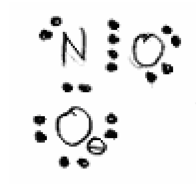
Chemistry 135 Semester 01-2012
Homework for Submission #6 - Key

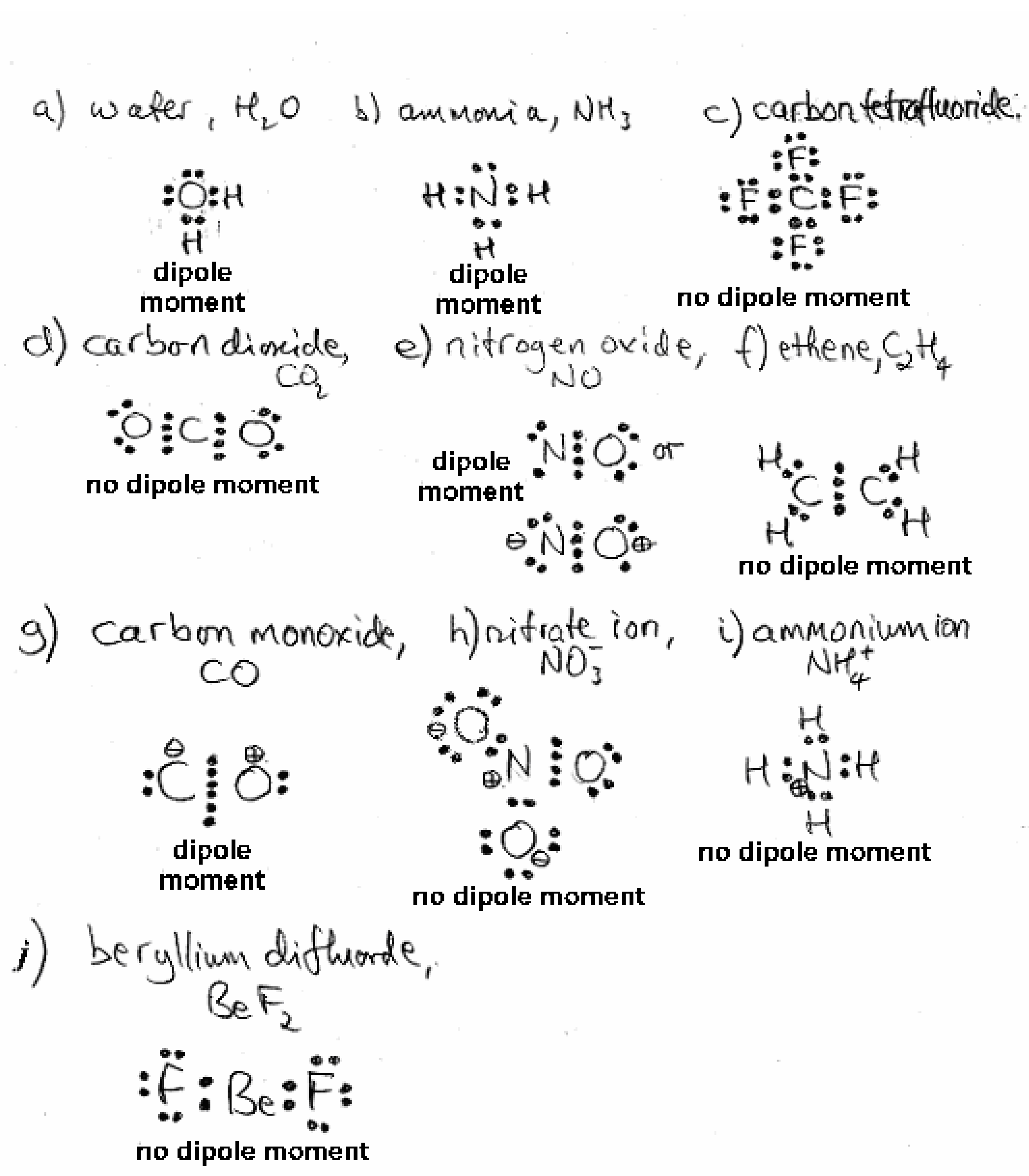
1) Draw Lewis electron-dot diagrams for the following molecules and ions. Show all lone pairs and any formal charges. (23)

a)	water	b)	ammonia	c)	carbon tetrafluoride	d)	carbon dioxide
e)	nitrogen oxide	f)	ethene	g)	carbon monoxide	h)	nitrate ion
i)	ammonium ion	j)	beryllium difluoride				

Indicate against each diagram whether each of the above molecules is expected to have a dipole moment.
Example: the nitrite ion



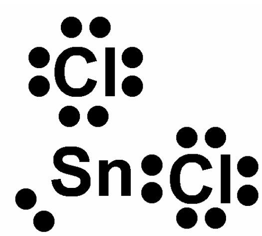
- dipole moment



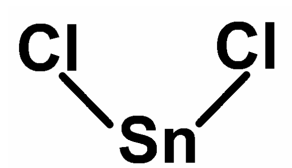
Notes: Some people appear to have copied the answer key for a previous homework which was subtly different. As a result they lost marks. (If they did they should have been given zero for plagiarism.) One mark was awarded for each Lewis structure, one for correct formal charges when they occurred, and one for stating whether or not there was a dipole moment. Apologies for the typo in the example stating the structure was for the nitrate ion whereas it showed the nitrite ion, but students of this level are expected to spot such obvious errors. The nitrate ion has no dipole moment, since it is symmetrical as a result of resonance.

2) What is meant by the *valence shell electron-pair repulsion (VSEPR)* theory? Explain carefully how it can predict the shape of the $SnCl_2$ molecule and describe this shape with a diagram and a name. (5)

The valence shell electron pair repulsion theory considers the arrangement of electrons about a central atom as dictated by Lewis theory. Rather than pairs, electron domains are considered. Whilst the repulsion between electrons within a domain is ignored, the domains are arranged around the central atom in order to minimise repulsion between them. In tin dichloride, $SnCl_2$, the Lewis structure, is

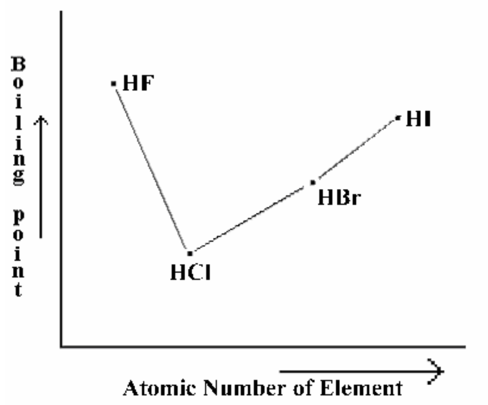


since tin is in group IV and so has 4 electrons in its outer shell, whilst chlorine is in group VII and so only requires one more electron to complete its outer shell. Note that the tin in this molecule is electron deficient, with only 6 electrons in its outer shell. Hence the central tin atom is surrounded by 3 electron domains, which in this case are electron pairs: two bonding pairs and one lone pair.
According to VSEPR, the electron domains repel one another and so try to get as far apart from each other as possible. This puts them at the corners of an equilateral triangle. This arrangement of electron domains is called *trigonal planar.*
This is not the shape of the molecule however, since the shape is dictated by the arrangement of the three atoms. The atoms cannot lie in a straight line because of the lone pair. The shape of the molecule is therefore V-shaped, or bent, with an angle of roughly 120° between the Sn-Cl bonds expected.
(*Note: the angle is in fact 95°, perhaps because the lone pair repels the bonding pairs more strongly than they repel each other.*)



3) The values given in the table below are the boiling points of the hydrides of the group VII elements in °C. Sketch a graph of these boiling points against the atomic number of the element. Explain the main features of your graph with reference to hydrogen bonding, dipole/dipole forces and London dispersion forces. (5)

HF	HCl	HBr	HI
20	-85	-67	-35



The trend for HCl, HBr and HI is one of increasing boiling point. This is what would be expected in view of the increasing RMM of these compounds: as RMM increases, the strength of the London dispersion force increases. HF does not follow the trend. This is because HF shows hydrogen bonding whereas the other hydrides do not. This intermolecular force is considerably stronger than the London dispersion force, making the boiling point of HF higher than the boiling points of the other hydrides, even HI, where the London dispersion force is strongest.

Since the electronegativity of the halogens decreases down group VII, the dipole moment of these molecules decreases too. If the dipole/dipole force were the most important force, a trend of decreasing boiling point with increasing atomic number would be expected. Since this is not observed, it is clear that the dipole/dipole force is not important.