AP Chemistry
1999 Sample Student Responses

These materials were produced by Educational Testing Service (ETS), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

8. Answer the following questions using principles of chemical bonding and molecular structure.

(a) Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

(i) Draw the complete Lewis electron-dot structure for each species.

(ii) Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

(b) Consider the molecules CF_4 and SF_4.

(i) Draw the complete Lewis electron-dot structure for each molecule.

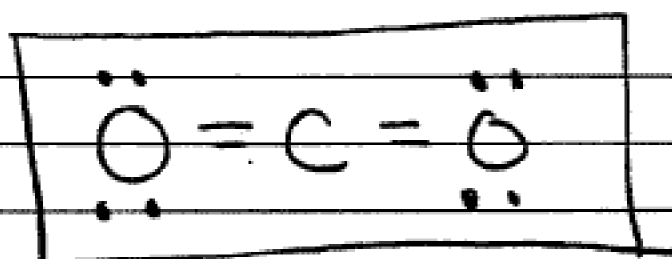
(ii) In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

a)(i) CO_2

C: 4

O: 2(6)

16

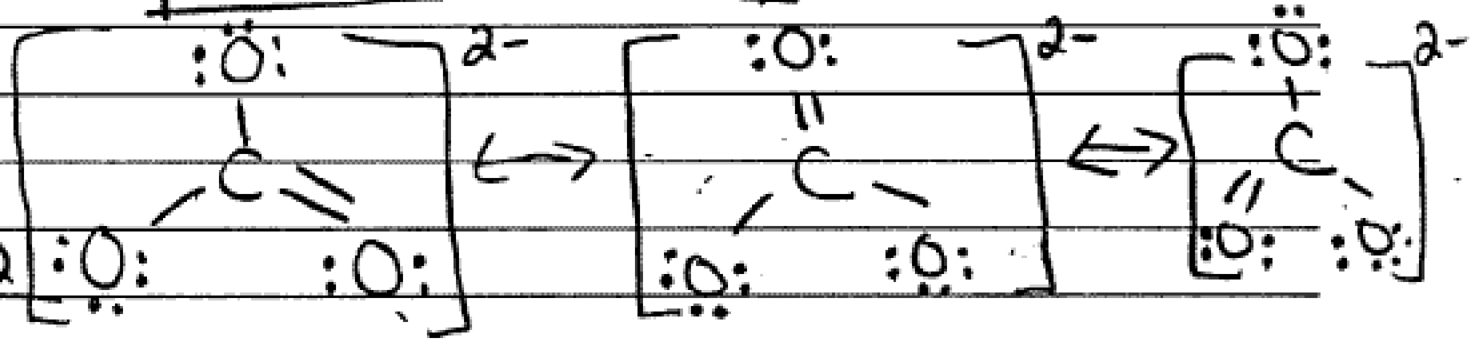


CO_3^{2-}

C: 4

O: 3(6) + 2

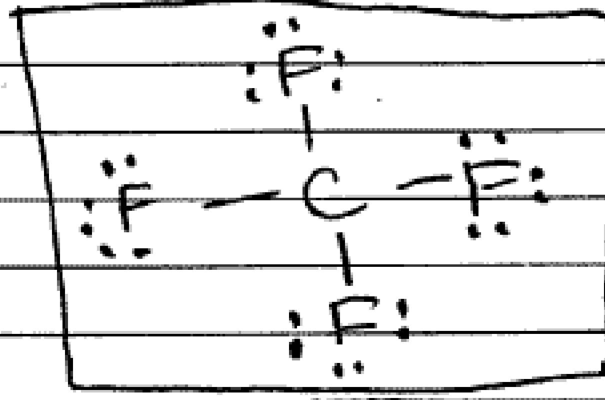
24



(ii) CO_3^{2-} consists of single bonds and double bonds. Since it shows resonance, then the strength of the bonds in CO_3^{2-} is greater than a single bond but smaller than a double bond. CO_2, however, contains only double bonds and therefore its bonds are stronger than those in CO_3^{2-}. The stronger the bond, the smaller length. Therefore, since CO_3^{2-} contains the weaker bonds, the C–O bond is greater in length than the C–O bond in CO_2.

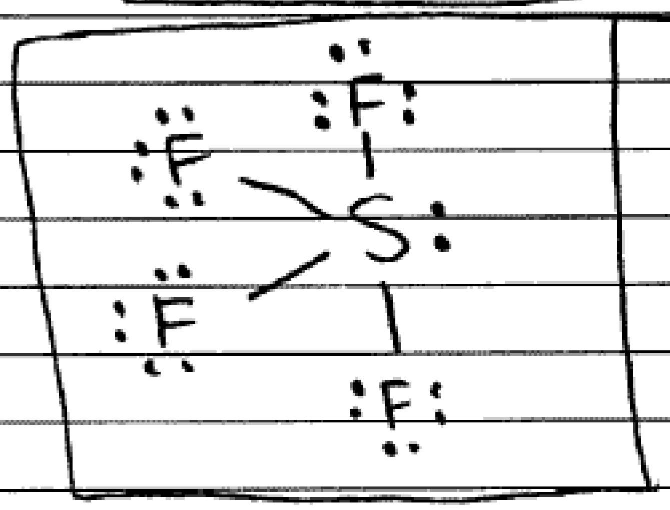
(b.) (i) CF_4

C: 4
F: 4(7)
32



SF_4

S: 6
F: 4(7)



(ii) CF_4 is nonpolar because the molecule has a tetrahedral shape. Each Flourine atom is pulling equally. SF_4 is polar because it has a trigonal byprimadal shape. Since S has a lone pair electrons, then the molecule has an uneven pull, making the molecule polar

8. Answer the following questions using principles of chemical bonding and molecular structure.

(a) Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

(i) Draw the complete Lewis electron-dot structure for each species.

(ii) Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

(b) Consider the molecules CF_4 and SF_4

(i) Draw the complete Lewis electron-dot structure for each molecule.

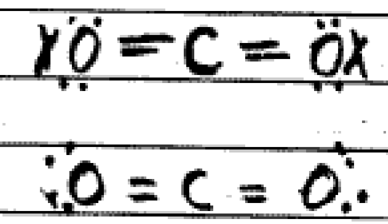
(ii) In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

a) i) CO_2

$4+6\cdot2=16$

-4

12

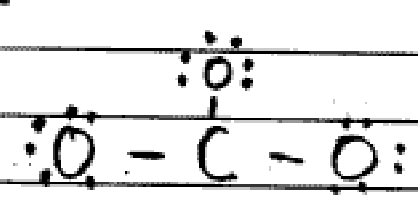


CO_3^{2-}

$4+6\cdot3=22+2=24$

-6

18



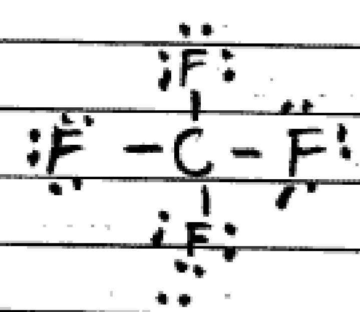
ii) CO_2 has 2 double bonds which are shorter than the single bonds of CO_3^{2-}

b) i) CF_4

$4+7\cdot4=32$

-8

24

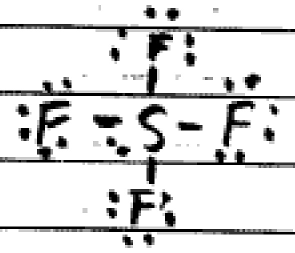


SF_4

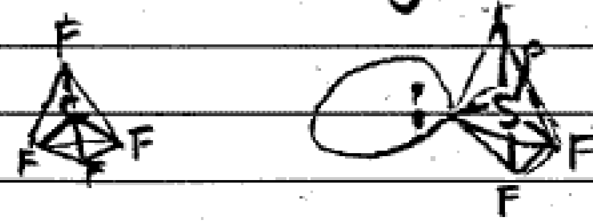
$7\cdot4+6=34$

-8

26



ii) CF_4 is Tetrahederal so there are no electron clouds, making it non-polar.



SF_4 is see-saw shaped so the electron cloud is unbalanced, making it polar.

8. Answer the following questions using principles of chemical bonding and molecular structure.

(a) Consider the carbon dioxide molecule, CO_2, and the carbonate ion, CO_3^{2-}.

(i) Draw the complete Lewis electron-dot structure for each species.

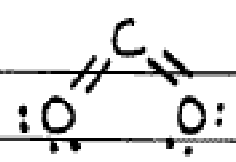
(ii) Account for the fact that the carbon-oxygen bond length in CO_3^{2-} is greater than the carbon-oxygen bond length in CO_2.

(b) Consider the molecules CF_4 and SF_4.

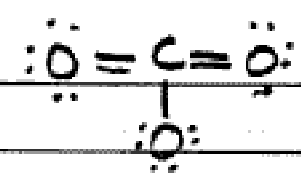
(i) Draw the complete Lewis electron-dot structure for each molecule.

(ii) In terms of molecular geometry, account for the fact that the CF_4 molecule is nonpolar, whereas the SF_4 molecule is polar.

a.)(i) CO_2:

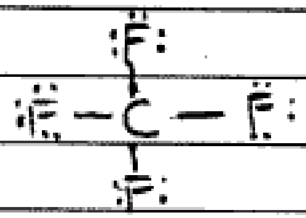


CO_3^{2-}

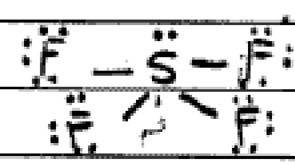


(ii) In CO_2 all of the carbon-oxygen bonds are double bonds, which are stronger and therefore shorter bonds

b.) (i) CF_4



SF_4:



(ii) The CF_4 molecule is in the tetrahedronal shape, which means that all of the F molecules are spaced evenly from each other (109° apart). This results in a molecule of uniform charge. In the SF_4 molecule, the S atom is capable of holding 10 valence electrons, and has one pair of free electrons. This deflects the F molecules away, and the result is a square pyramidal molecule, with the free pair of electrons creating a highly negative region, and a highly polar molecule.