1. For the following reaction: \( \text{N}_2 + \text{H}_2 \text{O} \rightarrow \text{N}_2\text{O}_4 + \text{H}_2 \)

a. Write the balanced chemical equation.

b. Estimate the enthalpy of the balanced reaction in kJ/mol nitrogen using the bond energies given below.

c. Estimate the enthalpy change for the reaction of 18.0g of water with excess nitrogen gas. Include the sign with your answer.

\[
\begin{align*}
\text{BE(H-H)} & = 440 \text{ kJ/mol} \\
\text{BE(H-O)} & = 460 \text{ kJ/mol} \\
\text{BE(H-N)} & = 400 \text{ kJ/mol} \\
\text{BE(O=O)} & = 500 \text{ kJ/mol} \\
\text{BE(N≡N)} & = 940 \text{ kJ/mol} \\
\text{BE(N-O)} & = 180 \text{ kJ/mol} \\
\text{BE(N=O)} & = 600 \text{ kJ/mol} \\
\text{BE(N-N)} & = 190 \text{ kJ/mol}
\end{align*}
\]

2. a1. The process \( \text{Mg(s)} \rightarrow \text{Mg(g)} \) represents which of the following energies in the Born-Haber cycle:

A) Electron affinity  
B) Sublimation  
C) Dissociation energy  
D) Ionization energy  
E) Formation energy

a2. Is this process endothermic or exothermic?

b1. Give the Lewis dot symbol associated with elemental magnesium 
b2. Give the Lewis dot symbol associated with the magnesium ion.

c. Write the chemical equation associated with the lattice energy of \( \text{MgCl}_2(s) \).
3. Answer the following questions based on the compound \( \text{CH}_4 \)
   
   a. What is the dominant intermolecular force seen in this compound?

   b1. What type of crystal results when a material is bonded with this force?
   b2. Is the material polar or nonpolar?

   c. Based on its crystal type, give 2 physical properties seen in this molecule.

4. a. Write the Lewis structure of \( \text{H}_2\text{SO}_4 \). Show all lone pair electrons and bonds.

   b1. Give the VSEPR notation for each central atom.
   b2. Give the electron pair geometry for each central atom.

   c1. Based on your Lewis structure, give the formal charge on the sulfur atom.
   c2. Based on your Lewis structure, give the formal charges for all terminal oxygens.
5. Use the following phase diagram to answer the questions given below. Assume the diagram is properly scaled.

a. What phase exists at 1 atm and 1000°C? (extrapolate out as needed)

b. Using the letters given below, a, b, or c and an arrow to go between the two phases, (a→b, c→b, a→c etc.) to define the compound freezing.

c. Briefly sketch a diagram and show the location where supercritical fluids would form.

![Phase Diagram](image)

6. Answer the following questions about this molecule: XeF₂

Keep in mind it will have an expanded octet, so do not take shortcuts when doing the Lewis structure.

a. Give the VSEPR notation for the central atom.

b1. Give the electron pair geometry.

b2. Give the molecular geometry.

c2. Give the hybridization for the central atom.
7. The molar heat of vaporization and fusion of water are 40.70kJ and 6.00kJ \( \cdot \) mol\(^{-1}\), respectively.

   a. Write the chemical equation associated with the enthalpy of sublimation of water.

   b. Calculate the molar heat of sublimation for water. Include the appropriate sign with your answer.

   c. Calculate the energy involved in the sublimation of 90g of water.

8. Use the chart below to answer the questions for the following compound: CO

   a1. How many electrons are present in the compound?
   a2. How many of these electrons are antibonding?

   b. What is the bond order of this molecule?

   c1. Is it diamagnetic or paramagnetic?
   c2. Which orbital(s) support this conclusion?
9. You dissolve calcium chloride, CaCl₂, in 250.0mL of water until it reaches a concentration of 0.12m. K_b = 0.52°C/m.

a1. Calculate the boiling point of this solution.

a2. What is the value of the van't Hoff factor?

b. Calculate the mass of calcium chloride in the solution.

c. What is the term used to describe a salt solution that has the same concentration both within the membrane and outside the membrane?

10. A solution containing 5.00 grams of a C₂H₄, in 250 g of cyclohexane, C₆H₁₂. The density of the solution is 1.2g/mL.

a. Calculate the mass percent of the C₂H₄ in the solution.

b. Calculate the molarity of the solution.

c. Calculate the mole fraction of the C₂H₄.
Answer Key

1. a. \( \text{N}_2^+ + 4\text{H}_2\text{O} \rightarrow \text{N}_2\text{O}_4^+ + 4\text{H}_2 \)
   b. +1110kJ
   c. +278kJ

2. a1. B                                      a2. Endothermic
   b1. Mg:                                 b2. Mg\(^{2+}\)
   c. \( \text{Mg}^{2+}(g) + 2\text{Cl}^-(g) \rightarrow \text{MgCl}_2(s) \)

3. a. dispersion forces
   b1. molecular                           b2. nonpolar
   c. see notes for nonpolar molecular crystal.

4. a. could also use single bonds to oxygens
   b1. S: \( \text{AB}_4 \)  O: \( \text{AB}_2\text{E}_2 \)
   b2. S: tetrahedral  O: bent

   c1. +2 if using all single bonds, 0 if double bonds
   c2. -1 if single bonded, 0 if double bonded

5. a. gas
   b. (b→a)
   c. see phase diagram in notes. Upper right corner.

6. a. \( \text{AB}_3\text{E}_3 \)
   b1. Trigonal bipyramid
   b2. Linear
   c. sp\(^3d\)

7. a. \( \text{H}_2\text{O}(s) \rightarrow \text{H}^+\text{O}(g) \)
   b. +46.7kJ/mol
   c. +233.4kJ

8. a1. 10
     a2. 2
     b 3

   c1 diamagnetic
   c2. \( \sigma_2p \)

9. a1. 100.2°C  a2=3
     b. 3.33grams
     c. isotonic

10. a. 1.96%
     b. 0.84NM
     c. 0.057