Physical Chemistry and Materials

Teaching Mathematics to Chemistry Students at the University of Sheffield

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Abstract

The department of chemistry offers over two semesters, Mathematics for Chemists 1 and 2, which provide students with the understanding and use of mathematical techniques for various chemistry degrees. This case study reviews these courses and illustrates their value in terms of providing the students with a positive foundation for future study.

Level of Material: First Year

The Execution

In the Department of Chemistry, the courses Mathematics for Chemists 1 and 2 are offered to first year students. The aim is to provide undergraduates with the understanding and use of mathematical techniques needed for various chemistry honours degrees.

Taught over two semesters by different tutors, each course runs for 12 weeks with two lectures a week and one tutorial. To monitor their progress the students are assessed every six weeks. Each lecture is designed to spend thirty minutes on basic mathematical principles and the remainder is taken up with questions. Questions are set each week to accompany the lectures and they are discussed in a tutorial the following week.

At the beginning the students are given a preliminary assessment. The topics range from basic arithmetic through to integration and differentiation. The tutor uses the results as an indication of the strengths and weakness within the group; the results are not part of the overall assessment. Students who do very well in the test have two options: they can stay and mentor the other students in the class or they can find another 10-credit module and take up the course in the second semester. Many stay on and take up the role of mentor.

During the first semester Mathematics for Chemists 1 starts with basic arithmetic and covers topics from the GCSE syllabus up to and including A-level. For the first six weeks the subjects include algebra, fractions and surds, linear equations, quadratics and simultaneous equations. The students then sit a test.

The next set of topics includes exponentials, logarithms, statistics, geometry, trigonometry and differentiation. At this stage, the students sit another test.

The second semester topics (Mathematics for Chemistry 2) are more advanced (integration, matrices, vectors etc.) and the mathematics is more chemistry based.

Where possible, every effort is made to incorporate mathematical problems in a chemistry context. Following the section on basic algebra, the students are presented with the re-arrangement of equations and fractions using chemistry equations. In doing quadratics and solving simultaneous equations, chemistry examples are also used. Figure 1 illustrates an example used in a trigonometry tutorial, which takes the student from the basic mathematics to calculating the hydrogen-to-hydrogen distance in the water molecule and calculating the 0-0 bond length in the ozone molecule.

The objective is to introduce the basic topics and establish a contextual link to the chemistry. The student can then see the role mathematics plays and broaden their understanding. Each course is designed to help the students as many are lacking in confidence and ongoing support is required. It is therefore important not to make the mathematics complicated but to create a foundation for future study and to let them see that it can be fun.

Pre-requisite Knowledge

The course caters for a variety of backgrounds. Essentially any student doing a chemistry course who does not have mathematics will take one or the other of the semesters depending on the level of maths. Those who do not have A-level mathematics will take both courses (Mathematics for Chemists 1 and 2) while students who have AS-level mathematics will take the course Mathematics for Chemists 2 in the second semester.

What Support Was Needed?

- Mentoring for the first semester is an important role in the course for guiding the weaker students. Mentors are set up unofficially in the class.

- Photocopies of each of the tests from the preliminary assessment are given to the student's personal tutor. This helps them to appreciate the level at which support is needed by the student during the semester.

- The students complete a questionnaire relating to the course. The responses are put up on a large notice board in the department. It is the responsibility of the staff to respond to these comments and the students get to see their written replies. Staff do respond to the students' concerns offering support and this can lead to changes in the course structure and teaching method.

The Barriers

The main barriers are time and resources. The setting up and co-ordination of the courses require ongoing attention. There have to be regular updates in the content and the support as the tutors face continuing changes in the level of mathematical skills.
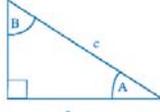
Evidence of Success

The continual assessment of the students indicates improvement during the year. Feedback from the students is extremely positive: "This was taught very well and I understood everything as I went along. Being examined half way also meant I understood more rather than just memorised content. Tutorials gave practice in rules and helped with revision". Another stated "The course has helped my maths in chemistry".

How Can Other Academics Reproduce This?

■ Teaching resources are required to set up the programme.

■ The two-semester courses Mathematics for Chemists 1 and 2 are structured to provide for different levels of mathematical skills amongst the students.

■ The tutors require an understanding of the current A-level and GCSE curricula.

■ The preliminary assessment is important in setting up the content of the early lectures.

■ The courses must accommodate for the wide level of ability, those acting as mentors are set difficult questions and the weaker students are advised "not to worry if they cannot do them".

Trigonometry tutorial

1. Show that triangles with sides in the ratios 5:12:13 and 8:15:17 are right angled triangles

2. A ladder leans against a wall with the top of the ladder resting 2 feet below the top of the wall. The wall is 8 feet high. The ladder is 8 feet long. How far is the base of the ladder from the wall?

3. The diagram shows a square based pyramid
   (a) calculate the distance AP, where P is the centre of the base
   (b) Given that V is the vertex directly above P find the height of the vertex V above the base
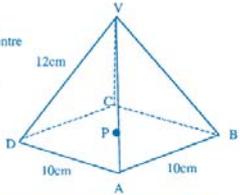
4. a) In the right triangle given below, evaluate the sin, cos, and tan of the angles A and . when given the following sides
   (i). c = 41, a = 9.
   (ii). c = 37, a = 35.
   (iii). a = 24, b = 7.
   Express the results as fractions.

   b) What are the angles A and B (in degrees) in i. ii and iii of 4a

5. a For acute angle θ, cos θ = 20/25 what is tan θ
   b For acute angle θ, sec θ = 25/24 what is cot θ
   c For acute angle θ, tan θ = 20/21 what is sin θ
   d For acute angle θ, sin θ = 15/25 what is csc θ
   e For acute angle θ, csc θ = 5/3 what is cot θ
   f for each of the above determine the angle θ in degrees

6. Find the angle between the line AG and the plane ABCD in the diagram on the right
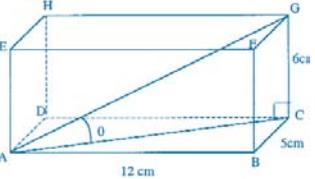
7. In the triangle below find the value of x and θ
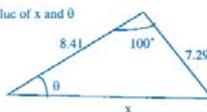
8. In the figure below find the value of x and y
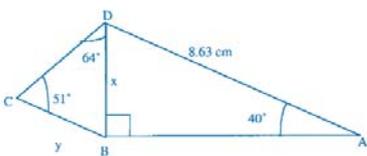
9. Calculate the Hydrogen to Hydrogen distance (a) in the water molecule below
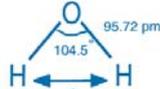
   pm = picometres

10. Calculate the O-O bond length in the ozone molecule below

   pm = picometres

Figure 1: Trigonometry Tutorial Example