The Chemistry Department ran four comparisons in 2017, involving ninety three participations in these studies by NMIs. Seven comparison reports were published as well as five papers in peer reviewed journals. A total of twenty visiting scientists from NMIs (on secondment to the BIPM from between three to eighteen months) participated in the Chemistry Department Programme in 2017, of which twelve undertook Capacity Building and Knowledge Transfer (CBKT) programme secondments either in “Metrology for Clean Air” or “Safe Food and Feed” projects, spending between 3 months and 1 year at the BIPM.

Small organic primary calibrator comparison programme
The final report of the CCQM-K55.d comparison on folic acid purity was approved by the CCQM Working Group on Organic Analysis (OAWG). Measurements for the CCQM-K78.a comparison on multi-component amino acid calibration solutions were completed, and the results presented to the working group, with the Draft A report in preparation. The BIPM submitted results to the CCQM-P150.b comparison on qNMR, as well as completing characterization of samples and their homogeneity and stability for the CCQM-K148.a comparison (bisphenol A calibrator purity).

First Internal Standard Reference Document for qNMR published
The first reference data document on ‘Internal Standards for qNMR’ was completed for maleic acid, and has been published on the BIPM website[9]. This was an output of the universal calibrator programme for qNMR at the BIPM; an activity initiated together with the NMIJ (Japan), and supported in 2017 by secondees from the NMIJ, and INMETRO (Brazil), with characterization of the performance of four standards in three different solvents undertaken in 2017.

Comparability of primary standards for peptide and protein analysis
The final reports of the key comparison and associated pilot study on C-peptide purity (CCQM-K115/P55.2) were published in Metrologia and the BIPM KCDB. A paper on the evolving calibration hierarchies for C-peptide measurements was published in Clinical Chemistry[10]. Preparative work for the next comparison of peptide calibrant value assignment facilities, focusing on oxytocin (CCQM-K155.b) in collaboration with NIM (China) has continued with the secondment of a visiting scientist from NIM. Methods for pure peptide characterization to be used in future comparisons have been studied during secondments by visiting scientists from the LGC (UK), studying BNP calibrators, and from the NIBSC (UK) studying short-peptide tryptic digest calibrators. The methods used to characterize pure peptide calibrators were published in Analytical and Bioanalytical Chemistry[11], Journal of Chemical Metrology[12] and Trends in Analytical Chemistry[13].

Metrology for “Safe Food and Feed” Knowledge Transfer secondments at the BIPM

The BIPM Chemistry Department hosted five secondees during 2017 who took part in a series of three-month-long “Knowledge Transfer” secondments for scientists from NMIs wishing to develop mycotoxin metrology capabilities. The secondees from INMETRO, INTI (Argentina), KEBS (Kenya), NIMT (Thailand) and NMISA (South Africa) received training on the production of mycotoxin calibration solutions, characterization and value assignment. The training programme was performed on the mycotoxin zearalenone (ZEN). Pure materials for aflatoxin B1 and have also been characterized, and are available for future training programmes and comparisons. The secondments were part of the Mycotoxin Metrology CBKT project. The PTB (Germany) provided financial support for the secondments from INTI, INMETRO, KEBS and NIMT.

The laboratory programme on Mycotoxin Standards was supported by three visiting scientist from the NIM (for related structure impurity analysis and calibration solution characterization) and from UME (Turkey) and INMETRO in the area of qNMR analysis of pure mycotoxin materials.
Air quality measurement standard comparisons

The BIPM continued to contribute to the CCQM GAWG Ozone Cross Section Task Group, organizing the review of input data by the group and drafting of the first version of the paper summarizing the recommended best value and uncertainty for the ozone cross-section to be used in the key comparison BIPM.QM-K1. Six NMIs: VSL (the Netherlands), NPL, ISCII (Spain), INE (Mexico), NIST and CHMI (Czech Republic) sent their ozone standards to the BIPM and participated in BIPM.QM-K1, with four reports of the comparison published in *Metrologia* and the BIPM KCDB. Collaboration with the NIST on the upgrade of the electronic module for the ozone SRP continued, with a prototype electronics module successfully constructed and tested at the BIPM, and the components and design for the final version agreed. The final report of the CCQM-K90 comparison on formaldehyde in nitrogen standards at 2 µmol/mol was completed and published in *Metrologia* and the BIPM KCDB. Measurements on 24 standards from NMIs submitted to the BIPM as part of CCQM-K137 (NO in N₂ at 30 µmol/mol and 70 µmol/mol) were completed, with standards returned to participating NMIs for stability assessment. The protocols for the comparison of NO₂ in N₂ standards at 10 µmol/mol (CCQM-K74.2018) and the pilot study of HNO₃ measurements in such standards (CCQM-P172) were agreed with the CCQM Working Group on Gas Analysis (GAWG), with 14 NMIs electing to participate in the comparisons.

Greenhouse gas standard comparisons

Measurements on 46 standards of CO₂ in air submitted for the CCQM K120 comparison were completed at the BIPM, including Fourier transform infrared spectroscopy (FTIR), isotope ratio infrared spectrometer (IRIS) and gas chromatography with a flame ionization detector (GC FID) methods for mole fraction and isotope ratio value assignment. The Draft A report of the comparison has been prepared. The method developed for measuring isotopic abundances in CO₂ with optically-based instruments was published in *Analytical Chemistry* [14], and presented to the WMO-IAEA GGMT experts meeting in Switzerland in September 2017. This demonstrated the measurement standards and methods that could be used for such instruments in the future. Development and validation of a manometric system for CO₂ measurements, in support of a future planned ongoing comparison of CO₂ standards (BIPM.QM-K2), has progressed with a second secondment from the NIST. The first all-glass prototype was replaced with a coated stainless steel version, with much improved mechanical stability. The measurement protocol was optimized, including the identification and elimination of biases caused by trace gases within the system: new results are expected in early 2018. Preparation for a comparison on CO₂ isotope ratio standards, coordinated jointly by the BIPM and the IAEA continued, with an IRIS system for isotope ratio measurements integrated into the SIRM-GEN facility and the first blending experiments for CO₂ gases have been carried out. Validation work on optical tuneable diode laser spectroscopy (TDLS) and gas chromatography with electron capture detection (GC-ECD) systems, in preparation for CCQM-K68.2019 (N₂O in air, ambient level), were undertaken during a three month secondment by a visiting scientist from KRISS, with linearity and measurement uncertainty of the optical instrument being verified.

Metrology for Clean Air CBKT project

Three visiting scientists have now taken part in the Metrology for Clean Air Course on FTIR Measurements on Gas Standards (NO₂, HCHO, HNO₃, CO₂) in the BIPM laboratories. They were trained on the use of B-FOS software for use with Fourier Transform Infrared spectroscopy (FTIR) in gas metrology applications, with the software being made available for use within the participating NMIs.

The National Physical Laboratory (NPL), UK, has provided additional sponsorship for the programme, enabling three visiting scientists to undertake six-month knowledge transfer secondments at the BIPM during 2017-2019 as well as providing sets of primary reference gas mixtures for each institute involved in the programme.

The project is designed to allow NMIs to strengthen their gas standard capabilities and further develop their national metrology infrastructure in support of their air quality and emissions measurement communities. Within the project the BIPM provides knowledge transfer on the establishment and operation of FTIR capabilities for the value assignment and comparison of gas standards for air quality and emissions monitoring.

Edgar Flores (BIPM), R.S. Radha (NPLI) and Michael Ward (NPL) setting up the FTIR for accurate measurements of NOx gases