

SAFETY @ IISER TIRUPATI

PHYSICS LABS

Edition 01

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Department of Physics

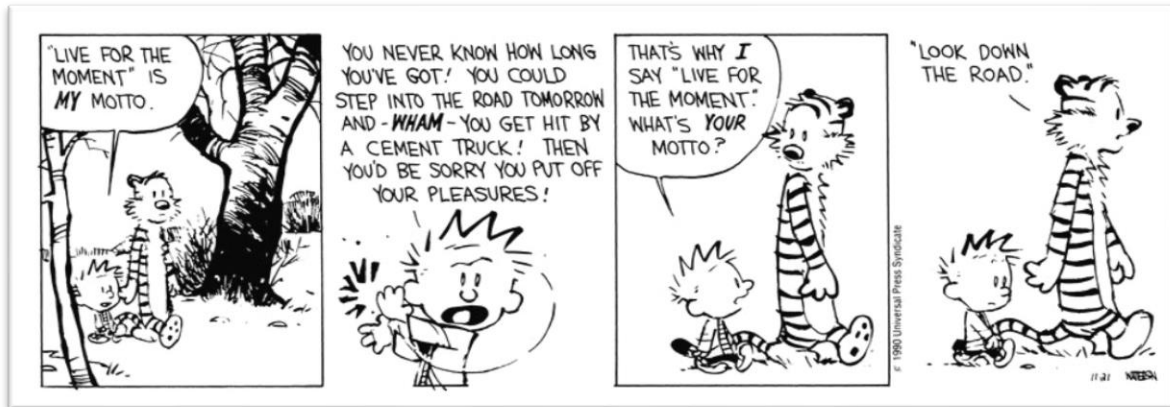
IISER TIRUPATI



YOUR LIFE IS MORE IMPORTANT THAN YOUR 'DREAMS'!

IISER Tirupati is committed to ensuring the health and the safety of every individual working in the institute. We strive to make the necessary arrangements for everyone's safety within the institute. However, no safety measures are of use unless there is active cooperation of the individual under concern. Therefore, we urge everyone to follow the safety policies and regulations of the institute.

This safety manual is primarily targeted to the students, even though it is very well applicable to the teaching assistants, the technical assistants, and the faculty members of IISER Tirupati. Students include the BS-MS, i-Ph.D., and Ph.D. students and project fellows. Most of the work-related accidents occur to those who lack experience in handling devices of a potential safety hazard. Therefore, it is imperative that all the students and the staff of the institute understand the dangers related to the experiments in the labs and take proper care to avoid any accidents.



Calvin & Hobbes by Bill Watterson

So, "look down the road" and have a safe life at IISER Tirupati!



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Safety at IISER Tirupati [Department of Physics]

There are several safety regulations one should keep in mind in an academic-cum-research institute. This booklet focuses on the safety measures the students working in Physics Laboratories – both teaching and research – must follow for a safe working atmosphere in our laboratories.

General safety guidelines for the Physics UG and Research Labs

- Before you start working in a teaching/research lab, carefully read the safety guidelines available in the lab and acknowledge that you understand the safety rules and regulations.
- Self-assessment of the safety of your working environment is perhaps the most important thing when it comes to being safe! If you notice that something does not look safe, report it to the lab technicians and the faculty members concerned with safety.
- Keep your laboratory clean and organized.
- Food or drinks (including water) are prohibited inside a teaching/research lab.
- Never work alone in a laboratory.
- Do not try to operate an instrument unless you know what you are doing.
- Wear shoes in a teaching/research lab especially when there are potential physical hazards (such as a sharp or heavy object that can fall on your foot).
- Experiments involving chemicals:
 - All chemicals (including water!) should be labeled clearly.
 - Never use a chemical from an unlabelled bottle.
 - Never smell or taste a chemical which is unknown (or known!) to you.
 - Avoid direct exposure to chemicals (wear dedicated gloves for handling chemicals).
 - Glassware used to treat dangerous chemicals must be cleaned very well after use.
 - Do not use bare hands to handle broken glassware. Use a dedicated glove.
 - Experiments involving volatile toxic chemicals must be performed inside a fume hood.
 - Chemical waste should be disposed of in the containers dedicated to them.
 - Wash your hands thoroughly after working with chemicals (even if you used gloves).
- Experiments involving lasers:
 - The lasers in the Physics UG labs are relatively safe. However, they may pose a threat when used with focusing optics such as lenses. Wear safety goggles when working with lasers of class 3 or above.
 - Avoid any circumstance where the laser is directed at you even by reflection especially when focusing optics are involved.
 - When you are working with a laser, do not bend down such that your head is at the level of the laser.
- Experiments involving electrical hazard:
 - The mains supply in India is 230-240 V / 50 Hz AC. Shocks from the mains can be deadly. All the mains cables must be checked for any damage. They must be plugged in to the socket before switching on the electrical equipment. The equipment must be switched off before unplugging the cable. Never unplug a cable by pulling the cord.

- AC voltages are more dangerous than an equivalent DC voltage because the body has much lower resistance to AC compared to DC.
- Never touch bare cables/electrodes in an electrical circuit or power supply! They may carry lethal voltages.
- Take great care while working with experiments involving high voltage/current. In some experiments, e.g., Arc emission spectrometer in UG lab, even after the power supply is switched off, the potential difference between the arc electrodes remain nearly the same for several minutes unless the electrodes are discharged. If the electrodes carry the high potential, it can pose a great threat to life.
- All the electrical cables used in the experiments must be properly insulated. Presence of any faulty cable should be reported and replaced immediately.
- Experiments with potential physical hazard:
 - Some experiments require the use of sharp or heavy objects that can injure you seriously unless handled carefully. Make sure that you wear shoes while working on these experiments.
 - Some experiments involve heating objects (metal and oil) up to nearly 100 °C. These can cause severe burns if not handled with care.
- Never leave the experimental setups unattended when they are operated with open flames, heated substances, live electrical cables, switched on lasers, etc.
- Spills in labs should be cleaned up immediately.
- After every experiment, tidy up the workspace and keep all the components at their respective places.
- Wash your hands thoroughly when you leave the lab after your lab hours.
- Twice in every month, scrutinize the safety measures in the lab and keep things organized.
- In case of fire inside a UG laboratory, and if the technical assistants or faculty are around, inform them about it and follow their advice. You may be advised to leave the lab immediately through the nearest exit, inform the security, and gather on the cricket ground.
- In case of fire in a research laboratory, follow the instructions as per the general safety guidelines described in detail in the main Safety Manual of IISER Tirupati.
- Ensure unblocked access to the following:
 - Doors and windows
 - Fire extinguishers
 - Electrical panels

Helpline Numbers [General]

- Fire station: 101
- Ambulance: 102
- Blood Requirement: 104
- Disaster management: 108
- Gas leakage: 1906
- A.P. State Emergency Service and Fire Station, Tirupati - 0877 226 0101

Major safety concerns in the Undergraduate (UG) labs

Chemical Safety in the UG labs:

One of the major safety concerns in a laboratory is handling chemicals. Even though there are no highly toxic chemicals in Physics UG labs, one should be aware of the potential health hazards in handling various chemicals used in the labs. Experiments which use various chemicals in Physics UG lab are the following:

S. No.	Chemical	Chemical Formula	Experiment	Dangerous? *
1	Glycerol	$C_3H_8O_3$	Viscosity measurements	No
2	Isopropanol	C_3H_8O	Several experiments	Yes
3	Potassium permanganate	$KMnO_4$	Arc Emission Spectrometer	Yes
4	Nitrobenzene	$C_6H_5NO_2$	Kerr Effect	Yes
5	Lithium Fluoride	LiF	X-Ray Diffraction	Yes
6	Bismuth Telluride	Bi_2Te_3	Scanning Tunnelling Microscope	Yes
7	Manganese Sulphate	$MnSO_4$	Quincke's Method for magnetic susceptibility	Yes

* For details of the safety in using these chemicals, refer to the section [Chemical Safety Documentation](#). Also, refer to [Globally Harmonized System \(GHS\) Pictograms](#).

Electrical safety in the UG labs:

There are dangerous high voltage sources in the Physics UG labs. The voltages can be up to 30 kV (for instance in XRD device, but this device is well-protected with interlocks so that you are completely safe to operate the machine as if there is no voltage at all). In the Kerr-effect apparatus, the voltage can go up to 10 kV, but the supply is configured to a maximum voltage of 3-4 kV. The maximum current the supply can provide is one milliamp which can indeed cause an unpleasant electric shock. The equipment with risky voltages/currents are:

S. No.	Experiment	Device	Maximum Voltage (V)	Maximum Current (A)
1	Kerr Effect	HV DC power supply	3.5k	0.001
2	Zeeman Effect	DC Power supply for Hg vapor lamp	30	10
3	Magnetic Susceptibility	DC Power supply for the electromagnet	35	3.5
4	Arc Emission Spectrometer	Power supply for arc electrodes	100	10
		Power supply for Mercury vapor lamp	4k	0.03
5	X-Ray Diffraction	Power supply for accelerating electrons	35k	0.001
6	Hall Effect	DC Power supply for the electromagnet	30	3.95
7	Biot-Savart's Law	DC power supply for the electromagnet	30	20
8	Hydrogen lamp	DC power supply	3.5k	0.01
9	Rectifier	Centre-tapped transformer (14-0-14)	28	1
10	General use	DC power supply	32	10
11	General use	DC power supply	30	2
12	General use	Transformer (AC)	9	0.5

For details of the danger associated with electrical safety, refer the section [Electrical Safety Documentation](#).

Laser Safety in the UG labs:

There are continuous wave lasers (diode lasers and diode pumped solid state lasers) in the UG lab. They belong to Class 3R (maximum power up to 5 mW). They are relatively safe. However, long direct exposure or exposure through a focusing optic like a lens can lead to eye injury.

S. No.	Experiment	Laser Type	Wavelength (nm)	Power (mW)	Class
1	Fabry-Perot Interferometer	Diode laser, continuous	650	5	3R
2	Kerr Effect	DPSS, continuous	532	5	3R
3	Waveplates	Diode laser, continuous	657.16	5	3R
4	Malus Law	Diode laser, continuous	650	3	3R
5	Ultrasonic diffraction	Diode laser, continuous	650	3	3R
6	Diffraction experiments	Diode laser, continuous	650, 532	3	3R
7	Michelson Interferometer	Diode laser, continuous	532	5	3R

For details about the dangers involved in working with lasers, refer to the section [Laser Safety Documentation](#).

Major Safety Concerns in the Research Labs

Electrical Safety in the Research labs:

Lethal high voltage is one of the major life-threatening agents in our research labs. Look for the signs of high voltage in these labs and take proper care. Never touch an un-insulated electric cable in an electrical circuit without switching off the supplies. Below is a list of power supplies used in our research labs.

S. No.	Device	Model	Maximum Voltage (V/Vp)	Maximum Current (mA)	Lab Concerned
1	ISEG HV DC power supply	NHQ 205M	5000	2	Research Lab I
2	Stahl DC HV Power supply	HV 400-16	400	0.07	
3	RF Output for Ion funnel		100	-	
4	RF Output for quadrupole ion guide		200	-	
5	RF output for quadrupole mass filter		500	-	
6	RF output for ion trap		500	-	

For details of the danger associated with electrical safety, refer the section [Electrical Safety Documentation](#).

Chemical Safety in Research labs:









S. No.	Chemical	Chemical Formula	Usage?
1	Isopropanol	C ₃ H ₈ O	General cleaning
2	Ethanol	C ₂ H ₅ OH	General cleaning
3	Methanol	CH ₃ OH	Preparation of samples for electrospray
4	Acetonitrile	CH ₃ CN	Preparation of samples for electrospray
5	Acetic Acid	CH ₃ COOH	Preparation of samples for electrospray

For details of the safety in using these chemicals, refer to the section [Chemical Safety Documentation](#). Also, refer to [Globally Harmonized System \(GHS\) Pictograms](#).

Chemical Safety











Globally Harmonized System (GHS) Pictograms

GHS stands for the Globally Harmonized System of Classification and Labelling of Chemicals that defines and classifies the hazards of chemical products and communicates health and safety information. The goal is that the same set of rules for classifying hazards, and the same format and content for labels and safety data sheets (SDS) will be adopted and used all around the world. It is important that those working with chemicals are aware of all the signs and symbols on the chemical containers. The following is the symbol and related hazard information that are commonly encountered in research labs.

Pictogram	GHS ID	What does It mean?	More information*
	GHS01 Explosive	<ul style="list-style-type: none"> Unstable explosives Self-reactive substances and mixtures Organic Peroxides 	Explosive material
	GHS02 Flammable	<ul style="list-style-type: none"> Flammable liquids, gases, solids Self-reactive substances and mixtures Pyrophoric substances Organic Peroxides 	Flammability
	GHS03 Oxidizing	<ul style="list-style-type: none"> Oxidizing liquids, solids, gases 	Oxidizing agent
	GHS04 Compressed gas	<ul style="list-style-type: none"> Compressed Gases Liquefied Gases Refrigerated liquefied gases Dissolved Gases 	Compressed Gases
	GHS05 Corrosive	<ul style="list-style-type: none"> Corrosive to metals 	Corrosive substance
	GHS06 Toxic	<ul style="list-style-type: none"> Acute toxicity (oral, dermal, inhalation) 	Toxicity
	GHS07 Harmful	<ul style="list-style-type: none"> Acute toxicity Skin irritation Eye irritation Respiratory tract irritation 	Lab Hazards & Risks
	GHS08 Health hazard	<ul style="list-style-type: none"> Carcinogenicity Reproductive toxicity Respiratory sensitization Germ cell mutagenicity 	Carcinogen

* 'More information' refers to the useful weblinks available in the e-copy of this document.

Chemicals used in UG and research labs

Chemical	Chemical Formula	Safe?	GHS Pictogram
Glycerol	$C_3H_8O_3$	Safe	None
Isopropanol	C_3H_8O	Danger	
Ethanol	C_2H_5OH	Danger	
Methanol	CH_3OH	Danger	
Acetonitrile	CH_3CN	Danger	
Acetic Acid	CH_3COOH	Danger	
Potassium permanganate	$KMnO_4$	Danger	
Nitrobenzene	$C_6H_5NO_2$	Danger	
Lithium Fluoride	LiF	Danger	
Bismuth Telluride	Bi_2Te_3	Danger	
Manganese Sulphate	$MnSO_4$	Danger	

Reference: <https://chemicalsafety.com>



Laser Safety

Lasers can be very dangerous! When?

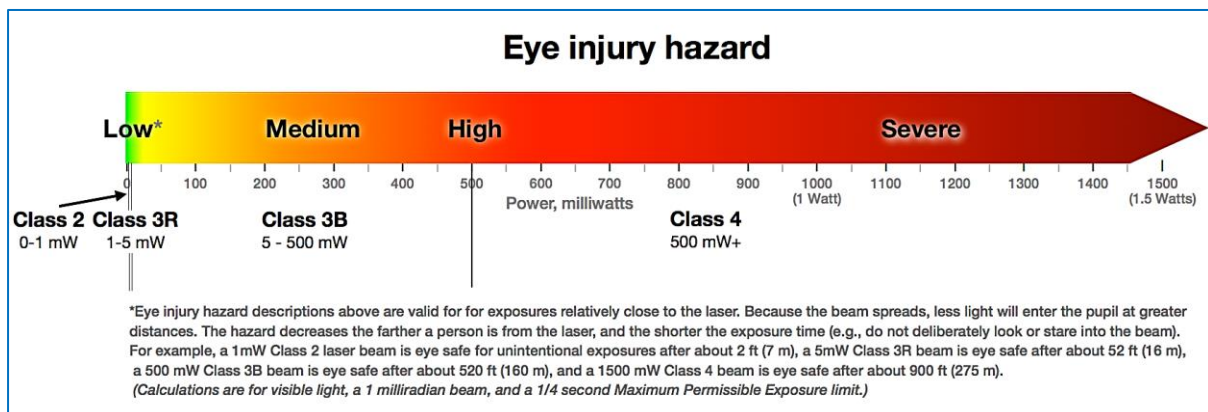
Lasers can be of diverse types depending on their power output, the wavelength range of the light they emit (UV, visible or infrared), and the way the energy is delivered (continuous or pulsed).

The following symbol will be displayed wherever a laser is present.










Maximum Permissible Exposure (MPE): This term refers to the safe limit of the exposure of laser radiation to the eye. It is the maximum amount of power or energy density (J/cm^2 or W/cm^2) of a light source that is considered safe, i.e., the negligible probability of causing damage to the eye. The MPE is measured at the cornea of a human eye or the skin for a given wavelength and exposure time.

The classification of lasers based on the seriousness of the danger they pose is given below.



Source: www.lasersafetyfacts.com

The details of the classification of lasers are illustrated in the table below.

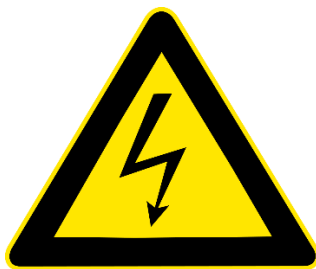
Class	Description	Warning label
1	<ul style="list-style-type: none"> • Safe under all conditions of normal use! • No precautions required • E.g., A high-class laser with proper protection so that any danger is only when the protection is removed when the laser is running. 	
1M	<ul style="list-style-type: none"> • Safe except when operated with focusing optical elements • The lasers emit large diameter or divergent beams 	
2	<ul style="list-style-type: none"> • Visible lasers (400-700 nm) with a maximum of 1 mW of continuous wave radiation • Safe because blink reflex limits the eye exposure of the laser to less than 250 ms 	
2M	<ul style="list-style-type: none"> • Safe if the beam is not viewed through optical instruments • Blink reflex limits the eye exposure of the laser. • This laser class also applies to larger-diameter or diverging laser beams. 	
3R	<ul style="list-style-type: none"> • Safe if handled with restricted beam viewing • Maximum permissible exposure (MPE) can be exceeded, but the injury is very likely minor • Visible continuous wave lasers up to 5 mW fall under this category 	
3B	<ul style="list-style-type: none"> • Hazardous to the eye if exposed directly • Diffuse reflections are not harmful • Use protective eyewear while operating the laser • Laser safety signs lightboxes should be used with lasers that require safety interlock • They should be equipped with a key switch and a safety interlock 	
4	<ul style="list-style-type: none"> • Utmost care required while operating this type of lasers • May cause damage to the skin and eye • Even diffuse reflections can be dangerous • They may also represent a fire risk • They should be equipped with a key switch and a safety interlock 	



Electrical Safety

Electricity can kill. Respect it!

Lethal voltages present in the labs can be identified by the following symbol.



Should you be concerned with high voltage or high current? In fact, it is a bit of both! If the voltage is not high enough, it may be relatively safe to touch an electrical circuit which can deliver high current. On the other hand, if the voltage is very high, but the current that the supply can deliver is very low, you might still be safe. Let us see why!

The electricity is nothing but the flow of charged particles. In most of our everyday life situations, it is the flow of electrons. The electrons flow from a high potential to a lower potential. What happens when you get a shock is that the electricity flows through your body from an electrical circuit carrying a high potential to the ground.

Your body has certain electrical resistance. From the tip of your finger to your feet, it is about 100 k Ω under normal circumstances. However, if you are wet, the resistance can drop to about one kilo-ohm! Thus, if you are touching a 100 V terminal, the current that can flow through your body is about one milliamp under normal conditions. The resultant shock is barely perceptible (See the table below)! However, once the current passes through the body, its resistance decreases and more current starts flowing, which is indeed dangerous. If your body is wet, the initial current can be up to 100 mA, which is indeed fatal! However, if the power supply can deliver a maximum of one milliamp of current, and if it is not faulty, you are very likely safe! If there is some failure in the grounding of the power supply, this factor will not be applicable! Therefore, do not touch any electrical terminals that look suspicious.

One important thing to note at this point is that once the electricity starts flowing through your body, your resistance will decrease drastically facilitating more current to flow.

Here is a description of how human body responds to various amounts of currents [Source: Fish, R. M. & Geddes, L. A. Conduction of electrical current to and through the human body: a review. *Eplasty* 9, e44 (2009).]

1 mA	Barely perceptible
16 mA	Maximum current an average man can grasp and “let go”
20 mA	Paralysis of respiratory muscles
100 mA	Ventricular fibrillation threshold
2 Amps	Cardiac standstill and internal organ damage
15/20 Amps	Common fuse or breaker opens circuit*

*Contact with 20 milliamps of current can be fatal. As a frame of reference, a common household circuit breaker may be rated at 15, 20, or 30 amps.

GHS Documents

ISOPROPANOL



DANGER

Causes serious eye irritation
Highly flammable liquid and vapour
May cause damage to organs through prolonged or repeated exposure
May cause drowsiness or dizziness
May cause respiratory irritation

Use only outdoors or in a well-ventilated area
Keep container tightly closed
Ground/bond container and receiving equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Wear protective gloves/protective clothing/eye protection/face protection
Keep cool
Call a POISON CENTER or doctor/physician if you feel unwell
Store locked up

Fisher Scientific

The information contained herein is based on data compiled from the chemical components of the (M)SDS and may not accurately represent the safety hazards for the product. Only the manufacturer of the product can make actual representations about the hazard profile of a chemical product. No warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof.

ETHANOL



DANGER

Causes serious eye irritation
Highly flammable liquid and vapour

Keep away from heat/sparks/open flames/hot surfaces – No smoking
Keep container tightly closed
Ground/bond container and receiving equipment
Use explosion-proof electrical/ventilating/lighting/.../equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Wash ... thoroughly after handling
Wear protective gloves/protective clothing/eye protection/face protection
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing, Rinse skin with water/shower
IF IN EYES: Rinse cautiously with water for several minutes, Remove contact lenses, if present and easy to do. Continue rinsing
If eye irritation persists: Get medical advice/attention
In case of fire: Use ... for extinction
Store in a well-ventilated place., Keep cool
Dispose of contents/container to ...

SIGMA ALDRICH

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METHANOL



DANGER

Causes damage to organs
Causes damage to organs through prolonged or repeated exposure
Highly flammable liquid and vapour
Toxic if inhaled
Toxic if swallowed
Toxic in contact with skin

Do not eat, drink or smoke when using this product
Wear protective gloves/protective clothing/eye protection/face protection
Use only outdoors or in a well-ventilated area
Keep container tightly closed
Ground/bond container and receiving equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Keep cool
Call a POISON CENTER or doctor/physician
Call a POISON CENTER or doctor/physician if you feel unwell
Wash contaminated clothing before reuse
Rinse mouth
Store locked up

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ACETONITRILE**DANGER**

Causes serious eye irritation
Harmful if inhaled
Harmful if swallowed
Harmful in contact with skin
Highly flammable liquid and vapour
May cause damage to organs through prolonged or repeated exposure
May cause drowsiness or dizziness
May cause respiratory irritation

Do not eat, drink or smoke when using this product
Wear protective gloves/protective clothing/eye protection/face protection
Use only outdoors or in a well-ventilated area
Keep container tightly closed
Ground/bond container and receiving equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Keep cool
Call a POISON CENTER or doctor/physician if you feel unwell
Call a POISON CENTER or doctor/physician if you feel unwell
Wash contaminated clothing before reuse
Rinse mouth
Store locked up

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POTASSIUM PERMANGANATE**DANGER**

Causes severe skin burns and eye damage
Harmful if swallowed
May cause respiratory irritation
May intensify fire; oxidizer

Do not eat, drink or smoke when using this product
Use only outdoors or in a well-ventilated area
Wear protective gloves/protective clothing/eye protection/face protection
Call a POISON CENTER or doctor/physician if you feel unwell
Rinse mouth
Store locked up

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ACETIC ACID



DANGER

Causes severe skin burns and eye damage
Flammable liquid and vapour

Take precautionary measures against static discharge
Wear protective gloves/protective clothing/eye protection/face protection
Use only outdoors or in a well-ventilated area
Keep container tightly closed
Immediately call a POISON CENTER or doctor/physician
Wash contaminated clothing before reuse
Store locked up

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NITROBENZENE (CERTIFIED ACS)**DANGER**

Causes damage to organs through prolonged or repeated exposure

Combustible liquid

May cause cancer

Toxic if inhaled

Toxic if swallowed

Toxic in contact with skin

Obtain special instructions before use

Do not handle until all safety precautions have been read and understood

Use personal protective equipment as required

Do not eat, drink or smoke when using this product

Use only outdoors or in a well-ventilated area

Keep cool

Call a POISON CENTER or doctor/physician

Call a POISON CENTER or doctor/physician if you feel unwell

Remove/Take off immediately all contaminated clothing

Wash contaminated clothing before reuse

Rinse mouth

Store locked up

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LITHIUM FLUORIDE**DANGER**

Causes serious eye irritation
Toxic if inhaled
Toxic if swallowed
Toxic in contact with skin

Do not eat, drink or smoke when using this product
Call a POISON CENTER or doctor/physician
Call a POISON CENTER or doctor/physician if you feel unwell
Take off contaminated clothing and wash before reuse
Rinse mouth
Store locked up

Fisher Scientific

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BISMUTH TELLURIDE



Causes serious eye irritation
Causes skin irritation
Harmful if inhaled
Harmful if swallowed
Harmful if swallowed, in contact with skin or if inhaled
Harmful in contact with skin
May cause respiratory irritation

Avoid breathing dust/fume/gas/mist/vapours/spray

Wear protective gloves/protective clothing/eye protection/face protection

IF IN EYES: Rinse cautiously with water for several minutes, Remove contact lenses, if present and easy to do. Continue rinsing

IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing

Store locked up

Dispose of contents/container to ...

American Elements

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MANGANESE SULFATE MONOHYDRATE



DANGER

Causes serious eye damage

May cause damage to organs through prolonged or repeated exposure

Wear protective gloves/protective clothing/eye protection/face protection

Do not eat, drink or smoke when using this product

Use only outdoors or in a well-ventilated area

Call a POISON CENTER or doctor/physician if you feel unwell

Immediately call a POISON CENTER or doctor/physician

Store locked up

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Important Safety Guidelines in brief

- Make sure that you read and understand the safety manuals available at <http://www.iisertirupati.ac.in/>.
- Follow strictly any safety precautions mandated by a laboratory.
- Observe for the safety labels and take necessary precautions.
- Do not work alone in a laboratory.
- Keep your lab clean and organized.
- Never take food or drink inside a lab.
- Wear shoes inside a laboratory.
- Keep everything labelled.
- Never smell or taste an unlabelled chemical.
- Avoid direct exposure to chemicals.
- Avoid direct or indirect eye exposure to lasers.
- Take extreme care when working with focusing optics along with lasers.
- Do not operate an unfamiliar instrument without supervision from an expert.
- In electrical circuits including mains, ensure that the cables have no damage.
- Never touch any bare electrical cables in a circuit even if you feel that it is safe.
- Wash your hands thoroughly before you leave the lab after experiments.
- In case of fire, inform the lab assistants and follow their advice.
- Fire alarms signal smoke or fire. When there is an alarm, leave the building immediately through the nearest exit and gather at the centre of the cricket ground.
- Ensure unblocked access to fire exists, fire extinguishers and electrical panels
- Sign the user safety declaration form.