

Working with a partner, go to this website:

<http://cms.gavirtualschool.org/Shared/Science/APChemistry13/Bonding/index.html>

Click on the page headings 1 – 13 to answer the questions in this packet.

# 1-19 should be completed by tomorrow while #20-30 are due Friday.

### Types of Bonds, Properties of Ionic Bonds, Properties of Covalent Bonds, Properties of Metallic Bonds

1. Describe what kind of event must occur (involving electrons) if the atoms of two different elements are to react to form (a) an ionic compound or (b) a molecular compound.
2. What holds an ionic compound together? Can we identify individual molecules in an ionic compound?

### Formation of Ionic Bonds, Lattice Energy, Formation of Covalent Bonds

3. What must be true about the change in the total potential energy of a collection of atoms for a stable compound to be formed from the elements?
4. How is the tendency to form ionic bonds related to the IE and EA of the atoms involved?
5. Magnesium forms the ion  $\text{Mg}^{2+}$ , but not the ion  $\text{Mg}^{3+}$ . Why?

### Polar and Nonpolar Covalent Bonds, Electronegativity, Predicting Bond Type

6. Which elements are assigned electronegativities of zero? Why?
7. If an element has a low electronegativity, is it likely to be a metal or a nonmetal? Explain your answer.

8. Nitrogen and arsenic are in the same group in the periodic table. Arsenic forms both  $\text{AsCl}_3$  and  $\text{AsCl}_5$ , but with chlorine, nitrogen only forms  $\text{NCl}_3$ . On the basis of the electronic structures of N and As, explain why this is so.
9. Use the table of electronegativities below to choose the atom in each of the following bonds that carries the partial negative charge: (a)  $\text{Hg-I}$ , (b)  $\text{P-I}$ , (c)  $\text{Si-F}$ , (d)  $\text{Mg-N}$ .
10. Which of the bonds in the previous problem is the least polar? Explain why.

**Lewis Symbols, Lewis Structures, Bond Order, Bond Length, and Bond Energy, Bond Length and Bond Order, Bond Strength and Bond Energy, Limitations to Lewis Structure Model**

11. Write Lewis symbols for the following atoms: (a) K, (b) Ge, (c) As, (d) Br, (e) Se.
12. How many dots must appear in the Lewis structures of (a)  $\text{HIO}_3$ , (b)  $\text{H}_2\text{CO}_3$ , (c)  $\text{HCO}_3^-$ , and (d)  $\text{PCl}_4^+$ ?
13. Draw Lewis structures for (a)  $\text{AsCl}_4^+$ , (b)  $\text{ClO}_2^-$ , (c)  $\text{HNO}_2$ , and (d)  $\text{XeF}_2$ .
14. Draw Lewis structures for (a)  $\text{HIO}_3$ , (b)  $\text{H}_2\text{CO}_3$ , (c)  $\text{HCO}_3^-$ , and (d)  $\text{PCl}_4^+$ .

15. Draw Lewis structures for (a)  $\text{SeO}_3$  and (b)  $\text{SeO}_2$ .

16. Draw Lewis structures for (a)  $\text{NO}^+$ , (b)  $\text{NO}_2^-$ , (c)  $\text{SbCl}_6^-$ , and (d)  $\text{IO}_3^-$ .

17. Draw Lewis structures for (a)  $\text{GeCl}_4$ , (b)  $\text{CO}_3^{2-}$ , (c)  $\text{PO}_4^{3-}$ , and (d)  $\text{O}_2^{2-}$ .

18. Arrange the following in order of increasing C–O bond length:  $\text{CO}$ ,  $\text{CO}_3^{2-}$ ,  $\text{CO}_2$ ,  $\text{HCO}_2^-$  (formate ion).

### Formal Charge

19. Draw the Lewis structure for  $\text{HClO}_4$ . Assign formal charges to each atom in the formula. Determine the preferred Lewis structure for this compound.

## Resonance

20. Why is the concept of resonance needed?

21. Draw the resonance structures of the benzene molecule. Why is it more stable than one would expect if the ring contained three carbon–carbon double bonds?

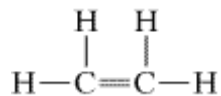
## Determining Molecular Shape Using VSEPR

22. Predict the shapes of (a)  $\text{SF}_3^+$ , (b)  $\text{NO}_3^-$ , (c)  $\text{SO}_4^{2-}$ , (d)  $\text{O}_3$ , and (e)  $\text{N}_2\text{O}$ .

23. Predict the shapes of (a)  $\text{FCl}_2^+$ , (b)  $\text{AsF}_5$ , (c)  $\text{AsF}_3$ , (d)  $\text{SbH}_3$ , and (e)  $\text{SeO}_2$ .

24. Predict the shapes of (a)  $\text{CS}_2$ , (b)  $\text{BrF}_4^-$ , (c)  $\text{ICl}_3$ , (d)  $\text{ClO}_3^-$ , and (e)  $\text{SeO}_3$ .

25. Ethylene, a gas used to ripen tomatoes artificially, has the Lewis structure



What would you expect the H–C–H and H–C–C bond angles to be in this molecule? (*Caution:* Don't be fooled by the way the structure is drawn here.)

26. Predict the bond angle for each of the following molecules: (a)  $\text{HOCl}$ , (b)  $\text{PH}_2^-$ , (c)  $\text{OCN}^-$ , (d)  $\text{O}_3$ , (e)  $\text{SnF}_2$ .

### Polar Molecules

27. Which of the following molecules have a permanent dipole moment? Draw each and show the net dipole moment for the polar molecules.

- a.  $\text{H}_2\text{O}$
- b.  $\text{CO}_2$
- c.  $\text{CH}_4$
- d.  $\text{N}_2$
- e.  $\text{CO}$
- f.  $\text{NH}_3$

28. Which of the following molecules would be expected to be polar: (a)  $\text{HBr}$ , (b)  $\text{POCl}_3$ , (c)  $\text{CH}_2\text{O}$ , (d)  $\text{SnCl}_4$ , (e)  $\text{SbCl}_5$ ? Draw each and show the net dipole moment for the polar molecules.

### Valence Bond Theory, Hybrid Orbitals

29. Draw Lewis structures for the following and use the geometry predicted by the VSEPR model to determine what kind of hybrid orbitals the central atom uses in bond formation:

- a)  $\text{SbCl}_6^-$ , (b)  $\text{BrCl}_3$ , (c)  $\text{XeF}_4$ .

### Sigma and Pi Bonds, Double and Triple Bonds

30. What kinds of bonds ( $\sigma$  or  $\pi$ ) are found in the numbered bonds in the following molecule?

