

1. Chlorine has an oxidation state of +3 in the compound  
A) HClO                      **B) HClO<sub>2</sub>**  
C) HClO<sub>3</sub>                    D) HClO<sub>4</sub>
2. What is the oxidation number of iodine in KIO<sub>4</sub>?  
A) +1    B) -1    **C) +7**    D) -7
3. What is the oxidation number of chromium in the chromate ion, CrO<sub>4</sub><sup>2-</sup>?  
**A) +6**    B) +2    C) +3    D) +8
4. In which substance does phosphorus have a +3 oxidation state?  
A) P<sub>4</sub>O<sub>10</sub>                    B) PCl<sub>5</sub>  
C) Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>              **D) KH<sub>2</sub>PO<sub>3</sub>**
5. What is the oxidation number of oxygen in OF<sub>2</sub>?  
A) +1    **B) +2**    C) -1    D) -2
6. 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?  
**A) Pb → Pb<sup>2+</sup> + 2 e<sup>-</sup>**    B) Pb<sup>4+</sup> + 4 e<sup>-</sup> → Pb  
C) Pb<sup>2+</sup> + 2 e<sup>-</sup> → Pb    D) Pb → Pb<sup>4+</sup> + 4 e<sup>-</sup>
7. Which particles are gained and lost during a redox reaction?  
**A) electrons**              B) protons  
C) neutrons                D) positrons
8. When a redox reaction occurs, there must be a transfer of  
**A) electrons**              B) neutrons  
C) protons                 D) ions
9. Half-reactions can be written to represent all  
A) double-replacement reactions  
B) neutralization reactions  
C) fission and fusion reactions  
**D) oxidation and reduction reactions**
10. Which half-reaction correctly represents oxidation?  
A) Sn<sup>2+</sup> + 2e<sup>-</sup> → Sn<sup>0</sup>    B) Sn<sup>4+</sup> + 2e<sup>-</sup> → Sn<sup>2+</sup>  
C) Sn<sup>2+</sup> → Sn<sup>0</sup> + 2e<sup>-</sup>    **D) Sn<sup>2+</sup> → Sn<sup>4+</sup> + 2e<sup>-</sup>**

11. In a chemical reaction, as a species is oxidized, its oxidation number  
A) decreases                      **B) increases**  
C) remains the same
12. In the reaction
- $$\text{H}_3\text{O}^+ + \text{OH}^- \rightarrow 2 \text{H}_2\text{O},$$
- the oxidation number of oxygen  
A) decreases                      B) increases  
**C) remains the same**

## Regents review Electrochemistry(redox)

13. Given the lead-acid battery reaction:

*InvalidEquation*

When the reaction produces electricity, which element changes its oxidation state?

- A) Pb                      B) S                      C) O                      D) H

14. During which process does an atom gain one or more electrons?

- A) transmutation                      **B) reduction**  
 C) oxidation                      D) neutralization

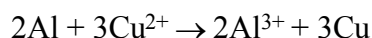
15. As a sodium atom is oxidized, the number of protons in its nucleus

- A) decreases                      B) increases  
**C) remains the same**

16. Which half-reaction correctly represents reduction?

- A)  $\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^-$                       B)  $\text{F}_2 \rightarrow 2 \text{F}^- + 2\text{e}^-$   
**C)  $\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$**                       D)  $\text{Fe}^{2+} + \text{e}^- \rightarrow \text{Fe}^{3+}$

17. Given the balanced equation representing a redox reaction:



Which statement is true about this reaction?

- A) Each Al loses  $2\text{e}^-$  and each  $\text{Cu}^{2+}$  gains  $3\text{e}^-$ .  
**B) Each Al loses  $3\text{e}^-$  and each  $\text{Cu}^{2+}$  gains  $2\text{e}^-$ .**  
 C) Each  $\text{Al}^{3+}$  gains  $2\text{e}^-$  and each Cu loses  $3\text{e}^-$ .  
 D) Each  $\text{Al}^{3+}$  gains  $3\text{e}^-$  and each Cu loses  $2\text{e}^-$ .

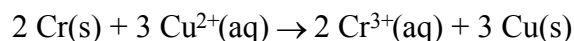
18. Which half-reaction equation represents the reduction of an iron(II) ion?

- A)  $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$                       **B)  $\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$**   
 C)  $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$                       D)  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$

19. Which half-reaction equation represents the reduction of a potassium ion?

- A)  $\text{K}^+ + \text{e}^- \rightarrow \text{K}$**                       B)  $\text{K} + \text{e}^- \rightarrow \text{K}^+$   
 C)  $\text{K}^+ \rightarrow \text{K} + \text{e}^-$                       D)  $\text{K} \rightarrow \text{K}^+ + \text{e}^-$

20. Base your answer to the following question on the reaction below



The electronic equation that represents the oxidation reaction that occurs is

- A)  $2\text{Cr}^0 - 6\text{e}^- \rightarrow 2\text{Cr}^{3+}$**   
 B)  $2\text{Cr}^0 + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}$   
 C)  $2\text{Cr}^{3+} - 6\text{e}^- \rightarrow 2\text{Cr}^0$   
 D)  $2\text{Cr}^{3+} + 6\text{e}^- \rightarrow 2\text{Cr}^0$

21. Which equation represents an oxidation-reduction reaction?

- A)  $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$   
**B)  $4 \text{HCl} + \text{MnO}_2 \rightarrow \text{MnCl}_2 + 2 \text{H}_2\text{O} + \text{Cl}_2$**   
 C)  $2 \text{HCl} + \text{CaCO}_3 \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$   
 D)  $2 \text{HCl} + \text{FeS} \rightarrow \text{FeCl}_2 + \text{H}_2\text{S}$

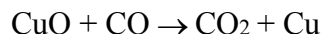
22. Which is a redox reaction?

- A)  $\text{Mg} + 2 \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$**   
 B)  $\text{Mg}(\text{OH})_2 + 2 \text{HCl} \rightarrow \text{MgCl}_2 + 2 \text{H}_2\text{O}$   
 C)  $\text{Mg}^{2+}(\text{aq}) + 2 \text{OH}^-(\text{aq}) \rightarrow \text{Mg}(\text{OH})_2$   
 D)  $\text{MgCl}_2 + 6 \text{H}_2\text{O} \rightarrow \text{MgCl}_2 \cdot 6 \text{H}_2\text{O}$

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

- A)  $2\text{Ca}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CaO}(\text{s})$**   
 B)  $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{KNO}_3(\text{aq})$   
 C)  $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$   
 D)  $\text{H}_3\text{O}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\ell)$

24. The reaction



is an example of

- A) reduction, only  
 B) oxidation, only  
**C) both oxidation and reduction**  
 D) neither oxidation nor reduction

## Regents review Electrochemistry(redox)

25. Which balanced equation represents a redox reaction?

- A)  $\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl} + \text{NaNO}_3$   
 B)  $\text{BaCl}_2 + \text{K}_2\text{CO}_3 \rightarrow \text{BaCO}_3 + 2\text{KCl}$   
**C)  $\text{CuO} + \text{CO} \rightarrow \text{Cu} + \text{CO}_2$**   
 D)  $\text{HCl} + \text{KOH} \rightarrow \text{KCl} + \text{H}_2\text{O}$

26. According to Reference Table J, which metal will react with  $\text{Zn}^{2+}$  but will *not* react with  $\text{Mg}^{2+}$ ?

- A) Al(s)** B) Cu(s) C) Ni(s) D) Ba(s)

27. According to Reference Table J, which of these metals will react most readily with 1.0 M HCl to produce  $\text{H}_2$  (g)?

- A) Ca **B) K** C) Mg D) Zn

28. According to Reference Table J, which species is the strongest oxidizing agent?

- A) Li(s) B)  $\text{Li}^+$  **C)  $\text{F}_2(\text{g})$**  D)  $\text{F}^-$

29. According to Reference Table J, which ion will oxidize Fe?

- A)  $\text{Zn}^{2+}$  B)  $\text{Ca}^{2+}$  C)  $\text{Mg}^{2+}$  **D)  $\text{Cu}^{2+}$**

30. Under standard conditions, which metal will react with 0.1 M HCl to liberate hydrogen gas?

- A) Ag B) Au C) Cu **D) Mg**

31. Which half-reaction for the reduction of  $\text{Al}^{3+}$  to Al is correctly balanced?

- A)  $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$**  B)  $\text{Al}^{3+} + 3\text{e}^- \rightarrow 3 \text{Al}$   
 C)  $\text{Al}^{3+} \rightarrow \text{Al} + 3\text{e}^-$  D)  $\text{Al}^{3+} \rightarrow 3 \text{Al} + 3\text{e}^-$

32. Which half-reaction shows both the conservation of mass and the conservation of charge?

- A)  $\text{Cl}_2 + 2\text{e}^- \rightarrow 2 \text{Cl}$**  B)  $\text{Cl}_2 \rightarrow \text{Cl}^- + 2\text{e}^-$   
 C)  $2 \text{Br}^- + 2\text{e}^- \rightarrow \text{Br}_2$  D)  $\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$

33. Which equation shows conservation of charge?

- A)  $\text{Fe} \rightarrow \text{Fe}^{2+} + \text{e}^-$  B)  $\text{Fe} + 2\text{e}^- \rightarrow \text{Fe}^{2+}$   
**C)  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$**  D)  $\text{Fe} + 2\text{e}^- \rightarrow \text{Fe}^{3+}$

34. Compared to the amount of mass and total charge at the beginning of a redox reaction, the amount of mass and total charge upon completion of the reaction is

- A) less B) greater  
**C) the same**

35. Given the unbalanced equation:



What is the coefficient of  $\text{Ag}_2\text{S}$  when the equation is completely balanced using the smallest whole numbers?

- A) 6 B) 2 **C) 3** D) 4

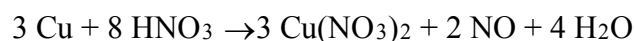
36. Given the unbalanced equation:



When the equation is correctly balanced using smallest whole number coefficients, the coefficient of HCl is

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

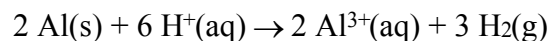
37. Given the equation:



What is the total number of moles of electrons lost by the copper as it completely reacts with 8 moles of nitric acid?

- A) 1 **B) 6** C) 8 D) 4

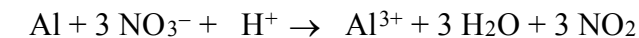
38. Given the balanced equation:



When 2 moles of Al(s) completely reacts, what is the total number of moles of electrons transferred from Al(s) to  $\text{H}^+(\text{aq})$ ?

- A) 5 **B) 6** C) 3 D) 4

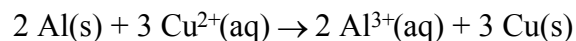
39. When the equation



is completely balanced, the coefficient of Al will be

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

40. Given the equation:



The total number of moles of electrons transferred from 2 Al(s) to  $\text{Cu}^{2+}(\text{aq})$  is

- A) 9 B) 2 C) 3 **D) 6**



50. Given the redox reaction:  
 $2 \text{NiOOH} + \text{Cd} \xrightarrow{\text{discharge}} 2 \text{Ni(OH)}_2 + \text{Cd(OH)}_2$

Which species is oxidized during discharge?

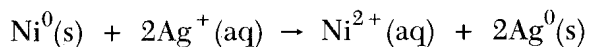
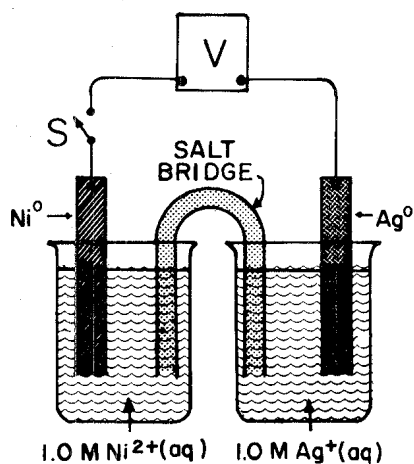
- A) Cd                              B)  $\text{Cd}^{2+}$   
 C)  $\text{Ni(OH)}_3$                   D)  $\text{Ni(OH)}_2$

51. Given the equation for the overall reaction in a lead-acid storage battery:  
 $\text{Pb}(s) + \text{PbO}_2(s) + 2 \text{H}_2\text{SO}_4(aq) \xrightarrow{\text{discharge}} 2 \text{PbSO}_4(s) + 2 \text{H}_2\text{O}(\ell)$

Which occurs during the charging of the battery?

- A) The concentration of  $\text{H}_2\text{SO}_4$  decreases and the number of moles of  $\text{Pb}(s)$  increases.  
 B) The concentration of  $\text{H}_2\text{SO}_4$  decreases and the number of moles of  $\text{H}_2\text{O}(\ell)$  increases.  
 C) The concentration of  $\text{H}_2\text{SO}_4$  increases and the number of moles of  $\text{Pb}(s)$  decreases.  
**D) The concentration of  $\text{H}_2\text{SO}_4$  increases and the number of moles of  $\text{H}_2\text{O}(\ell)$  decreases.**

52. Base your answer to the following question on the diagram of the chemical cell at 298 K and on the equation below.



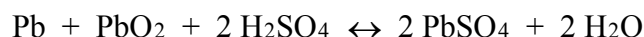
In the given reaction, the  $\text{Ag}^+$  ions

- A) **gain electrons**              B) lose electrons  
 C) gain protons                  D) lose protons

53. The electricity produced by a battery results from

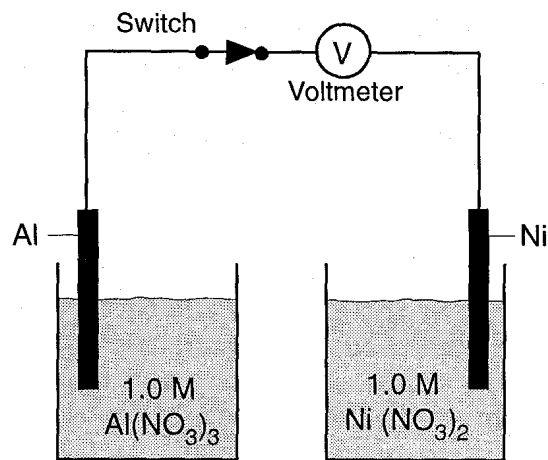
- A) an oxidation reaction, only  
 B) a reduction reaction, only  
**C) both an oxidation reaction and a reduction reaction**  
 D) neither an oxidation reaction nor a reduction reaction

54. What occurs during discharge in the lead-acid battery reaction below?



- A) Both Pb and  $\text{Pb}^{4+}$  undergo oxidation.  
 B) Both Pb and  $\text{Pb}^{4+}$  undergo reduction.  
**C) Pb is oxidized and  $\text{Pb}^{4+}$  is reduced.**  
 D) Neither the Pb nor the  $\text{Pb}^{4+}$  is oxidized or reduced.

55. The diagram below represents a chemical cell.



In order for the cell to operate, it should be provided with

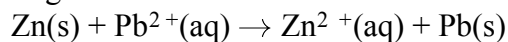
- A) a cathode  
 B) an anode  
**C) a salt bridge**  
 D) an external path for electrons

## Regents review Electrochemistry(redox)

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

- A) Both occur at the anode.
- B) Both occur at the cathode.
- C) Oxidation occurs at the anode and reduction occurs at the cathode.**
- D) Oxidation occurs at the cathode and reduction occurs at the anode.

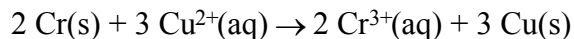
57. Given the balanced equation representing the reaction occurring in a voltaic cell:



In the completed external circuit, the electrons flow from

- A) Pb(s) to Zn(s)
- B) Pb<sup>2+</sup>(aq) to Zn<sup>2+</sup>(aq)
- C) Zn(s) to Pb(s)**
- D) Zn<sup>2+</sup>(aq) to Pb<sup>2+</sup>(aq)

58. Given the redox reaction:



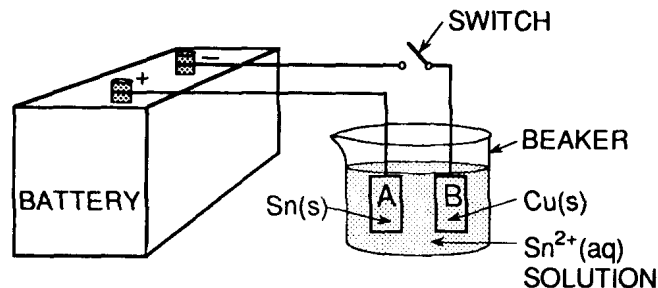
Which reaction occurs at the cathode in an electrochemical cell?

- A) reduction of Cu<sup>2+</sup>(aq)**
- B) reduction of Cu(s)
- C) oxidation of Cr<sup>3+</sup>(aq)
- D) oxidation of Cr(s)

59. What occurs when an electrolytic cell is used for silver-plating a spoon?

- A) A chemical reaction produces an electric current.
- B) An electric current produces a chemical reaction.**
- C) An oxidation reaction takes place at the cathode.
- D) A reduction reaction takes place at the anode.

60. Base your answer to the following question on the diagram below of an electrolytic cell in which the electrodes are tin and copper.



In this electrolytic cell, electrode A is designated as the

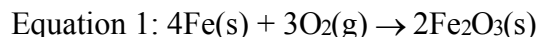
- A) anode and is positive**
- B) anode and is negative
- C) cathode and is positive
- D) cathode and is negative

## Regents review Electrochemistry(redox)

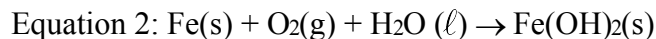
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61. Base your answer to the following question on the information below.

Iron has been used for thousands of years. In the air, iron corrodes. One reaction for the corrosion of iron is represented by the balanced equation below.



In the presence of water, iron corrodes more quickly. This corrosion is represented by the unbalanced equation below.

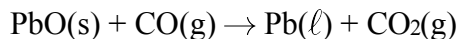


Balance the equation below, using the smallest whole-number coefficients.



Base your answers to questions **62** through **64** on the information below.

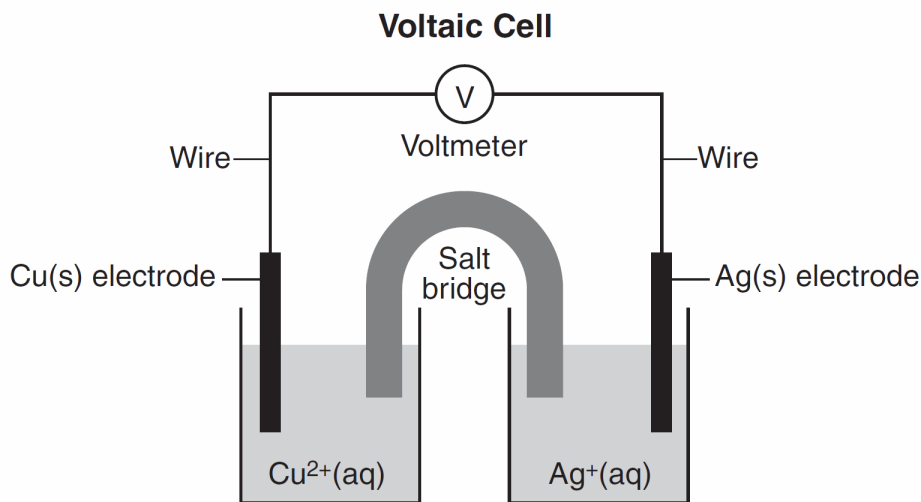
Litharge, PbO, is an ore that can be roasted (heated) in the presence of carbon monoxide, CO, to produce elemental lead. The reaction that takes place during this roasting process is represented by the balanced equation below.



62. Calculate the percent composition by mass of oxygen in litharge (gram-formula mass = 223.2 grams per mole). Your response must include *both* a numerical setup and the calculated result.
63. Determine the oxidation number of carbon in carbon monoxide.
64. Write the balanced equation for the reduction half-reaction that occurs during this roasting process.
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65. Base your answer to the following question on the information below.

The diagram and balanced ionic equation below represent a voltaic cell with copper and silver electrodes and the reaction that occurs when the cell is operating.



State the purpose of the salt bridge in this voltaic cell.

Base your answers to questions **66** and **67** on the information below.

Aluminum is one of the most abundant metals in Earth's crust. The aluminum compound found in bauxite ore is  $\text{Al}_2\text{O}_3$ . 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,  $\text{Na}_3\text{AlF}_6$ , would dissolve bauxite ore. Electrolysis of the resulting mixture caused the aluminum ions in the  $\text{Al}_2\text{O}_3$  to be reduced to molten aluminum metal. This less expensive process is known as the Hall process.

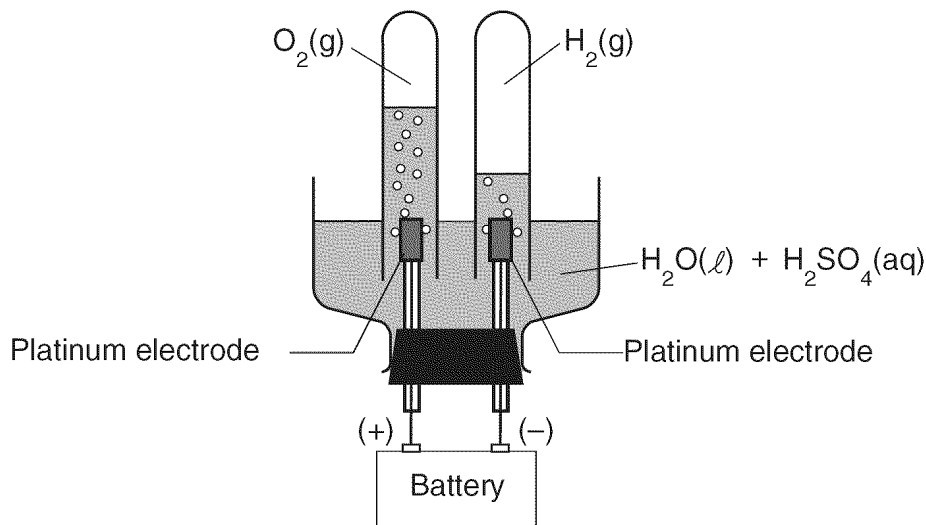
66. Explain, in terms of electrical energy, how the operation of a voltaic cell differs from the operation of an electrolytic cell used in the Hall process. Include *both* the voltaic cell and the electrolytic cell in your answer

67. Write the balanced half-reaction equation for the reduction of  $\text{Al}^{3+}$  to Al.



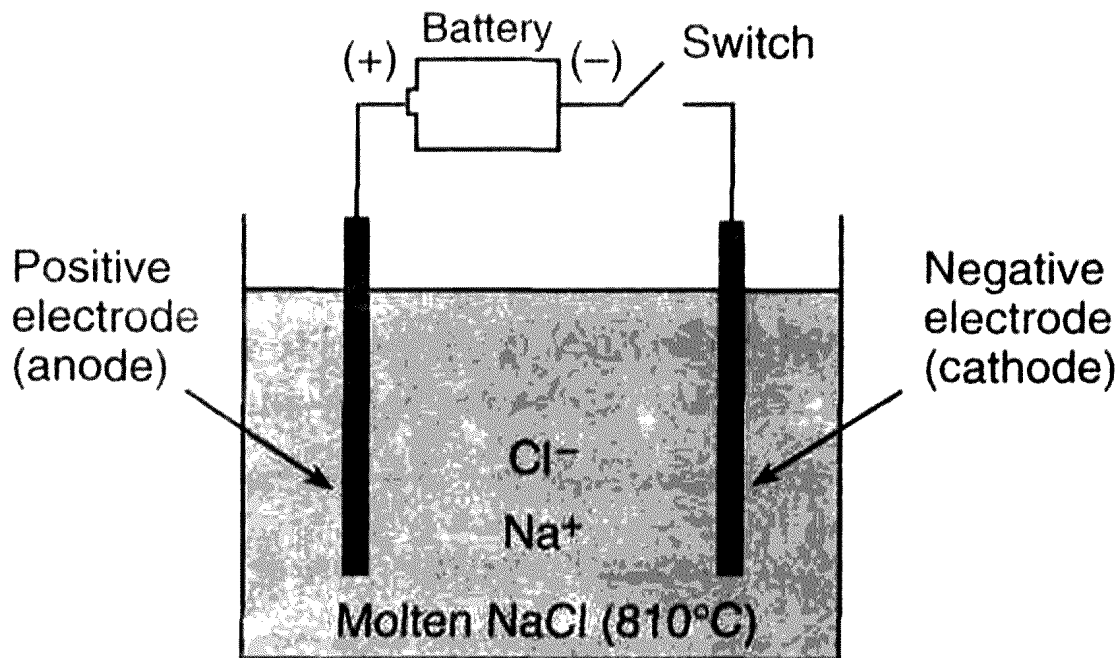
68. Base your answer to the following question on the information and diagram below.

The apparatus shown in the diagram consists of two inert platinum electrodes immersed in water. A small amount of an electrolyte,  $\text{H}_2\text{SO}_4$ , must be added to the water for the reaction to take place. The electrodes are connected to a source that supplies electricity.



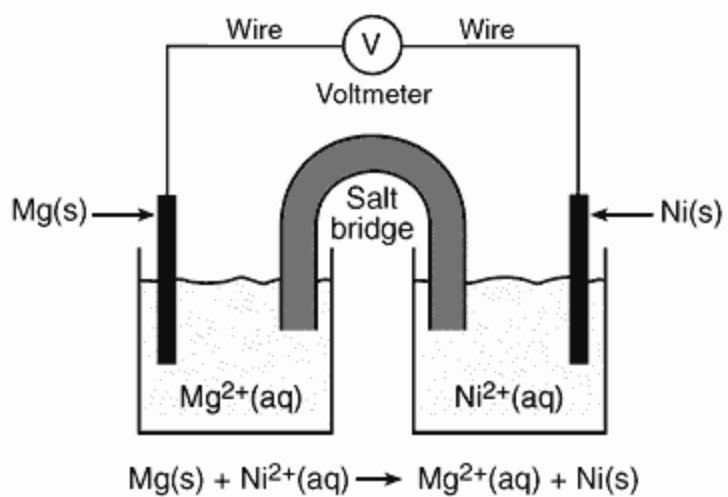
What particles are provided by the electrolyte that allow an electric current to flow?

69. Base your answer to the following question on the diagram and balanced equation below, which represent the electrolysis of molten  $\text{NaCl}$ .



Write the balanced half-reaction for the reduction that occurs in this electrolytic cell.

70. Base your answer to the following question on the diagram of a voltaic cell and the balanced ionic equation below.



Identify *one* metal from your Reference Tables that is more easily oxidized than Mg(s).

Answer Key

Regents review Electrochemistry(redox) 2011-2012

- |   |  |  |   |
|---|--|--|---|
| <p>1. <u>  B  </u></p> <p>2. <u>  C  </u></p> <p>3. <u>  A  </u></p> <p>4. <u>  D  </u></p> <p>5. <u>  B  </u></p> <p>6. <u>  A  </u></p> <p>7. <u>  A  </u></p> <p>8. <u>  A  </u></p> <p>9. <u>  D  </u></p> <p>10. <u> D  </u></p> <p>11. <u> B  </u></p> <p>12. <u> C  </u></p> <p>13. <u> A  </u></p> <p>14. <u> B  </u></p> <p>15. <u> C  </u></p> <p>16. <u> C  </u></p> <p>17. <u> B  </u></p> <p>18. <u> B  </u></p> <p>19. <u> A  </u></p> <p>20. <u> A  </u></p> <p>21. <u> B  </u></p> <p>22. <u> A  </u></p> <p>23. <u> A  </u></p> <p>24. <u> C  </u></p> <p>25. <u> C  </u></p> <p>26. <u> A  </u></p> <p>27. <u> B  </u></p> <p>28. <u> C  </u></p> <p>29. <u> D  </u></p> <p>30. <u> D  </u></p> <p>31. <u> A  </u></p> <p>32. <u> A  </u></p> <p>33. <u> C  </u></p> <p>34. <u> C  </u></p> <p>35. <u> C  </u></p> <p>36. <u> D  </u></p> | <p>37. <u>  B  </u></p> <p>38. <u>  B  </u></p> <p>39. <u>  A  </u></p> <p>40. <u>  D  </u></p> <p>41. <u>  D  </u></p> <p>42. <u>  B  </u></p> <p>43. <u>  C  </u></p> <p>44. <u>  A  </u></p> <p>45. <u>  A  </u></p> <p>46. <u>  D  </u></p> <p>47. <u>  B  </u></p> <p>48. <u>  C  </u></p> <p>49. <u>  A  </u></p> <p>50. <u>  A  </u></p> <p>51. <u>  D  </u></p> <p>52. <u>  A  </u></p> <p>53. <u>  C  </u></p> <p>54. <u>  C  </u></p> <p>55. <u>  C  </u></p> <p>56. <u>  C  </u></p> <p>57. <u>  C  </u></p> <p>58. <u>  A  </u></p> <p>59. <u>  B  </u></p> <p>60. <u>  A  </u></p> <p>61. <u>  2  </u> Fe(s) +<br/> <u>          </u> O<sub>2</sub>(g) + <u>  2  </u><br/> <u>  </u> H<sub>2</sub>O(l) → □ <u>  2  </u><br/> <u>  </u> Fe(OH)<sub>2</sub>(s).</p> | <p>62. allocated as follows:<br/>         • correct numerical setup. Acceptable responses include, but are not limited to:<br/>         • <math>\frac{16.0g/mol}{223.2g/mol} \times 100</math><br/>         • <math>\frac{16(100)}{223.2}</math><br/>         • 7.17% <i>or</i> for a response consistent with the student's numerical setup. Significant figures do <i>not</i> need to be shown. <b>Note:</b> Do <i>not</i> allow credit for a numerical setup and calculated response that are not related to the concept assessed by the question.</p> <p>63. +2.</p> <p>64. Acceptable responses include, but are not limited to: • Pb<sup>2+</sup> + 2e<sup>-</sup> → Pb</p> <p>65. Acceptable responses include, but are not limited to: • The salt bridge allows for the migration of ions between the half-cells. • The salt bridge prevents polarization of the half-cells maintains electrical neutrality</p> <p>66. <i>Examples:</i> – A voltaic cell produces electrical energy and an electrolytic cell used in the Hall process requires electrical energy – Electrolysis uses electrical energy. Voltaic cells produce electrical energy.</p> | <p>67. Al<sup>3+</sup> + 3e<sup>-</sup> → Al</p> <p>68. Examples: – ions – charged particles – H<sub>3</sub>O<sup>+</sup> - SO<sub>4</sub><sup>2-</sup></p> <p>69. • Na<sup>+</sup> + e<sup>-</sup> → Na or 2Na<sup>+</sup> + 2e<sup>-</sup> → 2Na</p> <p>70. Li; Ba; Rb; Sr; K; Ca; Cs; Na</p> |
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