197. Shown to the right are \([3_4](1,2,3,5)\)cyclophane and \([3_4](1,2,4,5)\)cyclophane in their preferred conformations (as determined in the cited reference). Do MMX calculations on these known compounds and on \([3_4](1,2,3,4)\)cyclophane [not known and not shown] in whatever conformations you think are of reasonable energy for it. Compare the relative energies of the isomeric \((1,2,3,5)\), \((1,2,4,5)\), and \((1,2,3,4)\) isomers and comment on what factors are responsible for the differences.  

198. At a seminar in this department on September 23, 1993, Prof. Alan Marchand of North Texas State University described a synthesis of \((E)\)- and \((Z)\)-1,2-di(1-adamantyl)ethene. One of the interests in these compounds is the large steric repulsion of the \((Z)\)-isomer. Compute the heats of hydrogenation of both stereoisomers as well as of their structural isomer, the 1,1-disubstituted ethene. Compare your results with those for the di-tert-butylethene compounds, as given in Chem. 550 lecture. 

199. This problem involves compounds similar to those in No. 196. The interesting cage compound "Golcondane" (\(C_{20}H_{24}\)) has recently been synthesized, more or less according to the route shown here. (In the actual case, there were carbonyl groups that had to be reduced at the end of the synthesis.) Do MMX calculations on golcondane, on the three precursors, and on its decomposition product; discuss the relative stability of these compounds and identify the source(s) of their strain energy. [The origin of the name "golcondane" is so obscure that the interested reader should consult the cited reference.] 

200. Shown to the right is \([2.2.2]\)triblattanetriene, a molecule that has recently been prepared as a pure enantiomer. Compute its structure and energy as well as those of its potential pyrolysis products via (1) retro \([2 + 2 + 2]\) conversion of three \(\sigma\)-bonds into \(\pi\)-bonds and (2) retro Diels-Alder reaction; compare your results with those reported in the reference. Also compute the heat of hydrogenation for one, two, and three moles of \(H_2\), eventually producing triblattane (see Problem No. 75); comment on any trends observed. 

201. The rather simple looking molecule to the right, tricyclohexylmethane, presents a difficult conformational analysis problem. Even if one keeps all three rings as chairs, there are seven distinct conformations corresponding to gauche (in either a + or - direction) and anti dihedral relationships of the several \(H-C-C-H\) units; one \(H-C\) is at \(C_1\) of each ring; the other \(C-H\) is at the central methine carbon. Compute the energies and structures of these seven structures and compare your answers with those in Table I of the cited reference; comment on similarities and differences observed. 
[Columbus, I.; Biali, S. E. J. Org. Chem. 1993, 58, 7029.]
202. Allinger and his co-workers have published two back-to-back articles on their new MM3 treatment of various N and O heterocycles. Choose an "interesting" series of N or O heterocycles and compare your calculated structural parameters and heats of formation with those in the tables found in the two articles.


203. The beautifully symmetrical dodecahedrane, C_{20}H_{20}, was the subject of calculations in Problems 113, 146, and others cited therein. The present problem is concerned with the effect of halogen substitution (which halogen, how many, and how arranged) on the strain energy of the molecule. Do calculations on the monohalo derivatives (F, Cl, Br), and on the 1,2- and 1,3-dihalo compounds. Compare your computed strain energies with those in the cited article. Also do calculations on other "crowded" derivatives that might appeal to you.


204. Spiro heterocyclic rings have been introduced at C_2 and C_3 of cyclohexanone. The heteroatoms X and Y can be either syn or anti. Choose either the syn or anti series and do calculations of the two chair conformations for the four compounds X=Y=O; X=S, Y=O; X=O, Y=S; and X=Y=S. Discuss the position of conformational equilibrium in terms of axial and equatorial groups. Compare your results with those in the cited reference.


205. The [2+2] syn dimer of acenaphthalene is hydrogenated under vigorous conditions to its H_{16} derivative; further hydrogenation to the H_{18} and H_{20} derivatives proved impossible. Do calculations on all four compounds and discuss why complete hydrogenation does not occur. Compare your structural parameters with those in the cited article.


206. Condensation of the bispyrimidine (to the right) with formaldehyde gave a product whose NMR spectrum did not permit a decisive choice between the two structures shown. Do MMX calculations on both of these products in their several available conformations (i.e., not only can the ring do its chair/chair interconversion but there is epimerization possible at the ring N's). Compare your results with those in the cited article.


207. Pyrolysis of the dienone to the right gives two products; both are formed (supposedly) by a stepwise Cope rearrangement. Do MMX calculations on all three of these compounds as well as on selected other compounds (especially the trienes) in the cited article; determine if the products and rates (see Table I) can be correlated with the computed energies.
208. Triene 1 is, in principle, capable of undergoing two different Cope rearrangements. Only the rearrangement involving bonding of C1 to C6 is observed - the exclusive product is 3 which, presumably, arises by a second Cope rearrangement on undetectable intermediate 2. (Note that two views of 2 are shown: in 2a, the carbon numbers correspond to those in reactant 1; in 2b, the carbons are numbered in anticipation of the second Cope rearrangement.) It’s interesting that 1 does not give the alternative Cope rearrangement (bonding of C1 to C6) leading to 4. Compute the energies of all of the structures shown. Try to formulate an explanation for the observed exclusivity of the first Cope reaction. Comment on the authors’ claim that compound 2 has a very short lifetime because of “substantial steric compression ... an olefinic carbon in the six-membered ring is forcibly compressed against a carbon atom from the trans double bond.”

209. In a problem reminiscent of No. 144, generation of the 9-basketyl radical, C10H11+, leads via a cascade to new radicals by the cleavage of one, two, and then three of the C-C bonds to the “upper” cyclobutane. Calculate the energies of all of these species and comment on the feasibility of this proposed sequence of steps. Speculate on why the last radical does not undergo cleavage of the one remaining C-C bond.

210. Isodicyclopentadiene (1) undergoes Diels-Alder reactions with a variety of dienophiles exclusively from the more hindered side of the diene (syn to the CH2CH2 bridge). Various explanations have been offered for this. Compounds 2 and 3 have recently been studied as a test of the various explanations. Do MMX calculations on all three compounds (do your calculations on both the chair and boat conformations for 3) and on the derivative of 3 in which its boat conformation is enforced by a CH2CH2 link between the unique carbons of the boat. Discuss these structures in terms of relative strain, steric ease of approach of dienophiles, etc.

211. The beautifully bowl-shaped molecule “Pinakene”, C28H14, is a fragment of C70 (one of the fullerenes). A possible synthetic route (reminiscent of that in Problem No.
190) involves removal of one mole of H₂ from the tetramethyl-dibenzo-naphthacene (shown) followed by removal of three more. The strain energy increases with each removal of a hydrogen molecule and creation of a five-membered ring. Do MMX calculations on the tetramethyl compound, on pinakene, and on the three intermediate structures. Compare your answers with those in the cited reference. Compare the shape of pinakene calculated by MMX with that in the article.


212. The polycyclic aromatic compound to the right (note the presence of only two sp³ carbons) has been synthesized. Because of repulsion between aryl hydrogens, the molecule cannot remain planar. In fact, both a meso and a dl form have been isolated, each of which consists of two helical arrays (see the article for details). Do MMX calculations on both stereoisomers; compare your structural parameters (angles between rings, distortions from planarity) with those cited in the article. Then, do calculations on related compounds (of your invention) that are similarly forced to be non-planar; for example, replace the five-membered rings with smaller or larger rings or fuse additional aromatic rings onto the basic nucleus, and so on.


213. The exo-fused "ladderanes" are an interesting class of molecules. Do MMX calculations on [10]ladderane (1) and on the two derivatives 2 and 3 in which CH₂ groups are inserted into the C-C bonds of the parent. Compare the shapes and structures that you calculate with those found in the article. Use these three as prototypes for others that may strike your fancy.


214. A recent article (with the intriguing title "A Molecular Brake") suggests that "free" rotation about a C-C bond can be blocked by what is the molecular equivalent of putting a stick in the spokes of a bicycle. The hydrocarbons to the right are modeled after the heterocyclic compounds actually used. Do MMX calculations on triptycene (1) and its 9-phenyl derivative (2). Then look at the biphenyl- and fluorenly-substituted compounds, 3 and 4. Because the biphenyl unit is locked into a planar moiety in 4, models suggest that it can play the role of the "stick in the spokes" of the triptycene-to-aromatic ring rotating bond (see the original article). Do your calculations confirm this prediction?


215. van der Waals forces can not only be destabilizing but stabilizing if the distance between the groups is correct. Consider the series of compounds to the right; in all of them, R₁ is the bulky (essentially spherical) 1-adamantyl group. First, do MMX calculations on the parent phenyl compound (R₂ = H) to determine whether or not the conformation shown, with the tertiary C-H coplanar with the
benzene ring, is preferred. Then do calculations on the other three compounds (R_2 = Me, t-Bu, 1-Ad) in their two possible conformations (the one with the C-H anti to R_2, the one with it syn) to determine if having the bulky groups closer to one another is actually preferred; compare your answers with the calculated and experimental results in the cited reference. [Anderson, J. E.; Bru-Capdeville, V.; Kirsch, P. A.; Lomas, J. S. J. Chem. Soc., Chem. Commun. 1994, 1077.]

216. The Diels-Alder reaction is one of the most important that conjugated dienes undergo. In order to take part, however, the diene must rotate from its usually more stable transoid to its cisoid conformation. A recent article describes the reaction of various methyl-substituted dienes with (CF_3)_2C=C(CN)_2: reaction from the transoid conformation proceeds via a zwitterion intermediate to a [2+2] cycloadduct; reaction from the cisoid proceeds in concerted fashion to the [4+2] (Diels-Alder) product. Do MMX calculations on both conformations of: 1,3-butadiene itself; (E)- and (Z)-1,3-pentadiene (R_1 = Me or R_2 = Me); 4-methyl-1,3-pentadiene (R_1 = R_2 = Me); and 2,4-dimethyl-1,3-pentadiene (R_1 = R_2 = R_3 = Me). Your calculation should include the relative energies of the conformations as well as the diene's ability to adopt an all-planar conformation. Use your calculations to comment on issues raised in the article, such as why all of the compounds enumerated above give only [4+2] reaction except for 4-methyl-1,3-pentadiene which gives exclusive [2+2]. [Brückner, R.; Huisgen, R. Tetrahedron Lett. 1994, 35, 3285.]

217. Like hindered biphenyls, the dibenzocyclooctatetraene molecule (to the right) is chiral with a significant twist angle between the benzene rings; the barrier to racemization is 30 kcal/mol. Do MMX calculations on this compound in both its twisted and all-planar conformations. Then, test the ability of related molecules to be twisted and/or planar by doing calculations on: the two possible dihydro derivatives and the one tetrahydro derivative; also on those compounds with three or two or one CH_2 group(s) bridging the ortho positions of a biphenyl nucleus. Discuss the factors that favor twist vs. coplanarity in these structures. [Burger, U.; Lottaz, P.-A.; Millasson, P.; Bernadinelli, G. Helv. Chim. Acta 1994, 77, 851.]

218. Caprolactam (shown to the right), despite its having a seven-membered ring, is conformationally quite similar to cyclohexane. That is, the amide group (which is constrained to be planar) acts like a very large CH_2 group, allowing chair and twist conformations to exist. First, convince yourselves that the chair and twist of the parent compound resemble those of cyclohexane. Then, do MMX calculations (four total) on the 7-t-butyl derivative with the group axial or equatorial in the chair and axial or equatorial in the twist. Do the same for the four possible 3-t-butyl structures. Compare your results with those in the article and with what you'd expect (based on cyclohexane) for energy differences in chair vs. twist and in equatorial vs. axial t-butyl. [Matallana, A.; Kruger, A. W.; Kingsbury, C. A. J. Org. Chem. 1994, 59, 3021.]
219. Intramolecular [4+4] photocycloaddition of the bis-pyridone to the right gives a remarkable product whose X-ray crystal structure reveals that the cyclohexane ring is in a boat conformation. Do MMX calculations on the simplified model compound (to the far right) in its various possible conformations (twist, half-chair) in order to determine which conformation is preferred. Compare your results with those in the article. [Sieburth, S. M.; Ravindran, K. Tetrahedron Lett. 1994, 35, 3861; Sieburth, S. M.; Lin, C.-H. J. Org. Chem. 1994, 59, 3597.]

220. Shown to the right is a stylized picture of [2,2](meta,para)cyclophane. As in most cyclophanes, the rings are bent out of planarity and are in more-or-less parallel planes. For the parent compound (all R's = H), there are two conformations of equal energy. Do MMX calculations on the parent; on the two different conformations for the monomethyl derivative (R1 = Me); on the two different conformations for the dimethyl derivative with R1 = R2 = Me; and on the two different conformations for the trimethyl derivative (R1 = R2 = R3 = Me). Discuss the factors that are responsible for the differences in conformational energy. [Lai, Y.-H.; Yap, A. H.-T.; Novak, I. J. Org. Chem. 1994, 59, 3381.]

221. Tetracyclohexylethene is a deceptively simple-looking molecule. In fact, steric interactions between the saturated rings lead to quite different energies for the various possible conformations of this molecule. Even if one limits the study to those conformations having equatorial sp3-sp2 bonds and chair rings, there are seven conformations to deal with (see Scheme I in the cited reference). Do MMX calculations of the energies and dihedral angles for these seven conformations and compare your results with those in the article; discuss the factors that lead to the differences in energy. [For simplicity, get one conformation drawn and minimized; then use the ROT-B command to rotate one or more saturated rings about the sp3-sp2 bond in order to generate the other conformations.] [Columbus, I.; Biali, S. E. J. Org. Chem. 1994, 59, 3402.]

222. Cyclopentadienes tethered to alkenes are known to give intramolecular Diels-Alder reactions. Consider the case where the tether is (CH2)3. When such an alkyl-substituted cyclopentadiene is prepared, a very rapid transfer of H from one ring carbon to another occurs (as shown on the upper line of the figure) in competition with the Diels-Alder process. Calculate the structures and energies of these three monocyclic molecules and of the intramolecular Diels-Alder adducts possible from each of them. For each adduct, be sure to consider the two possible stereoisomers at C* (the newly generated stereogenic center). Comment on the factors responsible for the energy differences among the adducts; decide which of these cyclizations seems feasible.

223. In a recent article is the surprising claim that the gauche conformation of 9,9'-bifluorenyl (1) is
more stable than the anti. Do calculations on these two conformations and comment on the factors leading to a difference in energy between them. Then, do an analogous study on the indenyl dimer 2 in both its meso and di stereoisomeric forms; note that the latter will have two different gauche conformations.