1. Which of the following is likely to yield the most acidic solution when dissolved in water?
   A. Li₂O
   B. CaO
   C. Al₂O₃
   D. SiO₂
   E. SO₃

2. Which atom below has the lowest electronegativity?
   A. Cl
   B. N
   C. Si
   D. Mg
   E. K

3. Pick the species in which the central element can be further oxidized.
   A. CO₃²⁻
   B. SiO₄⁴⁻
   C. PO₄³⁻
   D. IO₄⁻
   E. SO₃²⁻
4. What is the maximum concentration of Cd\(^{2+}\) that can exist in a solution in which the S\(^{2-}\) concentration is 2.5 x 10\(^{-6}\) M? \([K_{sp} (CdS) = 8.0 \times 10^{-27}]\)

A. 8.9 x 10\(^{-14}\)
B. 2.2 x 10\(^{-19}\)
C. 3.2 x 10\(^{-21}\)
D. 2.0 x 10\(^{-32}\)
E. 5.2 x 10\(^{-11}\)

5. If the pH is lowered, the solubility of which one of the following compounds will increase:

A. AgCl
B. AgI
C. PbSO\(_4\)
D. PbCl\(_2\)
E. PbCO\(_3\)

6. The \(K_{sp}\) for Zn(OH\(_2\)) is 5.0 x 10\(^{-17}\). Determine the solubility of Zn(OH\(_2\)) in a solution with pH of 11.50.

A. 5.0 x 10\(^6\) mol/L
B. 1.2 x 10\(^{-12}\) mol/L
C. 1.6 x 10\(^{-14}\) mol/L
D. 5.0 x 10\(^{-12}\) mol/L
E. 1.6 x 10\(^{-9}\) mol/L

7. Which one of the following substances, when added to a saturated solution of CaCO\(_3\), will decrease the solubility of CaCO\(_3\) in the solution?

A. NaCl
B. CaCl\(_2\)
C. HCl
D. HNO\(_3\)
E. NaNO\(_3\)

8. Which of the following decreases when solid Ba(OH)\(_2\) is added to a saturated solution of BaCO\(_3\) \([K_{sp} = 5.1 \times 10^{-9}]\)?

A. \([\text{Ba}^{2+}]\)
B. \([\text{CO}_3^{2-}]\)
C. \([\text{OH}^-]\)
D. pH
E. none of the above

9. Solid NaBr is slowly added to a solution that is 0.010 M in Cu\(^+\) and 0.010 M in Ag\(^+\). Which of the following statements is true? (\(K_{sp}\) for CuBr = 5.3 x 10\(^{-8}\), \(K_{sp}\) for AgBr = 5.0 x 10\(^{-13}\))

A. NaBr will precipitate first
B. CuBr will precipitate first
C. AgBr will precipitate first
D. no precipitate will form when \([\text{Br}^-]=0.010\) M
E. none of the above
10. What is the concentration of free cadmium (II) ion in solution when the total Cd(II) concentration (free ions + complex ions) is 0.20 M, and the solution also contains 2.0 M sodium cyanide (NaCN)? (Kf for Cd(CN)\(_4^{2–}\) = 7.1 x 10\(^{16}\))
   A. 2.0 M  
   B. 0.20 M  
   C. 1.4 x 10\(^{-17}\) M  
   D. 1.8 x 10\(^{-19}\) M  
   E. 3.1 x 10\(^{-25}\) M

11. The oxidation state for chlorine in HClO\(_4\) is:
   A. –1  
   B. 0  
   C. +3  
   D. +5  
   E. +7

12. Which of the following is the best oxidizing agent?
   A. F\(^–\)  
   B. I\(_2\)  
   C. H\(_2\)  
   D. Zn\(^{2+}\)  
   E. Li\(^+\)

13. How many grams of Ca metal would be produced by the electrolysis of molten CaBr\(_2\) using a current of 30.0 amp for 10.0 hours?
   A. 22.4 g  
   B. 452 g  
   C. 0.0622 g  
   D. 224 g  
   E. 5.60 g

14. When an aqueous solution that is 1M each in HCl, CuCl\(_2\) and CoBr\(_2\) is electrolyzed, the elemental products formed initially at the cathode and anode are, respectively
   A. Zn(s) and Cl\(_2\)(g).  
   B. Cu(s) and Br\(_2\)(g).  
   C. H\(_2\)(g) and Cl\(_2\)(g).  
   D. Zn(s) and Br\(_2\)(g).  
   E. H\(_2\)(g) and Br\(_2\)(g).

15. An voltaic cell is made from Pb and Co electrodes, immersed respectively in 1.0 M solutions of Pb(NO\(_3\))\(_2\) and Co(NO\(_3\))\(_2\). Which statement is true concerning the reaction:
   \[ Pb^{2+}(aq) + Co(s) \rightarrow Pb(s) + Co^{2+}(aq) \]
   A. E\(_{\text{cell}}\) = 0.41 V  
   B. \(\Delta G\) > 0  
   C. The voltage will increase as the mass of the Pb electrode is increased  
   D. The reaction is non-spontaneous as written.  
   E. The cell voltage will decrease as more Co\(^{2+}\) is formed.

16. Which of the following is true under standard conditions?
   A. Fe\(^{3+}\) is a stronger oxidizing agent than O\(_2\)  
   B. F\(^–\) is a good reducing agent  
   C. Zn metal can be produced by electrolysis of aqueous ZnCl\(_2\)  
   D. Cu\(^{2+}\) can oxidize Ag  
   E. Cu\(^{2+}\) can be reduced by H\(_2\).
17. What is the lowest whole-number coefficient of C₂O₄²⁻ when the following equation is completed and balanced?

\[ \text{Cr}_2\text{O}_7^{2–} + \text{C}_2\text{O}_4^{2–} \rightarrow \text{Cr}^{3+} + \text{CO}_2 \]  (acidic solution)

A. 1  
B. 2  
C. 3  
D. 4  
E. 6

18. Calculate \( \Delta G^0 \) for the following reaction.

\[ \text{Ag}^{3+}(aq) + \text{Fe}^{2+}(aq) \rightarrow \text{Ag}(s) + \text{Fe}^{3+}(aq) \]

A. 2.89 kJ  
B. 151.5 kJ  
C. –151.5 kJ  
D. –2.89 kJ  
E. –5.79 kJ

19. Which of the following metals will not provide cathodic protection to prevent corrosion of iron?

A. Zn  
B. Mg  
C. Cu  
D. Al  
E. Cr

20. Contact of a dental filling (containing dental amalgam) with aluminum foil causes a momentary sharp tooth pain. Dental amalgam is a mixture of Ag₂Hg₃, Ag₃Sn and Sn₈Hg. The standard reduction potentials for these are: \( E_{\text{red}}(\text{Hg}_2^{2+}/\text{Ag}_2\text{Hg}_3) = 0.85 \) V; \( E_{\text{red}}(\text{Sn}^{2+}/\text{Ag}_3\text{Sn}) = –0.05 \) V; \( E_{\text{red}}(\text{Sn}^{2+}/\text{Sn}_8\text{Hg}) = –0.13 \) V. Which of the following statements is false for this electrochemical reaction:

A. aluminum acts as the cathode  
B. substances in the dental amalgam act as the cathode  
C. the most likely species to be reduced is Hg₂²⁺  
D. aluminum will be oxidized  
E. none of the above is a false statement

21. What is the equilibrium constant (at 25°C) for the following reaction?

\[ \text{Zn} (s) + \text{Cu}^{2+}(aq) \rightleftharpoons \text{Zn}^{2+}(aq) + \text{Cu}(s) \]

A. \( 1.9 \times 10^{37} \)  
B. \( 2.1 \times 10^{29} \)  
C. \( 1.8 \times 10^{24} \)  
D. \( 1.1 \times 10^{11} \)  
E. \( 9.8 \times 10^{-12} \)

22. What is the concentration of Zn²⁺(aq) when the cell based on the following reaction has a potential of 1.30 V at 25°C?

\[ \text{Zn}(s) + \text{Cu}^{2+}(aq) (1.0 \times 10^{-5} \text{ M}) \rightarrow \text{Zn}^{2+}(aq) (x \text{ M}) + \text{Cu}(s) \]

A. 1.0 M  
B. 1.7 \times 10^{-12} M  
C. 4.4 \times 10^{-87} M  
D. 4.1 \times 10^{-9} M  
E. 60.2 M
23. In the blast furnace production of iron from its ore, the purpose of adding carbon is

1. to heat the furnace  
2. to serve as a reducing agent  
3. to remove silicate impurities as slag

A. 1 and 2  
B. 2 and 3  
C. 1 and 3  
D. 2 only  
E. 3 only

24. The following aqueous reaction is important in the purification of silver:

$$4Ag(s) + 8CN^- (aq) + O_2(g) + 2H_2O(l) \rightarrow 4[Ag(CN)_2]^-(aq) + 4OH^- (aq)$$

What is oxidized in this reaction?

A. Ag(s)  
B. CN^- (aq)  
C. O_2(g)  
D. H_2O(l)  
E. this is not a reduction-oxidation reaction

END OF EXAM