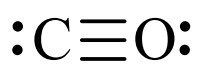
Marks 6

- Explain, using words and diagrams, the type of bonding present in lithium oxide and compare this to the type of bonding in carbon dioxide.

Lithium oxide is an ionic compound formed between a metal (Li) and a non-metal (O) by the complete transfer of electrons from Li to O to give Li^+ cations and O^{2-} anions. These ions are held in place in the crystal lattice by strong electrostatic attractions between the positively and negatively charged ions. This results in a solid compound with high melting point.

Carbon dioxide is a molecular covalent compound. The carbon and oxygen atoms share their electrons forming strong covalent C=O double bonds. There is no formal bonding between the individual O=C=O molecules. The molecules are attracted to each other by weak dispersion forces. CO_2 is therefore a gas at room temperature.

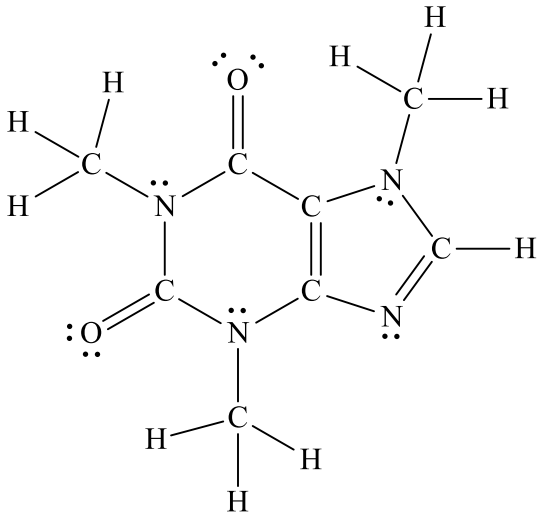
Carbon and oxygen can also react to form carbon monoxide. Draw the Lewis structure of this molecule.



Explain any difference in the polarity of carbon monoxide and carbon dioxide.

Covalent bonds formed between atoms with different electronegativities are always polarised, hence CO is a polar molecule. Although the two C=O bonds in CO_2 are polarised, CO_2 is a linear molecule and the two bond dipoles cancel each other out. Hence CO_2 does not have a permanent dipole moment.

	Marks
• By adding double bonds and lone pairs, complete the structural formula of the molecule caffeine below.	2

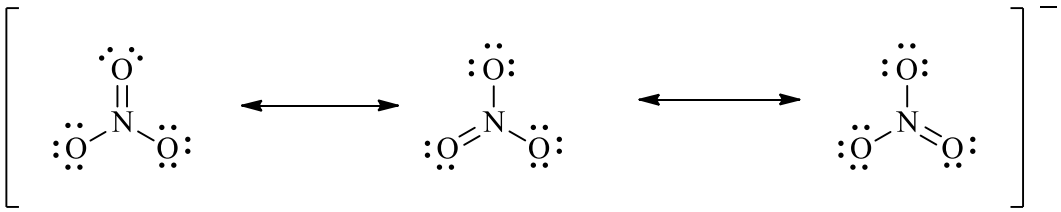


Marks

- Explain the term ‘resonance structures’ and give an example. **2**

Resonance structures are different valid Lewis structures for a molecule or ion. The true distribution of electrons is an average of all of the different resonance structures.

For example, there are three equivalent resonance structures for the NO_3^- ion:



- Explain why stable compounds of oxygen have 8 electrons in the valence shell, but compounds of sulfur may have 8, 10 or 12 electrons in their valence shell. **2**

Oxygen belongs to the 2nd period and there is only space for 8 electrons in its valence shell. Stable compounds of oxygen obey the octet rule.

Sulfur belongs to the 3rd period and there is space for up to 18 electrons in its valence shell. It has 6 valence electrons and can use 2, 4 or 6 of these to make covalent bonds leading to molecules like SF_2, SF_4 and SF_6 respectively. These have 8, 10 and 12 electrons around sulfur respectively.

- In the spaces provided, briefly explain the meaning of the following terms. **3**

Valence electrons

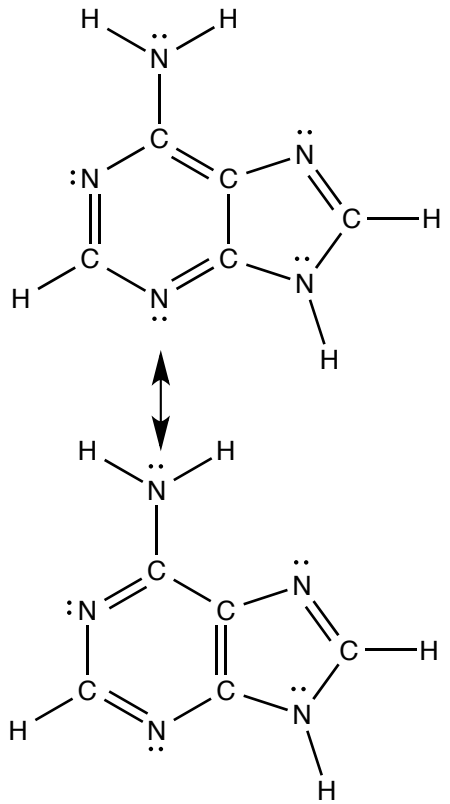
The electrons in the outer shell of an atom that can contribute to bonding.

Polar bond

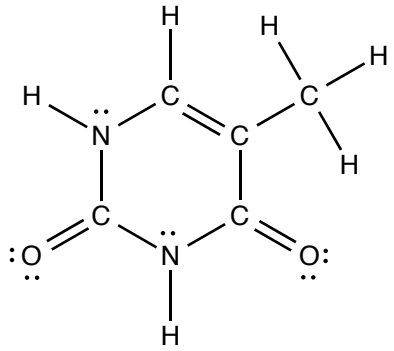
A covalent bond involving two elements of different electronegativity. The different electronegativities lead to an unequal share of the bonding electrons, resulting in a partial positive charge at one end and a partial negative charge at the other end of the bond.

- By adding double bonds and lone pairs, complete the structural formulae of the nitrogen bases adenine and thymine below.

Marks 3



adenine

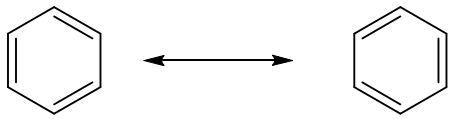


thymine

- Briefly explain the concept of resonance. Give at least one example. **2**

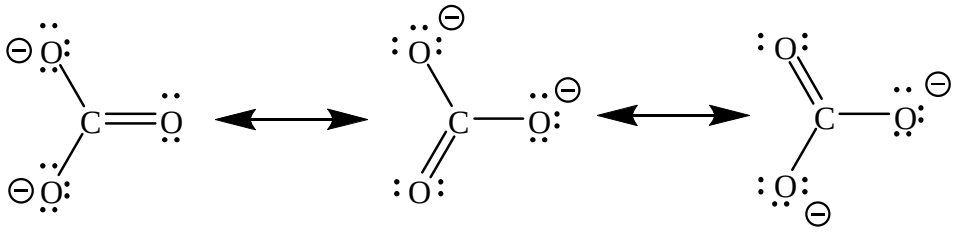
If two or more Lewis structures are equally valid for a molecule, the true structure is none of the structures that is drawn, but an average made up of all these resonance restructures.

In benzene, for example, either of two Lewis structures below is equally valid:



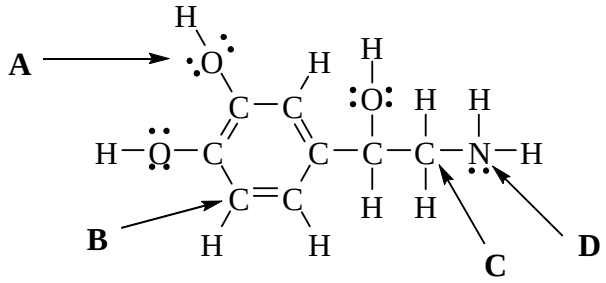
They differ only in are the double and which are the single bonds. The true structure is an average of the two and the ring is a symmetrical hexagon.

Similarly, the Lewis structure of the carbonate ion, CO_3^{2-}, can be drawn in three ways depending on which oxygen atoms have the negative charges:



Again, all are equally valid and the real distribution of the electrons is an average of these resonance structures.

- The structure of adrenaline is shown below. **3**



Give the approximate bond angles at the indicated atoms.

A: **109.5°**	**B**: **120°**	**C**: **109.5°**	**D**: **109.5°**

ANSWER CONTINUES ON THE NEXT PAGE

Which, if any, of the indicated atoms has at least one lone pair of electrons?

An oxygen atom like (A) which is making two bonds has two lone pairs.

A nitrogen atom like (D) which is making three bonds has one lone pair.

Carbon atoms like (B) and (C) which are making four bonds have no lone pairs.