



What Makes Acids and Bases so Troublesome for Undergraduates?



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Introduction Chemistry is a subject that is comprised of many challenging concepts. These issues can render learning chemistry an arduous experience. One important topic that appears to challenge students is acidity / basicity. This poster details an investigation into difficulties are encountered by undergraduate students regarding acidity and basicity, and our initial work to address these issues, particularly through the use of concept maps.

Why Acids and Bases?

Our previous research showed that academic instructors from a wide range of higher educational institutions recognised that understanding of acidity and basicity underpins learning across all subfields of chemistry.

Common definitions of acids:

Brønsted-Lowry:
(Proton donor)



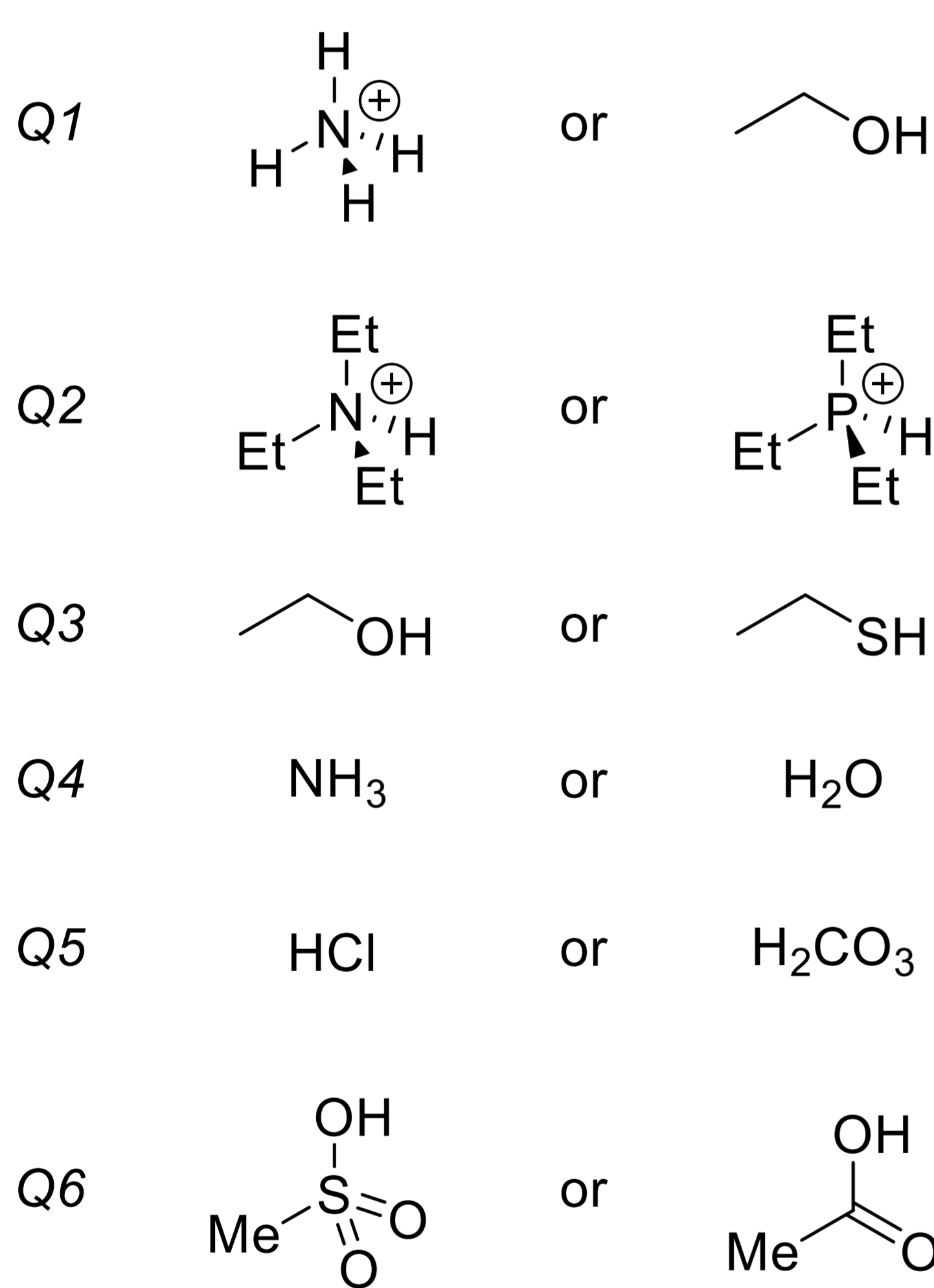
Lewis:
(Lone pair acceptor)



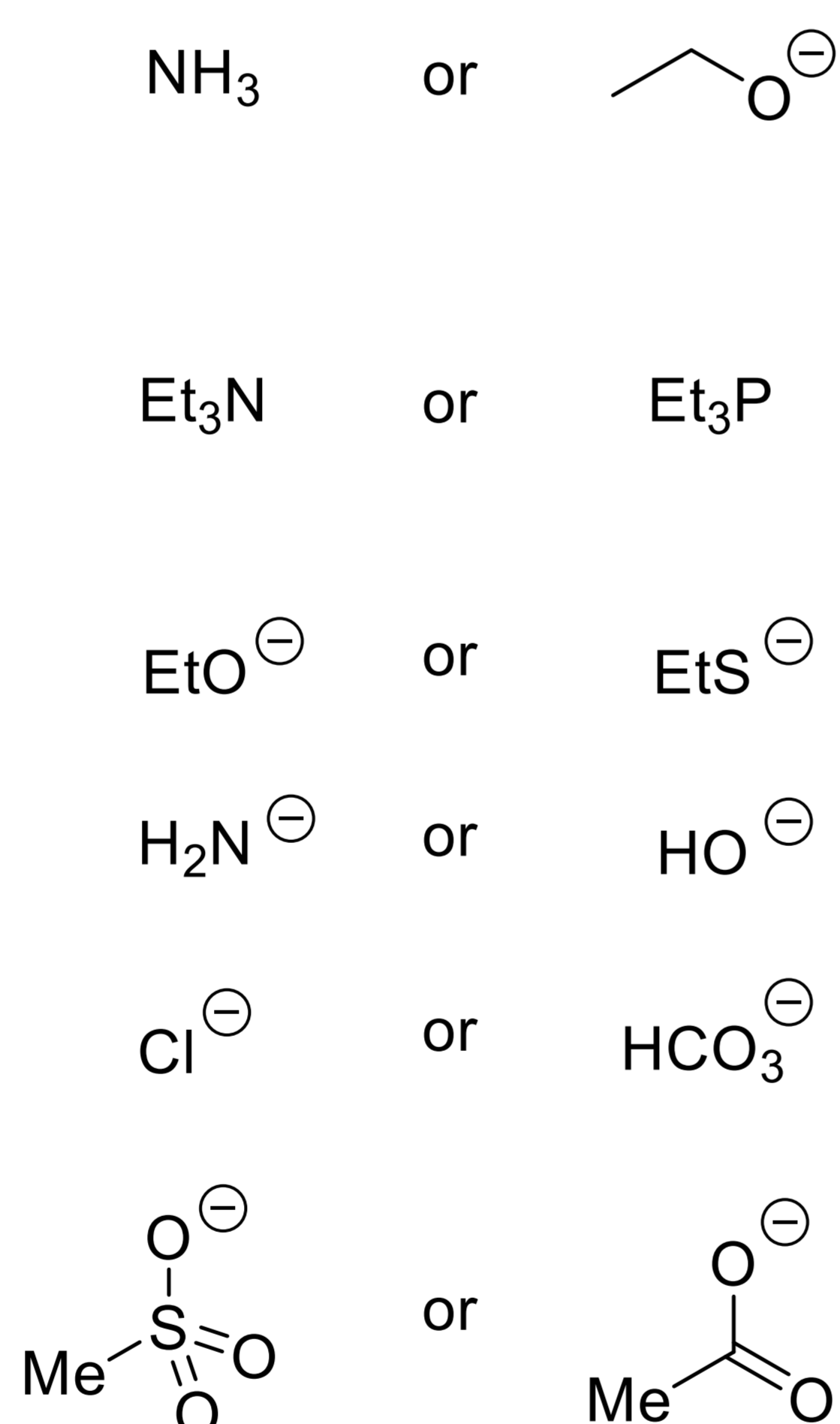
Interview/Survey Questions

- Interviewed University of Oxford first year undergraduates (21 students) and first year undergraduates from three other UK institutions (61 students total).
- Posed same questions to all students, with ~50% asked questions from an **acidity** perspective, ~50% asked from a **basicity** perspective.

Which is the stronger acid?



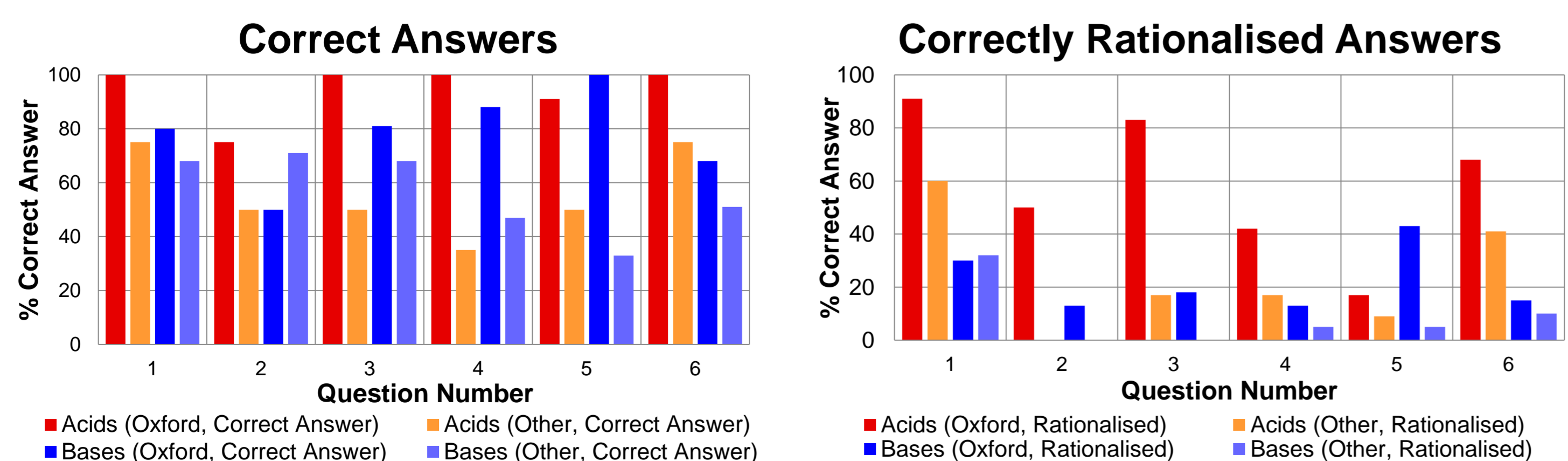
Which is the stronger base?



Also asked students:

- Name four acids / bases
- Define the term pK_a/pK_{aH} (50% asked pK_a 50% asked pK_{aH})
- Estimate the pK_a of ethanoic acid in water.
- Estimate the pK_b of ammonia in water.

Student Interview Results



- Students had significantly greater confidence and understanding with questions posed from an **acidity perspective** than with basicity.
- Students could confidently name many acids, but not more than two bases.
- Greater exposure to acids/acidity in everyday life.
- Quantitative consideration of bases also not covered in A-Level syllabus.

Troublesome Issues/Misconceptions

Students generally could not rationalise their answer, or had significant misconceptions:

- Assumed something was more basic if they had heard of it (e.g. ammonia).
- Invoked conjugate base stability when considering which was stronger acid; >90% **neglected** stability of the conjugate acid when considering basicity.
- Often neglected X-H bond strength in arguments.
- Confused kinetic reactivity vs thermodynamic stability.

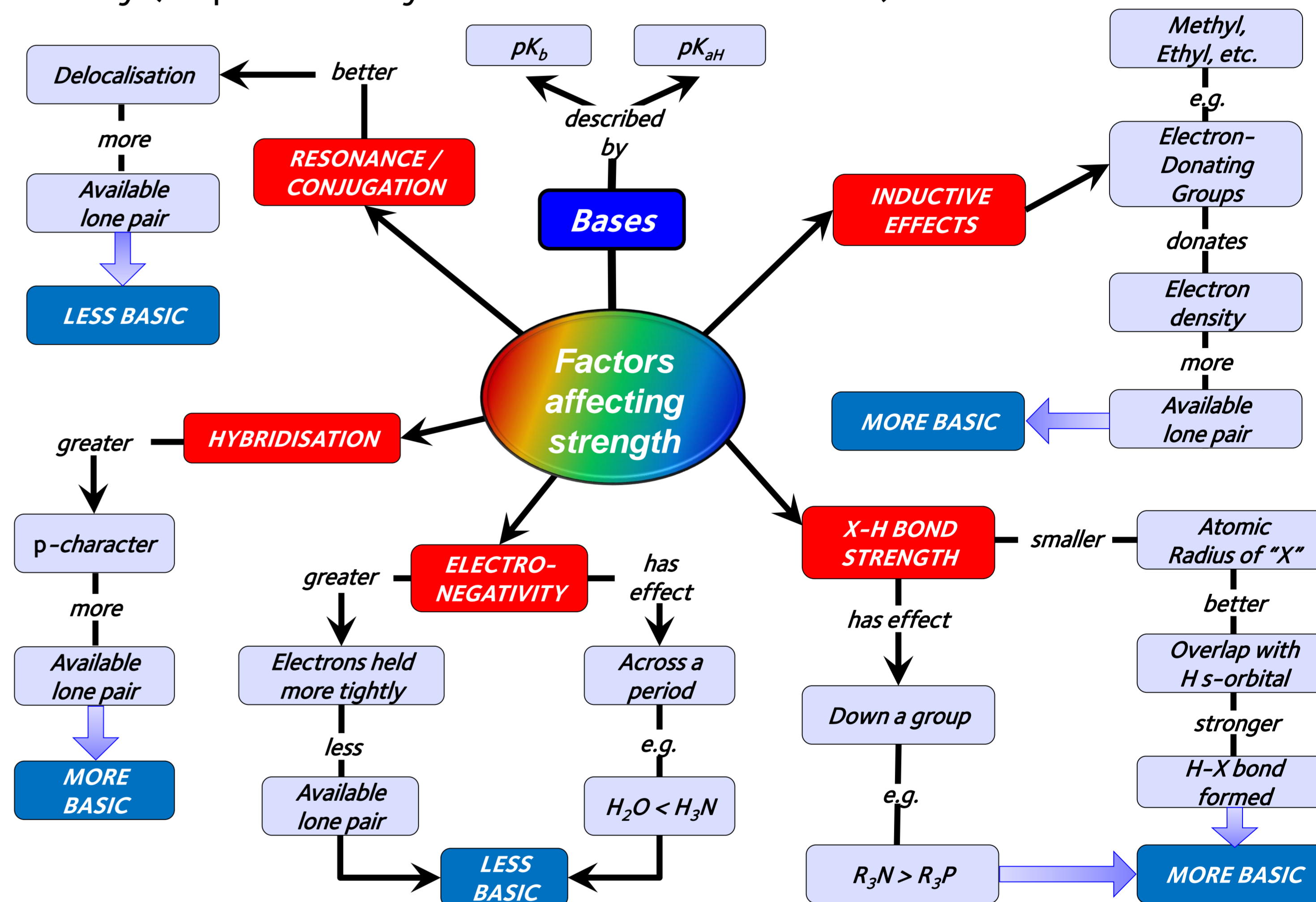
- e.g. Q2 (R₃N vs R₃P):

"Et₃P is more basic because you've got the higher energy lone pair further from the nucleus, so more electron shielding. So there's more interaction with any incoming protons."

"N is more electronegative so the N-H bond would be more polar and so Et₃N is more basic."

Concept Map

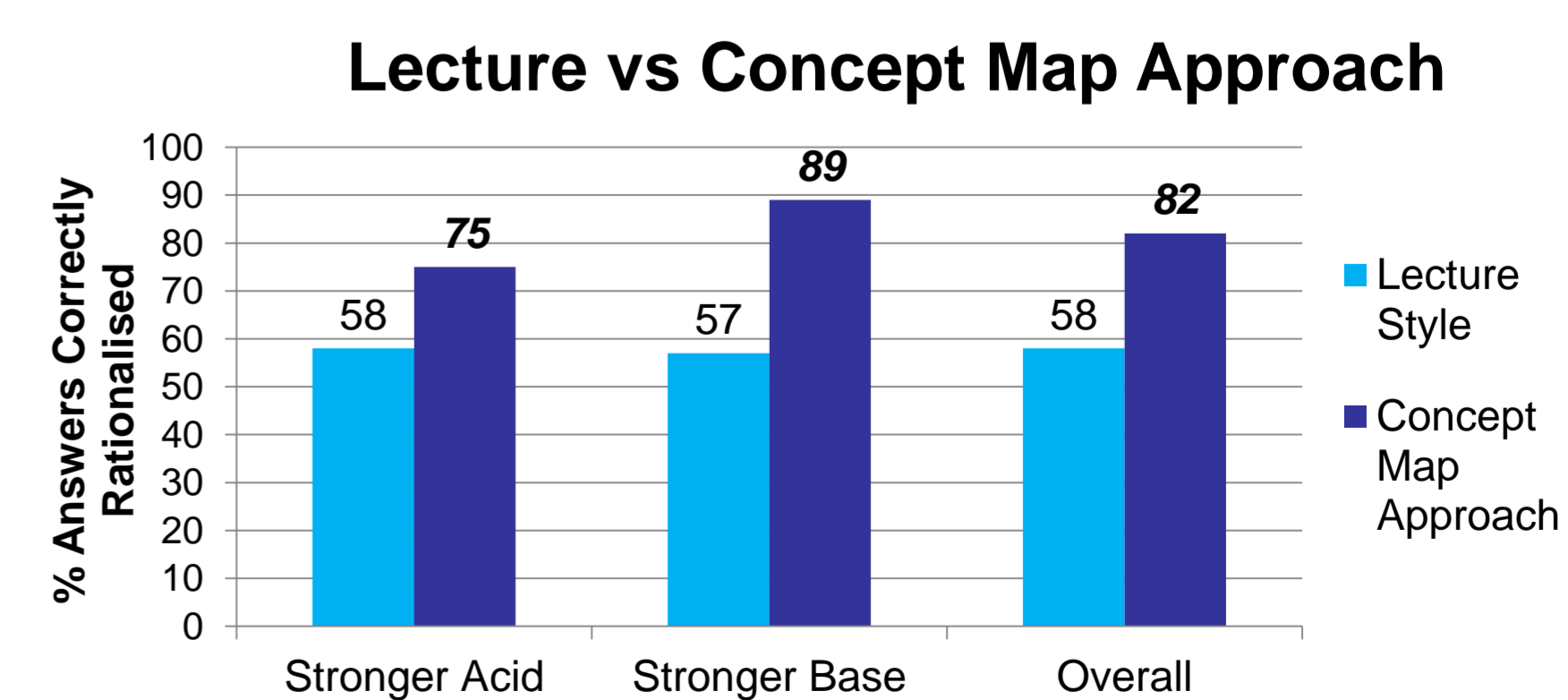
Concept maps are a meaningful tool to aid student learning (Novak & Gowin, 1984), and are a powerful resource to help identify key issues for students. We devised a general concept map for both acidity and basicity (map for basicity shown below for illustration).



Other, more advanced, concepts were not included here, including *solvent*, *sterics*, *intramolecular interactions*. These will be introduced in further work.

Teaching Using Concept Map Approach

A focus group of 8 students was split into two groups: one half were taught about acids and bases in a lecture style, and the other *via* concept maps. The latter half also designed their own concept maps in order to aid meaningful learning. Both groups then sat an identical test at the end of their respective lessons. Preliminary results suggest the concept map approach significantly improved students' rationalisation of answers.



Conclusions

Students particularly struggle with basicity. Initial results show teaching *via* a concept map approach is effective in increasing students' understanding of basicity and, crucially, factors that affect acidity and basicity.

Reference

Novak, J. D., & Gowin, D. B. (1984). *Learning How to Learn.*, Cambridge University Press.