Think It Over

This section of* Resonance *is meant to raise thought-provoking, interesting, or just plain brain-teasing questions every month, and discuss answers a few months later. Readers are welcome to send in suggestions for such questions, solutions to questions already posed, comments on the solutions discussed in the journal, etc. to* Resonance, *Indian Academy of Sciences, Bangalore 560 080, with "Think It Over" written on the cover or card to help us sort the correspondence. Due to limitations of space, it may not be possible to use all the material received. However, the coordinators of this section (currently A Sitaram and R Nityananda) will try and select items which best illustrate various ideas and concepts, for inclusion in this section.

From J Chandrasekhar

1 The Richness of Chemistry

One simple way to appreciate the richness of chemistry is to go through the following exercise: Think of any two elements in the Periodic Table. Try to work out the number of possible binary compounds that can be made from them. Then, check how many have indeed been made experimentally. Invariably, you will come to the conclusion that a large chunk of chemistry remains unexplored.

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Let us try this procedure for carbon and oxygen. How many oxides of carbon are known? Carbon monoxide (CO) and carbon dioxide (CO_2) would immediately spring to mind. The former is a colourless, odourless poisonous gas emitted all around us by the incomplete combustion of carbon compounds. It is also the key ingredient of the industrially important 'water gas'. Carbon dioxide, present in larger amounts in the atmosphere, is useful as dry ice and provides the fizz in soft drinks. It is also the prime suspect in the global warming process caused by the greenhouse effect.

Are there any other oxides? Text books usually list carbon suboxide, C_3O_2. More advanced inorganic books mention a few more.

However, one can easily write the formulae of several possible oxides. One can generalise and have a series of oxides of the formula C_nO and another of the type OC_nO. The first few members in both the series have been made in the laboratory. Their structures have been determined by microwave (or rotational) spectroscopy. Some have been detected first in inter-stellar clouds, by their characteristic spectral features, and confirmed later by laboratory experiments.

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Based on the nature of hybridisation of the atoms involved, the two series of compounds are expected to be linear. But there is another interesting pattern in their electronic structures. In the series of linear molecules with the general formula C_nO, the ground electronic state is a singlet if n is odd and a triplet if n is even. There is a qualitative explanation based on molecular orbital theory for the trend (although the space in the margin is not enough to write it down). Can the rule be extended to the OC_nO series of molecules too?

Finally, one must mention the oxides of fullerenes. Just as C_{60} and C_{70} are unique molecular allotropes of carbon, their oxides are entities in themselves. Both $C_{60}O$ and $C_{70}O$ have been made, retaining the spheroidal shapes of the fullerenes. How many reasonable isomeric structures are possible in each case?

2 Prisoner's Dilemma

Three prisoners, *A*, *B* and *C* are each held in solitary confinement. *A* knows that two of them will be hanged, but one will go free. However, he does not know who will go free. He thus reasons that there is a 1/3 chance of his survival. Anxious to know his fate, he asks his guard. But the guard will not tell *A* his fate. *A* thinks and puts the following proposal to the guard: "If two of us must die, then I know that either *B* or *C* must die and possibly both. If you tell me the name of just one of them who is certain to die, then I learn nothing about my fate; and since we are kept apart, I cannot inform them of theirs. So tell me which one of *B* or *C* is to die?" The guard accepts the logic and tells *A* that *C* is to die. *A* now reasons that either he or *B* will live. Thus *A* now has a 1/2 chance of survival. Is *A*'s reasoning correct?

Will the knowledge of probability theory resolve the prisoner's dilemma?