

## NEET Important Questions with Solutions from Chemical Bonding and Molecular Structure

Q.1. The bond order of a molecule is given by\_\_\_\_\_.

- A) the total number of electrons in bonding and antibonding orbitals
- B) the difference between the number of electrons in bonding and antibonding orbitals
- C) twice the difference between the number of electrons in bonding and antibonding orbitals
- D) half the difference between the number of electrons in bonding and antibonding orbitals

**Answer:** half the difference between the number of electrons in bonding and antibonding orbitals

**Solution:** Bond order of a molecule is determined by molecular orbital theory. It is half the difference between the number of electrons in bonding and anti-bonding orbitals.

$$\text{Bond order} = \frac{1}{2} (N_b - N_a)$$

Where,  $N_b$  = Number of bonding molecular orbitals.

$N_a$  = Number of anti-bonding molecular orbitals.

Q.2. Which of the following is an incorrect rule for drawing resonance structures?

- A) The nuclei of the atoms never move and the bond angle remains the same.
- B) Only  $\pi$  electrons and lone pair of electrons can move during resonance.
- C) The resonance structure with the highest energy is the major resonance contributor.
- D) Negative charges are more stable on more electronegative atoms such as O, N and S.

**Answer:** The resonance structure with the highest energy is the major resonance contributor.

**Solution:** Due to resonance, various contributing structures are formed and the structure which is the most stable will have the lowest energy "so the statement "the resonance structure with the highest energy is the major resonance contributor" is incorrect".

Q.3. Which of the following carbon-carbon bonds has the highest energy?

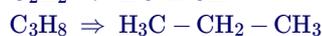
- A)  $C_2H_6$
- B)  $C_2H_4$
- C)  $C_2H_2$
- D)  $C_3H_8$

**Answer:**  $C_2H_2$



**Solution:** Bond energy is directly related to bond order.

Bond order is the number of bonds present between the two bonded atoms. Higher the bond order, more will be the bond energy. Let's write down the structure of all the given molecules:



As we can see, the bond order of  $\text{C}_2\text{H}_2$  is maximum, i.e., 3. So, it will have the highest bond energy among all.

Q.4. Resonance is due to \_\_\_\_\_

- A) delocalization of sigma electron
- B) delocalization of pi electrons
- C) migration of H atoms
- D) migration of protons

**Answer:** delocalization of pi electrons

**Solution:** Resonance is a hypothetical process in which delocalization of pi electrons in a conjugated system takes place. It is required when one structure of a molecule can not explain all the properties of a molecule. Each of these structures can explain most of the properties of a molecule. The actual structure is in between these resonating structures and is called resonance hybrid and other structures are known as canonical structures.

Q.5. Which of the following species CANNOT exist under normal conditions?

- A)  $\text{Be}_2$
- B)  $\text{He}^+$
- C)  $\text{H}_2^+$
- D)  $\text{Be}_2^+$

**Answer:**  $\text{Be}_2$

**Solution:** Electronic configuration of  $\text{Be}_2$  is:



$$\text{Bond order of } \text{Be}_2 \text{ is : } \frac{1}{2} (N_b - N_a) = \frac{1}{2} (4 - 4) = 0$$

If there is zero bond order, it means that it does not exist.

Q.6. What is the value of actual charge on  $\text{Al}^{3+}$  ion?

- A)  $4.8 \times 10^{-19} \text{ C}$
- B) Zero
- C) +3
- D)  $5.01 \times 10^{-24} \text{ C}$

**Answer:**  $4.8 \times 10^{-19} \text{ C}$

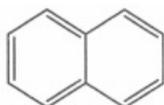


**Solution:** A positive ion is formed by losing electrons. The magnitude of unit positive charge will be equal to the charge on one electron.

In the case of  $Al^{+3}$ , it contains three electrons less than the neutral Aluminium atom.

Thus, the magnitude of the charge =  $3 \times 1.6 \times 10^{-19} \text{ C} = 4.8 \times 10^{-19} \text{ C}$ .

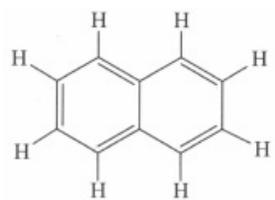
Q.7. The ratio of  $\sigma$  to  $\pi$  bonds in naphthalene is



- A) 5 : 19.
- B) 19 : 5.
- C) 19 : 6.
- D) 11 : 5.

**Answer:** 19 : 5.

**Solution:** Structure of naphthalene:



In case of multiple bonds between two atoms, one bond is always  $\sigma$  and others are  $\pi$  bonds. All single bonds are essentially sigma bonds.

Thus, in naphthalene,

Number of  $\sigma$  bonds = 19.

Number of  $\pi$  bonds = 5.

Therefore, the ratio of  $\sigma$  to  $\pi$  bonds in naphthalene is =  $\frac{19}{5}$ .

Q.8. What is true about CO molecule?

- a. It has two lone pairs.
- b. It has one dative bond.
- c. It has two  $\pi$  bonds.
- d. It has one  $\sigma$  bond.

- A) a, b, c
- B) a, b, d
- C) b, c, d
- D) a, b, c, d

**Answer:** a, b, c, d



**Solution:**

The molecular structure of CO is : C  $\equiv$  O :

The electron pair not taking part in bond formation is called lone pair.

Among multiple bonds, one bond is always  $\sigma$  and rest all are  $\pi$  bonds.

Dative bond is another name for coordinate bond.

Thus, CO has two lone pairs, one  $\sigma$  and two  $\pi$  bonds.

Q.9. The correct order of bond strength is:

A) I – I < F – F < Cl – F < H – F

B) I – I < Cl – F < F – F < H – F

C) F – F < I – I < Cl – F < H – F

D) I – I < Cl – F < H – F < F – F

**Answer:** I – I < F – F < Cl – F < H – F

**Solution:**

Bond strength is inversely proportional to the bond length because, the shared electrons are far away from the nuclei, which decreases nuclei's hold on the electrons.

Bond length is approximately equal to the sum of the radius of combining atoms.

Among the given atoms, I is the largest in size. Thus, I – I bond has the least bond strength.

H – F bond has high bond strength due to the smallest size of H atom.

However, F – F bond has lower bond strength than Cl – F, due to more repulsion between lone pairs on smaller F atoms.

Q.10. Select the correct option by assigning true (T) and false (F) for the following statements.

(a) In  $\text{IF}_7$ , iodine is in the super octet state.

(b)  $\text{BF}_3$  is a hypervalent compound.

(c)  $\pi$ -bond is cylindrically symmetrical.

A) TFF

B) FFF

C) TTT

D) FTF

**Answer:** TFF

**Solution:**

The central atom in a super octet molecule contains more than an octet of electrons. Examples are  $\text{IF}_7$ ,  $\text{ClF}_3$  and  $\text{SF}_6$ .

(a) The central atom I in  $\text{IF}_7$  has 14 electrons, so, it is in the super octet state.

Hypervalent compounds are the chemical compounds containing a central atom having more than eight electrons in the valence electron shell.

Hypovalent compounds are the chemical compounds containing a central atom with less than eight electrons in the valence electron shell.

(b) The central atom B in  $\text{BF}_3$  has 6 electrons, hence, it is a hypovalent compound.

A  $\pi$ -bond is generated by the overlapping of two p-orbitals that are not radially symmetric.

(c)  $\pi$ -bond is an unsymmetrical bond.



Q.11. What is true about the change:  $\text{SO}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{SO}_3$ ?

(i) Hybrid state of sulfur changes from  $sp$  to  $sp^2$ .

(ii) The bent shape of  $\text{SO}_2$  changes to trigonal planar.

(iii) Bond angles between  $\text{O} - \text{S} - \text{O}$  atoms are different.

A) (i) and (ii).

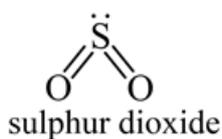
B) (i) and (iii).

C) (ii) and (iii).

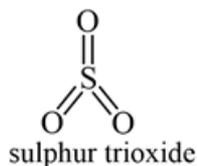
D) (iii) only.

**Answer:** (ii) and (iii).

**Solution:** In  $\text{SO}_2$ , the sulphur atom has one lone pair and two bond pairs around it. Thus, it is  $sp^2$  hybridised and according to VSEPR theory, it will have a bent geometry with an angle less than  $120^\circ$  due to lone pair-bond pair repulsion.



In  $\text{SO}_3$ , the sulphur atom has three bond pairs around it. Thus, it is  $sp^2$  hybridised and according to VSEPR theory, it will have a trigonal planar geometry with an angle of  $120^\circ$ .



Q.12. There are three diatomic species with each having a bond order of three. What is true regarding them?

(a) All of them can be isoelectronic.

(b) They are isostructural.

(c) They may include cationic/anionic species.

(d) They may include neutral species.

A) Both (a) and (b).

B) (a), (b) and (c).

C) (c) and (d).

D) (a), (b), (c) and (d).

**Answer:** (a), (b), (c) and (d).



**Solution:**  $\text{NO}^+$ ,  $\text{CN}^-$  and  $\text{N}_2$  all have a bond order = 3.

These are isoelectronic means have same number of electrons, in this case have  $14 e^-$  and isostructural as they are all linear in shape. These can be ions or neutral species.

All the options are correct.

Q.13. The correct order of boiling point for the substances  $\text{H}_2\text{O}$ ,  $\text{NH}_3$ ,  $\text{CsF}$  and  $\text{He}$  is:

- A)  $\text{NH}_3 < \text{He} < \text{H}_2\text{O} < \text{CsF}$ .
- B)  $\text{He} < \text{NH}_3 < \text{H}_2\text{O} < \text{CsF}$ .
- C)  $\text{CsF} < \text{NH}_3 < \text{H}_2\text{O} < \text{He}$ .
- D)  $\text{H}_2\text{O} < \text{NH}_3 < \text{CsF} < \text{He}$ .

**Answer:**  $\text{He} < \text{NH}_3 < \text{H}_2\text{O} < \text{CsF}$ .

**Solution:** The boiling point is directly proportional to the strength of intermolecular forces. The intermolecular forces in the following compounds are as follows:

$\text{CsF} \rightarrow$  It is an ionic compound. Thus, each of its ion is surrounded by an oppositely charged ion, which is attached through the electrostatic force of attraction. It is the strongest intermolecular force.

$\text{H}_2\text{O}$ ,  $\text{NH}_3 \rightarrow$  In both compounds, H is directly attached to the small-sized electronegative O and N atoms. Thus, their molecules are attracted to each other by a hydrogen bond. The strength of H-bond is directly proportional to the electronegativity difference between H and the other atom. Thus, the hydrogen bond in  $\text{H}_2\text{O}$  is stronger than  $\text{NH}_3$ .

$\text{He} \rightarrow$  In  $\text{He}$ , there is a possibility of only Van der Waal's force that arises due to the movement of electrons in the atom, which creates temporary dipoles. It is the weakest type of intermolecular force.

Thus, the order of boiling point:



Q.14. Some ionic compounds like  $\text{AgBr}$ ,  $\text{BaSO}_4$  and  $\text{CaCO}_3$  do not dissolve in water because

- A) ionic compounds are insoluble in water.
- B) these compounds have exceptionally high lattice energy.
- C) water has a high dipole moment.
- D) water is not a good ionizing solvent.

**Answer:** these compounds have exceptionally high lattice energy.



**Solution:** Some ionic compounds are insoluble in water due to high lattice energy.

$$\text{Lattice energy} \propto \frac{q_c q_a}{r_c + r_a}$$

$q_c$  = Charge on Cation

$q_a$  = Charge on anion

$r_c + r_a$  = Interionic distance

These salts have high value of  $q_c q_a$  like in  $\text{BaSO}_4$  and  $\text{CaCO}_3$  or low value of  $(r_c + r_a)$  like  $\text{AgBr}$  due to low radius or high value of effective nuclear charge of Silver ion which makes their lattice energy high.

If the lattice energy (LE) is higher than the hydration energy (HE) i.e.,  $\text{LE} > \text{H.E}$ , then, the compound is insoluble in water.  $\text{AgBr}$ ,  $\text{BaSO}_4$  and  $\text{CaCO}_3$  have higher lattice energy than hydration energy.

According to the solubility rule, like dissolves like, which means that polar dissolves in polar and non-polar dissolves in non-polar. Water can dissolve most of the ionic compounds.

Q.15. The bond energies for single covalent bonds of hydrogen atoms with elements A, B, C and D are 140, 228, 325 and 190  $\text{kJ mol}^{-1}$ , respectively. The element which has the smallest atom is:

A) A

B) B

C) C

D) D

**Answer:** C

**Solution:** Bond energy (BE):

The quantity of energy needed to break the bonds in any molecule and bring it down to the elementary atoms. It gives the measure of the strength of a chemical bond.

It decreases as the size of atom increases, and because of this, the shorter the bond length, the higher is the bond energy.

$$\text{Bond energy} \propto \frac{1}{\text{Size of atom}}$$

And as the size of the atom increases, bond length increases.

Atomic size  $\propto$  Bond length

Here, bond energy is the highest for H – C bond ( $325 \text{ kJ mol}^{-1}$ ). So, the C atom is the smallest.

Q.16. Which is the largest bond angle around central oxygen atom?

A)  $\text{CH}_3\text{OCH}_3$

B)  $\text{Cl}_3\text{C} - \text{O} - \text{CCl}_3$

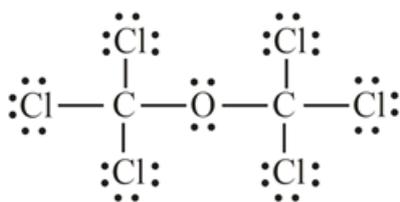
C)  $\text{CH}_3\text{CH}_2\text{OH}$

D)  $\text{O}_2\text{NOH}$

**Answer:**  $\text{Cl}_3\text{C} - \text{O} - \text{CCl}_3$



Solution:



The largest bond angle in  $\text{CCl}_3 - \text{O} - \text{CCl}_3$  due to repulsion between electron pairs of big sized  $\text{CCl}_3$  groups.

Bond angle around central atom depends upon the type of hybridization, difference in electronegativity of bonded atoms, presence of lone pairs, size of groups connected etc.

Q.17. A molecule  $\text{AB}_4$  is isostructural with non-polar  $\text{CH}_4$ . The bond moment of  $\text{A} - \text{B}$  is 1.2 D and bond length is  $1 \text{ \AA}$ . The charge developed on the central atom of  $\text{AB}_4$  (neglecting any orbital dipoles), is:

- A)  $1.2 \times 10^{-10}$  esu
- B)  $1.6 \times 10^{-19}$  esu
- C)  $3.6 \times 10^{-10}$  esu
- D) zero charge

Answer:  $1.6 \times 10^{-19}$  esu

Solution: Charge =  $\frac{\text{Dipole moment}}{\text{Bond length}} = \frac{1.2 \times 10^{-18} \text{ esu cm}}{10^{-8} \text{ cm}} = 1.2 \times 10^{10}$  esu

Structure of  $\text{AB}_4$  is shown below.



Therefore, the central atom 'A' will have four times the charge on each B.

$$\begin{aligned} \text{Total charge} &= 1.2 \times 10^{-10} \times 4 \\ &= 4.8 \times 10^{-10} \text{ esu} \\ &= 1.6 \times 10^{-19} \text{ C.} \end{aligned}$$

Q.18. Two compounds given are,  $\text{PX}_2\text{Y}_3$  and  $\text{PX}_3\text{Y}_2$  (where, P = Phosphorous atom, X and Y are monovalent atoms). If all 'X' atoms are replaced by 'Z' atoms (Z is a monovalent) and electronegativity order for the three atoms is  $\text{X} > \text{Y} > \text{Z}$ , then, the dipole moment of the product obtained after displacing X by Z will be:

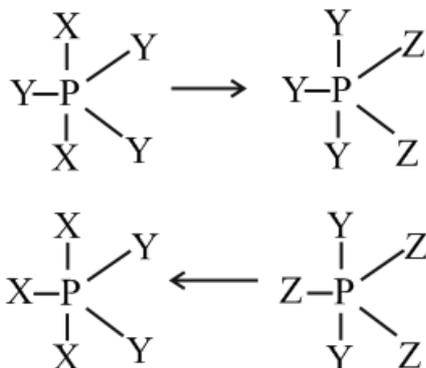
- A)  $\text{PX}_2\text{Y}_3$  is non-zero.
- B)  $\text{PX}_3\text{Y}_2$  is non-zero.
- C)  $\text{PX}_3\text{Y}_2$  is zero.
- D) Both (i) and (iii).

Answer: Both (i) and (iii).



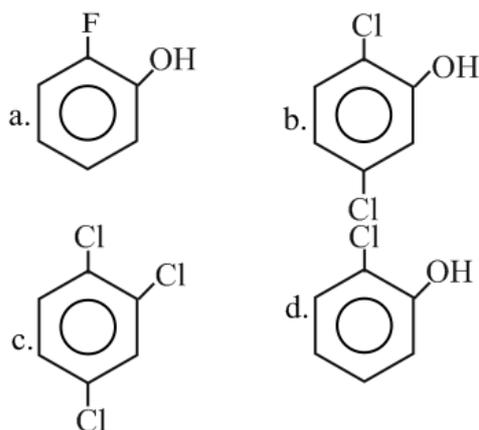
**Solution:** According to the Bent's rule, the more electronegative atom is placed at the axial positions of trigonal bipyramid geometry.

Electronegative order is,  $X > Y > Z$ .



Dipole moment after displacement is non-zero in the first case and in the second case, it is zero.

Q.19. What is the correct order of the dipole moment for the compounds given below?



- A)  $d > a > b > c$   
B)  $b < d < c < a$   
C)  $a > d > b > c$   
D)  $c < a < b = d$

**Answer:**  $a > d > b > c$

**Solution:** Compound c is least polar due to the presence of less polar C – Cl bond.

Compound b is more polar than compound c due to the presence of more polar C – OH bond.

Compounds a and d both have polar C – OH bonds, but a is most polar due to the presence of highly polar C – F bond.

So, order of dipole moment will be  $a > d > b > c$



Q.20. Which of the following statements is false?

- A) Geometry around both nitrogen and carbon in  $\text{N}(\text{CH}_3)_3$  is pyramidal.
- B) Geometry around nitrogen is pyramidal and around carbon is tetrahedral in  $\text{N}(\text{CH}_3)_3$
- C)  $\text{N}(\text{SiH}_3)_3$  is planar.
- D)  $p\pi - d\pi$  overlapping occurs in  $\text{N}(\text{SiH}_3)_3$

**Answer:** Geometry around both nitrogen and carbon in  $\text{N}(\text{CH}_3)_3$  is pyramidal.

**Solution:** Steric number can be used to predict the hybrid state of an atom in a molecule.

For Steric Numbers(S)=2,3,4 and 5, the corresponding hybrid states are  $sp$ ,  $sp^2$ ,  $sp^3$ ,  $sp^3d$  respectively.

In  $\text{N}(\text{CH}_3)_3$ , trimethyl amine, N atom is  $sp^3$  hybridized, which results in pyramidal geometry as it has 3 covalent bonds and 1 lone pair. There is no pi-bonding because C has no low-lying d-orbital.

So, the geometry of carbon in  $\text{N}(\text{CH}_3)_3$  is tetrahedral as carbon is forming 4 covalent bonds. Geometry of nitrogen in  $\text{N}(\text{CH}_3)_3$  is pyramidal.

$\text{N}(\text{SiH}_3)_3$  is planar as lone pair of nitrogen is involved in  $p\pi - d\pi$  back bonding,

Q.21. Which of the following is not isostructural with  $\text{SiCl}_4$ ?

- A)  $\text{PO}_4^{3-}$
- B)  $\text{NH}_4^+$
- C)  $\text{SiCl}_4$
- D)  $\text{SO}_4^{2-}$

**Answer:**  $\text{SiCl}_4$

**Solution:** Isostructural chemical compounds mean the chemical compounds given should have similar chemical structures.

From the VSEPR: valence shell electron pair repulsion theory, the structure of each chemical compound is predicted using the number of electron pairs surrounding their central atoms.

It is found that  $\text{SiCl}_4$  is tetrahedral. In the options  $\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$  and  $\text{SO}_4^{2-}$  are all tetrahedral shape because of 4 bond pairs and steric number=4, but  $\text{SiCl}_4$  has seesaw shape because of 4 bond pairs and 1 lone pair.

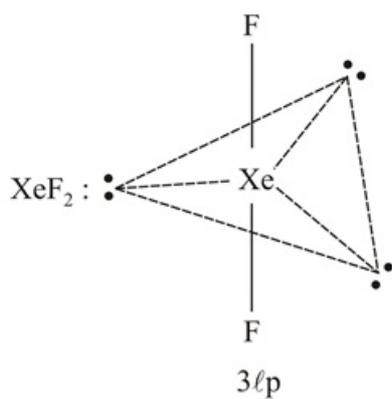
Q.22. Which of the following has a maximum number of lone pairs associated with Xe?

- A)  $\text{XeF}_4$
- B)  $\text{XeF}_6$
- C)  $\text{XeF}_2$
- D)  $\text{XeO}_3$

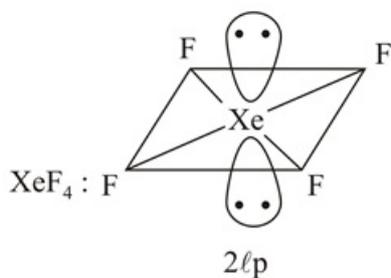
**Answer:**  $\text{XeF}_2$



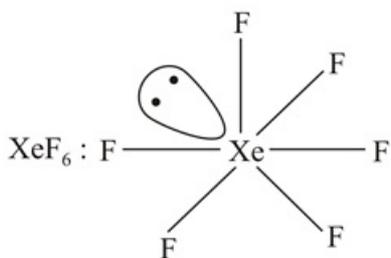
Solution:



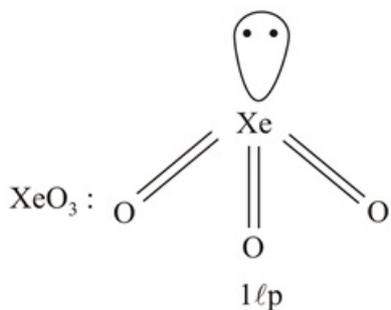
In  $\text{XeF}_2$ , there are 2 bond pairs and 3 lone pairs.



In  $\text{XeF}_4$ , there are 4 bond pairs and 2 lone pairs.



In  $\text{XeF}_6$ , there are 6 bond pair and 1 lone pair.



In  $\text{XeO}_3$ , there are 3 bond pair and 1 lone pair.

Hence,  $\text{XeF}_2$  has the maximum number of lone pair of electrons.

Q.23. What is the hybridization of P in  $\text{PCl}_5$ ?

- A)  $\text{sp}^3$
- B)  $\text{sp}^3\text{d}^2$



C)  $sp^3d$

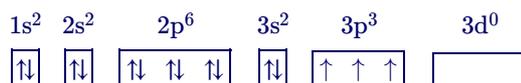
D)  $sp^2$

**Answer:**  $sp^3d$

**Solution:** Each phosphorous atom is bonded to chlorine atom with a single bond.

The electronic configuration of phosphorous in the ground state and the excited state is as follows:

Ground state:



Excited state:



Thus, to form a bond with chlorine atoms, one 3s, three 3p and one 3d orbitals hybridize to give the five  $sp^3d$  orbitals.

Q.24. KF combines with HF to form  $KHF_2$ . The compound contains the species

A)  $K^+$ ,  $F^-$  and  $H^+$

B)  $K^+$ ,  $F^-$  and HF

C)  $\mathit{K}^+$  and  $[HF_2]^-$

D)  $[KHF]^+$  and  $F^-$

**Answer:**  $\mathit{K}^+$  and  $[HF_2]^-$

**Solution:** KF exists in the form of the ions  $K^+$  and  $F^-$ . Since fluoride ion is highly electronegative, it forms a bond with HF. It forms a H-bond.



Hence,  $KHF_2$  contains  $K^+$  and  $[HF_2]^-$  ions.

Q.25. Which of the following hydrogen bonds are the strongest in vapour phase?

A)  $HF \cdots HF$

B)  $HF \cdots HCl$

C)  $HCl \cdots HCl$

D)  $HF \cdots HI$

**Answer:**  $HF \cdots HF$

**Solution:** Hydrogen bonding is a special type of dipole-dipole attraction between molecules. It results from the attractive force between a hydrogen atom, covalently bonded to a very electronegative atom such as a N, O or F atom and another very electronegative atom. I is too big and not electronegative enough.

A compound having the maximum electronegative element will form strong hydrogen bond. F is the most negative element among halogens, hence, forms the strongest hydrogen bond.



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