

Discovery and Assignment of Elements with Atomic Numbers 113, 115, 117 and 118

On 30 December 2015, IUPAC announced the verification of the discoveries of four new chemical elements; the 7th period of the periodic table of elements is complete.

The fourth IUPAC/IUPAP Joint Working Party (JWP) on the priority of claims to the discovery of new elements has reviewed the relevant literature for elements 113, 115, 117, and 118 and has determined that the claims for discovery of these elements have been fulfilled in accordance with the criteria for the discovery of elements of the 1991 IUPAC/IUPAP Transferrmium Working Group (TWG). These elements complete the 7th row of the periodic table of the elements, and the discoverers from Japan, Russia, and the USA have recently been invited to suggest permanent names and symbols.

The new elements and assigned priorities of discovery are as follows:

Element 113

(temporary working name and symbol: ununtrium, Uut) The RIKEN collaboration team in Japan have fulfilled the criteria for element $Z=113$ and have been invited to propose a permanent name and symbol.

Elements 115, 117, and 118

(temporary working names and symbols: ununpentium, Uup; ununseptium, Uus; and ununoctium, Uuo)

The collaboration between the Joint Institute for Nuclear Research in Dubna, Russia; Lawrence Livermore National Laboratory, California, USA; and Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA has fulfilled the criteria for elements $Z=115$ and $Z=117$ and has been invited to propose permanent names and symbols.

The collaboration between the Joint Institute for Nuclear Research in Dubna, Russia and Lawrence Livermore National Laboratory, California, USA have fulfilled the criteria for element $Z=118$ and has been invited to propose a permanent name and symbol.

The priorities for four new chemical elements are being introduced simultaneously, after the careful verification of the discoveries and priorities. The decisions are detailed in two reports by the Joint Working Party (JWP), which includes experts drawn from IUPAC and IUPAP (the International Union of Pure and Applied

Zn zinc 65.38(2)	Ga gallium 69.72	Ge germanium 72.63	As arsenic 74.92	Se selenium 78.97	Br bromine (79.90, 79.91)	Kr krypton 83.80
48	49	50	51	52	53	54
Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3
80	81	82	83	84	85	86
Hg mercury 200.6	Tl thallium 204.4	Pb lead 207.2	Bi bismuth 208.9804	Po polonium	At astatine	Rn radon
112	113 Uut ununtrium	114 Fl flerovium	115 Uup ununpentium	116 Lv livermorium	117 Uus ununseptium	118 Uuo ununoctium
Cn copernicium						

65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.0	71 Lu lutetium 175.0
97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

Physics). These reports have recently been published in the January issue of the IUPAC journal *Pure and Applied Chemistry (PAC)*.* The JWP has reviewed the relevant literature pertaining to several claims of these new elements. The JWP has determined that the RIKEN collaboration have fulfilled the criteria for the discovery of element with atomic numbers $Z=113$. Several studies published from 2004 to 2012 have been confirmed as sufficient to ratify the discovery and priority.

In the same *PAC* report, the JWP also concluded that the collaborative work between scientists from the Joint Institute for Nuclear Research in Dubna, Russia; the Lawrence Livermore National Laboratory, California, USA; and the Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA (the Dubna-Livermore-Oak Ridge collaborations), starting in 2010 and subsequently confirmed in 2012 and 2013, have met the criteria for discovery of the elements with atomic numbers $Z=115$ and $Z=117$.

Finally, in a separate *PAC* article the Dubna-Livermore collaboration started in 2006 is reported as having satisfied the criteria for discovery of element $Z=118$.

"A particular difficulty in establishing these new elements is that they decay into hitherto unknown isotopes of slightly lighter elements that also need to be unequivocally identified" commented JWP chair Professor Paul J. Karol, "but in the future we hope to improve methods that can directly measure the atomic number, Z ."

"The chemistry community is eager to see its most cherished table finally being completed down to the seventh row. IUPAC has now initiated the process of formalizing names and symbols for these elements temporarily named as ununtrium, (Uut or element 113), ununpentium (Uup, element 115), ununseptium (Uus, element 117), and ununoctium (Uuo, element 118),"