

# Think It Over

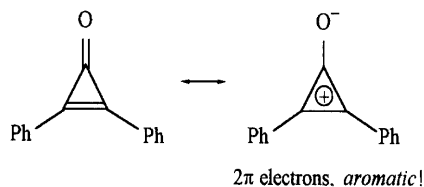


This section of *Resonance* presents thought-provoking questions, and discusses answers a few months later. Readers are invited to send new questions, solutions to old ones and comments, to 'Think It Over', *Resonance*, Indian Academy of Sciences, Bangalore 560 080. Items illustrating ideas and concepts will generally be chosen.

Answer to Think-it-Over problems posed by A Krishna Murthy in , Vol.2, No.9, 1998, p.73.

Three questions were asked with the hint that the answers had a common basis. All answers are derived from Hückel's rule: cyclic conjugated systems with  $(4n+2)\pi$  electrons are aromatic.

The first question was about the large dipole moment of diphenylcyclopropenone. Normally carbonyl groups are polarized such that the carbon has a partial positive charge, and the oxygen has a partial negative charge. This polarization is enhanced in cyclopropenones because the three membered ring effectively becomes aromatic with  $2\pi$  electrons. As a result, the molecule has a high dipole moment of 5.07 D.



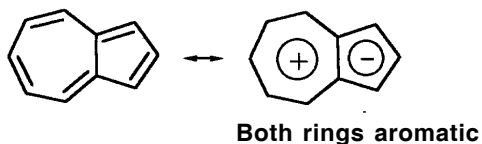
The acidity of the hydrocarbons cyclopentadiene, indene and fluorene result from the aromatic character of the corresponding anions (six  $\pi$  electrons in the 5-membered ring). The extraordinarily high acidity of pentakis (trifluoromethyl) cyclopentadiene (stronger acid than nitric acid) is due to further stabilization of the aromatic carbanion by the combined strong electron withdrawing effects of the trifluoromethyl groups.

Correct answers were sent by the following:

Shubham Sharma (Hardwar)  
Prमित Chowdhury (Kanpur)  
R G Revaiah (Shimoga)



Azulene is a fused 7/5 ring system with five double bonds. One can rearrange the double bonds to write an ionic structure shown below in which both rings have six  $\pi$  electrons – which makes both rings aromatic. This necessarily leads to a charge separation (as in the first example) which results in a moderate dipole moment for the hydrocarbon even without any polar substituent.



### Answer to 'A Poser' <sup>1</sup>

By convention, a nuclide is defined as fissile if even a slow moving neutron with very low energy (about 0.025 electron-volt at room temperature) can cause it to fission. There are other nuclides that undergo fission only upon collision with neutrons of higher energy (as much as one million electron-volt, or more), but these do not fall in the same category. While uranium-235 is fissile, uranium-238 is not and the reason for this is explained below.

While the incoming neutron is absorbed, a compound nucleus is formed, which is in an excited state. The excitation energy of the compound nucleus is equal to the binding energy of the absorbed neutron plus its kinetic energy. For low energy neutrons, of negligible kinetic energy, the excitation energy is equal to the binding energy.

For the compound nucleus uranium-236 (resulting from absorption of a slow neutron in uranium-235), the excitation energy is about 6.8 MeV, while it is 5.5 MeV for the compound nucleus uranium-239 (resulting from absorption of a slow neutron in uranium-238). The excitation energy for uranium-239 is lower because the nucleus contains an odd number of neutrons and the last neutron is an unpaired one with lower

<sup>1</sup> Think-it-Over problem posed by Manpreet Singh, *Resonance*, Vol.3, No.10, 1998, p.99.

'When we bombard  $^{235}\text{U}_{92}$  with a neutron it undergoes fission, while  $^{238}\text{U}_{92}$  on bombarding with a neutron initiates  $\beta$ -decay and changes into  $^{239}\text{Pu}_{94}$ . According to neutron/proton ratio  $^{238}\text{U}_{92}$  should be less stable than  $^{235}\text{U}_{92}$ . Then why does not  $^{238}\text{U}_{92}$  undergo fission?

Answered by L V Krishnan and SMLee, Safety Research, Health Physics, Information Services, Instrumentation and Electronics Group, Indira Gandhi Centre for Atomic Research, Kalpakkam Tamilnadu 603 102, India.



binding energy. In uranium-236, however, each neutron pairs off with another and this leads to a higher binding energy for the last neutron, and consequently higher excitation energy.

The compound nucleus undergoes fission only if the excitation energy is greater than the activation energy, that is, the energy needed to overcome the fission barrier. For the compound nucleus uranium-236, the activation energy is estimated to be 6.5 MeV. This makes fission with low energy neutrons possible. For the compound nucleus uranium-239, however, the activation energy is estimated to be about 7 MeV, which rules out fission with low energy neutrons. The fission barrier is created by a balance between the repulsive Coulomb forces between the protons and the attractive forces between the nucleons. The three extra neutrons in uranium-239, as compared to uranium-236, tend to raise the activation energy for uranium-239. However, when a neutron with kinetic energy greater than 1 MeV collides with uranium-238 nucleus, the excitation energy of the compound nucleus is raised to a level higher than the activation energy, paving the way for fission.

The values for excitation energy and activation energy are as given in *Elements of Nuclear Reactor Theory* by S Glasstone and M C Edlund. This book may also be referred to for further details.

The relative stability due to deviation from  $N/Z$  stability ratio line of either the compound nuclei (U-236 and U-239) or the target nuclei (U-235 and U-238) does not enter the arguments given above for fissionability. In fact, U-235, U-236 and U-238 are stable against beta decay, but decay by alpha emission with extreme half lives of respectively 710 million, 24 million and 4500 million years. On the other hand U-239 does deviate significantly from the  $N/Z$  stability ratio line, having too many neutrons, and decays by beta emission with a half life of 23.5 minutes.

