

exam. First are 16 multiple-choice questions similar to what you will encounter in Section I of the AP Chemistry exam. Following those is a multipart free-response question like the ones in Section II of the exam. To make these questions an even more authentic practice for the actual exam, time yourself following the instructions provided.

### Multiple-Choice Questions

Answer the following questions in 20 minutes. You may not use a calculator. You may use the periodic table and the equation sheet at the back of this book.

- VSEPR predicts an  $\text{SbF}_5$  molecule will be which of the following shapes?
    - tetrahedral
    - trigonal bipyramidal
    - square pyramid
    - trigonal planar
  - The shortest bond would be present in which of the following substances?
    - $\text{I}_2$
    - $\text{CO}$
    - $\text{CCl}_4$
    - $\text{O}_2^{2-}$
  - Which of the following does not have one or more  $\pi$  bonds?
    - $\text{H}_2\text{O}$
    - $\text{HNO}_3$
    - $\text{O}_2$
    - $\text{N}_2$
  - Which of the following is polar?
    - $\text{SF}_4$
    - $\text{XeF}_4$
    - $\text{CF}_4$
    - $\text{SbF}_5$
  - Resonance structures are necessary to describe the bonding in which of the following?
    - $\text{H}_2\text{O}$
    - $\text{ClF}_3$
    - $\text{HNO}_3$
    - $\text{CH}_4$
- For questions 6 and 7, pick the best choice from the following:**
- ionic bonds
  - hybrid orbitals
  - resonance structures
  - van der Waals attractions
- An explanation of the equivalent bond lengths of the nitrite ion is:
    - ionic bonds
    - hybrid orbitals
    - resonance structures
    - van der Waals attractions
  - Most organic substances have low melting points. This may be because, in most cases, the intermolecular forces are:
    - ionic bonds
    - hybrid orbitals
    - resonance structures
    - van der Waals attractions
  - Which of the following has more than one unshared pair of valence electrons on the central atom?
    - $\text{BrF}_5$
    - $\text{NF}_3$
    - $\text{IF}_7$
    - $\text{ClF}_3$

Bonding < 157

What is the expected hybridization of the central atom in a molecule of  $\text{TiCl}_4$ ? This molecule is tetrahedral.

- $sp^3$
- $sp^3d$
- $sp$
- $sp^2$

The only substance listed below that contains  $\sigma$ , and  $\pi$  bonds is:

- $\text{Na}_2\text{CO}_3$
- $\text{HClO}_2$
- $\text{H}_2\text{O}$
- $\text{NaCl}$

13. Which molecule or ion in the following list has the greatest number of unshared electrons around the central atom?

- $\text{CF}_4$
- $\text{ClF}_3$
- $\text{BF}_3$
- $\text{NH}_4^+$

14. Which of the following molecules is the least polar?

- $\text{PH}_3$
- $\text{CH}_4$
- $\text{H}_2\text{O}$
- $\text{NO}_2$

The electron pairs point toward the corners of which geometrical shape for a molecule with  $sp^2$  hybrid orbitals?

- (A) trigonal planar
- (B) octahedron
- (C) trigonal bipyramid
- (D) trigonal pyramid

Regular tetrahedral molecules or ions include which of the following?

- (A)  $SF_4$
- (B)  $NH_4^+$
- (C)  $XeF_4$
- (D)  $ICl_4^-$

15. Which of the following molecules is the most polar?

- (A)  $NH_3$
- (B)  $N_2$
- (C)  $CH_3I$
- (D)  $BF_3$

16. Which of the following processes involves breaking an ionic bond?

- (A)  $H_2(g) + Cl_2(g) \rightarrow 2 HCl(g)$
- (B)  $2 KBr(s) \rightarrow 2 K(g) + Br_2(g)$
- (C)  $Na(s) \rightarrow Na(g)$
- (D)  $2 C_2H_6(g) + 7 O_2(g) \rightarrow 4 CO_2(g) + 6 H_2O(g)$

### Answers and Explanations for the Multiple-Choice Questions

• **B**—The Lewis (electron-dot) structure has five bonding pairs around the central Sb and no lone pairs. VSEPR predicts this number of pairs to give a trigonal bipyramidal structure.

• **B**—All the bonds except in CO are single bonds. The CO bond is a triple bond. Triple bonds are shorter than double bonds, which are shorter than single bonds. Drawing Lewis structures might help you answer this question.

• **A**—Answers B through D contain molecules or ions with double or triple bonds. Double and triple bonds contain  $\pi$  bonds. Water has only single ( $\sigma$ ) bonds. If any of these are not obvious to you, draw a Lewis structure.

• **A**—The VSEPR model predicts all the other molecules to be nonpolar.

5. **C**—All the other answers involve species containing only single bonds. Substances without double or triple bonds seldom need resonance structures.

6. **C**—Resonance causes bonds to have the same average length.

7. **D**—Many organic molecules are nonpolar. Nonpolar substances are held together by weak van der Waals attractions.

8. **D**—Lewis structures are required. You do not need to draw all of them. A and B have one unshared pair, while C does not have an unshared pair. D has two unshared pairs of electrons.

9. **A**—Tetrahedral molecules are normally  $sp^3$  hybridized.

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10. **A**—Only A and D are ionic. The chloride ion has no internal bonds, so  $\sigma$  and  $\pi$  bonds are not possible.

11. **A**—This hybridization requires a geometrical shape with three corners.

12. **B**—One or more Lewis structures may help you. A is an irregular tetrahedron (seesaw); C and D are square planar.

13. **B**—A has 0. B has 2. C and D have 0. You may need to draw one or more Lewis structures.

14. **B**—All the molecules are polar except B.

15. **A**—Drawing one or more Lewis structures may help you. Only A and C are polar. Only the ammonia has hydrogen bonding, which is very, very polar.

16. **B**—C is breaking metallic bonding. All the others involve covalently bonded molecules.