1) The equilibrium constant $K_c$ for forming Nitrogen monoxide gas from its elements is $1.0 \times 10^{-5}$ at 1500K. If 0.80 mol of $N_2$ and 0.20 mol of $O_2$ were placed in a 1L flask, what is the equilibrium concentration of NO?

A) $6.32 \times 10^{-4}$ M  
B) $1.26 \times 10^{-3}$ M  
C) $3.16 \times 10^{-4}$ M  
D) $8.94 \times 10^{-4}$ M  
E) $1.79 \times 10^{-3}$ M

2) $K_c$ for the reaction $C_2 + D_2 \leftrightarrow 2CD$ is 2.0 at 600°C. 0.50 mol of each reactant are put in a 2L flask, predict the percent yield of $CD$ at 600°C.

A) 20.7%  
B) .207%  
C) .414%  
D) 41.4%  
E) 82.8%

3) For which of the following reactions does $K_c = K_p$ at 25°C?

I: $3\text{ A(s)} + 5\text{ B(g)} \rightleftharpoons 3\text{ AB(g)} + \text{ B}_2\text{(g)}, \Delta H = 30 \text{ J}$

II: $2\text{ C(g)} + 2\text{ D(g)} \rightleftharpoons 4\text{ CD(g)}, \Delta H = -15 \text{ J}$

III: $2\text{ Y(s)} + \text{ E}_2\text{Y(g)} \rightleftharpoons \text{ YE(g)} + \text{ Y}_2\text{(g)} + \text{ E(g)}, \Delta H = 0 \text{ J}$

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

4) Sodium-24 is a radioactive isotope that decays via first order kinetics and has a half-life of 15 hours. What fraction of an original sample of sodium-24 will decompose in 3 days?

A) 4%  
B) 13%  
C) 50%  
D) 87%  
E) 96%

5) Given the overall reaction $2\text{H}_2 + 2\text{NO} \rightarrow 2\text{H}_2\text{O} + \text{N}_2$ and the following mechanism:

Step 1: $\text{NO} + \text{NO} \rightleftharpoons \text{N}_2\text{O}_2$ (fast)

Step 2: $\text{N}_2\text{O}_2 + \text{H}_2 \rightarrow \text{H}_2\text{O} + \text{N}_2\text{O}$ (slow)

Step 3: $\text{N}_2\text{O} + \text{H}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O}$ (fast)

Which of the following is/are true?

I: The rate law for the overall reaction is $\text{Rate} = k[\text{N}_2\text{O}_2][\text{H}_2]$

II: The absolute value of the rate of change of $\text{H}_2$ is $\frac{1}{2}$ the rate of change of $\text{N}_2$

III: The rate of the reaction is equal to the rate of change of $\text{H}_2$

A) Only I  
B) Only II  
C) Only III  
D) I, II, and III  
E) None
6) How many structural isomers does C\textsubscript{5}H\textsubscript{12} have (including itself)?
   A) one  B) two  C) three  D) four  E) five

7) Given the reaction for the following hypothetical weak acid: HA + H\textsubscript{2}O ⇌ NaA + H\textsubscript{3}O\textsuperscript{+}, which would increase the buffer component concentration ratio?
   I: Adding 0.1 M NaOH to the buffer  II: Adding 0.1 M HCl to the buffer
   A) I only  B) II only  C) both  D) none

8) Calculate the pH of a 0.20 M Na\textsubscript{2}CO\textsubscript{3} solution. K\textsubscript{a} of HCO\textsubscript{3}\textsuperscript{−} is 4.8 \times 10^{-11}
   A) 8.49  B) 2.19  C) 5.51  D) 11.81  E) 9.62

9) A 1.00g piece of chalk containing CaCO\textsubscript{3} (and other materials) was placed in 500. mL of hydrochloric acid solution with an initial pH of 1.00. After all of the CaCO\textsubscript{3} reacts with the HCl (forming CO\textsubscript{2} gas, H\textsubscript{2}O, Ca\textsuperscript{2+}, and Cl\textsuperscript{−}), the final pH is 1.19. About what mass percent of the chalk was CaCO\textsubscript{3}?
   A) 89%  B) 77%  C) .89%  D) .77%  E) 50%

10) Hypobromous acid is a commonly used disinfectant in swimming pools. At 25°C HBrO dissociates in water with a K\textsubscript{a} = 2.3 \times 10^{-9}. Is this dissociation a spontaneous process when [H\textsubscript{3}O\textsuperscript{+}] = 6.0 \times 10^{-4} M, [BrO\textsuperscript{−}] = 0.10 M, and [HBrO] = 0.20 M?
   A) Yes, because ΔG > 0  B) No, because ΔG > 0  C) Yes, because ΔG < 0  D) No, because ΔG < 0

11) What is the value for the standard free energy of the following reaction:
   Pb(s) | Pb\textsuperscript{2+} (aq) || Mg\textsuperscript{2+}(aq) | Mg(s)
   A) +432.3 kJ/mol  B) −432.3 kJ/mol  C) +216.1 kJ/mol  D) −216.1 kJ/mol
12) A hydrogen fuel cell operates with the following reaction taking place at the anode:

$$2H_2(g) + 4OH^- \rightarrow 4H_2O(l) + 4e^-$$

What volume of $H_2$ gas at 30°C and 120 atm is required for the fuel cell to run a motor drawing 8.5A for 10.0 hours?

A) 16.6L B) 0.16L C) 33.3L D) 0.033L E) 0.33L

13) The magnetic moment of an inorganic complex represents the number of unpaired electrons present in its d-orbital splitting configuration. A complex $[MCl_6]^{4-}$ has a magnetic moment of around 3. Which two elements in the 3d block could be “M”?

A) V and Ni B) V and Co C) Sc and Ni D) Sc and Co

14) Rank the following in order of increasing magnetism. I: $[Mn(NO_2)_6]^{1-}$ II: $[Fe(en)_3]^{2+}$ III: $[CoCl_3F_3]^{3-}$

A) I < II < III B) I < III < II C) II < III < I D) II < I < III E) III < I < II

15) What is the binding energy per nucleon of fluorine?

A) $1.25 \times 10^{-12}$ J/nucleon B) $-1.25 \times 10^{-12}$ J/nucleon C) 56.06 MJ/nucleon D) -56.06 MJ/nucleon