Heat of Combustion

Problem: Resonance Stabilization Energy

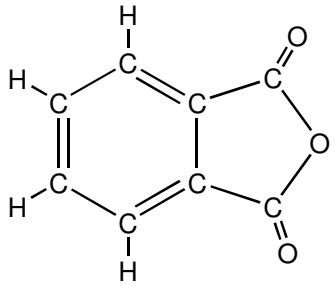
PURPOSE

The purpose of this investigation is to determine the heats of combustion of three related compounds. From these the heats of formation and the resonance stabilization energy may be calculated.

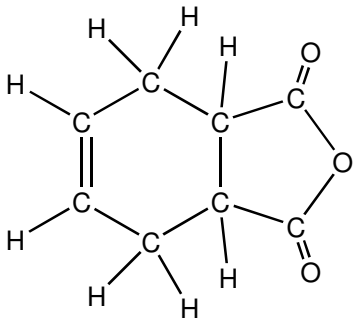
DISCUSSION

Consider the molecular structural differences in these three compounds.

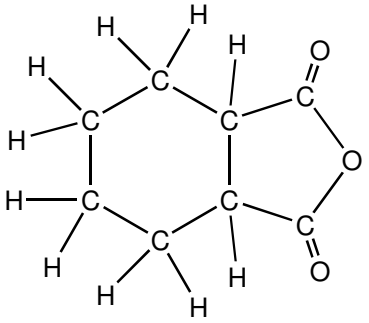
1. phthalic anhydride:



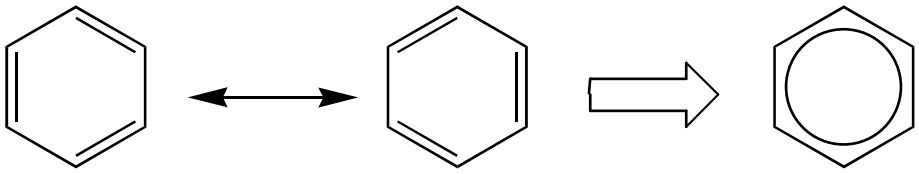
2. cis-4-cyclohexene-1,2-dicarboxylic anhydride



3. cis-1,2-cyclohexanedicarboxylic anhydride



The difference between the heats of formations of compounds (3) and (2) is the heat of formation of one double bond. You might expect that the difference between the heats of formation of compounds (3) and (1) would be three times that of compounds (3) and (2). Actually the heat of formation of (1) is less due to the resonance stabilization energy. The aromatic nucleus of phthalic anhydride may be written as the following:



Resonance leads to increased stability and a lower heat of formation.

DIRECTIONS

Calibrate the calorimeter with benzoic acid and measure heats of combustion of the acid anhydrides. Remember to use samples no larger than approximately one gram.

For each anhydride calculate the heat of combustion, the enthalpy of combustion, and the enthalpy of formation. From the enthalpies of formation determine the resonance stabilization energy of the aromatic nucleus.

Compare your value with the literature value of 49 kcal/mol (205 kJ/mol) for benzene and try to account for any difference.

SAMPLE CALCULATIONS

Experiment: Bomb Calorimeter 2