IB Chemistry HL
Topic4 Questions

1. What is the best description of the carbon-oxygen bond lengths in CO_3^{2-}?

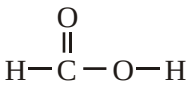
A. One short and two long bonds

B. One long and two short bonds

C. Three bonds of the same length

D. Three bonds of different lengths

2. What is the number of sigma (σ) and pi (π) bonds and the hybridization of the carbon atom in



	Sigma	Pi	Hybridization
A.	4	1	sp^2
B.	4	1	sp^3
C.	3	2	sp^3
D.	3	1	sp^2

3. Which of the following contain a bond angle of 90°?

I. $PC1_4^+$

II. PCl_5

III. PCl_6^-

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

4. Which allotropes contain carbon atoms with sp^2 hybridization?

I. Diamond

II. Graphite

III. C_{60} fullerene

A. I and II only B. I and III only

C. II and III only

D. I, II and III

5. What is the molecular shape and the hybridization of the nitrogen atom in NH_3?

	Molecular shape	Hybridization
A.	tetrahedral	sp^3
B.	trigonal planar	sp^2
C.	trigonal pyramidal	sp^2
D.	trigonal pyramidal	sp^3

6. Which statement about sigma and pi bonds is correct?

A. Sigma bonds are formed only by s orbitals and pi bonds are formed only by p orbitals.

B. Sigma bonds are formed only by p orbitals and pi bonds are formed only by s orbitals.

C. Sigma bonds are formed by either s or p orbitals, pi bonds are formed only by p orbitals.

D. Sigma and pi bonds are formed by either s or p orbitals.

7. Consider the following statements.

I. All carbon-oxygen bond lengths are equal in CO_3^{2-}.

II. All carbon-oxygen bond lengths are equal in CH_3COOH.

III. All carbon-oxygen bond lengths are equal in CH_3COO^-.

Which statements are correct?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

8. Which statement is correct about multiple bonding between carbon atoms?

A. Double bonds are formed by two π bonds.

B. Double bonds are weaker than single bonds.

C. π bonds are formed by overlap between s orbitals.

D. π bonds are weaker than sigma bonds.

9. Which particles can act as ligands in complex ion formation?

I. $C1^-$

II. NH_3

III. H_2O

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

10. Which statements correctly describe the NO_2^- ion?

I. It can be represented by resonance structures.

II. It has two lone pairs of electrons on the N atom.

III. The N atom is sp^2 hybridized.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

11. Which is the smallest bond angle in the PF_5 molecule?

A. 90°

B. 109.5°

C. 120°

D. 180°

12. Which types of hybridization are shown by the carbon atoms in the compound $CH_2 = CH–CH_3$?

I. sp

II. sp^2

III. sp^3

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

13. Identify the types of hybridization shown by the carbon atoms in the molecule

$$CH_3CH_2CH_2COOH$$

I. sp

II. sp^2

III. sp^3

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

14. Which molecule is square planar in shape?

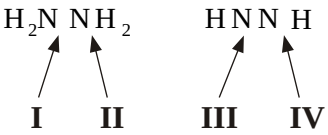
A. XeO_4

B. XeF_4

C. SF_4

D. SiF_4

15. What is the hybridization of nitrogen atoms I, II, III and IV in the following molecules?



	I	II	III	IV
A.	sp^2	sp^2	sp^3	sp^3
B.	sp^3	sp^3	sp^2	sp^2
C.	sp^2	sp^2	sp	sp
D.	sp^3	sp^3	sp	sp

16. What is the molecular geometry and the Cl–I–Cl bond angle in the ICl_4^- ion?

A. Square planar 90°

B. Square pyramidal 90°

C. Tetrahedral 109°

D. Trigonal pyramidal 107°

17. What is the geometry of the bonds around an atom with sp^2 hybridization?

A. 2 bonds at 180°

B. 3 bonds at 120°

C. 2 bonds at 90°, 1 bond at 180°

D. 4 bonds at 109°

18. How many sigma (σ) and pi (π) bonds are present in the structure of HCN?

	σ	**π**
A.	1	3
B.	2	3
C.	2	2
D.	3	1

19. How many lone pairs and bonding pairs of electrons surround xenon in the XeF_4 molecule?

	Lone pairs	**Bonding pairs**
A.	4	8
B.	0	8
C.	0	4
D.	2	4

20. (a) Explain the meaning of the term *hybridization*.

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(1)

(b) State the type of hybridization shown by the carbon atom in the H–C≡N molecule, and the number of σ and π bonds present in the C≡N bond.

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(2)

(c) Describe how σ and π bonds form.

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(4)
(Total 7 marks)

21. (i) Draw the Lewis structures for carbon monoxide, carbon dioxide and the carbonate ion.

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(3)

(ii) Identify the species with the longest carbon-oxygen bond and explain your answer.

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(3)
(Total 6 marks)

22. In 1954 Linus Pauling was awarded the Chemistry Nobel Prize for his work on the nature of the chemical bond. Covalent bonds are one example of intramolecular bonding.

Explain the formation of the following.

(i) σ bonding

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(2)

(ii) π bonding

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(2)

(iii) double bonds

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(1)

(iv) triple bonds

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(1)
(Total 6 marks)

23. Atomic orbitals can mix by hybridization to form new orbitals for bonding.

Identify the type of hybridization present in each of the **three** following molecules. Deduce and explain their shapes.

(i) OF_2

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(3)

(ii) H_2CO

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(3)

(iii) C_2H_2

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(3)
(Total 9 marks)

24. For the following compounds

PCl_3, PCl_5, $POCl_3$

(i) Draw a Lewis structure for each molecule in the gas phase.
(Show all non-bonding electron pairs.)

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(3)

(ii) State the shape of each molecule and predict the bond angles.

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(6)

(iii) Deduce whether or not each molecule is polar, giving a reason for your answer.

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(3)
(Total 12 marks)

25. (i) Explain the meaning of the term *hybridization*.

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(1)

(ii) Discuss the bonding in the molecule CH_3CHCH_2 with reference to

- the formation of σ and π bonds
- the length and strength of the carbon-carbon bonds
- the types of hybridization shown by the carbon atoms

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(6)

(Total 7 marks)

26. (a) Draw the Lewis structures for the compounds XeF_4, PF_5 and BF_4^-.

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(b) Use the valance shell electron pair repulsion (VSEPR) theory to predict the shapes of the three compounds in (a). State and explain the bond angles in each of the three compounds.

(3)
(Total 6 marks)

27. (a) State the meaning of the term hybridization. State the type of hybridization shown by the nitrogen atoms in N_2, N_2H_2 and N_2H_4.

(4)

(b) By referring to the N_2H_2 molecule describe how sigma (σ) and pi (π) bonds form and describe how single and double bonds differ.

(4)
(Total 8 marks)

28. (i) Explain why the first ionization energy of magnesium is lower than that of fluorine.

(2)

(ii) Write an equation to represent the third ionization energy of magnesium. Explain why the third ionization energy of magnesium is higher than that of fluorine.

(3)
(Total 5 marks)

29. Draw the Lewis structures, state the shapes and predict the bond angles for the following species.

(i) PCl_5

(3)

(ii) SCl_2

(3)

(iii) ICl_4^-

(3)
(Total 9 marks)

30. (a) (i) State the meaning of the term *hybridization*.

(1)

(ii) State the type of hybridization around the carbon atoms in C_{60} fullerene, diamond and graphite.

(3)

(iii) Explain why graphite and C_{60} fullerene can conduct electricity.

(2)

(b) (i) Compare how atomic orbitals overlap in the formation of sigma (σ) and pi (π) bonds.

(2)

(ii) State the number of sigma bonds and pi bonds in $H_2CC(CH_3)CHCH_2$.

(2)

(Total 10 marks)

31. (i) Apply the VSEPR theory to deduce the shape of NO_2^-, ICl_5 and SF_4. For each species, draw the Lewis (electron dot) structure, name the shape, and state the value of the bond angle(s).

(9)

(ii) Discuss the bond angle(s) in SF_4.

(1)

(iii) Explain the hybridization involved in the C_2H_4 molecule.

(4)

(iv) State the hybridization involved in the NO_2^- ion and comment on the nitrogen-oxygen bond distances.

(2)

(v) Using Table 7 of the Data Booklet, predict and explain which of the bonds O-H, O-N or N-H would be most polar.

(2)

(Total 18 marks)