Laboratory Regulations of the Chair of Solid State Chemistry

Operating Instructions as defined by
the Hazardous Substances Ordinance (*Gefahrstoffverordnung*)

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1. General

1.1 This laboratory regulation contains the general operating instructions for hazardous substances in accordance with § 14 *Gefahrstoffverordnung* in conjunction with § 4.13 of the "Activities Involving Hazardous Substances at Universities" (DGUV Information 213-039).

1.2 Should individual provisions of these regulations become inapplicable due to changes in legal requirements, the remaining provisions shall remain valid. In such cases, the ineffective passages shall be interpreted in such a way that the intended purpose is achieved as far as possible in accordance with the applicable legal provisions.

1.3 Any references to persons apply equally to all genders, even if, for reasons of readability, only one grammatical form is used.

1.4 The provisions of these laboratory regulations must be observed by everyone who works in or is present in a chemical laboratory or in related facilities.

These laboratory regulations are hereby enacted for the **Chair of Solid State Chemistry**.

Augsburg, on

(Prof. Dr. Dirk Volkmer)

2. Important Legal Provisions

2.1 All regulations relating to hazardous substances that are relevant to laboratory work and concern the protection of human health and the environment must be complied with. Important regulations include:

- the German Hazardous Substances Ordinance (GefStoffV.)
- die DGUV Information 213-851
  ("Guidelines for Laboratories")
- the DGUV Information 213-027
  ("Safety in University Chemistry Courses")
- the DGUV Information 213-039 (available only in German)
  ("Activities Involving Hazardous Substances at Universities")
- the Technical Rules for Hazardous Substances (TRGS),
  e.g. TRGS 800 "Fire Protection Measure"
- the Accident Prevention Regulations (UVV),
  e.g. "Principles of Prevention" DGUV Vorschrift 1

2.2 Sources for legal texts can be found in:

- "Kühn Birett: Merkblätter gefährliche Arbeitsstoffe (Instruction sheets on hazardous substances)"

2.3 Guidance on safe working practices in chemical laboratories is provided in the brochure Technische Regeln für Gefahrstoffe: Laboratorien (TRGS 526) (Technical Rules for Hazardous Substances: Laboratories). The instructions contained therein must also be observed.

2.4 Further information can be found on the intranet page Occupational Safety of the Unit (*Referat*) V/6 Safety Management and Environmental Protection:

https://www.uni-augsburg.de/de/portal/intranet/umfeld/arbeitssicherheit/

3. Responsibilities

3.1 Area supervisors (Bereichsverantwortliche)

3.1.1 Area supervisors (Bereichsverantwortliche) are heads of research groups or other departments. They are responsible for the safety of all employees over whom they have supervisory authority, as well as for the safety and proper operation of all rooms and facilities used or jointly used by their group or department.

3.1.2 Area supervisors (Bereichsverantwortliche) must carry out a risk assessment, taking into account the information provided in Chapter 6. For this purpose, they must

• obtain all necessary and available information concerning the substances used or received
• assess the hazards, considering the nature of their use
• determine the appropriate protection level in accordance with the Hazardous Substances Ordinance (*Gefahrstoffverordnung*) based on this assessment.

• examine whether hazardous chemicals or work procedures can be replaced by less hazardous alternatives.

Separate risk assessments must be conducted for workplaces with different hazard profiles. If work procedures change or unforeseen hazards arise, the risk assessment must be reviewed and revised accordingly. The results of this evaluation must be documented. The Safety Engineering Unit of the University of Augsburg (*Referat)* V/6, Herr Thomas Cyris, thomas.cyris@zv.uni-augsburg.de, 598-4963) provides guidance and support for this process.

3.1.3 Based on the risk assessment, area supervisors (Bereichsverantwortliche) responsible for an area must define appropriate protective measures and ensure compliance with them. Operating instructions for handling chemicals are available. Where necessary, these operating instructions must be supplemented with additional instructions for equipment and apparatus. Protective measures also include the provision of Safety Data Sheets (SDSs).

3.1.4 Employees and other personnel, including persons working temporarily in the area (e.g., interns), must receive workplace-specific instruction before commencing work and at least once annually thereafter. This instruction must be given orally on the basis of these Laboratory Regulations and any applicable operating instructions. Furthermore, it must be provided in a language the employees and personnel understand. It must also be ensured that individuals without chemical training who need to carry out short-term activities in the laboratory, such as contractors or cleaning staff, are adequately informed about the required protective measures.

3.1.5 The area supervisors (Bereichsverantwortliche) may delegate individual tasks necessary for fulfilling their responsibilities to members of their group or department. **However, overall organizational and supervisory responsibility remains with the area supervisor (Bereichsverantwortlichen) and cannot be delegated further.**

3.2 Employees

3.2.1 For the purposes of these Laboratory Regulations, employees are persons who, in the course of their activities, normally work in or spend time in laboratories, such as staff members (e.g., doctoral researchers/PhD students), laboratory technicians, and students.

3.2.2 Employees must

• comply with the provisions of these Laboratory Regulations,
• participate in all required safety training and instruction sessions,
• observe all prescribed protective measures and use the required personal protective equipment (PPE),
• remain alert to potential hazards and either eliminate identified dangers themselves, where possible, or report them to the area supervisor (Bereichsverantwortlichen) if they are unable to do so.

4. Specific Regulations of the Chair of Solid State Chemistry

4.1 Safety Representative

The Safety Representative supports the employer or supervisor, through their expertise, in implementing measures to prevent occupational accidents and work-related illnesses. The appointment of a Safety Representative is made by the employer in consultation with the works council or staff council. The legal basis for the appointment of a Safety Representative is set out in: §22 Seventh Book of the Social Code (Sozialgesetzbuch – Siebtes Buch (SGB VII)).
The Safety Representative serves in an honorary capacity and acts as a point of contact for colleagues within their area of responsibility. They promote safe working practices among staff and monitor whether safety-related equipment on technical installations is functioning properly, as well as whether personal protective equipment (PPE) is available and being used correctly. For this reason, the Safety Representative must be granted access at all times to all rooms within their area of responsibility.

4.2 Safety Briefings

As **Senior Lecturer (*Akademischer Rat*)** of the Chair of Solid State Chemistry, **Dr. Björn Bredenkötter** is responsible for the implementation and enforcement of these Laboratory Regulations. He conducts the required safety briefings for the Chair of Solid State Chemistry and for the laboratory courses organized by the Chair.
If the research group of Prof. Höppe (AK Höppe) conducts its own safety briefings for its staff and the courses it offers, these briefings must be carried out by personnel possessing adequate knowledge of chemistry and laboratory practices.
In all cases, both the record of the safety briefing and the participants' attendance sheet (signed attendance list) must be filed in the designated folder in **Office 439**.

4.3 Authorization to Access the Laboratories of the Chair

Before any new employee begins laboratory work in the Chair's laboratories, including practical course laboratories, a safety briefing must be conducted in every case (see Section 4.1). People who have not received the required safety briefing will be removed from the laboratories immediately. Safety briefings given as part of student laboratory courses are **not valid** for authorization to work in the Chair's research laboratories!

4.3.1 Bachelor's students, student assistants, and research assistants may enter chemical storage areas only when accompanied by their supervisor. It is expressly prohibited to issue keys to these rooms to such persons.

4.3.2 Bachelor's students, student assistants, and research assistants may work in the Chair's laboratories only under the supervision of a doctoral researcher, postdoctoral researcher, or a permanent staff member with appropriate expertise in chemistry.

5. Hazards in the Laboratory

Working in a laboratory involves a wide range of hazards. These arise primarily from handling hazardous substances or products ("hazardous substances"), for which the pictograms prescribed under the Globally Harmonized System (GHS) of Classification, Labelling and Packaging (CLP) have been used since January 20, 2009 (see table below). The following categories are distinguished:

5.1 Physical Hazards

These occur with hazardous substances that, due to their physicochemical properties, may:

- be explosive,
- be flammable, highly flammable, or extremely flammable,
- be oxidizing (causing or promoting fire),
- be corrosive to metals, or
- be hazardous as compressed gases.

Volatile, highly flammable, or extremely flammable substances can form explosive or deflagration-capable vapor-air mixtures even at relatively low concentrations.

5.2 Toxic Hazards

These arise from hazardous substances that, due to their physiological properties, are:

- acutely toxic (oral, dermal, or inhalation),
- corrosive,
- irritating, or
- sensitizing, carcinogenic, toxic to reproduction, mutagenic, or otherwise chronically harmful.

5.3 Environmental Hazards

These may become effective if hazardous substances are released into the environment.

5.4 Hazard Classes



Oxidizers



Flammables, Self Reactives, Pyrophorics, Self-Heating, Emits Flammable Gas, Organic Peroxides



Explosives, Self Reactives, Organic Peroxides



Acutely Toxic (severe)



Burns Skin, Damages Eyes, Corrosive to Metals



Gases Under Pressure



Carcinogen, Respiratory Sensitizer, Reproductive Toxicity, Target Organ Toxicity, Mutagenicity Aspiration Toxicity



Toxic to aquatic environment



Acutely toxic(harmful), Irritant to skin, eyes or respiratory tract, Skin sensitizer, Hazardous to the Ozone layer.

One of the signal words "Warning" or "Danger" is added to the pictograms to indicate the severity of the hazards.

5.5 Additional Hazards

- When carrying out chemical reactions, additional hazards may arise from an as yet unknown reaction course, from a possible induction period, or from significant heat or gas evolution and the resulting potential pressure increase in the reaction vessel.
- The use of glassware in the laboratory entails the ever-present risk of injury from broken glass.
- The use of very high or very low temperatures creates the risk of burns or frostbite. When using dry ice, liquid nitrogen, or liquid helium, displacement of breathable air may create an asphyxiation hazard; cooling baths based on organic solvents present a fire hazard.
- The use of vacuum or closed systems is associated with the risk of implosions or explosions resulting from a sudden increase in pressure.
- The use of numerous electrical devices is associated with the risk of electric shock in the event of a malfunction.
- Hazards also arise from exposure to ultraviolet radiation and laser radiation, which can cause severe injuries to the skin and eyes, as well as from X-ray radiation, which can cause both acute damage to the human body and cancer after a prolonged latency period.
- The use of strong magnetic fields is particularly dangerous for individuals with pacemakers or metallic implants.
- Noise generated by equipment and installations can damage hearing.
- Ultrasound at the intensities used for laboratory applications can damage body tissue.
- The use of running water as a cooling medium can lead to serious property damage in the event of leaks.

6. Hazard Identification

The Institute for Occupational Safety and Health of the German Social Accident Insurance (BGIA) has defined a standard hazard potential typical for laboratories in a recommendation. Unless there is evidence to the contrary, compliance with the German Hazardous Substances Ordinance (*Gefahrstoffverordnung*) may, according to this recommendation, be assumed. Consequently, the monitoring of occupational exposure limits (airborne concentrations in workplace air) otherwise required under the Hazardous Substances Ordinance may be waived, provided that the conditions for this standard laboratory hazard potential are met. These conditions are as follows:

- All provisions of the Guidelines for Laboratories (DGUV Information 213-851) are complied with.
- Work activities in which hazardous substances may occur in hazardous concentrations or quantities in workplace air are carried out exclusively in fume hoods whose performance complies with the applicable DIN standards and which are used as intended, i.e., in particular with the front sash kept as closed as possible. Performance must be monitored through regular inspections by the technical operations department.
- The maximum quantity used is adjusted to the hazard potential of the individual substance:
  - Typical laboratory liquids, e.g., methanol, are used in quantities not exceeding 2.5 L.
  - Highly toxic, carcinogenic, mutagenic, or reproductive-toxic liquids are used in quantities not exceeding 0.5 L
  - For solids, the corresponding maximum quantities are 1 kg and 0.1 kg, respectively.
- The maximum quantity used is adjusted to the hazard potential of the individual substance.
- If no central compressed gas supply is available for standard gases, the smallest possible container size shall be used, with a maximum of one 50 L compressed gas cylinder.
- For highly toxic, carcinogenic, mutagenic, or reproductive-toxic gases, lecture bottles or, if this is not possible, containers with a maximum volume of 10 L shall be used. In all cases, these must be properly secured and positioned inside the fume hood.
- Spare cylinders shall be stored outside the laboratory.

If these conditions are not met, the situation cannot be regarded as a standard laboratory hazard potential. In such cases, a specific risk assessment is required, demonstrating that the requirements of the Hazardous Substances Ordinance are being fulfilled. This includes measures for the effective monitoring of airborne concentrations in workplace air.

7. General Measures

7.1 Handling Hazardous Substances

7.1.1 Before handling hazardous substances and before carrying out procedures in which hazardous substances may potentially be released, the hazard potential must be assessed, and the necessary protective measures must be implemented.

Sources of information:

Operating instructions (*Betriebsanweisungen*)
Safety Data Sheets (SDS)
Manufacturer or supplier catalogs
Literature or standard operating procedures (SOPs) / work instructions
CLP- Annex VI – harmonised classifications

The determined hazard statements (H) and precautionary statements (P) are binding components of this operating instruction.

7.1.2 Hazardous substances must not be stored or kept in containers that could be mistaken for food containers.

7.1.3 Highly toxic and toxic substances must be kept under lock and key or stored in such a way that only qualified personnel or persons authorized by them have access.

7.1.4 Flammable liquids requiring cool storage, as well as highly flammable and easily flammable substances, may only be stored in refrigerators or freezers whose interior is explosion-proof.

7.1.5 All storage containers must be labeled with the name of the substance and the hazard symbols; larger containers (more than 1 liter) must be fully labeled, including H-statements and P-statements.

7.1.6 Hazardous substances must not be stored or kept in containers that could be mistaken for food containers. Food must not be stored together with chemicals.

7.1.7 Chemicals that release gases harmful to health, environmentally hazardous gases, or flammable gases must be stored in tightly sealed containers. For ground-glass joint vessels, the joints must be secured if the substances develop a noticeable vapor pressure at room temperature. Containers must be made of suitable materials. Plastics are often not sufficiently resistant. Particular attention must also be paid to bottle closures.

7.1.8 For the transport of containers holding hazardous substances, buckets or transport crates must be used that can safely contain the entire contents in the event of breakage.

7.1.9 Liquefied gases may only be transported in containers intended for this purpose (insulated steel tanks, transport vessels).

7.1.10 Hazardous substances must not be transported together with persons in elevators. This applies particularly to the transport of cryogenic gases in Dewar vessels.

7.1.11 Work involving substances that generate flammable or health-threatening gases, vapors, or dusts must be carried out in a fume hood.

7.1.12 Compressed gas cylinders must not be stored in laboratories. Only those compressed gas cylinders necessary for the uninterrupted continuation of work may be present.

Laboratories in which compressed gas cylinders are installed must be marked with warning sign W 19 "Warning: Gas Cylinders." Compressed gas cylinders must not stand unsecured; they must be fastened with the designated chains to a wall or another suitable support. The transport of compressed gas cylinders, including "empty" cylinders, must be carried out using the designated carts and the required safety measures (screwed-on protective cap, chain restraint). **When handling highly toxic, toxic, or corrosive compressed gases, work with the gas cylinder must be carried out inside a fume hood.** Only fittings and hoses approved for the respective type of gas and the operating pressure may be used for the withdrawal of gas from compressed gas cylinders.

7.1.13 The following publications must be read, and their contents must be observed during laboratory work:

- Guidelines for Laboratories (DGUV Information 213-851).
- Safety in University Chemistry Courses (DGUV Information 213-027).
- Special operating instructions for particularly hazardous substances, substance groups, and activities.

7.2 Work Hygiene

7.2.1 Everyone is responsible for cleanliness in the laboratory. Chemical containers must be kept sufficiently clean on the outside so that they can be handled without risk. Contaminated equipment and work surfaces must be cleaned immediately. Work surfaces must be designed so that cleaning is possible at all times. The removal of hazardous substances, for example from floor surfaces, must not be left to cleaning personnel.

7.2.2 Only equipment and chemicals required for the immediate continuation of work may be present in fume hoods. The simultaneous storage of equipment or chemicals in fume hoods is not permitted. Shelving in fume hoods is not permitted.

7.2.3 Food must not be prepared, stored, or consumed in containers or equipment intended for working with chemicals.

7.2.4 Smoking, eating, and drinking are prohibited in all laboratories.

7.2.5 The storage, keeping, or preparation of food is prohibited in all laboratories.

7.2.6 Safety glasses must be worn in the laboratory; persons who wear prescription glasses must either wear over-goggles over their own glasses or safety glasses with prescription lenses. Over-goggles are available from the materials management office.

7.2.7 A laboratory coat must be worn in the laboratory. The fabric must not present an increased hazard in the event of fire due to its burning or melting behavior. Suitable fabrics are cotton or blended fabrics with a sufficiently high cotton content. Laboratory coats contaminated with chemicals must be removed immediately. A sufficient number of spare laboratory coats must be kept available to allow work to continue without interruption. Laboratory coats should be worn only in the laboratory. They must be removed before entering seminar rooms, offices, or the library.

7.2.8 Personal protective equipment specified in the safety instructions (P-statements) and special operating instructions, such as safety glasses, face protection, and suitable gloves, must be used.

7.2.9 Other clothing should adequately cover the body and arms and should likewise be made of materials that do not readily ignite or melt when exposed to heat. Clothing not required in the laboratory (e.g., coats) must be stored in lockers during work. **It is strongly recommended that a complete set of spare clothing be kept in the locker so that clothing contaminated with chemicals can be changed immediately.** Only sturdy, closed-toe, slip-resistant footwear may be worn.

7.2.10 When working with chemicals that are hazardous upon skin contact, suitable protective gloves must be worn. Protective gloves with limited chemical resistance must be discarded in good time (generally no later than after 2 years). Sweaty gloves must be changed and thoroughly dried before any reuse. Perspiration inside gloves can be prevented by wearing inner gloves (cotton, nitrile, or latex). While wearing protective gloves, no objects may be touched that, under normal use, never come into contact with chemicals (e.g., door handles, books).

7.3 Additional General Measures

7.3.1 Each laboratory must be identified by a door sign showing the names of the employees working there and the name of the research group. For jointly used rooms (e.g., measurement rooms and storage rooms), responsibilities for compliance with obligations, particularly under Sections 7.3.12, 7.4.9, 8.1.5, 8.1.6, 8.1.10, and 8.1.11, must be defined. The responsible person must be indicated on the laboratory door.

7.3.2 Unauthorized persons are not permitted to enter laboratories or practical training rooms. Persons not working in the laboratory may only remain there with the permission of the person responsible for the laboratory concerned or when accompanied by a person working in that laboratory.

7.3.3 Cooling-water lines for non-permanently installed equipment may only be installed using reinforced pressure hoses. Hose connections must be secured with hose clamps.

7.3.4 Only the quantities of hazardous substances necessary for the continuation of work may be kept in laboratories. The storage of chemicals is not permitted.

7.3.5 The front sashes of fume hoods must be kept closed. During work in a fume hood, the front sash must be kept as closed as possible. The user's head should remain behind the protective glass whenever possible.

7.3.6 Defective or deactivated fume hoods must not be used.

7.3.7 Reaction flasks are heated most safely using Heat-On mantles or heating baths. The mantle or heating bath:

- must be easily removable at any time and sufficiently sized to contain the entire flask contents in the event of flask breakage, and
- must not undergo violent or otherwise hazardous reactions with the flask contents in the event of breakage.

Water-miscible heating baths are preferable because, at higher temperatures, the ingress of water (e.g., from leaking cooling water) can otherwise cause violent splashing. If water-immiscible bath liquids are used, cooling-water hoses must be secured against slipping off. (See Section 14.9!). Heating baths may only be heated to a temperature up to 10 °C below their flash point. It should be noted that the flash point of the bath liquid may decrease during use due to decomposition.

7.3.8 Experimental work involving hazardous substances may not be carried out in laboratories unless at least one additional qualified person is present in the laboratory or in its immediate vicinity. Hazardous lone working is prohibited.

7.3.9 For experiments involving a particular hazard potential, all other persons in the laboratory must be informed so that everyone can provide appropriate assistance in the event of an emergency.

7.3.10 Open flames may only be used when unavoidable. They must not be operated near highly flammable substances.

7.3.11 Everyone working in a laboratory has a duty to use all operational resources (gas, electricity, water, cooling media, etc.) carefully and economically.

7.3.12 Everyone working in a laboratory has a duty to keep all equipment and premises in good condition. Defects in the building, furnishings, or utility lines must be reported immediately to the building maintenance staff. Appropriate reporting forms are available at the reception desk.

7.3.13 If safety deficiencies cannot be corrected immediately, the area supervisor (Bereichverantwortliche*)* must be informed without delay. If it is unclear how the deficiency should be remedied, the safety officers must be consulted.

7.3.14 Interventions in electrical, water, or gas supply systems, as well as modifications to door locking systems, may only be carried out by authorized persons.

7.3.15 Floor drains and sink traps must be kept filled with water to seal the wastewater system against the negative pressure prevailing in the laboratory.

7.4 Equipment

7.4.1 As a general rule, the operating instructions for all equipment must be observed.

7.4.2 When working with X-ray or laser radiation, the corresponding safety regulations and operating instructions must be followed.

7.4.3 Everyone working in the laboratory is required to familiarize themselves with the proper operation of equipment before use and to use it only for its intended purpose. The person responsible for the equipment is responsible for providing instruction and ensuring that the equipment is maintained in a clean and proper condition. Where applicable, use of the equipment must be recorded in the equipment logbook before operation.

7.4.4 **Large glass vacuum apparatuses must be operated in a closed fume hood or be fitted with shatter protection (e.g., a fine-mesh wire screen or a protective shield in front of the apparatus).** When working with glass vacuum apparatuses, at a minimum, safety goggles with side protection must be worn.

7.4.5 Gases evacuated by pumps must be vented into the fume hood exhaust system. Oil pumps must be protected against contamination by means of a cold trap.

7.4.6 Iced-up refrigerators must be defrosted.

7.4.7 Any work on electrical laboratory equipment may only be carried out by the authorized qualified technicians.

7.4.8 Portable electrical equipment must undergo an annual insulation test conducted by a qualified electrician. Hazards arising from poor electrical contacts (corrosion, mechanical overloading) must be eliminated. This includes risks resulting from leakage currents, contacts becoming welded together ("sticking"), temperature increases up to the point of ignition, and inadequate protection against accidental contact.

7.4.9 In the event of defective equipment, repairs must be arranged immediately. Equipment that cannot be removed from the work area without delay must be clearly marked as defective. If equipment with hazardous defects remains in the workplace pending repair, it must be rendered unusable, for example by cutting off the mains plug.

7.4.10 The use of the following electrical devices is prohibited in all rooms:

- Immersion heaters and water baths without dry-run protection.
- Space-heating devices (e.g., hot-air blowers) without overheating protection or with inadequate protection against contact with the heating elements.·
- Devices that do not comply with VDE regulations (check for VDE certification marking). Heating devices must be placed on a non-combustible surface.

7.4.11 Equipment whose heat generation must be dissipated through ventilation grilles or slots (e.g., monitors) must be positioned so that the ventilation openings remain unobstructed and the necessary air circulation is not impaired.

7.4.12 Heating devices (e.g., drying ovens, magnetic stirrers) may only be operated unattended if they are equipped with an emergency shut-off function in the event of temperature control failure, or if exceeding the set temperature is impossible due to the device's low heating capacity (i.e., for example: do not set the heating control of a magnetic stirrer to maximum and always use a contact thermometer).

7.4.13 All containers placed in refrigerators and freezers must be sealed and properly labeled. No sources of ignition may be present inside refrigerators or freezers where a dangerous explosive atmosphere could develop. Suitable refrigerators are available on the market. Standard refrigerators and freezers can be modified accordingly (see DGUV Information 213-039). Storing food and hazardous substances together is prohibited.

7.4.14 Broken glassware must not be kept on work surfaces. It should be taken for repair or disposed of immediately.

7.4.15 Suitable measures must be taken to reduce the risk associated with an implosion or explosion of a rotary evaporator (e.g., protective shields, the use of glass components coated with plastic film, or wire mesh guards).

7.4.16 Vacuum should be generated exclusively using diaphragm pumps rather than water-jet pumps, since the latter may allow solvent vapors to enter the wastewater system. The exhaust air from diaphragm pumps must be discharged into a fume hood or a designated exhaust connection ("sniffer connection").

7.4.17 Ultrasonic baths must be operated in a closed condition whenever aerosol formation may create a hazard. Ultrasonic homogenizers may only be operated in the designated sound-insulated enclosures. If chemical reactions are carried out in ultrasonic baths, it must be taken into account that such reactions may proceed at an accelerated rate (risk of overheating, fire hazard).

7.5 Risk to and from third parties

7.5.1 Hazardous substances must be protected against misuse and improper use.

7.5.2 It is prohibited to bring unauthorized or unqualified persons into the laboratories or to remove hazardous substances from the institute. Trained laboratory personnel are considered qualified.

7.5.3 For the performance of necessary maintenance and cleaning work, laboratory personnel must ensure that the affected areas of the laboratory are cleared of chemicals and equipment and that the persons assigned to these tasks can carry out their work without exposure to hazards. This applies in particular to cleaning personnel and maintenance workers. Prior to welding, cutting, or soldering operations, combustible materials must be removed from the vicinity. The tradespeople carrying out the work must possess a permit-to-work for the activities being performed and present it upon request.

7.5.4 Items intended for the glassblower must not contain any chemical residues. If they have been rinsed with solvents, it must be ensured that these are subsequently removed completely. In particular, no flammable atmosphere may remain within the cavities of the items.

7.5.5 Laboratories must be locked when laboratory personnel are absent. If this cannot be reliably ensured for operational reasons, for example in teaching laboratories, the entrance doors must be marked with the following notice:

"Unauthorized persons are not permitted to enter; visitors are requested to register in Room xxx."

8. Hazardous Situations

8.1 Safety Equipment and Preventive Measures

8.1.1 All personnel working in the laboratory must familiarize themselves with the location and, where appropriate, the operation of the following facilities nearest to their workplace:

- Telephone
- First-aid kit
- Fire extinguisher
- Emergency shower and eyewash station
- Absorbent or binding agents for spilled chemicals
- Respiratory protection mask and available filters
- Emergency shut-off devices for electricity, water, and gas
- Emergency exits and escape routes
- Manual fire/evacuation alarm activation button

8.1.2 The protective and safety equipment listed in Section 8.1.1 must be maintained in good condition at all times. Fire extinguishers with damaged seals must be reported to Unit (*Referat*) V/4 (Mr. Stempfle, ext. -5020) and to the permanent staff. The functionality of emergency showers is checked regularly (Unit (*Referat*) V/4). Eyewash stations must be flushed through at least once per month to prevent microbial contamination and must be checked for proper operation during this process.

8.1.3 The protective and safety equipment listed in Section 8.1.1 must always be clearly visible and readily accessible. No objects may be hung on or otherwise attached to this equipment.

8.1.4 Traffic routes and emergency escape routes must be adequately dimensioned. The minimum width must not be less than 1 m. If workstations are located on both sides (e.g., a fume hood and a laboratory bench), the minimum width increases to 1.55 m. If stools, pump stands, or similar equipment permanently reduce the minimum width, the required width must be increased accordingly.

8.1.5 Traffic routes and emergency escape routes must be kept clear at all times. In particular, nothing may be placed on floor surfaces, even temporarily. Doors and emergency escape windows must be capable of being opened without obstruction. In laboratories where work is being carried out, all existing doors must generally be unlocked.

8.1.6 Unnecessary combustible materials must be removed. Packaging materials containing polystyrene foam present a particular hazard because they generate extremely dense smoke in the event of fire.

8.1.7 Holding fire doors or smoke-control doors open by force, for example by means of mechanical devices, is prohibited. An exception is holding them open with electromagnetic retainers connected to the fire alarm system, since these doors close automatically in the event of a fire.

8.1.8 Access routes and designated staging areas for the fire brigade must be kept clear.

8.1.9 Posted emergency plans must be observed and, where they contain location-specific information, kept up to date.

8.1.10 Each area must maintain an adequate supply of first-aid materials that is accessible at all times. Materials removed from first-aid kits or those that have exceeded their expiration date must be replaced immediately. The contents of the first-aid kit must

always be maintained in a hygienically satisfactory condition. The responsible person must designate an individual responsible for maintaining the first-aid kit. The location of the first-aid kit must be indicated on the outside of the room or laboratory door by a green sign with a white cross. The sign must be removed if the first-aid kit is relocated. Appropriate signs can be obtained through the materials management office. An entry must always be made in the first-aid logbook for every injury!

8.1.11 A sticker displaying the current emergency telephone numbers must be clearly visible on or immediately adjacent to every telephone. At a minimum, the following emergency numbers must be listed:

- Fire Brigade (0-112)
- Emergency Medical Services (0-112)
- Police Emergency Number (0-110)
- Central Building Services Control Center (-5205)

8.1.12 Appropriate organizational arrangements must be made for the evacuation of severely disabled persons, visitors, or students in the event of an evacuation alarm. The necessary measures must be specified during safety briefings.

8.2 Conduct in Dangerous Situations

8.2.1 Remain calm and avoid hasty or ill-considered actions.

8.2.2 Incipient fires must be extinguished immediately using fire extinguishers. Maintain a sufficient distance, as the spray jet may otherwise scatter burning liquids. Do not use water for extinguishing! The simultaneous use of several extinguishers is more effective than sequential use. It should be noted that some chemicals require special extinguishing agents. Extinguished fire sources must be continuously monitored until they have cooled down because of the danger of re-ignition.

8.2.3 Shut down hazardous experiments and turn off gas, electricity, and, where appropriate, water supplies. In the event of an explosion hazard, the electrical supply must be disconnected outside the danger zone.

8.2.4 Secure the accident scene.

8.2.5 If a fire cannot be extinguished by those present, the fire brigade must be alerted immediately. All doors must be closed (but not locked). It is also advantageous to close windows.

8.2.6 When making an emergency call, the type and location of the incident (fire, chemical burn, number of injured persons, address, building section/room number, etc.) must be stated as precisely as possible. The call must not be ended until instructed to do so by the fire brigade or emergency services. Arriving emergency personnel must be guided to the scene of the incident.

8.2.7 Remove hazardous materials (e.g., compressed gas cylinders) from the danger zone, provided this can be done without endangering oneself.

8.2.8 The evacuation alarm consists of a penetrating electronic signal and can be activated using the red alarm buttons located in the corridors. When an evacuation alarm is activated, everyone must leave the institute building by the shortest route and proceed to the designated assembly point (lawn on the east side of the building). Elevators must not be used.

8.2.9 If rooms or corridors are filled with smoke, escape by crawling close to the floor.

8.2.10 Each area supervisor (Bereichsverantwortliche) must ensure that, in the event of an evacuation alarm, verification is made so that all personnel within their area of responsibility have left the building.

8.2.11 Gas Alarm (Levels 4 and 0): A continuous alarm signal indicates an alarm condition in Laboratory 415, 417 (carbon monoxide) or 003 (methane, carbon monoxide, ammonia). Immediate assistance must be provided.

8.2.12 Accidents must be reported to the responsible area manager and the safety officer. In the case of accidents involving significant property damage or personal injury, Unit (*Referat*) V/6 (Safety Engineering) must also be informed.

8.2.13 Spilled chemicals must be disposed of in accordance with Section 21.8.

8.3 First Aid

8.3.1 **Protection of people takes precedence over protection of property**.

8.3.2 For all first-aid measures, pay attention to your own safety first!

8.3.3 Whenever possible, seek assistance from a trained first aider (see Section 8.3.9).

8.3.4 General first-aid measures include:

• Cuts: Allow the wound to bleed slightly. Then dress it appropriately. Foreign objects should generally not be removed. Do not rinse with water.

• Skin contact with chemicals: Rinse with water as quickly as possible. Remove contaminated clothing completely and without delay. If there are no open wounds, wash with soap as well. Water-insoluble substances can be removed using polyethylene glycol 400 (ROTICLEAN). Do not use organic solvents and do not apply ointments.

• Eye contact with chemicals: Immediately rinse thoroughly using the eyewash station. Note: The injured person may be unable to keep the eye open. Effective first aid therefore often requires two people, one to rinse and one to hold the eye open. Contact lenses, if present, must be removed.

• Inhalation: Remove the person from the danger area, provide fresh air, and avoid stressing the lungs. Change contaminated clothing and shower if necessary, particularly after exposure to dusts or aerosols.

• Burns and scalds: Cool with running cold water regardless of the degree of burn.

• Burning persons: Extinguish using the most readily available extinguishing agent, preferably a fire extinguisher.

• After ingestion: Give plenty of water to drink. Do not induce vomiting.

• Unconsciousness: Check breathing and, if necessary, provide artificial respiration by a trained first aider.

Generally:

• Do not leave the injured person alone.

• Watch for signs of shock and, if necessary, take appropriate anti-shock measures.

8.3.5 In all cases where an injury cannot unequivocally be considered harmless, medical attention must be sought. For insurance purposes, an authorized occupational accident physician must also be consulted.

8.3.6 For all injuries requiring medical attention, an accident report must be submitted immediately. All other injuries must be documented in the first-aid logbook. These records must be retained for at least five years.

8.3.7 If medical treatment is sought, it is advantageous in cases of intoxication involving a known substance to bring a Safety Data Sheet with you.

8.3.8 Each area must ensure that at least 10% of its members are trained and periodically retrained as first aiders.

8.3.9 FIRST-AID INFORMATION

A list of the current first aiders can be found next to the telephones in our department, beside the elevator doors, and on the department server.





Assembly Point at the Institute of Physics

Lawn area east of buildings R and S.

Do not re-enter evacuated buildings until instructed to do so by the Fire Brigade.

9. Special Measures When Handling Flammable, Highly Flammable, or Pyrophoric Hazardous Substances

9.1 The following are classified as **flammable**:

Liquids with a flash point below room temperature (< 21 °C). This means:
• that they can be ignited at room temperature, and
• that, upon evaporation, they can create an explosive atmosphere.
Solids that can be ignited by brief contact with an ignition source.
Such liquids and solids are classified using the hazard statement **H225**.
Substances that *release highly flammable gases upon contact with water* (**H260/H261**).
Pyrophoric substances that, when left standing in air, heat up to such an extent that they ignite spontaneously (**H251**).
The substances mentioned above are labeled with the indicated H-statements and the **flame hazard pictogram (GHS02)**.

9.2 The following are classified as **highly flammable**:

Liquids with a flash point < 0 °C and an initial boiling point not exceeding 35 °C.
Gases that are flammable under normal conditions.
They are labeled with the hazard pictogram **"Flame / GHS02 Danger"** and hazard statement **H224**.

9.3 Flammable or highly flammable liquids may be kept at the workplace for immediate use only in containers with a **maximum capacity of 1 liter**. If larger quantities are required on a continuous basis, storage in safety cabinets is permitted, limited to the minimum quantity necessary, in non-shatterproof containers of up to 2.5 L or in shatterproof containers of up to 10 L capacity. Smaller containers should also be stored in safety cabinets whenever possible.

9.4 Sources of ignition must be kept away.

9.5 Electrostatic charges must be avoided. Electrostatic charging may occur:

• through clothing capable of accumulating static electricity (synthetic fibers),
• through the rapid movement of the chemicals themselves.
Attention must be paid to precautionary statement **P243: "Take precautionary measures against static discharge."** When transferring volumes greater than 5 L, all containers and equipment involved (e.g., funnels) must be grounded.

9.6 Solvent waste must be disposed of immediately.

9.7 When working with more than 3 L of flammable or highly flammable solvents in thin-walled glass containers, a suitable spill tray must be placed underneath. The tray must be capable of containing the entire solvent volume and must be self-extinguishing ("fire-protection tray," e.g., with a honeycomb grid insert or mineral-fiber filling).
The use of such trays is also strongly recommended whenever smaller quantities of solvents are handled over extended periods, without continuous supervision, or together with hazardous reagents (e.g., solvent distillations).

9.8 Highly flammable and flammable substances may only be stored in refrigerators or freezers whose interior is free of ignition sources. Stored containers must be positioned securely and sealed gas-tight, as otherwise an explosive atmosphere may develop even inside the refrigerator.

9.9 In the event of a spill of a flammable or highly flammable liquid, all ignition sources must be eliminated immediately.

9.10 Pyrophoric substances (e.g., metal alkyls, lithium aluminum hydride) must be stored separately from explosive, oxidizing, highly flammable, and flammable substances. Only the quantities required for the immediate continuation of work are permitted at the workplace.

9.11 Safe handling is particularly important when working with pyrophoric substances. The necessary procedures and techniques should, where appropriate, be learned through practical instruction.

9.12 For reaction mixtures heated to boiling that react dangerously with water (e.g., alkali metals), metal condensers must be used.

10. Special Measures for Handling Oxidizing Substances

10.1 The following are classified as oxidizing substances:

• Peroxides that may cause a fire through self-decomposition (H241/H242).
• Substances that may cause ignition upon contact with combustible materials or that promote combustion (H270/H272).
• Substances that form an explosive mixture when combined with combustible materials (H271).
These substances are labeled with the indicated H-statements and the hazard pictogram "Flame over Circle / GHS03 Danger."

10.2 Oxidizing substances must be stored separately from combustible materials. In particular, they must not be stored in safety cabinets designated for solvents.

10.3 Clean containers must be used for storage or reactions. These containers must be covered in such a way that no other substances can accidentally enter them. If an experimental procedure requires oxidizing substances to be combined with flammable substances, parameters such as temperature and concentrations must be observed with the utmost precision.

10.4 Spilled oxidizing substances can easily react, including with dirt and other residues, especially underneath cabinets, and may ignite as a result. They must therefore be properly deactivated (e.g., by dilution).

10.5 Before deactivation, spilled oxidizing substances must not be absorbed using filter paper or other combustible materials.

11. Special Measures When Handling Corrosive, Toxic, Highly Toxic, or Sensitizing Substances

11.1 Substances are classified as **corrosive** if they destroy the full thickness of intact skin within 4 hours or within 3 minutes (**H314**).

The **toxicity** of substances is classified according to the magnitude of the lethal dose. The H-statements indicate the route of exposure.

	Toxic	**Highly Toxic** (Fatal)
By inhalation	H331	H330
In contact with skin	H311	H310
If swallowed	H301	H300

Sensitizing substances are substances that may cause allergic reactions. A distinction is made between:

- Respiratory sensitization (**H334**, symbol: **GHS08**)
- Skin sensitization (**H317**, symbol: **GHS07**)

11.2 When handling corrosive, toxic, highly toxic, or sensitizing substances, it must be determined whether they can be replaced by substances with a lower hazard potential.

11.3 The handling of corrosive, toxic, highly toxic, or sensitizing substances requires particularly strict adherence to the general hygiene measures specified in Section 7.2. Where appropriate, low-exposure working techniques (e.g., syringe-septum techniques) must be employed. Suitable operating instructions should be prepared where appropriate.

11.4 Highly toxic and toxic hazardous substances must be kept under lock and key. Only limited quantities necessary for the immediate continuation of work may be stored in the laboratory. The requirement for secure storage is considered fulfilled if the laboratories are locked or appropriately marked in accordance with Section 7.5.5 and the hazardous substances concerned are not openly accessible.

11.5 Substances that release corrosive or toxic vapors may only be stored under continuous exhaust ventilation. Corrosion-resistant trays must be provided in closed cabinets.

11.6 Excess corrosive, toxic, or highly toxic gases must be captured in suitable absorption solutions or rendered harmless by other means. When using absorption solutions, backflow must be reliably prevented. The absorption capacity of the medium must be adequately dimensioned. Gases escaping from the absorption medium must be vented directly into the fume hood exhaust system.

11.7 Preventive measures must be taken against accidental release (e.g., by spillage) to ensure safe cleanup and disposal (e.g., by keeping suitable absorbent materials available).

11.8 Pregnant or breastfeeding mothers must not remain in rooms where highly toxic, toxic, harmful, or otherwise chronically harmful hazardous substances are handled if relevant exposure limits (e.g., occupational exposure limits) are exceeded. Pregnancy must be reported immediately to the area supervisor (Bereichsverantwortlichen). If continued employment in the laboratory is intended, a risk assessment must be carried out with the involvement of the occupational physician.

12. Special Measures When Handling Carcinogenic, Mutagenic, or Reprotoxic Hazardous Substances

12.1 Definitions and Restrictions

12.1.1 Carcinogenic, mutagenic, and reprotoxic substances of Categories 1 and 2 are labeled with the hazard pictogram "GHS08". The following H-statements apply:

H350 = May cause cancer
H340 = May cause genetic defects
H350i = May cause cancer by inhalation
H360 = May damage fertility or the unborn child

Additional classifications that are valid only nationally can be found in TRGS 905 "List of Carcinogenic, Mutagenic or Reprotoxic Substances." Substances listed in TRGS 905 must be handled according to the hazard level assigned therein, even if they are not correspondingly labeled.
Preparations (solutions) containing carcinogenic substances are considered carcinogenic if the mass fraction of the carcinogenic substance is equal to or greater than 0.1%. In individual cases, a lower threshold may be specified in Directive 67/548/EEC or in TRGS 905.
Information concerning classifications according to TRGS 905 can also be found in the BIA Report.

12.1.2 Carcinogenic or mutagenic substances may only be used when their use is unavoidable and no substitute substance with a lower hazard potential is available. The extent of the hazard must be assessed regularly, particularly when manufacturing processes are modified. Changes to manufacturing or application procedures required for the use of a substitute substance are considered reasonable. The results of such assessments and decision-making processes must be documented and made available to the supervisory authority upon request.

12.1.3 Pregnant women must not remain in rooms where carcinogenic, mutagenic, or reprotoxic hazardous substances are handled. Breastfeeding women must not remain in such rooms if established exposure limits (e.g., occupational exposure limits) are exceeded. Pregnancy must be reported immediately to the area supervisor (Bereichsverantwortlichen).

12.2 Conditions of Use

12.2.1 Work areas in which carcinogenic substances are handled must be clearly separated and marked. The affected areas must be kept as small as possible. The number of employees exposed must also be kept to a minimum.

12.2.2 Meticulous personal hygiene and low-exposure working techniques are mandatory.

12.2.3 Exposure must be prevented. Unless there is evidence to the contrary, exposure is considered to be prevented if work is carried out in accordance with the conditions of Section 4.8.2 of the Rules for Safety and Health Protection When Handling Hazardous Substances in Higher Education Institutions (GUV-SR).

12.2.4 Increased requirements apply to ensuring the proper handling of carcinogenic, mutagenic, or reprotoxic hazardous substances. Trainees (students) must be properly instructed and supervised.

13. Special Measures for Environmentally Hazardous Substances

13.1 For environmentally hazardous substances, measures must be taken to prevent their release into the environment.

13.2 For substances that are hazardous to the ozone layer (EUH059), measures must be taken to minimize evaporation as far as possible. To this end, any open handling must be restricted to the absolute minimum necessary.

14. Special Measures for Unattended Apparatus

14.1 Experiments involving hazardous substances must be adequately monitored. If this cannot be achieved through direct personal supervision, the following protective measures must be observed.

14.2 No hazards may arise either from the experiment itself or from equipment or chemicals placed in the immediate vicinity of the experiment.

14.3 Devices and apparatus that are heated without supervision must be protected against exceeding the operating temperature. Reaction apparatus must additionally be safeguarded against cooling water failure by means of a water monitor and the use of a recirculating thermostat.
The operating temperature of a reaction apparatus is considered adequately monitored if it:
• is controlled by a contact thermometer,
• has a heating capacity adjusted such that, during the switching cycles of the contact thermometer, the residual heat does not lead to unacceptable control fluctuations.

14.4 Experiments involving hazardous substances must be adequately monitored. If this cannot be achieved through direct personal supervision, the following protective measures must be observed.

14.5 Reaction apparatus may only be heated using Heat-On heating mantles or heating baths.

14.6 Reaction contents must be reliably contained in the event of flask breakage. Where only stirring is involved, a catch tray must be placed beneath the flask.

14.7 The apparatus must be labeled with a clearly legible notice containing at least the following information:
• Name of the experimenter
• Telephone number (private)
• Reagents used, including additives (catalysts) and reaction medium (this may also be provided in the form of a reaction equation)
• Hazard designation, H-statements, and P-statements; where necessary, any specific hazards associated with the reaction. For reaction mixtures, H- and P-statements must be determined based on plausible hazard assessment criteria. As a rule, for example, the hazard potential of the solvent used will not be significantly altered by the dissolved reactants.
• Start time of the reaction (date and time) and expected reaction duration.
The notices must be removed upon completion of the experiment.

14.8 The apparatus must be observed under the intended operating conditions for a sufficient period to ensure that these conditions can be maintained safely without

further adjustment and without additional supervision. Auxiliary systems for heating, cooling, gas supply, stirring, etc., as well as the emergency shutdown devices required under Section 13.3, must be carefully checked for reliable operation.

14.9 Air condensers (e.g., Findenser®) should be used whenever possible. If this is not possible, cooling water hoses must fit securely on the hose connectors (barbed fittings). They must additionally be secured with hose clamps or wire wrapping. Particular attention must be paid to the use of hose material in good condition.

14.10 No flammable substances may be present in the immediate vicinity (= within the same fume hood) of unattended apparatus.

15. Operating Instructions

15.1 Given the typically high personnel turnover at universities, the preparation of the legally required operating instructions is particularly important. Operating instructions must contain the following elements:

- Activity- or experiment-specific description of the hazard potential
- Instructions for proper handling (e.g., personal protective equipment)
- Disposal instructions
- Measures to be taken in the event of accidental spillage
- First-aid measures

15.2 This laboratory regulation shall serve as the general operating instruction, as it contains the measures to be taken for hazardous substances typically encountered in laboratories. Subject to Sections 15.3 to 15.5, no additional operating instructions are normally required.

15.3 Separate operating instructions must generally be prepared for persons undergoing training (e.g., students). For students, these instructions may be provided in the form of laboratory course regulations and/or experimental manuals. Relevance to the workplace must be ensured. The protective objectives of these operating instructions must not fall below those established by these laboratory regulations.

15.4 If the protective measures specified in Sections 9 to 13 are not sufficient, separate operating instructions must be prepared. This may be necessary in particular when handling toxic, highly toxic, carcinogenic, mutagenic, reprotoxic, pyrophoric, or explosive substances.

15.5 Operating instructions must be prepared for equipment or apparatus shared by multiple users if their operation is not self-explanatory.

16. Labeling of Chemicals

16.1 Everyone working in a laboratory is required to ensure that chemicals stored, used, or produced there as intermediates or final products are clearly identified.

16.2 Chemicals should remain in their original containers whenever possible in order to preserve the original labeling. Labeling with H-statements, P-statements, and hazard pictograms may be omitted:

• for small containers with a maximum volume of 125 mL, provided the substance is harmful, irritating, flammable, highly flammable, or oxidizing;
• for new substances ("research chemicals"). However, new substances must still be labeled in such a way that they can be clearly identified.
Storage containers holding chemicals for daily use or kept ready for use need only be labeled with the substance name, (where applicable, the concentration), and the relevant hazard pictograms.

16.3 Labels must be clearly legible, durable, and of a size appropriate to the container. Existing labels must not be painted over or covered.

16.4 Labels that are no longer applicable must be removed or at least permanently obscured. This applies particularly to emptied and cleaned chemical containers.

17. Inventory of Hazardous Substances

17.1 All hazardous substances that are present in a laboratory for an extended period, brought into the laboratory, or produced there must be entered without delay into a hazardous substances inventory that is updated at least annually. The inventory must include references to the corresponding Safety Data Sheets. The inventory is accessible to all employees via the **"fkch-m"** network drive.

17.2 Reference samples generated only in small quantities and for which there is no indication that they are toxic, highly toxic, carcinogenic, reprotoxic, or mutagenic may be recorded in summarized form.

17.3 The annual update of the hazardous substances inventory required under Section 17.1 should also be used as an opportunity to conduct a review of the chemical stock with the objective of:

• sorting out chemicals that are no longer needed and either disposing of them or making them available to other interested users; and
• inspecting all chemicals intended to remain in storage to verify that they are properly labeled, tightly sealed, and that their containers are in a hygienically satisfactory condition.

18. Compressed Gas Cylinders

18.1 Because of their high hazard potential and the rental costs involved, the use of compressed gas cylinders must be limited to the minimum necessary.

18.2 Compressed gas cylinders may only be transported with the protective cap screwed on and secured by a chain to a designated transport cart. At their place of use, they must be secured against tipping over by appropriate retaining devices. Straps, chains, or ropes used for securing cylinders must not be attached around the valve.

18.3 Compressed gas cylinders must be operated in safety cabinets. If installation in safety cabinets is not possible, the area supervisor must be consulted unless the gases involved are inert gases (nitrogen and noble gases, but not carbon dioxide).

18.4 Compressed gas cylinders should be as small as possible. This applies in particular to highly toxic, toxic, harmful, highly flammable or flammable, and carcinogenic gases, for which **lecture bottles** should preferably be used. The maximum quantities specified in Chapter 7 must be observed. The use of toxic, highly toxic, or carcinogenic compressed gases must be coordinated with the area supervisor.

18.5 Gases may only be withdrawn from compressed gas cylinders through pressure-reducing valves installed downstream of the cylinder valve. Only regulators approved for the specific gas type may be used. The installation of regulators may only be carried out by appropriately instructed personnel.

18.6 Whenever the regulator is removed, the protective cap must be screwed on immediately.

18.7 Compressed gas cylinders must not be completely emptied; when returned, they should still contain a residual pressure.

18.8 After use, the cylinder valve must always be closed (not only the regulator valve). Once the main valve is closed, the regulator must be depressurized by briefly opening it. In the case of corrosive gases (e.g., chlorine), this must be done immediately after gas withdrawal has ended, as the valves would otherwise corrode rapidly. During extended interruptions of work, the regulators must be removed and purged with inert gas.

18.9 Repairs to regulators may only be carried out by qualified personnel. Oil, grease, and glycerin must be strictly kept away from all fittings used with strongly oxidizing compressed gases such as oxygen, chlorine, and nitrous oxide.

18.10 No forceful attempts may be made to open cylinder valves that cannot be opened normally. In such cases, a permanent staff member must be informed.

18.11 Compressed gas hoses in use must be secured against slipping off.

18.12 For introducing gases into typical laboratory reaction apparatus, either fine-control valves must be used to reliably prevent excessive pressures, or a venting outlet must be provided that is either completely pressure-free or allows excess gas to escape at low overpressure (e.g., a bubble counter). If the apparatus is specifically designed and rated for operation under pressure, the provisions of Section 19 of these laboratory regulations must be observed.

18.13 When introducing gases into liquids, devices must be used that prevent liquid from flowing back into the gas line (e.g., safety wash bottles).

19. Pressure Reaction Vessels

19.1 Only vessels approved for the intended purpose may be used as pressure reaction vessels. Such vessels must not be subjected to pressures exceeding their approved limits. This applies particularly to reaction vessels made of glass.

19.2 Pressure reaction vessels must be inspected regularly by visual examination.

19.3 Only stainless steel tubing or pressure-resistant (jacketed) PTFE tubing may be used for operating autoclaves.

20. Reactions in Microwave Devices

20.1 The manufacturer's operating instructions must be observed, particularly the information regarding the average service life of pressure reaction vessels. The equipment must have a sufficiently robust design and be equipped with sensors for pressure and temperature monitoring.

20.2 When heating flammable liquids, the device must be equipped with additional safety features (e.g., mechanical ventilation and explosion sensors).

20.3 If apparatus extending outside the microwave chamber is installed, devices must be used that are fitted with suitable openings incorporating radiation shielding.

20.4 Pressure digestion procedures require equipment specifically designed for this purpose and equipped with additional monitoring functions.

20.5 If substances may escape from the oven chamber in the event that a vessel vents or ruptures, they should, wherever possible, be prevented from entering the laboratory atmosphere and instead be captured and safely discharged.

21. Waste Disposal

21.1 General

21.1.1 The amount of waste generated must be kept as low as possible. For large quantities of waste (e.g., solvents), recycling or recovery takes precedence over disposal.

21.1.2 All chemicals, reaction mixtures, or reaction residues for which there is no further intended use must be disposed of immediately. The accumulation of waste in the laboratory is not permitted.

21.1.3 Chemicals must not be disposed of in household waste. Sharp-edged objects must not be placed in household waste containers.

21.1.4 Hazardous wastes (e.g., alkali metals, peroxides, hydrides, organometallic compounds, catalyst residues) must be deactivated immediately so that they no longer present a hazard. The deactivation process must be supervised until the reaction has completely ceased.

21.1.5 Waste must be collected in a manner that excludes hazards.

• Particularly hazardous are solid wastes that may react with a delayed and unexpected onset.
• Organic solvent waste may begin boiling due to low-boiling components even when only mildly heated.
• Reactive wastes must be deactivated before being placed in collection containers.

21.1.6 Waste containers must be permanently resistant to the substances placed in them. Plastic collection containers resistant to organic solvent waste are marked with a UN number.

21.1.7 Waste containers must be kept sufficiently clean during waste collection and during transfer for disposal so that they can be handled safely.

21.1.8 Waste containers must be clearly labeled.

21.1.9 Mercury-containing waste must always be collected separately from all other waste.

21.2 4.2 Organic Solvent Waste

21.2.1 As a rule, solvent waste is collected as "halogen-containing solvent waste." Containers (1-5 L) must be placed into a 60 L overpack container before storage in the "South Storage Area" (Lager Süd).

21.2.2 Halogen-free water-miscible solvent waste (especially ethanol and acetone) should preferably be distilled and reused as cleaning solvent ("washing solvent").

21.2.3 The presence of small amounts of aqueous waste is currently tolerated.

21.3 Disposal of Waste via the Wastewater System

21.3.1 The following salts, acids, bases, and their aqueous solutions may be discharged to the wastewater system in small quantities:

• Sodium chloride (including technical-grade salt used for cooling mixtures)
• Sodium sulfate
• Magnesium chloride
• Calcium chloride
• Sodium carbonate
• Hydrochloric acid
• Hydrobromic acid
• Sulfuric acid
• Nitric acid
• Phosphoric acid
• Acetic acid
• Sodium hydroxide solution
• Potassium hydroxide solution
• Aluminum hydroxide

This is permitted only if these substances are not contaminated with materials that may not be discharged into the wastewater system.

21.3.2 It must be ensured that the substances listed in Section 21.3.1 do not damage the piping system. Acids must be neutralized where necessary. The wastewater system must then be flushed with water.

21.3.3 Compounds containing arsenic, lead, cadmium, chromium, copper, nickel, mercury, silver, zinc, halogenated hydrocarbons, or hydrocarbons must not be discharged into the wastewater system.

21.4 Acidic aqueous solutions containing heavy metals are collected separately as (Cl^-, NO_3^-)-containing or (SO_4^{2-})-containing waste.

21.5 Glass Waste and Needles

21.5.1 To protect laboratory cleaning personnel, sharp-edged waste must not be disposed of in household waste containers.

21.5.2 High-melting laboratory glass must not be disposed of in municipal glass recycling containers, since it cannot be recycled together with bottle glass. Glass waste must be collected according to the following categories:

- Clean bottle glass
- Clean high-melting laboratory glass
- Contaminated glass or contaminated porcelain

21.5.3 Needles must be collected in puncture-resistant containers.

21.6 Operational Material Waste

21.6.1 Other substances or items contaminated with chemicals, such as filter papers, thin-layer chromatography plates, and silica gel from column chromatography, must be disposed of as "chemical-contaminated operating materials."

21.6.2 Filter papers must no longer contain reactive residues (e.g., hydrides or catalyst residues).

21.7 Other Waste

21.7.1 Chemicals that cannot be placed in the containers for solvent waste may be submitted as individual waste containers. The substance should be described as clearly as possible. This includes, among others:

- Heavy-metal-containing acids
- Strong alkalis
- Waste oil

21.7.2 The disposal of waste with unknown composition that cannot be placed in solvent waste containers must be coordinated with Dr. Björn Bredenkötter or Dr. Richard Röß-Ohlenroth.

21.7.3 Electrical equipment: Collection container located in the workshop courtyard.

21.8 Spilled Chemicals

21.8.1 Spilled chemicals should be removed, as far as possible, in a manner that allows the normal disposal procedures to be followed.

21.8.2 If chemicals have been spilled on the floor, the affected area must be cleaned thoroughly over a wide area, including locations that are difficult to access.

21.8.3 Spilled liquids must either be absorbed using suitable absorbents or allowed to evaporate under controlled conditions. Mineral acids are neutralized with bicarbonate and then flushed into the wastewater system. When absorbing liquids with paper towels, it must be ensured that the protective gloves used provide adequate resistance to the spilled hazardous substance. Paper towels are not suitable for absorbing oxidizing agents.

21.8.4 If oily liquids are spilled on the floor, the floor must be cleaned so that no slipping hazard remains.

21.8.5 Spilled solids may only be swept up if this does not create a hazard through dust generation. Dust may become trapped in clothing and therefore continue to be inhaled long after the actual exposure. Dust formation can be prevented by moistening the material with a solvent. The solvent must not create any additional hazard. Spraying with water is often advantageous.

21.8.6 Spilled mercury must always be removed completely. Wherever possible, it should first be swept together over a wide area (using a small brush on work surfaces or a hand brush on floors).

21.8.7 It is unnecessary and ineffective to sprinkle sulfur, zinc powder, or iodine-treated carbon onto spilled mercury. Instead, the collected mercury should either be picked up using zinc sheet metal or mercury tongs, or the collected material should be disposed of as mercury-contaminated sweepings.

21.8.8 Any remaining traces may subsequently be absorbed using the binding agent Mercurisorb®.

21.8.9 Section 21.1.9 must be strictly observed.