1. The hybrid molecular orbitals used by the carbon atom in C$_2$H$_2$ are
   a. sp
   b. sp$^2$
   c. sp$^3$
   d. d$^2$sp$^3$
   e. dsp$^2$

2. What bond angle is associated with sp hybrid orbitals?
   a. 180°
   b. 90°
   c. 120°
   d. 109.5°
   e. none of the above

3. Which of the following conditions can result in a spontaneous reaction only at low temperatures?
   a. $\Delta H > 0$, $\Delta S = 0$
   b. $\Delta H > 0$, $\Delta S < 0$
   c. $\Delta H < 0$, $\Delta S > 0$
   d. $\Delta H < 0$, $\Delta S < 0$
   e. $\Delta H > 0$, $\Delta S > 0$

4. In total, how many localized bonds and how many lone pairs respectively are there in H$_2$O, respectively?
   a. 2 and 2
   b. 4 and 8
   c. 4 and 6
   d. 2 and 6
   e. 2 and 8

5. Which one of the following molecules is polar because of its geometry (which molecule has a dipole moment)?
   a. SiH$_4$
   b. CH$_4$
   c. BCl$_3$
   d. SF$_6$
   e. CHBr$_3$
6. Given: \[ \text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g) \quad \Delta H^0 = 178.0 \text{ kJ} \]
   How much energy would be required to decompose exactly 2 moles of \( \text{CaCO}_3(s) \)
   a. 178.0 kJ
   b. 356 kJ
   c. -356 kJ
   d. 89 kJ
   e. -89 kJ

7. The thermochemical equation which defines the enthalpy of formation of acetylene, \( \text{C}_2\text{H}_2(g) \) is
   a. \( 2 \text{C(s)} + \text{H}_2(g) \rightarrow \text{C}_2\text{H}_2(g) \)
   b. \( 2 \text{C}(g) + 2\text{H}(g) \rightarrow \text{C}_2\text{H}_2(g) \)
   c. \( 2 \text{C}_2(g) + 2\text{H}(g) \rightarrow \text{C}_2\text{H}_2(g) \)
   d. \( \text{C}_2\text{H}_6(g) \rightarrow \text{C}_2\text{H}_2(g) + \text{H}_2 \)
   e. none of the above

8. Which of the following has a standard molar enthalpy of formation of zero at 25° and 1 atm pressure?
   a. \( \text{CO}_2(g) \)
   b. \( \text{H}_2\text{O}(l) \)
   c. \( \text{Zn}(s) \)
   d. \( \text{NO}(g) \)
   e. \( \text{CH}_4 \)

9. Given the enthalpies of formation of n-hexanol, \( \text{C}_6\text{H}_{13}\text{OH}(l) \): –377.5; \( \text{CO}_2(g) \): -393.5; and \( \text{H}_2\text{O}(g) \): –241.8 kJ/mol, what is the enthalpy change for the combustion of a mol of n-hexanol, to form gaseous \( \text{CO}_2 \) and \( \text{H}_2\text{O} \)?
   a. 3984 kJ
   b. \(-3676.1 \text{ kJ} \)
   c. –3984 kJ
   d. +3676.1 kJ
   e. \(-462.1 \text{ kJ} \)

10. Calculate the amount of energy required to raise the temperature of a 13.5 gram piece of copper from 25.0 °C to 423 °C. The specific heat of copper is 0.385 J/g °C.

\[
13.5 \text{ g} \times 0.385 \text{ J/g °C} \times (423-25) \text{ °C} = 2069 \text{ J}
\]

11. Write Lewis dot structures showing the valence electrons for:
   a. hydrogen sulfide \( \text{H}_2\text{S} \)
   \[
   \begin{array}{c}
   \text{H} \quad \text{S} \quad \text{H} \\
   \text{H} \quad \quad \quad \text{H} \\
   \end{array}
   \]
   b. ethylene, \( \text{C}_2\text{H}_4 \)
   \[
   \begin{array}{c}
   \text{C} :: \text{C} \\
   \text{H} \quad \quad \quad \text{H} \\
   \end{array}
   \]
12. Write Lewis dot structures showing the valence electrons for:

a. borohydride ion, BH$_4^-$

H $\cdot\cdot\cdot$ B $\cdot\cdot\cdot$ H

b. ammonium ion NH$_4^+$

H $\cdot\cdot\cdot$ N $\cdot\cdot\cdot$ H

\[ H \]

14. The relative rates of effusion of H$_2$ to He in an equal molar mixture of both is:

a. $\left(\frac{2}{1}\right)^{1/2}$

b. $(1/1)^{1/2}$

c. 1/2

d. 2/1

e. not enough information

15. Sulfuric acid (H$_2$SO$_4$), the most widely produced chemical in the world, is made by a two-step oxidation of sulfur to sulfur trioxide, SO$_3$, followed by reaction with water. Calculate $\Delta H^\circ_f$ for SO$_3$ (in kilojoules per mole), given the following data:

\[
\begin{align*}
S(s) + O_2(g) &\rightarrow SO_2(g) & \Delta H^\circ = -296.8 \text{ kJ} \\
SO_3(g) &\rightarrow SO_2(g) + \frac{1}{2} O_2(g) & \Delta H^\circ = +98.9 \text{ kJ}
\end{align*}
\]

\[
\begin{align*}
S(s) + O_2(g) &\rightarrow SO_2(g) & \Delta H^\circ = -296.8 \text{ kJ} \\
SO_2(g) + \frac{1}{2} O_2(g) &\rightarrow SO_3(g) & \Delta H^\circ = -98.9 \text{ kJ} \\
S(s) + 1\frac{1}{2}O_2(g) &\rightarrow SO_3(g) & \Delta H^\circ = -395.7 \text{ kJ/mol}
\end{align*}
\]

16. Assuming that Coca Cola has the same specific heat as water (4.184 J/(g°C)), the amount of heat lost when one can (about 350 g) is cooled from 25 °C to 5 °C is:

a. -29.3 kJ

b. 29.3 kJ

c. -36.6 kJ

d. -29.3 J

e. 36.6 kJ

17. What is the molecular weight of 2 liters of a gas at 25 °C and 2 atmospheres pressure if the mass of the gas is 36 g?

a. 220.3 g mol$^{-1}$

b. 18.5 g mol$^{-1}$

c. 22 g mol$^{-1}$

d. 110 g mol$^{-1}$

e. not enough information
18. The vaporization of water going from the liquid phase to the gas phase is accompanied by
a. a decrease in entropy
b. **an increase in entropy**
c. a negative enthalpy
d. none of the above

19. At a constant temperature, if the volume of a cylinder is decreased by ½ of its original volume, the pressure in the cylinder will
a. remain the same
b. will also decrease by ½
c. **will double**
d. will quadruple

20. Draw two different Lewis structures for compounds with the formula: C$_2$H$_6$S Make sure each heavy atom has a complete octet. (use a line to indicate the sharing of two electrons). non-bonding electrons or lone pair electrons need not be shown.