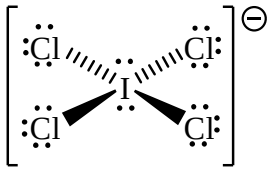
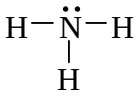
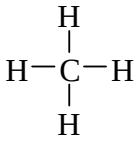
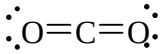
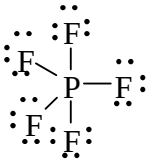
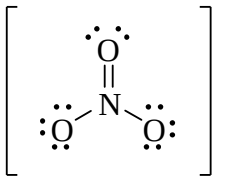
	Marks
• Draw a Lewis structure and thus determine the geometry of the ICl_4^- ion. (The I is the central atom.)	**2**



There are two lone pairs and 4 bonds around the iodine: the geometry is based on an octahedron with the lone pairs located opposite to one another to minimise repulsion between them. The geometry of the actual molecule is therefore square planar.

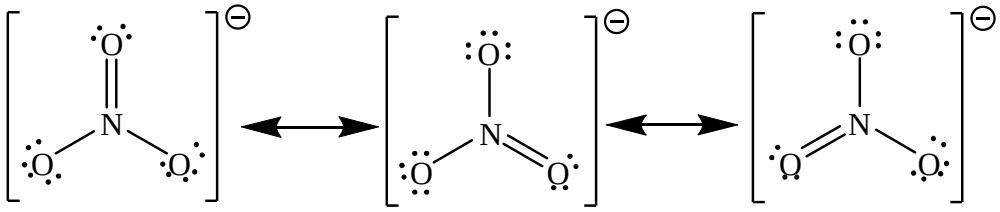
Marks 9

- Complete the table below showing the number of valence electrons, the Lewis structure and the VSEPR predicted shape of each of the following species.

Formula	Number of valence electrons	Lewis structure	Geometry of species
e.g. NH_3	8		trigonal pyramidal
CH_4	**8**		**tetrahedral**
CO_2	**16**		**linear**
PF_5	**40**		**trigonal bipyramidal**
NO_3^-	**24**		**trigonal planar**

Which one of the species above displays resonance, and how many resonance forms are possible?

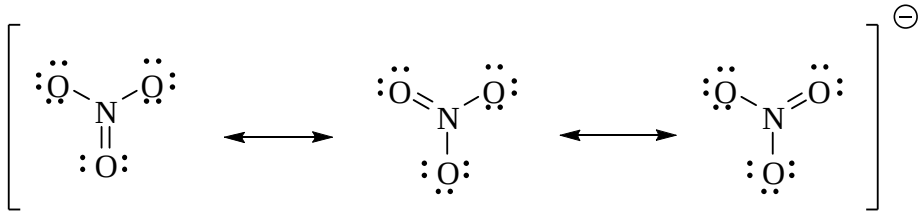
NO_3^- shows resonance – three forms are possible:



- pWhat is the bond order of the nitrogen-oxygen bonds in the nitrate ion, NO_3^-? Explain your answer.

Marks 2

Three equivalent Lewis structures can be drawn for the nitrate ion:



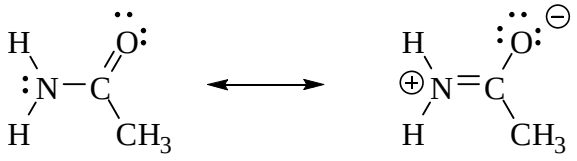
These *resonance* structures contribute equally and the real electron distribution is an average of them. The N-O bond order is an average of its bond order in the resonance structures:

$$\textbf{bond order} = \frac{1}{3}(1 + 1 + 2) = \frac{4}{3}$$

- The observed geometry of the atoms attached to the N atom in H_2NCOCH_3 is trigonal planar. Explain this observation.

2

The molecule has two major resonance contributors as shown below:

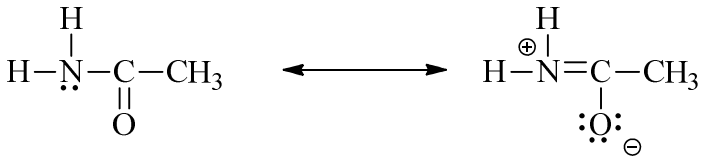


Although the form on the left is more important, the contribution of the form on the right means that the C-N bond has partial double bond character.

This causes the peptide bond to be planar with restricted rotation. It also means that the amide nitrogen atom has low basicity and that the C-N bond is strong.

- The observed geometry of the N atom in H_2NCOCH_3 is trigonal planar. Draw a Lewis structure consistent with this observation and explain this observation.

Marks 2

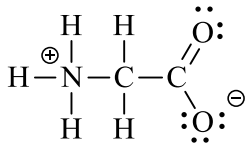


The canonical form on the right is a significant contributor to the resonance stabilised molecule. The N atom in this structure is sp^2 hybridised with trigonal planar geometry.

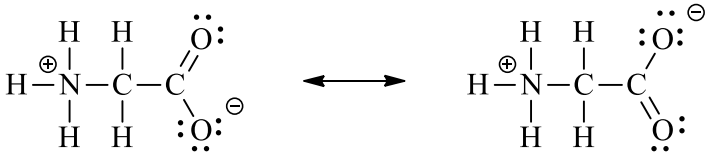
This hybridisation means that the 'lone pair' is in a *p*-orbital on N and is able to become involved in π bonding with the C=O. This resonance acts to strengthen the N-C bond.

Marks 7

- Glycine, NH_2CH_2COOH, the simplest of all naturally occurring amino acids, has a melting point of 292 °C. The pK_a of the acid group is 2.35 and the pK_a associated with the amino group is 9.78. Draw a Lewis structure that indicates the charges on the molecule at the physiological pH of 7.4.



Use your structure to illustrate the concept of resonance.



Describe the hybridisation of the two carbon atoms and the nitrogen atom in glycine and the molecular geometry of the atoms surrounding these three atoms.

N: sp^3 hybridised; tetrahedral geometry

CH_2: sp^3 hybridised; tetrahedral geometry

CO_2^-: sp^2 hybridised; trigonal planar geometry

Glycine has an unusually high melting point for a small molecule. Suggest a reason for this.

In its zwitterionic state, glycine has very strong electrostatic attractions (*i.e.* ionic bonds) between the NH_3^+ and CO_2^- groups giving it very high melting point.

Do you expect glycine to be water soluble? Give a reason for your answer.

Yes. It is ionic so dissolves in the very polar solvent water.