

Chemistry Review

Unit 8 - Oxidation/Reduction (REDOX)

Reduction, Oxidation, Redox Reactions, Corrosion, Half-Reactions, Electrochemical (Voltaic) Cell, Electrolytic Cell, Electroplating, Reduction of Metals

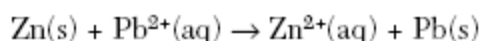
Oxidation-Reduction (Redox)

- 1. An oxidation-reduction (redox) reaction involves the transfer of electrons (e^-).**
- 2. Reduction is the gain of electrons and decrease of oxidation number.**
 - ✓ A half reaction can be written to represent reduction.
- 3. Oxidation is the loss of electrons and increase of oxidation number.**
 - ✓ A half reaction can be written to represent oxidation.
- 4. In redox the number of electrons lost is equal to the number of electrons gained.**
- 5. Oxidation numbers/states can be assigned to atoms and ions. Changes in oxidation numbers indicate that a redox reaction has occurred.**
 - ✓ Double replacement reactions are not redox reactions.
 - ✓ A reaction in which an element is alone on one side of a reaction, and part of a compound on the other side is always a redox reaction.
- 6. An electrochemical cell can be either voltaic or electrolytic.**
- 7. In an electrochemical cell oxidation occurs at the anode and reduction at the cathode.**
- 8. A voltaic cell spontaneously converts chemical energy to electrical energy.**
- 9. An electrolytic cell requires energy to produce a chemical change. This is called electrolysis.**

Unit 8 - Oxidation/Reduction (REDOX)

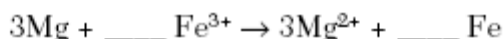
August 2007

- 42 Given the balanced equation representing the reaction occurring in a voltaic cell:



In the completed external circuit, the electrons flow from

- (1) Pb(s) to Zn(s)
 - (2) $\text{Pb}^{2+}(\text{aq})$ to $\text{Zn}^{2+}(\text{aq})$
 - (3) Zn(s) to Pb(s)
 - (4) $\text{Zn}^{2+}(\text{aq})$ to $\text{Pb}^{2+}(\text{aq})$
- 43 Which balanced equation represents a redox reaction?
- (1) $\text{CuCO}_3(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{CO}_2(\text{g})$
 - (2) $2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$
 - (3) $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{KNO}_3(\text{aq})$
 - (4) $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{KOH}(\text{aq}) \rightarrow \text{K}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\ell)$
- 44 Given the unbalanced ionic equation:



When this equation is balanced, both Fe^{3+} and Fe have a coefficient of

- (1) 1, because a total of 6 electrons is transferred
- (2) 2, because a total of 6 electrons is transferred
- (3) 1, because a total of 3 electrons is transferred
- (4) 2, because a total of 3 electrons is transferred

June 2007

- 22 Which changes occur when Pt^{2+} is reduced?

- (1) The Pt^{2+} gains electrons and its oxidation number increases.
- (2) The Pt^{2+} gains electrons and its oxidation number decreases.
- (3) The Pt^{2+} loses electrons and its oxidation number increases.
- (4) The Pt^{2+} loses electrons and its oxidation number decreases.

- 45 A student collects the materials and equipment below to construct a voltaic cell.

- two 250-mL beakers
- wire and a switch
- one strip of magnesium
- one strip of copper
- 125 mL of 0.20 M $\text{Mg}(\text{NO}_3)_2(\text{aq})$
- 125 mL of 0.20 M $\text{Cu}(\text{NO}_3)_2(\text{aq})$

Which additional item is required for the construction of the voltaic cell?

- (1) an anode
- (2) a battery
- (3) a cathode
- (4) a salt bridge

- 23 Which balanced equation represents an oxidation-reduction reaction?

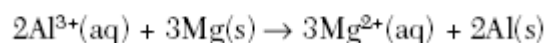
- (1) $\text{BaCl}_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{NaCl}$
- (2) $\text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$
- (3) $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
- (4) $\text{Mg}(\text{OH})_2 + 2\text{HNO}_3 \rightarrow \text{Mg}(\text{NO}_3)_2 + 2\text{H}_2\text{O}$

Unit 8 - Oxidation/Reduction (REDOX)

24 Which energy conversion occurs during the operation of a voltaic cell?

- (1) Chemical energy is spontaneously converted to electrical energy.
- (2) Chemical energy is converted to electrical energy only when an external power source is provided.
- (3) Electrical energy is spontaneously converted to chemical energy.
- (4) Electrical energy is converted to chemical energy only when an external power source is provided.

47 Given the balanced ionic equation representing a reaction:



In this reaction, electrons are transferred from

- (1) Al to Mg^{2+}
- (2) Al^{3+} to Mg
- (3) Mg to Al^{3+}
- (4) Mg^{2+} to Al

January 2007

20 In which reaction are electrons transferred from one reactant to another reactant?

- (1) $2\text{Ca}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CaO}(\text{s})$
- (2) $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{KNO}_3(\text{aq})$
- (3) $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$
- (4) $\text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\ell)$

Base your answers to questions 52 and 53 on the information below.

During a laboratory activity, a student reacted a piece of zinc with 0.1 M $\text{HCl}(\text{aq})$.

52 Complete the equation *in your answer booklet* by writing the formula of the missing product. [1]

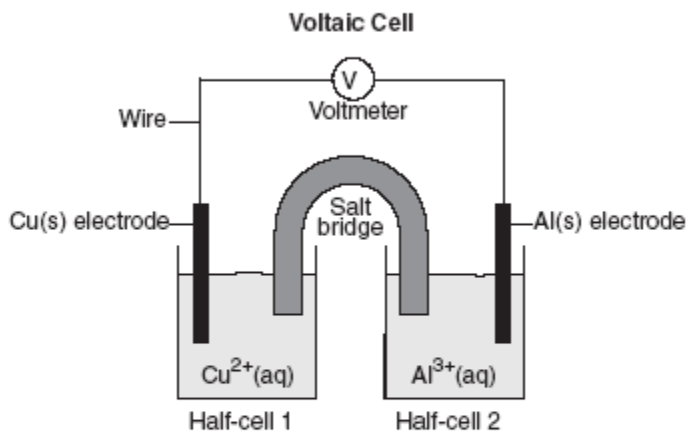
53 Based on Reference Table J, identify *one* metal that does *not* react spontaneously with $\text{HCl}(\text{aq})$. [1]



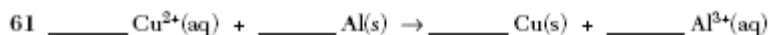
53 _____

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 61 through 63 on the diagram below. The diagram shows a voltaic cell with copper and aluminum electrodes immediately after the external circuit is completed.



- 61 Balance the redox equation *in your answer booklet*, using the smallest whole-number coefficients. [1]
- 62 As this voltaic cell operates, the mass of the Al(s) electrode decreases. Explain, in terms of particles, why this decrease in mass occurs. [1]
- 63 Explain the function of the salt bridge. [1]



62 _____

63 _____

Unit 8 - Oxidation/Reduction (REDOX)

August 2006

5 Which statement is true about oxidation and reduction in an electrochemical cell?

- (1) Both occur at the anode.
- (2) Both occur at the cathode.
- (3) Oxidation occurs at the anode and reduction occurs at the cathode.
- (4) Oxidation occurs at the cathode and reduction occurs at the anode.

22 Half-reactions can be written to represent all

- (1) double-replacement reactions
- (2) neutralization reactions
- (3) fission and fusion reactions
- (4) oxidation and reduction reactions

24 Given the balanced equation representing a redox reaction:



Which statement is true about this reaction?

- (1) Each Al loses $2e^-$ and each Cu^{2+} gains $3e^-$.
- (2) Each Al loses $3e^-$ and each Cu^{2+} gains $2e^-$.
- (3) Each Al^{3+} gains $2e^-$ and each Cu loses $3e^-$.
- (4) Each Al^{3+} gains $3e^-$ and each Cu loses $2e^-$.

June 2006

23 Which balanced equation represents a redox reaction?

- (1) $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$
- (2) $\text{BaCl}_2 + \text{K}_2\text{CO}_3 \rightarrow \text{BaCO}_3 + 2\text{KCl}$
- (3) $\text{CuO} + \text{CO} \rightarrow \text{Cu} + \text{CO}_2$
- (4) $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$

25 Which conversion of energy always occurs in a voltaic cell?

- (1) light energy to chemical energy
- (2) electrical energy to chemical energy
- (3) chemical energy to light energy
- (4) chemical energy to electrical energy

36 Which half-reaction shows conservation of charge?

- (1) $\text{Cu} + e^- \rightarrow \text{Cu}^+$
- (2) $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$
- (3) $\text{Cu}^+ \rightarrow \text{Cu} + e^-$
- (4) $\text{Cu}^{2+} \rightarrow \text{Cu} + 2e^-$

24 Which process occurs at the anode in an electrochemical cell?

- (1) the loss of protons
- (2) the loss of electrons
- (3) the gain of protons
- (4) the gain of electrons

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 78 through 81 on the information below.

Aluminum is one of the most abundant metals in Earth's crust. The aluminum compound found in bauxite ore is Al_2O_3 . Over one hundred years ago, it was difficult and expensive to isolate aluminum from bauxite ore. In 1886, a brother and sister team, Charles and Julia Hall, found that molten (melted) cryolite, Na_3AlF_6 , would dissolve bauxite ore. Electrolysis of the resulting mixture caused the aluminum ions in the Al_2O_3 to be reduced to molten aluminum metal. This less expensive process is known as the Hall process.

78 Write the oxidation state for *each* of the elements in cryolite. [1]

79 Write the balanced half-reaction equation for the reduction of Al^{3+} to Al. [1]

80 Explain, in terms of ions, why molten cryolite conducts electricity. [1]

81 Explain, in terms of electrical energy, how the operation of a voltaic cell differs from the operation of an electrolytic cell used in the Hall process. Include *both* the voltaic cell and the electrolytic cell in your answer. [1]

78 Na_3AlF_6 Na: _____

Al: _____

F: _____

79 _____

80 _____

81 _____

January 2006

20 In an oxidation-reduction reaction, reduction is defined as the

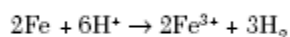
- (1) loss of protons (3) loss of electrons
(2) gain of protons (4) gain of electrons

21 What is the oxidation number assigned to manganese in KMnO_4 ?

- (1) +7 (3) +3
(2) +2 (4) +4

Unit 8 - Oxidation/Reduction (REDOX)

83 Because tap water is slightly acidic, water pipes made of iron corrode over time, as shown by the balanced ionic equation below:

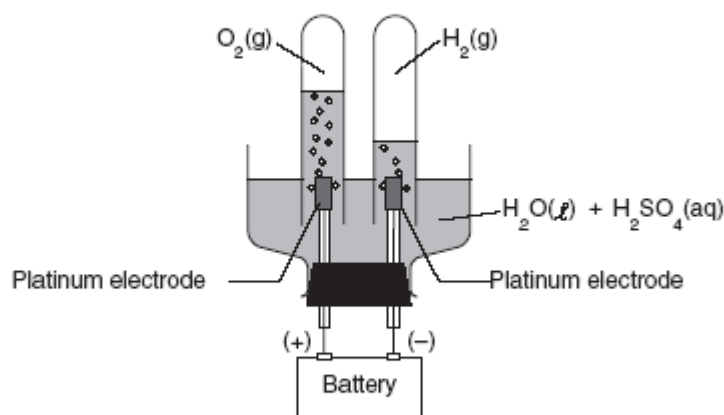


Explain, in terms of chemical reactivity, why copper pipes are *less* likely to corrode than iron pipes. [1]

83 _____

Base your answers to questions 84 and 85 on the information and diagram below.

The apparatus shown in the diagram consists of two inert platinum electrodes immersed in water. A small amount of an electrolyte, H_2SO_4 , must be added to the water for the reaction to take place. The electrodes are connected to a source that supplies electricity.



84 What type of electrochemical cell is shown? [1]

85 What particles are provided by the electrolyte that allow an electric current to flow? [1]

84 _____

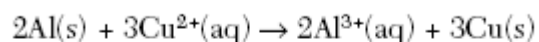
85 _____

August 2005

23 In a voltaic cell, chemical energy is converted to

- (1) electrical energy, spontaneously
- (2) electrical energy, nonspontaneously
- (3) nuclear energy, spontaneously
- (4) nuclear energy, nonspontaneously

30 Given the balanced ionic equation:

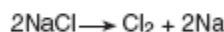
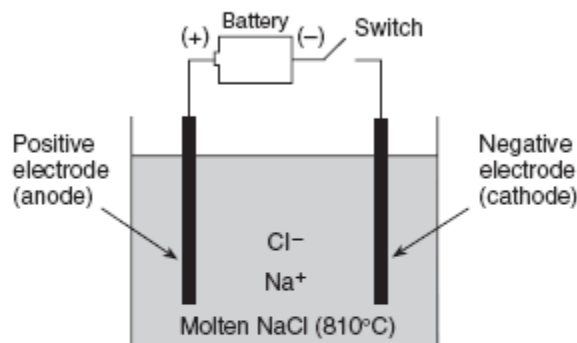


Compared to the total charge of the reactants, the total charge of the products is

- (1) less
- (2) greater
- (3) the same

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 74 through 76 on the diagram and balanced equation below, which represent the electrolysis of molten NaCl.



74 When the switch is closed, which electrode will attract the sodium ions? [1]

75 What is the purpose of the battery in this electrolytic cell? [1]

76 Write the balanced half-reaction for the reduction that occurs in this electrolytic cell. [1]

74 _____

75 _____

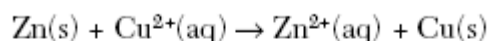
76 _____

June 2005

26 Where does oxidation occur in an electrochemical cell?

- (1) at the cathode in both an electrolytic cell and a voltaic cell
- (2) at the cathode in an electrolytic cell and at the anode in a voltaic cell
- (3) at the anode in both an electrolytic cell and a voltaic cell
- (4) at the anode in an electrolytic cell and at the cathode in a voltaic cell

49 Given the balanced ionic equation:

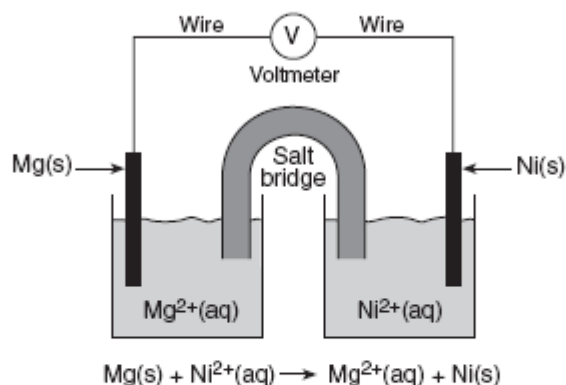


Which equation represents the oxidation half-reaction?

- (1) $\text{Zn}(s) + 2e^- \rightarrow \text{Zn}^{2+}(\text{aq})$
- (2) $\text{Zn}(s) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2e^-$
- (3) $\text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu}(s) + 2e^-$
- (4) $\text{Cu}^{2+}(\text{aq}) + 2e^- \rightarrow \text{Cu}(s)$

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 71 through 73 on the diagram of a voltaic cell and the balanced ionic equation below.



71 What is the total number of moles of electrons needed to completely reduce 6.0 moles of $\text{Ni}^{2+}(\text{aq})$ ions? [1]

72 Identify *one* metal from Reference Table J that is more easily oxidized than Mg(s) . [1]

73 Explain the function of the salt bridge in the voltaic cell. [1]

71 _____ mol

72 _____

73 _____

January 2005

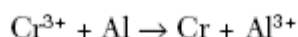
23 Which change in oxidation number indicates oxidation?

- (1) -1 to $+2$ (3) $+2$ to -3
 (2) -1 to -2 (4) $+3$ to $+2$

45 Which half-reaction can occur at the anode in a voltaic cell?

- (1) $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$ (3) $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$
 (2) $\text{Sn} + 2\text{e}^- \rightarrow \text{Sn}^{2+}$ (4) $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+} + \text{e}^-$

24 Given the redox reaction:



As the reaction takes place, there is a transfer of

- (1) electrons from Al to Cr^{3+}
 (2) electrons from Cr^{3+} to Al
 (3) protons from Al to Cr^{3+}
 (4) protons from Cr^{3+} to Al

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 80 and 81 on the information below.

The outer structure of the Statue of Liberty is made of copper metal. The framework is made of iron. Over time, a thin green layer (patina) forms on the copper surface.

80 When copper oxidized to form this patina layer, the copper atoms became copper(II) ions (Cu^{2+}). Write a balanced half-reaction for this oxidation of copper. [1]

81 Where the iron framework came in contact with the copper surface, a reaction occurred in which iron was oxidized. Using information from Reference Table J, explain why the iron was oxidized. [1]

80 _____

81 _____

August 2004

24 Which half-reaction correctly represents reduction?

- (1) $\text{Ag} \rightarrow \text{Ag}^+ + e^-$ (3) $\text{Au}^{3+} + 3e^- \rightarrow \text{Au}$
(2) $\text{F}_2 \rightarrow 2\text{F}^- + 2e^-$ (4) $\text{Fe}^{2+} + e^- \rightarrow \text{Fe}^{3+}$

25 In a redox reaction, how does the total number of electrons lost by the oxidized substance compare to the total number of electrons gained by the reduced substance?

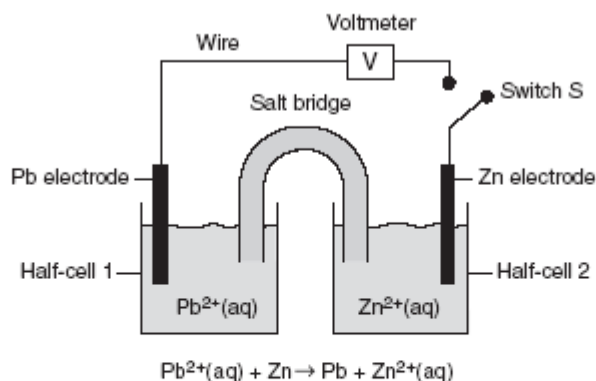
- (1) The number lost is always greater than the number gained.
(2) The number lost is always equal to the number gained.
(3) The number lost is sometimes equal to the number gained.
(4) The number lost is sometimes less than the number gained.

26 Which reaction is an example of an oxidation-reduction reaction?

- (1) $\text{AgNO}_3 + \text{KI} \rightarrow \text{AgI} + \text{KNO}_3$
(2) $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
(3) $2\text{KOH} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$
(4) $\text{Ba}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O}$

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 76 through 78 on the diagram below, which represents a voltaic cell at 298 K and 1 atm.



76 In which half-cell will oxidation occur when switch S is closed? [1]

77 Write the balanced half-reaction equation that will occur in half-cell 1 when switch S is closed. [1]

78 Describe the direction of electron flow between the electrodes when switch S is closed. [1]

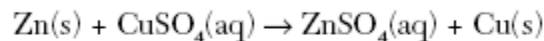
76 _____

77 _____

78 _____

June 2004

26 Given the reaction that occurs in an electrochemical cell:



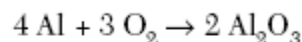
During this reaction, the oxidation number of Zn changes from

- (1) 0 to +2 (3) +2 to 0
 (2) 0 to -2 (4) -2 to 0

27 A voltaic cell spontaneously converts

- (1) electrical energy to chemical energy
 (2) chemical energy to electrical energy
 (3) electrical energy to nuclear energy
 (4) nuclear energy to electrical energy

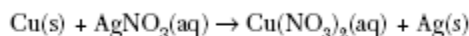
48 Given the reaction for the corrosion of aluminum:



Which half-reaction correctly represents the oxidation that occurs?

- (1) $\text{Al} + 3\text{e}^- \rightarrow \text{Al}^{3+}$
 (2) $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$
 (3) $\text{O}_2 + 4\text{e}^- \rightarrow 2 \text{O}^{2-}$
 (4) $\text{O}_2 \rightarrow 2 \text{O}^{2-} + 4\text{e}^-$

Base your answers to questions 54 and 55 on the unbalanced redox reaction below.



54 Write the reduction half-reaction. [1]

55 Balance the redox equation in *your answer booklet*, using the smallest whole-number coefficients. [1]

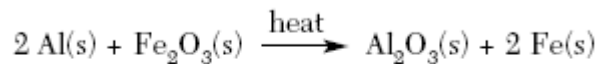
54 _____

55 _____ $\text{Cu}(\text{s}) +$ _____ $\text{AgNO}_3(\text{aq}) \rightarrow$ _____ $\text{Cu}(\text{NO}_3)_2(\text{aq}) +$ _____ $\text{Ag}(\text{s})$

Unit 8 - Oxidation/Reduction (REDOX)

January 2004

23 Given the reaction:



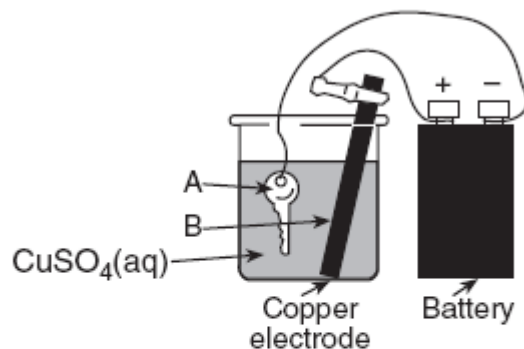
Which species undergoes reduction?

- (1) Al (3) Al^{3+}
(2) Fe (4) Fe^{3+}

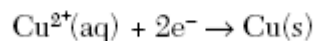
24 Which energy transformation occurs when an electrolytic cell is in operation?

- (1) chemical energy \rightarrow electrical energy
(2) electrical energy \rightarrow chemical energy
(3) light energy \rightarrow heat energy
(4) light energy \rightarrow chemical energy

44 The diagram below shows a key being plated with copper in an electrolytic cell.



Given the reduction reaction for this cell:

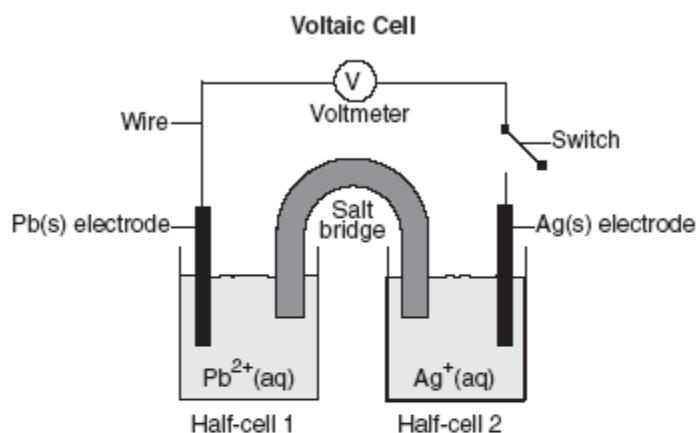


This reduction occurs at

- (1) A, which is the anode
(2) A, which is the cathode
(3) B, which is the anode
(4) B, which is the cathode

Unit 8 - Oxidation/Reduction (REDOX)

Base your answers to questions 59 through 61 on the diagram of the voltaic cell below.



- 59 When the switch is closed, in which half-cell does oxidation occur? [1]
- 60 When the switch is closed, state the direction that electrons will flow through the wire. [1]
- 61 Based on the given equation, write the balanced half-reaction that occurs in half-cell 1. [1]

59 _____

60 _____

61 _____

August 2003

- 21 Which type of reaction occurs when nonmetal atoms become negative nonmetal ions?
- (1) oxidation (3) substitution
(2) reduction (4) condensation
- 27 Given the reaction:
- $$\text{Zn}(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g})$$
- Which statement correctly describes what occurs when this reaction takes place in a closed system?
- (1) Atoms of Zn(s) lose electrons and are oxidized.
(2) Atoms of Zn(s) gain electrons and are reduced.
(3) There is a net loss of mass.
(4) There is a net gain of mass.
- 53 Given the reaction: $\text{Cl}_2 + 2 \text{HBr} \rightarrow \text{Br}_2 + 2 \text{HCl}$
- Write a correctly balanced reduction half-reaction for this equation. [1]
- 48 A voltaic cell differs from an electrolytic cell in that in a voltaic cell
- (1) energy is produced when the reaction occurs
(2) energy is required for the reaction to occur
(3) both oxidation and reduction occur
(4) neither oxidation nor reduction occurs
- 49 What is the purpose of the salt bridge in a voltaic cell?
- (1) It blocks the flow of electrons.
(2) It blocks the flow of positive and negative ions.
(3) It is a path for the flow of electrons.
(4) It is a path for the flow of positive and negative ions.

53 _____

Unit 8 - Oxidation/Reduction (REDOX)

June 2003

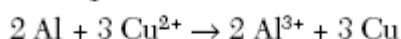
26 In which substance does chlorine have an oxidation number of +1?

- (1) Cl_2 (3) HClO
(2) HCl (4) HClO_2

27 Which statement is true for any electrochemical cell?

- (1) Oxidation occurs at the anode, only.
(2) Reduction occurs at the anode, only.
(3) Oxidation occurs at both the anode and the cathode.
(4) Reduction occurs at both the anode and the cathode.

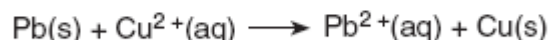
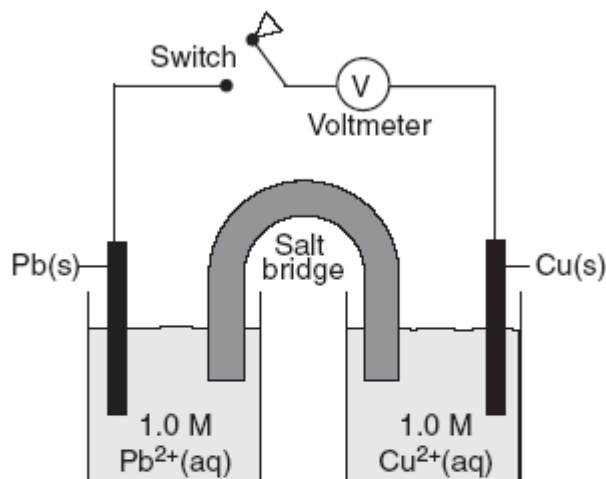
28 Given the equation:



The reduction half-reaction is

- (1) $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$ (3) $\text{Al} + 3\text{e}^- \rightarrow \text{Al}^{3+}$
(2) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ (4) $\text{Cu}^{2+} \rightarrow \text{Cu} + 2\text{e}^-$

46 A diagram of a chemical cell and an equation are shown below.



When the switch is closed, electrons will flow from

- (1) the Pb(s) to the Cu(s)
(2) the Cu(s) to the Pb(s)
(3) the $\text{Pb}^{2+}(\text{aq})$ to the Pb(s)
(4) the $\text{Cu}^{2+}(\text{aq})$ to the Cu(s)

63 State one difference between voltaic cells and electrolytic cells. Include information about *both* types of cells in your answer. [1]

63 _____

January 2003

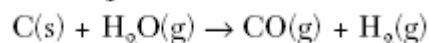
4 In which compound does chlorine have the highest oxidation number?

- (1) NaClO (3) NaClO_3
(2) NaClO_2 (4) NaClO_4

27 When a neutral atom undergoes oxidation, the atom's oxidation state

- (1) decreases as it gains electrons
(2) decreases as it loses electrons
(3) increases as it gains electrons
(4) increases as it loses electrons

28 Given the equation:



Which species undergoes reduction?

- (1) C(s) (3) C^{2+}
(2) H^+ (4) $\text{H}_2(\text{g})$

Unit 8 - Oxidation/Reduction (REDOX)

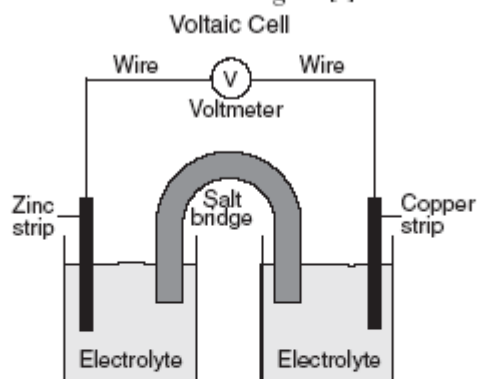
Base your answers to questions 53 through 55 on the diagram of a voltaic cell provided in *your answer booklet* and on your knowledge of chemistry.

53 On the diagram provided in *your answer booklet*, indicate with one or more arrows the direction of electron flow through the wire. [1]

54 Write an equation for the half-reaction that occurs at the zinc electrode. [1]

55 Explain the function of the salt bridge. [1]

53



54

55
