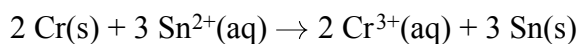


- \_\_\_\_\_ 1. What is the oxidation number of manganese in  $\text{KMnO}_4$ ?
- 1) +7    2) +2    3) +3    4) +4
- \_\_\_\_\_ 2. What is the oxidation state of nitrogen in  $\text{NaNO}_2$ ?
- 1) +1    2) +2    3) +3    4) +4
- \_\_\_\_\_ 3. In which substance does hydrogen have an oxidation number of zero?
- 1)  $\text{LiH}$     2)  $\text{H}_2\text{O}$     3)  $\text{H}_2\text{S}$     4)  $\text{H}_2$
- \_\_\_\_\_ 4. In an oxidation-reduction reaction, the number of electrons lost is
- 1) equal to the number of electrons gained  
2) equal to the number of protons gained  
3) less than the number of electrons gained  
4) less than the number of protons gained
- \_\_\_\_\_ 5. The transfer of which particle is required for a redox reaction to occur?
- 1) electron                      3) neutron  
2) ion                              4) proton
- \_\_\_\_\_ 6. Given the reaction that occurs in an electrochemical cell:
- $$\text{Zn(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu(s)}$$
- 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
- \_\_\_\_\_ 7. Which half-reaction correctly represents reduction?
- 1)  $\text{Mn}^{4+} \rightarrow \text{Mn}^{3+} + \text{e}^-$   
2)  $\text{Mn}^{4+} \rightarrow \text{Mn}^{7+} + 3\text{e}^-$   
3)  $\text{Mn}^{4+} + \text{e}^- \rightarrow \text{Mn}^{3+}$   
4)  $\text{Mn}^{4+} + 3\text{e}^- \rightarrow \text{Mn}^{7+}$
- \_\_\_\_\_ 8. Which changes occur when  $\text{Pt}^{2+}$  is reduced?
- 1) The  $\text{Pt}^{2+}$  gains electrons and its oxidation number increases.  
2) The  $\text{Pt}^{2+}$  gains electrons and its oxidation number decreases.  
3) The  $\text{Pt}^{2+}$  loses electrons and its oxidation number increases.  
4) The  $\text{Pt}^{2+}$  loses electrons and its oxidation number decreases.

- \_\_\_\_\_ 9. Given the balanced ionic equation:
- $$\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$$
- Which equation represents the oxidation half-reaction?
- 1)  $\text{Zn(s)} + 2\text{e}^- \rightarrow \text{Zn}^{2+}(\text{aq})$   
2)  $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$   
3)  $\text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu(s)} + 2\text{e}^-$   
4)  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$
- \_\_\_\_\_ 10. Given the lead-acid battery reaction:
- $$\text{Pb} + \text{PbO}_2 + 2 \text{H}_2\text{SO}_4 \rightarrow 2 \text{PbSO}_4 + 2 \text{H}_2\text{O}$$
- Which electronic equation represents the half-reaction for the oxidation that occurs?
- 1)  $\text{Pb} \rightarrow \text{Pb}^{2+} + 2 \text{e}^-$     3)  $\text{Pb}^{2+} + 2 \text{e}^- \rightarrow \text{Pb}$   
2)  $\text{Pb}^{4+} + 4 \text{e}^- \rightarrow \text{Pb}$     4)  $\text{Pb} \rightarrow \text{Pb}^{4+} + 4 \text{e}^-$
- \_\_\_\_\_ 11. What occurs during the reaction below?
- $$4 \text{HCl} + \text{MnO}_2 \rightarrow \text{MnCl}_2 + 2 \text{H}_2\text{O} + \text{Cl}_2$$
- 1) The manganese is reduced and its oxidation number changes from +4 to +2.  
2) The manganese is oxidized and its oxidation number changes from +4 to +2.  
3) The manganese is reduced and its oxidation number changes from +2 to +4.  
4) The manganese is oxidized and its oxidation number changes from +2 to +4.
- \_\_\_\_\_ 12. Given the cell reaction:
- $$\text{Ca(s)} + \text{Mg}^{2+}(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{Mg(s)}$$
- Which substance was oxidized?
- 1)  $\text{Ca(s)}$                       3)  $\text{Ca}^{2+}(\text{aq})$   
2)  $\text{Mg}^{2+}(\text{aq})$                 4)  $\text{Mg(s)}$
- \_\_\_\_\_ 13. Given the redox reaction:
- $$\text{Mg(s)} + \text{CuSO}_4(\text{aq}) \rightarrow \text{MgSO}_4(\text{aq}) + \text{Cu(s)}$$
- Which species acts as the oxidizing agent?
- 1)  $\text{Cu(s)}$                       3)  $\text{Mg(s)}$   
2)  $\text{Cu}^{2+}(\text{aq})$                 4)  $\text{Mg}^{2+}(\text{aq})$

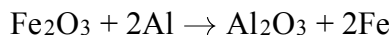
14. Given the redox reaction:



Which species serves as the reducing agent?

- 1) Cr    2)  $\text{Sn}^{2+}$     3)  $\text{Cr}^{3+}$     4) Sn

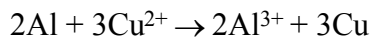
15. Given the balanced equation representing a reaction:



During this reaction, the oxidation number of Fe changes from

- 1) +2 to 0 as electrons are transferred  
2) +2 to 0 as protons are transferred  
3) +3 to 0 as electrons are transferred  
4) +3 to 0 as protons are transferred

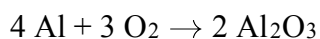
16. Given the balanced equation representing a redox reaction:



Which statement is true about this reaction?

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

17. Given the reaction for the corrosion of aluminum:



Which half-reaction correctly represents the oxidation that occurs?

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

18. Which half-reaction correctly represents reduction?

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

19. 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)  $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$

20. Given the equations A, B, C, and D:

- (A)  $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$  (B)  $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HClO} + \text{HCl}$   
(C)  $\text{CuO} + \text{CO} \rightarrow \text{CO}_2 + \text{Cu}$   
(D)  $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

Which two equations represent redox reactions?

- 1) A and B                      3) C and A  
2) B and C                      4) D and B

21. Which metal reacts spontaneously with a solution containing zinc ions?

- 1) magnesium                  3) copper  
2) nickel                         4) silver

22. According to Reference Table J, which of these ions is most easily reduced?

- 1)  $\text{Ca}^{2+}$     2)  $\text{Cr}^{3+}$     3)  $\text{Cu}^+$     4)  $\text{Ag}^+$

23. Based on Reference Table J, which reaction will take place spontaneously?

- 1)  $\text{Mg}(s) + \text{Ca}^{2+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{Ca}(s)$   
2)  $\text{Ba}(s) + 2 \text{Na}^+(\text{aq}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2 \text{Na}(s)$   
3)  $\text{Cl}_2(\text{g}) + 2 \text{F}^-(\text{aq}) \rightarrow 2 \text{Cl}^-(\text{aq}) + \text{F}_2(\text{g})$   
4)  $\text{I}_2(\text{g}) + 2 \text{Br}^-(\text{aq}) \rightarrow 2 \text{I}^-(\text{aq}) + \text{Br}_2(\text{g})$

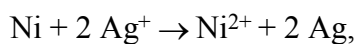
24. According to reference Table J, which reaction will occur spontaneously?

- 1)  $\text{Co}^{2+} + \text{Cu}(s) \rightarrow \text{Co}(s) + \text{Cu}^{2+}$   
2)  $\text{Ag}^+ + \text{Cu}(s) \rightarrow \text{Ag}(s) + \text{Cu}^+$   
3)  $\text{Fe}^{2+} + \text{Hg}(e) \rightarrow \text{Fe}(s) + \text{Hg}^{2+}$   
4)  $\text{Mg}^{2+} + \text{Sn}^{2+} \rightarrow \text{Mg}(s) + \text{Sn}^{4+}$

25. When an equation is correctly balanced, it must show conservation of

- 1) charge but not of mass  
2) mass but not of charge  
3) both charge and mass  
4) neither charge nor mass

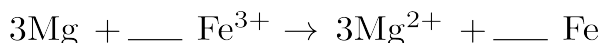
26. In the reaction



what is the total number of moles of electrons lost by 1 mole of Ni?

- 1) 1    2) 2    3) 0.5    4) 4

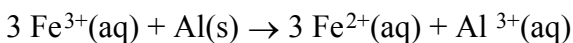
27. Given the unbalanced ionic equation:



When this equation is balanced, both  $\text{Fe}^{3+}$  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

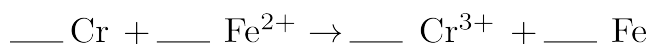
28. Given the balanced equation:



What is the total number of moles of electrons lost by 2 moles of  $\text{Al}(\text{s})$ ?

- 1) 1 mole                      3) 3 moles  
2) 6 moles                     4) 9 moles

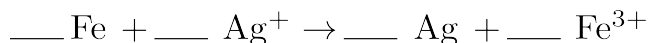
29. Given the reaction:



When the reaction is completely balanced using the smallest whole number coefficients, the sum of the coefficients is

- 1) 10    2) 6    3) 3    4) 4

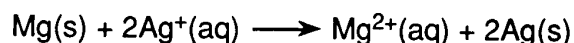
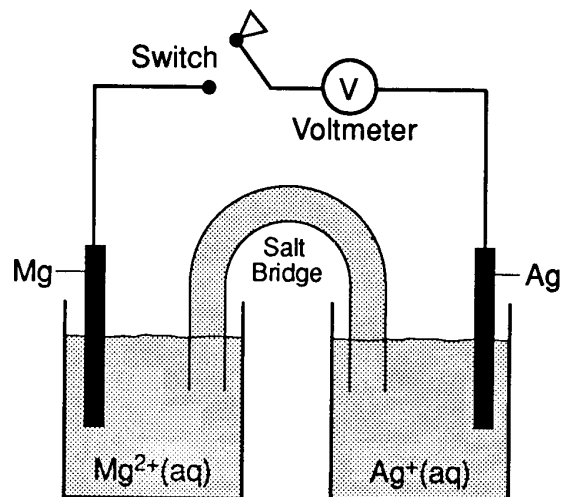
30. Given the unbalanced equation:



When the equation is correctly balanced using smallest whole numbers, the coefficient of  $\text{Ag}^+$  is

- 1) 5    2) 2    3) 3    4) 4

31. Base your answer to the following question on the equation and diagram below represent an electrochemical cell at 298 K and 1 atmosphere.



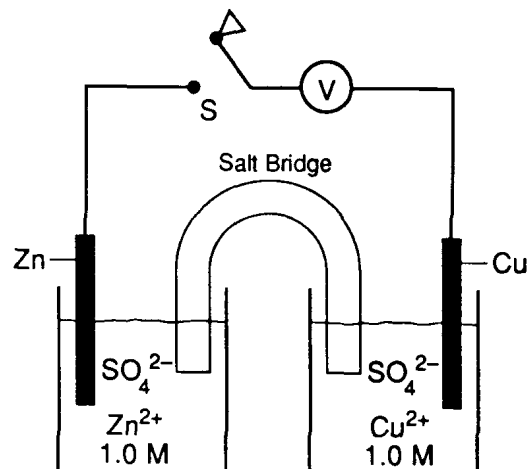
Which species is oxidized when the switch is closed?

- 1)  $\text{Mg}(\text{s})$                       3)  $\text{Ag}(\text{s})$   
2)  $\text{Mg}^{2+}(\text{aq})$                 4)  $\text{Ag}^+(\text{aq})$

32. The type of reaction in an electrochemical cell is best described as a

- 1) spontaneous oxidation reaction, only  
2) non-spontaneous oxidation reaction, only  
3) spontaneous oxidation-reduction reaction  
4) non-spontaneous oxidation-reduction reaction

33. Base your answer to the following question on the diagram below which represents a chemical cell at 298 K and 1 atmosphere.



Which species represents the cathode?

- 1) Zn    2)  $\text{Zn}^{2+}$     3) Cu    4)  $\text{Cu}^{2+}$

34. In a chemical cell composed of two half-cells, ions are allowed to flow from one half-cell to another by means of

- 1) electrodes
- 2) a voltmeter
- 3) an external conductor
- 4) a salt bridge

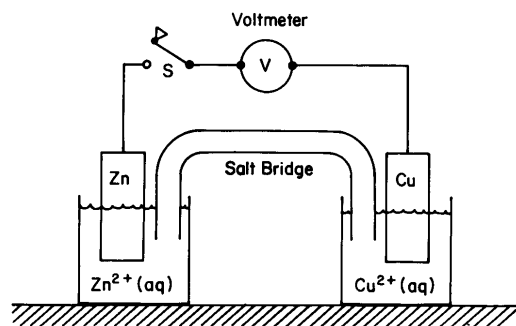
35. Given the overall cell reaction:



Which will occur as the cell operates?

- 1) The amount of Zn(s) will increase.
- 2) The amount of Ag(s) will decrease.
- 3) The concentration of  $\text{Zn}^{2+}(\text{aq})$  will increase.
- 4) The concentration of  $\text{Ag}^+(\text{aq})$  will increase.

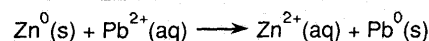
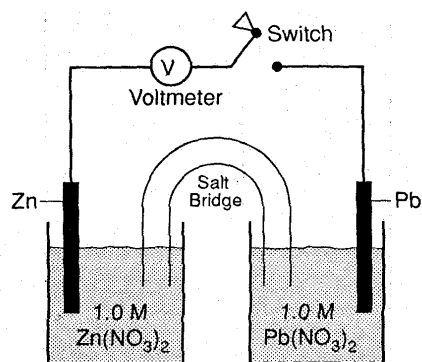
36. The diagram below represents an electrochemical cell.



When switch  $S$  is closed, which particles undergo reduction?

- 1)  $\text{Zn}^{2+}$  ions
- 2) Zn atoms
- 3)  $\text{Cu}^{2+}$  ions
- 4) Cu atoms

37. Base your answer to the following question on the diagram of the chemical cell shown below. The reaction occurs at 1 atmosphere and 298 K.



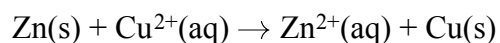
When the switch is closed, what occurs?

- 1) Pb is oxidized and electrons flow to the Zn electrode.
- 2) Pb is reduced and electrons flow to the Zn electrode.
- 3) Zn is oxidized and electrons flow to the Pb electrode.
- 4) Zn is reduced and electrons flow to the Pb electrode.

38. 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.

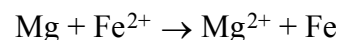
39. Given the reaction:



What is the net potential ( $E^\circ$ ) for the overall reaction?

- 1)  $-1.10 \text{ V}$
- 2)  $-0.42 \text{ V}$
- 3)  $+0.42 \text{ V}$
- 4)  $+1.10 \text{ V}$

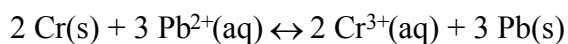
40. Given the reaction:



What is the net cell potential ( $E^\circ$ ) for the overall reaction?

- 1)  $0.45 \text{ V}$
- 2)  $1.92 \text{ V}$
- 3)  $2.37 \text{ V}$
- 4)  $2.82 \text{ V}$

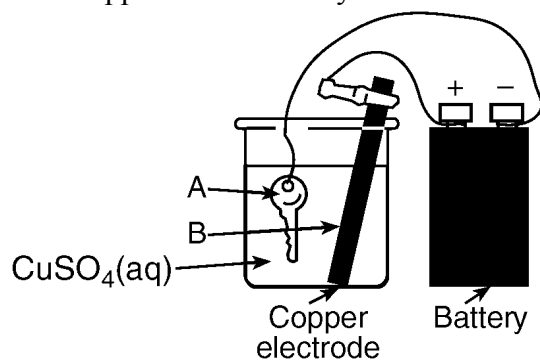
41. Given the reaction:



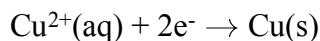
The cell voltage ( $E^0$ ) for the overall reaction is

- 1) 0.61 volt
- 2) 0.87 volt
- 3) 1.09 volts
- 4) 1.87 volts

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



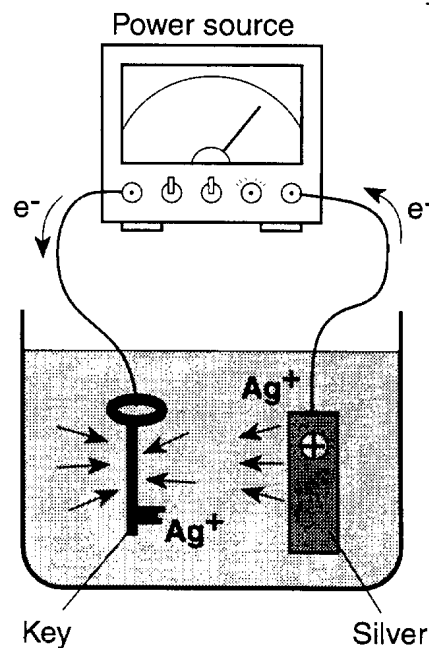
Given the reduction reaction for this cell:



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

43. Which statement best describes the key?



- 1) It acts as the cathode and is negative.
- 2) It acts as the cathode and is positive.
- 3) It acts as the anode and is negative.
- 4) It acts as the anode and is positive.

44. In both the electrochemical cell and the electrolytic cell, the anode is the electrode at which

- 1) reduction occurs and electrons are lost
- 2) reduction occurs and protons are lost
- 3) oxidation occurs and electrons are lost
- 4) oxidation occurs and protons are lost

45. In an electrolytic cell, to which electrode will a positive ion migrate and undergo reduction?

- 1) the anode, which is negatively charged
- 2) the anode, which is positively charged
- 3) the cathode, which is negatively charged
- 4) the cathode, which is positively charged

46. Which procedure requires the use of an external electric current to force a redox reaction to occur?

- 1) polymerization
- 2) distillation
- 3) electrolysis
- 4) saponification

47. In an electrolytic cell, the positive electrode is the

- 1) anode, where oxidation occurs
- 2) anode, where reduction occurs
- 3) cathode, where oxidation occurs
- 4) cathode, where reduction occurs