329. A remarkable double ring expansion occurs when the substituted bicyclobutylidene (C_{11}H_{18}) shown here is treated with strong acid. Only one bicyclo[3.3.0] derivative is formed, even though the mechanism would allow the double bond to be located at several positions. Do MMX calculations on the structure shown and on its trans fused stereoisomer. Then do MMX calculations on the isomers with the C=C located at positions a, b, c, d, e, and f; for several of these, there will be two stereoisomers that you’ll need to consider. These are the only alkenes that could arise from a tertiary carbocation. Compare your calculated energies with those in the article. Do the energies provide an explanation for why only one isomer is formed? What factors lead to the differences in energy among the various regio- and stereoisomers?


330. Tetraethylmethane (Et_{4}C) is a compound whose conformational analysis one would think had been well worked out years ago. Such is not the case. A very recent article discusses this compound’s conformations and their relative energies. The article also presents a most elegant way of generating all of the staggered conformations and avoiding any that are eclipsed. (The method is similar to that used in Problem 160 for the conformations of heptane.) Shown to the immediate right is a small piece of diamond, a structure consisting of nothing but chair conformations wherever you look. This piece of diamond can be used as a template for Et_{4}C by putting the tetrasubstituted C at the center of the diamond and using the diamond bonds to serve as a lattice for the bonds of the four ethyls (as shown by the dark shaded bonds in the accompanying figure). If you choose this problem, first assemble (and minimize) the diamond structure. Then assemble the various conformations of Et_{4}C on the framework (one is shown here; five others are in the literature reference). Delete the excess carbons (there will be 22) and hydrogens. Calculate the relative energies of the conformations.


331. Tricyclo[4.2.0.0^{2,5}]octa-3,7-diene consists of three fused four-membered rings with two double bonds. Two stereoisomers are possible: syn (shown here) and anti. Various substituted derivatives have been made and their chemistry is described in the literature citation. In particular if an octa-substituted derivative is irradiated, ring-closure to a cubane and isomerization to another tricyclic diene can occur; the latter is the same as reactant if all R’s are identical, but differs for different alkyls or for cases when the R’s are parts of rings (as they are in this article). Do MMX calculations on some of the molecules found in the article; for example, calculate the energies of these three structural types for the case in which an R from the top ring is connected to R on the bottom ring as a (CH_{2})_{3} chain.


332. Cyclodecane, as you might expect, has a large number of conformations of comparable stability. Using Figure 1 in the cited reference as your guide, calculate the energies of the six conformations shown. Compare your answers with those in the article; comment on the factors that lead to the different energies of the conformations.

333. Cyclobutadiene is a very unstable molecule, but it can be generated and trapped either inter- or (as shown here) intramolecularly. The first two products shown are the result of [4+2] cycloadditions of the diene to either the C1-C2 or to the C3-C4 double bond in the four-membered ring; the third product is a [2+2] cycloaddition product. Do MMX calculations on these and compare your results with those in the reference; note that the first structure has endo and exo forms, each of which should be calculated.


334 By thermal or acid-catalyzed or base-catalyzed isomerization, the double bond in the structure to the right can move out of conjugation with the fused benzene ring and into conjugation with the phenyl group (two different locations). Each of these three positional isomers for the C=C has two stereoisomers (cis/trans for the methyl and phenyl or cis/trans for the ring fusion). Do calculations on all six structures and compare your results with those in the cited reference. Compare geometrical parameters as well. Discuss those factors that lead to the differences in stability among the six isomers.


335. Hexabenzotriphenylene (to the immediate right) has been prepared. Determination of its structure by X-ray crystallography reveals that the molecular is non-planar and exists in a propeller-like conformation. Do MMX calculations on this molecule; on triphenylene itself (the structure to the far right with X = H); and on various substituted triphenylenes (e.g. with one, two, ... fused benzenes; e.g. with one, two ... methyls in the ortho positions; etc.) to see how crowded the molecule must be for it to be non-planar.


336. Condensation of triethylenetetramine with glyoxal gives a mixture of four compounds: two stereoisomers (cis or trans fusion) of A and two stereoisomers (meso or dl) of B. Do MMX calculations on all of these and determine their relative energies. Discuss whether your findings are in accord with those of the authors who heated the initial reaction mixture and caused two of these isomers to be irreversibly transformed into two others.

337. The very unstable 1-phenyl-1-adamantene has been generated and found to undergo, among other reactions, a [4+2] dimerization. The approach can be in head-to-tail fashion (as shown to the right) leading to two stereoisomers (cis and trans) or it can occur in head-to-head fashion leading to two other cis/trans isomers. Calculate the energies of these four structures. Discuss whether the product energies reflect the transition state energies well enough to predict correctly which is going to be the major product. [Okazaki, T.; Tokunaga, K.; Kitagawa, T.; Takeuchi, K. Bull. Chem. Soc. Jpn. 1999, 72, 549.]

338. An earlier problem (No. 174) introduced the idea of using "octaplanes" as a way of preparing (and perhaps stabilizing) planar tetracooridinate carbon species. Further calculations on such compounds have now been published. Use MMX to see if you can reproduce the published work on predicting the degree of planarity of the central carbon in the structures shown to the right. [Radom, L.; Rasmussen, D. R. Pure Appl. Chem. 1998, 70, 1977.]

339. In an interesting article, there is speculation concerning the conformation of the 1,1-linked polycyclobutanes (n = 1, 2, 3 ...) and their rearrangement to polyspiro molecules with five-membered rings. Do MMX calculations on the first several members of each series. Compare your results with the stability and conformational data that you'll find in the cited reference. [Gaini-Rahimi, S.; Steeneck, C.; Meyer, I.; Fitjer, L.; Pauer, F.; Noltemeyer, M. Tetrahedron 1999, 55, 3905.]

340. The unsaturated carboxylic acid shown to the right cyclizes under acidic conditions to give a mixture of unrearranged and rearranged lactones. Calculate the relative energies of these three products and compare your answers with those for MM2 and MM3 calculations in the cited reference. [Kulkarni, S. C.; Allinger, N. L. J. Phys. Org. Chem. 1999, 12, 122.]
341. In an article related to Problem 310, there is an analysis of the equilibrium and rate of interconversion of the conformations of 1-X-2,3,4,5,6-pentaethylbenzene. Your task, if you choose this problem, is to calculate the relative energies of the conformations of hexaethylbenzene: the all cis; the one with five cis ethyl groups; the three with four cis; and the three with three cis. Decide which factor(s) are responsible for the calculated energy differences.


342. Generation of the cation shown here results in a remarkable transformation, the result of an intramolecular Diels-Alder reaction of the S-substituted diene on the ring double bond followed by trapping of the cation by the alkenyl side chain. Do MMX calculations on the three products; assess their relative energies and discuss whether this helps to explain the actual percent distribution of these compounds as revealed in the article. [To simplify the calculations, the substituent on S has been changed from phenyl to methyl and the substituent on O from isobutyl to methyl.]


343. Intramolecular photochemical [4+4] cyclization of a bispyridone (not shown here) gives a mixture of products A and B. The latter is unstable and undergoes a rapid Cope rearrangement to C. (All three isomers are simpler versions of those in the cited reference, as they are lacking an -OSiR3 group.) Do MMX calculations on these three isomers and on related compounds that you'll find in the article.


344. In a continuation of work first described in Problem 197, the various conformations for the three-carbon saturated tethers in [34](1,2,4,5)cyclophane have been examined. The cited reference presents MMX data on the relative energies of five conformations; the least stable of these may cause you some difficulty when you try to do your own calculation, unless you deliberately twist one benzene ring with respect to the other. This twist also allows the calculation of the relative energy of a sixth conformation, one that is not shown in the article. Compare your results with those in the reference.

345. In an extension of ideas that were first presented in Problem 258, conformational studies were performed on the all-cis trispiro compound (on the left) and on the cis,trans hexaspiro compound (on the right). According to the cited reference, the conformations with oxygens equatorial are more stable than those with oxygens axial for both systems. Do your own MMX calculations on the two chair conformations for each of these structures and compare your results with the published data.


346. In imitation of enzyme-catalyzed cyclizations leading to terpenes and steroids, achiral acyclic homofarnesol can be cyclized, by means of an enantiomerically pure Lewis acid, to a mixture of four optically active compounds having the stereochemistries (from left to right) trans-anti-trans, trans-syn-cis, cis-syn-trans, and cis-anti-trans. Do MMX calculations on all four of these; determine if product stability is in accord with the relative amounts of products actually formed.


347. In an extension of ideas addressed in Problems 265, 275, and 276 consider the conformational analysis of 2-chloro-4-X-pentane and 2,6-dichloro-4-X-heptane. Even though rotation is possible about all of the C-C bonds in these molecules, a couple of conformations are enormously preferred so as to avoid having serious 1,3-interactions of Cl and X. Using the drawings in the cited reference as your guide, calculate the relative energies of the two important conformations of the 2,4-dichloro- and 2,4,6-trichloro compounds (X = Cl); then calculate the relative energies of the two important conformations for each of these systems when X = methyl. Determine if the conformational effects found for the smaller molecules hold when these units are found in the larger molecules.

[Hoffmann, R. W.; Stenkamp, D. Tetrahedron 1999, 55, 7169.]

348. Problem 295 addressed the partially hydrogenated [2,2]-paracyclophane (1) with cis H's at the stereocenters. More recently experimental and theoretical work has been done on the trans stereoisomer of this system; on the cis and trans stereoisomers of 2 in which the attachment to the saturated ring is 1,3; of the cis and trans stereoisomers of 3 in which the attachment to both rings is 1,3; and of the cis and trans stereoisomers of 4 in which the aromatic ring is substituted.
1,2 by the saturated ring is 1,3. Do calculations on all of these systems and compare your results with the published energy values. [Lin, S.-T.; Yang, F.-M.; Liang, D. W. J. Chem. Soc., Perkin Trans 1 1999, 1725.]

349. In a recent report on spiro indolylpiperidines, there is a claim that the position of conformational equilibrium changes dramatically as the substituent on the indole nitrogen is varied in size. Do calculations on the system where \( R = \text{H, Me, Et, etc.} \) to see if this effect can be detected by MMX. [This system is somewhat simpler than the one actually investigated.] [Sulsky, R.; Gougoutas, J. Z.; DiMarco, J.; Biller, S. A. J. Org. Chem. 1999, 64, 5504.]