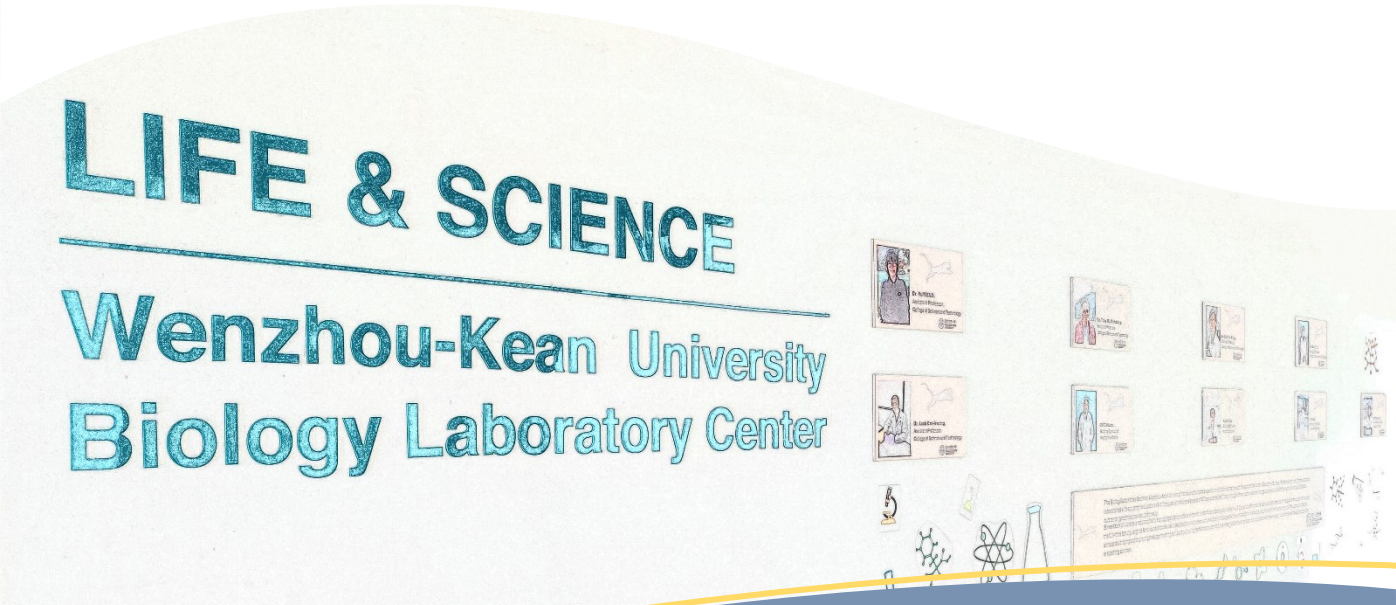
温州肯恩大学
WENZHOU-KEAN UNIVERSITY

实验室安全手册

LABORATORY SAFETY MANUAL

温州肯恩大学 实验中心



序言

温州肯恩大学是浙江省和美国新泽西州友好省州合作项目，是一所具有独立法人资格的中美合作大学。中美融合的教育教学模式鼓励学生多元化发展，而自然科学领域的实验方法学习和开放式探索正是这其中的一项重要环节。因此，实验室是温肯学子进行学习和科研探索的重要场所。而实验室中不可避免地存在众多潜在的危险环节，所以关于实验室安全教育的重要性不言而喻。

本手册主要针对我校实验室中存在的潜在危险源、相应的防范要点以及简单的应急方法等内容进行说明，旨在帮助学生提升风险意识，丰富安全知识，养成良好的实验习惯，维护正常的教学和科研秩序。请所有的实验室使用者在进入实验室前仔细阅读本手册，并自觉遵守实验室安全规章制度。如需了解更详细、更专业的安全知识，可查阅相关的国家和地方法律法规、标准、书籍以及学校的相关管理制度等。

因编写时间仓促，加之编者水平有限，手册中可能存在不当之处，敬请各位读者批评指正。

温州肯恩大学实验中心

2020年4月

Preface

Wenzhou-Kean University is a Sino-US cooperative university with independent legal personality. The Sino-US integrated education and teaching model encourages the diversified development of students, therefore the experimental method learning and open exploration in the field of natural sciences is an important part of this. As a result, the laboratory is an important place for WKU students to study and research. However, there are inevitably many potentially dangerous links in the laboratory, so the importance of laboratory safety education is self-evident.

This manual mainly describes the potential hazards, corresponding prevention and simple emergency methods in the WKU laboratory. It aims to help students raise risk awareness, enrich safety knowledge, develop good experiment habits and maintain normal order of teaching and research. All laboratory users should read this manual carefully before entering the laboratory and consciously abide by the laboratory safety rules and regulations. For more detailed and professional safety knowledge, you can refer to relevant national and local laws and regulations, standards, books, and university management systems.

Due to the short time for writing and the limited level of editors, there may be improper places in the manual, please readers criticize and correct.

Wenzhou-Kean University Laboratory Center

April 2020

实验室安全事故应急联系方式

■ 重要指南

应急处置顺序：发生紧急事故时，应按以下优先次序处置：

1. 保护人身安全，即本人安全与他人安全
2. 保护公共财产
3. 保护学术资料

致电求助，应说明：

1. 事故地点
2. 事故性质和严重程度
3. 你的姓名、位置、联系电话

■ 联系电话

校保卫处报警电话：0577-55870110（710110）

校医务室急救电话：0577-55870120（710120）

火警电话：119

匪警电话：110

医疗急救：120

实验中心应急联络：　生物：0577-55870178（710178）

化学：0577-55870465（710465）

物理：0577-55870179（710179）

Laboratory Emergency Contact

■ Principles of Emergency Response

In the event of an lab emergency, measures should be taken in the following priority order:

1. Personal safety is paramount. Protect yourself and others is always the first priority.
2. Protection of public property.
3. Protection of academic materials.

Provide the following information when calling for help:

1. Accident location.
2. Accident description with its severity.
3. Your name, location and contact number.

■ Emergency Number

Campus Security Office：0577-55870110（710110）
Campus Medical Office：0577-55870120（710120）
Fire：119
Police：110
First-aid Ambulance ：120

Lab Emergency Number:

Biology：	0577-55870178（710178）
Chemistry：	0577-55870465（710465）
Physics：	0577-55870179（710179）

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Chapter 1 Basic Knowledge of Laboratory Safety

The laboratory is an important base for students to study and conduct scientific research. In order to ensure the safety of all the laboratory users, everyone who enters the laboratory should strictly abide by the laboratory regulations to avoid injury to themselves and others.

1.1 Laboratory Personal Code of Conduct

1) The laboratory is not open to all students nor all faculty. Except for students who are enrolled in experimental courses, scientific researchers, and laboratory technicians, no one else can enter the laboratory without permission.

2) All personnel who need to enter the laboratory to work and study must pass the "Wenzhou-Kean University Laboratory Admission Test" to obtain admission qualification.

3) Wear shoes which completely cover your feet. Sandals or any open-toed footwear are not permitted. Long hair should be tied back and jewelry should not be worn in the laboratory.

4) Know the location of exits, fire extinguishers, the first aid box, and emergency phone numbers. All aisles must be kept open at all times.

5) Do not begin working or gathering supplies or equipment until your instructor is present.

6) Before beginning lab activity, read the lab manual completely and pay close attention to instructions given by your instructor. Researchers must read the MSDS of chemicals in advance and be familiar with the properties, safe use, storage and disposal methods of

the materials.

7) Before performing any experiment, examine all apparatus for defects. Do not use damaged equipment or defective glassware. Immediately report to your instructor or lab technician any equipment that does not function properly.

8) Don't carry out experiments beyond the scope of the course content without permission. Scientific researchers must make the experiment plan and then conduct the experiment according to the plan.

9) No eating, drinking or smoking are allowed in the laboratory.

10) Any playful and mischievous behavior is prohibited in the laboratory.

11) Never leave an ongoing experiment unattended.

12) All personnel must wear laboratory uniforms before conducting experiments. For specific experiments, the experimenter must wear personal protective equipment such as goggles, protective gloves, or a mask as required.

13) Please pay attention to the safety of electricity in the experiments involving electrical equipment. Do not connect the wires indiscriminately in the laboratory. Equipment wires, plugs and terminal blocks of the equipment must meet the requirements for electricity safety. If you suspect any damage, immediately report it to your instructor or lab technician.

14) Notify your instructor and lab technician immediately of any injury, spill, fire or explosion. Regardless of severity, all injuries and accidents must be reported. In case of an emergency, immediately contact campus security personnel or call the police.

15) Leave your work station clean and organized before leaving the lab.

1.2 Laboratory safety facilities and personal protective equipment

All personnel should be familiar with the location, applicable scenarios, and methods of use of laboratory safety facilities and protective equipment. The safety facilities currently involved in our university are: emergency sprinklers, eye washers, fire extinguishers, fire blankets, fire sand, first-aid boxes, etc.; personal protective equipment: laboratory clothes, goggles, latex gloves, nitrile gloves, thermal gloves , Anti-cut gloves, medical masks, activated carbon masks, gas masks, etc.

1.2.1 First-aid Box

All science laboratories in WKU are equipped with first-aid boxes. And all medicines in the first-aid box are regularly replenished. Typically, the first-aid box contains sterilized cotton swabs, 75% alcohol, iodophor, sterilized gauze and adhesive plaster, band-aid, surgical scissors, etc. Any safety accidents in the laboratory should be reported immediately and measures should be taken actively for emergency response.

1.2.2 Personal protective equipment

Common protective equipment includes: 1) head protection; 2) eye and face protectors; 3) hearing protection; 4) respiratory protection; 5) hand protection; 6) body protection; 7) foot protection; 8) fall protective facilities, etc.

Eye protection, respiratory protection and hand protection are mainly used in WKU laboratory. For more information about personal protective equipment, please refer to "GB/T 29510-2013 Basic Requirements for Personal Protective Equipment".

◇ Eye protection

Eye protectors mainly prevent potential damage to eyes caused by solid debris splashing, chemical liquid splashing, and radiating strong light. The relevant protective equipment in WKU laboratory are safety glasses and goggles. The functions of the two are similar, the main difference is the sealing protection level of the eyes. The specific use should be selected according to the usage scenario (such as whether there is potential damage caused by chemical vapor, etc.).

◇ Respiratory protective equipment

Respiratory protective equipment is equipment to prevent hypoxic air and air pollutants from entering the respiratory tract. Its main function is to prevent operators from inhaling excessive amounts of harmful substances,

such as smoke, dust, harmful gases, and fibers. The factors to be considered in the selection of respiratory protective equipment are: type of pollutant, concentration of pollutant, exposure limit, comfort, user's health requirements, life cycle, etc. The relevant protective equipment in WKU laboratory are medical masks, activated carbon masks, gas masks, etc. After identifying the source of potential hazards, use appropriate equipment for protection. In addition, it should be noted that before using the gas mask, you need to check whether the filter box is within the valid working period, otherwise please replace the filter box before use.

The correct way to wear ordinary masks is as follows:

a. Facing the side of the mask without the nose clip, pull one ear strap with each hand so that the nose clip is above the mask;

b. Use the mask against the chin;

c. After pulling the ear strap to the ear, adjust the ear strap to feel as comfortable as possible;

d. Place the fingers of both hands in the middle of the metal nose clip and move the fingertips along the nose clip to both sides while pressing inwards until the nose clip is fully pressed into the shape of the bridge of the nose. Pinching the mask nose clip with only one hand may affect the tightness of the mask.

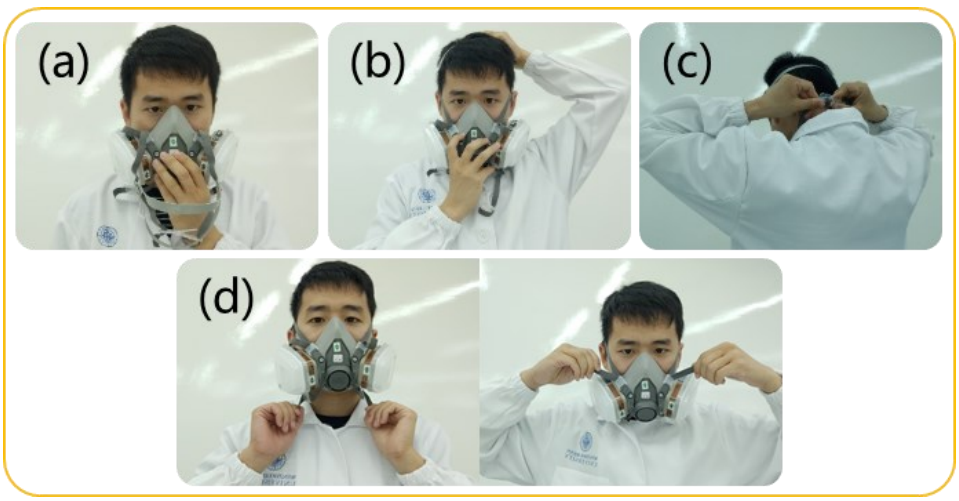
The correct way to wear the gas mask in the laboratory is as follows:

a. Unfasten the bottom buckle and cover the mouth and nose;

b. Pull up the upper headband so that the headband is comfortably placed on the top of the head;

c. Fasten the buckle at the bottom of the headband with both hands behind the neck;

d. Adjust the elasticity of the headband so that the mask fits the face well. Adjust the headband behind the neck first. If the headband is too tight, use your fingers to push the plastic sheet outward to loosen the headband.



Method for checking the tightness of the gas mask:

a. Positive pressure tightness check: cover the breathing valve with your palm and exhale slowly, the mask should expand slightly outward. If gas leaks between the face and the mask, readjust the position of the mask and adjust the tightness of the headband to achieve a good fit.

b. Negative pressure tightness check: Use your palm against the center of the filter box and gently inhale. The mask should slightly move closer to the face. If you feel gas leaking between the face and the

mask, readjust the position of the mask and adjust the tightness of the headband to achieve a good fit.

(a) Positive pressure tightness test

(b) Negative pressure tightness test

◇ Hand protection

Protective gloves can be divided into different types according to the purpose of protection, such as general work gloves, anti-static, insulation, anti-chemical, anti-acid, anti-cut, anti-scald and other gloves. The factors that should be considered when choosing protective gloves are as follows: potential source of exposure, type of chemical exposure, concentration of chemical, working (exposure) time, frequency of use, flexibility, product protection, whether the user is allergic to rubber, etc.. The gloves commonly used in WKU laboratory are: nitrile gloves, latex gloves, anti-scald gloves, anti-cut gloves, etc.

1.3 Laboratory fire safety

Fire is one of the most common laboratory accidents. The weak fire safety awareness and illegal operations by laboratory personnel are usually the main causes of laboratory fire accidents. Therefore, we should keep in mind the fire prevention work policy of "prevention first", master basic fire prevention knowledge and firefighting skills, and take the initiative to prevent fire accidents.

1.3.1 Common fire hazards in the laboratory

1) Violation of laboratory safety management regulations, such as laboratory smoking, illegal use of open flames, etc.;
2) Improper storage or use of flammable and explosive chemicals;
3) Illegal experiment operation, igniting flammable or explosive gas-liquid substances;
4) Leaving the ongoing heating equipment unattended, or the accident cannot be handled in time due to the lack of firefighting skill of the experimenter;
5) The use of high-power electrical equipment exceeds the laboratory electrical load;
6) Improperly equipped fire extinguishing equipment or its failure due to the lack of maintenance.

1.3.2 Laboratory fire prevention

The experimenter must be familiar with occupational fire safety, that is: understand ① the fire hazards of this position, ② the preventive measures, ③ the rescue methods, and ④ the escape methods; be able to ① report to the police, ② use fire extinguishing equipment, ③ handle accidents and ④ escape, which can be summarized as "four understands and four be-able-toes". It is particularly important to note that laboratory personnel must be aware of the hazards of the substances used and the possible dangers during the experiment, and strictly follow the experimental specifications.

The staff of the laboratory center will also organize regular inspections to identify hidden fire safety hazards.

1.3.3 Common fire fighting methods

Fires usually need to be handled according to the type of fire. The following table summarizes the fire types and extinguishing methods of fires.

Table1-1 Common fire types and fire fighting methods

Category	Combustion Characteristics	Extinguishing Method
Solid fire (Type A)	Fire caused by the burning of carbonaceous solid combustibles, such as wood, cotton wool, hemp, paper and other organic substances.	Water type fire extinguisher, foam fire extinguisher, dry powder fire extinguisher, halogenated alkane fire extinguisher.
Liquid, Meltable Solid fire (Type B)	Fire caused by combustion of gasoline, kerosene, diesel, methanol, asphalt and paraffin. The fire easily flows with the burning liquid, and the burning is violent. It is easy to explode, and difficult to extinguish.	Dry powder fire extinguisher, foam fire extinguisher, halogenated alkane fire extinguisher, carbon dioxide fire extinguisher.
Gas fire (Type C)	Fire caused by combustible gases, such as coal gas, natural gas, methane, etc., often cause deflagration or explosion, which is extremely destructive and difficult to extinguish.	The gas transmission valve or pipeline should be closed first, the power supply should be cut off, and then cooled to extinguish the fire. Dry powder fire extinguishers and halogenated fire extinguishers can be used.
Metal fire (Type D)	Refers to the fire of active metals, such as potassium, sodium, magnesium etc., mostly caused by spontaneous ignition when exposed to moisture and high temperature.	Dry sand, cast iron powder or sodium chloride dry powder metal fire extinguishers can be used (no water, foam, water-based substances, carbon dioxide and dry powder fire extinguishers).
Electric fire (Type E)	Refers to the fire with electric, such as fire in switchboard, substation, weak electricity equipment room, etc.	Carbon dioxide, dry powder, and halogenated fire extinguishers (water is prohibited) can be used. When extinguishing the fire, first cut off the power or keep a safe distance from the electrified area.

1.3.4 Common fire extinguishers and the methods of use

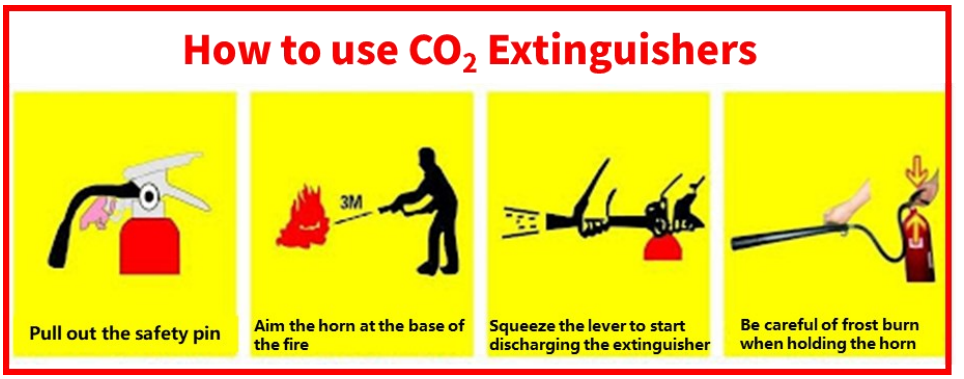
◇ Dry powder fire extinguisher

Dry powder fire extinguishers use carbon dioxide or nitrogen as the power to spray dry powder fire extinguishing agents. Among them, the sodium bicarbonate dry powder fire extinguisher is suitable for extinguishing the initial fire of flammable and combustible liquids, gases, and electrical equipment. In addition to the above, ammonium phosphate dry powder fire extinguishers can also extinguish the initial fire of solid materials. Before use, turn the fire extinguisher upside down several times to loosen the dry powder in the cylinder, then aim the nozzle at the most violent burning place, pull out the safety pin, and press down the lever.

◇ Carbon dioxide fire extinguisher

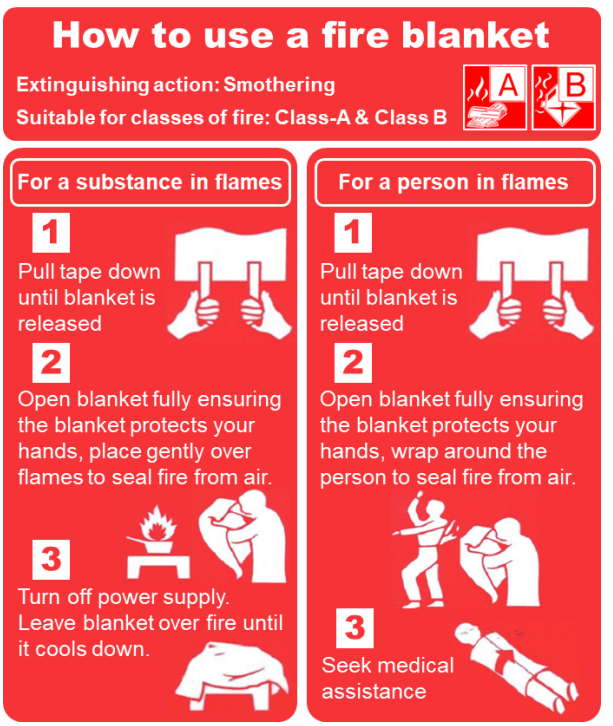
Carbon dioxide fire extinguishers use carbon dioxide to extinguish fires.

They are suitable for extinguishing the initial fire of precision instruments, electrical equipment below 600 volts, library materials, flammable liquids and gases. However, it cannot be used to extinguish metal fires or fires caused by chemicals containing oxidized groups. When in use, pull out the safety pin and pull the trumpet-shaped nozzle up to 70 ~ 90 degrees. Hold the bottom of the fire extinguisher cylinder with one hand, and hold the pressure lever of the valve with the other hand. Aim at the target and press down the lever.



◇ Fire blanket

Fire extinguishing blanket is a fabric made of glass fiber and other materials after special treatment, which can isolate the heat source and the flame.



Covering the burning items with a fire blanket can extinguish the combustion by isolating it from oxygen. When in use, pull down the two straps to take the fire blanket out of the package. Unfold the fire blanket completely, cover the fire source and cut off the power or gas source until the fire source cools. When besieged by the fire, you can also wrap the fire blanket and quickly escape from the fire area.

◇ Fire sand

Dry sand is mainly used to extinguish fires by isolating the combustion source from the air, which is particularly safe and effective for extinguishing small-scale metal fires and flowing liquid fires. When extinguishing the fire, spread the dry sand directly onto the fire, and dispose of it after the fire source has cooled down.

1.3.5 Handle laboratory fire accidents and self-rescue

When a fire occurs in the laboratory, it should be reported as soon as possible. Refer to the following principles to deal with laboratory fire accidents.

(1) Keep Calm

Never panic if a fire accident occurs. Calm down and organize the personnel present to use fire extinguishers to put out the fire immediately at its beginning stage according to the fire safety knowledge you learned from the safety training and the fire drills. If the fire develops quickly, you must escape from the scene as soon as possible.

(2) Race against time

When using a fire extinguisher to put out a fire, it is more effective to use all the fire extinguisher at the same time instead of using them one by one. Race against time to extinguish the fire as soon as possible is the best way to prevent the fire from spreading. Don’ t panic or run wildly, which would probably miss the best fire extinguishing time window and lead to a disaster.

(3) Evacuation

In the event of a fire, a fire extinguishing team shall be formed by a person with strong ability on site to put out the fire. The rest people shall be organized to evacuate from the scene. The evacuation process should be orderly to prevent accidents such as trampling.

(4) Emergency call in time

When extinguishing the initial fire, report it at the same time. In this way, you can get the support of campus security or firefighters earlier, extinguish the fire quickly and reduce the loss.

(5) Life is paramount

In the process of extinguishing fires, the principle of "saving people has priority over firefighting" must be followed. If there is a siege of fire, the trapped people must first be rescued. If the fire is difficult to control, the non -professional firefighters must evacuate to ensure their own safety.

(6) Power off and gas off

If there is a fire in the electrical circuit or equipment, cut off the power before putting out the fire. If a leak of flammable gas is found, do not touch any electrical switch, or use an open flame, and do not call the police indoors

to avoid ignition sources. Close the gas source quickly, open the windows and doors, reduce the concentration of combustible gases, and prevent deflagration.

(7) Open doors and windows with caution

Don't rush to open the doors and windows when fighting the fire, so as to prevent the air convection accelerate the fire spread. If the fire area is indoor, opening doors and windows will accelerate the spread of fire; if the fire area is outdoor, smoke will pour in through the doors and windows, easily poisoning and suffocating people.

When escaping from the fire, you should pay attention to the following tips.

1) Get familiar with the escape path of the laboratory, firefighting facilities and self-help methods, and actively participate in emergency escape drills;
2) When a fire occurs, keep calm, identify the direction, and evacuate quickly, and don't be crowded or rushed. You should run down as far as possible. If the passage is blocked by the fire or smokes, you should leave away from the direction of the fire or smokes and escape upward through the balcony, transom, rooftop, etc.;
3) In order to prevent the inhalation of smoke, wet towels and masks can be used to cover the nose while creeping to evacuate. You can also wear air-filled plastic bags to escape from thick smoke;
4) It is strictly forbidden to escape through the elevator. If the passageway has been burned out or blocked by the fire, you can escape through the rooftop, balcony, downspout, etc., or tie a rope to a fixed object, and then pull the rope slowly down;

5) If you cannot evacuate, you should retreat indoors and close the doors and windows that towards fire area. Water the doors and windows, plug the door gap with a damp cloth strip, and send out help signals by waving clothes, throwing objects, shouting, flashlights, etc., waiting for rescue;

6) If your body is on fire, you must not run or flap. You should quickly extinguish the fire by tearing off the clothes, splashing water on body, rolling on the ground, or covering the heavy clothes, etc. ;

7) Don't be greedy for the property. Never return to the fire easily.

1.4 Laboratory electricity safety

There are many high-power electrical equipment in the laboratory. If the electricity problem occurs, it will easily cause power failure, fire, electric shock and other problems, which will be a threat to personal safety, equipment safety, property safety, etc.. Attention should be paid to the safe use of electricity in the laboratory:

1) The power supply, socket power, etc. must match the power requirement of the equipment;

2) Do not connect the wiring board in series, directly put the wiring board on the ground, or connect the wires indiscriminately in the laboratory. The power socket or switch must be fixed;

3) Do not allow wires and electrical appliances to be wetted by water or immersed in conductive liquids;

4) Before starting the experiment, it is necessary to check the electrical equipment before turning on the power. After the experiment, turn off the electrical equipment first, then turn off the power;

5) During the experiment, if a power failure suddenly occurs, the device should be turned off before checking the cause.

Chapter 2 Hazardous Chemicals

Chemicals are the most direct source of potential hazards for everyone working and studying in the laboratory. Therefore, everyone entering the laboratory must learn about the safe use of chemicals. This chapter will explain the classification, storage, use, and disposal of hazardous chemicals, and provide practical emergency knowledge for laboratory chemical accidents.

2.1 Classification of hazardous chemicals

Hazardous chemicals refer to the chemicals that are highly toxic, corrosive, explosive, combustible, combustion-supporting, and other chemicals that are harmful to humans, facilities, and the environment. ("Regulations on the Safety Management of Dangerous Chemicals" Order No. 591 of the State Council of the People's Republic of China, 2011)

The current classification standards for hazardous chemicals in China are "General Rules for Classification of Chemicals and Hazard Announcement" (GB 13690-2009) and "Dangerous Goods Classification and Name Code" (GB 6944-2012). "Dangerous Goods Classification and Name Code" divides chemicals into 21 types in 9 categories according to their hazards or the most important hazards. The 9 categories are: 1) Explosives; 2) Compressed and liquefied gases; 3) Flammable liquids; 4) Flammable solids, substances that are easy to ignite spontaneously, and substances that emit flammable gases in contact with water; 5) Substances with oxidizing properties and organic peroxides; 6) Toxic substances and infectious substances; 7) Radioactive substances; 8) Corrosive substances; 9) Miscellaneous dangerous substances.

In addition, precursor chemicals in WKU laboratories are also included in the control list of hazardous chemicals. According to the "Regulations on the

Management of Precursor Chemicals", precursor chemicals are divided into three categories. The first category is the main raw materials that can be used for drug production, and the second and third categories are chemical formulations that can be used for drug production.

Based on the above criteria, the common hazardous chemicals in WKU laboratory are as follows. (Please note that this table is not a complete example. Please check the MSDS of the chemical to be used, or consult the course instructor before use.)

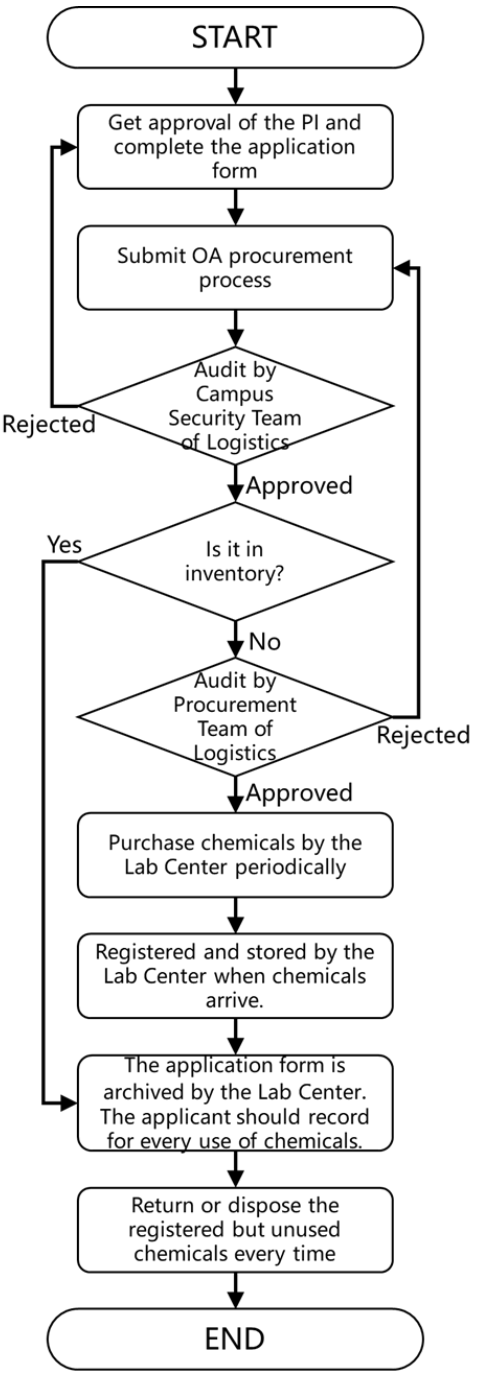
Table2-1 Common Hazardous Chemicals in WKU Lab

Hazard category	Chemicals
Combustion-supporting or flammable Chemicals	Hydrogen peroxide, acetone, barium nitrate, cyclohexane, ether, formaldehyde, methanol, petroleum ether, potassium nitrate, potassium permanganate, calcium nitrate, cyclohexanone, dichloromethane, magnesium, toluene
Precursor Chemicals	Acetic anhydride, toluene, chloroform, hydrochloric acid, ether, acetone
Corrosive Chemicals	Hydrochloric acid, nitric acid, sulfuric acid
Toxic Chemicals	Aniline, chloroform, potassium dichromate, mercury iodide, phenol

2.2 Purchase of hazardous chemicals

Any research group or individual applying for the purchase or use of hazardous chemicals must comply with the "Wenzhou-Kean University Hazardous Chemicals Management Regulations" . It is forbidden to purchase or transfer chemicals privately.

The application flowchart is as follows:



2.3 Storage of hazardous chemicals

The storage of chemicals should follow the general principles listed:

1) All chemicals and prepared reagents should be placed in appropriate containers and labeled with clear information. Reagents without labels or with unrecognizable labels should be treated as hazardous wastes and should not be discarded casually before re-identification;
2) All chemicals should be stored properly: a) The storage place must be ventilated, insulated and safe; b) All the chemical containers should be kept sorted, neat and clean; c) Do not store large amounts of reagents in the laboratory; d) Never leave a chemical container uncovered (it will pollute the air);
3) The laboratory must establish a chemical ledger and update it in time, and record the storage, usage, and return;
4) Clean up the unnamed and expired chemicals in time.

The following tips should be noted when sorting and storing the chemicals:

1) Flammable liquids: should be kept in a cool, dry, and well-ventilated place away from light and fire. The bottles should not be full. It is best to keep the flammable liquids in an explosion-proof refrigerator;
2) Corrosive liquids: Use a corrosion-resistant reagent cabinet to store corrosive liquids, and place all the corrosive liquids in the lower position of the cabinet;
3) Highly toxic chemicals: should be placed in a reagent cabinet with double locks;
4) Flammable and explosive solids: should be stored at low temperatures away from flammables and oxidants. It is best to keep the flammable and explosive solids in an explosive-proof refrigerator;
5) Chemicals requiring low-temperature storage: it is recommended to store below 10 ℃, such as styrene, acrylonitrile, vinyl acetylene, me-

thyl methacrylate, ammonium hydroxide;

6) Specially stored chemicals: alkaline metals such as potassium and so-

Table 2-2 Common Chemicals That Cannot Be Stored Together

Chemicals That Cannot Be Stored Together	
Chemicals	DO NOT be co-stored with
Strong acid (especially concentrated sulfuric acid)	Strong oxidant salts (potassium permanganate, potassium chlorate, etc.) and water
Potassium cyanide, sodium sulfide, sodium nitrite, sodium chloride, sodium sulfite	Acid
Reducing agent, organic matter	Oxidants, sulfuric acid, nitric acid
Alkali metals (sodium, potassium, etc.)	Water or aqueous solution
Easily hydrolyzed drugs (acetic anhydride, acetyl chloride, thionyl chloride)	Aqueous solution, acid, alkali, etc.
Halogen (fluorine, chlorine, bromine, iodine)	Ammonia, acid and organic matter
Ammonia	Halogen, mercury, hypochlorous acid, acid

Table 2-3 Common Combustible or Explosive Chemical Reactions

Common Combustible or Explosive Chemical Reactions		
Chemicals	React with	Results
Concentrated nitric acid, sulfuric acid	Turpentine, ethanol	Combustion
Hydrogen peroxide	Acetic acid, methanol, acetone	Combustion
Potassium perchlorate	Ethanol, organic matter; sulfur, organic matter	Explosion
Potassium, sodium	Water	Explosion
Acetylene	Silver, copper, mercury compounds	Explosion
Nitrate	Esters, sodium acetate, stannous chloride	Explosion
Peroxide	Magnesium, zinc, aluminum	Explosion

dium (stored in kerosene), yellow phosphorus (stored in water), picric acid (keep the solids wet with a layer of water), magnesium and aluminum (stored in a moisture-proof place), moisture-prone and Easy to hydrolysate (stored in a dry place, the seal should be tight), hydrogen peroxide (stored in a plastic bottle, wrapped in black paper). For other cases, refer to the SDS of specific chemicals.

2.4 Use of hazardous chemicals

Pay attention to the following tips when using hazardous chemicals:

1) Before the experiment, you should carefully read the SDS of the chemicals used, understand the properties of the chemicals, and take necessary protective measures;
2) Before using the chemicals, you must learn about the operating specifications of the chemicals. Do not touch, taste, or smell the chemicals directly;
3) On the premise of not affecting the experimental results, try to replace the high-hazard substances with low-hazard substances, and conduct small-scale or semi-micro experiments to reduce the amount of hazardous chemicals;
4) Operate in strict accordance with the operating procedures. Observe experiment and record data carefully, do not leave the ongoing experiment unattended;
5) It is strictly forbidden to heat the organic solvent in an open container or closed system with an open flame, and it is not allowed to store or bake flammable organic materials in the oven;
6) All operations involving toxic gas must be carried out in a fume hood that works effectively. Before conducting experiments involving toxic chemicals, an emergency plan must be prepared based on SDS. All

students must be led by instructors when using toxic chemicals, and unauthorized personnel is forbidden to use any chemicals in the laboratory;

7) After the experiment, the waste should be collected and recorded in accordance with the regulations, and transferred to the qualified company for disposal by laboratory center staff afterwards. Clean yourself thoroughly and leave without contaminants after finishing the experiment.

SDS (Safety Data Sheet), also known as MSDS (Material Safety Data Sheet), is a document used by chemical manufacturers and importers to clarify the physical and chemical properties of chemicals and the possible harm to users' health. The Chinese standard document "GBT16483-2008 Safety Data Sheet for Chemical Products -- Content and Order of Sections" and the US OSHA standard document "Hazard Communication Standard: Safety Data Sheets (29 CFR 1910.1200 (g))" have similar regulations on the form of SDS, which state that the following contents need to be included in a SDS document:

1) Chemical identification;
2) Hazard(s) identification;
3) Composition/information on ingredients;
4) First-aid measures;
5) Fire-fighting measures;
6) Accidental release measures;
7) Handling and storage;
8) Exposure control and personal protection;

9) Physical and chemical properties;

10) Stability and reactivity;

11) Toxicological information;

12) Ecological information;

13) Disposal considerations;

14) Transport information;

15) Regulatory information;

16) Other information.

Therefore, SDS is the most important reference document in the safe use of hazardous chemicals.

2.5 Emergency response to chemical related accidents

When a chemical safety accident occurs in the laboratory, it should be reported to the teacher in charge immediately, and active measures should be taken for emergency treatment. If the situation is serious, it should be sent to the hospital for treatment immediately. The Chemical Safety Data Sheet (MSDS) contains information on the emergency treatment plan for the safety accidents of specific substances. Before operating a chemical with a higher risk, the operator must carefully read the MSDS and prepare an emergency plan. For common chemical-related accidents, such as chemical poisoning, burns, leaks, and fires, please refer to Chapter 6 "Labor Safety Accident Emergency Response" of this manual.

Chapter 3 Biological Safety

Due to several outbreaks of infectious diseases worldwide in recent years and the occurrence of laboratory infections accidents in many countries, biological safety has become an increasing concern of various countries. Once a laboratory biological safety accident occurs, it not only harms the health of the laboratory users, but is also more likely to bring unpredictable harm and impact to the entire human society. Therefore, laboratory biological safety is of great importance. Laboratory personnel must learn the basic knowledge and skill of biological safety, be equipped with appropriate personal protective equipment, and be familiar with laboratory standard operating procedures and emergency plans before entering the laboratory.

3.1 Essentials of biological safety

3.1.1 Definition of biological safety

Biological safety is the discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. It refers to the use of things such as animal or human tissues, blood, microorganisms, genetically modified organisms, and dangerous pathogens. In order to minimize the possibility of incidents occurring, standard laboratory practices and risk assessments must be used.

3.1.2 Risk group classification

The World Health Organization has developed a classification standard for risk levels according to the relative hazards of infective microorganisms (WHO Risk Groups 1, 2, 3, 4). Research involving organisms in risk groups 2, 3, and 4 are NOT permitted at Wenzhou-Kean University.

Table 3-1 Classification of infective microorganisms by risk group (WHO)

Infectious microorganism risk groups
Risk Group 1 (no or low individual and community risk)
A microorganism that is unlikely to cause human or animal disease.
Risk Group 2 (moderate individual risk, low community risk)
A pathogen that can cause human or animal disease but is unlikely to be a serious hazard to laboratory workers, the community, livestock or the environment. Laboratory exposures may cause serious infection, but effective treatment and preventive measures are available and the risk of spread of infection is limited.
Risk Group 3 (high individual risk, low community risk)
A pathogen that usually causes serious human or animal disease but does not ordinarily spread from one infected individual to another. Effective treatment and preventive measures are available.
Risk Group 4 (high individual and community risk)
A pathogen that usually causes serious human or animal disease and that can be readily transmitted from one individual to another, directly or indirectly. Effective treatment and preventive measures are not usually available.

3.1.3 Biosafety levels (BSL)

Biosafety level designations are based on a composite of the design features, construction, containment facilities, equipment, practices, and operational procedures required for working with agents from the various risk groups. Experiments involving pathogenic microorganisms should be carried out in the corresponding biosafety level laboratories. There are four biosafety levels including BSL-1, BSL-2, BSL-3, and BSL-4, of which BSL-3 and BSL-4 can perform experimental activities with highly pathogenic microorganisms. Before starting these researches, nationally recognized qualifications should be obtained.

The biological hazard warning symbol must be displayed on the doors of the

rooms to notify workers about the presence of infectious agents. The warning sign should include the information as follows: biosafety level, infectious pathogens, responsible investigator, and emergency call.

Table 3-2 Laboratory Biosafety Levels in China

Laboratory Biosafety Levels in China		
Lab Level	Hazard Level	Safety Facilities
BSL-1	Level 1	No need, open experimental bench
BSL-2	Level 2	Open experimental bench, a biological safety cabinet is required to protect against possible aerosols
BSL-3	Level 3	Biological safety cabinets, autoclaves, and other basic equipment
BSL-4 (Top Level)	Level 4	Class III biological safety cabinet, or class II biological safety cabinet with positive pressure suit, double-door autoclave, filtered air, etc.

3.2 Regulations for biological safety

3.2.1 Operation safety in the laboratory

1) Only authorized persons can be allowed to enter the laboratory working areas.
2) Know what you are handling at all times, understand the risks involved and what to do in case of emergency.

3) Always wear appropriate personal protective equipment such as gloves, lab coat, goggles, masks, and face shields.

4) Gloves should not be used to touch doorknobs, cellphones, or faces.

5) Always use appropriate pipetting devices. Never pipet with your mouth. Hypodermic needles and syringes should not be used as substitutes for pipetting devices.

6) Personnel must wash their hands after handling infectious materials and animals, and before they leave the laboratory working areas.

7) All technical procedures should be performed in a way that minimizes the formation of aerosols and droplets.

8) The laboratory should be kept neat, clean, and free of materials that are not pertinent to the work.

9) Work surfaces must be cleaned and decontaminated after any spill of potentially dangerous material and at the end of the working day.

10) Bleach solutions or 70% alcohol solutions can be used to deal with the biohazard spill. Bleach solutions should not be used on fabric, carpeting, or metal surfaces.

11) All contaminated materials, specimens, and cultures must be decontaminated before disposal or cleaning for reuse.

12) All spills, accidents and overt or potential exposures to infectious materials must be reported to the laboratory supervisor or technicians.

13) Do not work alone in a laboratory; be sure someone is nearby in case of emergency.

14) Work areas, items, or equipment which may be exposed to pathogenic microorganisms should be disinfected regularly.

15) Appropriate biological safety cabinets, autoclaves, or other means of decontamination should be available in the lab. Experiments involv-

ing biohazardous factors should be performed in the biological safety cabinets.

3.2.2 Personal protective equipment (PPE)

Individuals should wear appropriate personal protective equipment in the lab. All PPE should be removed when leaving the work area or if overtly contaminated and placed in an appropriately designated area for washing, decontamination, or disposal.

Table 3-3 Common laboratory protective equipment and functions

Equipment	hazardous	Security features
Lab coats, gowns	Contaminating clothes	Must be worn at all times when working in the lab
Plastic aprons	Contaminating clothes	Waterproof
Shoes	Splashes or collision	Closed-toed
Safety goggles	Splashes or collision	Protect eyes, anti-collision lenses with side shields
Face shields	Splashes or collision	Protect face
Gas masks	Inhaling aerosols	Face shield with air purifying respirator
Gloves	Contacting with microorganisms	Must be worn when handling or touching biological materials

3.2.3 Animal use

1) Experimental animals should be purchased from the companies which have the license for laboratory animal production.

2) Animals should be raised and animal experiments should be performed in the labs which have the license for the use of laboratory animal. It is prohibited to handle animals in those labs without the license.

3) 3R principles (reduction, refinement, replacement) should be complied with when performing animal experiments in order to reduce the impact of research on animals. Replacing experiments on animals with alternative techniques.

4) Individuals that work on animal experiments or researches should be trained and get the qualification of using laboratory animal.

5) Animals' corpses or tissues should be disposed properly. It is prohibited to throw them into trash bins.

3.2.4 Biological waste management

Biological waste management is a critical part of biosafety. In addition to the same classification, storage, and unified treatment processes as other laboratory wastes, infectious biological wastes need to be autoclaved and other innocuous treatments. For specific treatment methods and points of attention, please refer to Chapter 4 "Laboratory Waste Safety Management Regulations" in this manual, and the "Wenzhou-Kean University Laboratory Waste Disposal Regulations".

Chapter 4 Laboratory Waste Management

Laboratory waste refers to the waste generated in the daily research and experiment process that has lost its use-value and is intended to be discarded, including waste gas, waste liquid, and waste solids. The wastes may have the characteristics of diversified, corrosive, ignitable, toxic, and infectious. Therefore, in order to protect laboratory users and the campus environment, it is crucial to strengthen the management of laboratory wastes and establish a waste disposal process.

4.1 Classification of Laboratory waste

4.1.1 Ordinary waste

Table4-1 Classification of Ordinary Waste

No.	Category	Contents
1	Paper	Newspapers, tissues, books, packaging papers, paper boxes, etc.
2	Plastic	Plastic bags, plastic packages, disposable plastic items, beverage bottles, etc.
3	Glassware	Glass bottles, broken glasses, mirrors, bulbs, etc.
4	Metal	cans
5	Cloth	Discarding clothes, towels, tablecloth, etc.
6	Hazardous waste	Batteries, lamps, mercury thermometer, expired drugs etc., need special handling
7	Others	In addition to the above types of wastes

4.1.2 Solid waste

1) Infectious waste: refers to the items produced in biological experiments, contaminated by infectious organisms or media, such as masks, gloves, waste specimens, pipette tips, plastic tubes, laboratory clothes, etc.

2) Sharps waste: refers to the sharps generated in the labs, such as needles, blades, syringes, Petri dishes, test tubes, glass slides, etc.

3) Pathological waste: refers to the discarded tissues, organs, medical laboratory animal carcasses, tissue sections after pathological sectioning, etc., generated during the experiment.

4.1.3 Liquid waste

Table 4-2 Definition and classification of liquid waste

No.	Category	Contents
1	General liquid waste	Water for cooling, water for cleaning
2	Laboratory liquid waste	Chemical liquid waste (inorganic and organic)
3		Biological liquid waste
4		Physical liquid waste (overheating and super cooling)
5		Radioactive liquid waste

4.1.4 Gaseous waste

Laboratory gaseous wastes includes volatiles of reagents and samples, by-products of the experimental process, and leaked experimental gas.

1) Inorganic gaseous waste includes carbon dioxide, oxynitride, hydrogen chloride, hydrogen fluoride, hydrogen sulfide, and sulfur dioxide.

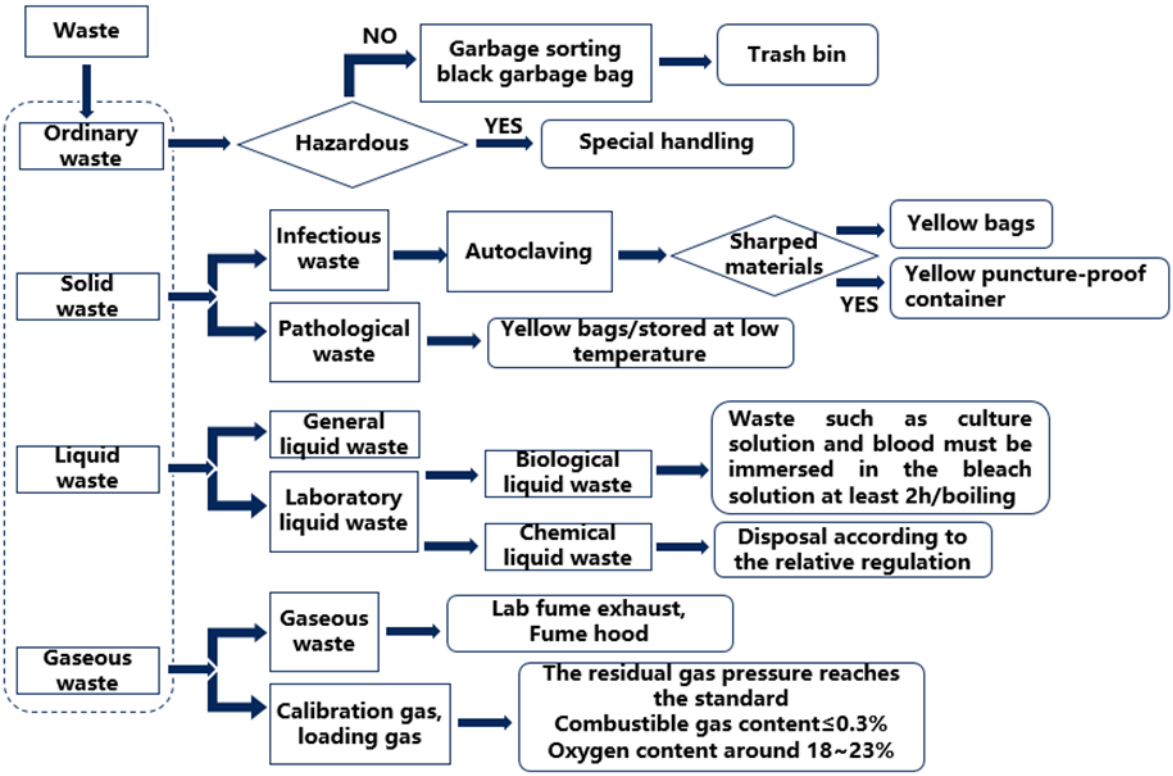
2) Organic gaseous waste includes aroma, aldehyde, ketone, ester, and alcohol.

4.2 General guidelines of laboratory waste collection and storage

In the process of laboratory waste disposal, collection and storage are inevitably involved. The following points should be noted during waste collection and storage:

1) Use a classified storage container and place it in a specified location with a warning sign;
2) Compatible wastes can be collected in the same container, and incompatible wastes are prohibited from mixing to prevent reactions;
3) A label should be firmly attached to the waste collection container. The label content should include:
    a. Waste composition, amount and its hazard,
    b. Storage start date and due date,
    c. Location,
    d. Responsible personnel and contact phone number;
4) Avoid storing waste for too long, generally not more than one year. It should be treated in time or sent to a professional department for disposal;
5) For infectious wastes or hazardous biological wastes, appropriate containers and locations should be selected according to their characteristics. Dedicated personnel should be responsible for collecting, disinfection, and burnt treatment. And all infectious wastes must be daily disposed;
6) Harmless biological waste should not be discarded at will. The waste should be put into a specified plastic bag, sealed, labeled, and stored in a specified location for regular treatment;
7) Highly toxic chemical waste and radioactive waste must be separately managed, collected, stored and transported per relevant management requirements.
8) Recycled waste containers must be cleaned before reuse, and discarded waste containers must also be disposed of as laboratory waste.

4.3 Waste management process



4.4 Disposal of chemical waste

4.4.1 Storage of chemical waste

The storage of chemical waste should choose a suitable container and storage location. The storage location has corresponding warning signs (as shown in the figure); the label of the waste container indicates: type and time. Chemical waste should be collected and stored separately.

Due to the different types of chemical reagents used, each laboratory will set up different chemical waste containers to temporarily store the chemical waste according to the actual situation. After collection, the laboratory center is responsible for regularly entrusting a qualified organization for processing. For the detailed implementation rules, please refer to the

"Experimental Waste Disposal Regulations of Wenzhou-Kean University".

4.4.2 Classification and disposal of chemical waste liquid

Table 4-3 Classification and Disposal Methods of Waste Chemical Liquids

Waste classification			Disposal
Inorganic waste liquids	Acidic waste	Acids stronger than pH2.0 are equivalent to a more than 5% nitric acid	After neutralization or dilution, waste liquid with a pH above 5.0 can be poured into a inorganic liquid waste container
	Alkaline waste	Bases stronger than pH12.0 are equivalent to a more than 1% sodium hydroxide	After neutralization or dilution, waste liquid with a pH below 12.0 can be poured into a inorganic liquid waste container
	Wastewater containing heavy metals	Heavy metals such as: Iron, cobalt, copper, manganese, lead, gallium, chromium, titanium, germanium, tin, aluminum, magnesium, nickel, zinc	waste liquid should be poured into a separate container
	Mercuric	Mercury、Organic mercury compounds	waste liquid should be poured into a separate container
	Cyanide	Waste containing cyanide ion or cyanide compounds	waste liquid should be poured into a separate container, and must maintain a strong alkalinity
	Fluoride	Waste containing fluoric acid or fluorine compound	A little of waste liquid could be poured into a inorganic liquid container if there has no separate container
Organic waste liquids	Fat and oil	Turpentine, heavy oil, insulating oil（excluding PCBS）, lubricating oil, cooling oil, vegetable oil, etc.	It should be poured into a separate container for fat and oil
	Organic solvent with halogen	Aliphatic compounds with halogen, or aromatic compounds with halogen	It should be poured into halogenated solvent organic liquid waste container
	Organic solvent without halogen	various alcohols, ethers, alkanes, aromatic compounds with benzene rings	It could be poured into an organic liquid waste container

4.5 Reduce laboratory waste

Despite the classified treatment, the environmental impact of the waste produced in the laboratory cannot be ignored. The best treatment of laboratory waste is to reduce waste generation from the source. It can be considered from the following aspects:

1) Modification of experimental methods: use precision analytical instruments to replace traditional analytical methods; try to use micro-analysis techniques to reduce the use of chemical reagents;
2) Avoid over-purchasing: The amount of reagents should be evaluated reasonably to avoid over-purchasing, which may cause reagents to expire;
3) Reduce the amount of toxic and hazardous reagents: optimize experimental methods, reduce the amount of toxic and hazardous reagents used, or use low-toxic reagents instead of high-toxic ones;
4) Appropriate amount of prepared solution: The solution should be prepared according to the experimental amount. Excessive storage solution is a major source of laboratory waste;
5) Reagent recycling: some reagents can be recycled and reused after experiment, or low-purity reagents after use can be recycled for low-precision experiments to reduce unnecessary reagent waste.

Chapter 5 Safe Use of Laboratory Equipment

Many instruments and equipment are commonly used in the laboratory, such as glass instruments, high-pressure equipment, heat device and low-temperature device. If it is used improperly, it may cause the accident. Before using a piece of equipment for the first time, the operator should study the instruction manual and seek training by an experienced personnel. If a piece of equipment breaks down or needs maintenance, make sure it is decontaminated before asking someone to work on it. Do not keep using a piece of equipment that seems faulty nor try to repair it yourself; simply report it to the Lab safety staff.

5.1 General equipment

5.1.1 refrigerator

Laboratory refrigerators are generally used for the preservation of chemical reagents and biological samples.

1) The refrigerator should be placed in a well-ventilated place to ensure heat dissipation. Inflammable and explosive products, gas cylinders and sundries are prohibited to be stacked near the refrigerator.
2) The refrigerator is not allowed to be used for an extended period of 10 years.
3) No food shall be stored in the laboratory refrigerator.
4) The stored items should be clearly marked (name, time, etc.).
5) Hazardous chemicals with low flash point must be stored in the refrigerator with explosion-proof function, and marked warning labels should be pasted on the refrigerator.
6) The refrigerator storing samples of infectious microorganisms should

be equipped with appropriate locks and pasted with warning labels.

7) Containers for storing volatile organic reagents must be sealed to avoid accumulation of volatile reagents in the refrigerator.

8) Chemical should be transferred promptly if the electricity goes off and should use backup power.

5.1.2 Heat device

Different sources of heat within laboratories can do a lot of harm. Here are some simple guidelines that can be followed to prevent heat related injuries:

1) Heating devices should be set up on a sturdy fixture and away from any ignitable materials (such as flammable solvents, paper products, and other combustibles). Do not leave open flames (e.g., Bunsen burners) unattended.

2) Heating devices should not be installed near drench showers or other water spraying apparatus.

3) Ensure that heating does not cause a drastic reaction and that there is a way to cool the reaction.

4) Post signs to warn people of the heat hazard.

5) It is forbidden to use oven to heat flammable and volatile materials such as solvents, oils, and plastic baskets. If toxic, flammable, or otherwise hazardous chemicals are generated by the oven, it should be placed in a ventilated location.

6) When using the water bath, the heat conduction medium should be added but not be full. Notice the water bath and not to touch the heating surface.

5.1.3 Centrifuges:

The centrifuge is commonly used in biology and chemistry experiment. When using the centrifuge, the following operations must be paid attention to:

1) Centrifuges spin at a high rate of speed and, if not balanced, will damage equipment and harm individuals. The centrifuge tube must be placed symmetrically in the casing to prevent fuselage vibration. If there is only one sample tube, the other one should be replaced with water of equal quality.
2) Be sure to wipe up any spills immediately to avoid solidification or corrosion of the machine.
3) Any corrosive, hazardous, or biohazardous materials should only be centrifuged after proper second sealing.
4) The power should be cut off immediately and obstacles should be removed timely if there is noise or vibration in the centrifuge.
5) The centrifuge lid should be covered before starting the centrifuge.

5.1.4 Fume hood

1) It should be established that the hood is functioning properly before it is used. Let the blowers operate with no activity inside.
2) Operate at least 15cm from the fume hood. Reduce sharp movement in front of the fume hood.
3) Hoods are not intended to be a primary storage unit for chemicals. Materials stored in them should be kept to a minimum. Stored chemicals should not block vents or alter airflow patterns. Whenever practical, chemicals should be moved from hoods into cabinets for storage.
4) Do not put your head or upper body into the fume hood during the

experiment.

5) When the operator is not operating, make sure the glass window is closed.

6) An emergency plan should always be prepared for the event of ventilation failure (power failure, for example) or other unexpected occurrences such as fire or explosion in the hood.

7) Do not close the exhaust immediately when the experiment is completed. Continue to exhaust for 1-2 minutes to ensure that all harmful gases and residual exhaust gases are discharged from the fume hood.

8) The workbench must be cleaned thoroughly after finishing working.

5.1.5 Biological Safety Cabinet

1) Biological Safety Cabinets are isolation mechanisms for limiting the spread and exposure of biological materials.

2) They are to be cleaned and disinfected on a regular basis, and their germicidal UV lights replaced at least once per year with regular use.

3) Operate the cabinet blowers for at least five minutes before beginning work to allow the cabinet to purge or remove particulates.

4) Avoid rapid movements inside the cabinet. Perform procedures slowly to avoid disrupting the containment properties of the cabinet.

5) Raise arms slightly and perform operations in the middle third area of the work surface, being sure not to block the rear exhaust grille.

6) When the work is completed, remove all items inside the cabinet. Do not use the interior of the BSC as a storage area. Clean all the interior surfaces of the cabinet with a suitable disinfectant. Let the blowers operate for at least five minutes with no activity inside the cabinet to purge the BSC of contaminants.

5.2 Special equipment

The special equipment used in our laboratory is pressure vessels, including autoclave and gas cylinder.

5.2.1 Autoclave

1) Proper training and operating procedures should be taken before using the autoclave.
2) Read the owner' s manual when using the autoclave for the first time. Operating instructions should be posted near the autoclave. Follow the instructions for operating the autoclave.
3) Autoclave should be inspected regularly to ensure its safety and effectiveness. If the autoclave stop running for a long time, it should pass the quality inspection before reuse.
4) Fill bottles halfway to allow for liquid expansion and loosen screw caps on bottles and tubes of liquid before autoclaving to prevent them from shattering.
5) Do not overload the autoclave compartment to ensure enough space between items for the steam to circulate.
6) At the end of the run, open the autoclave slowly: first, open the door only a crack to let any steam escape slowly for several minutes, and then open all the way. Opening the door suddenly can scald a bare hand, arm, or face.
7) Wait at least five minutes after opening the door before removing items.
8) Wear appropriate PPE, including eye protection and heat-resistant gloves.

5.2.2 Gas cylinder

1) The contents of any compressed gas cylinder must be clearly identified by being stenciled or stamped on the cylinder, or attached with a label.
2) When transporting cylinders, always use a hand truck equipped with a chain or belt for securing the cylinder. A protective cap must be used to cover the cylinder valve. Do not move compressed gas cylinders by carrying, rolling, sliding, or dragging them across the floor.
3) Do not transport oxygen and combustible gases at the same time.
4) Gas cylinders must be secured to prevent them from falling over. Be sure the chain is high enough (at least halfway up) on the cylinder to keep it from tipping over.
5) Do not store incompatible gases next to each other. Cylinders of oxygen must be stored at least 20 feet away from cylinders of hydrogen or other flammable gases, or the storage areas must be separated by a firewall five feet high with a fire rating of 1/2 hour.
6) All cylinders should be stored away from heat and away from areas where they might be subjected to mechanical damage. Equipped with emergency rescue facilities, gas detection and alarm devices
7) Gas cylinders should be regularly inspected. If severe corrosion, bulge, cracks, etc. are found, the cylinder should be returned to the manufacturer for maintenance. No cylinder shall be used beyond the validity period of inspection or without a valid inspection stamp.
8) Confirm the emergency procedure for each type of gas
9) Before and after use, check the gas pipes, joints, switches and instruments for leakage.
10) Close the main valve on gas cylinders, then to release excess pressure in the regulator after use.

Chapter 6 Responses to Laboratory Emergency

Emergencies can occur at any time and without warning. Careful planning and appropriate responses can save lives – including your own. Every member of the Wenzhou-Kean university community shares responsibility for emergency preparedness. In the case of an emergency, please follow your College' s Emergency Procedure Manual and contact the security guard as well as the lab center. This chapter mainly introduces the possible accident and handling methods.

6.1 Preparations for Emergency

6.1.1Prepare for fire

1) Be familiar with the safety escape route around the laboratory.
2) Be familiar with the location of fire alarms and fire extinguishers. Ensure that the fire extinguishers can be used at hand.
3) Do not tamper with any fire extinguishers. Keep all fire doors closed.
4) Make a risk assessment before starting the experiment.

6.1.2 Preparation for lab emergency

1) Check the MSDS of the chemical before using it.
2) Be familiar with the location of safety equipment.
3) Prepare adequate first aid supplies.
4) Understand the potential hazard of the materials. Follow the standard operation procedure.
5) Take the operation training and safety training before accessing to the lab.

6) If there is a doubt about handling, let safety personnel handle it.

6.1.3 Preparation for injury

1) Learn first aid
2) Be familiar with the location of emergency shower, eyewash and first aid kit.
3) If a hazardous chemical like hydrofluoric acid will be used, the operator should learn how to use the antidote and make full preparations before the experiment.

6.2 General procedure for emergency

6.2.1 Principles of Emergency Response

In the event of an lab emergency, measures should be taken in the following priority order:

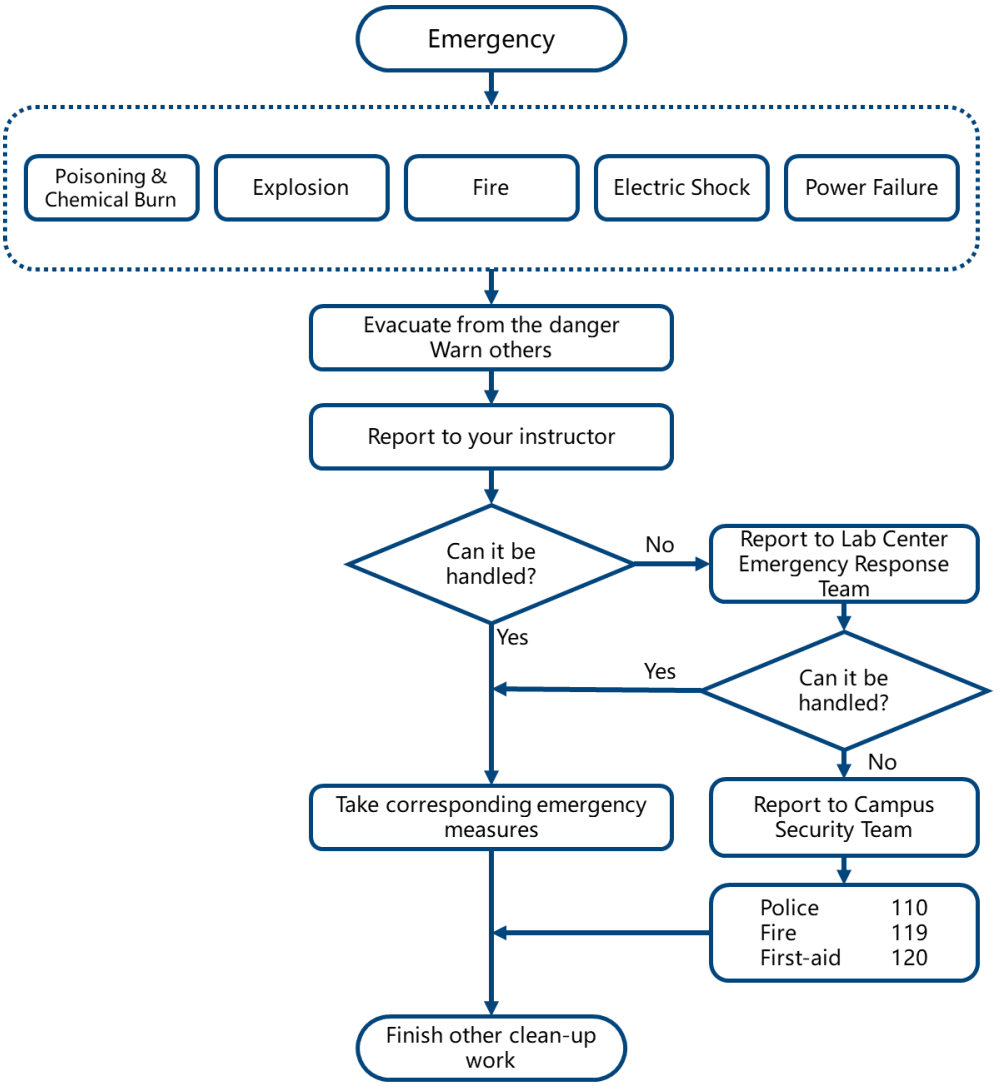
1) Personal safety is paramount. Protect yourself and others is always the first priority.
2) Protection of public property.
3) Protection of academic materials.

6.2.2 Common Procedures for Emergency Response

Provide the following information when calling for help:

1) Accident location.
2) Accident description with its severity.
3) Your name, location and contact number.

Refer to the following flowchart for emergency response:



6.3 Emergency response to all kinds of accident

6.3.1 Hazardous Chemicals Emergency

The two main routes of poisoning are inhalation, ingestion.

◊ Inhalation of hazardous chemicals

1) Cut off the source of hazardous chemicals, then open doors, windows to reduce the toxic concentration. Alert personnel in the affected area and advise them to evacuate. Move the victim to an air circulation area, loose the collar button, make the victim breathe easy.

2) If the patient has a reduced respiratory capacity, give immediate artificial respiration until medical help arrives.

3) Emergency responders must pay attention to their own safety during the rescue process and wear appropriate PPE.

◊ Ingestion of Hazardous Chemicals

1) If the chemical has not been swallowed in the mouth, spit it out immediately and then rinse your mouth with plenty of water. Drink plenty of water to induce vomiting.

2) Reduce the concentration of chemicals in the stomach by drinking milk, starch, mashed potato suspension, slowing the poison absorption, and protecting the gastric mucosa.

3) People poisoned by heavy metals can also drink milk or egg whites to reduce the binding of heavy metals to proteins in the body and reduce the harm to people. Arsenic and mercury poisoning victims must seek urgent medical attention.

4) Emetics: Emetics is effective up to four hours after taking the poison. A simple method is to stimulate the pharynx and tongue with a finger, cotton swab or metal spoon handle. It is forbidden in cases of unconsciousness, seizures, and when strong acids, alkalis and other corrosives, gasoline, kerosene and other organic solvents are swallowed.

6.3.2 Chemical Burn

1) Quickly remove all contaminated clothing and jewelry while using the safety shower or other available water sources. Immediately flood the affected body area in cold water for at least 15 minutes.

2) Some chemical burns, such as cyanide, phenols, barium chloride, hy-

drofluoric acid, etc., should be properly detoxified when washing.

3) After rinsing with water, acid and alkali burns can be reasonably neutralized with weak alkali or weak acid. A 3%-5% sodium bicarbonate solution is commonly used to treat acid burns, and a 1%-2% boric acid solution is used for alkali burns.

4) It should be noted that if the burning area is the eye, do not neutralize with weak acids or alkalis, and flood the conjunctival sac with available water source at hand as soon as possible. Seek medical help immediately after emergency treatment.

6.3.3 Chemical Spill or Leak Emergency

Response to chemical spill varies depending on the type of spill. In broad terms, spills are classified into Minor and Major. A Minor Chemical Spill is a small quantity spill of a known material that laboratory personnel or chemical users are capable of handling safely without the assistance of the lab center staff or other emergency response personnel. A Major Chemical Spill or Leak is one that (1) is unknown or unfamiliar to the person who discovered the spill; (2) is likely to cause injury to personnel; (3) with a volume that is not easily cleaned up by the chemical user; (4) has the potential to cause a fire.

In the event of a chemical spill or leak, the first priority is to ensure the safety of personnel. If the spill is found to be unfamiliar to the people involved, or if there is doubt as to whether it is safe to handle the spill, they should quickly evacuate the area, warn the people around, and immediately contact the lab center staff for assistance.

For potentially toxic chemicals, evacuate personnel in the affected area immediately. When handling spills, appropriate protective equipment should be worn to avoid injury. For specific disposal measures of different chemicals, refer to the SDS. The general disposal solution can be referred to as fol-

lows.

1) Response to a Minor Spill: Dry the spill with absorbent cotton (neutralize or dilute with large amounts of water if the spill is acid or alkali), and then rinse or wipe with an appropriate solvent. For volatile substances, it is necessary to keep the area ventilated. The used absorbent cotton should be collected and disposed of.

2) Response to a Major Spill or Leak: The spill or leak should be quickly located and plugged to prevent the leak from continuing. At the same time, use absorbent cotton wool to enclose the leak area and prevent it from spreading. The SDS must be referred to when subsequently treating the leak to avoid other hazardous situations during disposal.

3) Solids Spilling: Collect the spilled solids immediately, as some substances become difficult to handle when they absorb moisture from the air. After collection, wipe or rinse off the spilled solids with a suitable solvent. Collected spilled solids should be disposed of in the appropriate chemical waste container.

4) If the spilled chemical is toxic or hazardous, human safety should be the first priority. On this basis, dispose of it quickly according to SDS. If necessary, evacuate the crowd first and leave the disposal to professionals.

6.3.4 Explosion emergency

1) When a lab explosion occurs, all personnel should be immediately evacuated. If possible, cut off the power supply, close the gas supply valve, and quickly transfer other explosive materials. Report the situation to the laboratory center staff as soon as possible once you are in a safe situation.

2) Determine whether or not to fight the fire with a laboratory equipped fire extinguisher based on the toxicity of the gas. The priority is to ensure personal safety.

3) If the gas is toxic or the fire is uncontrollable, call 119 immediately and inform the fire department of the cause of the fire and the conditions at the scene.

6.3.5 Fire emergency

1) All fires must be reported to School security office (0577-55870110) and laboratory emergency response team. If fire is large, call 119 immediately and notify the location, size of fire and the other details.

2) In case of small fire, self-rescue should be carried out at the first opportunity using the corresponding fire extinguishers, fire blankets, fire sand and other equipment according to the type of fire.

3) Identify your surroundings, determine whether there are risk remained and whether secondary disasters are likely to occur.

6.3.6 Laboratory Power Outage Procedures

In the case of a power outage, use the following procedures:

1) Assess the scope of the outage and confirm whether the outage is limited to one lab or a larger area.

2) Report the outage to lab center.

3) Turn off and/or unplug non-essential electrical equipment.

4) Keep refrigerators and freezers closed to help keep contents cold.

5) Power loss to fume hoods may require evacuation of laboratories due to the spread of hazardous gases

6.3.7 Electric Shock Emergency Response

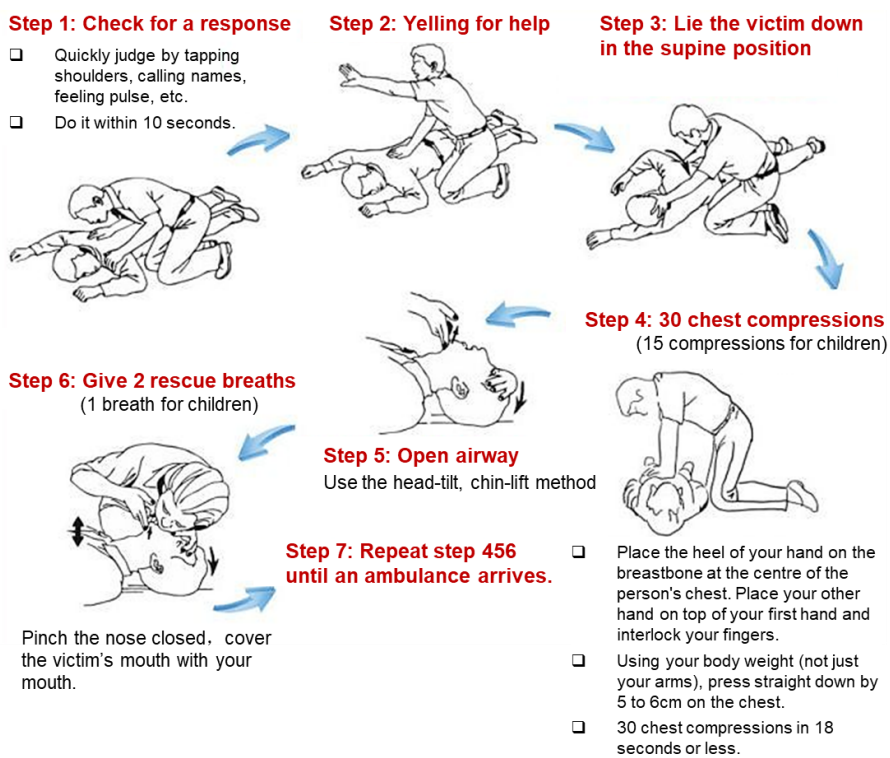
Principles of First Aid for Electrocution: Take proactive measures at the scene to protect the life of the injured person.

In the event of an electric shock, report the accident as soon as possible and apply first aid according to the following steps.

1) Disconnecting the electric shock victim from the power source: the power should be cut off immediately, by turning off the power switch, picking apart the wires with an insulated object, or pulling down the circuit breaker.

2) Examine the injured person: he or she should be quickly moved to a dry, ventilated area, lying on his or her back, and immediately observed for respiration and heartbeat.

3) First aid and seek medical help: Determine the treatment according to the injury, if the heartbeat, respiratory arrest, immediately give CPR on the spot, and call 0577-55870120 or 120 for emergency services. CPR should be performed persistently until the doctor arrives.



第一章 实验室安全基本知识

实验室是学生进行学习和科研的重要基地。为确保在实验过程中的安全，每一个进入实验室的人员都应严格遵守实验室规定，避免自己和他人受到伤害。

1.1 实验室个人行为守则

1) 实验室不对外开放，除选修实验课程的学生、科研人员及实验中心工作人员外，其他人不得擅自进入实验室；

2) 所有需进入实验室工作、学习的人员，须通过“温州肯恩大学实验室准入考试”，取得准入资格；

3) 进入实验室前要求穿着未裸露脚趾的鞋，长发需扎起，并且不宜佩戴金属首饰；

4) 请注意出口、灭火器、医疗箱、紧急喷淋洗眼装置的位置，了解紧急电话号码。 所有过道必须始终保持开放状态；

5) 在课程导师到达前，不要自行收集实验仪器或开始实验操作；

6) 在开始实验操作之前，请完整阅读实验手册并仔细听取课程导师给出的说明。科研人员须提前阅读实验化学品的安全技术说明书(SDS)，熟悉材料的性质、安全使用、保管和应急处置的方法等；

7) 在进行任何实验之前，检查所有设备是否有缺陷。请勿使用损坏的设备或破损的玻璃器皿。当你发现无法正常工作的设备时，立即向你的实验室指导员报告；

8) 不要擅自进行课程内容以外的实验，科研人员需作好实验方案后再按计划进行实验；

9) 实验室内不允许饮食或吸烟；

10) 在实验室里禁止出现任何嬉戏、打闹和恶作剧的行为；

11) 禁止将正在进行的实验处于无任何人员看护的情况下；

12) 所有人员进行实验前必须穿好实验服。对于特定的实验，实验者必须按规定配戴护目镜、防护手套或口罩等个人防护用品；

13) 涉及电气设备的实验中请务必注意用电安全。实验室不得乱拉电线，仪器设备的电线、插头和接线板必须符合用电要求，若有损坏，立即向指导老师报告；

14) 当发现实验室出现任何人员受伤、试剂打翻、起火或者爆炸情况，必须立即告知指导老师。不管严重程度大小，所有受伤和意外情况都必须报告。如果发生重大紧急情况，必须立即寻求校园安保人员的援助，或拨打报警电话；

15) 在离开实验室之前，请将所有实验仪器归位，保持实验台整洁有序。

1.2 实验室安全设施与个人防护用品

所有人员应熟悉实验室安全设施与防护用品的位置、适用场景和使用方法。我校目前涉及的安全设施有：应急喷淋器、洗眼器、灭火器、灭火毯、消防沙、医疗箱等；个人防护用品有：实验服、护目镜、乳胶手套、丁腈手套、隔热手套、防割手套、医用口罩、活性炭口罩、防毒面具等。

1.2.1 医疗箱

我校所有实验室均配备医疗箱，并定期更换药品。医疗箱内放有灭菌棉签、75%

酒精、碘伏、灭菌纱布和橡皮膏、创可贴、手术剪等。涉及使用酸碱试剂的实验室额外准备3%-5%碳酸氢钠溶液和1%-2%硼酸溶液用于酸碱灼伤，涉及使用水银温度计、压力计的实验室额外准备硫磺用于水银泄漏。实验室发生安全事故时，应立即报告主管老师，并积极采取措施进行应急处置。

1.2.2 个人防护用品

常见的防护用具包括：a）头部保护；b）眼和面部保护器；c）听力保护；d）呼吸防护；e）手部防护；f）身体防护；g）足部防护；h）坠落防护设施等。我校实验室中主要使用的是眼部防护、呼吸防护与手部防护用具。关于个人防护用品的更多知识，可参考《GB/T 29510-2013 个体防护装备配备基本要求》。

◇ 眼部防护用具

眼部护具主要防止固体碎片飞溅、化学液体泼溅、辐射强光等对眼部的潜在伤害。我校实验室相关防具为安全眼镜与护目镜。两者功能相似，主要区别在于眼部的封闭性不同，应根据使用场景（如是否存在化学蒸汽造成潜在伤害等）具体选择使用。

◇ 呼吸防护用具

呼吸防护用具是防御缺氧空气和空气污染物进入呼吸道的装备，其主要作用是防止操作者过量吸入有害物质，如烟雾、粉尘、有害气体、纤维等。呼吸防护用具选择需考虑的因素有：污染物的类别、污染物的浓度、暴露极限、舒适性、使用者的健康要求、使用周期等。我校实验室相关防具为医用口罩，活性炭口罩，防毒面具等。应识别潜在危害源后，使用合适的防具进行防护。另外需要注意的是，使用防毒面具前需要检查滤盒是否处于有效工作期内，否则请更换滤盒后使用。

普通口罩正确佩戴方式如下：

a. 面向口罩无鼻夹的一面，两手各拉住一边耳带，使鼻夹位于口罩上方；

b. 用口罩抵住下巴；

c. 将耳带拉至耳后，调整耳带至感觉尽可能舒适；

d. 将双手手指置于金属鼻夹中部，一边向内按压一边顺着鼻夹向两侧移动指尖，直至将鼻夹完全按压成鼻梁形状为止。仅用单手捏口罩鼻夹可能会影响口罩的密合性。

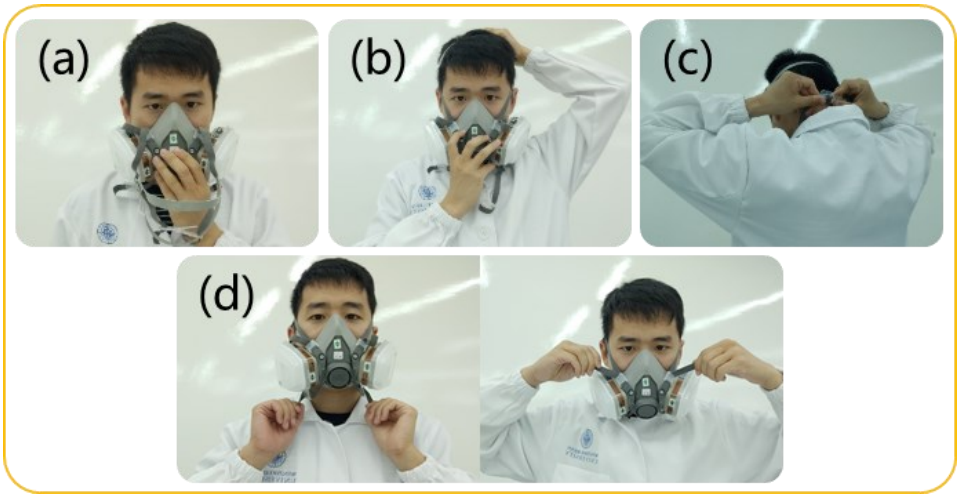
实验室防毒面具正确佩戴方式如下：

a. 解开头带底部搭扣，将面具盖住口鼻；

b. 拉起上端头带，使头箍舒适的置于头顶位置；

c. 双手在颈后将头带底部搭扣扣好；

d. 调整头带松紧，使面具与脸部密合良好。先调整颈后头带，如果头带拉得过紧，可用手指向外推塑料片，将头带放松。调节完成后应进行密闭性检查。



对防毒面具进行密闭性检查的方法：

a. 正压密闭性检测：将手掌盖住呼吸阀并向外慢慢呼气，面具应向外轻轻膨胀。如果气体从面部及面具间泄漏，重新调整面具位置并调节头带的松紧度，达到密合良好；

b. 负压密闭性检测：用手掌抵住滤盒中心部位并轻轻吸气，面具应轻微的塌陷，并向脸部靠拢。如果感觉气体从面部和面具间漏进，重新调整面具位置并调节头带的松紧度，达到密合良好。

(a) 正压密闭性检测　　(b) 负压密闭性检测

◇ 手部防护用具

防护手套根据防护目的可分为不同类型，如防尘手套、防静电手套、绝缘手套、防化学品（防酸碱）手套、防割手套、防烫手套等。选择防护手套应考虑的因素如下：接触的潜在危险源、接触化学品的类型、接触的化学品浓度、工作（接触）的时间、使用频率、灵活性、产品保护、使用者是否对橡胶过敏等。我校实验室常用手套：丁腈手套、乳胶手套、防烫手套、防割手套等。

1.3 实验室消防安全

火灾是最常见的实验室事故之一。而引发实验室火灾事故的主要原因通常是实验室人员消防安全意识淡薄、违规操作等。因此，应谨记“预防为主，防消结合”的消防安全工作方针，掌握基本防火常识和技能，主动预防火灾事故的发生 。

1.3.1 实验室常见的消防隐患

1) 违反实验安全管理规定，如实验室吸烟，违规使用明火等；
2) 易燃易爆化学品存储或使用不当；
3) 违规实验操作，引燃易燃或易爆气液物质；
4) 使用加热设备期间脱岗，或实验人员缺乏消防技能，发生事故不能及时处理；
5) 使用大功率用电设备，超出实验室用电负荷；
6) 灭火器材配备不当，或缺乏维护造成失效。

1.3.2 实验室火灾预防

实验人员须熟知“四懂四会”，即：懂本岗位火灾危险性、懂预防措施、懂扑救方法、懂逃生方法；会报警、会使用灭火器材、会处理肇事事故、会逃生。尤其是，实验人员须清楚所用物质的易燃易爆等特性和实验过程中的危险环节，严格按照实验规范操作。实验中心工作人员也将定期组织巡检，识别消防安全隐患。

1.3.3 常见火灾处理方式

火灾通常需要根据起火类型的不同而做对应处理。下表总结了常见火灾的起火类型与灭火方法。

表1-1 常见火灾类型与灭火方法

分类名称	燃烧特性	灭火方式
固体火灾（A类）	含碳固体可燃物，如木材、棉毛、麻、纸张等有机物质燃烧造成的火灾。	可用水型灭火器、泡沫灭火器、干粉灭火器、卤代烷灭火器。
液体、可熔化固体物质火灾（B类）	如汽油、煤油、柴油、甲醇、沥青和石蜡等燃烧造成的火灾。火势易随燃烧液体流动，燃烧猛烈，易发生爆炸、爆燃或喷溅，不易扑救。	可用干粉灭火器、泡沫灭火器、卤代烷灭火器、二氧化碳灭火器。
气体火灾（C类）	可燃烧气体，如煤气、天然气、甲烷等燃烧的火灾，常引起爆燃或爆炸，破坏性极大，且难以扑救。	应先关闭气体输送阀门或管道，切断电源，再冷却灭火，可用干粉灭火器、卤代烷灭火器。
金属火灾（D类）	指可燃的活泼金属，如钾、钠、镁等燃物的火灾，多因遇湿和遇高温自燃引起。	可用干沙，以及干沙式、铸铁粉末或氯化钠干粉金属火灾专用灭火器。忌用水、泡沫、水性物质，也不能用二氧化碳及干粉灭火器。
带电火灾（E类）	指带电设备燃烧的火灾，如配电盘、变电室、弱电设备间等的火灾。	可用二氧化碳、干粉、卤代烷灭火器（禁止用水），灭火时应先断电或与带电体保持安全距离。

1.3.4 常见实验室灭火器材与使用方式


干粉灭火器


二氧化碳灭火器

灭火毯

消防沙

◇ 干粉灭火器

干粉灭火器是利用二氧化碳或者氮气作为动力，将干粉灭火剂喷出灭火，主要适用于A、B、C类火灾。其中，碳酸氢钠干粉灭火器适用于易燃、可燃液体、气体及电器设备的起初灭火；磷酸铵盐干粉灭火器除可用于上述情况外，还可扑救固体类物质的初起火灾。使用前将灭火器上下颠倒几次，使筒内干粉松动，然后将喷嘴对准燃烧最猛烈处，拔去保险销，压下压把。

◇ 二氧化碳灭火器

二氧化碳灭火器是利用二氧化碳不能燃烧也不能支持燃烧的性质来灭火，适用于扑救精密仪器、600伏以下电气设备、图书资料、易燃液体和气体等的初起火灾。但不能用于扑灭金属火灾，也不能扑灭含有氧化基团的化学物质引起的火灾。使用时

拔出灭火器的保险销，把喇叭筒往上扳70~90度。一手托住灭火器筒底部，一手握住启动阀的压把。对准目标，压下压把。 需要注意的是，喷出的二氧化碳会使得喇叭筒处快速降温，使用时要防止被冻伤。

◇ 灭火毯

灭火毯是由玻璃纤维等材料经过特殊处理和编制而成的织物，能起到隔离热源及火焰的作用。灭火毯盖在燃烧的物品上可使燃烧无法得到氧气而熄灭。使用时双手拉住灭火毯包装外的两条手带，向下拉出灭火毯。将灭火毯完全抖开，覆盖在火源上同时切断电源或气源，直至火源冷却。受火势围困时，也可将灭火毯披裹在身上迅速逃离火场。

◇ 消防沙

干沙主要通过隔绝空气灭火，对于扑灭小范围金属起火、地面流淌火特别安全有效。灭火时直接将干沙铺洒至起火处，待火源冷却后再行处置。

1.3.5 实验室火灾处理及逃生自救

当实验室发生火灾时，应第一时间报告事故情况，以便工作人员第一时间启动应急处理方案，及时处理火情。可参考以下原则处理实验室火灾事故。

（1）沉着冷静

发生起火，切忌惊慌。要沉着冷静，根据实验室安全培训和消防演练中学到的消防知识，组织在场人员利用灭火器具，在火灾的初起阶段将其扑灭。如果火情发展较快，要迅速逃离现场。

（2）争分夺秒

使用灭火器进行扑救火灾时可按灭火器的数量，组织人员同时使用，迅速把火扑灭。避免只由一个人使用灭火器的错误方法。要争分夺秒，尽快将火扑灭，防止火情蔓延。切忌惊慌失措、乱喊乱跑，延误灭火时机，酿成大灾。

（3）兼顾疏散

发生火灾，现场能力较强人员组成灭火组负责灭火，其余人员要在老师的带领下或自行组织疏散逃生。疏散过程要有序，防止发生踩踏等意外事故。

（4）及时报警

扑救火灾的同时，应立即报告。这样可以更早地得到校园安保人员和火警的支援，快速扑灭火灾，减小损失。

（5）生命至上

在灭火过程中，要本着“救人先于救火”的原则，如果有火势围困人员，首先要想办法把受困人员抢救出来；如果火情危险难以控制，非专业的灭火人员要迅速撤离，以确保自身安全。

（6）断电断气

电气线路、设备发生火灾，首先要切断电源，然后再考虑扑救。如果发现可燃气体泄漏，不要触动电器开关，不能用打火机或火柴等明火，也不要在室内打电话报警，避免产生着火源。要迅速关闭气源，打开窗门，降低可燃气体浓度，防止爆燃。

（7）慎开门窗

救火时不要贸然打开门窗，以免空气对流加速火势蔓延。如果室内着火，打开门窗会加速火势蔓延；如果室外着火，烟火会通过门窗涌入，容易使人中毒、窒息死亡。

从火场逃生时，应注意：

1) 平时注意熟悉实验室的逃生路径、消防设施及自救的方法，积极参与应急逃生演练；

2) 火灾发生时，应保持冷静、明辨方向、迅速撤离，千万不要相互拥挤、连冲乱撞。应尽量往楼层下面跑。若通道已被烟火封阻，则应背向烟火方向离开，通过阳台、气窗、天台等往室外逃生；

3) 为了防止火场浓烟呛入，可采用湿毛巾、口罩蒙鼻，匍匐撤离。浓烟中还可以戴充满空气的塑料袋逃生；

4) 严禁通过电梯逃生。若楼梯被烧断、通道被堵死时，可通过屋顶天台、阳台、落水管等逃生，或在固定的物体上栓绳子，然后手拉绳子缓缓而下；

5) 如果无法撤离，应退居室内，关闭通往火区的门窗。还可向门窗上浇水，用湿布条塞住门缝，并向窗外挥舞衣物、抛出物件、呼喊、打手电筒等方式发送求救信号，等待救援；

6) 如果身上着火，千万不可奔跑或者拍打，应迅速撕脱衣物，泼水、就地打滚、覆盖厚重衣物等方式压灭火苗；

7) 生命第一，不要贪恋财物，切勿轻易重返火场。

1.4 实验室用电安全

实验室用电设备较多，且大功率仪器比例高，用电问题若有不慎极易引发断电、火灾、触电等问题，对实验室人员的人身安全、设备安全、国家财产安全等造成威胁。实验室用电时应注意以下要点：

1) 电源、插座功率等需与仪器设备的功率匹配；

2) 接线板不要串接，不要直接放在地面上。实验室不乱拉乱接电线；电源插座或开关必须固定；

3) 电线、电器不要被水淋湿或浸在导电液体中；

4) 实验开始前，需先检查用电设备，再接通电源。实验结束后，先关闭用电设备，再关闭电源；

5) 在实验过程中，若出现突然断电，应先关闭电源，再检查确认原因。

第二章 危险化学品安全

化学品是每一个在实验室工作学习的人员最直接接触的潜在危险源，因此，每一个进入实验室的人员必须学习关于化学品的安全知识。本章将对危险化学品的分类、储存、使用、废弃，以及实验室化学品事故应急常识进行说明。

2.1 危险化学品的定义和分类

危险化学品是指具有毒害、腐蚀、爆炸、燃烧、助燃等性质，对人体、设施、环境具有危害的剧毒化学品和其他化学品（《危险化学品安全管理条例》中华人民共和国国务院令第 591 号，2011 年）。

我国现行的危险化学品分类标准是《化学品分类和危险性公示通则》（GB 13690-2009）和《危险货物分类和品名编号》（GB 6944-2012）。其中，《危险货物分类和品名编号》将化学品按其危险性或最主要的危险性划分为9个类别的21项。这9个类别分别为：

1) 爆炸品；
2) 压缩气体和液化气体；
3) 易燃液体；
4) 易燃固体、易于自燃的物质和遇水放出易燃气体的物质；
5) 氧化性物质与有机过氧化物；
6) 毒性物质和感染性物质；
7) 放射性物质；
8) 腐蚀性物质；
9) 杂项危险物质和物品。

此外，我校实验室中涉及到的易制毒化学品也纳入危险化学品管理范围之内。按照《易制毒化学品管理条例》的规定，易制毒化学品分为三类。第一类是可以用于制毒的主要原料，第二类、第三类是可以用于制毒的化学配剂。

危险化学品具体的种类和名称，可以参照《危险化学品目录（2018版）》、《易制毒化学品分类和品种目录（2018版）》。

基于以上标准，温州肯恩大学实验室中常见的危险化学品如下表。（请注意，此表格并非完整举例。请在使用前查询所需使用的化学品SDS，或咨询课程导师。）

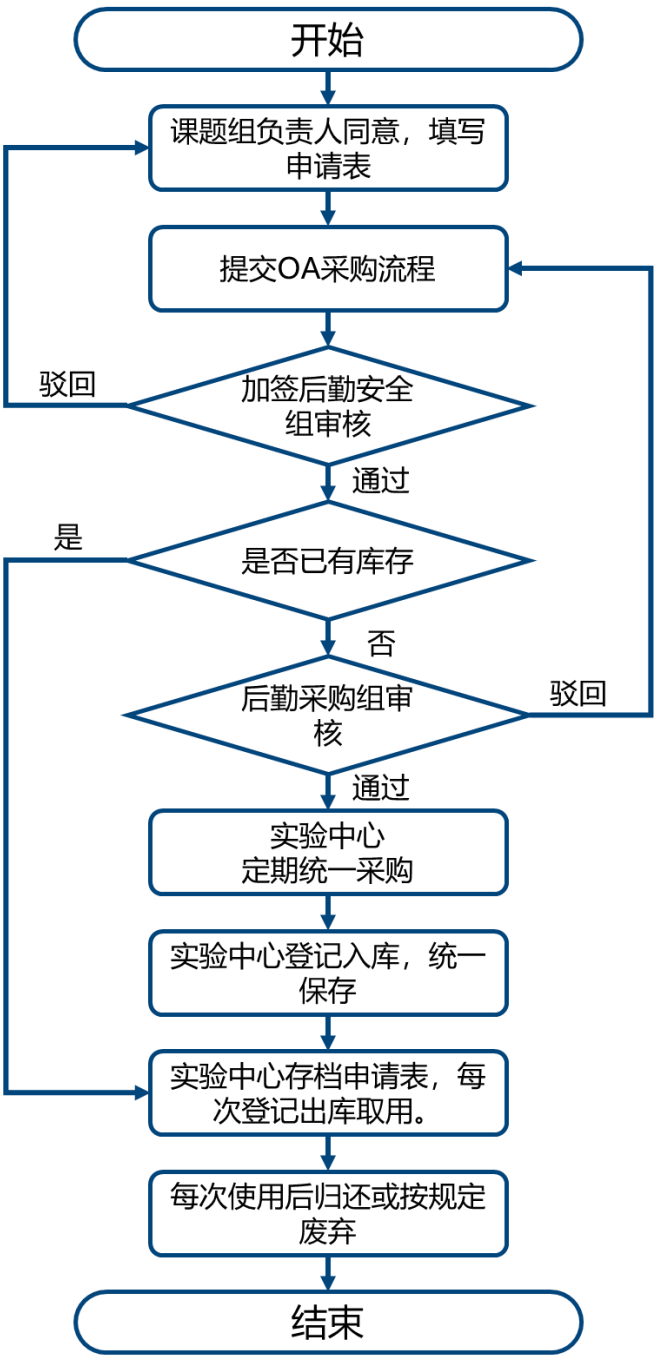
表2-1 温州肯恩大学实验室常见危化品

危险性分类	常见危险化学品
助燃或易燃	过氧化氢、丙酮、硝酸钡、环己烷、乙醚、甲醛、甲醇、石油醚、硝酸钾、高锰酸钾、硝酸钙、环己酮、二氯甲烷、镁、甲苯
易制毒	乙酸酐、甲苯、三氯甲烷、盐酸、乙醚、丙酮
腐蚀性	盐酸、硝酸、硫酸
高毒性	苯胺、三氯甲烷、重铬酸钾、碘化汞、苯酚

2.2 危险化学品的申购

任何单位和个人申请采购或使用危险化学品必须遵照《温州肯恩大学危化品管理规定》执行，填写《温州肯恩大学危险化学品购置使用申请表》，不得自行购买或私下转让。其中，易制毒化学品受国家严格管控，申购者需配合实验中心完成公安局的备案工作。

操作流程图如下：



2.3 危险化学品的储存

化学品的储存遵循以下一般原则：

1) 所有的化学品和配制试剂都应置于适当的容器内，并贴有内容清晰、信息明确的标签。无标签或者标签无法辨认的试剂都要当作危险品重新鉴别后小心处理，不可随便丢弃，以免造成严重后果；

2) 合理存放化学品：a）存放点必须通风、隔热、安全；b）分类摆放，避免混放，摆放整齐、清洁；c）实验室不存放大桶试剂和大量试剂；d）不得无盖放置（污染空气）；

3) 实验室须建立并及时更新化学品台账，登记入库、取用、归还记录；

4) 及时清理无名和过期的化学品。

其中，分类存放时应注意以下要点：

1) 易燃液体：远离火源，阴凉干燥处避光保存，通风良好，不装满瓶，最好保存于防爆冰箱内；

2) 腐蚀液体：选用耐腐蚀材料的药品柜存放试剂，并将腐蚀性液体置于药品柜下方；

3) 剧毒品：放置于保险柜中，双人双锁；

4) 易燃易爆类固体：与易燃物、氧化剂隔离存放，以低温存储，最好放置在防爆柜或防爆冰箱中；

5) 需低温储存的化学品：建议存于 10℃以下，如苯乙烯、丙烯腈、乙烯基乙炔、甲基丙烯酸甲酯、氢氧化铵；

6) 特殊存放的化学品：钾、钠等碱性金属（储存于煤油中），黄磷（储存于水中），苦味酸（保湿存放），镁和铝（避潮保存），易潮物和易水解物（储存于干燥处，封口应严密），双氧水（储存于塑胶瓶中，外包黑纸）。其他情况参考具体化学品的SDS。

下面两个表格整理了实验室中常见的不可共存的化学品，以及会产生燃烧或爆炸等危险情况的化学反应：

表2-2 常见不能共存的化学品

常见不能共存的化学品	
化学品	存放要求
强酸（尤其是浓硫酸）	不能与强氧化剂的盐类（如高锰酸钾、氯酸钾等）、水共混放
氰化钾、硫化钠、亚硝酸钠、氯化钠、亚硫酸钠	不能与酸混放
还原剂、有机物	不能与氧化剂、硫酸、硝酸混放
碱金属（钠、钾等）	不能与水接触
易水解的药品（醋酸酐、乙酰氯、二氯亚砜）	不能与水溶液、酸、碱等混放
卤素（氟、氯、溴、碘）	不能与氨、酸及有机物混放
氨	不能与卤素、汞、次氯酸、酸等共存

表2-3 常见发生燃烧或爆炸的化学反应

常见发生燃烧或爆炸的化学反应		
主要物质	互相作用的物质	产生结果
浓硝酸、硫酸	松节油、乙醇	燃烧
过氧化氢	乙酸、甲醇、丙酮	燃烧
高氯酸钾	乙醇、有机物；硫磺、有机物	爆炸
钾、钠	水	爆炸
乙炔	银、铜、汞化合物	爆炸
硝酸盐	酯类、乙酸钠、氯化亚锡	爆炸
过氧化物	镁、锌、铝	爆炸

2.4 危险化学品的使用

危险化学品的使用应注意：

1) 实验之前应认真阅读所用化学品的安全技术说明书（SDS），了解化学品的性质，采取必要的防护措施；
2) 使用化学品前，须学习掌握化学品的操作规范，不能直接接触药品、品尝药品味道、把鼻子凑到容器口嗅闻药品气味；
3) 在不影响实验结果的前提下，尽量用危险性低的物质替代危险性高的物质，采用小量或半微量型实验以减少危险化学品的用量；
4) 严格按照操作规程进行操作，认真观察记录，不擅离岗；
5) 严禁在开口容器或密闭体系中用明火加热有机溶剂，不得在烘箱内存放、烘烤易燃有机物；
6) 一切有毒气体的操作必须在有效工作的通风橱中进行。使用剧毒品等高风险操作，须做好应急预案；学生使用须由老师带领，未经授权的人员不得自行使用实验室中的任何化学品；
7) 实验结束后，废弃物按规定分类收集、记录相关信息，由实验中心统一移交资质公司处理。做好自身清洁，不带污染物离开。

化学品的安全技术说明书SDS（Safety Data Sheets）也称为MSDS（Material Safety Data Sheets），是化学品生产商和进口商用来阐明化学品的理化特性以及对使用者的健康可能产生的危害的一份文件。中国标准文件《GBT16483-2008 化学品安全技术说明书 内容和项目顺序》和美国OSHA标准文件《Hazard Communication Standard: Safety Data Sheets (29 CFR 1910.1200 (g))》对于SDS的形式有类似的规定，需要包括以下内容：

1) 化学品及企业标识；

2) 危险性概述；

3) 成分/组成信息；

4) 急救措施；

5) 消防措施；

6) 泄漏应急处理；

7) 操作处置与储存；

8) 接触控制和个体防护；

9) 理化特性；

10) 稳定性和反应性；

11) 毒理学信息；

12) 生态学信息；

13) 废弃处置；

14) 运输信息；

15) 法规信息；

16) 其他信息。

因此，SDS是危险化学品的安全使用过程中最重要的参考文件，使用危险化学品前应认真阅读，必要时可在实验室放置备份文本用于应急翻阅。

2.5 化学品相关事故应急常识

实验室发生化学品安全事故时，应立即报告主管老师，并积极采取措施进行应急处置，情况严重的应立即送医院治疗。化学品的安全技术说明书中包含了具体物质的安全事故应急处理方案的信息，在操作风险性较高的化学品前，操作人员务必仔细阅读SDS，做好应急预案。对于常见的化学品相关事故，如化学品中毒、灼伤、泄漏、起火等，应急处理方式可参考本手册第六章《实验室安全事故应急处理》。

第三章 生物安全

由于近年来数次爆发全球范围流行的传染病，以及多国实验室感染事故的发生，生物安全已成为各个国家日益关切的问题。实验室生物安全事故一旦发生，危害的不仅仅是实验室工作者的个人健康，更有可能给整个人类社会带来不可估计的危害和影响。因此，实验室生物安全问题事关重大，实验室人员必须学习生物安全基本知识和技能，做好个人防护，熟悉实验室标准操作程序和突发事件应急处置方案。更多生物安全的相关知识，可以参考中国国家标准文件《GB19489-2008 实验室生物安全通用要求》。

3.1 实验室生物安全基础知识

3.1.1 生物安全的定义

生物安全是指对感染微生物及有害的生物材料进行安全处理及控制，它涉及的内容主要有动物或人类组织、血液、微生物、转基因生物和病原菌等。为了降低事故发生的可能性，实验相关人员要做好风险评估及严格遵守标准实验操作。

3.1.2 危险度等级分类

世界卫生组织根据感染性微生物的相对危害程度制定了危险度等级的划分标准（WHO 的危险度1级、2级、3级和4级）。目前在温州肯恩大学实验室中不能从事涉及危险度2级、3级、4级的相关研究。

1) 危险度1级（无或极低的个体和群体危险）：不太可能引起人或动物致病的微生物。

2) 危险度2级（个体危险中等，群体危险低）：病原体能够对人或动物致病，但对实验室工作人员、社区、牲畜或环境不易导致严重危害。实验室暴露也许会引起严重感染，但对感染有有效的预防和治疗措施，并且疾病传播的危险有限。

3) 危险度3级（个体危险高，群体危险低）：病原体通常能引起人或动物的严重

疾病，但一般不会发生感染个体向其他个体的传播，并且对感染有有效的预防和治疗措施

4) 危险度4级（高度的个体和群体的危险均高）：病原体通常能引起人或动物的严重疾病，并且很容易发生个体之间的直接或间接传播，对感染一般没有有效的预防和治疗措施

3.1.3 生物安全实验室分级

根据操作不同危险度等级微生物所需的实验室设计特点、建筑构造、防护设施、仪器、操作以及操作程序来决定实验室的生物安全水平。涉及病原微生物的实验，须在相应等级的生物安全实验室内开展相关实验。生物安全实验室分为BSL-1、BSL-2、BSL-3、BSL-4四个级别，其中BSL-3、BSL-4可从事高致病性病原微生物实验活动，但必须先取得国家认可的资质。

相关实验室需张贴生物危害警告标识，安全信息牌须明示生物安全等级、所使用的传染性病原体、实验室负责人姓名及联系电话等信息。

表3-1 我国生物安全实验室的分级

我国生物安全实验室的分级		
实验室分级	危险度等级	安全设施
一级（BSL-1）	1级	不需要，开放实验台
二级（BSL-2）	2级	开放实验台，此外需生物安全柜用于防护可能生成的气溶胶
三级（BSL-3）	3级	生物安全柜及高压灭菌器等其他实验室所需要的基本设备
四级（BSL-4） (防护级别最高)	4级	III级生物安全柜或II 生物安全柜并穿着正压服、双开门高压灭菌器、经过滤的空气等

3.2 实验室生物安全管理规定

3.2.1 实验安全操作

1) 只有经过批准的人员才可进入实验室工作区域；
2) 了解所操作实验相关风险及应急措施；
3) 根据不同的实验要求配备恰当的个人防护装备，例如手套、实验服、护目镜、口罩和面罩等；
4) 严禁戴手套触摸门把、手机和脸部等部位；
5) 使用恰当的移液器，严禁用口吸移液。皮下注射针头和注射器不能用于替代移液管或用作其他用途；
6) 在处理完感染性实验材料和动物后，以及在离开实验室工作区域前，都必须洗手；
7) 所有的技术操作要按尽量减少气溶胶和微小液滴形成的方式来进行；
8) 实验室应保持清洁整齐，严禁摆放和实验无关的物品；
9) 发生具有潜在危害性的材料溢出，及在每天实验结束后，都必须清除工作台面的污染；
10) 漂白剂或70%酒精溶液可以用于处理生物危害材料溢出，其中漂白剂不能处理织布、毛毯或金属表面；
11) 所有受到污染的材料、标本和培养物在废弃或清洁再利用之前，必须清除污染；
12) 出现溢出、事故以及明显或可能暴露于感染性物质时，必须向实验室负责人或实验员报告；
13) 尽量不要独自一人在实验室工作，确保万一遇到紧急情况附近有人能协助；
14) 应定期对可能接触病原微生物的实验场所、物品、设备等进行消毒杀菌；
15) 不同等级的生物安全实验室应配备相应的生物安全柜及高压蒸汽灭菌器或其他恰当的消毒设备，实验涉及生物危害因子的须在生物安全柜中进行或其他防护设施中进行。

3.2.2 实验室生物安全个人防护

所有人员进入实验室必须做好个人防护工作，使用恰当的防护用具。当要离开实验室，或者防护用具受到污染时要及时移除，并放置在指定位置洗涤、清除污染或者丢弃。

表3-3 生物实验室常见防护用具与防护功能

装备	避免的危害	安全性特征
实验服、隔离衣	污染衣服	实验操作时罩在日常服装外
塑料围裙	污染衣服	防水
鞋袜	碰撞和喷溅	不露脚趾
护目镜	碰撞和喷溅	防碰撞镜片，侧面有护罩
面罩	碰撞和喷溅	罩住整个面部，发生意外时易于取下
防毒面具	吸入气溶胶	在设计上包括一次性使用的、整个面部或一半面部空气净化的、整个面部或加罩的动力空气净化呼吸器的以及供气的防毒面具
手套	直接接触微生物	得到微生物学认可的一次性乳胶、乙烯树脂或聚腈类材料的保护手套

3.2.3 实验动物

1) 使用动物需向具有《实验动物生产许可证》的单位购买，索要动物质量合格证明书；
2) 饲养实验动物及进行动物实验须在持有《实验动物使用许可证》的实验室内进行，严禁在其他场所进行；
3) 进行动物实验时，应善待动物并遵循“3R”（即减少、代替和优化）原则，尽可能用别的方法或技术代替动物实验；

4) 凡从事动物实验生产或动物实验研究的工作人员要经过培训，取得实验动物从业人员资格证；

5) 动物尸体或被解剖的动物器官须及时进行妥善处置，严禁混入生活垃圾随意处理。

3.2.4 生物废弃物管理

生物废弃物管理是生物安全的一个重要环节。除了与其他实验室废弃物相同的分类、储存、统一处理等流程外，有感染性的生物废弃物需要首先经过高压灭菌等无害化处理。具体的处理方式和注意要点，可参照本手册第四章《实验室废弃物安全管理规定》及《温州肯恩大学实验废弃物处理规定》。

第四章 实验室废弃物安全管理规定

实验室废弃物是指在实验室日常研究与实验过程中产生的，已失去使用价值并打算丢弃的废物，包括废气、废液、废固，可能具有种类多、腐蚀性、易燃性、具毒性及感染性等特征。因此为保护实验工作者和环境，加强对实验室废弃物的管理及建立废弃物处置方案至关重要。

4.1 实验室废弃物的分类

4.1.1 一般垃圾

表4-1 一般垃圾的分类

序号	类目	注解
1	废纸	主要包括报纸、期刊、图书、各种包装纸、纸盒等
2	塑料	主要包括各种塑料袋、塑料包装物、一次性塑料用品、饮料瓶等
3	玻璃	主要包括各种玻璃瓶、碎玻璃片、镜子、灯泡、暖瓶等
4	金属	主要包括易拉罐、罐头盒等
5	布料	主要包括废气衣服、桌布等
6	有害垃圾	废电池、废灯管、废水银温度计、过期药品等，需要特殊安全处理
7	其他	包括除上述几类垃圾之外的砖瓦陶瓷、渣土、废纸巾等难以回收的

4.1.2 固体性废弃物

1) 感染性废弃物：通常在生物实验中产生，被感染性生物或媒介所污染，例如口罩、手套、废标本、枪头、塑料管、实验服等。

2) 损伤性废弃物：由实验室在实验过程中所产生的损伤感染性废弃物，例如针头、刀片、注射器、培养皿、试管、载玻片等。

3) 病理性废弃物：指实验过程中产生的废弃组织、器官、医学实验动物尸体、病理切片后废弃的组织切片等。

4.1.3 液体性废弃物

表4-2 液体废弃物的定义与分类

序号	分类	注解
1	一般废水	冷却水、清洗用水
2	实验废液	化学性实验废液（有机废液、无机废液）
3		生化性实验废液
4		物理性实验废液（过热、过冷）
5		放射性实验废液

4.1.4 气体性废弃物

实验室废气包括试剂和样片的挥发物、分析过程中间产物、泄漏和排空的标准气和载气等。

1) 无机废气：氮氧化物、硫酸雾、氯化氢、氟化氢、硫化氢、二氧化硫等；

2) 有机废气：主要包括芳香类、醛酮类、酯类、醇类等。

4.2 实验废弃物收集及存储的一般原则

在实验废弃物处置过程中，不可避免地涉及收集和储存的问题。在废弃物收集和储存的过程中应注意以下几点：

1) 使用专门的储存容器，放置在规定位置并设置警示牌；

2) 相容的废弃物可以收集在一起，不具相容性的实验废弃物应分别储存，切勿将不相容的废弃物放置在一起；

3) 废弃物标签应牢固地贴在容器上。标签内容应该包括：组分及含量，危害性，开始存储日期及处理日期、地点、存储人及电话；

4) 避免废弃物存储时间过长，一般不要超过一年。应及时做无害化处理或送专业部门处理；

5) 对感染性废弃物或有毒有害生物废物，应根据其特性选择合适的容器和地

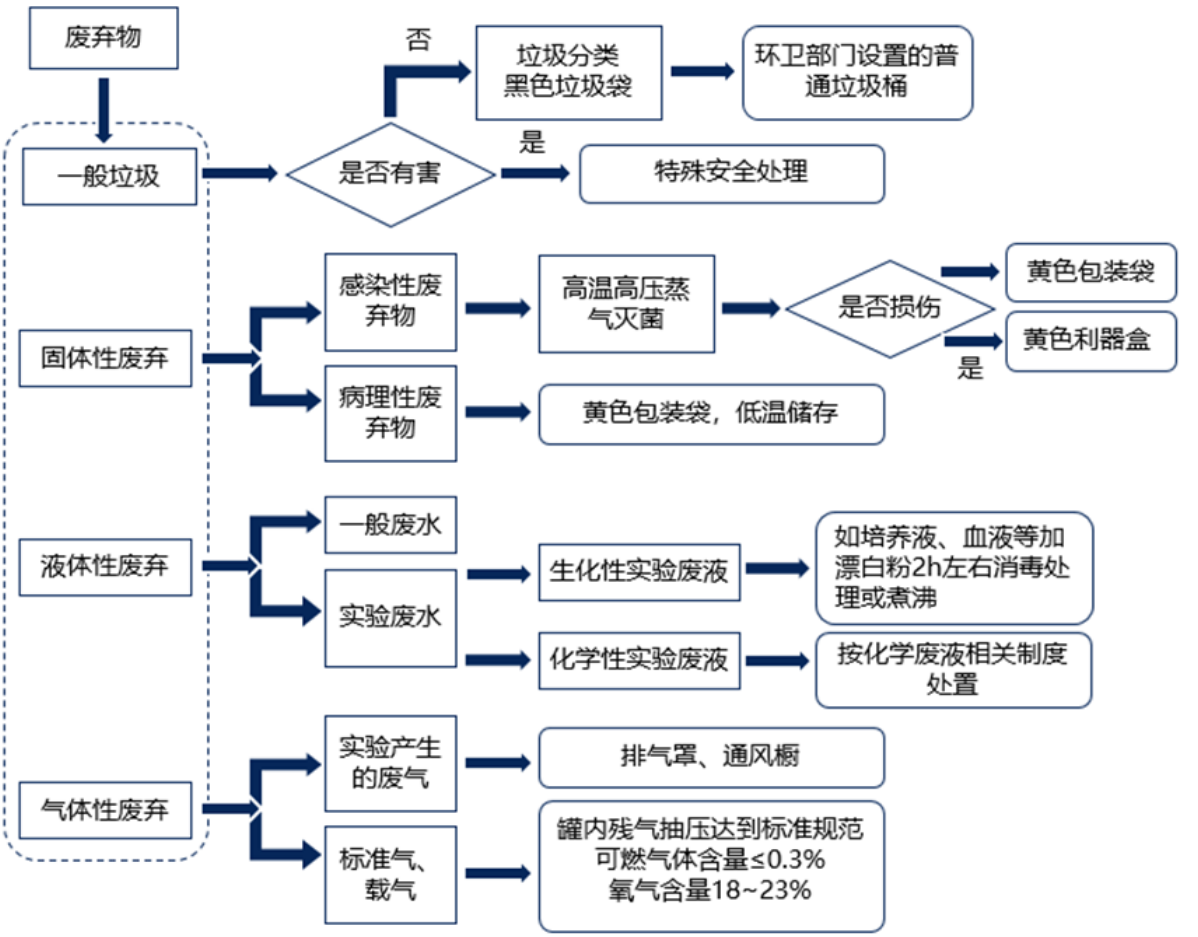
点，专人分类收集进行消毒、烧毁处理，须日产日清；

6) 对无毒无害的生物性废弃物，不得随意丢弃，实验完成后将废弃物装入统一的塑料袋密封后贴上标签，存放在规定的地点，定期统一处理；

7) 高危类剧毒品、放射性废物必须按照相关管理要求单独管理储存，单独收集清运；

8) 回收使用的废弃物容器一定要清洗后再用，废弃不用的容器也要作为废弃物处置。

4.3 实验室废弃物处置流程



4.4 化学实验室废弃物处理

4.4.1 化学废液分类与处置

表4-3 化学废液的分类与对应处理方法

废液分类			处理
无机废液	酸性废液	酸度相当于浓度在5%以上的硝酸酸溶液（PH≤2）	中和或稀释后PH＞5后，倒入无机废液桶中。
	碱性废液	碱度相当于浓度在1%以上的NaOH溶液（PH＞12）	中和或稀释后PH＜9后，倒入无机废液桶中。
	含重金属废液	重金属如铁、钴、铜、锰、铅、镓、铬、钛、锗、锡、铝、镁、镍、锌等	存放于专门的废液桶中。
	含汞废弃物	水银、有机汞化合物	存放于专门的废液桶中。
	含氰废液	含有游离氰废液或含有氰化合物	单独存放此容器中的废料务必保持强碱性，以免有氢氰酸气体逸出。
	含氟废液	含有氟酸或氟化合物	若现场没有此类容器，且量较少（小于无机酸废料体积的30%），可在无机酸废弃物容器中处置。
有机废液	油脂类	松节油、重油、绝缘油（不含多氯联苯）、润滑油、冷却油、植物油等	单独存储在油脂类收集废液桶中。
	含卤素有机溶剂	含卤素脂肪族化合物，或含卤素类芳香族化合物	倒入卤代溶剂类有机废液桶内。
	不含卤素有机溶剂	各种醇、醚、烷烃、带苯环的芳香族化合物	倒入非卤代溶剂有机废液桶内。

4.4.2 化学废液的储存

化学废液的储存应该选择合适容器和存放地点，存放地点有相应的警示标识（如图）；废弃物容器标签注明：种类、时间；禁止混放，分类收集，隔离存放。

由于使用的化学试剂种类不同，各实验室会根据实际情况设置不同的废液桶暂存化学废液，收集后定期由实验中心负责统一委托有资质的机构处理。实施细则可参考《温州肯恩大学实验废弃物处理规定》。

4.5 生物实验室废弃物处理

生物实验室废弃物因其潜在的生物危害性，除了分类储存及处理外还需要注意必要的灭菌或消毒。生物废弃物具体的处理要点可参考如下：

1) 所有生物废弃物采用密封容器收集保存并做好标记，注明废弃物名称、日期及数量等信息；
2) 锐器类废弃物(例如针头、注射器、刀片、载玻片、盖玻片、破碎玻璃等)应使用耐扎容器收集，统一回收处理；
3) 非感染性废弃物可装入黑色垃圾袋，按照生活垃圾分类丢弃；
4) 感染性废弃物常采用高压灭菌处理，将废弃物置于灭菌袋中，在103kPa、121℃条件下，维持至少45分钟；
5) 液体废弃物如细胞培养液、液体培养基等可用化学消毒剂处理至少2小时再丢弃；
6) 动物尸体或被解剖的动物器官可用专用塑料袋密封后冷冻储存，定期交由有资质的公司回收进行无害化处理。

4.6 减少实验室废弃物

尽管进行了分类处理，实验室产出的废弃物对环境的影响仍不容忽视。对实验室废弃物最好的处理就是从源头上减少废弃物的产生。可以从以下几个方面考量：

1) 实验方法修正：使用精密分析仪器替代传统的分析方法；尽量使用微量分析技术，减少化学试剂的使用；

2) 避免过量购置：应合理评估试剂用量，避免过量购置而造成试剂过期；

3) 减少有毒有害试剂用量：优化实验方法，减少有毒有害试剂的使用量，或使用低毒害的试剂代替高毒害的试剂；

4) 适量储备配制的溶液：应依据实验用量配制溶液，过量的贮备溶液是实验室废液一大来源；

5) 试剂回收利用：部分试剂使用后可以回收处理后再次使用，或将使用后低纯度的试剂循环用于低精度的实验，减少不必要的试剂浪费。

第五章 实验室设备使用安全

实验室中的各种常用仪器设备，如玻璃仪器、高压设备、高温/低温设备、机械加工设备以及一些分析测试仪器等在使用不当的时候都可能会造成安全事故。因此，在使用这些仪器设备前应该经过学习和培训，并做好必要的防护措施，严格按照操作规程操作。本章主要介绍我校实验室常用设备安全使用的注意事项。

5.1 一般设备使用安全

5.1.1 实验室冰箱

实验室冰箱常用于化学试剂与生物样品的保存，使用时应注意以下事项：

1) 冰箱应放置在通风良好处，严禁将易燃易爆品、气体钢瓶和杂物等堆放在冰箱附近；
2) 原则上不得超期使用冰箱，一般规定为10年；
3) 实验室冰箱内不得存放食物；
4) 普通家用冰箱未经防爆改造不得储存化学试剂；
5) 储存的物品应标识明确(物品名称、使用人姓名、时间等)；
6) 闪点低的危险化学品必须存放在具有防爆功能的冰箱中，并在冰箱上粘贴醒目的警示标识；
7) 存放传染性病原微生物样品的冰箱应配备相应的锁具并粘贴警示标识；
8) 存放易挥发有机试剂的容器必须加盖密封，避免试剂挥发在冰箱内积聚；
9) 若冰箱出现断电或故障停止工作，必须及时转移化学药品或使用备份电源 。

5.1.2 加热设备

实验室常用的加热设备包括：明火电炉、电阻炉、电磁炉、微波炉、烘箱、培养

箱、干燥箱、电热枪、电吹风及各类水浴、油浴锅和各类酒精灯等。

1) 使用加热设备必须采取必要的防护措施；加热设备使用完毕，必须关掉电源，如因特殊情况确需开机过夜，须先向实验中心管理人员报告，并做好必要的安全防范与应急处置措施；

2) 使用明火加热时必须有人看管；

3) 加热设备须放置在阻燃的稳固的实验台或者地面上进行操作，不得在其周围堆放易燃易爆化学品或者纸板、泡沫、塑料等易燃杂物。使用有明火的加热设备时此项须尤其注意；

4) 禁止用电热设备烘烤溶剂、油品、塑料筐等易燃、可挥发物。若加热时会产生有毒有害气体，应在通风橱内进行；

5) 加热化学试剂时，应确保不会引起剧烈反应，并且有办法冷却该反应；

6) 不要触摸加热仪器的灶面，防止烫伤。应在断电的情况下，采取安全的方式取放被加热物品；

7) 使用水浴或油浴锅时，应加入适量的导热介质，不可加得太满，以免液体外溢。同时注意观察，避免干烧损坏浴锅。

5.1.3 电动离心机

电动离心机是生物与化学实验中常用的设备。使用时特别要注意防止在离心机转动期间因不平衡或脚垫老化而出现设备移动，以致从实验台上掉落；或盖子未盖，离心管因振动而破裂后，玻璃碎片随着旋转飞出，造成事故。使用离心机时，应注意以下要点：

1) 合理使用离心管，若为玻璃离心管，则离心机套管底部要垫棉花；

2) 离心管必须对称地放入离心机套管中，防止因不平衡而出现机身振动。若只有一支样品管，另外一支要用等质量的水替代；

3) 使用时应盖上离心机顶盖后才可启动离心。离心时间一般为数分钟，在此期间，实验者不准离开；

4) 对任何具有腐蚀性、危险性或生物危险性的溶液进行离心操作时，离心管需

要进行适当的二次密封；

5) 电动离心机如有异常噪声或振动时，应立即切断电源，及时排除障碍；

6) 分离结束后，先关闭离心机，在离心机停止转动后，方可打开离心机盖，再取出样品，不可用外力强制其停止运动；

7) 离心结束后如有溢出物需立即擦拭，避免腐蚀机身 。

5.1.4 通风橱

在各种实验过程中，难免会在试剂使用和实验反应中产生各种不同的有毒气体，有些甚至对人体的危害极大。因此保持室内环境安全就显的尤为重要。通风橱是实验室内的一种局部排风设备，它可以将实验中所产生的有害气体经过处理后排放到室外，从而保护在实验室中的操作人员的安全。通风橱在使用中应注意以下事项：

1) 使用通风橱前检查抽风功能是否正常运转，先开启排风后才能在通风橱内进行操作；若发现故障切勿进行实验，应立即关闭玻璃视窗并报告实验室管理人员；

2) 应在距离通风橱至少 15cm 处进行操作；操作时应尽量减少在通风橱以及调节门前的大幅度动作，减少实验室人员流动；

3) 切勿储存会伸出通风橱外或妨碍玻璃视窗开合或遮挡导流板开口与排气槽的物品或设备；确需要在橱内储放必要物品时，应将其垫高至于左右侧边上，同通风柜台面隔空，以使气流能从其下方通过，且远离污染产生源；

4) 切勿把纸巾或者较轻的物件随意放置于通风橱内，通风橱气流会将纸巾吹起，堵塞排气出口从而影响通风橱正常工作；

5) 通风橱台面不可存放过多实验器材或化学品，禁止长期堆放；

6) 进行实验时，操作人员应将玻璃视窗调节至手肘处，使胸部以上受到玻璃视窗屏护，切勿将头部及上半身伸进通风柜内；

7) 人员不操作时，应确保玻璃视窗处于关闭状态；

8) 实验操作完毕后不要立即关闭排风，应继续排风1-2分钟，确保通风橱内残留的有害气体全部排出；

9) 每次使用完毕，必须彻底清理工作台及仪器，对于被污染的通风橱应放置明显的警示牌，以免对他人造成不必要的伤害。

5.1.5 生物安全柜

生物安全柜的主要作用是通过风机循环过滤柜内空气，从而防止生物样品受到污染，同时利用垂直气流，避免柜内生物样品污染外部空气，保护实验人员安全。使用中有以下注意要点：

1) 生物安全柜应该定期消毒，一年至少更换一次消毒紫外线灯；
2) 使用生物安全柜前应该让其工作五分钟，以净化柜内空气，形成稳定气流；
3) 禁止在生物安全柜内快速操作。操作时应动作缓慢避免破坏柜内气流，从而影响密封性；
4) 使用时轻微抬手，在工作台三分之一处操作，确保不挡住后面的排气格栅；
5) 当工作结束时，须清理生物安全柜里的物品，不能将物品堆放在生物安全柜。并用消毒液清理安全柜内部区域，打开鼓风机吹五分钟，清除生物安全柜中的污染物。

5.1.6 玻璃器皿

玻璃器皿由于具有相当高的热稳定性和化学稳定性，在生物和化学实验中有着广泛的应用。常用的实验室玻璃器皿有刻度管、移液管、量筒、滴定管、容量瓶、温度计、试管、烧瓶、烧杯、锥形瓶、漏斗、滴管、玻璃棒、胶头滴管等等。 由于玻璃材料的特性，如果玻璃器皿使用不当，也容易造成实验人员受伤，或导致实验试剂倾洒而造成其他实验室事故。使用玻璃器皿有以下注意事项：

1) 使用前检查玻璃器皿是否有破损或缺陷，不要使用有缺口或裂缝的器皿；
2) 在进行减压蒸馏时，要采用适当保护措施（如有机玻璃挡板），可以防止玻璃器皿发生爆炸或破裂而造成人员受伤；
3) 须使用正确方式加热玻璃器皿（如加热烧杯使用石棉网，加热烧瓶使用电热套等），不可直接加热不适宜加热的玻璃器皿（如试剂瓶），避免玻璃破裂

造成危险。不要将加热的玻璃器皿直接放在过冷的台面上，以防止温度的急剧变化而造成玻璃破裂；

4) 对粘结在一起的玻璃仪器不要试图用力拉，以防伤手；

5) 连接玻璃管或将玻璃管插在橡胶塞中时，不要用蛮力。操作者可用管一端蘸取少量的水或润滑剂，二者反方向边轻轻旋转边用力连接。必要时须戴防割手套进行操作；

6) 破碎的玻璃器皿要戴上防割手套小心地彻底清除，丢在专用利器盒中，统一回收处理。

5.2 特种设备使用安全

根据《国务院特种设备安全监察条例》（国务院549号令），特种设备是指涉及生命安全、危险性较大的锅炉、压力容器（含气瓶）、压力管道、电梯、起重机械、客运索道、大型游乐设施， 还包括场（厂）内机动车辆，以及法律、行政法规规定适用本法的其他特种设备。我校的实验室使用的特种设备主要为压力容器，包括高压灭菌锅和气体钢瓶。

5.2.1 高压灭菌锅

1) 使用高压灭菌锅前须经过实验中心管理人员或课题组负责人的培训，使用者须严格按照操作规程进行操作；

2) 高压灭菌锅需定期检验，确保其安全有效。启用长期停用后的高压灭菌锅须经过检验，确认合格后才能使用；

3) 高压灭菌前检查水位是否在正常范围；适当松开灭菌瓶盖以防液体在灭菌过程中溢出；

4) 高压灭菌锅不能一次性装入太多样品，要留出足够的空间供锅内气流循环；

5) 使用时操作人员不得离开，如需离开要有专人代为看管。使用时发现有异常现象，应立即停止使用，并通知设备管理员；

6) 灭菌后，须慢慢打开高压灭菌锅。起初可只开一条缝，让任何蒸汽慢慢逸出

几分钟，之后再全部打开。若突然开启，大量蒸汽溢出容易烫到手、胳膊或脸。开启后至少等待五分钟再拿取灭菌样品；

7) 灭菌后开启灭菌锅和取样品时须佩戴适当的个人防护用品，包括护目镜和隔热手套；

8) 压力表应保持清洁，示值清晰，有破损、漏气、玻璃结露、指针不回零等现象时，应及时更换。

5.2.2 气体钢瓶

1) 采购的气体钢瓶须确保质量可靠，标识准确、完好，不得擅自更改气体钢瓶的钢印和颜色标记；

2) 气体钢瓶应定期委托厂商进行技术检验，使用过程中若发现严重锈蚀、漏气、裂纹等情况，应提前检验。超过检验有效期或无有效检验钢印标识的气瓶不得使用；

3) 气体钢瓶存放地点应严禁明火，保持通风和干燥，避免阳光直射，配备气体检测、报警装置和应急救援设施；

4) 气体钢瓶必须远离热源、放射源、易燃易爆和腐蚀性物品，实行分类隔离存放，不得存放在走廊和公共场所。空瓶内必须保留一定剩余压力，与实瓶应分开放置，并有明显标识；

5) 气体钢瓶须直立放置，使用链条或皮带妥善固定，确保固定链条在钢瓶半高以上位置，以防倾倒。有多种气体或多条管路时需指定详细的供气管路图，并做好气体标识；

6) 使用前后应检查气体管道、接头、开关及器具是否有泄漏；使用后，必须关闭气体钢瓶上的主气阀并释放减压阀内的多余气压；

7) 若发现气体泄漏，应立即采取关闭气源、开窗通风、疏散人员等应急措施。切忌在易燃易爆气体泄漏时开关照明、电器等电源；

8) 移动气体钢瓶时应使用带有链条或皮带等固定装置的手推车，切勿拖拉、滚动和滑动气体钢瓶。

第六章 实验室安全事故应急处理

针对实验室中可能出现的各类突发事件，每一个实验室使用者都应具备基本的应急常识，从而在事故真正发生时能够快速应对处理，保证实验室使用人员的人身安全和学校财产安全。本章主要介绍我校实验室中可能发生的事故及其处理方式和注意事项，具体的应急预案可参见《温州肯恩大学教学部实验中心应急预案》。

6.1 实验室应急准备

6.1.1为火警准备

1) 熟悉实验室周围的安全逃生通道；
2) 了解火警警报及灭火器的位置，确保可以迅速使用灭火器具；
3) 切勿乱动任何火警侦查或者灭火装置，保持所有防火门关闭；
4) 实验前应细致评估实验风险，对于有火灾隐患的实验要做好灭火准备。

6.1.2为实验室紧急事件准备

1) 使用化学品前，须详细查阅化学品的安全技术说明书（SDS）；
2) 熟知实验室内安全设施所在位置；
3) 准备恰当且充足的急救物资；
4) 了解所用物品的潜在危险性，严格按照实验室操作规程实验；
5) 进入实验室前须接受实验操作培训和实验室安全教育；
6) 若对某种做法是否安全有所怀疑，最好采取保守做法，把处置工作留给专业人员。

6.1.3 为损伤准备

1) 学习简单的急救方法；

2) 熟知紧急喷淋、洗眼器和医疗箱的位置；

3) 如需要使用氢氟酸或者氰化物等有毒物时，须先学习如何使用解毒剂，并在实验前做好充分准备。

6.2 实验室事故应急处置原则

6.2.1 事故应急处置原则

发生紧急事故时，应按以下优先次序处置：

1. 保护人身安全，即本人安全与他人安全

2. 保护公共财产

3. 保护学术资料

6.2.2 应急处置通用流程

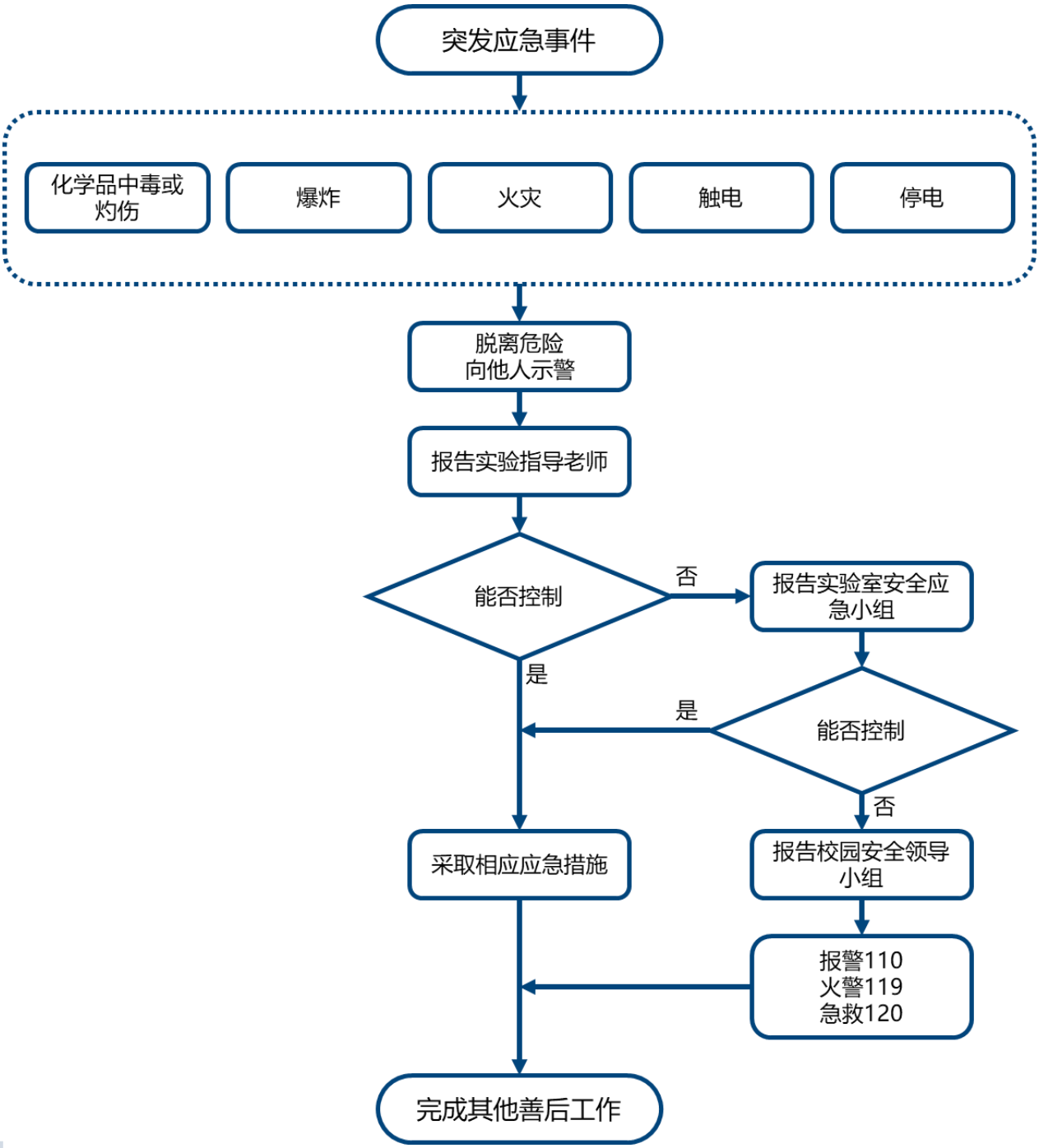
发生事故时应快速评估严重程度，脱险后第一时间致电报告或求助。致电报告或求助时，应说明：

1. 事故地点

2. 事故性质和严重程度

3. 你的姓名、位置、联系电话

事故应急处置可参照以下流程图：



6.3 实验室各类事故应急处置

6.3.1 化学品中毒应急处置

实验中若感觉咽喉灼痛、嘴唇脱色或发绀，胃部痉挛或恶心呕吐等症状时，则可

能是中毒所致。视中毒原因施以急救后（参考对应化学品的SDS），立即送院，不得延误。常规应急救援方法可参考如下：

吸入式中毒：

1) 切断毒源，立即打开窗户通风降低毒物浓度，警示污染区的人员并安排疏散。将中毒者转移至安全地带，解开领扣，让中毒者呼吸到新鲜空气；
2) 中毒者出现呼吸能力减弱时，应立即进行人工呼吸，直至医疗救援到达；
3) 应急施救人员须注意救援过程中的自身安全，佩戴合适的个人防护用具。

误食性中毒：

1) 应立即吐出误食的化学品，再用大量水冲洗口腔，反复漱口；
2) 催吐：催吐在服毒后四小时内有效，简单的办法是用手指、棉棒或金属匙柄刺激咽部舌根。对昏迷、痉挛发作以及吞食强酸、强碱等腐蚀品，汽油、煤油等有机溶剂时禁用或慎用；
3) 重金属中毒者还可饮用牛奶或蛋清，减少重金属与体内蛋白的结合，降低对人的伤害。

6.3.2 化学灼伤应急处置

化学灼伤常有强酸、强碱、黄磷、液溴、酚类等腐蚀性物质引起。伤处剧烈灼痛，轻者发红或起疱，重者溃烂，创面不易愈合。某些化学品可被皮肤、粘膜吸收，出现合并中毒现象。严重者应立即送医，紧急处置办法可参考如下：

1) 迅速移离现场，脱去受污染的衣物，立即用大量流动清水冲洗 15~30min。碱性物质污染后冲洗时间应该延长，特别要注意眼睛及其他特殊部位如头、面、手的冲洗；
2) 对有些化学物灼伤，如氰化物、酚类、氢氟酸等在冲洗时应进行适当解毒救急处理；

3) 酸碱灼伤创面经水冲洗后，可使用弱碱或弱酸进行合理的中和治疗。常用3%-5%碳酸氢钠溶液处理酸灼伤，1%-2%硼酸溶液用于碱灼伤；

4) 需要特别注意的是，若灼伤部位为眼睛，忌用弱酸弱碱中和，应争分夺秒利用一切能得到的水源进行结膜囊冲洗。紧急处理后迅速就医。

6.3.3 化学品倾洒或泄漏应急处置

对于化学品倾洒或泄漏事故，首先应确保人员安全。若发现泄漏事故的人员对泄漏物性质不熟悉，或对处理方式是否安全存在怀疑，应快速撤离事故区域，向周围人员示警，并立即联系实验中心工作人员协助处理。

对于有潜在毒害的化学品，应立即疏散人员。处理泄漏物时，应佩戴合适的防护用具，避免受到伤害。针对不同化学品的具体处置措施，应参考SDS。通用处置方案可参考如下：

1) 小量液体倾洒或泄漏：利用吸液棉将泄漏物吸干（泄漏物为酸碱时可先中和或使用大量水稀释），然后选用合适的溶剂进行冲洗或擦拭。对于有挥发性的物质，需要保持现场通风。处理后的吸液棉须收集后统一处置；

2) 大量液体泄漏：应快速定位泄漏处并做堵漏处理，防止泄漏持续。同时使用吸液棉围住漏液区，防止影响范围扩大。随后处理漏液时必须参考SDS，防止在处理时出现其他危险情况；

3) 固体倾洒：出现倾洒后应立即收集倾洒的固体，因为一些物质在吸收空气中的水分后会变得难以处理。收集完成后使用合适的溶剂对倾洒去进行擦拭或冲洗。收集的倾洒固体应投入对应的化学品废物桶或作其他统一处理；

4) 对于倾洒或泄漏的化学品，如果存在毒性或其他危害，应首先保障人身安全。在此基础上根据SDS迅速处置。必要时可先疏散人群，将处置工作交给专业人员。

6.3.4 实验室爆炸应急处置

1) 当化学危险气体爆炸事故发生时，应立即疏散人员。有条件的要马上切断现

场电源、关闭气源阀门，迅速转移其他易爆物品；第一时间将情况报告给实验中心工作人员；

2) 根据气体是否有毒来确定是否用实验室配备的灭火器扑火，首先需确保人身安全；

3) 若气体有毒或火势难以控制，应迅速拨打火警电话119，并告知起火原因与现场情况等。

6.3.5 实验室火灾应急处置

1) 发生火灾事故时，发现人员应立即通知校保卫处（0577-55870110）和实验室应急小组（见册首“应急联系方式”）。如果火势较大，须迅速拨打火警电话（119），报警时必须讲明起火地点、火势大小、起火物资等详细情况；

2) 若发生局部火情，应第一时间根据火灾类型使用对应的灭火器、灭火毯、消防沙等设备开展自救；

3) 明确火灾周围环境，判断出是否有重大危险源分布及是否会带来次生灾难发生。

6.3.6 实验室停电

实验室出现停电情况时，请参考以下事项。

1) 评估停电的范围，确认停电只限于一个实验室还是更大的范围。

2) 向实验室中心报告停电情况。

3) 关闭和/或拔掉非必要的电气设备的插头。

4) 保持冰箱和冰柜关闭，以帮助保持内容的低温。

5) 工作中的通风橱断电导致有害气体扩散时，需要疏散实验室人员。

6.3.7 触电应急处置

触电急救的原则是：在现场采取积极措施保护伤员生命。

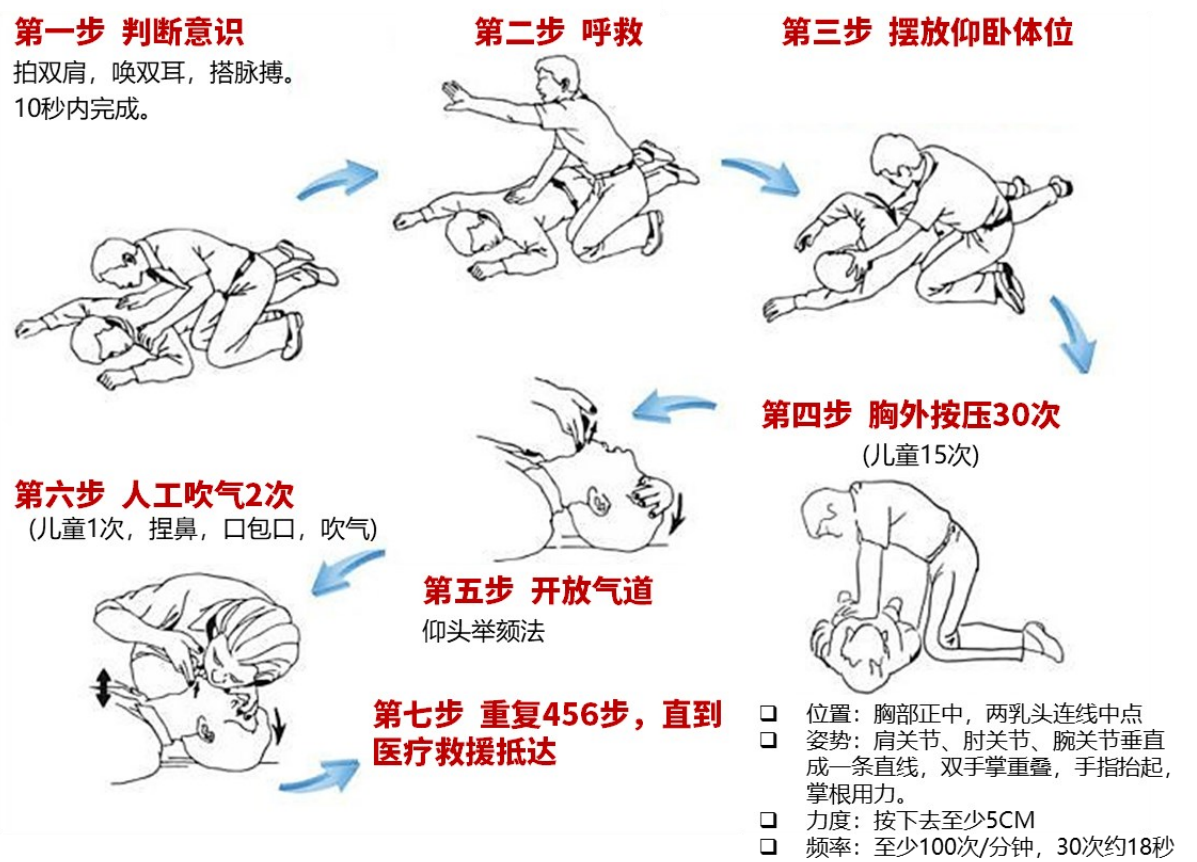
若出现触电事故，应第一时间报告，并根据以下步骤展开急救：

1) 使触电者脱离电源：应立即切断电源，可以采用关闭电源开关，用绝缘物体挑开电线或拉下电闸；

2) 检查伤员：应迅速将其移到通风干燥的地方仰卧，并立即观察伤员呼吸、心跳的情况；

3) 急救并求医：根据受伤情况确定处理方法，对心跳、呼吸停止的，立即就地采用人工心肺复苏方法抢救，并及时拨打0577-55870120或者120急救电话。应坚持不懈地做心肺复苏，直到医生到达。

急救与人工心肺复苏流程可参考下图：



附录：温州肯恩大学实验室相关安全管理规定

1. 《温州肯恩大学实验室废弃物管理规定（试行）》
2. 《温州肯恩大学生物实验室安全条例》
3. 《温州肯恩大学化学实验室安全条例》
4. 《温州肯恩大学物理实验室安全条例（试行）》
5. 《温州肯恩大学危险化学品安全管理规定（试行）》
6. 《温州肯恩大学实验室准入管理规定（试行）》
7. 《温州肯恩大学实验室耗材管理规则（试行）》
8. 《温州肯恩大学实验动物突发事件应急预案（试行）》

*各规定的详细内容请前往温州肯恩大学网站实验室页面进行查阅。点击进入>>

附录：主要参考资料

1. “NJCSTM Laboratory Safety Manual”，Kean University.

2. 《华南理工大学实验室安全手册》

3. 《复旦大学实验室安全手册》

4. 《浙江大学实验室安全教育手册》

5. 《化学化工实验室安全管理规范》（T/CCSAS 005-2019），中国化学品安全协会

6. “Laboratory Biosafety Manual (3rd Edition)”，World Health Organization.

7. “Lab Safety Handbook", New York University.

8. “Health and Safety Handbook”，Department of Chemistry, Xi'an Jiaotong-Liverpool University.

9. “Health and Safety Handbook”，Department of Biological Sciences, Xi'an Jiaotong-Liverpool University.

*注：本手册其他参考的标准、法规等信息已在文中提及，详见各章节说明文字。

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