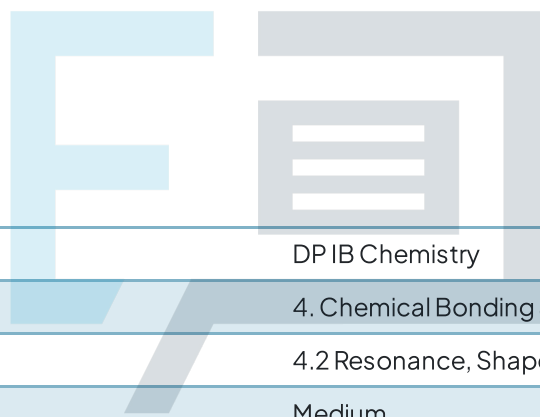




4.2 Resonance, Shapes & Giant Structures

Mark Schemes



Course	DP IB Chemistry
Section	4. Chemical Bonding & Structure
Topic	4.2 Resonance, Shapes & Giant Structures
Difficulty	Medium

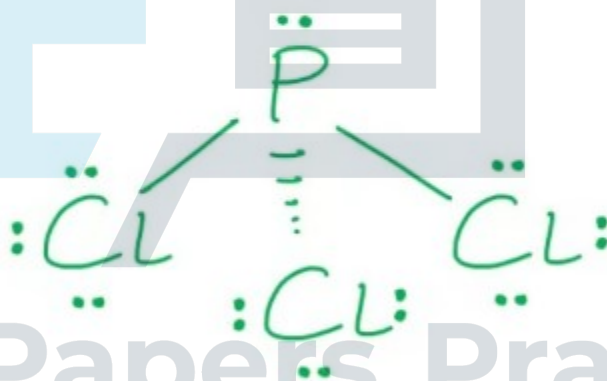
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To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

1

The correct answer is **C** because:

- If the reaction has a higher yield at a higher temperature, then the reaction will be endothermic
- The **VESPR theory** states that electron pairs **repel** each other whether or not they are in bond pairs or lone pairs; therefore the electrons will spread as much as possible to **reduce repulsion**
 - This creates the shape of the molecules based on the atoms and lone pairs present
- PCl_3 has three atoms around the central atom with one lone pair on the phosphorus making it trigonal pyramidal in shape with a bond angle of 107.5°



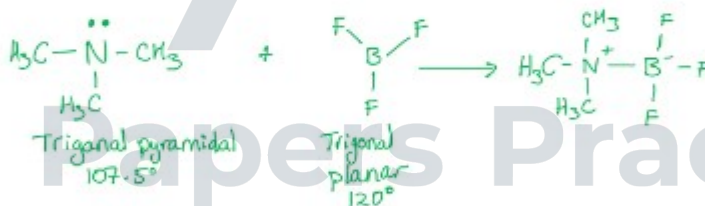
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A & B are incorrect as	if the reaction was exothermic it would produce less yield at higher temperatures
D is incorrect as	the phosphorus atom has a lone pair of electrons and the shape is not planar

2

The correct answer is **A** because:

- The **VESPR theory** states that electron pairs **repel** each other whether or not they are in bond pairs or lone pairs; therefore the electrons will spread as much as possible to **reduce repulsion**
 - This creates the shape of the molecules based on the atoms and lone pairs present
- Trimethylamine has a **lone pair of electrons** on the nitrogen atom, giving it the structure of **trigonal pyramidal** (107.5°)
- Boron trifluoride has no lone pair of electrons forming a **trigonal planar** molecule with angles of 120°
- The molecule formed in this reaction will have a **dative covalent bond** between the two structures, as boron is described as being **electron-deficient**
- The Lewis diagrams look like this

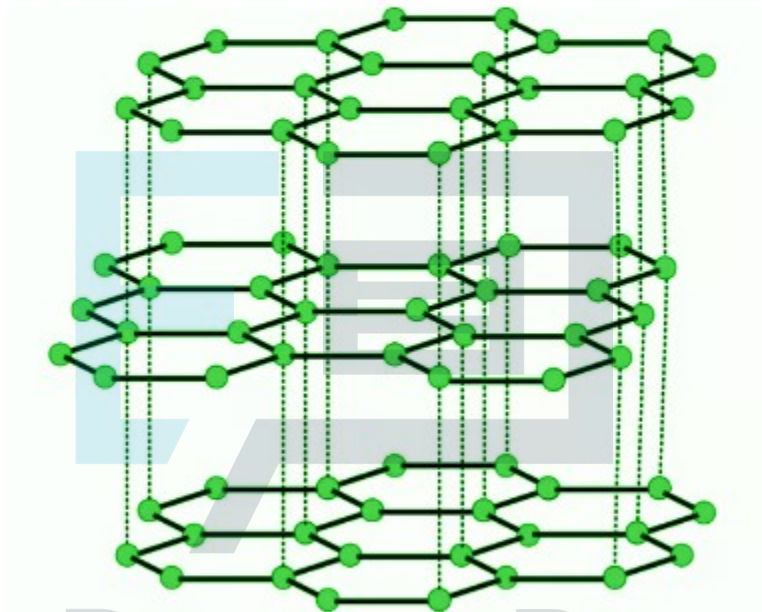


B & C are incorrect as	they do not show the correct structure of boron trifluoride, it is drawn as if a lone pair of electrons are present
D is incorrect as	this structure is not taking into account the repulsion from the dative bonding pair between the nitrogen and the boron

3

The correct answer is **A** because:

- Graphite is a layered structure with three covalent bonds around each carbon atom in the same plane
- The three bonds, or electron **domains**, mean that the C-C-C bond angle is 120° (not 109.5° as statement III suggests)

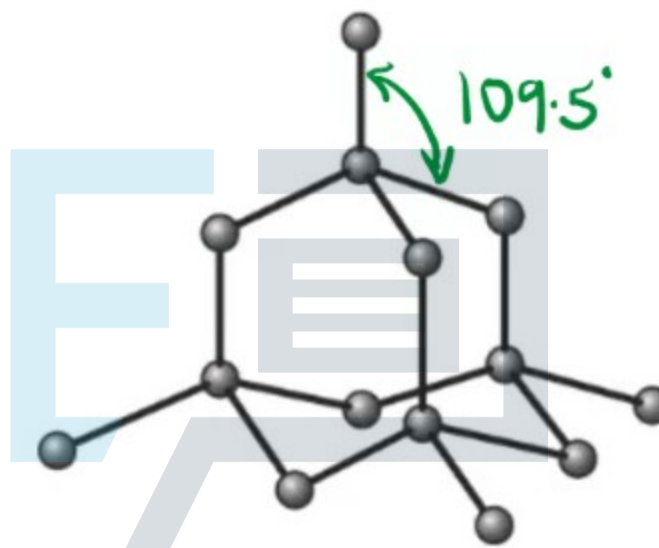


- Between the layers are weak London dispersion forces that arise from the movement of delocalised electrons within the layers
- The delocalised electrons are responsible for the conductivity of graphite

4

The correct answer is **B** because:

- Diamond and silicon both have four covalent bonds around each atom in a tetrahedral arrangement
- They form a giant network or macromolecular structure
- The bond angle in each structure is 109.5°



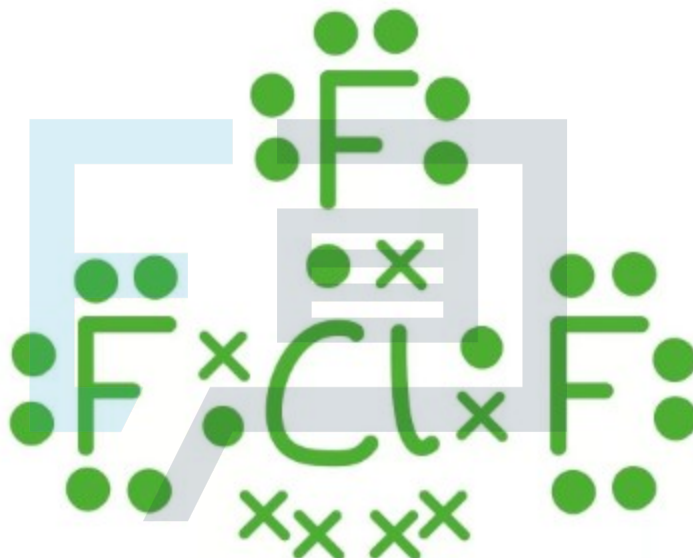
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A is incorrect as	silicon has a macromolecular structure
C is incorrect as	silicon is below carbon in group 14, so silicon atoms are larger than carbon atoms and the bond length in Si-Si will be longer than C-C
D is incorrect as	all the valence electrons are in covalent bonds so neither structure has delocalised electrons

5

The correct answer is **B** because:

- The ClF_3 molecule has the following number of valence electrons
 - Chlorine = 7
 - Fluorine = $7 \times 3 = 21$
 - Number of electrons = 28
- The arrangement of electrons would be:



- The remaining electrons surround the chlorine atom
- As you can see there are 5 electron pairs, 3 are bonding pairs and 2 are lone pairs

A, C & D are incorrect as

1, 3 and 0 are not the correct number of lone pairs in the ClF_3 molecule



6

The correct answer is **C** because:

- The BCl_3 has the following number of valence electrons
 - B = 3
 - Cl = $7 \times 3 = 21$
 - 24 electrons overall
- There are 24 electrons overall which means 12 pairs of electrons
 - 9 pairs surrounding the 3 chlorine atoms
 - 3 bonding pairs (B-Cl bonds)
 - No lone pairs
- Therefore BCl_3 is trigonal planar with a bond angle of 120°

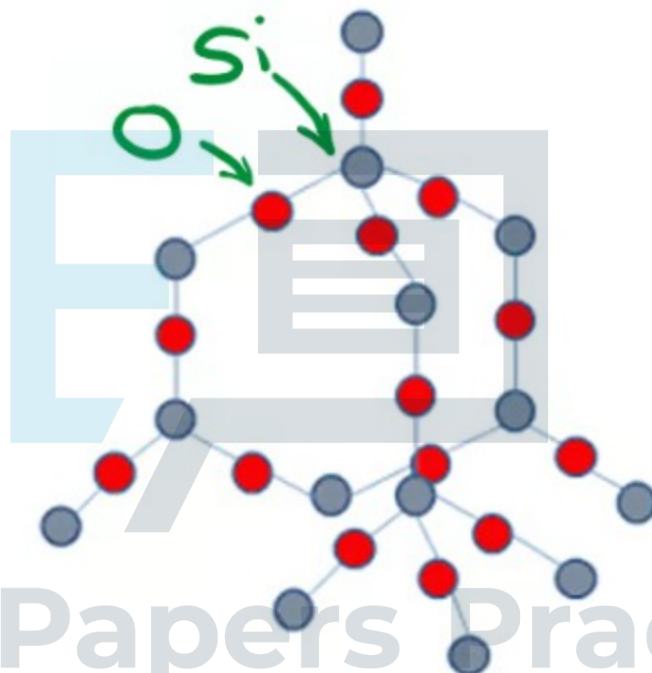
A is incorrect as	H_3O^+ has a trigonal pyramidal shape with a bond angle of 107°
B is incorrect as	TlBr_3^{2-} has a trigonal pyramidal shape with a bond angle of 107°
D is incorrect as	NH_3 has a trigonal pyramidal shape with a bond angle of 107°

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7

The correct answer is **A** because:

- Silicon dioxide is a giant covalent structure consisting of silicon and oxygen
- The structure of silicon dioxide is the same as diamond - a tetrahedral shape consisting of strong covalent bonds



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- Each silicon atom is bonded to four oxygen atoms, and each oxygen atom is bonded to two silicon atoms
- Silicon dioxide will not exist as a discrete molecule as the structure is giant covalent which is part of a network of atoms
- Therefore the shape of the silicon dioxide molecule is irrelevant and incorrect

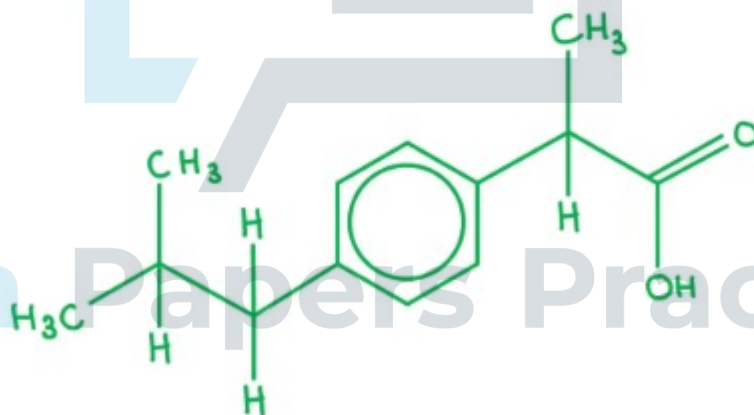
B, C & D are incorrect as

these are not the correct combination of statements

8

The correct answer is **C** because:

- Bond angle *a* is 109.5°
 - The shape will be tetrahedral
- Bond angle *a* is C-C-C where the central C atom is bonded to one H atom and three C atoms, therefore there are 4 bonding pairs of electrons and no lone pairs
- Bond angle *b* is 120°
 - The shape will be trigonal planar
- Bond angle *b* is C-C-O where the central C atom is bonded to 1 C atom, and 2 O atoms, one of which is a C=O bond
 - The C=O contains 2 bonding pairs of electrons
- There are 'hidden hydrogens' in the structure shown which makes it more challenging so check the structure carefully



<p>A, B & D is incorrect as</p>	<p>these are not the correct bond angles for tetrahedral and trigonal planar molecules</p>
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9

The correct answer is **D** because:

- The molecule CS_2 does obey the octet rule as shown in the diagram
- The central carbon atom and both S atoms have 8 electrons
 - The molecule exists as $\text{S}=\text{C}=\text{S}$



A is incorrect as



The B atom in BF_3 does not obey the octet rule as it only contains 6 electrons

B is incorrect as



The H atom in HCN does not obey the octet rule as it only contains 2 electrons

<p>C is incorrect as</p>	<p>The BeCl_2 atom does not obey the octet rule as it only contains 4 electrons</p>
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10

The correct answer is **D** because:

- Diamond is an allotrope of carbon and is a giant covalent structure
- The carbon atoms in diamond are arranged in a tetrahedral structure as each atom is bonded to 4 other carbon atoms, therefore the shape is tetrahedral
- Buckminsterfullerene, C_{60} , is also an allotrope of carbon, though, it is a simple molecule and will therefore have a much lower boiling point than diamond and graphene
- Graphene is also an allotrope of carbon and is a giant covalent structure
- Each carbon atom is bonded to three other carbon atoms in a trigonal planar arrangement, therefore the bond angle is 120°



A is incorrect as	the shape of the diamond structure is not square planar, the melting point of buckminsterfullerene is not relatively high and the bond angle in graphene is not 90°
B is incorrect as	the bond angle in graphene is not 107°
C is incorrect as	the shape of the diamond structure is not trigonal planar, the melting point of buckminsterfullerene is not relatively high and the bond angle in graphene is not 109.5°
There are three different types of structure being asked about in this question, and three different concepts so take care to read the question and select your answer	

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