

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.

? In introducing the Bohr theory of the hydrogen atom, one makes a postulate that electrons in certain special orbits around the centre do not radiate. How does one reconcile this with what students have already learnt about radiation?

From G Venkatesh, Hindustan Academy of Engineering and Applied Science, Bangalore.

? As an example of special relativity in action, one quotes the case of the muon, with a half-life of less than ten nanoseconds (1 nanosecond = 10^{-9} sec). Travelling at almost the speed of light, it should only be able to cover a few metres in this time. But cosmic ray physicists are able to detect muons which have travelled several kilometres, from the top of the atmosphere. Is this an example of length contraction or time dilation?

? How does one find out the molecular/empirical formula of an organic compound?

From Uday Maitra, Department of Organic Chemistry, Indian Institute of Science, Bangalore.

We are taught even at the high school level the significance of molecular and empirical formulae of molecules. It is therefore important to know how the relative compositions of carbon, hydrogen and nitrogen (the three most common elements in an organic compound, besides oxygen) are experimentally obtained.

Interestingly, the analysis is usually done by *burning* the compound,



after carefully purifying it! If you burn any organic compound in excess oxygen, the carbon and hydrogen contents get converted to CO_2 and H_2O , respectively. If the amounts of CO_2 and H_2O obtained from a given weight of the compound can be estimated (by absorbing these two gases in appropriate absorbents), then %C and %H can be easily calculated. The estimation of nitrogen is more involved, and there are classical methods like Kjeldahl's method¹ for determining organic nitrogen. Before the advent of automated analyzers, these methods were followed extensively for the determination of elemental compositions.

¹ Use of Kjeldahl's method is a standard experiment in the M.Sc. programme in many universities.

In modern C/H/N analyzers, the entire operation is automated, and C, H and N percentages can be determined in as little as 10 minutes! The principle here is basically the same, except for N analysis. A known weight of the sample (which may even be one milligram!) is burnt in an excess of oxygen (at about 1000°C) in the presence of oxidizing agents and catalysts. Carbon, hydrogen and nitrogen in the organic compound produce CO_2 , H_2O , and a mixture of nitrogen oxides, respectively. This mixture is then passed over heated (650°C) copper metal, thereby reducing the nitrogen oxides to elemental nitrogen. The mixture of CO_2 , H_2O and N_2 is then passed through a 'Gas Chromatograph',² which separates and detects the three gases passing through a thermal conductivity detector. The output from the GC shows three peaks. In order to properly calibrate them, a known weight of a known compound (such as 2,4-dinitrophenylhydrazine) is also analyzed under identical conditions. Therefore, the GC signals coming from the known compound can be utilized for calibrating the peak areas. Thus the areas under the peaks for the unknown sample can be attributed to certain quantities of the three gases.

² The details of a 'Gas Chromatograph' will be discussed in a future issue.

In practice, this whole operation is automated, and a computer processes all these data. It may be interesting to know that in many machines twenty different samples can be analyzed automatically, one after the other! Of course, this convenience does not come cheap. Modern C/H/N analyzers can cost as much as Rs. 10 lakhs, and require special chemicals and accessories for their routine operation.



Despite the cost, however, these machines are extremely useful for routine analysis of new organic compounds.

It is appropriate to mention here that a mass spectrometer can also give you the molecular weight, and in some cases (under high resolution) the molecular formula as well. However, it does not give any idea about the purity of a sample. On the other hand, the correct composition of a compound of known molecular formula can always be used as a criterion of sample purity.

? Given a choice of career, what would you like to be?

A contribution from Milind Watve of M E Society, Abasaheb Garware College, Pune. The original manuscript was titled "On Being a Teacher".

For the last fifteen years, since I became a teacher, I have been conducting personal interviews of all final year students and this is invariably one of the questions. Altogether my sample size must be 900 or so. Only one out of the 900 student said : "A teacher, maybe at a primary school, but I won't mind a high-school or even college".

That reminds me. One of my professors had asked me almost the same question. "What do you plan after your Ph.D?"

This, I think was just casual and personal. Unlike me he didn't seem to be surveying.

"Back to teaching".

"Really?"

The "really" had all the shades of disbelief, amusement and an exclamation, "After doing a Ph.D in IISc, people talk of going abroad, my son!"

"Well, I would go back to teaching, no doubt, but I might shift from undergraduate teaching"

"Oh, to the university ! That will be good".



“No, I mean, given a decent chance, I might shift to school teaching.”

I certainly find teaching a very exciting, interesting and challenging job. But I think I belong to a rare species. Few people take to teaching by choice. Those who do, are discouraged by a large number of environmental factors acting against them. Teachers who love teaching even after 8-10 years on the job are likely to do so all their lives. And they constitute the really endangered species.

I often wonder why it is so, when there are several obvious advantages of being a teacher, particularly a science teacher in a college. For one, science teaching involves a constant interaction and what can be more absorbing than that? Teaching at the undergraduate level is an enjoyable exercise, and teaching at high school is even more so. Younger students are more open minded and, given a chance, interact so well with the teacher that the teacher emerges a hundred fold more enlightened. I have a few research papers to my credit and the central ideas in a couple of them have flashed to me in the classroom. Apart from obvious intellectual advantages, being in the company of young minds also keeps you fresh and young. And most of all, you get plenty of free time. For those who decide not to work, there is practically no work; for those who wish to work there is no upper limit. By the way, I have enjoyed both the extremes!

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But none of these benefits seem to attract talented youth. After the +2 level in science, the most successful take professional courses. The sediment comes to B.Sc., after which a talented group opts for management and other professional courses open to them. The next choice is a Masters degree course. After the Masters degree a small but willing fraction gets an opportunity in industries. Those who can manage GRE go abroad and those who survive CSIR tests take to research in India. This leaves us with the last fragment who come to teaching by default.

Who is to be blamed for this state of affairs? Most probably the teachers themselves. The profession to which the student community has maximum exposure is teaching. And teachers have failed



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Who is to be blamed for this state of affairs? Most probably the teachers themselves. The profession to which the student community has maximum exposure is teaching. And teachers have failed to make a good impact. The major attractions of any profession are prestige and money. There is little prestige in teaching but the money is not too bad. Indeed, compared to the work input required the money is very good. But day by day, other jobs and business opportunities have started paying better, and therefore have become more attractive.

One would certainly find a number of candidates for whom the intellectual challenge is a sufficient motive. Unfortunately this group finds much stagnation in this career. Teaching is largely ritualized and both students as well as college or university



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in with enthusiasm, claims originality and attempts innovation.

As a result we have entered a vicious cycle. Since teachers have failed to make a good impression about their profession, talented youngsters are not drawn to it. This leaves the teaching community impoverished. From what I can recall when I was a student, the picture was no better. We only had a couple of good teachers; (incidentally one of them took early retirement and the other bid goodbye to teaching). There were many good personalities, no doubt. But being a good teacher is probably more difficult. I won't attempt a formal definition of a good teacher. As a student, I had a very simple measure. One who would keep the attention and interest of a student, no matter how bad, was a good teacher.

We need to take a radical new look at teaching itself and science teaching in particular. This is not possible until we have a substantial number of innovative minds in the teaching community and they are encouraged. We certainly need to attract talented young graduates to the teaching profession as an indispensable part of any educational policy. But the present picture is grim. A brief look at the interviews of students in the merit list of the SSLC's every year makes it evident. They want to be anything and everything but teachers.

But I haven't lost hope. When I asked the only student who wanted to be a teacher why she was inclined to being one, she came the answer: "I have seen very few good teachers (does that include me? I dare not ask), and that makes me think it must be challenging!"

And that is the only ray of hope.

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