R - 8.314 J/mol-K = 0.082059 L-atm/mol-K,  \( c = 2.998 \times 10^8 \text{m/s}, \) \( \Delta E = -2.178 \times 10^{-18} \text{J} \) (Z) \( (1/n_f^\text{final} - 1/n_i^\text{initial}) \)

1. For the redox reaction \( 2\text{Fe}^{2+} + \text{Cl}_2 \rightarrow 2\text{Fe}^{3+} + 6\text{Cl}^- \) which of the following are the correct half-reactions?
   - I. \( \text{Cl}_2 + 2e^- \rightarrow 2\text{Cl}^- \)
   - II. \( \text{Cl}^- + e^- \rightarrow \text{Cl}^- \)
   - III. \( \text{Cl}_2 \rightarrow 2\text{Cl}^- + 2e^- \)
   - IV. \( \text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e^- \)
   a) II and V  b) II and IV  c) III and IV  d) I and V  e) I and IV

2. When the following reaction is balanced in acidic solution, what is the coefficient of \( \text{I}_2 \)?
   \( \text{IO}_3^- + \text{I}^- \rightarrow \text{I}_2 \)
   (a) 2  (b) 4  (c) 1  (d) 3  (e) none of these

3. The following unbalanced equation represents a reaction that occurs in basic solution:
   \( \text{MnO}_4^- + \text{C}_2\text{O}_4^{2-} \rightarrow \text{MnO}_2^- + \text{CO}_3^{2-} \)
   How many moles of \( \text{MnO}_4^- \) are required to produce 1 mole of \( \text{CO}_3^{2-} \)?
   a) 2  b) 4  c) 1  d) 3  e) none of these

4. A gas sample is held at constant pressure. The gas occupies 3.62 L of volume when the temperature is 21.6°C. Determine the temperature at which the volume of the gas is 3.55 L.
   a) 562 K  b) 300 K  c) 295 K  d) 289 K  e) 21.2 K

5. A gas sample is heated from -20.0°C to 57.0°C and the volume is increased from 2.00 L to 4.50 L. If the initial pressure is 0.143 atm, what is the final pressure?
   a) -0.181 atm  (b) 0.0829 atm  c) 0.0487 atm  d) 0.420 atm  e) 0.247 atm

6. Hydrogen and chlorine gases react to form HCl. You and a friend are on opposite sides of a long hallway, you with \( \text{H}_2 \) and your friend with \( \text{Cl}_2 \). You both want to form HCl in the middle of the room. Which of the following is true?
   a) You both should release the gases at the same time.
   b) You need to know the temperature to answer this question.
   c) Your friend should release the \( \text{Cl}_2 \) first.
   d) You should release the \( \text{H}_2 \) first.
   e) You need to know the length of the room to answer this question.
7. What would happen to the average kinetic energy of the molecules of a gas sample if the temperature of the sample increased from 20°C to 40°C?
   a) It would decrease.  
   b) Two of these.  
   c) It would become half its value.  
   d) It would increase.  
   e) It would double.

8. What volume does 41.8 g of N₂ occupy at STP?
   a) 464 L  
   b) 66.8 L  
   c) 1.87 L  
   d) 33.4 L  
   e) none of these

9. Calculate the ratio of the effusion rates of N₂ and N₂O.
   a) 1.61  
   b) 0.798  
   c) 1.57  
   d) 0.637  
   e) 1.25

10. For a particular process \( q = 20 \text{ kJ} \) and \( w = 15 \text{ kJ} \). Which of the following statements is true?
   a) \( \Delta E = 35 \text{ kJ} \).
   b) Heat flows from the system to the surroundings.  
   c) The system does work on the surroundings.  
   d) All of the above are true.  
   e) None of the above are true.

11. Which one of the following statements is false?
   a) The change in enthalpy, \( \Delta H \), for a process is equal to the amount of heat absorbed at constant pressure, \( q_p \).
   b) If \( q_p \) for a process is negative, the process is exothermic.
   c) The freezing of water is an example of an exothermic reaction.
   d) A bomb calorimeter measures \( \Delta H \) directly.
   e) The change in internal energy, \( \Delta E \), for a process is equal to the amount of heat absorbed at constant volume, \( q_v \).

12. Calculate the work associated with the expansion of a gas from 152.0 L to 189.0 L at a constant pressure of 17.0 atm.
   a) -315 L atm  
   b) 171 L atm  
   c) -629 L atm  
   d) 315 L atm  
   e) 629 L atm

13. Consider the reaction
   \[ \text{H}_2(g) + \frac{1}{2}\text{O}_2(g) \rightarrow \text{H}_2\text{O}(l) \quad \Delta H^o = -286 \text{ kJ} \]
   Which of the following is true?
   a) The reaction is exothermic.
   b) Heat is absorbed by the system.
   c) The enthalpy of the products is less than that of the reactants.
   d) The reaction is endothermic.
   e) Both a and e are true.
14. Given the following two reactions at 298 K and 1 atm, which of the statements is true?

1. \( \text{N}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}(g) \) \( \Delta H_1 \)
2. \( \text{NO}(g) + (1/2)\text{O}_2(g) \rightarrow \text{NO}_2(g) \) \( \Delta H_2 \)

\( \textbf{a)} \) \( \Delta H_f \) for NO(g) = \( \Delta H_1 \)
\( \textbf{b)} \) \( \Delta H_f = \Delta H_1 \)
\( \textbf{c)} \) \( \Delta H_f \) for \( \text{NO}_2(g) \) = \( \Delta H_2 + (1/2)\Delta H_1 \)
\( \textbf{d)} \) \( \Delta H_f \) for \( \text{NO}_2(g) \) = \( \Delta H_2 \)
\( \textbf{e)} \) none of these

Use the following to answer questions 15-19:

From the following list of observations, choose the one that most clearly supports the following conclusion:

\( \textbf{a)} \) emission spectrum of hydrogen
\( \textbf{b)} \) the photoelectric effect
\( \textbf{c)} \) scattering of alpha particles by metal foil
\( \textbf{d)} \) diffraction
\( \textbf{e)} \) cathode "rays"

15. Electrons have wave properties.

16. Electromagnetic radiation has wave characteristics.

17. The mass of the atom is located mainly in the nucleus.

18. Atoms contain electrons.

19. Electrons in atoms have quantized energies.

20. In Bohr's atomic theory, when an electron moves from one energy level to another energy level more distant from the nucleus

\( \textbf{a)} \) light is emitted.
\( \textbf{b)} \) no change in energy occurs.
\( \textbf{c)} \) energy is emitted.
\( \textbf{d)} \) energy is absorbed.
\( \textbf{e)} \) none of these

What is the wavelength of light that is emitted when an excited electron in the hydrogen atom falls from \( n = 5 \) to \( n = 4 \)?

\[ \Delta E = -2.178 \times 10^{-16} \left( \frac{1}{10} - \frac{1}{25} \right) \]

\[ \Delta E = -2.178 \times 10^{-18} \left( \frac{1}{10} - \frac{1}{25} \right) \]

\[ \Delta E = -2.178 \times 10^{-20} \]

\[ \frac{-4.701 \times 10^{-8}}{6.626 \times 10^{-34} (2.978 \times 10^3)} \]

\[ \lambda = 4.053 \times 10^{-6} \]