



**NCEC**  
HAZMAT  
ACADEMY

# Toxic Substances

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## Aim & Objectives

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The aim of the session is to understand the nuances and protection measures for substances and chemicals that possess health hazards

### **Objectives**

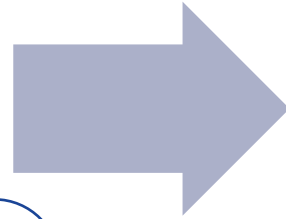
- Identify toxic substances
- Discuss the measure of toxicity
- Determine constraints for working with toxic materials
- Describe the differences between chemical and biohazard toxicity

## How do we measure Toxicity?

- Everything is capable of causing harm if administered in sufficiently large quantities

### Dosage

- Amount swallowed or absorbed through the skin
- Concentration in the air breathed in over time



### Units

- mg/kg – g/kg
- mg/m<sup>3</sup> – g/m<sup>3</sup>
- PPM

## COSHH – Control of Substances Hazardous to Health

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Industries covered:

- Agriculture
- Baking
- Beauty
- Caterers
- Cleaning
- Chemical Industry
- Engineering
- Fumigation
- Hairdressers
- Offshore oil and gas
- Printing
- Motor vehicle repair
- Welding
- Woodworking

## Acute Exposure Guideline Levels – members of the public

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## Immediately Dangerous to Life and Health

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A threshold concentration of a substance in the air, in which an operator must have suitably reliable RPE (e.g. BA)

Substance	IDLH (ppm)
Chlorine	10
Hydrogen Cyanide	50
Acrylonitrile	60
Ammonia	300
Carbon Monoxide	1200

## AEGL – 10 minutes

Material	AEGL 1	AEGL 2	AEGL 3	IDLH	LFL/LEL
Ammonia (NH <sub>3</sub> )	30	220	2700	300	150,000
Carbon Monoxide (CO)	NR	420	1700	1200	125,000
Hydrogen Sulphide (H <sub>2</sub> S)	0.75	41	76	100	43,000
Chlorine (Cl <sub>2</sub> )	0.5	2.8	50	10	-
Hydrogen Cyanide (HCN)	2.5	17	27	50	56,000
Sulphur Dioxide (SO <sub>2</sub> )	0.2	0.75	30	100	-
Phosphine (PH <sub>3</sub> )	NR	4.0	7.2	50	18,000
Phosgene (COCl <sub>2</sub> )	NR	0.6	3.6	2	-

## Occupational Exposure Limits – EH40

Substance	CAS number	Workplace exposure limit				Comments
		Long-term exposure limit (8-hr TWA reference period)		Short-term exposure limit (15-minute reference period)		The Carc, Sen and Sk notations are not exhaustive.
		ppm	mg.m <sup>-3</sup>	ppm	mg.m <sup>-3</sup>	
Sulfotep (ISO)	3689-24-5	-	0.1	-	-	Sk
Sulphur dioxide	7446-09-5	0.5	1.3	1	2.7	
Sulphur hexafluoride	2551-62-4	1000	6070	1250	7590	
Sulphuric acid (mist)	7664-93-9	-	0.05	-	-	The mist is defined as the thoracic fraction
Sulphuryl difluoride	2699-79-8	5	21	10	42	
Talc, respirable dust	14807-96-6	-	1	-	-	
Tantalum	7440-25-7	-	5	-	10	
Tellurium and compounds, except hydrogen telluride (as Te)		-	0.1	-	-	
Terphenyls, all isomers	26140-60-3	-	-	0.5	4.8	
Terphenyl, hydrogenated	61788-32-7	2	19	5	48	
1,1,2,2-Tetrabromoethane	79-27-6	0.5	7.2	-	-	Sk
Tertiary-butyl-methylether	1634-04-4	50	183.5	100	367	



## Lethal Doses and Concentrations

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**LD<sub>50</sub> = lethal dose to kill 50% of a population of 10 within 14 days**

- Sugar = 29.7g/kgbw (rat, ORAL)
- Ethanol = 12g/kgbw (human, ORAL)
- Caffeine = 0.192g/kgbw (rat, ORAL)
- VX = 0.14mg/kgbw (human, ORAL [estimated])
- Botulinum Toxin = 1ng/kgbw (human, ORAL)

**LC<sub>50</sub> = lethal concentration of vapour / gas to kill 50% of a population of 10 or more in 4 hrs**

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1/100 = pphundred

1/1,000,000 = ppmillion

Carbon Monoxide

0.002% = 20ppm

12.5% = 125,000ppm

Hydrogen Sulphide

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1/100 = pphundred

1/1,000,000 = ppmillion

Hydrogen Sulphide

0.0005% = 5ppm 1<sup>st</sup> alarm

0.001% = 10ppm 2<sup>nd</sup> alarm

4.3% = 43,000ppm LEL

# Biohazards

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## Difference to Chemical Hazard

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- Viruses & bacterium reproduce:
  - 10g of chemicals will never become more than 10g
  - 0.001g of biohazard will grow as much as they can
- Solid, liquid or aerosol forms
- Found in living creatures
- Contaminating the working environment.

## Established Infection

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- Infection will be established if:
- Pathogen released in adequate numbers (infectious dose)
- Form & purity are sufficient
- Environmental conditions are suitable
- A suitable host is present.

Pathogen	Infectious Dose/ Organisms (route)
Vibrio Cholerae	10 <sup>8</sup> (ingestion)
Influenza A2	800 (nasopharyngeal inoculation)
West Nile Fever	1 (intramuscular inoculation)

## Hazard Groups (HG)

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- Infectious substances classified according to risk (personal, communal):
- HG1: Unlikely to cause human disease
- HG2: Can cause human disease
- HG3: Can cause severe human disease – curable
- HG4: Causes severe human disease – no cure
- Chemdata provides initial advice on Class 2 & 3 transport classifications later.

## Encountering Biohazards

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Research /  
testing  
cultures

Patient  
specimens

Animal  
products

Agriculture

‘Sharps’

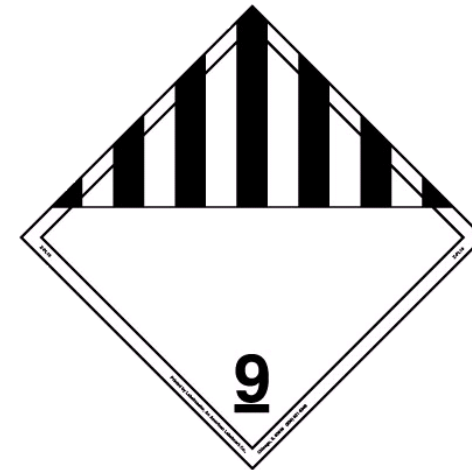
Genetically  
modified  
organisms

Clinical  
waste



## Other Hazards

- Non-infectious genetically modified organisms
- Dry ice used (-78oC) during transport & storage
- Preserve biological samples
- Cold burns, asphyxiation, condenses water out of air (fog)
- Aerosols / propellants

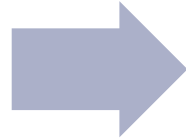


## Classification of Infectious Substances

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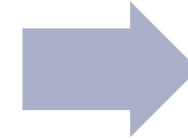
### Category A:

- Debilitating or fatal to human and/or animal



### Category B:

- Not meeting criteria for category A



### Exceptions:

- Blood for transfusions, organs for donation.

## What is ricin?

Ricin is a highly toxic, water-soluble protein, often occurring as a white powder

Discovered in 1888 and extracted from the seeds of the castor plant (*Ricinus communis*).

It can be isolated from the waste of castor oil extraction process

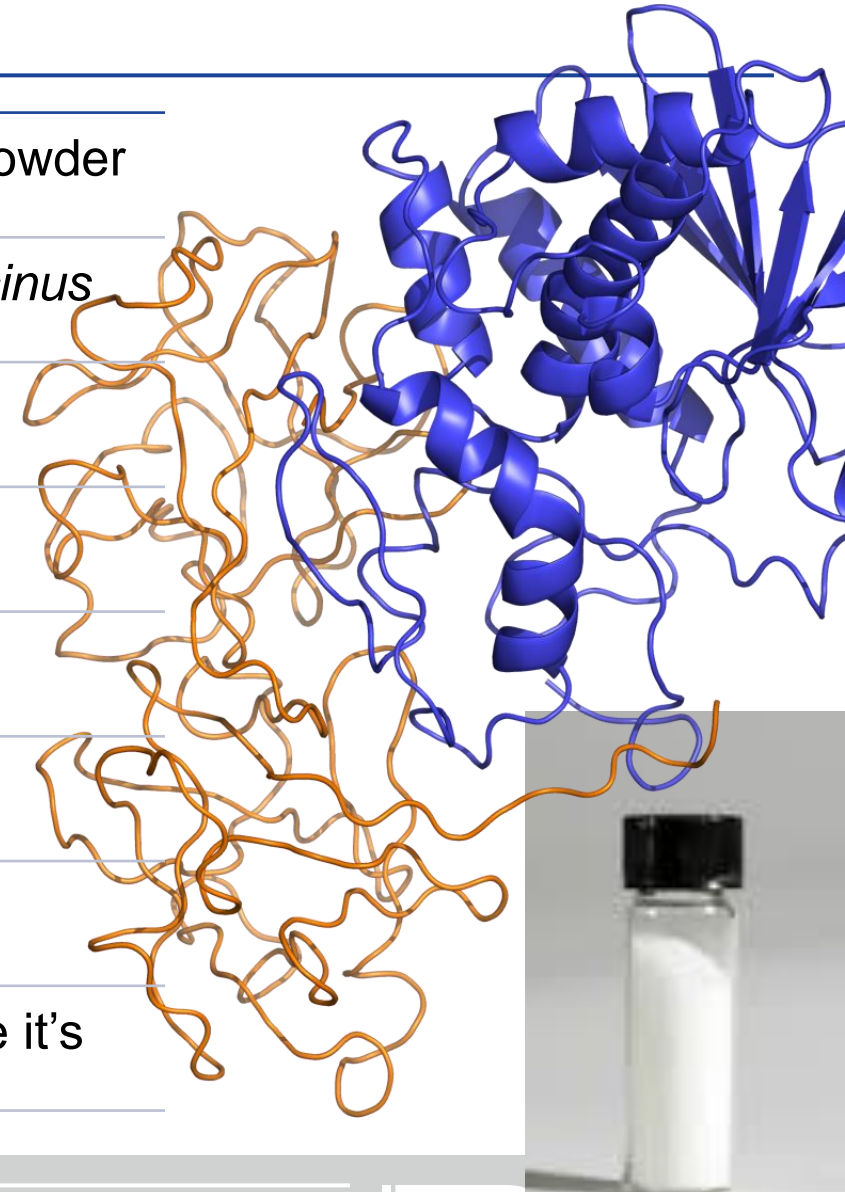
One of the most toxic substances known

Concern over weaponisation – toxic through most exposure routes

When in the body, it induces apoptosis within cells

Apoptosis (aka programmed cell death) = cell self-destruct trigger

High temperatures ( $>80^{\circ}\text{C}$ ) can denature/degrade the protein and reduce its toxicity (cooking is part of castor oil production)



## How can you acquire castor seeds (beans)

- Readily available from 'herbal/natural remedy' outlets
- Castor seeds contain 1-5% by weight ricin.



### 10 Castor Bean Tropical Mix, Ricinus Communis Impala Rare Jatropha Castor Bean Oil Plant Seeds

Brand: SVI

4.0 ★★★★★ (46)

Lowest price in 30 days

-45% £5<sup>99</sup> (£0.60 / count)

Was: £10.99 ⓘ

£5<sup>99</sup> (£0.60 / count)

FREE delivery 29 - 30 January.

[Details](#)

📍 Deliver to Joshua - Cheltenham  
GL51 6

In stock

Quantity: 1 ▼

Add to basket

Buy Now



## Extracting ricin



Use an oil press or crush & squeeze seeds



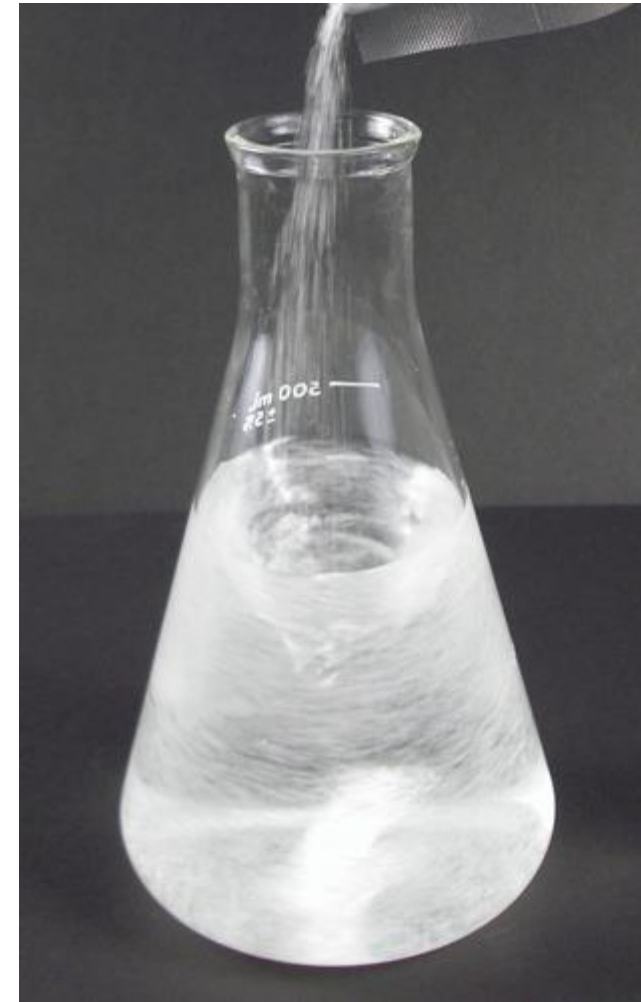
Collect the 'meal', discard the oil

## Extracting ricin

Extract proteins from the meal with acidified salt water (pH 3.8 – use hydrochloric acid), discard remaining pulp



Add ammonium sulphate to liquid filtrate gradually, ricin protein (A/B) will precipitate (selective fractionation)  
- further purification can be achieved through liquid chromatography



## How toxic is ricin?

- Ricin causes cells to self-destruct (apoptosis) – cancer treatment
- Various symptoms occur following specified exposure routes:

### Ingestion

- Diarrhoea
- Vomiting
- Hallucinations
- Seizures
- Liver and Renal Failure

### Inhalation

- Difficulty Breathing
- Tightness of chest
- Chemical pneumonia
- Respiratory failure
- Red blood cell destruction

### Absorption

- None
  - Unless through damaged skin
- Solvents may aid absorption

- All can occur within 72hrs (depending on dose)
- Even small amounts via inhalation (or injection) can be lethal
- Ingestion requires greater doses to be lethal in comparison to inhalation/injection
- Accidental ricin poisoning is rare (30 seeds, injection)

## How toxic is ricin?

- Reports of just 1 milligram is enough to kill an adult
- More detailed reports suggest that 22 µg per Kg body mass is lethal = 2.2mg (100kg [15st 10lb] person)
- There is no antidote, simply treating the symptoms sufficiently to increase chances of survival.



Substance	LD <sub>50</sub>	100kg dose
Heroin	21.8 mg/kg	2.18g
LSD	16.8 mg/kg	1.68g
Hydrogen Cyanide	3.7 mg/kg	0.37g
Robustoxin (from Sydney funnel-web spider)	140 µg/kg	14mg
Amatoxin (from Amanita phalloides mushrooms)	100 µg/kg	10mg
Ricin	22 µg/kg	2.2mg



## PPE & Decontamination

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- Use of BA and GTS recommended (Chemdata states liquid tight suits)
  - Risk from skin exposure is low, primary routes are inhalation and ingestion
  - Priority activities such as MTFA, life-saving activities can afford lower levels of PPE – minimum recommended requirements are BA
  - Where BA is not available then powered respiratory protection is recommended. At the absolute minimum, particulate filtering RPE is a must
  - Ricin particles less than 10µm is required for effective inhalation admission:
    - <1 µm remain airborne for long periods,
    - 3 – 5 µm remain aerosolized for less than an hour
    - >10 µm fall out of the air straight away

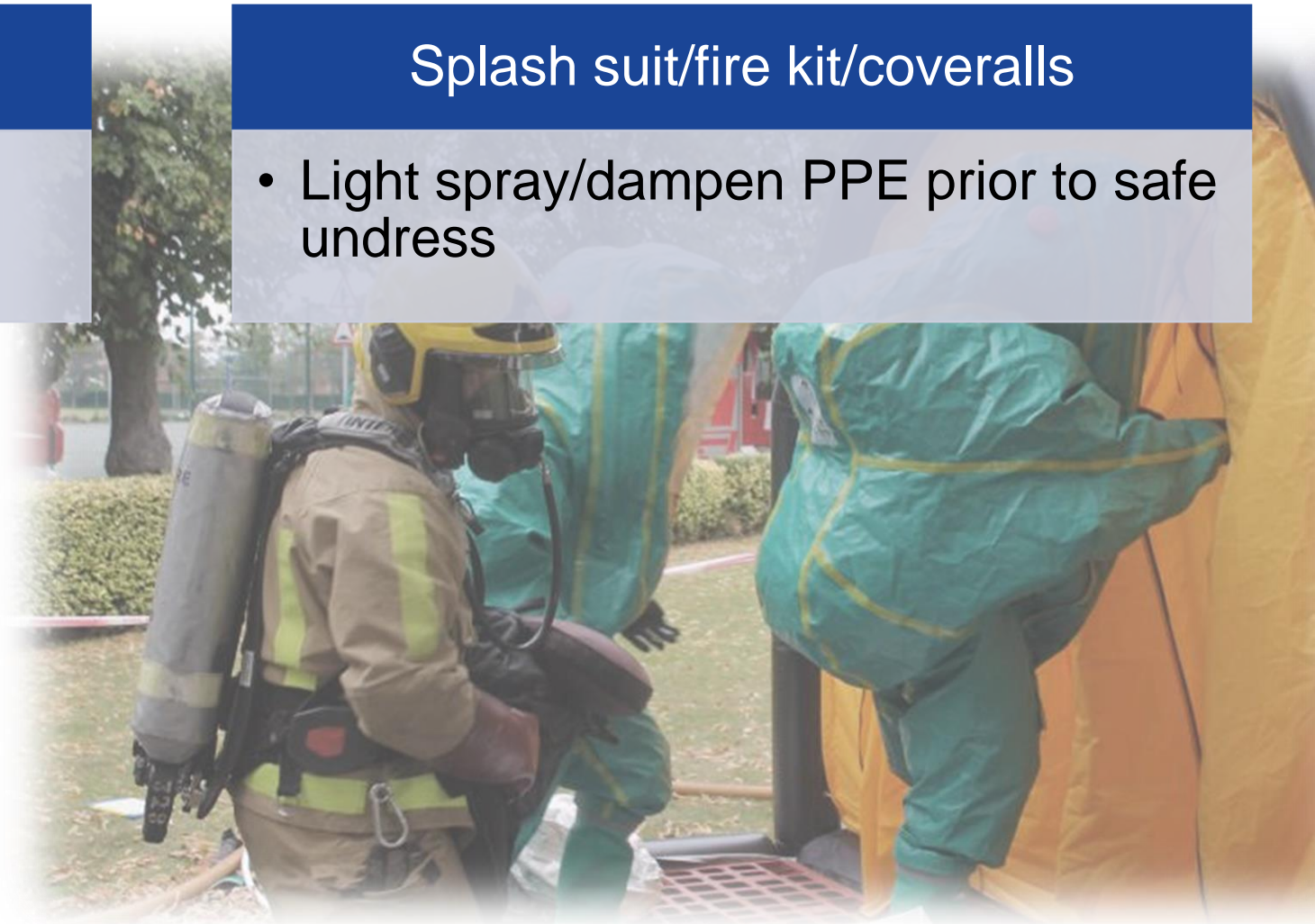
## Ppe & decontamination

### GTS/LTS

- Wet decontamination
- Contain water run-off
- Incinerate PPE
  - Ricin becomes inactive over 80°C
  - Can still be harmful even when dissolved in water

### Splash suit/fire kit/coveralls

- Light spray/dampen PPE prior to safe undress



# Chemical Warfare Agents

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# Chemical Warfare Agents

CW agents are extremely toxic synthetic chemicals that can be dispersed as a gas, liquid or aerosol or as agents adsorbed to particles to become a powder. These CW agents have either lethal or incapacitating effects on humans

## Nerve agents

- VX
- Novichock

## Vesicants (blistering agents)

- Mustard Gas

## Bloods agents (cyanogenic agents)

- Cyanides

## Choking agents (pulmonary agents)

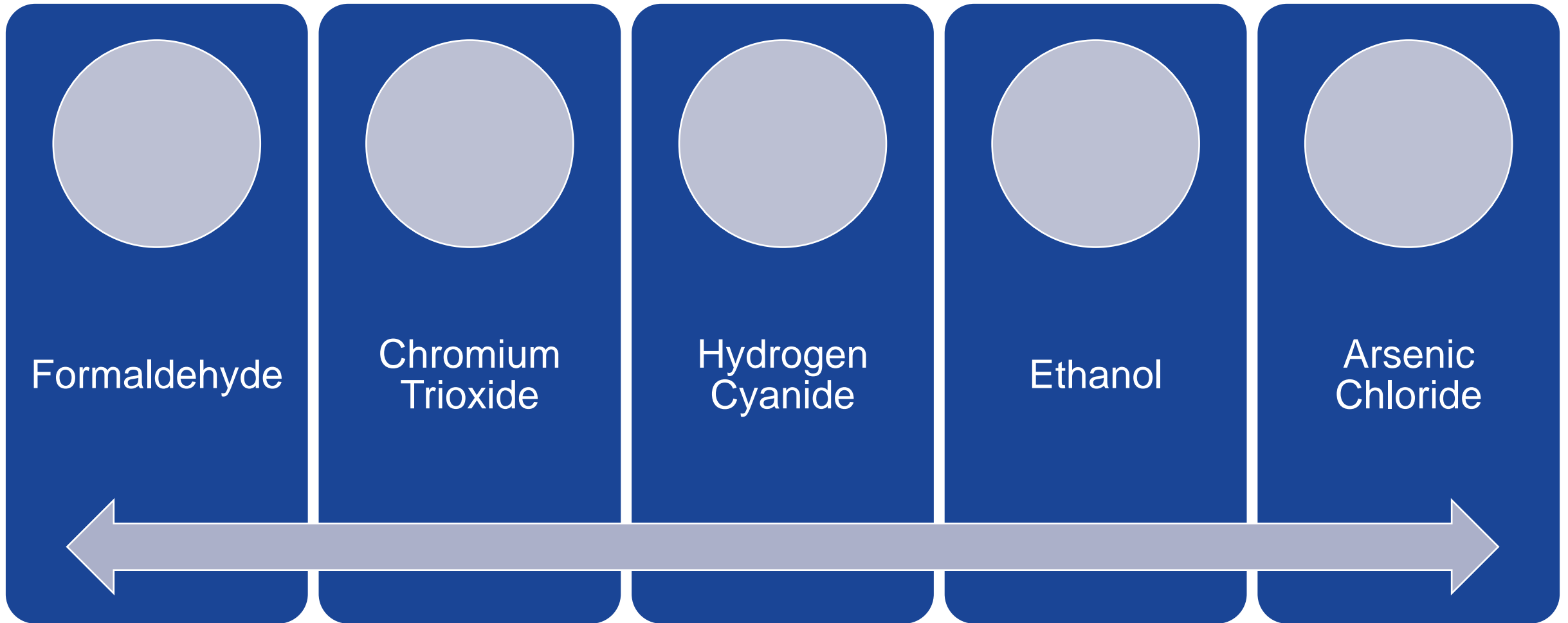
- Chlorine
- Ammonia

## Riot-control agents (tear gases)

# Exercise

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## How Toxic are they?





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Any Questions?