Classroom

In this section of Resonance, *we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.*

Question raised by
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Cadmium bars are used to absorb excess number of neutrons. So when these metal bars absorb more and more number of neutrons their mass number certainly increases. And as the mass number increases the metal becomes less stable (as its specific binding energy is less). Hence it should also undergo fission reaction releasing enormous amount of energy. But this does not happen. How is this accounted for?

Nuclear fission reactions take place mainly when unstable nuclei like uranium-235 or plutonium-239 react with neutrons. Such nuclei, in a fission reaction, break into 2 fragments (of lighter elements of unequal weight), with simultaneous release of a few neutrons which propagate the chain reaction. The energy release in each fission is of the order of 200 Mev (million electron volts), which is large, and the rapid propagation of the chain reaction leads to the generation of enormous energy. It is the significant mass difference between the products and the reactants that appears as energy ($E=mc^2$).

Such a possibility does not exist in the case of a lighter element like Cadmium (atomic weight about 112), though cadmium does absorb neutrons.

Natural cadmium is made up of a number of isotopes with different abundances: Cd^{106}(1.25%), Cd^{110}(12.49%), Cd^{111} (12.8%), Cd^{112} (24.13%), Cd^{113} (12.22%), Cd^{114}(28.73%), Cd^{116}(7.49%). Of these Cd^{113} is the main neutron absorber; it has an absorption cross section of 2065 barns for thermal neutrons (a barn is equal to 10^{-24} sq.cm), and the cross section is a measure of the extent of reaction.

When Cd^{113} absorbs a neutron, it forms Cd^{114} with a prompt release of γ radiation. There is not much energy release in this reaction. Cd^{114} can again absorb a neutron to form Cd^{115}, but the cross section for this reaction is very small. Cd^{115} is a β-emitter (with a half-life of 53hrs) and gets transformed to Indium-115 which is a stable isotope. In none of these cases is there any large release of energy, nor is there any release of fresh neutrons to propagate any chain reaction.

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The Möbius Strip

The Möbius strip is easy enough to construct. Just take a strip of paper and glue its ends after giving it a twist, as shown in *Figure 1a*. As you might have gathered from popular accounts, this surface, which we shall call M, has no inside or outside. If you started painting one "side" red and the other "side" blue, you would come to a point where blue and red bump into each other.

The space M is the simplest example of a *non–orientable* surface. In fact, it is a theorem that a surface (i.e. a two dimensional manifold) is non-orientable if and only if it contains a Möbius strip embedded inside it. That is, you could take a pair of scissors and cut out a Möbius strip from it. *Figure 1b* illustrates this for the other famous non-orientable surface, called the Klein Bottle.