KEY

Bonding Practice Problems

1) Which of the following statements is TRUE? 1) _____

A) The Real World is still one of the best shows on television.
B) Energy is released when two like charged species are brought closer to one another.
C) Energy is given off when two oppositely charged species are separated.
D) The force between two ions is larger in water than in a vacuum.
E) The potential energy of oppositely charged particles decreases as they are brought closer together.

2) The distance between two atoms involved in a bond is 2) _____

A) determined primarily by the size of the nuclei.
B) generally larger as the bond energies become larger.
C) always larger for double and triple bonds.
D) not related to bond energies.
E) the distance where the potential energy of the interaction is at a minimum.

3) The dielectric constant of water is 3) _____

A) roughly twice the dielectric constant of a vacuum
B) approximately one
C) approximately equal to the dielectric constant of a methanol solution
D) approximately zero
E) about 80 times greater than air or a vacuum

4) In which of he following molecules would you expect the nitrogen to nitrogen bond to be the shortest? 4) _____

A) N_2H_2 B) N_2O_4 C) N_2H_4 D) N_2O E) N_2

5) Given the following bond energies (in kJ/mol) N≡N (946), H—H (436), H—N (389), estimate ΔH for the following reaction: 5) _____

$$N_2(g) + 3\ H_2(g) \rightarrow 2NH_3(g)$$

-80 kJ

6) Given the following bond energies (in kJ/mol) I—Cl (209), H—H (435), H—I (297), and H—Cl (431), estimate ΔH for the folowing reaction: 6) _____

$$ICl_3(g) + 2\ H_2(g) \rightarrow HI(g) + 3\ HCl(g)$$

-93 kJ

7) Given the following following bond energies (in kJ/mol) H—O (464), Cl—Cl (243), Cl—O (205), and H—Cl (431), estimate ΔH for the following reaction: 7) _____

$$H_2O(g) + Cl_2(g) \rightarrow HOCl(g) + HCl(g)$$

71 kJ

8) Given the following bond energies (in kJ/mol) C=O (707), O=O (498), H—O (464), and C—H (414), estimate ΔH for the following reaction: 8) _____

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$$

-618 kJ

9) Given the following bond energies (in kJ/mol) C—O (360), C=O (707), O=O (498), H—O (464), C—H (414) estimate ΔH for the following reaction: 9) _____

$$CH_3OCH_3(g) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(g)$$

-602 kJ

10) Given the following bond energies (in kJ/mol) C—C (348), C=O (707), O=O (498), H—O (464), C—H (414) estimate ΔH for the complete combustion of heptane. 10) _____

-3130 kJ

11) Given the listed average bond energies, calculate the enthalpy change for the production of 48 g of methanol by the reaction: 11) _____

$$CO_2(g) + 3\,H_2(g) \rightarrow CH_3OH(g) + H_2O(g)$$

C—O	360 kJ/mol
C=O	736 kJ/mol
H—H	436 kJ/mol
H—O	464 kJ/mol
H—C	414 kJ/mol

-312 kJ

12) Given the tabulated data, what is the lattice energy of crystalline calcium chloride? 12) _____

heat of sublimation for calcium	+178 kJ/mol
first ionization energy for calcium	+590 kJ/mol
second ionization energy for calcium	+1145 kJ/mol
heat of dissociation for chlorine	+122 kJ/mol(Cl)
electron affinity for chlorine	–349 kJ/mol
heat of formation for calcium chloride	–796 kJ/mol

-2255 KJ/mol

13) Given the following information, calculate $\Delta H°$(in ~~kcal~~ KJ mole^{-1}) for: $CaI_2(s) \rightarrow Ca^{+2}(g) + 2$ I$^-$ (g) 13) _____

Process	$\Delta H°$ (~~kcal~~ KJ/mole)
$Ca(s) \rightarrow Ca(g)$	+178
$I_2(g) \rightarrow 2I(g)$	+36 (per mole I_2)
$I_2(s) \rightarrow I_2(g)$	+15
$Ca(g) \rightarrow Ca^+(g) + e^-$	+590
$Ca^+(g) \rightarrow Ca^{+2}(g) + e^-$	+1145
$I(g) + e^- \rightarrow I^-(g)$	–71
$Ca(s) + I_2(s) \rightarrow CaI_2(s)$	+534 (per mole CaI_2)

1288 KJ/mol

14) Given the following information, calculate $\Delta H°$(in kcal mole^{-1}) for: $I(g) + e^- \rightarrow I^-(g)$ 14) _____

Process	$\Delta H°$ (kcal/mole)
$Ca(s) \rightarrow Ca(g)$	+178
$I_2(g) \rightarrow 2I(g)$	+36 (per mole I_2)
$I_2(s) \rightarrow I_2(g)$	+15
$Ca(g) \rightarrow Ca^+(g) + e^-$	+590
$Ca^+(g) \rightarrow Ca^{+2}(g) + e^-$	+1145
$CaI_2(s) \rightarrow Ca^{+2}(g) + 2\ I^-(g)$	+1288
$Ca(s) + I_2(s) \rightarrow CaI_2(s)$	+534 (per mole CaI_2)

-71 KJ/mol

15) Given the tabulated data, what is the electron affinity for chlorine? 15) _____

heat of sublimation for calcium	+178 kJ/mol
first ionization energy for calcium	+590 kJ/mol
second ionization energy for calcium	+1145 kJ/mol
heat of dissociation for chlorine	+122 kJ/mol(Cl)
heat of formation for calcium chloride	–796 kJ/mol
lattice energy of crystalline calcium chloride	–2255 kJ/mol

-349 KJ/mol

16) The description of covalent bond formation as an overlap of atomic or hybrid atomic orbitals between the two bonded atoms is referred to as: 16) _____

A) MOJO theory
B) atomic orbital theory
C) VSEPR method
D) molecular orbital theory
E) valence-bond theory

17) The concept of the anti-bonding orbital is unique to: 17) _____

A) molecular orbital theory
B) bond hybridization theory
C) electrostatic repulsion theory
D) valence bond theory
E) pessimistic theory

18) What would you predict the bond order would be for the C-C bonds in benzene (C_6H_6)? 18) _____

A) 0 B) 1 C) 3/2 D) 1/2 E) 2

1.5

19) Which statement is INCORRECT about molecular orbital theory? 19) _____

A) The bonding orbitals are at a lower energy than antibonding orbitals.
B) Lower energy molecular orbitals are filled with electrons first.
C) Bond order = $\frac{(\#\text{ bonding } e^-) - (\#\text{ antibonding } e^-)}{2}$
D) The number of molecular orbitals formed is equal to the number of atomic orbitals combined.
E) Hund's rule does not apply in molecular orbital theory.

20) According to molecular orbital theory, when two atoms bond together, their *p* orbitals combine to form: 20) _____

A) two sigma M.O.'s and two pi M.O.'s
B) four pi M.O.'s only
C) one sigma and one pi M.O.
D) two sigma M.O.'s and four pi M.O.'s
E) none of these

21) If a set of p-orbitals on two identical axes (x, y, z) are brought together along the x-axis, how many bonds can be formed that have no electron density along the axes? 21) _____

A) 1 B) 4 C) 0 D) 2 ← 2 PI BONDS

22) Which of the following statements concerning the relative energy levels of molecular orbitals for the O_2 molecule is INCORRECT? 22) _____

A) $\sigma 2s < \sigma 2p$
B) $\sigma 2s < \sigma^* 2s$
C) $\pi^* 2p < \sigma^* 2p$
D) $\pi 2p < \sigma 2p$
E) all of the above are correct

23) Which of the following molecules is paramagnetic? 23) _____

A) C_2

B) B_2

C) N_2

D) F_2

E) none – all are diamagnetic

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

24) Molecular orbital theory describes covalent bonding as the overlap of partially filled atomic orbitals. 24) F

25) Valence bond theory describes covalent bonding as the overlap of partially filled atomic orbitals. 25) T

26) The best way to predict the magnetic properties of a molecule is to draw its lewis structure and look for any unpaired electrons. 26) F

27) Molecular orbitals can be calculated by combining valence atomic orbitals using the linear combinations of atomic orbitals (LCAO) method. 27) T

28) Because molecular orbital theory correctly explains observations that valence bond theory cannot, MO theory is better, and the use of VBT should be discouraged. 28) F

29) Valence bond theory is widely used, useful and powerful theory that can be applied to a large number of molecules. However, it cannot explain all observations. 29) T