aq) + \_\_BrO_2^-(aq)$

III $\_\_BrO_2^-(aq) \leftrightarrow \_\_BrO_3^-(aq) + \_\_BrO^-(aq)$

____ 40. In reaction II, the $BrO_2^-(aq)$ underdoes

a. oxidation and gains one electron.
b. oxidaiton and loses one electron.
c. reduction and gains one electron.
d. reduction and loses one electron.

____ 41. In reaction III, the bromine in $BrO_2^-(aq)$

a. undergoes oxidation only
b. undergoes reduction only
c. both loses and gains protons
d. both loses and gains electrons

Use the following information to answer the next question.

Common household bleach is an aqueous solution that contains approximately 5% sodium hypochlorite. The equilibrium involved in the production of bleach from chlorine can be represented by the reaction equation

$$Cl_2(g) + 2\ OH^-(aq) \leftrightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$$

____ 42. In the production of bleach, the reduction half-reaction is

a. $Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$
b. $2\ Cl^-(aq) \rightarrow Cl_2(g) + 2\ e^-$
c. $4\ OH^-(aq) \rightarrow O_2(g) + 2\ H_2O(l) + 4\ e^-$
d. $ClO^-(aq) + H_2O(l) + 2\ e^- \rightarrow Cl^-(aq) + 2\ OH^-(aq)$

____ 43. A student has one coin made of copper and one coin made of nickel. Which of the following solutions could the student use to demonstrate which of these metals is the stronger reducing agent?

a. $Hg^{2+}(aq)$
b. $Fe^{3+}(aq)$
c. $Fe^{2+}(aq)$
d. $Sn^{4+}(aq)$

Use the following information to answer the next _ questions.

Poisonous oxalic acid is found in non-toxic concentrations in vegetables such as spinach and rhubarb. Manufacturers of spinach juice are required to analyze the concentrations of oxalic acid to avoid problems that could arise from unexpectedly high concentrations of oxalic acid. The reaction of oxalic acid with acidified potassium permanganate can be represented by the following equation.
$5\ HOOCCOOH(aq) + 2\ MnO_4^-(aq) + 6\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 10\ CO_2(g)$

____ 44. If 15.0 mL of oxalic acid solution is completely reacted with 20.0 mL of 0.0015 mol/L acidified permanganate solution, then the oxalic acid concentration will be

a. 8.0×10^{-4} mol/L
b. 2.4×10^{-3} mol/L
c. 5.0×10^{-3} mol/L
d. 6.0×10^{-3} mol/L

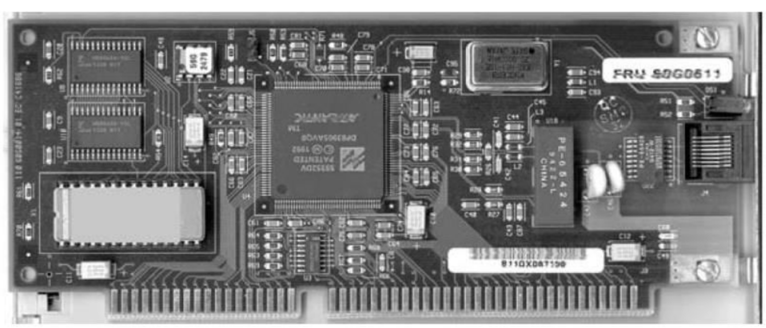
____ 45. A technician reacting oxalic acid with acidified potassium permanganate is **not** likely to observe

a. an increase in electrical conductivity
b. a visible colour change
c. a slight increase in pH
d. the formation of a gas

____ 46. Acidic permanganate solutions and acidic dichromate solutions are often used in redox titrations because they are strong
a. reducing agents that change colour when they are reduced.
b. reducing agents that change colour when they are oxidized.
c. oxidizing agents that change colour when they are reduced.
d. oxidizing agents that change colour when they are oxidized.

Use the following information to answer the next _ questions.

Electronic circuit boards can be made by etching a copper board that is coated with plastic on one side. A special masking tape is applied to the surface of the copper board in the shape of the desired circuit pattern. The circuit board is then etched by reacting it with $FeCl_3(aq)$ to remove the unwanted copper.



____ 47. The net equation for the spontaneous reaction that occurs when the circuit board is immersed in the $FeCl_3(aq)$ is

a. $Fe^{2+}(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + Fe(s)$
b. $Cu^+(aq) + Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + Cu(s)$

c. $2\ Fe^{3+}(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + 2\ Fe^{2+}(aq)$
d. $2\ Fe^{3+}(aq) + 3\ Cu(s) \rightarrow 3\ Cu^{+}(aq) + 2\ Fe(s)$

____ 48. In this reaction, the copper acts as the

a. oxidizing agent and is oxidized.
b. oxidizing agent and is reduced.
c. reducing agent and is oxidized.
d. reducing agent and is reduced.

____ 49. Which of the following statements and corresponding net voltages are correct for this reaction?

a. It is a spontaneous reaction with a $E°_{net} = +0.43$ V.
b. It is a spontaneous reaction with a $E°_{net} = +1.11$ V.
c. A power supply is required because the $E°_{net} = -0.43$ V.
d. A power supply is required because the $E°_{net} = -1.11$ V.

Use the following information to answer the next _ questions.

At one time, an aqueous solution of formaldehyde called formalin($CH_2O(aq)$) was used as a disinfectant and as a tissue preservative. Today, formalin is commonly used in the industrial preparation of plastics and resins.
Formalin can be produced by reacting methanol with acidified potassium dichromate, as represented by the following **unbalanced** equation.

__$CH_3OH(l)$ + __$Cr_2O_7^{2-}(aq)$ __$H^+(aq) \rightarrow$__ $CH_2O(aq)$ + __$Cr^{3+}(aq)$ + __$H_2O(l)$

____ 50. When the above equation is balanced, the equation is
a. $CH_3OH(l) + Cr_2O_7^{2-}(aq) + 14\ H^+(aq) \rightarrow CH_2O(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$
b. $3\ CH_3OH(l) + Cr_2O_7^{2-}(aq) + 14\ H^+(aq) \rightarrow 3\ CH_2O(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$
c. $3\ CH_3OH(l) + Cr_2O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ CH_2O(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$
d. $3\ CH_3OH(l) + Cr_2O_7^{2-}(aq) + 8\ H^+(aq) \rightarrow 3\ CH_2O(aq) + 2\ Cr^{3+}(aq) + 8\ H_2O(l)$

Use the following information to answer the next question.

A sample of $Na_2S_2O_3(aq)$ is titrated with acidified $KMnO_4(aq)$ to a pink endpoint. One product of this redox reaction in $SO_4^{2-}(aq)$.

____ 51. A product of the half-reaction is
a. $H^+(aq)$
b. $Mn^{2+}(aq)$
c. $SO_4^{2-}(aq)$
d. $S_2O_3^{2-}(aq)$

____ 52. A student used an acidified 6.31×10^{-2} mol/L $KMnO_4(aq)$ solution to titrate 25.0 mL samples of $Fe^{2+}(aq)$ solution of unknown concentration. In the reactions, the $Fe^{2+}(aq)$ ion was oxidized to the $Fe^{3+}(aq)$ ion. The student completed five trials and summarized the data in a table.

Trial Number	**1**	**2**	**3**	**4**	**5**
Final Buret Reading (mL)	17.55	35.65	26.40	42.65	16.85
Initial Buret Reading (mL)	0.30	17.55	10.05	26.40	0.55
Final Colour	purple	purple	pink	pink	pink

According to the student's data, the concentration of $Fe^{2+}(aq)$ is

a. 0.206 mol/L

b. 0.218 mol/L
c. 0.213 mol/L
d. 0.223 mol/L

Use the following information to answer the next question.

Kawneer, a company in Lethbridge, processes aluminium “logs” for commercial use. The first step in the process involves removing the natural aluminium oxide coating from the logs.

____ 53. Once the protective coating has been removed, the Al(s) surface undergoes a redox reaction with $H_2O(l)$. In this reaction,

a. $H_2(g)$ is evolved and the solution becomes basic
b. $O_2(g)$ is evolved and the solution becomes basic
c. $H_2(g)$ is evolved and the solution becomes acidic
d. $O_2(g)$ is evolved and the solution becomes acidic

Use the following information to answer the next question.

$$U^{3+}(aq) + La(s) \rightarrow La^{3+}(aq) + U(s)$$
$$Y^{3+}(aq) + U(s) \rightarrow \text{no reaction}$$
$$Y^{3+}(aq) + La(s) \rightarrow La^{3+}(aq) + Y(s)$$

____ 54. The oxidizing agents above, listed from strongest to weakest, are

a. $U^{3+}(aq)$, $La^{3+}(aq)$, $Y^{3+}(aq)$
b. $U^{3+}(aq)$, $Y^{3+}(aq)$, $La^{3+}(aq)$
c. $Y^{3+}(aq)$, $U^{3+}(aq)$, $La^{3+}(aq)$
d. U(s), Y(s), La(s)

Use the following information to answer the next question.

Standard Reduction Potentials

$VO_2^{+}(aq) + 2\ H^+(aq) + e^- \rightarrow VO^{2+}(aq) + H_2O(l)$	E° = +0.999 V
$VO^{2+}(aq) + 2\ H^+(aq) + e^- \rightarrow V^{3+}(aq) + H_2O(l)$	E° = +0.340 V
$VO_2^{+}(aq) + 4\ H^+(aq) + 5\ e^- \rightarrow V(s) + 2\ H_2O(l)$	E° = −0.250 V
$V^{3+}(aq) + e \rightarrow V^{2+}(aq)$	E° = −0.255 V

____ 55. Which of the following substances is the strongest reducing agent?

a. $V^{2+}(aq)$
b. $V^{3+}(aq)$
c. $VO_2^{+}(aq)$
d. $VO^{2+}(aq)$

____ 56. In the balanced redox reaction equation
$3\ Cu(s) + 2\ NO_3^-(aq) + 8\ H^+(aq) \rightarrow 3\ Cu^{2+}(aq) + 2\ NO(g) + 4\ H_2O(l)$
the oxidation number of nitrogen

a. decreases by 3
b. increases by 3
c. increases by 2
d. decreases by 6

____ 57. In a reaction, $Sn^{2+}(aq)$

a. will undergo oxidation when combined with $Pb(NO_3)_2(aq)$
b. acts as a reducing agent when combined with Ni(s)
c. always acts as an oxidizing agent
d. acts as an oxidizing agent when combined with Cd(s)

____ 58. A redox reaction occurs when an iron nail is placed in a solution of copper(II) sulfate. Elemental copper begins to form, and the colour of the solution changes. In this reaction, the reducing agent is

a. Fe(s)
b. Cu(s)
c. $Fe^{2+}(aq)$
d. $Cu^{2+}(aq)$

Use the following information to answer the next question.

> To prevent it from contaminating the air, chlorine gas can be reacted as represented by the **unbalanced** equation
>
> $$Cl_2(g) + S_2O_3^{2-}(aq) + H_2O(l) \rightarrow SO_{42-}(aq) + H^+(aq) + Cl^-(aq)$$

____ 59. The balanced oxidation half-reaction for this change is

a. $H_2O(l) + S_2O_3^{2-}(aq) \rightarrow SO_4^{2-}(aq) + 4\ e^- + 2\ H^+(aq)$
b. $Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(aq)$
c. $5\ H_2O(l) + S_2O_3^{2-}(aq) \rightarrow 2\ SO_4^{2-}(aq) + 10\ H^+(aq) + 8\ e^-$
d. $5\ H_2O(l) + S_2O_3^{2-}(aq) + 4\ e^- \rightarrow 2\ SO_4^{2-}(aq) + 10\ H^+(aq)$

Use the following information to answer the next question.

In a laboratory, a student obtained the following results when testing, under standard conditions, reactions between various metals and their corresponding ions.

	Ga(s)	**Fe(s)**	**Zn(s)**	**Mg(s)**		**Key**
Ga^{3+}(aq)	-	🖱	🗏	🗏		
Fe_{2+}(aq)	🗏	-	🗏	🗏	🗏	reaction
Zn^{2+}(aq)	🖱	🖱	-	🗏	🖱	reaction
Mg^{2+}(aq)	🖱	🖱	🖱	-	-	no test performed

____ 60. The reduction potential of the $Ga^{3+}(aq)$ could be

a. - 0.53 V
b. - 1.41 V
c. +1.21 V
d. +1.92 V

Use the following information to answer the next question.

> The following reaction will occur at high temperatures.
>
> $$2\ Na(g) + Cl_2(g) \rightarrow 2\ NaCl(g) + energy$$

____ 61. The half-reaction for the reduction that occurs in this reaction

a. $Na(g) \rightarrow Na^+(g) + e^-$
b. $Na(g) + e^- \rightarrow Na^+(g)$
c. $Cl_2(g) + 2\ e^- \rightarrow 2\ Cl^-(g)$

d. $Cl_2(g) \rightarrow 2\ Cl^-(g) + 2\ e^-$

____ 62. Four metals represented by the symbols R, S, T, and V and their ions combine with each other in the following manner:

$$S^{2+}(aq) + 2\ T(s) \rightarrow 2\ T^+(aq) + S(s)$$
$$R^{3+}(aq) + T(s) \rightarrow \text{No Reaction}$$
$$2\ R^{3+}(aq) + 3\ V(s) \rightarrow 2\ V^{2+}(aq) + 2\ R(s)$$

When the oxidizing agents are arranged from strongest to weakest, the order is

a. $S^{2+}(aq)$, $T^+(aq)$, $R^{3+}(aq)$, $V^{2+}(aq)$
b. $V^{2+}(aq)$, $R^{3+}(aq)$, $T^+(aq)$, $S^{2+}(aq)$
c. V(s), R(s), T(s), S(s)
d. S(s), T(s), R(s), V(s)

____ 63. *In the reaction of sodium metal with water, the reduction half-reaction produces ___i___, which results in a pH ___ii____ than 7.*

The row that best completes the statement above is

	i	*ii*
A.	hydroxide ions	greater
B.	hydroxide ions	less
C.	hydrogen gas	greater
D.	hydrogen gas	less

Use the following information to answer the next _ questions.

A student dipped 12.50 g strips of four different metals, Ag(s), Cu(s), Pb(s), and Mg(s), into a beaker containing 250 mL of 1.00 mol/L HCl(aq) in order to determine an activity series. One of the metals reacted immediately and vigorously with the acid.

____ 64. The balanced net ionic equation for the first reaction that occurred is

a. $2\ Ag(s) + 2\ H^+(aq) \rightarrow H_2(g) + 2\ Ag^+(aq)$
b. $Cu(s) + 2\ H^+(aq) \rightarrow H_2(g) + Cu^{2+}(aq)$
c. $Pb(s) + 2\ H^+(aq) \rightarrow H_2(g) + Pb^{2+}(aq)$
d. $Mg(s) + 2\ H^+(aq) \rightarrow H_2(g) + Mg^{2+}(aq)$

____ 65. The following data were collected during a redox laboratory investigation.

	W(s)	X(s)	Q(s)	Z(s)	**Key**
$W^-(aq)$	▯	▤	▤	▯	▤ evidence of reaction
$X^{2-}(aq)$	▯	▯	▤	▯	▯ no evidence of reaction
$Q^{2-}(aq)$	▯	▯	▯	▯	
$Z^{3-}(aq)$	▤	▤	▤	▯	

In this investigation, the responding variable is the

a. reducing agent
b. oxidizing agent
c. evidence of reaction
d. time required for reaction

____ 66. Which of the following aqueous ions can either gain or lose electrons in a redox reaction?

a. Sn^{2+}(aq)
b. Cl^{-}(aq)
c. Ca^{2+}(aq)
d. S^{2-}(aq)

____ 67. The equation representing a spontaneous reaction at standard conditions is

a. $Co^{2+}(aq) + 2\ Fe^{2+}(aq) \rightarrow Co(s) + 2\ Fe^{3+}(aq)$
b. $Sn^{4+}(aq) + 2\ Br^{-}(aq) \rightarrow Sn^{2+}(aq) + Br_2(l)$
c. $2\ I^{-}(aq) + Cl_2(g) \rightarrow I_2(s) + 2\ Cl^{-}(aq)$
d. $Pb(s) + Fe^{2+}(aq) \rightarrow Pb^{2+}(aq) + Fe(s)$

____ 68. Two reagents that will oxidize Pb(s) to Pb^{2+}(aq) but that will **not** oxidize I^{-}(aq) to I_2(s) are

a. F_2(g) and Fe^{3+}(aq)
b. Fe^{3+}(aq) and Br_2(l)
c. Cd^{2+}(aq) and Ag^{+}(aq)
d. Cu^{2+}(aq) and Sn^{4+}(aq)

____ 69. Bacteria in our mouths and digestive systems convert sodium nitrate and other nitrate salts into nitrites, as indicated by the incomplete and unbalanced half-reaction $NaNO_3(aq) \rightarrow NaNO_2(aq)$. In this half-reaction,

a. the oxidation number for sodium changes from -9 to -7
b. the oxidation number of nitrogen increases
c. the oxidation number of oxygen increases
d. reduction occurs

____ 70. Metals W(s), X(s), Y(s), and Z(s) were placed in solutions of each of their respective ionic salts. The results are summarized in the data table below.

	X^{+}(aq)	Y^{2+}(aq)	Z^{3+}(aq)	W^{+}(aq)	🗎 - evidence of reaction
X(s)	🗄	🗄	🗎	🗎	
Y(s)	🗎	🗄	🗎	🗎	
Z(s)	🗄	🗄	🗄	🗎	🗄 - no evidence of reaction
W(s)	🗄	🗄	🗄	🗄	

According to the results, the strongest reducing agent is

a. Y^{2+}(aq)
b. W(s)
c. Y(s)
d. W^{+}(aq)

Use the following information to answer the next question.

> Owners of an acreage had their well water analyzed by the Alberta Research Centre. The well water was found to contain Cl^{-} (aq), I^{-} (aq), Fe^{2+}(aq), NO_3^{-}(aq), Ni^{2+}(aq), Zn^{2+}(aq), Ca^{2+}(aq), and Na^{+}(aq).

____ 71. To carry water from the well to their home, the owners should choose a metal pipe made of

a. Fe(s)
b. Cu(s)

c. $Cr(s)$
d. $Al(s)$

____ 72. A researcher wants to test aluminium, zinc, chromium, and copper individually for their suitability as a dental filling. Keeping in mind many foods are acidic, which metal would be most suitable to investigate as a filling?

a. aluminium
b. zinc
c. chromium
d. copper

____ 73. Given the reactions

$$2\,X^-(aq) + Y_2(s) \rightarrow X_2(s) + 2\,Y^-(aq)$$
$$2\,Z^-(aq) + Y_2(s) \rightarrow \text{no reaction}$$
$$2\,Z^-(aq) + W_2(s) \rightarrow Z_2(s) + 2\,W^-(aq)$$

another spontaneous reaction would be

a. $Z_2(s) + 2\,X^-(aq) \rightarrow X_2(s) + 2\,Z^-(aq)$
b. $X_2(s) + 2\,Y^-(aq) \rightarrow 2\,X^-(aq) + Y_2(s)$
c. $X_2(s) + 2\,W^-(aq) \rightarrow 2\,X^-(aq) + W_2(s)$
d. $Y_2(s) + 2\,W^-(aq) \rightarrow 2\,Y^-(aq) + W_2(s)$

Use the following information to answer the next _ questions.

A thermite reaction is a highly exothermic process that is used in welding massive objects such as ship propellers and train rails. The reaction can be represented by the equation

$$2\,Al(s) + Fe_2O_3(s) \rightarrow Al_2O_3(s) + Fe(l)$$

____ 74. In this thermite reaction, the substance that undergoes oxidation is

a. iron
b. aluminium
c. iron(III) oxide
d. aluminium oxide

Use the following standard electrode potentials to answer the next question.

Reduction Half-Reaction	**Electrical Potential (V)**
$PbO_2(s) + SO_4^{2-}(aq) + 4\,H^+(aq) + 2\,e^- \rightarrow PbSO_4(s) + 2\,H_2O(l)$	+1.69
$O_2(g) + 2\,H_2O(l) + 4\,e^- \rightarrow 4\,OH^-(aq)$	+0.40
$NiO_2(s) + 2\,H_2O(l) + 2\,e^- \rightarrow Ni(OH)_2(s) + 2\,OH^-(aq)$	- 0.49
$Zn(OH)_4^{2-}(aq) + 2\,e^- \rightarrow Zn(s) + 4\,OH^-(aq)$	- 1.20

____ 75. In the half-reactions above, the strongest oxidizing agent is the

a. $PbO_2(s)$, $SO_4^{2-}(aq)$, and $H^+(aq)$ combination
b. $O_2(g)$ and $H_2O(l)$ combination
c. $Zn(OH)_4^{2-}(aq)$
d. $OH^-(aq)$

Use the following standard electrode potentials to answer the next question.

Reduction Half-Reaction	**Electrical Potential (V)**
$X^{3+}(aq) + 3\ e^- \rightarrow X(s)$	+1.95
$Q(l) + e^- \rightarrow Q^-(aq)$	+0.61
$Y^{2+}(aq) + e^- \rightarrow Y^+(aq)$	+0.02
$M(s) + 3\ e^- \rightarrow M^{3-}(aq)$	- 0.25

____ 76. Which of the following tables identifies, with checkmarks (✓), the spontaneous reactions that would be predicted given the half-reactions shown above?

a.

	$X_{(s)}$	$Q^-_{(aq)}$	$Y^+_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	–	–	–	–
$Q_{(l)}$	✓	–	–	–
$Y^{2+}_{(aq)}$	✓	✓	–	✓
$M_{(s)}$	✓	✓	–	–

b.

	$X_{(s)}$	$Q^-_{(aq)}$	$Y^+_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	–	✓	✓	✓
$Q_{(l)}$	–	–	✓	✓
$Y^{2+}_{(aq)}$	–	–	–	✓
$M_{(s)}$	–	–	–	–

c.

	$X_{(s)}$	$Q^-_{(aq)}$	$Y^+_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	✓	✓	✓	–
$Q_{(l)}$	✓	✓	–	–
$Y^{2+}_{(aq)}$	✓	–	–	–
$M_{(s)}$	–	–	–	–

d.

	$X_{(s)}$	$Q^-_{(aq)}$	$Y^+_{(aq)}$	$M^{3-}_{(aq)}$
$X^{3+}_{(aq)}$	–	✓	✓	✓
$Q_{(l)}$	–	✓	✓	–
$Y^{2+}_{(aq)}$	–	✓	–	–
$M_{(s)}$	–	–	–	–

____ 77. At API Grain Processors in Red Deer, Alberta, tanks used in the fermentation of wheat are sterilized using $ClO_2(aq)$. The balanced half-reaction that represents the change that occurs when $ClO_2(aq)$ changes to $Cl^-(aq)$ in an acidic solution is

a. $2\ ClO_2(aq) + 8\ H^+(aq) \rightarrow 2\ Cl^-(aq) + 4\ H_2O(l) + 6\ e^-$
b. $ClO_2(aq) + 6\ H^+(aq) \rightarrow Cl^-(aq) + 3\ H_2O(l) + 5\ e^-$
c. $ClO_2(aq) + 4\ H^+(aq) + 4\ e^- \rightarrow Cl^-(aq) + 2\ H_2O(l)$
d. $ClO_2(aq) + 4\ H^+(aq) + 5\ e^- \rightarrow Cl^-(aq) + 2\ H_2O(l)$

Use the following information to answer the next question.

Nova Chemicals is a major producer of ethene in Alberta. Ethene is produced by thermally cracking ethane that has been separated from natural gas. The following equation represents the cracking process.

$$C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$$

____ 78. In the cracking process, the oxidation number of

a. carbon changes from -2 to -3
b. carbon changes from -3 to -2
c. hydrogen changes from 0 to +1
d. hydrogen increases and decreases

____ 79. If the reference half-cell was changed to the standard nickel half-cell, the reduction potential of a standard bromine half-cell would be

a. +0.26 V
b. +0.81 V

c. +1.07 V
d. +1.33 V

Use the following information to answer the next question.

An AgO-Cd cell is used in satellite batteries. This cell is very compact and it can supply a great deal of energy. Relevant equations for this cell are

$$2\ AgO(s) + H_2O(l) + 2\ e^- \rightarrow\ Ag_2O(s) + 2\ OH^-(aq) \quad E° = +\ 0.61\ V$$
$$Cd(OH)_2(s) + 2\ e^- \rightarrow\ Cd(s) + 2\ OH^-(aq) \quad E° = -\ 0.81\ V$$

____ 80. The E°net value for this cell is

a. -1.42 V
b. -0.20 V
c. +0.20 V
d. +1.42 V

____ 81. In a functioning electrochemical cell,

a. anions migrate inside the cell from the anode to the cathode.
b. cations migrate inside the cell from the cathode to the anode.
c. electrons move in the external circuit from the anode to the cathode, where reduction occurs.
d. electrons move in the external circuit from the cathode to the anode, where reduction occurs.

____ 82. An electrolytic cell contains 2.00 mol/L $NiCl_2$(aq) and operates at 0.500 A. In order to plate 5.87 g of Ni(s), the cell will have to operate for

a. 1.93×10^4 s
b. 3.86×10^4 s
c. 7.72×10^4 s
d. 1.54×10^5 s

____ 83. The cell capable of recharging a 1.25 V battery is

a. $Ag(s)|Ag^+(aq)||Cu^{2+}(aq)|Cu(s)$
b. $Al(s)|Al^{3+}(aq)||Sn^{2+}(aq)|Sn(s)$
c. $Co(s)|Co^{2+}(aq)||Pb^{2+}(aq)|Pb(s)$
d. $Fe(s)|Fe^{2+}(aq)||Ni^{2+}(aq)|Ni(s)$

Use the following information to answer the next _ questions.

Corrosion of iron causes billions of dollars in damage every year. A reaction that occurs during corrosion is

$$4\ Fe(s) + 3\ O_2(g) + 6\ H_2O(l) \rightarrow 4\ Fe(OH)_3(s) + \text{energy}$$

____ 84. The oxidizing agent in this reaction is

a. Fe(s)
b. O_2(g)
c. H_2O(l)
d. $Fe(OH)_3$(s)

____ 85. One reason that copper pipes rather than iron pipes are used in household plumbing is that

a. iron has a greater tendency to be oxidized than copper.
b. iron will react with dissolved minerals such as calcium salts.
c. copper is a better conductor of heat energy than iron.
d. commercial drain cleaners containing sodium hydroxide will react with iron.

Use the following information to answer the next _ questions.

Galvanizing, a process used to prevent corrosion, involves coating iron metal with a thin layer of zinc metal.

____ 86. Iron nails can be galvanized using an electrolytic process. The nails to be galvanized would be attached to the

a. anode
b. electrode at which anions react
c. electrode at which oxidation occurs
d. electrode at which reduction occurs

____ 87. A galvanized nail was placed in a copper(II) sulfate solution. After a day, the blue colour of the solution disappeared and copper metal was produced. The procedure was repeated with objects made of other metals. Similar results would **not** be predicted for

a. an uncoated iron nail
b. a chromium-plated spoon
c. a nickel-plated coin
d. a gold-plated bracelet

____ 88. In a voltaic cell,

a. chemical energy is converted to electrical energy in a spontaneous change.
b. chemical energy is converted to electrical energy in a non-spontaneous change.
c. electrical energy is converted to chemical energy in a spontaneous change.
d. electrical energy is converted to chemical energy in a non-spontaneous change.

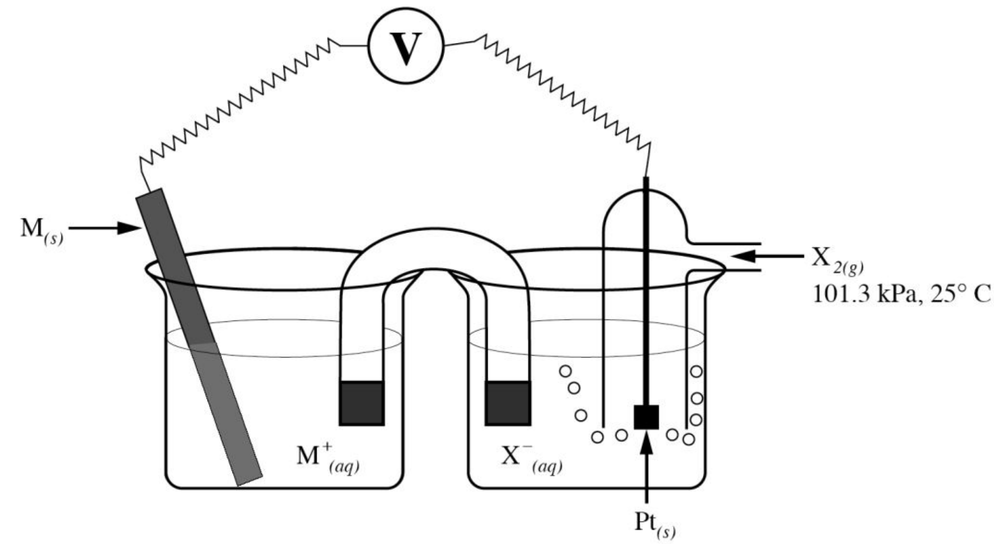
____ 89. One way in which voltaic cells differ from electrolytic cells is that

a. anions migrate to the anode in one but to the cathode in the other.
b. oxidation occurs at the cathode in one but at the anode in the other.
c. voltaic cells have an external circuit but electrolytic cells do not.
d. the cell potential for one is positive but negative for the other.

Use the following information to answer the next _ questions.

A student constructed the following cell and recorded her observations.

Observations:
I. The voltmeter registers 1.32 V.
II. The mass of electrode M decreases.
III. The colur or X^{-}(aq) becomes more intense.
IV. The colour of M^{+}(aq) ion becomes more intense.



____ 90. The oxidation half-reaction for the voltaic cell shown would be

a. $2\ X^{-}(aq) \rightarrow X_2(g) + 2\ e^{-}$
b. $X_2(g) + 2\ e^{-} \rightarrow 2\ X^{-}(aq)$
c. $M(s) \rightarrow M^{+}(aq) + e^{-}$
d. $M^{+}(aq) + e^{-} \rightarrow M(s)$

____ 91. Which of the following observations would **not** identify the oxidizing agent?

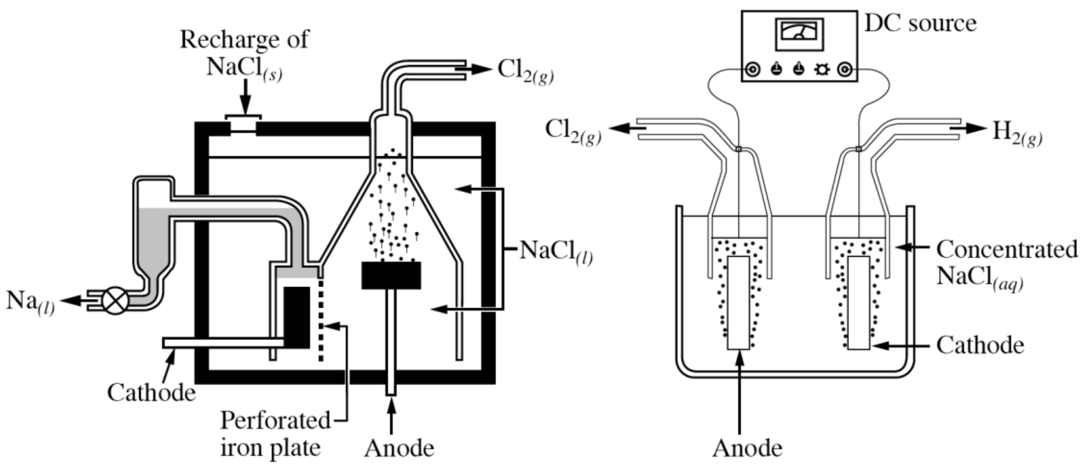
a. Observation I
b. Observation II
c. Observation III
d. Observation IV

____ 92. Electrolytic cells are used commercially in

a. cameras
b. fuel cells
c. flashlights
d. metal plating

Use the following information to answer the next _ questions.

The electrolyis of molten sodium chloride (NaCl(l)) in the Downs Cell and the electrolysis of brine (NaCl(aq)) are two important industrial applications of electrolysis. They produce large quantities of chlorine gas, hydrogen gas, sodium hydroxide, and sodium metal. All of these products have important industrial uses. The design of these cells is illustrated below.



Electrolysis of Molten Sodium Chloride

Electrolysis of Brine

____ 93. In both cells, the design is such that the products of the electrolysis reactions are removed. If the products were not removed, they would

a. react with the original reactants
b. react with the electrodes
c. react spontaneously with each other
d. react with the electrolytes

____ 94. The Downs Cell operates at a high temperature so that the sodium chloride is maintained in the liquid state. The design of this cell suggests that

a. Cl_2(l) is very soluble in NaCl(l)
b. Na(l) is less dense than NaCl(l)
c. Na(l) is soluble in NaCl(l)
d. Na(l) could react spontaneously with NaCl(l)

____ 95. Sodium metal is **not** produced in the electrolysis of brine because

a. Na(s) reacts smpontaneously with H_2O(l)
b. Cl^-(aq) is more readily reduced than Na^+(aq)
c. H_2O(l) is more readily oxidized than Cl^-(aq)
d. H_2O(l) is more readily reduced than Na^+(aq)

____ 96. An electron flow of 12.0 A is used in the electrolysis of molten sodium chloride. The time required to produce 1.00 kg of Na(l) is

a. 2.23 h
b. 48.6 h
c. 97.2 h
d. 194 h

____ 97. The products of the electrolysis of brine can be used to produce HCl(g). A saturated solution of HCl(aq) has a concentration of 12.2 mol/L. What mass of NaCl(s) must be consumed to produce 100 L of this HCl(aq)?

a. 44.5 kg
b. 71.3 kg
c. 89.0 kg
d. 143 kg

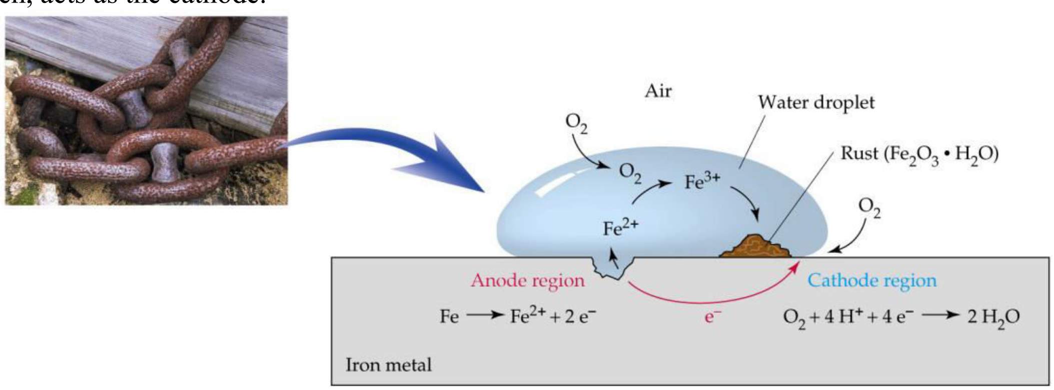
Use the following information to answer the next _ questions.

Corrosion of iron costs the public millions of dollars annually. The corrosion process can be simply represented by two half-reactions:

$$Fe(s) \rightarrow Fe^{2+}(aq) + 2\ e^-$$

$$O_2(g) + 2\ H_2O(l) + 4\ e^- \rightarrow 4\ OH^-(aq)$$

The $Fe(OH)_2(s)$ that forms if futher oxidized by $O_2(g)$ in the presence of water to form rust, a mixture of hydrated oxides that is represented by the general formula $Fe_2O_3 \bullet xH_2O(s)$.
One region on the iron surface acts as the anode, and another region, whre the wet iron is exposed to oxygen, acts as the cathode.



____ 98. Under standard conditions, the net voltage for the oxidation-reduction reaction that results in the formation of $Fe(OH)_2(s)$ is

a. - 0.85 V
b. +0.85 V
c. - 1.30 V
d. +1.30 V

____ 99. Iron is often alloyed with zinc to minimize corrosion. The zinc in the alloy acts as the

a. anode and is oxidized.

b. anode and is reduced.
c. cathode and is oxidized.
d. cathode and is reduced.

____ 100. Salt spread on highways during the winter months increases the rate of rust formation on cars because the salt

a. reacts with the rust to form iron salts.
b. reacts with the iron salts to form iron.
c. increases the conductivity of the electrolyte solution.
d. decreases the conductivity of the electrolyte solution.

Use the following information to answer the next _ questions.

Leaching technology is used in the mining and refining of copper ore. In the first step of the leaching process, sulfuric acid flows through a copper ore deposit. Under ideal conditions, the copper metal in the ore reacts with the concentrated sulfuric acid to form copper(II) ions. The resulting copper(II) slurry is transferred to an electrolytic cell where pure copper is produced. (Assume that the sulfuric acid completely ionizes to hydrogen ions and sulfate ions.)

____ 101. A non-spontaneous reaction may occur if the concentrations are manipulated. The balanced net ionic equation for the reaction of copper metal with sulfuric acid under these ideal conditions is

a. $Cu(s) + SO_4^{2-}(aq) + 4\ H^+(aq) \rightarrow Cu^{2+}(aq) + H_2SO_3(aq) + H_2O(l)$
b. $Cu^{2+}(aq) + H_2S(aq) \rightarrow Cu(s) + 2\ H^+(aq) + S(s)$
c. $Cu(s) + H_2S(aq) \rightarrow Cu^{2+}(aq) + H_2(g) + S^{2-}(aq)$
d. $Cu(s) + 2\ H^+(aq) \rightarrow Cu^{2+}(aq) + H_2(g)$

____ 102. What mass of pure copper is produced from the electrolysis of ecess copper(II) ions over a 24.0 h period when the cell is operated at 100 A?

a. 2.84 kg
b. 5.69 kg
c. 11.4 kg
d. 549 kg

____ 103. The net ionic equation for the conversion of copper(II) oxide in copper ore is

$$CuO(s) + 2\ H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$$

The copper in the copper(II) oxide is

a. reduced
b. oxidized
c. the oxidizing agent
d. neither oxidized nor reduced

____ 104. In the Hall-Heroult process, aluminium is produced by the electrolysis of molten $Al_2O_3(l)$. The half-reactions that occur are

$$C(s) + 2\ O^{2-}(aq) \rightarrow CO_2(g) + 4\ e^-$$
$$Al^{3+}(l) + 3\ e^- \rightarrow Al(s)$$

The mass of Al(l) produced for each 1.00 kg of C(s) consumed is

a. 1.69 kg
b. 2.45 kg
c. 3.00 kg

d. 6.00 kg

Use the following information to answer the next question.

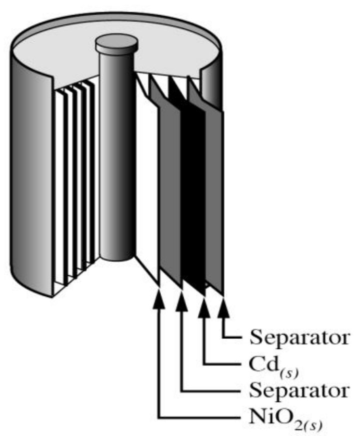
A particular voltaic cell is represented by $Ag(s)\,|\,Ag^{+}(aq)\,||\,Cr_2O_7^{2-}(aq), Cr^{3+}(aq), H^{+}(aq)\,|\,C(s)$

____ 105. The net ionic equation for this voltaic cell is

a. $6\ Ag(s) + Cr_2O_7^{2-}(aq) + 14\ H^{+}(aq) \rightarrow 6\ Ag^{+}(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$
b. $6\ Ag^{+}(aq) + Cr_2O_7^{2-}(aq) + 14\ H^{+}(aq) \rightarrow 6\ Ag(s) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$
c. $Ag^{+}(aq) + Cr_2O_7^{2-}(aq) + 14\ H^{+}(aq) \rightarrow Ag(s) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$
d. $Ag(s) + Cr_2O_7^{2-}(aq) + 14\ H^{+}(aq) \rightarrow Ag^{+}(aq) + 2\ Cr^{3+}(aq) + 7\ H_2O(l)$

Use the following information to answer the next _ questions.

Voltaic cells are used as portable sources of electrical energy. One common cell is the rechargeable nickel-cadmium cell.



The equation representing the discharge of this cell is

$$NiO_2(s) + Cd(s) + 2\ H_2O(l) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$$

____ 106. The oxidation half-reaction for the discharge of this cell is

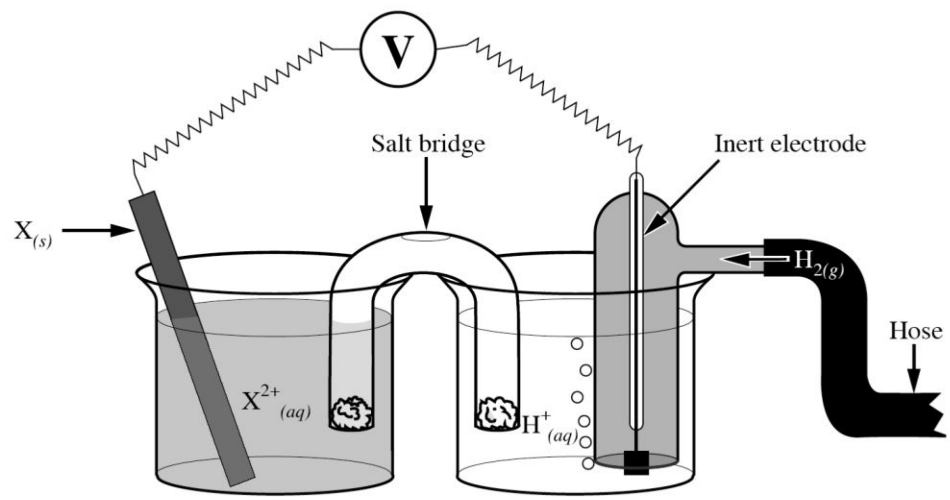
a. $Cd(s) + 2\ OH^{-}(aq) \rightarrow Cd(OH)_2(s) + 2\ e^{-}$
b. $NiO_2(s) + 2\ H_2O(l) + 2\ e^{-} \rightarrow Ni(OH)_2(s) + 2\ OH^{-}(aq)$
c. $NiO_2(s) + 2\ H_2O(l) \rightarrow Ni(OH)_2(s) + 2\ OH^{-}(aq) + 2\ e^{-}$
d. $Cd(s) + 2\ OH^{-}(aq) + 2\ e^{-} \rightarrow Cd(OH)_2(s)$

____ 107. In this system, the strongest oxidizing agent is

a. $NiO_2(s)$
b. $Cd(s)$
c. $Cd(OH)_2(s)$
d. $H_2O(l)$

Use the following information to answer the next _ questions.

Voltaic Cell



In this apparatus, the anions in the solution move from the hydrogen half-cell solution into the salt bridge and migrate toward the X(s) electrode.

____ 108. As this cell operates, electrons flow from

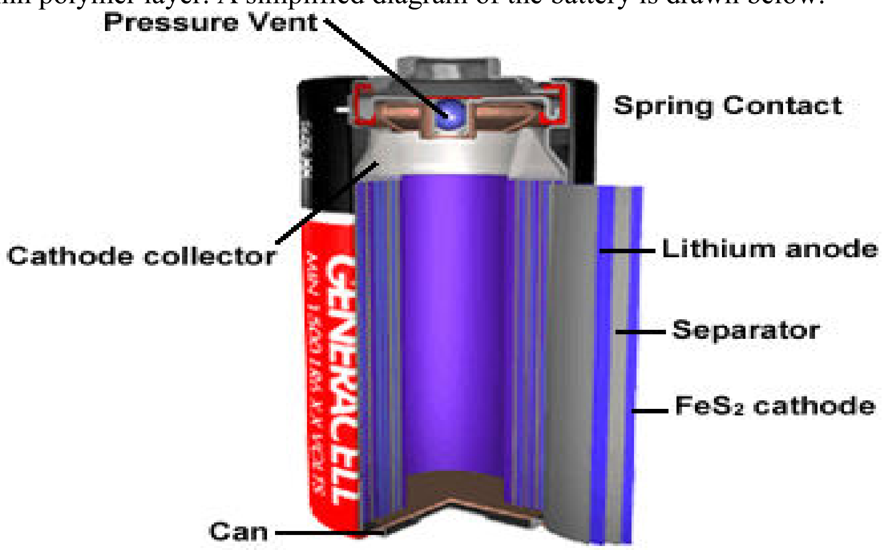
a. X(s) to the inert electrode and the pH in the hydrogen half-cell increases
b. X(s) to the inert electrode and the pH in the hydrogen half-cell decreases
c. the inert electrode to X(s) and the pH in the hydrogen half-cell increases
d. the inert electrode to X(s) and the pH in the hydrogen half-cell decreases

____ 109. If the voltmeter reads +0.45 V under standard conditions, then X(s) is most likely

a. Ni(s)
b. Fe(s)
c. Zn(s)
d. Mg(s)

Use the following information to answer the next _ questions.

Solid-state lithium batteries are being developed as miniature, rechargeable energy sources. Different sizes and shapes of batteries are possible because the electrolyte is a very thin polymer layer. A simplified diagram of the battery is drawn below.



Relevant Equations

$Li(s) \rightarrow Li^{+}(s) + e^{-}$

$FeS_2(s) + e^{-} \rightarrow FeS_2^{-}(s)$

____ 110. If the net cell potential of a solid-state lithium battery is +3.00 V, the the reduction potential for the half-reaction $FeS_2(s) + e^{-} \rightarrow FeS_2^{-}(s)$ is

a. +6.04 V
b. +3.04 V
c. - 0.04 V
d. - 6.04 V

____ 111. The strongest reducing agent in the solid-state lithium battery is

a. $Li(s)$
b. $Li^{+}(s)$
c. $FeS_2(s)$
d. $FeS_2^{-}(s)$

____ 112. During the operation of the solid-state lithium battery,

a. $FeS_2^{-}(s)$ ions migrate toward the strongest oxidizing agent in the system
b. $FeS_2^{-}(s)$ ions migrate toward the $FeS_2(s)$ electrode
c. lithium ions migrate toward the lithium electrode
d. lithium ions migrate toward the cathode

Use the following information to answer the next question.

Iron objects will readily corrode when exposed to air and moisture, as represented by the following equation.

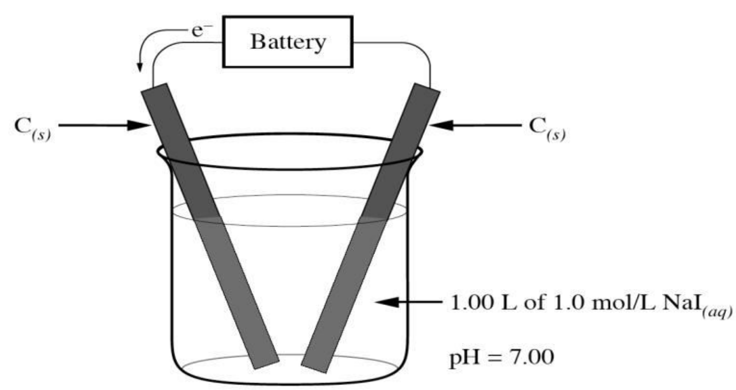
$$O_2(g) + 2\ H_2O(l) + 2\ Fe(s) \rightarrow 2\ Fe^{2+}(aq) + 4\ OH^{-}(aq)$$

____ 113. Which of the following metals can be attached to an iron object to prevent corrosion of the iron?

a. Copper
b. Nickel
c. Lead
d. Zinc

Use the following information to answer the next question.

Electrochemical Cell



The diagram above provides a representation of the process of electrolysis.

____ 114. Which of the following statements describes what happens during the operation of this cell?

a. Chemical energy is converted to electrical energy.
b. Electrical energy is converted to chemical energy.
c. Electrons flow toward the anode.
d. Plating takes place at the anode.

____ 115. A solution containing a metal ion with a 3+ charge was electrolyzed by a 5.0 A current for 10.0 min. If 1.19 g of the metal was electroplated, then the metal was likely

a. indium
b. scandium
c. aluminium
d. potassium

Use the following information to answer the next question.

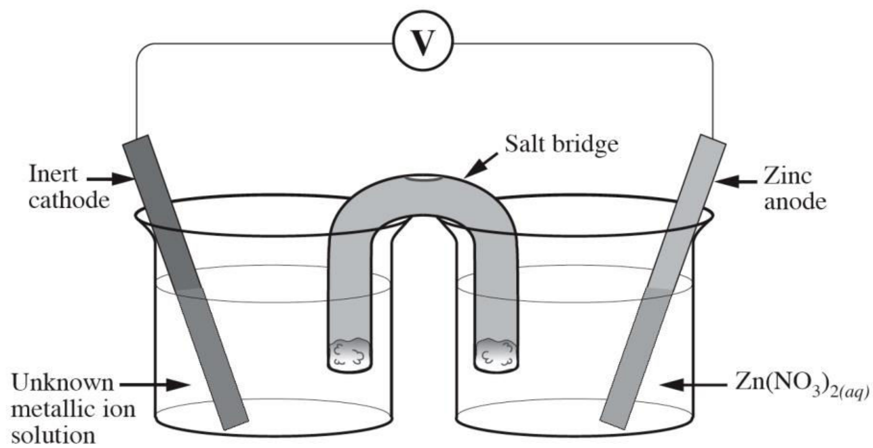
Some car manufacturers have designed an anticorrosion system that sends a weak electric current from the battery to the frame of the car. The current provides a source of electrons, which reduces corrosion of the steel frame.

____ 116. Which of the following methods could **not** be used as an alternative to the method of corrosion prevention described above?

a. Galvanize the steel frame with zinc.
b. Coat the steel frame with inert plastic polymers.
c. Use a paint that prevents contact of the steel frame with the environment.
d. Bolt sacrificial anodes made of copper to the steel frame.

Use the following information to answer the next _ questions.

To determine the identity of an unknown metallic ion in a solution, a student designed the voltaic cell shown below.



____ 117. The student chose zinc for the anode because zinc

a. gains electrons easily
b. can be easily reduced
c. is an oxidizing agent
d. is a reducing agent

____ 118. If the cell generates a voltage of +1.24 V under standard conditions, the half-reaction occurring at the cathode will have an electrode potential of

a. +2.00 V
b. - 2.00 V
c. +0.48 V
d. - 0.48 V

____ 119. If the zinc anode loses 200 g of mass during the operation of the cell, then the number of moles of electrons transferred is

a. 1.53 mol
b. 3.06 mol
c. 6.12 mol
d. 12.2 mol

Use the following information to answer the next question.

Some pacemakers use specialized lithium cells as a power source. The half-reactions and electrode potential in thise cells are

$2\ SOCl_2(aq) + 4\ e^- \rightarrow 4\ Cl^-(aq) + S(s) + SO_2(aq)$ E° = +0.36 V

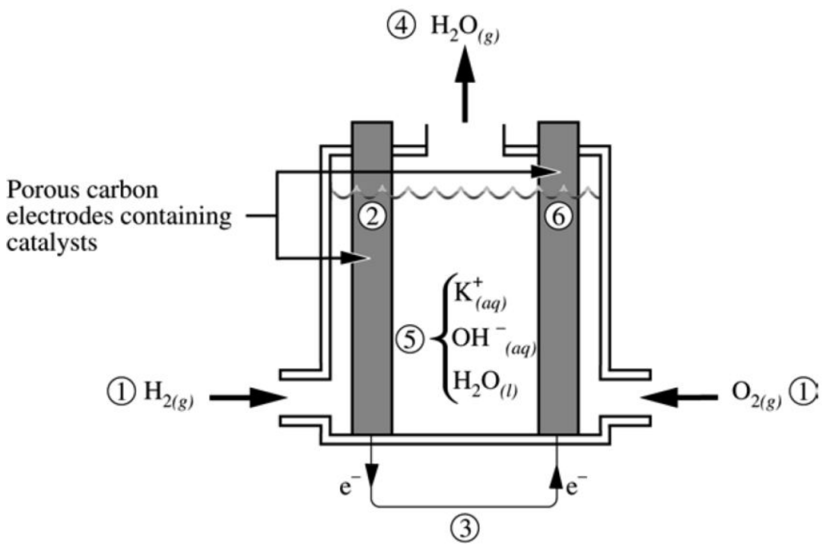
$Li^+(aq) + e^- \rightarrow Li(s)$ E° = - 3.04 V

____ 120. The net ionic equation and potential of this lithium cell are

a. $2\ SOCl_2(aq) + Li^+(aq) \rightarrow 4\ Cl^-(aq) + S(s) + SO_2(aq) + Li(s)$ $E°_{net} = +3.40$ V
b. $2\ SOCl_2(aq) + 4\ Li^+(aq) \rightarrow 4\ Cl^-(aq) + S(s) + SO_2(aq) + 4\ Li(s)$ $E°_{net} = +2.68$ V
c. $2\ SOCl_2(aq) + Li(s) \rightarrow 4\ Cl^-(aq) + S(s) + SO_2(aq) + Li^+(aq)$ $E°_{net} = +2.68$ V
d. $2\ SOCl_2(aq) + 4\ Li(s) \rightarrow 4\ Cl^-(aq) + S(s) + SO_2(aq) + 4\ Li^+(aq)$ $E°_{net} = +3.40$ V

Use the following information to answer the next _ questions.

Hydrogen-oxygen fuel cells have been used for years in spacecraft and more recently in small-scale power plants to generate electricity. Now, some governments and companies are working together to perfect this type of fuel cell for automobile use, and experiments are currently being conducted with operational prototypes. A diagram of a hydrogen-oxygen fuel cell is shown below.



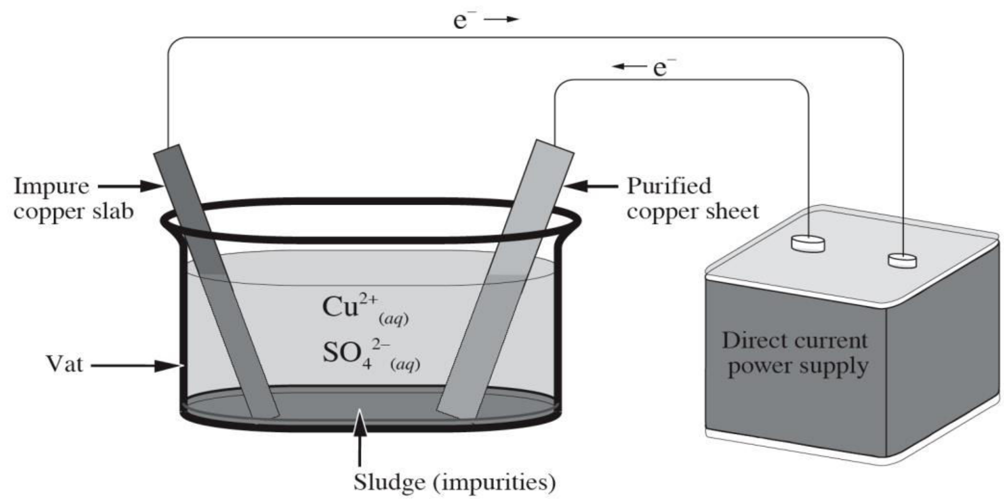
____ 121. From an ecological perspective, a reason why hydrogen-oxygen fuel cells should **not** be used to power automobiles is that

a. hydrogen fuel can be produced through the electrolysis is seawater by using the energy produced from burning fossil fuels
b. cars powered by a hydrogen-oxygen fuel cell would be up to 30% more efficient than cars powered by gasoline
c. water vapour is the primary byproduct of the cell

d. oxygen is readily available from the atmosphere

Use the following information to answer the next _ questions.

Copper can be refined (purified) using an apparatus like the one shown below, which is a small-scale version of an industrial apparatus.

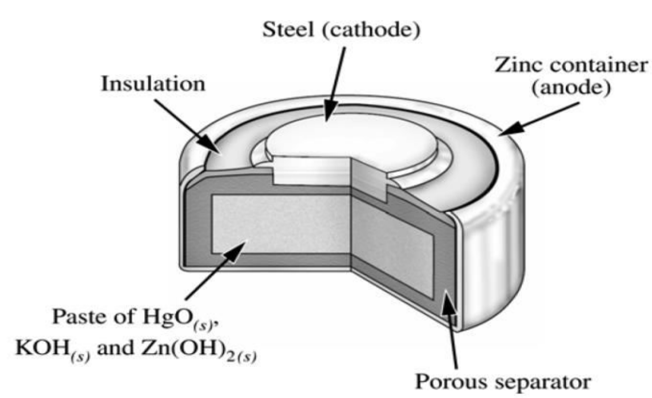


____ 122. In this electrochemical cell, the purified copper sheet acts as the

a. anode and is the site where SO_4^{2-}(aq) ions are oxidized
b. cathode and is the site where SO_4^{2-}(aq) ions are reduced
c. anode and is the site where Cu^{2+}(aq) ions are oxidized
d. cathode and is the site where Cu^{2+}(aq) ions are reduced

Use the following information to answer the next _ questions.

The silver oxide alkaline cell is a miniature power source used in watches, calculators, hearing aids, and cameras. The construction of this cell is shown in the following diagram.



Half-Reactions

$Zn(OH)_2(s) + 2\ e^- \rightarrow Zn(s) + 2\ OH^-(aq)$	E° = - 1.25 V
$Ag_2O(s) + H_2O(l) + 2\ e^- \rightarrow 2\ Ag(s) + 2\ OH^-(aq)$	E° = +0.34 V

____ 123. During the discharge of this cell, the substance oxidized is

a. Zn(s)
b. Ag(s)
c. $H_2O(l)$
d. $Ag_2O(s)$

____ 124. In this cell, the separator must be porous in order to

a. allow migration of ions
b. replenish the electrolyte
c. provide a pathway for electron flow
d. provide a surface on which electron transfer can occur

____ 125. Using lowest whole number coefficients, the coefficient for $H_2O(l)$ in the balanced net cell equation for the reaction that occurs during the discharge of the cell is

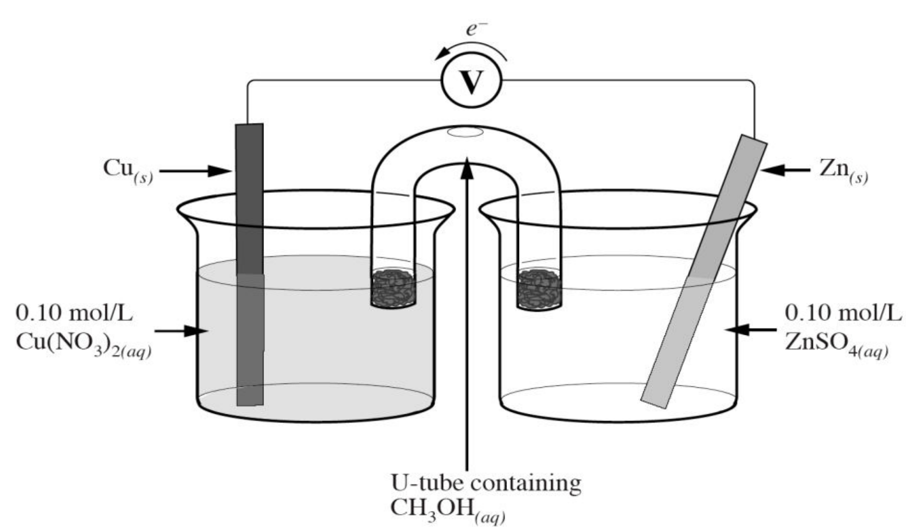
a. 1
b. 2
c. 3
d. 4

____ 126. As the cell operates, the

a. $[OH^-(aq)]$ increases
b. mass of Zn(s) increases
c. mass of $Ag_2O(s)$ decreases
d. mass of $Zn(OH)_2(s)$ decreases

Use the following diagram to answer the next question.

Electrochemical Cell



____ 127. The cell in the diagram was constructed and connected by a chemistry student. The voltage of the cell remained at 0.00 V trial after trial. One possible reason for the malfunction of the cell was that the

a. concentration of the solutions were too low
b. solution in the U-tube was a non-electrolyte
c. redox reaction was non-spontaneous
d. voltmeter was connected backward

Use the following information to answer the next question.

In the late 1980s, the Canadian dollar bill was replaced by a coin commonly called the "loonie." The loonie is manufactured from nickel discs that are stamped and then coated with a thin layer of copper (87.5%) and tin (12.5%) to provide the shiny gold-coloured appearance. This layer is applied through an electrolysis process in which the stamped loonie is one of the electrodes and copper metal is the other electrode.

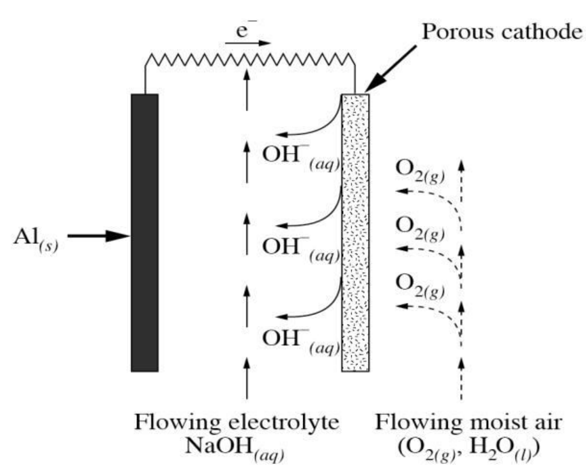
____ 128. If the plating of the loonie occurs in a Sn^{2+}(aq) and Cu^{2+}(aq) solution, the reaction that occurs at the cathode is

a. $2\ H_2O(l) + 2\ e^- \rightarrow H_2(g) + 2\ OH^-(aq)$
b. $2\ H_2O(l) \rightarrow O_2(g) + 4\ H^+(aq) + 4\ e^-$
c. $Cu^{2+}(aq) + 2\ e^- \rightarrow Cu(s)$
d. $Cu(s) \rightarrow Cu^{2+}(aq) + 2\ e^-$

Use the following information to answer the next _ questions.

Concern about increased air pollution and the increasing use of non-renewable resources has accelerated research into alternatives to the internal combustion engine. One alternative is a battery-powered electric motor. Several "new" efficient batteries are being tested. The diagram below represents one of these batteries.

Aluminium-Air Battery



____ 129. In this aluminium-air battery, the $O_2(g)$ acts as the

a. reducing agent and gains electrons
b. reducing agent and loses electrons
c. oxidizing agent and gains electrons
d. oxidizing agent and loses electrons

____ 130. The reduction half-reaction for this aluminium-air battery is

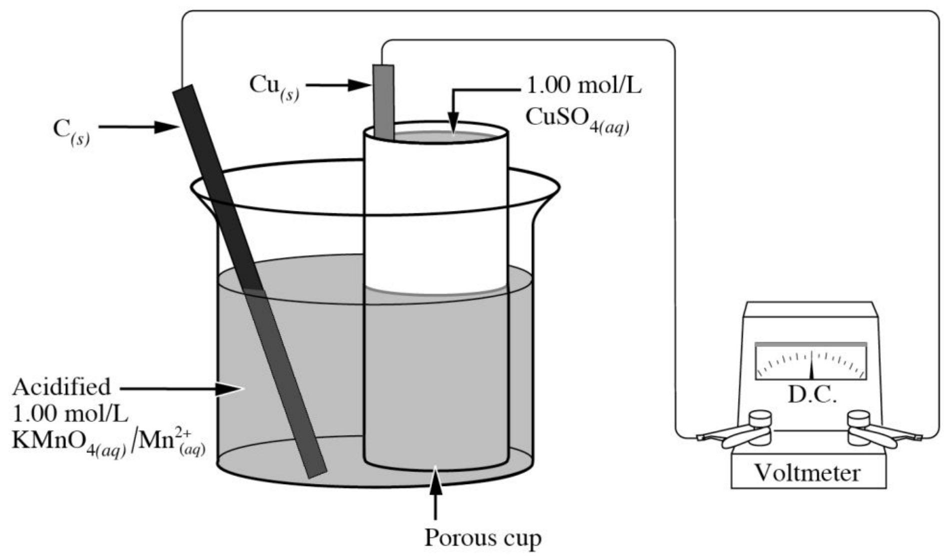
a. $2\ H_2O(l) + 2\ e^- \rightarrow H_2(g) + 2\ OH^-(aq)$
b. $Na^+(aq) + e^- \rightarrow Na(s)$
c. $O_2(g) + 4\ H^+(aq) + 4\ e^- \rightarrow 2\ H_2O(l)$
d. $O_2(g) + 2\ H_2O(l) + 4\ e^- \rightarrow 4\ OH^-(aq)$

____ 131. The standard voltage produced by this aluminium-air cell is

a. +2.36 V
b. +2.06 V
c. +0.83 V
d. - 1.05 V

Use the following information to answer the next _ questions.

A chemistry student constructs the cell shown below.



____ 132. The net equation and the predicted voltage for the operating cell are
a. $MnO_4^-(aq) + 8\ H^+(aq) + Cu(s) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + Cu^{2+}(aq)$ $E°_{net} = +1.17$ V
b. $MnO_4^-(aq) + 8\ H^+(aq) + Cu(s) \rightarrow Mn^{2+}(aq) + 4\ H_2O(l) + Cu^{2+}(aq)$ $E°_{net} = +1.85$ V
c. $MnO_4^-(aq) + 16\ H^+(aq) + 5\ Cu(s) \rightarrow Mn^{2+}(aq) + 8\ H_2O(l) + 5\ Cu^{2+}(aq)$ $E°_{net} = +1.17$ V
d. $MnO_4^-(aq) + 16\ H^+(aq) + 5\ Cu(s) \rightarrow Mn^{2+}(aq) + 8\ H_2O(l) + 5\ Cu^{2+}(aq)$ $E°_{net} = +1.85$ V

____ 133. During the operation of this cell,

a. electrons flow from the copper electrode to the carbon electrode
b. cations migrate toward the copper electrode
c. anions migrate toward the carbon electrode
d. the concentration of the sulfate ions decreases

____ 134. Which of the following statements does **not** apply to the operation of this cell?

a. The oxidation state of the reducing agent changes from 0 to +2.
b. MnO_4^-(aq) is reduced at the carbon cathode.
c. Cu(s) is oxidized at the anode.
d. MnO_4^-(aq) loses electrons.

____ 135. The voltage of an electrochemical cell is +0.20 V. If one of the half-reactions is the reduction of Cu^{2+}(aq), then the other half-reaction that occurs could be

a. $2\ I^-(aq) \rightarrow I_2(s) + 2\ e^-$
b. $S(s) + 2\ H^+(aq) + 2\ e^- \rightarrow H_2S(aq)$
c. $H_2S(aq) \rightarrow S(s) + 2\ H^+(aq) + 2\ e^-$
d. $I_2(s) + 2\ e^- \rightarrow 2\ I^-(aq)$

____ 136. Sacrificial metals may be used to protect pipelines, septic tanks, and ship propellers. A metal that could be used as a sacrificial anode to protect iron is

a. magnesium
b. tin
c. lead
d. silver

____ 137. *Electrolysis of $MgCl_2(aq)$ will not produce magnesium metal because ___i___ is a stronger ___ii___ agent than $Mg^{2+}(aq)$.*

The row that best completes the statement above is

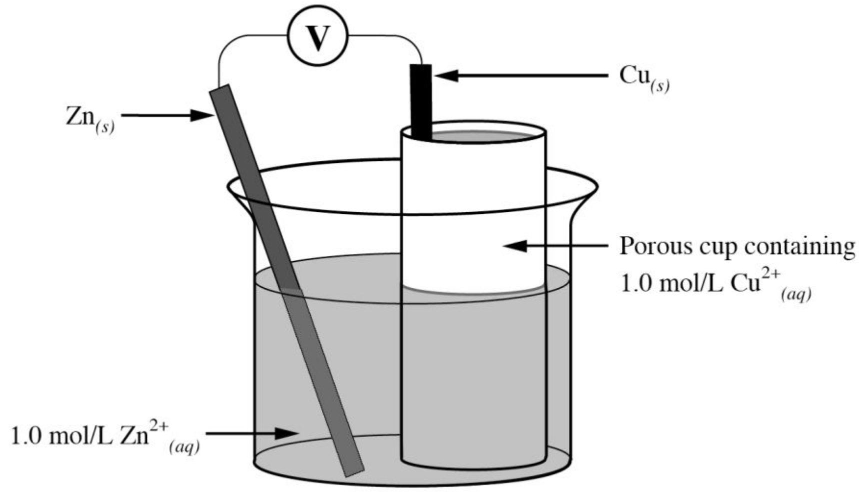
	i	*ii*
A	Cl^-(aq)	oxidizing
B	H_2O(l)	reducing
C	H_2O(l)	oxidizing
D	Cl^-(aq)	reducing

____ 138. If the Cu^{2+}(aq) / Cu(s) reduction half-reaction was assigned a reduction potential value of 0.00 V for an electrode potential table, then the Ni^{2+}(aq) / Ni(s) half-reaction on that table would have a reduction potential value of

a. +0.26 V
b. +0.08 V
c. - 0.26 V
d. - 0.60 V

Use the following diagram to answer the next question.

Electrochemical Cell



____ 139. For this cell, the potential is

a. +1.10 V
b. +0.42 V
c. - 0.42 V
d. - 1.10 V

Use the following information to answer the next _ questions.

Chromium plating of objects, such as iron car bumpers, to prevent corrosion actually involves the plating of three different meals in three separate electolyic cells. The first cell contains a solution of a copper salt, the second a solution of nickel salt, and the third a solution of chromium salt.

____ 140. *During the nickel stage of of the electroplating process, the nickel(II) ions ___i___ electrons, and the metal is deposited on the ___ii___.*

The row that best completes the statement above is

	i	*ii*
A	gain	anode
B	gain	cathode
C	lose	anode
D	lose	anode

Use the following information to answer the next 3 questions.

Restorers of antique cars often refinish chrome-plated parts by electroplating them. The part is attached to one electrode of an electrolytic cell in which the other electrode is lead. The electrolyte is a solution of dichomic acid, $H_2Cr_2O_7(aq)$.

____ 141. The plating of chromium metal will take place at the

a. anode where oxidation occurs
b. anode where reduction occurs
c. cathode where oxidation occurs
d. cathode where reduction occurs

____ 142. During the operation of this cell,
a. Pb(s) is reduced
b. $H_2Cr_2O_7$(aq) is oxidized
c. the pH of the solution increases
d. the total energy of the system decreases

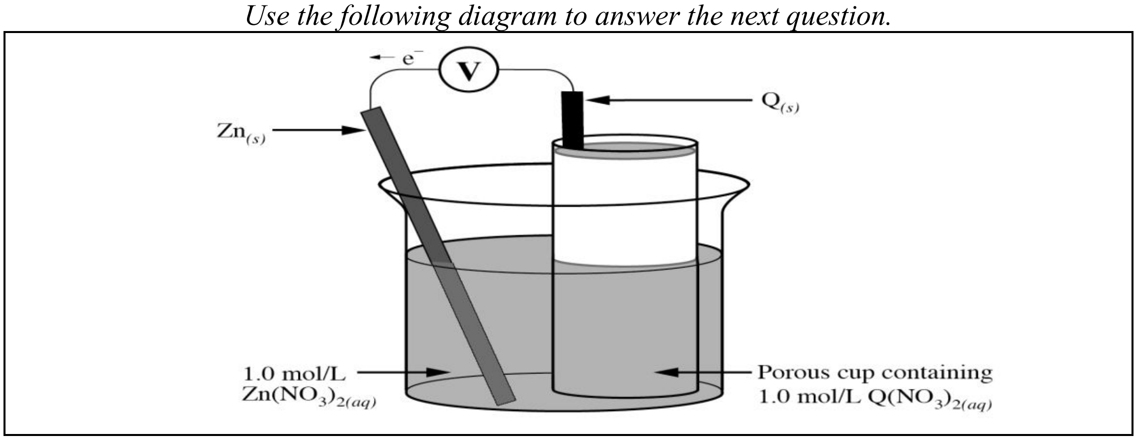
____ 143. A metal that will react spontaneously with Cr^{3+}(aq) in a chromium-plating solution is
a. aluminium
b. cadmium
c. lead
d. tin

____ 144. If the electrochemical cell Cd(s) | Cd^{2+}(aq) || Ag^{+}(aq) | Ag(s) produces a 6.00 A current for 2.00 h, the mass change of the anode will be
a. 25.2 g decrease
b. 2.25 g increase
c. 48.3 g decrease
d. 48.3 g increase

____ 145. "Tin" cans used to store food are made from steel electroplated with a thin layer of tin. The standard reduction potential for the reduction of Sn^{2+}(aq) ions for this process is
a. - 0.15 V
b. - 0.14 V
c. +0.14 V
d. +0.15 V

____ 146. In an experiment, a student compares several electrochemical cells. Each cell contains two metal strips in their metallic ion solutions. A voltmeter is connected by a wire between the metal strips, and a salt bridge connects the solutions. The dependent (responding) variable is the
a. voltage
b. concentration of the solution
c. reaction of the metal and metallic ion
d. metal and metallic ion solution selected

Use the following diagram to answer the next question.



____ 147. Given that the reading on the voltmeter for this cell is +1.74 V, which of the following statements is correct?
  a. The reduction potential of Q^{2+}(aq) is +2.50 V.
  b. Zn(s) is a weaker reducing agent than Q(s).
  c. Q^{2+}(aq) would react spontaneously with Cu(s).
  d. Q^{2+}(aq) is a stronger oxidizing agent than Zn^{2+}(aq).

____ 148. An electrolytic cell differs from a voltaic cell in that the electrolytic cell
  a. is spontaneous
  b. consumes electricity
  c. has an anode and a cathode
  d. has a positive $E°_{net}$ value

____ 149. If the lithium reduction half-reaction, $Li^+(aq) + e^- \rightarrow Li(s)$, had been assigned an E° value of 0.00 V, the predicted $E°_{net}$ value for the reaction $Cu(s) + Zn^{2+}(aq) \rightarrow Cu^{2+}(aq) + Zn(s)$ would be
  a. +3.38 V
  b. - 2.28 V
  c. - 0.42 V
  d. - 1.10 V

Electrochemistry review
Answer Section

MULTIPLE CHOICE

1. ANS: A PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.1k TOP: oxidation KEY: definition
2. ANS: A PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.4k TOP: redox reaction
KEY: identification of species undergoing reduction
3. ANS: C PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.4k TOP: electrochemistry KEY: oxidizing agents
4. ANS: B PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.7k TOP: electrochemistry KEY: predicting reactions from a table
5. ANS: B PTS: 1 REF: June 1992 Diploma
OBJ: 30-1.7k TOP: electrochemistry KEY: oxidation number
6. ANS: D PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.7k TOP: electrochemistry KEY: oxidation numbers
7. ANS: D PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.2k TOP: electrochemistry KEY: reducing agent
8. ANS: A PTS: 1 REF: June 1992 Diploma
OBJ: 30-B1.6k TOP: electrochemistry KEY: spontaneity
9. ANS: A PTS: 1 REF: June 1997 Diploma
OBJ: 30-B1.7k TOP: electrochemistry KEY: half-reactions
10. ANS: D PTS: 1 REF: June 1997 Diploma
OBJ: 30-B1.4k TOP: electrochemistry KEY: redox reactions in humans
11. ANS: A PTS: 1 REF: June 1997 Diploma
OBJ: 30-B1.7k TOP: electrochemistry KEY: balancing equations
12. ANS: B PTS: 1 REF: June 1997 Diploma
OBJ: 30-B1.7k TOP: electrochemistry KEY: balancing reactions from the table
13. ANS: D PTS: 1 REF: June 1997 Diploma

OBJ: 30-B1.8k TOP: redox titrations KEY: calculation of mass
14. ANS: A PTS: 1 REF: June 1997 Diploma
OBJ: 30-B1.2s TOP: electrochemistry KEY: redox titration
15. ANS: D PTS: 1 REF: June 1998 Diploma
OBJ: 30-B1.3k TOP: redox reactions KEY: recognizing a redox reaction
16. ANS: B PTS: 1 REF: June 1998 Diploma
OBJ: 30-B1.6k TOP: redox reactions KEY: predicting from a table
17. ANS: D PTS: 1 REF: June 1998 Diploma
OBJ: 30-B1.3s TOP: reduction tables
KEY: predicting a table based on spontaneity
18. ANS: B PTS: 1 REF: June 1998 Diploma
OBJ: 30-B1.7k TOP: redox titration KEY: predicting a reaction
19. ANS: C PTS: 1 REF: June 1998 Diploma
OBJ: 30-D1.3k TOP: oxidation numbers KEY: assigning oxidation numbers
20. ANS: A PTS: 1 REF: June 1991 Diploma
OBJ: 30-1.2k TOP: redox reactions KEY: identifying a RA
21. ANS: C PTS: 1 REF: June 1991 Diploma
OBJ: 30-1.3s TOP: reduction tables KEY: predicting a table from data
22. ANS: D PTS: 1 REF: June 1991 Diploma
OBJ: 30-1.5k TOP: reduction table KEY: identifying the SOA
23. ANS: D PTS: 1 REF: January 1990
OBJ: 30-B1.7k TOP: oxidation numbers KEY: assigning ONs
24. ANS: D PTS: 1 REF: June 1990 Diploma
OBJ: 30-B1.3s TOP: reduction tables KEY: selecting an inconsistant statement
25. ANS: A PTS: 1 REF: June 2000 OBJ: 30-B1.4k
TOP: redox reaction KEY: recognizing reduction
26. ANS: B PTS: 1 REF: June 2000 Diploma
OBJ: 30-B1.7k TOP: redox reactions KEY: recognizing disproportionation
27. ANS: C PTS: 1 REF: June 2001 Diploma
OBJ: 30-B1.6k TOP: redox reactions KEY: predicting spontaneity
28. ANS: B PTS: 1 REF: June 2001 Diploma
OBJ: 30-B1.2s TOP: redox reactions KEY: products of reaction
29. ANS: D PTS: 1 REF: January 2000 Diploma
OBJ: 30-B1.3s TOP: reduction tables KEY: ordering OA from empirical data
30. ANS: D PTS: 1 REF: January 2000 Diploma
OBJ: 30-B1.7k TOP: redox reactions KEY: predicting from a table
31. ANS: A PTS: 1 REF: January 2000 Diploma
OBJ: 30-B1.3k TOP: oxidation numbers
KEY: assigning ON and identifying OA given a reaction
32. ANS: C PTS: 1 REF: June 2000 Diploma
OBJ: 30-B1.4k TOP: redox reactions KEY: identify reduction
33. ANS: B PTS: 1 REF: June 2000 Diploma
OBJ: 30-B1.7k TOP: redox reaction KEY: balancing in an acid
34. ANS: B PTS: 1 REF: 2003 Released Items
OBJ: 30-B1.4k TOP: corrosion KEY: environmental corrosion of copper
35. ANS: B PTS: 1 REF: 2005 Released items
OBJ: 30-B1.4k TOP: corrosion of copper KEY: Statue of Liberty
36. ANS: D PTS: 1 REF: 2004 Released Items
OBJ: 30-B1.6k TOP: spontaneity KEY: identify metals based on reactions

37. ANS: A PTS: 1 REF: 2004 Released Items
OBJ: 30-B1.2k TOP: redox reaction KEY: identify RA
38. ANS: A PTS: 1 REF: 2004 Released items
OBJ: 30-B1.4k TOP: redox reactions KEY: identify a half-reaction
39. ANS: A PTS: 1 REF: 2004 Released Items
OBJ: 30-B1.7k TOP: redox reaction KEY: predicting from a table
40. ANS: C PTS: 1 OBJ: 30-B1.2k TOP: redox reaction
KEY: identifying reduction
41. ANS: D PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.2k TOP: redox reaction KEY: disproportionation
42. ANS: A PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.7k TOP: redox reactions KEY: identifying a reduction half reaction
43. ANS: D PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.6k TOP: spontaneity of reactions KEY: differentiate between two RA
44. ANS: C PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.8k TOP: redox titration KEY: concentration of sample
45. ANS: A PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.2s TOP: redox titration KEY: qualitative observations
46. ANS: C PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.2s TOP: redox titration KEY: selecting a titrant
47. ANS: C PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.6k TOP: redox reactions KEY: predicting from a table
48. ANS: C PTS: 1 REF: January 2002 Diploma
OBJ: 30-B1.4k TOP: redox reaction KEY: identifying RA
49. ANS: A PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.7k TOP: voltaic cell KEY: prediction of cell potential
50. ANS: C PTS: 1 REF: June 2001 Diploma
OBJ: 30-B1.7k TOP: redox equations KEY: balancing in an acid
51. ANS: B PTS: 1 REF: June 2001 Diploma
OBJ: 30-B1.7k TOP: redox reactions KEY: reduction half-reaction
52. ANS: A PTS: 1 REF: June 2001 Diploma
OBJ: 30-B1.8k TOP: redox titration KEY: calculation of [iron(II) ions]
53. ANS: A PTS: 1 REF: June 2001 Diploma
OBJ: 30-B1.7k TOP: redox reaction KEY: predicting from a table
54. ANS: B PTS: 1 REF: January 2001 Diploma
OBJ: 30-B1.3s TOP: spontaneity of reaction KEY: experimental data
55. ANS: A PTS: 1 REF: January 2001 Diploma
OBJ: 30-B1.3s TOP: reduction table KEY: selecting the SRA
56. ANS: A PTS: 1 REF: June 1999 Diploma
OBJ: 30-B1.3k TOP: oxidation numbers KEY: decrease
57. ANS: D PTS: 1 REF: June 1999 Diploma
OBJ: 30-B1.7k TOP: reactions KEY: predicting from a table
58. ANS: A PTS: 1 REF: June 1999 Diploma
OBJ: 30-B1.7k TOP: reactions KEY: predicting from a table
59. ANS: C PTS: 1 REF: June 1999 Diploma
OBJ: 30-B1.7k TOP: reaction KEY: identifying the oxidation half-reaction
60. ANS: A PTS: 1 REF: June 1999 Diploma
OBJ: 30-B1.3s TOP: predicting table KEY: experimental results
61. ANS: C PTS: 1 REF: January 1999 Diploma

OBJ: 30-B1.7k TOP: reaction KEY: predicting from a table
62. ANS: A PTS: 1 REF: January 1999 Diploma
OBJ: 30-B1.3s TOP: predicting table KEY: from experimental data
63. ANS: A PTS: 1 REF: January 1999 Diploma
OBJ: 30-B1.7k TOP: predicting a reaction KEY: from a table
64. ANS: D PTS: 1 REF: January 1999 Diploma
OBJ: 30-B1.7k TOP: activity series KEY: order of reaction
65. ANS: C PTS: 1 REF: January 1998 Diploma
OBJ: 30-B1.3s
66. ANS: A PTS: 1 REF: January 1998 Diploma
OBJ: 30-B1.4k
67. ANS: C PTS: 1 REF: January 1998 Diploma
OBJ: 30-B1.6k
68. ANS: D PTS: 1 REF: January 1998 Diploma
OBJ: 30-B1.6k
69. ANS: D PTS: 1 REF: January 1996 Diploma
OBJ: B1.3k
70. ANS: C PTS: 1 REF: January 1996 Diploma
OBJ: 30-B1.3s
71. ANS: B PTS: 1 REF: January 1996 Diploma
OBJ: 30-B1.6k
72. ANS: D PTS: 1 REF: January 1996 Diploma
OBJ: 30-B1.6k
73. ANS: A PTS: 1 REF: January 1996 Diploma
OBJ: 30-B1.3s
74. ANS: B PTS: 1 REF: 2005 Released items
OBJ: 30-B1.4k TOP: oxidation KEY: identification in a reaction
75. ANS: A PTS: 1 REF: 2005 Released items
OBJ: 30-B1.2s TOP: SOA KEY: from a table
76. ANS: B PTS: 1 REF: 2005 Released items
OBJ: 30-B1.6k TOP: predicting spontaneity KEY: from a table
77. ANS: D PTS: 1 REF: 2005 Released items
OBJ: 30-D1.7k TOP: balancing KEY: under acidic conditions
78. ANS: B PTS: 1 REF: 2005 Released items
OBJ: 30-D1.7k TOP: change in oxidation number KEY: given balanced equation
79. ANS: A PTS: 1 REF: June 1992 Diploma
OBJ: 30-B2.5k TOP: cell chemistry KEY: reference half-cells
80. ANS: D PTS: 1 REF: June 1992 Diploma
OBJ: 30-B2.6k TOP: cell chemistry KEY: E°net
81. ANS: C PTS: 1 REF: June 1992 Diploma
OBJ: 30-B2.1k TOP: electrochemical cells KEY: electron flow
82. ANS: A PTS: 1 REF: June 1992 Diploma
OBJ: 30-B2.8k TOP: electrolytic cells KEY: Faraday's calculation
83. ANS: B PTS: 1 REF: June 1992 Diploma
OBJ: 30-B2.6k TOP: voltaic cells KEY: predicting voltage
84. ANS: B PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.2sts TOP: cells KEY: corrosion
85. ANS: A PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.2sts TOP: cells KEY: corrosion of pipes

86. ANS: D PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.3k TOP: electrolytic cells KEY: electroplating
87. ANS: D PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.7k TOP: cells KEY: spontaneity of reaction
88. ANS: A PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.2k TOP: voltaic cells KEY: description
89. ANS: D PTS: 1 REF: June1997 Diploma
OBJ: 30-B2.2k TOP: cells KEY: differences between voltaic and electrolytic
90. ANS: C PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.3k TOP: voltaic cells KEY: predictions
91. ANS: A PTS: 1 REF: June 1997 Diploma
OBJ: 30-B2.3s TOP: voltaic cells KEY: predictions
92. ANS: D PTS: 1 REF: June 1998 Diploma
OBJ: 30-B2.1sts TOP: electrolysis KEY: commercial use
93. ANS: C PTS: 1 REF: June 1998 Diploma
OBJ: 30-B2.1sts TOP: electrolysis of sodium chloride KEY: design of cells
94. ANS: B PTS: 1 REF: June 1998 Diploma
OBJ: 30-B2.1 sts TOP: electrolysis of NaCl KEY: cell design
95. ANS: D PTS: 1 REF: June 1998 Diploma
OBJ: 30-B2.3k TOP: electrolysis of sodium chloride KEY: products of reaction
96. ANS: C PTS: 1 REF: June 1998 Diploma
OBJ: 30-B2.8k TOP: electrolysis of sodium chloride KEY: calculation of time
97. ANS: B PTS: 1 REF: June 1998 Diploma
OBJ: 30-B2.8k TOP: electrolysis of sodium chloride KEY: calculation of mass
98. ANS: B PTS: 1 REF: January 2000 Diploma
OBJ: 30-B2.6k TOP: corrosion of iron KEY: calculation of potential
99. ANS: A PTS: 1 REF: January 2000 Diploma
OBJ: 30-B2.3k TOP: corrosion KEY: sacrifical anode
100. ANS: C PTS: 1 REF: January 2000 Diploma
OBJ: 30-B2.2sts TOP: corrosion KEY: salt on highways
101. ANS: A PTS: 1 REF: June 2000 Diploma
OBJ: 30-B1.7k TOP: net equation KEY: prediction from the table
102. ANS: A PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.8k TOP: Faraday calculation
KEY: calculate mass given time and current
103. ANS: D PTS: 1 REF: June 2000 Diploma
OBJ: 30-B1.3k TOP: redox reactions KEY: identifying electron transfer
104. ANS: C PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.8k TOP: cell stoich KEY: calculation of mass from mass consumed
105. ANS: A PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.3k TOP: standard cell notation KEY: predicting net ionic equation
106. ANS: A PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.3k TOP: voltaic cell KEY: identify the oxidation half-reaction
107. ANS: A PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.3k TOP: voltaic cell KEY: identify the SOA
108. ANS: B PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.1k TOP: voltaic cell KEY: electron flow and pH change
109. ANS: B PTS: 1 REF: June 2000 Diploma
OBJ: 30-B2.6k TOP: voltaic cell KEY: identify the anode from voltage

110. ANS: C PTS: 1 REF: 2007 Released Items
OBJ: 30-B2,6k TOP: battery chemistry
KEY: calculation of reduction potential for a half-reaction
111. ANS: A PTS: 1 REF: 2007 Released Items
OBJ: 30-B2.7k TOP: voltaic cells KEY: identify the SRA
112. ANS: D PTS: 1 REF: 2007 Released Items
OBJ: 30-B2.1s TOP: voltaic cell KEY: cation migration
113. ANS: D PTS: 1 REF: 2007 Released Items
OBJ: 30-B2.2sts TOP: corrosion KEY: sacrifical anode
114. ANS: B PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.2k TOP: electrolysis KEY: energy change
115. ANS: A PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.8k TOP: Electrolysis KEY: Faraday calculation
116. ANS: D PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.2sts TOP: corrosion KEY: prevention
117. ANS: D PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.1s TOP: voltaic cell KEY: anode selection
118. ANS: C PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.6k TOP: voltaic cells KEY: predicting E° cathode
119. ANS: C PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.8k TOP: cell stoich KEY: mol of e- transferred
120. ANS: D PTS: 1 REF: January 2002 Diploma
OBJ: 30-B2.6k TOP: voltaic cell KEY: predicting net cell equation and potential
121. ANS: A PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.3sts TOP: fuel cell KEY: ecological perspective
122. ANS: D PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.3k TOP: electrolytic cell KEY: predicting cathode reaction
123. ANS: A PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.3k TOP: battery KEY: predicting RA
124. ANS: A PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.1k TOP: battery KEY: definition of salt bridge
125. ANS: A PTS: 1 REF: January 1996 Diploma
OBJ: 30-B2.3k
126. ANS: C PTS: 1 REF: January 1996 Diploma
OBJ: 30-B2.3s
127. ANS: B PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.1s TOP: voltaic cell KEY: identifying an error in construction
128. ANS: C PTS: 1 REF: June 2001 Diploma
OBJ: 30-B2.3k TOP: electrolysis KEY: identification of cathode reaction
129. ANS: C PTS: 1 REF: January 2001 Diploma
OBJ: 30-B2.3k TOP: battery KEY: identification of the OA
130. ANS: D PTS: 1 REF: January 2001 Battery
OBJ: 30-B2.3k TOP: voltaic cell KEY: reduction half-reaction
131. ANS: B PTS: 1 REF: January 2001 Diploma
OBJ: 30-B2.6k TOP: voltaic cell KEY: calculation of potential
132. ANS: C PTS: 1 REF: January 2001 Diploma
OBJ: 30-B2.3k TOP: voltaic cell KEY: predict net equation and potential
133. ANS: A PTS: 1 REF: January 2001 Diploma
OBJ: 30-B2.1k TOP: voltaic cell KEY: cell details

134. ANS: D PTS: 1 REF: January 2001 Diploma
OBJ: 30-B2.2k TOP: voltaic cell KEY: details
135. ANS: C PTS: 1 REF: June 1999 Diploma
OBJ: 30-B2.6k TOP: identifying an oxidation half-reaction
KEY: given cell potential and reduction half
136. ANS: A PTS: 1 REF: June 1999 Diploma
OBJ: 30-B2.2sts TOP: corrosion protection KEY: sacrificial anode
137. ANS: C PTS: 1 REF: June 1999 Diploma
OBJ: 30-B2.7k TOP: electrolysis KEY: predicting products
138. ANS: B PTS: 1 REF: June 1999 Diploma
OBJ: 30-B2.5s TOP: reference half cell KEY: change to copper half-reaction
139. ANS: A PTS: 1 REF: June 1999 Diploma
OBJ: 30-B2.6k TOP: voltaic cell KEY: predicting cell potential
140. ANS: B PTS: 1 REF: June 1999 Diploma
OBJ: 30-B2.3s TOP: electrolysis KEY: identifying products
141. ANS: D PTS: 1 REF: January 1999 Diploma
OBJ: 30-B2.3s TOP: electroplating KEY: site of reduction
142. ANS: C PTS: 1 REF: January 1999 Diploma
OBJ: 30-B2.3s TOP: electrolysis KEY: products of cell
143. ANS: A PTS: 1 REF: January 1999 Diploma
OBJ: 30-B2.7k TOP: spontaneous reaction KEY: given OA
144. ANS: A PTS: 1 REF: January 1999 Diploma
OBJ: 30-B2.8k TOP: Faraday calculation
KEY: mass change at anode given current and time
145. ANS: B PTS: 1 REF: January 1999 Diploma
OBJ: 30-B2.3k TOP: reduction potential KEY: selecting from the table
146. ANS: A PTS: 1 REF: January 1999 Diploma
OBJ: 30-B2.1s TOP: voltaic cells KEY: identifying variables
147. ANS: B PTS: 1 REF: January 1998 Diploma
OBJ: 30-B2.3s
148. ANS: B PTS: 1 REF: January 1998 Diploma
OBJ: 30-B2.2k
149. ANS: D PTS: 1 REF: January 1998 Diploma
OBJ: 30-B2.5k
150. ANS: C PTS: 1 REF: January 1998
OBJ: 30-B2.3k