Metallurgy

1. Which one of the following elements is most likely to be found as the free metal in nature?
   A. Ca  
   B. Au  
   C. Al  
   D. Fe  
   E. Zn

2. Which of the following oxides would be most useful as an additive to remove SiO₂ by an acid-base reaction in pyrometallurgy?
   A. V₂O₅  
   B. Mn₂O₇  
   C. CrO₃  
   D. Fe₂O₃  
   E. CaO

3. Which one of the following elements uses hydrometallurgy as an important part in its processing?
   A. Pb  
   B. Cr  
   C. Fe  
   D. Si  
   E. Al

4. The following chemical reactions occur in a blast furnace during the refining of iron ore:
   1. \( 2C(s) + O₂(g) \rightarrow 2CO(g) + \text{heat} \)
   2. \( \text{heat} + C(s) + H₂O(g) \rightarrow CO(g) + H₂(g) \)
   3. \( \text{Fe}_₃\text{O}_₄(s) + 4\text{CO}(g) \rightarrow 3\text{Fe}(l) + 4\text{CO}_₂(g) \)
   4. \( \text{Fe}_₃\text{O}_₄(s) + 4\text{H}_₂(g) \rightarrow 3\text{Fe}(l) + 4\text{H}_₂\text{O}(g) \)
   Which reaction is responsible for cooling the furnace?
   A. Reaction 1  
   B. Reaction 2  
   C. Reaction 3  
   D. Reaction 4  
   E. Reactions 3 and 4
5. The hydrometallurgical process used in refining gold ore entails converting metallic gold to a water-soluble complex. The formula of the complex is __________.

A. \( \text{Au(NH}_3\text{)}_2^+ \)
B. \( \text{Au(NH}_3\text{)}_4^- \)
C. \( \text{Au(CN)}_2^- \)
D. \( \text{Au(CO)}_4^{2-} \)
E. \( \text{Au(CO)}_4^+ \)

6. Processes used to reduce metal ores or to refine metals that are based on the process of electrolysis are collectively referred to as __________.

A. pyrometallurgy
B. hydrometallurgy
C. electrometallurgy
D. calcination
E. roasting

7. One of the ores containing copper is known as chalcocite. What is the oxidation state of copper in \( \text{Cu}_2\text{S} \)?

A. 0
B. +1
C. +2
D. +3
E. +4

8. The respective standard oxidation potentials for \( \text{Cu} \rightarrow \text{Cu}^{2+} \), \( \text{Ni} \rightarrow \text{Ni}^{2+} \), and \( \text{Ag} \rightarrow \text{Ag}^+ \) are (in V) -0.34, +0.28 and -0.80. Impure copper slabs at the anode are refined electrochemically, affording much purer metallic copper at the cathode. Which statement below is true?

A. Cu is oxidized preferentially over both Ni and Ag, so both Ni and Ag metals are separated as sludges below the anode.
B. Ni is oxidized preferentially over Cu, and \( \text{Ni}^{2+} \) is reduced much less readily than \( \text{Cu}^{2+} \), so Ni is separated as \( \text{Ni}^{2+} \) in the electrolyte solution.
C. Ag is oxidized preferentially over Cu, and \( \text{Ag}^+ \) is reduced much less readily than \( \text{Cu}^{2+} \), so Ag is separated as \( \text{Ag}^+ \) in the electrolyte solution.
D. Ag is oxidized preferentially over Cu, and \( \text{Ag}^+ \) is reduced much more readily than \( \text{Cu}^{2+} \), so Ag plates out with Cu at the cathode and cannot readily be removed from impure copper.
E. Both Ni and Ag are oxidized preferentially over Cu and \( \text{Ni}^{2+} \), and \( \text{Ag}^+ \) is reduced much less readily than \( \text{Cu}^{2+} \), so Ni and Ag are separated as \( \text{Ni}^{2+} \) and \( \text{Ag}^+ \) in the electrolyte solution.
9. The following aqueous reaction is used as a first step in the process of recovering copper from copper containing ore CuFeS$_2$(s).

$$2\text{CuFeS}_2(s) + 2\text{H}^+(aq) + \text{SO}_4^{2-}(aq) + 4\text{O}_2(g) \rightarrow 2\text{Cu}^{2+}(aq) + 2\text{SO}_4^{2-}(aq) + \text{Fe}_2\text{O}_3(s) + 3\text{S}(s) + \text{H}_2\text{O}$$

What is oxidized in this reaction?

A. CuFeS$_2$(s)  
B. H$^+$(aq)  
C. SO$_4^{2-}$(aq)  
D. O$_2$(g)  
E. Nothing is oxidized in this reaction.

10. Which metals can only be made in pure form via electrolysis.

I. Group I metal  
II. Group II metals  
III. Transition metals

A. I only  
B. II only  
C. III only  
D. I and II  
E. I and III

11. Hydrometallurgy involves leaching a metal from an ore by selectively dissolving it, then obtaining the free metal by reduction. One such example is Au, which can be leached from an ore with cyanide to form a soluble Au(CN)$_2^-$ complex. The standard reduction potential ($E^\circ$) for Au(CN)$_2^-$ is –0.6 V and corresponds to the reaction below:

$$\text{Au(CN)}_2^- + \text{e}^- \rightarrow \text{Au} + 2\text{CN}^- \quad E^\circ = -0.6 \text{ V}$$

Which of the following metals could be used to reduce Au(CN)$_2^-$ to Au metal?

(i) Pd $E^\circ = 0.9$ V for $\text{Pd}^{2+} + 2\text{e}^- \rightarrow \text{Pd}$
(ii) Mg $E^\circ = -2.4$ V for $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$
(iii) Fe $E^\circ = -0.4$ V for $\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$

A. (i) only  
B. (ii) only  
C. (iii) only  
D. (i) and (ii)  
E. (ii) and (iii)
12. When hydrogen gas is used to reduce an ore (as in a blast furnace), it is converted to _______.

   A. ammonia
   B. helium
   C. hydrogen peroxide
   D. water
   E. hydroxide