

IBDP HL Chemistry Worksheet:

Chemical Bonding

SECTION A: Multiple Choice Questions (20 marks)

Select the best answer for each question. Each question is worth 1 mark.

1. Which of the following molecules has the smallest bond angle?

- A) NH_3
- B) H_2O
- C) CH_4
- D) BF_3

2. The hybridization of the central atom in SF_4 is:

- A) sp^3
- B) sp^3d
- C) sp^3d^2
- D) sp^2

3. Which statement about resonance structures is correct?

- A) Resonance structures represent different compounds
- B) The actual structure is a hybrid of all possible resonance structures
- C) Resonance structures differ in the arrangement of atoms
- D) Only one resonance structure exists at any given time

4. The strongest intermolecular force present in liquid HF is:

- A) London dispersion forces
- B) Dipole-dipole interactions
- C) Hydrogen bonding
- D) Ion-dipole interactions

5. Which molecule is polar?

- A) CO_2
- B) BF_3
- C) CCl_4
- D) SO_2

6. The bond order in the nitrate ion (NO_3^-) is:

- A) 1
- B) 1.33
- C) 1.5
- D) 2

7. Which of the following has the highest lattice energy?

- A) NaCl
- B) MgO
- C) CaO
- D) NaF

8. The molecular geometry of XeF_4 is:

- A) Tetrahedral
- B) Square planar
- C) Square pyramidal
- D) Octahedral

9. Which bond has the highest percentage of ionic character?

- A) C-H
- B) C-O
- C) N-H
- D) O-H

10. The hybridization of carbon in ethyne (C_2H_2) is:

- A) sp
- B) sp^2
- C) sp^3
- D) sp^3d

11. Which of the following molecules can form hydrogen bonds with water?

- A) CH₄
- B) NH₃
- C) CCl₄
- D) CO₂

12. The bond angle in a trigonal bipyramidal molecule is:

- A) 109.5° only
- B) 120° only
- C) 90° and 120°
- D) 90°, 120°, and 180°

13. Which statement about metallic bonding is incorrect?

- A) Electrons are delocalized throughout the structure
- B) Metallic bonding explains the electrical conductivity of metals
- C) The strength of metallic bonding increases with the number of valence electrons
- D) Metallic bonding is directional like covalent bonding

14. The formal charge on the central sulfur atom in SO₂ is:

- A) 0
- B) +1
- C) +2
- D) -1

15. Which molecule has a coordinate (dative) covalent bond?

- A) NH₃
- B) NH₄⁺
- C) H₂O
- D) HCl

16. The strongest type of intermolecular force in liquid Br₂ is:

- A) Hydrogen bonding
- B) Dipole-dipole interactions
- C) London dispersion forces
- D) Ion-dipole interactions

17. Which molecule has an incomplete octet around the central atom?

- A) PCl₅
- B) SF₆
- C) BF₃
- D) ClF₃

18. The bond length order (shortest to longest) for C-C bonds is:

- A) C≡C < C=C < C-C
- B) C-C < C=C < C≡C
- C) C=C < C≡C < C-C
- D) C=C < C-C < C≡C

19. Which of the following ions has the largest radius?

- A) F⁻
- B) O²⁻
- C) N³⁻
- D) Ne

20. The molecular orbital theory predicts that O₂ is:

- A) Diamagnetic with a bond order of 2
 - B) Paramagnetic with a bond order of 2
 - C) Diamagnetic with a bond order of 1
 - D) Paramagnetic with a bond order of 1
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SECTION B: Structured Questions (40 marks total)

Question 1: VSEPR Theory and Molecular Geometry (8 marks)

Consider the molecules PCl_5 and ICl_4^- .

- Draw the Lewis structure for PCl_5 . [2 marks]
- State the electron domain geometry and molecular geometry of PCl_5 . [2 marks]
- Draw the Lewis structure for ICl_4^- . [2 marks]
- Explain why ICl_4^- is square planar while PCl_5 is trigonal bipyramidal. [2 marks]

Question 2: Hybridization and Bonding (8 marks)

Ethene (C_2H_4) contains a double bond between carbon atoms.

- Draw the Lewis structure of ethene. [1 mark]
- State the hybridization of each carbon atom in ethene. [1 mark]
- Describe the formation of the $\text{C}=\text{C}$ double bond in terms of sigma (σ) and pi (π) bonds. [3 marks]
- Explain why rotation around the $\text{C}=\text{C}$ double bond is restricted. [2 marks]
- State the $\text{H}-\text{C}-\text{H}$ bond angle in ethene and justify your answer. [1 mark]

Question 3: Intermolecular Forces (8 marks)

The boiling points of the following compounds are given:

- CH_4 : -164°C
- NH_3 : -33°C
- H_2O : 100°C
- HF : 20°C

- Identify the strongest intermolecular force present in each compound. [4 marks]

CH_4 : _____

NH_3 : _____

H_2O : _____

HF : _____

- Explain why H_2O has a higher boiling point than HF , even though both exhibit hydrogen bonding. [2 marks]
- Explain why NH_3 has a higher boiling point than CH_4 . [2 marks]

Question 4: Resonance and Formal Charge (8 marks)

Consider the sulfate ion, SO_4^{2-} .

- (a) Draw the Lewis structure for SO_4^{2-} showing all lone pairs and formal charges. [3 marks]
- (b) Calculate the formal charge on the sulfur atom and each oxygen atom in your structure. [2 marks]
- (c) Draw one possible resonance structure that minimizes formal charges. [2 marks]
- (d) Explain why the actual structure of SO_4^{2-} is a resonance hybrid. [1 mark]

Question 5: Lattice Energy and Ionic Bonding (8 marks)

The lattice energies of some ionic compounds are:

- NaF: 923 kJ/mol
- NaCl: 786 kJ/mol
- MgO: 3791 kJ/mol
- CaO: 3401 kJ/mol

- (a) Define lattice energy. [1 mark]
- (b) Explain why MgO has a much higher lattice energy than NaCl. [3 marks]
- (c) Explain why NaF has a higher lattice energy than NaCl. [2 marks]
- (d) Predict and justify whether BeO would have a higher or lower lattice energy than MgO. [2 marks]
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