Ch. 9 Practice Questions

- 1. The hybridization of the carbon atom in the cation CH_3^+ is:
 - A) sp^2
 - B) *sp*³
 - C) dsp
 - D) sp
 - E) none of these
- 2. In the molecule C_2H_4 the valence orbitals of the carbon atoms are assumed to be
 - A) not hybridized
 - B) sp hybridized
 - C) sp^2 hybridized
 - D) sp^3 hybridized
 - E) *dsp* hybridized
- 3. The hybridization of the central atom in I_3^- is:
 - A) sp
 - B) sp^2
 - C) *sp*³
 - D) dsp^3
 - E) d^2sp^3
- 4. Consider the following Lewis structure:

$$\begin{array}{cccc} H & O & H & H \\ H - C - C & C & C & -C \\ & & & & \\ H \end{array}$$

Which statement about the molecule is false?

- A) There are 10 sigma and 2 pi bonds.
- B) C-2 is sp^2 hybridized with bond angles of 120° .
- C) Oxygen is sp^3 hybridized.
- D) This molecule contains 28 valence electrons.
- E) There are some H–C–H bond angles of about 109° in the molecule.

5. The hybridization of the central atom, Al, in AlBr₃ is

- A) sp
- B) sp^2
- C) *sp*³
- D) dsp^3
- E) d^2sp^3

- 6. In which of the compounds below is there more than one kind of hybridization (sp, sp^2, sp^3) for carbon?
 - I. CH₃CH₂CH₂CH₃
 - II. $CH_3CH = CHCH_3$
 - III. $CH_2 = CH CH = CH_2$
 - IV. $H C \equiv C H$
 - A) II and III
 - B) II only
 - C) III and IV
 - D) I, II, and III
 - E) III only
- 7. A π (pi) bond is the result of the
 - A) overlap of two *s* orbitals
 - B) overlap of an *s* orbital and a *p* orbital
 - C) overlap of two *p* orbitals along their axes
 - D) sidewise overlap of two parallel *p* orbitals
 - E) sidewise overlap of two *s* orbitals

Consider the skeletal structure shown below:

N—C—C—N

Draw the Lewis structure and answer the following:

- 8. How many of the atoms are *sp* hybridized?
 - A) 0
 - **B**) 1
 - C) 2
 - D) 3
 - E) 4
- 9. How many pi bonds does the molecule contain?
 - A) 0
 - B) 2
 - C) 4
 - D) 6
 - E) 7
- 10. Which of the following molecules contains the shortest C-C bond?
 - A) C_2H_2
 - B) C_2H_4
 - $C)\quad C_2H_6$
 - $D) \quad C_2 Cl_4$
 - $E) \quad b \ and \ d$

- 11. The electron configuration of a particular diatomic species is $(\sigma_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p})^2$. What is the bond order for this species?
 - A) 3.5
 - B) 3
 - C) 2.5
 - D) 2 E) 1.5
- 12. What is the bond order of He_2^+ ?
 - A) 0
 - B) $\frac{1}{2}$
 - C) 1
 - D) $1\frac{1}{2}$

 - E) 2
- 13. If four orbitals on one atom overlap four orbitals on a second atom, how many molecular orbitals will form?
 - A) 1
 - B) 4
 - C) 8
 - D) 16
 - E) none of these
- 14. When comparing Be_2 and H_2 :
 - I. Be₂ is more stable because it contains both bonding and antibonding valence electrons.
 - II. H_2 has a higher bond order than Be_2 .
 - III. H₂ is more stable because it only contains σ_{1s} electrons.
 - IV. H₂ is more stable because it is diamagnetic, whereas Be₂ is paramagnetic.
 - A) I, II
 - B) III only
 - C) II, III
 - D) II, III, IV
 - E) III, IV

15. The configuration $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2py})^1(\pi_{2px})^1$ is the molecular orbital description for the ground state of

- A) Li_2^+
- B) Be₂
- C) B₂
- D) B_2^{2-}
- E) C₂

- 16. Which of the following species is paramagnetic?
 - A) C₂
 - B) O₂
 - $C) \quad F_2$
 - D) Li_2
 - E) none of these

17. Which of the following species has the largest dissociation energy?

- A) O₂
- B) O₂⁻
- C) O_2^{2-}
- $D) \quad O_2{}^+$
- E) O₂²⁺

18. Which of the following diatomic molecules has a bond order of 2?

- A) B_2
- B) C₂
- $C) \quad P_2$
- D) F₂
- E) Li₂
- 19. Consider the molecular orbital energy level diagrams for O₂ and NO. Which of the following is true?
 - I. Both molecules are paramagnetic.
 - II. The bond strength of O_2 is greater than the bond strength of NO.
 - III. NO is an example of a homonuclear diatomic molecule.
 - IV. The ionization energy of NO is smaller than the ionization energy of NO⁺.
 - A) I only
 - B) I and II
 - C) I and IV
 - D) II and III
 - E) I, II, and IV
- 20. The hybridization of the lead atom in $PbCl_4$ is
 - A) dsp^2
 - B) sp^2
 - C) d^2sp^3
 - D) dsp^3
 - E) none of these

Ch. 9 Practice Questions Answer Section

1.	ANS:	A REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories hybridization
2.	ANS:	C REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories hybridization
3.	ANS:	D REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories hybridization
4.	ANS:	C REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories
5.	ANS:	B REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories hybridization
6.	ANS:	B REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories hybridization
7.	ANS:	D REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories multiple bonding
8.	ANS:	E REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories hybridization
9.	ANS:	C REF: 9.1
	KEY:	Chemistry general chemistry bonding bonding theories multiple bonding
10.	ANS:	A REF: 9.2
	KEY:	Chemistry general chemistry bonding bonding theories molecular orbital theory bond order
11.	ANS:	D REF: 9.2
	KEY:	Chemistry general chemistry bonding bonding theories molecular orbital theory bond order
12.	ANS:	B REF: 9.2
	KEY:	Chemistry general chemistry bonding bonding theories molecular orbital theory bond order
13.	ANS:	C REF: 9.2
	KEY:	Chemistry general chemistry bonding bonding theories molecular orbital theory
14.	ANS:	C REF: 9.3
	KEY:	Chemistry general chemistry bonding bonding theories diatomic molecule
15.	ANS:	C REF: 9.3
	KEY:	Chemistry general chemistry bonding bonding theories diatomic molecule
16.	ANS:	B REF: 9.3
. –	KEY:	Chemistry general chemistry bonding bonding theories diatomic molecule
Γ7.	ANS:	$E \qquad REF: 9.3$
10	KEY:	Chemistry general chemistry bonding bonding theories molecular orbital theory bond order
18.	ANS:	B REF: 9.3 Chamisters have not a hear directly and in a three directly interview of hear hear hear hear hear hear hear hear
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Solutions to Ch. 9 Proactice Questions

(2) The only way to write the skeletal structure is H-C-C-H because hydrogens must be peripheral H

Carbon needs to make 4 bonds to avoid a (+) charge. That can be easily accomplished by simply adding a bond between the two carbons:

$$\begin{array}{c} H - C = C - H \\ I & I \\ H & H \end{array}$$

The second bond in the double bond is a TT bond, and does not affect hybridization, which is a property of only the J bonds and lone pairs.

Both carbon atoms have 3 electron groups (2 of the groups are simple of bonds, and the third group is a J sigma bond with a TT bond tagging along (a double-bond).

3 groups of e => sp2 hybridized

3) The skeletal structure is I - I - I peripheral central peripheral

Peripheral halogens make one bond, and art like "normal" halogens, following the octet rule. A peripheral halogen with a single bond has a zero formal charge. That leaves the central I as the only atom that can carry the (-) charge. Central halogens routinely violate the octet rule and thus carry a charge and make multiple bonds.

Using our shortcut:
$$\binom{no.of}{lone pair} = 7 - 2 - (-1) = 6 \Longrightarrow \binom{no.of}{lone} = \frac{6}{2} = 3$$

Thus we have :

$$\vdots$$
 $\vec{I} - \vec{I} - \vec{I}$:

The central I has 3 lone pairs and 2 bonds, for a total of 5 e groups. 5 e groups => sp3d Since s and porbitals can only create a maximum of 1+3=4 hybrid orbitals, we 1 + 3 + 1 = 5 need to bring in an extra d-orbital to the mix.

4) To count the no. of sigma bonds, we just count all the bonds regardless of their being single, double, or triple. A double bond has one J bond and one TT bond, so it contributes one or bond. A triple bond again has only one G bond and two TT bonds, again contributing one G bond to the total. There are 10 sigma bonds 2 TT bonds (one TT bond from each double bond),

C-2 has 3 e groups => sp² hybridized => bond angles = 120°
The oxygen has a double bond. To calculate the number of e groups
around it, we need to know the no. of lone pairs. Since the double
bond uses 2 e pairs (A electrons) it leaves A e for lone pairs, which
means the oxygen has
$$\frac{4}{2}$$
 = 2 lone pairs, for a total of 3 e groups => sp²
Oxygen has sp² hybridization, not sp³
The molecule contains $(4)(4) + (6)(1) + (1)(6) = 28$ valence e⁻
The carbon in H-c- has sp³ hybridation (4 e groups), and bond angles of 109°

(5) Al like B violator the actual of the line in the second
six electrons. Therefore Al in AIRs does not need a limith only
Our chartent Calue anice a lone pair:
Br-Al-Br of the octet rule.
Br Hoflone pair e= 3-3-0=0 => no lone pairs
We used a charge of Ø because the peripheral Br with
and the molecule is neutral, so Al has zero formal charge.
Al has 3 e groups => sp² hybridized
6 I. H-C-C-C-H each C has 4 e groups => only sp ³ H H H H
T H H T I H I H P
1. H-C-C=C-C-H Two carbons with 4 e provips =) sp] 2 kinds
H H H H
II. H-C=C-C=C-H Each carbon has 3 € groups ⇒ only sp?
IV. H-C≡C-H Each carbon has 2€ groups ⇒ only sp
() All bond is the result of the sidewise overlap of two porallel portities
0
Q. Q
(8) The skeletal structure contains all the Thads Since raches anot
exceed the octet it is limited to hybrids without d orbitals. It is very
rare for C to have lone pairs, and we should consider it only if there is
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the contraction of the second satisfy the octeds using them.

:NEC-CEN: Indeed the octets are satisfied, and all the atoms have 2 electron groups. So 4 atoms have sp hybridization.

(9) :N EC - C = N: contains 2 triple bonds. Each triple bond contains two TT-bonds. Number of TT bonds = 2x2 = 4

(1) For bonds between two given atoms, the strength of the bond increases in the following order X-X < X=X < X = X triple bond strongest and the length of the bond goes in the reverse order X-X>X=X>X=X triple bond shortest The molecule with the triple bond contains the shortest C-C band. We write the Lewis structures of each choice. We can use the long, standard procedure or use our rules of thumb (4 bonds for C, 2 bonds for 0, 1 bond for H or peripheral halogens; use lone pairs or multiple bonds as needed). H-CEC-H e has the shortest C-C bond C2H2 C_2H_4 H - C = C - HH H H H H-C-C-H H H C_2H_6 ce - c = c - ce C_2Cl_4 # of e in bonding orbitals= 2+2+4=B # of e in anti-bonding orbitals = 2+2=4 Bond order = $\frac{8-4}{2}$ = 2

~



(6 cond.) Two F atoms bring 7 valence electrons each (for a total of 14)

$$G_{1p}^{*}$$
 —
 π_{2p}^{*} $\frac{1}{4}$ $\frac{1}{4}$
 G_{2p}^{*} $\frac{1}{4}$
 π_{2p}^{*} $\frac{1}{4}$
 $\frac{1}{6}$
 $\frac{$

18) We construct the M.O. energy diagrams for all the choices

(19) Oz has the "expected" M.O. Liagram, while NO has the modified diagram like Nz



* Both O₂ and NO are paramagnetic
* Bond strength of O₂ is not greater than that of NO

While it's not totally safe to use B.O. to compare the bond strengths of diatomic species made of different atoms, O₂ and NO are dose enough
* NO is not an example of a homonuclear diatomic molecule
It's heteronuclear

* The ionization energy of NO is smaller than that of NO⁺

The higher the energy of the highest energy e⁻, the smaller the ionization energy. The highest energy e⁻ in NO is in Tt^{*}_{2P}, whereas that of NO⁺

(20) Although Pb Clq is a metal-nonmetal compound, it actually has covalent bonds, às you must surmise from the context (although "none of These" would be appropriate if it were an ionic compound). A statement like "PbCly is a yellow, oily liquid which is stable below O'c and decomposes at 50°C" at the beginning of a question would give you enough hint to conclude that the compound is not ionic and you can use the covalent bond concepts like hybridization. (Simple binary ionic compounds have high melting points and don't decompose easily) Since the peripheral atoms are halogens (expected to have single bonds and zero formal charges, making the formal charge of Pb also zero, because PbCly is a neutral molecule), we can use our shortcut for finding the no. of lone pairs on the central allom. $\binom{no. of}{lone paire} = \binom{no. of}{valence e} - \binom{no. of}{bords} - \binom{formal}{charge} = 4 - 4 - \emptyset = \emptyset$ No lone pours, and 4 bands => 4 e promps => sp³ hybridization So the correct answer indeed is "none of these". However, I don't know if the writers of the question meant that because they (understandably) thought that it had ionic bunds and hybridization didn't apply, or actually understood that it had sp3 hybridization. Lucky for the person who has to answer the question, both trains of thought lead to "none of these".