Numbas and Chemistry Teaching

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E-Assessment in Mathematical Sciences

What our students expect.

What they might not expect.

(b) i) $\nu = \frac{1}{2\pi}\sqrt{\frac{k}{\mu}}$ so $(2\pi\nu)^2\mu = k$

$(2\pi \times 6.424\times10^{13})^2 \times 1.138\times10^{-26} = 1854$ $N\,m^{-1}$

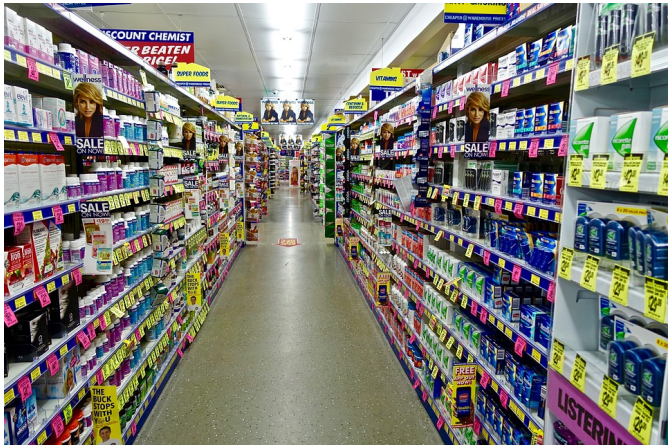
s^{-1} kg

[As an aside, because force = mass × acceleration, $F = ma$ then $1\,N = 1\,kg \times 1\,ms^{-2}$ which accounts for the units used in the equation above]

Calculating the force constant of a molecular bond from knowledge of a vibrational frequency measured by infrared spectroscopy.

Why do chemists need to teach mathematics?

Solving global problems requires knowledge of quantitative chemistry.



Good quantitative chemistry is also good economics.

"The dose makes the poison"

Teaching Chemistry at Stage 1

Challenges

- Many students arrive without A-Level Maths and lack an enthusiasm for mathematics. Contextualisation of problems is important.
- “Bimodal” population.
- Maths can be thought of as a language and must be practiced in order to learn. Attempting to “learn maths by rote” is ineffective.

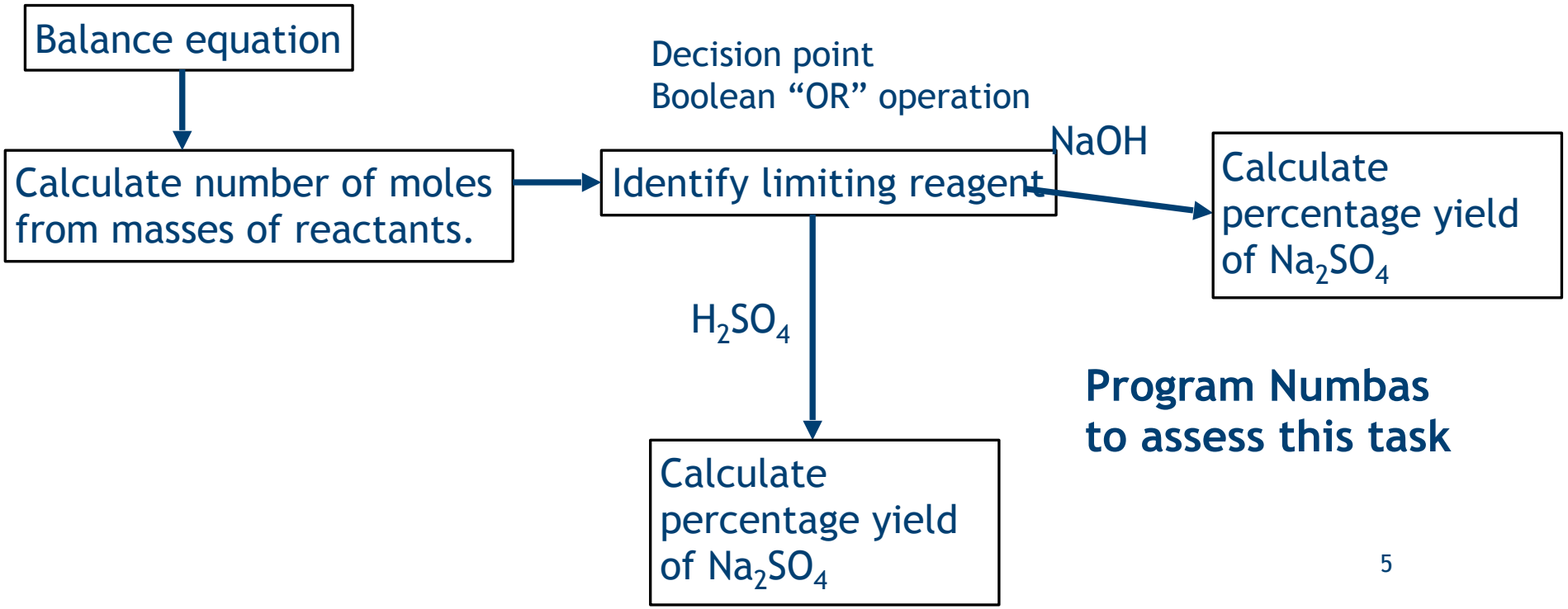
Opportunities

- **Laboratory classes** present an opportunity to;
  - Give students a reason to practice calculations *in context* of chemistry experiments.
  - Connect students with new tools (spreadsheets, software, computer programming) that assist understanding of numerical methods.
  - Generate a dialogue about the role of mathematics in chemistry.

Imagine you start an experiment with 0.151 g of H_2SO_4 and 0.15 g of NaOH. After the reaction is finished, you isolate and weigh 0.11 g of Na_2SO_4 product.

$$1\ H_2SO_4 + 2\ NaOH \longrightarrow 1\ Na_2SO_4 + 2\ H_2O$$

"Calculate the chemical yield"



Program Numbas to assess this task

Adaptive Marking in Numbas

- 70 students, each performing their own experiment to synthesise Na_2SO_4 from H_2SO_4 and NaOH.
- Each student weighs reactants used in their own experiment. Each student isolates their own chemical product, dries and weighs it.
- Each student uses *their own laboratory data* and Numbas to assist/verify/support their calculation of a chemical yield (formative assessment) OR Instructor uses Numbas to summatively assess students chemical yield calculations.
- An aim is to reduce the amount of laboratory time that instructors spend assisting students with numerical exercises when we could instead teach skills with apparatus handling.
- An aim is to increase student confidence with numerical calculations while contextualising their learning.

Laboratory Class Support by Numbas

Reaction Kinetics (chemical rates and rate constants)

Spectroscopy and photochemistry (Light/matter interactions)

Electrochemistry

Yield of chemical synthesis

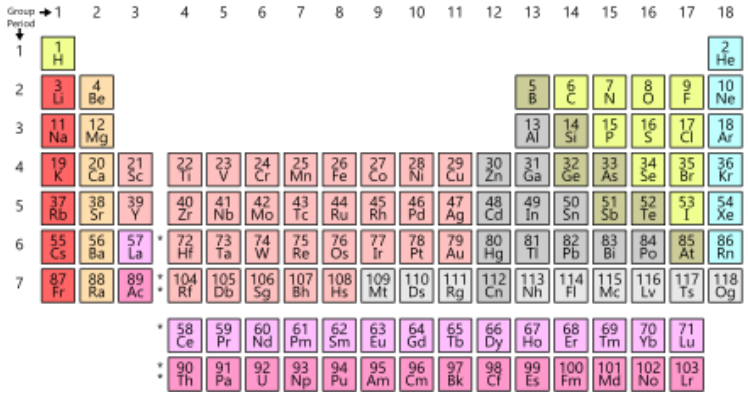
Interfacial chemistry (adsorption/ desorption from surfaces)

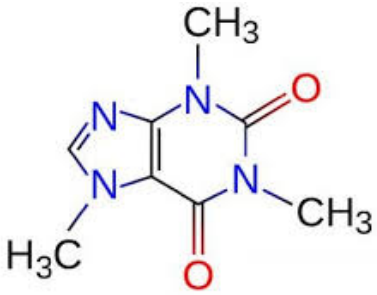
Calorimetry and thermodynamics

Numbas benefits maximised where tasks and calculations involve Boolean decision points.

Future work

Numbas lacks “chemical intuition”. It is very good at permutation of parameters but it does not know (*a priori*) which permutations are chemically reasonable. Nor does it have strategies for arriving at chemically-reasonable permutations quickly.





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