Hybridization, Quantum Numbers and Atomic Structure, Solids

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(ChemistNate)

1.

a) How many electrons can fit in n=3?
b) How many electrons can fit in n=4?
c) How many orbitals are in n=2?
d) How many orbitals are in n=3?
e) How many orbitals are in n=4?
f) How many possible orbitals can there be in n=5?
g) Which atom's electron configuration ends with $6s^1$?
h) Which atom's electron configuration ends with $4p^2$?
i) What is the hybridization of Be in $BeCl_2$?
j) What is the hybridization of B in BH_3?
k) What is the hybridization of C in CH_3F?
l) What is the hybridization of O in CO?
m) What is the hybridization of S in H_2S?

2. Draw the orbital overlap diagram for CH_3OH. Show the hybridization of each atom (if applicable), label each orbital and each σ and π bond.

3. Which of the following has the **higher** melting point?

a) SiO_2 vs CO_2
b) $C_{(diamond)}$ vs Cu
c) Cu vs K
d) Na vs Cs
e) NaCl vs $CaCl_2$
f) $CaCl_2$ vs CaO
g) KBr vs LiBr
h) $CaCl_2$ vs SCl_2
i) H_2O vs H_2S
j) NH_3 vs NH_4NO_3
k) CF_4 vs BrF
l) CH_4 vs CI_4
m) SO_2 vs CO_2

4. Why does $NaCl_{(s)}$ conduct electricity as a liquid, but SCl_2 does not?

5. Why do metal conduct electricity? Explain on an atomic level.

6. Why does graphite conduct electricity, but diamond does not?

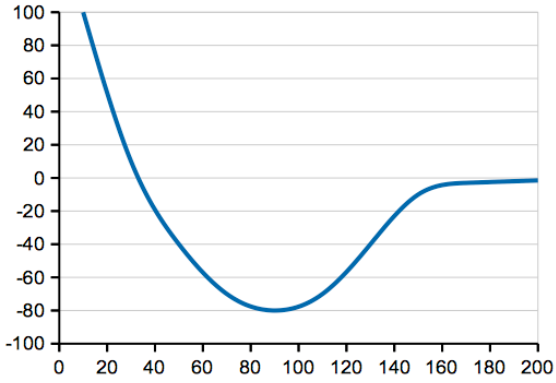
7. Why do short alcohol molecules dissolve in water, but similar-sized alkanes do not?

8. Label the axes on this graph, and explain:

a) The very fast rise at the far left of the graph

b) The horizontal asymptote at the far right of the graph

c) The trough in the center



Answers

1.a) How many electrons can fit in n=3? 2 in 3s, 6 in 3p, 10 in 3d = **18 total**

b) How many electrons can fit in n=4? 2 in 4s, 6 in 4p, 10 in 4d, 14 in 4f = **32 total**

c) How many orbitals are in n=2? 1 for 2s, 3 for 2p = **4 total**

d) How many orbitals are in n=3? 1 for 3s, 3 for 3p, 5 for 3d = **9 total**

e) How many orbitals are in n=4? 1 for 4s, 3 for 4p, 5 for 4d, 7 for 4f = **16 total**

f) How many possible orbitals can there be in n=5? 1+3+5+7+9 = **25 total**

g) Which atom's electron configuration ends with $6s^1$? 6th row, Group 1 = **Cs**

h) Which atom's electron configuration ends with $4p^2$? 4th row, 2 into the p-block = **Ge**

i) What is the hybridization of Be in $BeCl_2$? Linear = **2sp**

j) What is the hybridization of B in BH_3? Trigonal planal = **$2sp^2$**

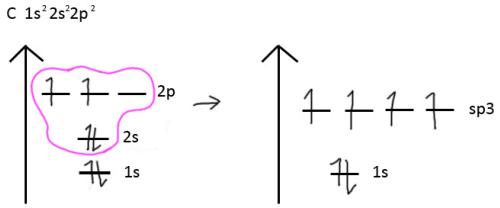
k) What is the hybridization of C in CH_3F? Tetrahedral = **$2sp^3$**

l) What is the hybridization of O in CO? Linear (2 π bonds) = **2sp**

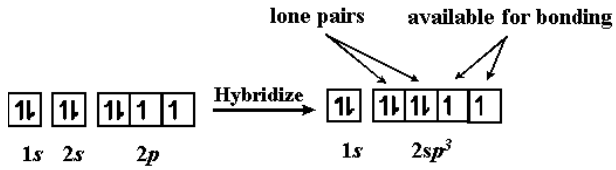
m) What is the hybridization of S in H_2S? Tetrahedral = **$3sp^3$**

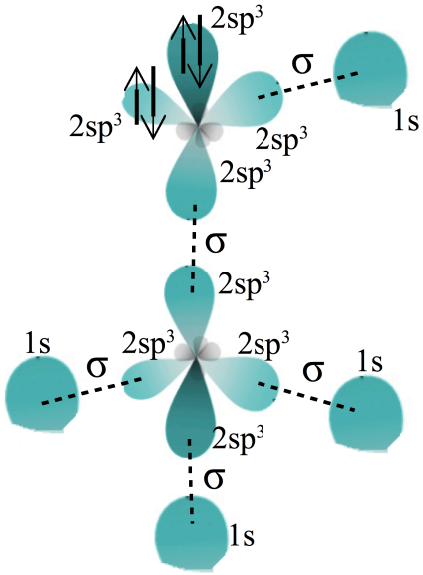
2. Draw the orbital overlap diagram for CH_3OH. Show the hybridization of each atom (if applicable), label each orbital and each σ and π bond.

Carbon is sp^3 hybridized:



Oxygen is sp^3 hybridized too:





3. Which of the following has the **higher** melting point?

a) SiO_2 vs CO_2 network vs molecular; network solid always wins

b) $C_{(diamond)}$ vs Cu network vs metallic; network solid always wins

c) Cu vs K both metallic; Cu has more valence electrons and so wins

d) Na vs Cs both metallic; same number of valence electrons; smaller ion wins

e) NaCl vs $CaCl_2$ both ionic; bigger charges win

f) $CaCl_2$ vs CaO both ionic; bigger charges win

g) KBr vs LiBr both ionic; same charges; smaller ions win

h) $CaCl_2$ vs SCl_2 ionic vs molecular; ionic wins

i) H_2O vs H_2S both molecular; hydrogen-bonding molecules win

j) NH_3 vs NH_4NO_3 molecular vs ionic; ionic wins

k) CF_4 vs BrF both molecular; one with dipole-dipole forces wins

l) CH_4 vs CI_4 both molecular; both non-polar; larger one wins (stronger LDFs)

m) SO_2 vs CO_2 both molecular; one with dipole-dipole forces wins.

4. Why does $NaCl_{(s)}$ conduct electricity as a liquid, but SCl_2 does not?

- NaCl is an ionic compound; when it melts, the ions are free to move around. Mobile ions = mobile charges and so the liquid will conduct electricity.
- SCl_2 is molecular and does not produce ions ever. It can not conduct in any form.

5. Why do metal conduct electricity? Explain on an atomic level.

- Metals are a lattice of positively-charged ions in a sea of delocalized electrons.
- This means the electrons are free to move around, and free-to-move-around electrons are the defining characteristic of conductivity.

6. Why does graphite conduct electricity, but diamond does not?

- Graphite has delocalized electrons within each 2D sheet. This is caused by resonance.
- Diamond has no such electron delocalization.

7. Why do short alcohol molecules dissolve in water, but similar-sized alkanes do not?

- Short alcohol molecules are polar, and so polar molecules can form dipole-dipole interactions with them. This is a favorable attraction and lets the alcohol molecules dissolve.
- Alkanes are non-polar. Water molecules would rather stick to other water molecules, and so the intermolecular forces holding the water molecules together will not break themselves to allow a non-polar molecule in.

8. Label the axes on this graph, and explain:

a) The very fast rise at the far left of the graph
- Nuclei (positive-charges) too close together → Repulsion.

b) The horizontal asymptote at the far right of the graph
- Nuclei too far apart → the electrons that would make the bond can barely see each other, so there is no attraction, and no repulsion.

c) The trough in the center
- There is a "magic" distance between the two nuclei where they repel each other a little, but the electrons in the bond between them hold them together in a bond.
- The covalent bond length between the two atoms is at the bottom of the trough: about 90 pm in this case.
- For the record, I don't know of any covalent bonds that are this short, but the shape of the graph is ok.