14.1 More Structures & Shapes

Question Paper

Course	DP IB Chemistry
Section	14. Chemical Bonding & Structure (HL only)
Topic	14.1 More Structures & Shapes
Difficulty	Hard

Time allowed: 70

Score: /51

Percentage: /100

Question 1a

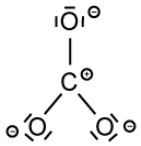
a)
Deduce the number of possible resonance structures for the carbonate ion, CO_3^{2-}, and draw two of them.
Include the formal charges for each oxygen.

[4]

[4 marks]

Question 1b

b)
An alternative structure for the carbonate ion is proposed:



Explain why this structure is not accepted as another resonance structure for the carbonate ion.

[2]

[2 marks]

Question 1c

c)
Deduce the number of sigma (σ) and pi (π) bonds present in any of the resonance structures of the carbonate ions shown in part a).

[2]

[2 marks]

Question 1d

d)
Deduce the bond order of the C-O bond in the carbonate ion, CO_3^{2-}.

[1]

[1 mark]

Question 2a

a)
Silicon can form silicon tetrachloride $SiCl_4$ and also silicon hexachloride, $SiCl_6^{2-}$.

i)
Draw the Lewis structure for $SiCl_4$ and $SiCl_6^{2-}$.

[2]

ii)
Use VSEPR theory to deduce the Cl-Si-Cl bond angles in both the $SiCl_4$ and $SiCl_6^{2-}$ molecules.

[2]

iii)
Predict the molecular geometry of each molecule.

[2]

[6 marks]

Question 2b

b)
Carbon can form CCl_4 but cannot form CCl_6^{2-}. Explain why.

[3]

[3 marks]

Question 2c

c)
Deduce which, if any, of $SiCl_4$ and $SiCl_6^{2-}$, are polar molecules and explain your choice.

[2]

[2 marks]

Question 2d

d)
Formal charge can be used to decide on the most stable, and therefore most likely, form a molecule can take. Resonance structures occur when more than one Lewis diagram describes a structure equally well.

i)
Deduce the formal charge on the silicon and each chlorine within $SiCl_4$ and $SiCl_6^{2-}$

[2]

ii)
Predict which will be the most stable molecule and explain your answer.

[2]

iii)
Predict if any resonance structures are possible for $SiCl_6^{2-}$ and explain your answer.

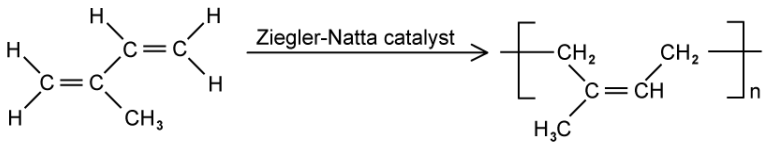
[2]

[6 marks]

Question 3a

a)

Natural rubber, polyisoprene, forms a flexible polymer in the following reaction:



Isoprene **Polyisoprene**

i)

Deduce the number of sigma (σ) and pi (π) bonds in the monomer.

[2]

ii)

Deduce the number of sigma (σ) and pi (π) bonds in the repeating unit.

[2]

[4 marks]

Question 3b

b)

Deduce the number of carbons with a tetrahedral geometry in both the monomer, isoprene, and the repeating unit of the polymer, polyisoprene.

[2]

[2 marks]

Question 3c

c)
Polymer formation involves a radical intermediate to lengthen the polymer chain.
The radical in the formation of polyisoprene is shown below, where X represents the existing chain:

$$X\text{-}CH_2CCH_3CHCH_2$$

i)
Identify the atom that is the radical in the structure shown.

[1]

ii)
Deduce the formal charge on the radical atom.

[1]

iii)
Use the information above, and your knowledge of structure and bonding, to predict if the structure is stable or not.

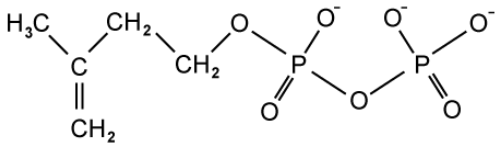
[2]

[4 marks]

Question 3d

d)
Isoprene is not produced directly by the rubber tree, but is the product of a series of biochemical reactions from the isopentenyl pyrophosphate molecules present in the tree.

The structure of isopentenyl pyrophosphate is shown below:



`Deduce the number of sigma (σ) and pi(π) bonds present in one molecule of isopentenyl pyrophosphate.

[2]

[2 marks]

Question 4a

a)
One interhalogen compound is IF_5.

i)
Draw the Lewis structure for IF_5.

[1]

ii)
Use VSEPR theory to deduce the bond angles in IF_5.

[1]

iii)
Predict whether IF_5 will be a polar molecule and explain your choice.

[2]

[4 marks]

Question 4b

b)
Iodine can also form the triiodide ion, I_3^-.

i)
Draw the Lewis structure for I_3^-.

[1]

ii)
Use VSEPR theory to deduce the bond angles in I_3^-.

[1]

iii)
Explain the position of the lone pairs on the central iodine.

[2]

[4 marks]

Question 4c

c)
Deduce the formal charge on each of the iodine atoms in the triiodide molecule, I_3^-.

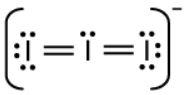
[2]

[2 marks]

Question 4d

d)

An alternative Lewis structure for the triiodide ion, I_3^-, is suggested:



Deduce the formal charges and use them to suggest if the structure is stable and likely to occur.

[3]

[3 marks]