**AP Chemistry**

**Bonding Practice Problems**

**Matching**

*Each set of lettered choices below refers to the numbered statements immediately following it. Select the one lettered choice that best fits each statement and then write in the letter corresponding to that choice. A choice may be used once, more than once, or not at all in each set. You may use your periodic table and reference sheet. Calculator use is not permitted for this section.*

Questions 1-3 refer to the following diatomic species.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | H2 | d. | O2 |
| b. | B2 | e. | F2 |
| c. | N2 |

\_\_\_\_ 1. Has the largest bond–dissociation energy

\_\_\_\_ 2. Has a bond order of 2

\_\_\_\_ 3. Contains 1 sigma *()* and 2 pi () bonds

Questions 4-7 relate to the following.

|  |  |
| --- | --- |
| a. | hydrogen bonding |
| b. | hybridization |
| c. | ionic bonding |
| d. | resonance |
| e. | London forces |

\_\_\_\_ 4. Is used to explain the fact that the four bonds in methane are equivalent

\_\_\_\_ 5. Is used to explain the fact that the carbon-to-carbon bonds in benzene, C6H6, are identical

**Multiple Choice**

*Identify the letter of the choice that best completes the statement or answers the question. You may use your periodic table and reference sheet. Calculator use is not permitted for this section.*

\_\_\_\_ 6. The best explanation for the fact that diamond is extremely hard is that diamond crystals

|  |  |
| --- | --- |
| a. | consist of positive and negative ions that are strongly attracted to each other |
| b. | are formed under extreme conditions of temperature and pressure |
| c. | contain orbitals or bands of delocalized electrons that belong not to single atoms but to each crystal as a whole |
| d. | are made up of atoms that are intrinsically hard because of their electronic structures |
| e. | are giant molecules in which each atom forms strong covalent bonds with all of its neighboring atoms |

\_\_\_\_ 7. For which of the following molecules are resonance structures necessary to describe the bonding satisfactorily?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | SO2 | c. | H2S |
| b. | CO2 | d. | OF2 |

\_\_\_\_ 8. Which of the following molecules has the shortest bond length?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | N2 | c. | Br2 |
| b. | O2 | d. | Cl2 |

\_\_\_\_ 9. Types of hybridization exhibited by the C atoms in propene, CH3CHCH2, include which of the following?

I. *sp* II. *sp*2 III. *sp*3

|  |  |  |  |
| --- | --- | --- | --- |
| a. | III only | d. | I and II only |
| b. | I only | e. | I, II, and III |
| c. | II and III only |

\_\_\_\_ 10. Of the following molecules, which has the largest dipole moment?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | O2 | c. | HF |
| b. | CO2 | d. | CO |

\_\_\_\_ 11. In a molecule in which the central atom exhibits sp2 hybrid orbitals, the electron pairs are directed toward the corners of a(n)

|  |  |  |  |
| --- | --- | --- | --- |
| a. | trigonal bipyramid | c. | octahedron |
| b. | equilateral triangle | d. | tetrahedron |

\_\_\_\_ 12. CCl4, CO2, PCl3, PCl5, SF6

Which of the following does NOT describe any of the molecules above?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | Octahedral | d. | Linear |
| b. | Tetrahedral | e. | Trigonal pyramidal |
| c. | Square planar |

\_\_\_\_ 13. Which of the following compounds is ionic and contains both sigma and pi covalent bonds?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | Fe(OH)3 | c. | H2S |
| b. | HClO | d. | NaCN |

\_\_\_\_ 14. Pi () bonding occurs in each of the following species EXCEPT

|  |  |  |  |
| --- | --- | --- | --- |
| a. | CN– | c. | CH4 |
| b. | C6H6 | d. | CO2 |

\_\_\_\_ 15. Which of the following has a zero dipole moment (i.e., is nonpolalr)?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | SO2 | c. | HCN |
| b. | PF5 | d. | NH3 |

\_\_\_\_ 16. The melting point of MgO is higher than that of NaF. Explanations for this observation include which of the following?

I. Mg2+ is more positively charged than Na+.

II. O2– is more negatively charged than F–.

III. The O2– ion is smaller than the F– ion.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | II only | d. | I and II only |
| b. | I and III only | e. | II and III only |
| c. | I, II, and III |

**Free Response Questions**

Your responses to the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses. You may use your periodic table, reference sheet, and calculator.

Use the principles of atomic structure and/or chemical bonding to explain each of the following. In each part, your answer must include references to both substances. (2002)

17. The carbon-to-carbon bond energy in C2H4 is greater than it is in C2H6. (2 pts)

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Answer the following questions about the element selenium, Se (atomic number 34). (2000)

18. Selenium reacts with fluorine to form SeF4. Draw the complete Lewis electron-dot structure for SeF4 and sketch the molecular structure. Indicate whether the molecule is polar or nonpolar, and justify your answer. (2 pts)

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Answer the following questions that relate to chemical bonding. (2005, modified)

19. a) Draw the the complete Lewis structure (electron-dot diagram) for each of the three molecules listed below. (3 pts)

i) CF4 ii) PF5 iii) XeF4

b) On the basis of the Lewis structures drawn above, answer the following questions about the particular molecule indicated.

i) What is the F-C-F bond angle in CF4? (1 pt)

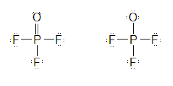
ii) What is the hybridization of the valence orbitals of C in CF4? (1 pt)

iii) What is the molecular geometry of XeF4? (1 pt)

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20. Two Lewis structures can be drawn for the OPF3 molecule, as shown below.

Structure 1 Structure 2



a) How many sigma bonds and how many pi bonds are in structure 1? (2 pts)

b) Which one of the two structures best represents a molecule of OPF3? Justify your answer in terms of formal charge. (1 pt)

Use principles of atomic structure, bonding, and/or intermolecular forces to respond to each of the following. Your responses must include specific information about all substances referred to in each question. (2005)

21. The melting point of KCl(s) is 776oC, whereas the melting point of NaCl(s) is 801oC.

a) Identify the type of bonding in each substance. (1 pt)

b) Explain why the melting point of NaCl is higher than the melting point of KCl. (1 pt)

22. Calculate the enthalpy of reaction for the chemical equation below using the information provided in the table.

|  |  |
| --- | --- |
| Bond | Average Bond Enthalpy, kJ/mol |
| H-C | 413 |
| CΞN | 891 |
| H-H | 436 |
| C-N | 293 |
| N-H | 391 |



+ H-H

 →

**Bonding Practice Problems**

**Answer Section**

**MATCHING**

1. ANS: C PTS: 1

2. ANS: D PTS: 1

3. ANS: C PTS: 1

4. ANS: B PTS: 1

5. ANS: D PTS: 1

**MULTIPLE CHOICE**

6. ANS: E PTS: 1 DIF: 3

7. ANS: A PTS: 1

8. ANS: A PTS: 1

9. ANS: C PTS: 1

10. ANS: C PTS: 1 DIF: 3

11. ANS: B PTS: 1 REF: after AP MC question

12. ANS: C PTS: 1

13. ANS: D PTS: 1

14. ANS: C PTS: 1

15. ANS: B PTS: 1

16. ANS: D PTS: 1

**PROBLEM**

17. ANS:

C-C single bond in C2H6 vs. C=C double bond in C2H4

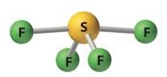
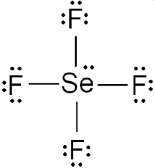
More energy is required to break a double bond than a single bond (double bond is stronger than single bond)

PTS: 1

18. ANS:

1 pt for correct Lewis structure & sketch Se has 4 bonds & 1 lone pair:

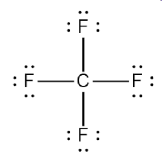
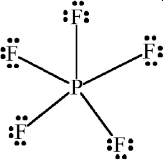
see saw or sawhorse geometry

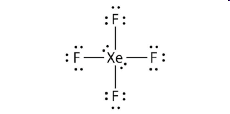


molecule is polar; polar Se-F bonds and bond vectors do not cancel/do not add up to zero

19. ANS:

a)

i)  ii) 

iii) 

b) i) 109.5 degrees

ii) sp3

iii) square planar

20. ANS:

a) 4 sigma bonds & 1 pi bond

b) Structure 1 is the more representative structure because all of its atoms have a formal charge of zero. Should show FC calculations or state that P, O have FC of zero.

21. ANS:

Both compounds are ionically bonded. Both cations have a +1 charge and both anions have a -1 charge.

Lattice energy & Coulomb's law argument: K+ ions have a larger radius than Na+ ions, so there is a larger internuclear distance between K+ and Cl- than between Na+ and Cl-. Therefore the coulombic attraction between K+ and Cl- is weaker than the coulombic attraction between Na+ and Cl-

#22: ΔH= Bonds Broken – Bonds Formed

= [H-C + CΞN + H-H] – [ 3 C-H + C-N + 2 H-N]

= [413 + 891 + 436] - [3(413) + 293 + 2(391)]

= 1740 – 2314 kJ/mol

= -574 kJ/mol

1 pt for setup, 1 pt for correct answer.