

3. L'atomo tende a trattenere nel guscio un numero pari di elettroni, di preferenza 8, che sono disposti simmetricamente agli otto spigoli di un cubo.
4. Due gusci atomici sono mutuamente compenetrabili.
5. Gli elettroni possono passare con facilità da una posizione a un'altra nel guscio. Tuttavia, essi sono mantenuti in posizione da vincoli più o meno forti, e sia la posizione che la forza del vincolo sono determinate dalla natura dell'atomo stesso e di quelli con cui è combinato.
6. Le forze elettriche agenti tra le particelle che si trovano a distanze molto piccole non obbediscono alla semplice legge del quadrato della distanza che vale per grandi distanze.

Questi postulati vengono a costituire l'impianto teorico per una definizione del concetto di legame che è di fondamentale importanza non solo nella scuola pre-universitaria ma, in generale, per un'acquisizione corretta e significativa dello sviluppo di questo aspetto fondamentale della chimica.

#### Video



Per il video della relazione completa di Testoni, clicca il seguente link:  
<https://youtu.be/e8ow-p4xjHE>



Per il video della relazione completa di Aquilini, clicca il seguente link:  
<https://youtu.be/8nLY2PMP5po>



#### Keith S. Taber

Emeritus Professor of Science Education, University of Cambridge

✉ [kst24@cam.ac.uk](mailto:kst24@cam.ac.uk)

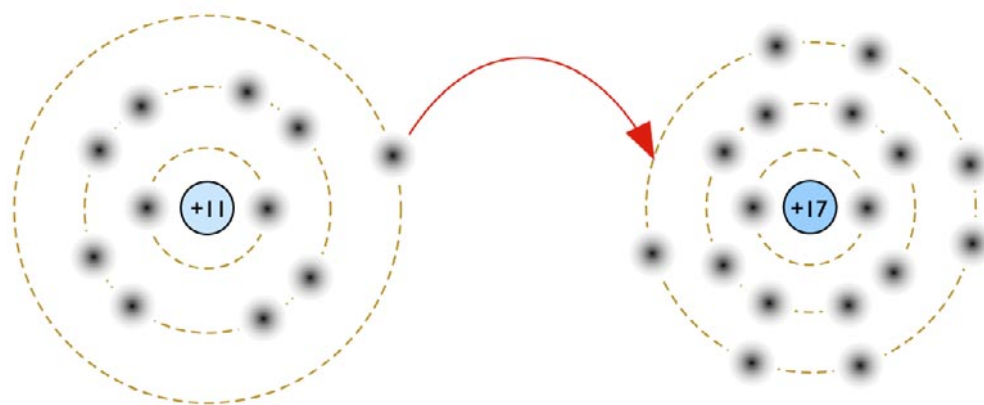
# A 'compound' of learning impediments: alternative conceptions of the chemical bond

**T**he lecture discussed student thinking about chemical bonding, and, in particular, how a range of alternative conceptions commonly exhibited by students can be understood to be linked into a general conceptual framework for understanding chemistry - a framework that is inconsistent with canonical science.

As background, the lecture briefly discussed the significance for teaching of learners' alternative ways of thinking ('misconceptions') in terms of how learning is an interpretive, incremental and iterative process [1]; and how 'teaching-learning' needs to be understood as a system where teaching is informed by assumptions about what a person already knows and understands, and how they will interpret new subject content. Such a system is susceptible to system 'bugs' or learning impediments. A particular challenge in chemistry teaching concerns what is sometimes known as the chemist's triplet: how phe-

nomena observed at the bench are both (i) redescribed in a theoretical conceptual language; and (ii) explained in terms of unseen, conjectured entities ('quantiles') at a submicroscopic scale; and (iii) represented in a specialised symbolic language, part of which is shared by (and so can bridge) the macroscopic and quantile level descriptions [2]. Chemical bonding is commonly discussed as if a property of actual substances, but strictly belongs to the quantile level descriptions.

A common way of thinking about ionic bonding was described, and it was explained how this amounts to a conceptual framework (a 'molecular' framework) based on several common alternative conceptions that collectively offer a coherent account, albeit one at odds with curriculum science. This was linked to a ubiquitous type of image (see Figure 1), often seen on websites and in textbooks, which inappropriately associates ionic bonding (for example,

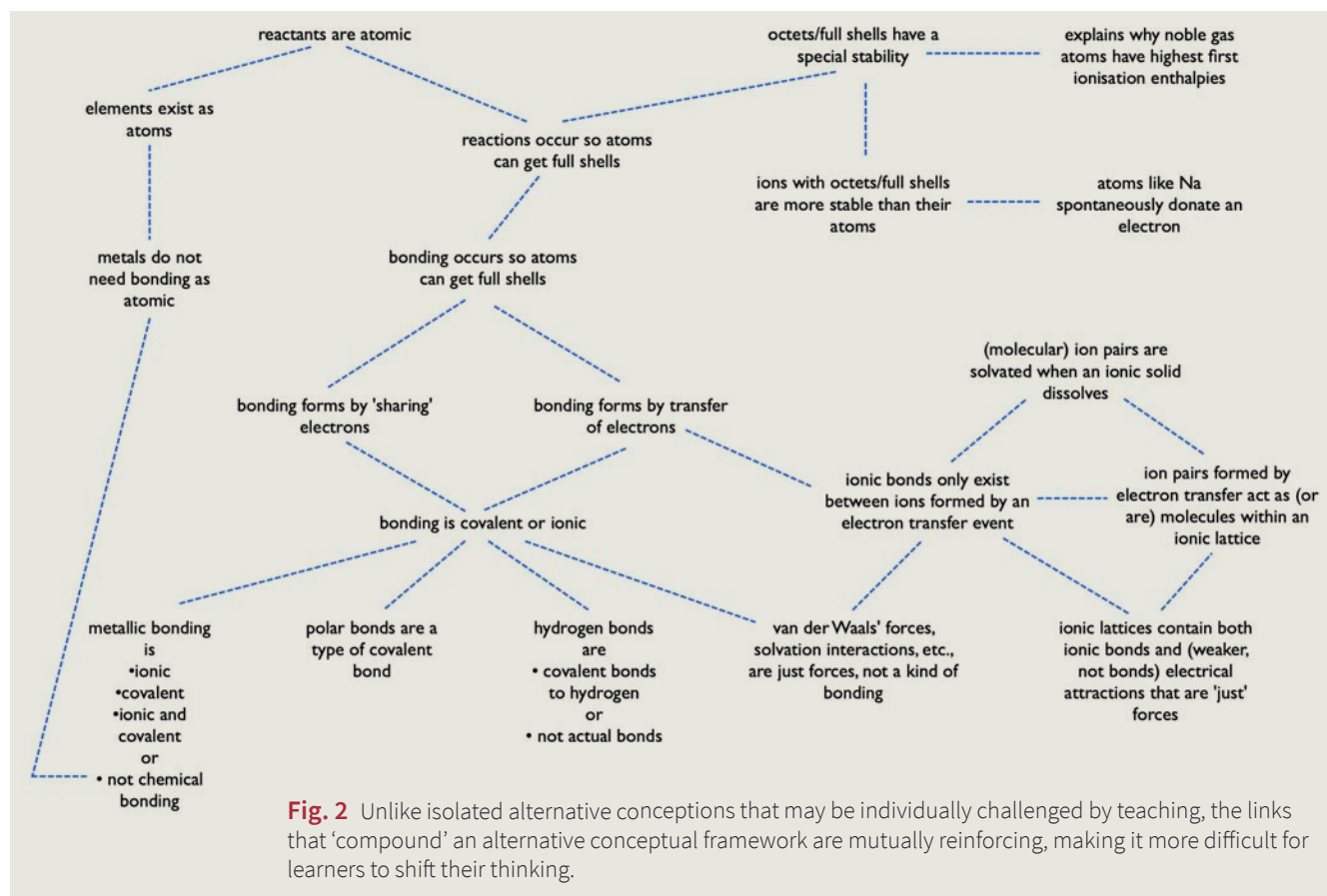


**Fig. 1** A common type of representation of ionic bond formation that is based on an assumption of sodium and chlorine existing as discrete atoms that somehow seek to obtain octets/full outer shells of electrons despite the process illustrated being energetically non-viable.

in NaCl) with an unlikely and energetically non-viable electron transfer event involving isolated atoms of sodium and chlorine.

This example reflects two misleading principles that students very commonly adopt in chemistry. One of these is *the assumption of initial atomicity*, which involves thinking about chemical reactions as starting with atoms - despite very few substances being atomic under common conditions, and those that are (e.g., He, Ne, Ar) tending to be largely chemically inert. The other tenet is *the full outer shell explanatory principle* which explains chemistry in teleological terms, seeing the purpose of chemical processes as

to allow atoms to obtain full outer shells or octets of electrons. Students readily adopt this principle even though most reactions they learn about in introductory chemistry have reactants in forms already having these 'desirable' configurations. Yet this is not obvious to students if they imagine reactants in the form of discrete atoms rather than molecules, ions, or metallic lattices. This is often an anthropomorphic form of explanation: that reactions happen because atoms 'want' or 'need' to donate, share, or accept, electrons to obtain octets or full outer shells. Indeed, these alternative conceptions tend to form an extensive conceptual framework [3] - that is, a



**Fig. 2** Unlike isolated alternative conceptions that may be individually challenged by teaching, the links that 'compound' an alternative conceptual framework are mutually reinforcing, making it more difficult for learners to shift their thinking.

‘compound’ of *connected* (‘bonded’) alternative conceptions, rather than just an assortment of discrete ideas - that is applied widely (see Figure 2). It leads to seeing ionic and covalent bonding as a dichotomy that makes learning about bond polarity difficult, and which may suggest that hydrogen bonding is covalent, and that metallic bonding, solvation forces, and intermolecular interactions, must be something other than chemical bonding.

This ‘octet’ conceptual framework (which subsumes the molecular framework for ionic bonding) leads to students making incorrect, and sometimes extreme, predictions of ionic stability (so  $\text{Na}^+$  is often considered chemically stable as it has an outer shell octet - despite being a highly charged metallic cation). It is also applied in explaining patterns in ionisation enthalpies: so, for example, explaining that Ne and Ar have the highest ionisation energies in their periods because of some mystical special stability of their octet structures (despite these elements fitting with the general ‘trends’ of increasing first ionisation energy with increasing core charge).

Being a ‘compound’ of linked and mutually reinforcing conceptions [4], these alternative ideas are especially insidious, and so are often retained despite teaching.

### References

- [1] K. S. Taber, *Student Thinking and Learning in Science: Perspectives on the nature and development of learners’ ideas*, Routledge, New York, 2014.
- [2] K. S. Taber, *Chemistry Education Research and Practice*, 2013, **14**(2), 156-168; doi:10.1039/C3RP00012E
- [3] K. S. Taber, *International Journal of Science Education*, 1998, **20**(5), 597-608.
- [4] K. S. Taber, in *Concepts of Matter in Science Education* (Eds. G. Tsaparlis, H. Sevian), pp. 391-418, Springer, Dordrecht, 2013.

### Video



Per il video della relazione completa, clicca il seguente link: <https://science-education-research.com/publications/miscellaneous/alternative-conceptions-of-the-chemical-bond>



### Donato Monti

Dipartimento di Chimica – Università degli Studi La Sapienza di Roma

✉ donato.monti@uniroma1.it

# L’acqua: una molecola, due legami, tre atomi. Quattro modi per descriverla

**L**a molecola dell’acqua è essenziale per la vita sul nostro pianeta, almeno per come la conosciamo. Per questo nella mia lezione ho voluto prendere spunto da questa molecola per ripercorrere brevemente l’approccio che generalmente segue per introdurre i concetti di legame covalente e struttura molecolare nelle mie lezioni di Chimica Generale per gli studenti del primo anno del Corso di Laurea in Chimica. I testi di riferimento di livello universitario trattano gli argomenti presentati in maniera sostanzialmente equivalente, anche se con accenti diversi [1].

Per la determinazione della struttura molecolare utilizzo a livelli successivi di complessità di descrizione del legame chimico: 1) formule (o strutture) di Lewis,

ovvero del legame formato per condivisione di una coppia di elettroni; 2) teoria di Gillespie (VSEPR), basata sulla minima energia di repulsione delle coppie elettroniche esistenti sulla molecola in seguito alla formazione dei legami; 3) ibridazione (teoria del legame di valenza, L. Pauling); 4) teoria degli orbitali molecolari (MO). Vedremo che i primi due modelli, sebbene offrano un utilissimo strumento per la determinazione della struttura generale (numero dei legami e loro disposizione spaziale tridimensionale), si fermano ad un piano di descrizione puramente qualitativo, senza fornire previsioni relative a distanze ed energie di legame, fattori chiave per l’interpre-