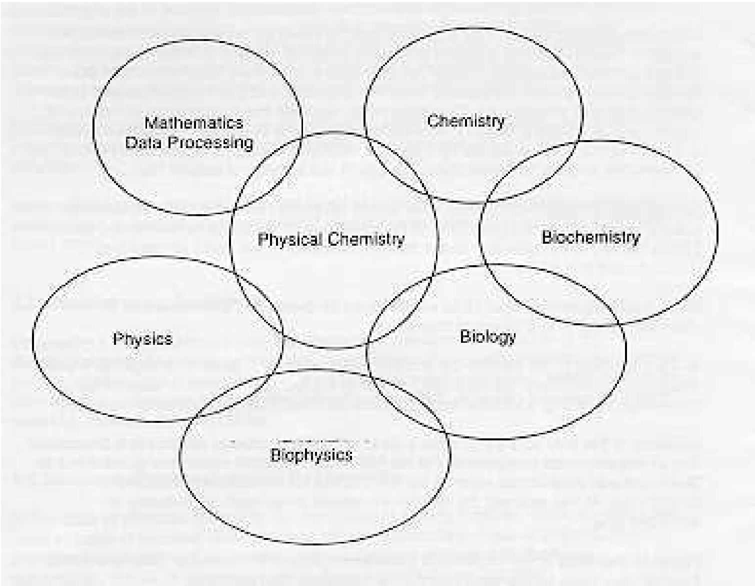
Факултет за физичку хемију усклађује своје наставне програме са захтевима европске праксе. То показује одлична сагласност сврхе и циљева програма основних и виших нивоа студија са захтевима које је пред образовне институције поставио форум од 4 национална удружења физикохемичара развијених западноевропских земаља (Deutsche Bunsen-Gesellschaft für Physikalische Chemie, Royal Society of Chemistry - Faraday Division, Società Chimica Italiana - Divisione di Chimica Fisica , Société Francaise de Chimie - Division de Chimie Physique) који су дати на интернет адреси:
http://www2.fci.unibo.it/dcfsci/the_physico_chemist_dbg.htm

Diagramme



а копија тог документа дата је у прилогу у наставку:

The Physico-Chemist - The Profession

The Job Description

edited by
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The Physico-Chemist - The Job Description

1. Preliminary remarks - lntroduction

Chemistry, physics and biology are those natural sciences we are first confronted with at school. Teachers make an effort to arouse students' interest in these disciplines and to point out their respective peculiarities and differences. They teach them that the chemist is interested in substances which he analyses and that he synthethises both existing and new substances. They teach their students the fundamental principies of organic and inorganic chemistry. The classical physicist studies the inanimate matter and discovers the law of nature by means of measurements and makes use of mathematics in order to define them. Biology is the science of natural life.

School leavers must decide upon their further education and students interested in natural science have the possibility of choosing one of the subjects mentioned above. This is related to the question about the job prospects in the fields of teaching, research and in industry.

In the following some useful hints will be given for those who are interested in chemistry, physics and physical chemistry.

At the beginning of his studies the student takes courses in general, inorganic, organic and physical chemistry. He soon gets aware of the fact that he has to deepen his knowledge by taking additional subjects such as theoretical and technical chemistry.

Germany is the only country to draw a clear distinction between physics in a theoretical and an experimental component. For his further professional career the student has to fix his optional subjects as soon as he has passed his intermediate examination (Vordiplom). At this moment the disciplines related to his main subject play an important role.

Physical chemistry is the borderland between physics and chemistry. Biophysics and biochemistry have similar functions for the corresponding sciences.

The diagramme briefly shows the main subjects and the disciplines they are related to including mathematics. This can be extended to engineering sciences. Thus physical chemistry is closely related to process engineering.

Physical chemistry is the oldest of the borderline sciences mentioned so far. Physical phenomena occurring in chemical processes are described and physical laws are investigated and applied to solve technical problems.

Physical laws can be applied above all in cases where physical and mathematical methods are needed and whenever quantitative statements on properties and states of substances, transformation of substances and reactions are required.

The classical fields of application of physical chemistry are thermodynamics and kinetics of chemical reactions as well as spectroscopy. Kinetic theory of gases, statistical mechanics and quantum theory are also defined by physical chemistry. Thermochemistry, electrochemistry, photo- and nuclear chemistry can be assigned simply by their names.

The term of 'physical chemistry" was first used by Lomonossow in 1752. He was a professor of chemistry at St. Petersburg and Moscow and he investigated the connections between physical and chemical properties of substances. Physical chemistry was given a striking profile by scientists like W. Nernst, H. J. van't Hoff, W. Ostwald and R. W. Bunsen.

Access to physical chemistry is in principle possible after a basic study of either chemistry or physics. In many cases chemists and physicists are confronted with physico-chemical problems not before they have already left university, a fact which makes them turn to this discipline.

The Physico-chemical Divisions of the Chemical Societies of France, Italy, the United Kingdom, the Netherlands and other countries of Europe as well as the German Society of Physical Chemistry (DBG) - Bunsen-Gesellschaft - aim at promoting this discipline and at encouraging interaction between science and technology. This is also the aim of this brochure. Il helps students to develop precise ideas of their professional life in case they turn to physical chemistry.

For this reason the course of studies is being outlined - including a description of future chances in research and industry.

Last but not least this brochure can support staff departments in their efforts to find qualified applicants for certain positions.

2. Studies

2.1. Germany

The first four semesters of basic studies in chemistry concentrate on the "core courses" inorganic, organic and physical chemistry. On the other hand intensive work is also required in mathematics, physics and numerical mathematics (electronic data processing). During this phase students acquire a fundamental knowledge which is a prerequisite for the advanced courses above all in physical chemistry. Whoever wants to be successful in this field will have little time left to take additional elective courses according to his personal interest.

This phase of fundamental physico-chemical studies concentrate on thermodynamics including the fundamentals of electrochemistry and thermodynamics of mixed phases, introduction into kinetics and transportation processes, fundamentals of quantum chemistry, spectroscopy and chemical bonding.

Depending of the number of courses (8 - 10 courses weekly, practical training not included) the importance of the different fields of science varies from university to university. The basic experimental training in physical chemistry deals with partial problems by experimental work in an exemplary way which means learning by doing.

Apart from planning and carrying out experiments, critical observation and evaluation as well as error analysis are of outstanding importance. Any experiment has to be carefully recorded. At some universities students of physical chemistry form groups with students of adjacent fields (f. e. physics, mineralogy, geology, biology). The intermediate examination of chemistry has to be passed in the core courses as well as in mathematics and physics. As a rule it is an oral, in mathematics also a written examination. At some universities electronic data processing is not yet compulsory, students should, however, acquire knowledge in this field in the advanced courses.

While details of basic courses are fixed, the advanced courses in chemistry offer the students more alternatives as far as both sequence and topics are concerned. There is a deepening of knowledge in the three core courses and in one elective course, which depends on the programme of the single universities. This can be analytical chemistry, biochemistry, biophysics, nuclear chemistry, polymer chemistry, technical chemistry, technical processing and theoretical chemistry. Some universities offer the possibility of taking physics and informatics as elective subjects. For advanced students of physical chemistry courses normally are divided into compulsory and elective courses which are accompanied by exercises and practical training.

The most important fields for students of physical chemistry are: statistical and chemical thermodynamics, reaction kinetics, molecular spectroscopy, theory of chemical bonding, transport properties, electrochemistry, interphase chemistry, biophysics and biochemistry.

This is a brief outline of the requirements for the final examination (Diplomprüfung).

Elective courses constitute a supplementary offer in a special field of science which can be elected out of the four examination subjects. There is a wide range of possibilities which vary from university to university. Some typical examples are: Laser spectroscopy, kinetics, high resolution spectroscopy and other modern methods of spectroscopy, quantum mechanics for chemists, molecular orbital theory, ligand field theory, theory of liquid state, physical chemistry of polymers, electrochemical kinetics, physical chemistry of interphases, catalysis, high pressure-high temperature chemistry, phase transitions in fluid systems, molecular modelling a. o.

This selection characterizes the versatility of physical chemistry. At the end of their studies most students are offered participation in a working group. For several weeks they can do research work and thus gain insight into experimental and theoretical methods of research and they recognize the importance of data processing in modern physical chemistry.

After this students take their final examination (Diplom-Hauptexamen) in the core courses: Inorganic, Organic and Physical Chemistry as well as in one elective subject. This is followed by the diploma thesis (Diplom-Arbeit) over a period of 6 to 12 months. Here, scientific problems are treated under the tutorship of a university lecturer. In physical chemistry these problems can have either stronger experimental or theoretical aspects.

During the period of basic studies of physics students can take chemistry as elective subject, but some universities offer them the possibility of taking as their fourth course physical chemistry or e. g. materials science.

When taking their examination in physical chemistry students of physics or chemistry meet with the same requirements.

For the advanced studies of physics some universities offer the possibility of taking physical chemistry. In many cases students of physics take their diploma or doctor thesis in one of the fields of physical chemistry.

The subjects of both diploma and doctor thesis cover a wide range in physical chemistry from solid state chemistry, materials science, biophysics or new developments especially for chemistry, e. g. multidimensional nuclear magnetic resonance, laser spectroscopy, kinetics, up to physico-chemical treatment - in experiment and theory - of problems in inorganic, organic, biological chemistry and molecular biology, or chemical engineering. This variety brings about that in a lot of physico-chemical working groups doctorands of different fields of science - chemists, physicists, engineers as well as mathematicians of biologists - closely cooperate. This encourages teamwork at an early stage and enables the chemist to deepen fundamental knowledge.

The principle aim of doctorate is to soave a scientific problem independently which means that the doctorand masters knowledge of physics as well as chemistry.

2.2 France

2.3 United Kingdom

2.4 Italy

2.5 The Netherlands, Belgium

2.6 Other European Countries

3. Professional Work

3.1 Areas

The physico-chemist deals with scientific problems between chemistry and physics, applies mathematical science to formulate and solve his problems, considers technical applications and extends his work to adjacent fields such as biology, mineralogy, materials science a. o.

Classical fields of application at professional work are e. g. the evaluation of physicochemical data bases, reaction schemes and kinetics which all play an important role for planning or optimizing chemical engineering of processes.

Short time or relaxation methods have to be mentioned as well. In this context analytical problems have to be solved, structure determination within syntheses may play a role, analysis of lowest amounts of substances is necessary within quality control and environmental protection. The determination and kinetics measurement of biochemical cycles are necessary for pharmacy and pharmakokinetics. Physicochemists in analytics use improved special measuring technics, e.g. in spectroscopy or in chemical sensor application.

Various applications are found due to the basic research on the gasous, liquid, glassy, amorphous, liquid crystalline or crystalline state of matter. Chemical reactions have to be measured in all phases - besides fluid phases where most biochemical and chemical reactions take place new gas phase and solid state reactions became special areas.

The solid phase is the domain of material science and materials technology, however, physico-chemists cooperate in the development of composition and molecular structure of materials which are used as construction materials. Even mechanical properties due to specialized application have to be modified or developed, other properties are those like electric or dielectric, superconducting, magnetic, linear and nonlinear optic, acoustic, thermal conducting, diffusive, ferroelectric, piezoelectric and many others.

Glasses, semiconductors, polymers, and liquid crystals are of industrial importance. Questions of crystalization and crystal growth play an eminent role in materials for electronics and optics. Ceramics and alloys which are multicomponent systems with inner interphases will have optimized properties by definite decomposition procedures. In cases where one material does not reach the specification, integrated or laminated materials have to be developed: polymers and metals e. g. in form of folios polymers and minerals.

Interphases thus produced are of interest for physical chemistry: the mechanism of adhesion and the function of adhesive material (bond) is a complicated question. Interphases between liquids and solids, even solids and solids are often questions in chemical engineering. Of high industrial importance is the research on catalysts (chemical industry, automobil industry)

Semiconductor and optical industry uses thin layers of different materials, e. g. prepared by vapour deposition. Surfaces sometimes have to be modified by physicochemical methods e. g. to obtain hydrophobic or hydrophilic properties.

Questions of interphase and surface tension of liquids as well as the influence of tensides are of economic importance and define most applications, not only within washing and cleaning processes but also at use of colours and dyes, at printing, even at mining and oil extraction. Theses questions are of importance for the production and stability of colloids, colours, herbicides and pesticides, pharmaceuticals, medicinal contrast substances, where colloidal dispersions are achieved by additional materials, i. e. formulations. Hydrogels are produced for medicine, for optical contact lenses or super absorbers or colloidal systems in food chemistry, soil science, production of ceramics.

Rheological problems must be solved in production and processing of polymers, glass, ceramics, materials transportation, motor lubrification, tooth pasta, cosmetics, biophysical applications and building industry. Physico-chemists have to deliver the desired viscous properties.

In the gas phase the combustion processes are of interest for physical chemistry: the combustion process in motor engines, turbines and jet propulsion engines. Atmospheric chemistry is of increasing importance as far as the environment is concerned.

Technical disciplines use data, results and general insights of physical chemistry. Thus many physicochemists work within areas of process optimization and chemical engineering and calculate due to criteria of cost and security, criteria of chemicals, materials and environment.

Reacting chemicals must be brought together and mixed. Mixtures have to be separated. Energy e. g. in form of heat has to be supplied. Not only calculations and procedures but also special materials are necessary. Membrane processes or special corrosion resistant covering e. g. by plasma spraying are examples.

Physicochemists elaborate security and safety relevant data for the planning, regulation and control of processes. Explosion limits of gas mixtures, lowest ignition energy values of gases and of dusts as well as reaction enthalpies, distribution, flammability or vapour pressure are such security examples.

The broad necessity and use of physical chemistry within chemical engineering includes the adjustment of product parameters by additives e. g. for the stability of polymers. On the other hand it has to be evaluated which type of trace materials interfere with application. Printing colours, paints, adhesives, lubricants, de-icing liquids, flame retardant preparations are examples of materials and questions in this area, today almost to be followed by a quality securing system.

3.2 Special professional areas

Electrochemistry is one of the oldest fields of physical chemistry, still or even increasingly important with electrolyses, galvanic industry or the new electropolymerisation. The development of primary and secundary batteries, of fuel cells are main aspects and applications of physical chemistry. Electrochemical sensors are other new applications.

The interaction of light and material is the basis of eminent practical significance. The properties of pigments or colours are due to absorption, light scattering, fluorescence of light interferences. These properties depend on the molecules, on concentration, particle size and structure. Photochemistry is the basis of photographic or photolithographic methods. Photocopying as part of electrophotography needs materials with photoconducting properties. Electronic and optic industries are working out materials with nonlinear properties for optoelectronics, for light amplification for intensity depending modulation of refraction index. One of the relatively new areas is the work of material with laser light.

There is increasing need on sensors for physical, chemical and biochemical data. Sensors are used with process automation, for environmental monitoring, protection against fire and medicinal diagnostics. The principle is the transformation of a physicochemical or biological signal into a physical signal, the amplification and transmission. Methods of instrumental analytics have to be applied to miniaturized sensors. Electrochemical, optical, acoustic or heat transfer coupling is used. The broad variety of applications reaches from filling indication e. g. of vessels to glucose sensors.

Theories and methods of physical chemistry were taken over by biology and microbiology, biophysical chemistry and biophysics when these sciences started molecular sights: membranes, cell surfaces, receptor ligand interactions, structure and conformity changes, cooperative phenomena, biophysico-chemical basics of nerves, muscles, sense organs, photosynthesis, problems of pharmakinetics. Physico-chemical knowledge is used in medicinal techniques, artificial limbs, development of cardiac pacemakers or anaesthetic apparatuses.

Mathematics and mathematical knowledge enables the physicochemist to deal with theoretical chemistry. Additional perspectives are connected with data processing, molecular modelling, a method widely used today to optimize receptor ligand binding when developing pharmaceuticals. Properties of solids may be foreseen. In future extremely expensive experiments should be tried to be substituted by computer simulation.

Physicochemists normally deal with systems of many particles. Thermodynamics present a mighty tool for a high number of particles with linear interactions and statistical treatment. A lot of real systems are far from thermodynamical equilibrium, some systems contain a number of elements too low for statistics, or coupling is not linear. Such systems might be complex and can show tilt phenomena to reestablish a quasi-stationary state: non equilibrium thermodynamics, chaos theory, self organization and evolutionary systems are dealt with. These theories are so basic that they lead out of physical chemistry, however, many physicochemists deal with oscillating chemical reactions, critical phenomena at phase transitions, thermodynamics of liquids, turbulences, dissipative structures, crystallization and morphogenesis even up to molecular evolution.

4. Fields of Activities

4.1 Universities and Scientific institutes

The main fields of activities of physico-chemists at universities and scientific institutes are research and teaching. This is true above all for universities whereas in professional schools' teaching is predominant. Research centers like Max-PlanckInstitutes, large scale research centers or Fraunhofer-Institutes cover the range from purely basic research to applied or commercial science. The transition towards commercial research institutes con be fluent. The fields of research comprise the whole field of physical chemistry and reach from problems of biophysical chemistry to physical problems or process engineering. Most important in teaching are: Lectures, exercises, discussions, tutorial activities in laboratory experiments and diploma theses and examination. To a certain extent students can prepare their diploma and doctor theses at the institutes mentioned above.

What does Work at University and Scientific Institute look like?
The research field of physico-chemists at universities and scientific institutes are very manifold. They partly overlap with the adjacent fields of physics, chemistry and biology or even with medicine or engineering. The physico-chemist often has to bridge the gap. In many cases there is a close cooperation between universities and different research institutes. As a consequence scientists frequently change from one institution to another in the course of their career. University professors in Germany are responsible for research as well as teaching, whereas scientific institutes concentrate on research work. In both cases scientists additionally are in leading administrative positions (expert committees, ---)

University, Research Institutes
- Entry after doctorate or post-doctorate year as scientific assistant, cooperation and assistance in research and teaching (University); permanent positions with these features are available to a smaller extent at the universities, to a larger extent at large scale research centres
- Further qualification by "Habilitation" which qualifies for lecturing and research in a certain field, in most cases at the end of several years of outstanding research a call to a university normally requires habilitation.
- University professors are independent in and responsible for their work,
lower amount of teaching is usually required at Max-Planck-institutes.
- These three fields of activity - doctorate, habilitation, professorship - briefly outline the career at universities and research institutes of the Federal Republic of Germany and of the Bundesländer.

4.2 Industry

A great number of physico-chemists find a position in chemical industry. They find interesting tasks in product development and process engineering, process transfer from laboratory to production, in analytics and environmental protection or data processing, but also in the field of production itself, production management and distribution of quality products, technical application, advisory tasks, quality management, as patent attorney, in research and enterprise planning.

Employers in industry are also: pharmaceutical industry, food industry, processing industry, paper industry, mineral oil industry, car production, electro- and electronic industry.

Moreover there are possibilities in the fields of materials - metals, ceramics, polymers construction of analytical apparatus and chemical plant, medicinal technique, air and space flight.

4.3 Administration, Societies

Councellors and experts in ministries, regional administrative offices e. g. of Bundesiánder in Germany, national and international (European) institutions (materials testing, criminal and forensic investigation, environmental protection, patent off ices. Or very special professional niches like scientific journalism, scientific societies, museum scientist, archeologist and others.

4.4 Access to physical chemistry by profession

In the case of physical chemistry we can speak of flowing outlines. Thus physicists can work in fields of physical chemistry and physico-chemists in fields of physics. Even transitions from fields of electrochemistry, solid state physics and chemistry, mineralogy, materials science, process engineering etc. are possible.

What might be the Career of a physico-chemist in Industry?
There are so many different possibilities which by no means can be described all. Special examples might be overvalued. Nevertheless some general aspects should be transmitted.
Activity in Industry in general
Flexibility and adaptability are necessary in the extremely fast changing markets. Starting from his basic knowledge the physico-chemist in industry has to get used to new areas of work, even of non physico-chemical nature. He may stay and adapt to research areas or change to product management or chemical engineering. The change sometimes occurs parallel to his themes under work in research.
Research and Development work nowadays in its complexity cannot be coped by single persons. The cooperation and agreement with colleagues of the same or other areas even in an international frame is of utmost importance.
The ascent in hierarchy normally goes with an increased responsibility in personnel and economic managing.

Chemical Industry
- Entry into the enterprise in chemistry
- Analytical or chemical process or engineering service work for research, production, environment, or as laboratory head etc.
- Research work mostly in interdisciplinary projects - cooperation with chemists, engineers, physicists, biologists, pharmaceutical or medicinal scientists, afterwards
- Taking over of other functions in successful projects: production,
customer advisory service, sale, product management
or change of project or laboratory
or change to research management
or change to marketing, service, patent division, quality management,
management abroad or central division, management of a factory, etc.

Electro- and Electronic Industry
- Entry into the development laboratory of producing division or research division, cooperation in a team
- responsible work of a project
- Similarity with chemical industry as far as management is concerned however, less colleagues of the same study as physico-chemist in an enterprise in electronics or electric apparatus production.

5. National Societies and Societies' Divisions of Physical Chemistry and Joint European Activities

5.1 Deutsche Bunsen-Geselischaft für Physikalische Chemie
(German Bunsen Society for Physical Chemistry)

5.2 Società Italiana di Chimica - Divisione di Chimica Physica

5.3 Société Francaise de Chimie - Division de Chimie Physique

5.4 Royal Society of Chemistry - Faraday Division

5.5 Joint European Activities