1. Which of the following is INCORRECTLY ordered with respect to size?
   a. Mg > Mg$^{+2}$
   b. F$^-$ > Na$^+$
   c. Br$^-$ > Cl$^-$
   d. Ca$^{+2}$ > K$^+$
   e. all of the above are incorrectly ordered

2. How many unpaired electrons does the ion Co$^{+2}$ have?
   a. 1  b. 3  c. 5  d. 7  e. 9

3. Which of the following pairs of elements is incorrectly ordered with respect to their ionization energies?
   I. He > H    II. Mg > Al    III. F > O    IV. B > C
   a. II only  b. I and III  c. IV only  d. II and IV  e. II, III, and IV

4. This element is very reactive, forms a basic oxide, has a very low ionization energy, reacts with water to produce hydrogen, and has a small electron affinity. This describes

5. Which one of the following would have a different Lewis structure from the other four?
   a. PCl$_3$  b. NF$_3$  c. BF$_3$  d. CCl$_3$  e. AsI$_3$

6. In which of the following molecules does the central atom have two lone pairs of electrons?
   a. PF$_3$  b. CO$_2$  c. OF$_2$  d. HCN  e. SO$_2$

7. Which of the following would have the shortest bond distance?
   a. N$_2$  b. NO$_2^-$  c. NO$_3^-$  d. NH$_3$  e. NO$^-$

8. Using the bond energies on the front page, calculate $\Delta H$ for the following reaction (see Book for bond enthalpies). NOTE: these are only skeleton structures!
   \[
   H - C - C - H + 2 \text{H} - \text{O} - \text{H} \rightarrow H - C - C - H \rightarrow \text{H} - \text{O} - \text{H}
   \]
   a. 179 kJ  b. -616 kJ  c. -590 kJ  d. -125 kJ  e. 691 kJ
9. In the SF$_4$ molecule, the ELECTRON PAIR GEOMETRY (EPG) around the central atom is
   a. tetrahedral
   b. trigonal bipyramidal
   c. square planar
   d. octahedral
   e. seesaw

10. In the SCl$_2$ molecule, the MOLECULAR GEOMETRY (MG) is
   a. linear
   b. tetrahedral
   c. bent
   d. trigonal planar
   e. trigonal bipyramidal

11. Of the molecules below, which one molecule will have an identical EPG and MG?
   a. PCl$_3$
   b. ClF$_5$
   c. AsF$_5$
   d. H$_2$O
   e. BrF$_3$

12. All of the following species will have a tetrahedral MOLECULAR GEOMETRY except
   a. AlCl$_4^-$
   b. CH$_4$
   c. NCl$_4^+$
   d. IF$_4^+$
   e. none of the above

13. Which of the following molecules will be polar?
   I. CCl$_4$
   II. CHCl$_3$
   III. NF$_3$
   IV. CO$_2$
   a. I and IV
   b. I, II, and III
   c. II and III
   d. II only
   e. I, II, and IV

14. In the molecule below (skeleton structure), how many total sigma and pi bonds are present, respectively?

   H ─ C ─ C ─ C ─ C ─ C ─ N ─ H

   a. 11, 3
   b. 8, 4
   c. 11, 4
   d. 8, 7
   e. 11, 0

15. Which of the following molecules can exhibit cis-trans isomerism?

   a. (tetrahedral)
   b. H
   c. (square planar)
   d. H$_3$C ─ C ≡ C ─ CH$_3$
   e. Both b and c
16. In the molecule below (skeleton structure), what is the approximate bond angle of the C-N-H_a portion?

H     H
⏐     ⏐
H — C — N — H_a
⏐     ⏐
H

a. 180°  b. 120°  c. 109.5°  d. 90°  e. none of the above

17. In the molecule ClF_3, what diagram would best depict the hybrid orbitals for the chlorine atom just before bonding to the fluorine atoms?

a. \[ \text{sp}^2 \]

b. \[ \text{sp}^3 \]

c. \[ \text{sp}^d \]

d. \[ \text{sp}^d^2 \]

e. \[ \text{sp}^d^2 \]

18. Using M.O. theory, which of the following species will be paramagnetic?

a. NO^+  b. C_2  c. BC^+  d. BC^-  e. OF^-