1. Balance the following half-reaction using the half-reaction method and determine the number of electrons lost or gained by the reactant.

\[ \Gamma \rightarrow \text{IO}_3^- \]

How many electrons are gained/lost:

- a. 6 lost
- b. 6 gained
- c. 1 gained
- d. 5 lost
- e. 5 gained

2. Is the half-reaction in #1 oxidation or reduction?

- a. oxidation
- b. reduction
- c. neither

3. Balance the following half-reaction using the half-reaction method and determine the number of electrons lost or gained by the reactant.

\[ \Gamma \rightarrow \text{I}_2 \]

How many electrons are gained/lost?

- a. 1 lost
- b. 2 gained
- c. 2 lost
- d. 1 gained
- e. 4 lost
4. When the following redox equation is balanced with smallest whole number coefficients, the coefficient for the iodide ion will be _____.

\[ \text{I}^{-(aq)} + \text{NO}_3^{-}(aq) \rightarrow \text{NO}(g) + \text{I}_2(s) \] (acidic solution)

a. 2  
b. 3  
c. 6  
d. 8

5. Consider the following redox equation

\[ \text{Mn}(\text{OH})_2(s) + \text{MnO}_4^{-}(aq) \rightarrow \text{MnO}_4^{2-}(aq) \] (basic solution)

When the equation is balanced with smallest whole number coefficients, what is the coefficient for \( \text{OH}^{-(aq)} \) and on which side of the equation is \( \text{OH}^{-(aq)} \) present?

a. 4, reactant side  
b. 4, product side  
c. 6, reactant side  
d. 6, product side

6. Which of the following species has the highest entropy \( (S^\circ) \) at 25°C?

a. \( \text{CH}_3\text{OH}(l) \)  
b. \( \text{CO}(g) \)  
c. \( \text{MgCO}_3(s) \)  
d. \( \text{H}_2\text{O}(l) \)  
e. \( \text{Ni}(s) \)

7. \[ 2 \text{NH}_3(g) \rightarrow \text{N}_2(g) + 3 \text{H}_2(g) \]

How does entropy change in this reaction?

a. increase  
b. decrease  
c. no change
8. A negative sign for $\Delta G^\circ$ indicates that:
   a. the reaction is exothermic.
   b. the reaction is endothermic.
   c. the reaction is spontaneous.
   d. the reaction is non-spontaneous.
   e. $\Delta S$ must be $>0$.

9. $\Delta H^\circ = -90.7$ kJ, and $\Delta G^\circ = +42$ kJ for the reaction below at 600K
   \[ \text{CO}(g) + 2\text{H}_2(g) \rightarrow \text{CH}_3\text{OH}(g) \]
   How would this reaction be described?
   a. Exothermic and non-spontaneous
   b. Endothermic and non-spontaneous
   c. Endothermic and spontaneous
   d. Exothermic and spontaneous

10. $\Delta H^\circ = 100$ kJ, and $\Delta S^\circ = 200$ J/K for the following reaction:
    \[ \text{A} + \text{B} \rightarrow \text{C} + \text{D} \]
    Given standard conditions (1 atm each species), at what temperature would this reaction be SPONTANEOUS?
    a. At all temperatures.
    b. Only at low temperatures.
    c. Only at high temperatures.
    d. It could never be spontaneous.

11. $\Delta H^\circ = -904.4$ kJ, and $\Delta S^\circ = +179.6$ J/K for the following reaction:
    \[ 4\text{NH}_3(g) + 5\text{O}_2(g) \rightarrow 4\text{NO}(g) + 6\text{H}_2\text{O}(g) \]
    Given standard conditions (1 atm each species), at what temperature would this reaction be SPONTANEOUS?
    a. At all temperatures
    b. Only at low temperatures
    c. Only at high temperatures
    d. It could never be spontaneous

12. The total entropy of a system and its surroundings always increases for a spontaneous process. This is a statement of
    a. the law of constant composition
    b. the first law of thermodynamics
    c. the second law of thermodynamics
    d. the law of conservation of energy
13. Entropy is a measure of
   a. order    b. disorder    c. energy    d. electric potential

14. Which of the following is necessary for a process to be spontaneous?
   a. $\Delta H_{\text{sys}} < 0$
   b. $\Delta S_{\text{sys}} > 0$
   c. $\Delta S_{\text{surr}} < 0$
   d. $\Delta S_{\text{univ}} > 0$