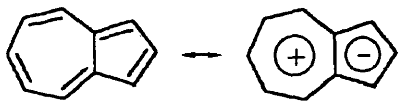
Azulene is a fused 7/5 ring system with five double bonds. One can rearrange the double bonds to write an ionic structure shown below in which both rings have six π electrons – which makes both rings aromatic. This necessarily leads to a charge separation (as in the first example) which results in a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



Both rings aromatic

Answer to 'A Poser' [1]

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.

[1] Think-it-Over problem posed by Manpreet Singh, *Resonance*, Vol.3, No.10, 1998, p.99.

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

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

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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.

The most prestigious award for mathematics is the Fields Medal which is awarded once in four years to three or four young mathematicians for their outstanding contributions. They receive the medal during the International Congress of Mathematicians held once in four years.

In the most recent International Congress of Mathematicians held in Berlin, Germany during August 18–August 27, 1998, the following four mathematicians were awarded the Fields Medals: Richard E Borcherds, W Timothy Gowers, Maxim Kontsevich and Curtis T McMullen.

The Work of the Fields Medallists: 1998 [1]

1. Richard E Borcherds

C S Rajan

The work of Borcherds draws upon diverse areas from mathematics and physics, and shows a surprising convergence of ideas from finite group theory, modular forms, Lie algebras, and conformal quantum field theory. The proof of the so-called monstrous moonshine conjecture is a major highlight of the work; in the following discussion we concentrate mainly on this topic. The moonshine conjecture predicts the existence of an intimate relationship between the monster group, the largest of the sporadic finite simple groups, and the theory of modular functions. In order to clarify the structures arising in this conjecture, Borcherds introduced the concept of vertex algebras, also known as chiral algebras, which provides a mathematically precise algebraic formulation of conformal quantum field theory, and has furthered the connection between automorphic forms and Lie algebras.

Finite groups are familiar objects not only in mathematics but also in various sciences, especially physics. Simple groups, namely those with no nontrivial normal subgroups, are the building blocks for finite groups. The classification of all finite simple groups, completed in the seventies, ranks among the major achievements of mathematics in this century. Apart from certain series of simple groups, such as the alternating groups consisting of even permutations on 5 or more symbols and the so-called Chevalley groups, there are 26 'sporadic' finite simple groups, making up the list of finite simple groups. The first sporadic groups were constructed by Mathieu in the last century, but it took more than 100 years before other sporadic groups were discovered. An interesting example was discovered by Conway, as the automorphism group of the Leech lattice, modulo $\{\pm 1\}$. The Leech lattice, which plays an important role in Borcherds' work as well, is the unique lattice in the 24-

[1] Reproduced with permission from *Current Science*, Vol.75, pp.1290–1292, 1998.