How to discover a new element

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(PhysOrg.com) -- It is not the same as it used to be, the element finding business. We have discovered and named all the elements from hydrogen (element 1) up to element 112 (copernicium)[1], and last week IUPAC (International Union of Pure and Applied Chemistry - it does to elements what the International Astronomical Union did to Pluto), the world governing body for chemistry, has announced the confirmation of a couple more. After bismuth (element 83) the elements are no longer regarded as 'stable' and so the atoms tend not to hang around. Admittedly the definition of stable means that the half-life (the time it takes for half a sample to disappear by radioactive decay) must be more than 10 billion years, so we can still find elements like uranium (element 92) on the Earth.

Back to the heyday of element hunting. Sir Humphry Davy's greatest discovery might have been Michael Faraday, but he also is credited with the discovery or isolation of sodium, potassium, calcium, magnesium, strontium, boron and barium. He also proved that 'Substance X' was an indivisible element, which he named iodine, in a bizarre episode during the Napoleonic wars between France and England. French chemists had made violet flakes of a new and unknown substance from burning seaweed, but could not decide if it was a new element or some mixture or compound. Humphry Davy[2] was the most famous chemist in the world and was offered the Napoleonic Gold medal for his contributions to knowledge. He was to receive it on November 2nd 1813 in Paris. Despite being on the wrong side in the middle of a fierce war, Davy and his young assistant Faraday were given passports to travel to France to collect the medal and help with understanding the chemical properties of 'Substance X'. Superstars trashing hotel rooms are not confined to modern rock bands – scientists have been there and done that. Davy and Faraday set up a lab in their Parisian hotel room and proceeded to conduct experiments, several resulting in explosions and clouds of noxious gases. Faraday writes in his Continental journal[3] on 1st December "when a solution of ammonia is poured on the new substance and left in contact with it for a short time a black powder is formed which when separated, dried and heated, detonates with great force." “Great force” usually meant the disintegration of the glassware, nearby furniture and occasionally bits of the experimenters. By December 11th Davy was satisfied that 'Substance X' was a new element, similar in chemical properties to chlorine, and he gave it the name iodine.

If there are any aspiring Davy's out there I must warn you that element hunting no longer can be done while on holiday in an hotel room. The latest additions to the world of elements are numbers 114 and 116, and the evidence that they have been made comes from measurements in seriously big atom colliders in Russia and America. No violet flakes, but traces on outputs of instruments designed to catch these fleeting particles

as they combine and decay. The committee charged with deciding on the existence of an element is just like a jury in a court case. Their criterion is “Discovery of a chemical element is the experimental demonstration, beyond reasonable doubt, of the existence of a nuclide...”, and they explain that ‘beyond reasonable doubt’ means “…no new element should be recognized officially until the data upon which the claim is based have been reproduced, preferably in another laboratory and preferably by a different technique.” The last-named element copernicium (112)[4] had to wait from 1975, when it was first hypothesised to exist, through experimental reports in 1996, 2002 and 2007, to 2009 when it was finally recognised. The claims and counter claims for the discovery of this element came thick and fast, with the German group of Sigurd Hofmann winning out over the Jerusalem-based Amnon Marinov. The committee commented on the Marinov claim that they were using “atypical studies” the results of which “remain unconvincing”. Marinov wrote a spirited response which appears to have not been published by IUPAC.

Elements 114 and 116 have had a smoother ride, with no-one complaining about the assignment to the “Dubna-Livermore” collaboration. The committee also looked at other potential candidates for element status; experiments that thump atoms together tend to make showers of products that when sifted through might yield more than one new atom. Alas, would-be elements 113, 115 and 118 did not satisfy the jury and their claims for albeit a brief existence must wait. “So what are these elements like?” you ask. What colour are they? Sorry – no one has actually seen any of these substances but it is possible to infer some of their chemistry. We do not make much of them and they do not survive long; copernicium isotopes last somewhere between a fraction of a second to a one or two minutes. The newest elements all fall apart in a second or less.

So what will the new elements be called? This is up to the discoverers to

suggest names and symbols, and IUPAC to ratify. Perhaps the Russians will name one of them and the Americans the other. Recent elements have been named after people (copernicium, roentgenium, meitnerium, bohrium, seagborgium) or places (darmstatium, hassium, dubnium), although not after considerable argument. From the 1960's until final resolution at the IUPAC General Assembly in 1997 elements 104 – 109 were given proposed names, named and renamed by groups in the USA, Russia and Germany in a stoush called the "Transfermium wars" (elements after fermium, element 100).

IUPAC is now established as the final arbiter. Australia has four votes in the General Assembly and has provided the present General Secretary of IUPAC (Professor David Black of UNSW). Brynn Hibbert is one of our representatives and has been a member of the Analytical Division when the past three elements (darmstatium, roentgenium and copernicium) have been ratified by the Union. He looks forward to voting for names of elements 114 and 116 and beyond.

More information:

[1] what makes an element is the number of protons in the nucleus. This is known as the atomic number. Hydrogen is 1, carbon 6, uranium 92, and so on. The mass number of a particular isotope is the sum of the number of protons and neutrons. Often isotopes have around the same number of each, so the most common carbon isotope is carbon-12, with 6 protons (which make it carbon) and 6 neutrons. Cabon-13 and carbon-14, with seven and eight neutrons also exist.

[2] A splendid Clerihew has been penned about him:
Humphry Davy hated gravy,
He died in the odium,
Of discovering sodium

[3] from James Hamilton, “Faraday: the life”, Harper Collins, London, 2003.

[4] www.iupac.org/publications/pac … 09/pdf/8107x1331.pdf , www.cas.org/newsevents/connections/element112.html

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