Chemistry

Background: the main purpose of this document is to assist reviewers and NWO panel members, who are not chemists themselves, to assess the quality of research proposals and CVs within chemistry. The document lists a number of characteristics of chemistry as a scientific discipline, including its publication culture.

In chemistry the properties, behaviour and transformation of matter are studied. The elements that make up matter are atoms, molecules and ions. Chemistry studies their composition, structure, properties, behaviour and the changes they undergo during a reaction with other substances. Also the nature of the chemical bonds within and between chemical compounds is addressed.

- Chemistry is also called the central science, because it forms the connection between physics and biology/life sciences. This also becomes evident in the various chemical sub-disciplines, which typically are classified by the type of molecules or materials that are synthesized and studied, such as carbon-based compounds (organic chemistry), compounds without carbon (inorganic chemistry), systems involving very large molecules or collections of molecules (polymer and supramolecular chemistry), the molecular basis of life (biochemistry), materials in the solid-state (materials or solid-state chemistry) or compounds that accelerate chemical reactions (catalysis). Due to its abundance of connections with other fields, many sub-disciplines also sit at the interface with other scientific specialties, most notably, physical chemistry, chemical biology, analytical chemistry, astrochemistry, electrochemistry, environmental chemistry, medicinal chemistry, colloid and interface science, food chemistry, chemical engineering, geochemistry and structural biology. In theoretical/computational chemistry a first principles approach is taken. Due to this wide variation in the discipline, there is also a broad diversity of working, publication, and recognition cultures.
- That chemistry is a central science also becomes apparent when the length scales at which chemistry operates are considered: from (sub)nanometer to meter, and from atoms or single molecules to industrial scale. The topics chemists work on vary from fundamental to highly applied. Chemistry is essential to achieve many of the sustainability goals, e.g., clean water, affordable clean energy, sustainable consumption and production patterns, good health and well-being, and industry, innovation and infrastructure.
- Chemical research requires research infrastructure and supporting personnel, which is dependent on the sub-discipline. Experimental chemists make use of laboratories, where compounds and samples are synthesized and/or prepared, and subsequently characterized. These labs need to fulfill certain safety requirements, e.g., when volatile solvents are used fume hoods are required, for biohazard samples laminar flow cabinets are used. Preparation/synthesis of compounds requires i) chemicals, varying from inexpensive solvents to very expensive specialty chemicals, ii) custom glassware and iii) consumables, that can only be used for a certain amount of time, like gloves, syringes and pipette tips. The characterization of compounds requires technical instrumentation, which vary from simple and inexpensive to sophisticated and expensive. Many chemistry groups/departments have their own instrumentation, which requires maintenance to keep it working and up-to-date. Technicians are responsible for the group/departmental research infrastructure, both the labs and the instrumentation. In some cases, research technicians work on a dedicated project. For some research instrumentation such as electron microscopes, mass spectrometers and cleanroom facilities, operation by trained technicians is required and user-fees are often requested. Theoretical chemists often use department-owned Beowulf clusters, which are small parallel supercomputers. In addition, chemists make use of large-scale infrastructure like neutron and x-ray beamlines, and the national super computer, in which chemists have the proportionally largest share in allotted time. To obtain access to these facilities, researchers have to apply for time, and successful applications can be seen as a type of research funding. Also, large scale equipment on pilot scale is being used for scale-up development activities to simulate production scale.
- Many chemists are members of scientific societies, which award prizes that are regarded as being prestigious. The KNCV is the chemical professional organization in the Netherlands. NextGenChem provides a platform to PIs in the first five years of their faculty position at a Dutch institution. The most important international scientific societies are the American Chemical Society (ACS), the Royal Society of Chemistry (RSC) and the Gesellschaft Deutscher Chemiker (GDCh).

- In terms of output, the most important items for academic chemistry are journal publications, invited talks and patents. The importance of contributions to a journal publication is reflected by author order in an 'inside to out' ranking where first and last authorships are the most important, next to the corresponding author, who commonly is the principal investigator. Shared first authorship and shared corresponding authorship are not uncommon. Both the ACS and RSC are also publishing companies, which are very important and highly regarded in the field. The key journals, also from other publishers (Elsevier, Wiley, CellPress, EMBO, Springer Nature and Science) vary widely by sub-discipline, and it is not uncommon to publish articles in interdisciplinary journals. Online publication of article preprints on websites (e.g. ChemRxiv) is growing, but is not common practice yet.
- Considering the breadth of the chemistry field and connected diversity of cultures, it is impossible to provide typical numbers for sizes of groups and collaborations, project time scales, number of co-authors per paper, and number of publications and citations per researcher. The quantities may vary considerably among sub-disciplines. It is also difficult to judge researcher independency based on these numbers only.