

Chapter 2: Chemical Hazards

Chapter Objectives

Upon completing this chapter, the reader should be able to:

1. Discuss and explain some of the key historical events using chemical agents.
2. Be able to list and describe several chemical weapons types.
3. Explain the mode of action of nerve agents and blister agents.

End-of Chapter Questions

3. What is the most common method of chemical weapon destruction in the United States?
What are the products of this destruction technology? Are there any hazards with use of this technology? Be specific.

The most common methods for CW destruction in the United States are controlled incineration and chemical neutralization.

If incineration is working optimally, the end-products include carbon dioxide, water, various phosphorus oxides, and possibly HCl or HF. Hazards include flameout (which

would release CWs directly out the stack) or releases from containers during transport and processing.

For chemical neutralization, concentrated sodium hydroxide reacts with the CW producing a mixture of compounds of relatively low hazard, termed a hydrolysate. This waste mixture is shipped to a commercial treatment and disposal facility for post-treatment. Hazards include releases from containers during transport and processing.

See: <http://www.cdc.gov/nceh/demil/methods.htm>

<http://www.cma.army.mil/fndocumentviewer.aspx?docid=003672521>

4. By what routes can chemical agents enter the body? Which route is most effective for VX?
For sarin?

- *Inhalation*
- *Ingestion*
- *Absorption through skin*
- *Puncture (injection)*

Most effective route of entry for VX: Inhalation is highly effective; however, given that VX has a low vapor pressure, inhalation may not be likely. Entry via ingestion, puncture and absorption through the skin are also extremely effective.

Most effective route of entry for sarin: Inhalation

5. Define the following terms: LD₅₀; edema; miosis; lachrymation; emesis, cytotoxic; vesicant.

LD₅₀: Standard measurement of acute toxicity that is stated in milligrams (mg) of compound per kilogram (kg) of body weight. An LD₅₀ represents the individual dose required to kill 50 percent of a population of test animals (e.g., laboratory rats).

Edema: Swelling caused by fluid accumulation in tissue

Miosis: Constriction of the pupil of the eye

Lachrymation: Excessive tearing of the eyes

Emesis: Vomiting

Cytotoxic: Can cause death of cells

Vesicant: An agent that causes blistering of tissue

6. The G-series nerve agents are based on the chemical properties of what common chemical(s)? Discuss the mode of action of the nerve agents in general.

Pesticides, specifically the organophosphates. This class of compounds disrupts the nervous system via binding and phosphorylation of the enzyme acetylcholinesterase. This results in the accumulation of acetylcholine, a neurotransmitter, to continually stimulate receptors throughout the central and peripheral nervous systems.

7. Does the dose rate of a nerve agent affect the body's response? Explain. What is the effect of daily exposure to small doses of a nerve agent over several days?

Dose rate is critical to the body's response. If a very large dose of nerve agent has been acquired quickly, death can occur rapidly.

Daily exposure to minute doses can be cumulative, resulting in symptoms after several days.

8. Explain 'persistence' of a chemical weapons agent, in terms of its reactions with air, microorganisms, sunlight, and so on. Which chemical agents are persistent? Is there a practical advantage to an army or terrorist organization using a persistent weapon? Explain.

A chemical agent that does not decompose readily in the presence of oxygen, sunlight and/or microbial populations is termed persistent.

VX is considered persistent due to its low vapor pressure. It is oily and will not decompose except over relatively long periods. Hence it may be used as an area denial weapon (See question 9).

9. Define and explain an 'area denial weapon.' How could it be employed in modern warfare? By a terrorist group?

Such a weapon may be sprayed on to a site to render it toxic to the opposing side in a conflict. Simple skin contact could result in severe effects, including death.

10. Response to chlorine or phosgene exposure involves rapid administration of an antitoxin such as atropine. True or false? Explain.

False. Atropine is effective against nerve agents, not choking agents.

Examination Test Bank

1. The very first chemical weapons ever used in modern times were developed by the French during the Franco-Prussian War of 1870. (*False*)
2. Certain chemical agents such as chlorine gas have had a history of use during wartime, particularly during World War I. (*True*)
3. Chemical weapons were extensively studied after World War I for potential future military use. (*True*)
4. Over the past century chemical warfare agents have been used on civilian populations in order to quell civilian uprisings, for example in Egypt and Italy. (*True*)

5. Chemical weapons stockpiles in the US had existed in most states; however, all these stockpiles have been destroyed since 1999 using both incineration and chemical neutralization technologies. (*False*)
6. A loss of kidney function with an ultimate failure to urinate is defined as:
- a. edema b. eshcar c. anuria d. amnesia e. mediastinitis
7. If no treatment is available for a blood agent (e.g., cyanide) victim, the person could die of a diminished amount of O₂ in blood and tissues resulting from:
- a. airway obstruction due to edema b. weakness of respiration muscles
- c. depression of cellular respiration d. anuria
- e. toxicoplasmolysis
8. Chemical agents can enter the body by all of the following routes EXCEPT:
- a. consumed through food b. inhaled
- c. absorbed through skin/wounds/abrasions d. absorbed through eyes
- e. all these routes are possible
9. Sulfur mustards have been linked with:
- a. decreased libido b. chronic depression c. miosis
- d. emesis e. a and b only

10. Sulfur mustard is a known:

- a. mutagen
- b. carcinogen
- c. allergen
- d. cholinesterase inhibitor
- e. all of the above

11. Indicators of a chemical weapons release:

- a. oily film on bodies of water
- b. large numbers of dead insects and dead birds
- c. blisters or rashes on skin
- d. large areas where vegetation appears burned or discolored
- e. all of the above

Refer to the table:

	LD ₅₀	Vapor Density	K _{ow}	Specific Gravity
		(Air = 1)		(Water = 1)
Sarin	0.0048	1.10	0.8	1.09
VX	0.00063	1.01	3.1	1.01
Cyanogen chloride	0.002	N/A	1.0	1.19
Potassium cyanide	0.004	0.94	0.004	1.20
Mustard gas	0.01	5.4	18.4	1.27

12. In the event of a release, which of the chemical weapons listed is most toxic?

- a. sarin b. VX c. cyanogen chloride
d. potassium cyanide e. mustard gas

13. Which of the agents in the table would be most readily absorbed in human fatty tissue?

- a. sarin b. VX c. cyanogen chloride
d. potassium cyanide e. mustard gas

14. Which of the agents will sink if in contact with a body of water?

- a. sarin b. cyanogen chloride c. potassium cyanide
e. mustard gas e. all of the above

15. The G-series chemical warfare agents are based on the chemical properties of common pesticides. (*True*)

16. Nerve agents (cholinesterase inhibitors) interfere with oxygen transfer to red blood cells, thus causing cell asphyxiation. (*False*)

17. A chemical agent that is termed 'persistent' is one that cannot be readily decomposed by sunlight or microorganisms, or via reactions with oxygen. (*True*)

18. Persistence of a chemical warfare agent increases in hilly, wooded terrain rather than open terrain. (*True*)
19. The V agents are non-persistent, whereas the G agents are persistent. (*False*)
20. Dose rate of a nerve agent is not very critical with regard to the body's response. (*False*)
21. Daily exposure to very small doses of a nerve agent can be cumulative, resulting in symptoms after several days. (*True*)
22. Regular clothing will not allow the penetration of nerve agents, whether they occur in a liquid or vapor form. (*False*)
23. Agent HD was originally H that had been purified through washing and vacuum distillation to reduce sulfur impurities. (*True*)
24. Blister agents dissipate or vaporize rapidly after release, and therefore are a short-duration hazard. (*False*)
25. Both G- and V- agents can be absorbed directly through the skin. (*True*)
26. Young military troops may have better survival rates in a chemical agent attack than older

civilians. (*True*)

27. Little effective medical care exists for persons with mustard agent exposure and lesions, other than relieving symptoms and preventing infection. (*True*)
28. Response to a chlorine or phosgene exposure involves rapid administration of an anti-toxin such as atropine. (*False*)
29. Hydrogen cyanide prevents transfer of oxygen to cells and tissue. (*True*)
30. Phosgene is a corrosive and highly toxic gas that leads to 'dry land drowning'. (*True*)
31. Several chemical warfare agents possess unique odors, which can be used as an initial identifier. For example, some agents smell like newly-mown hay or garlic. (*True*)
32. Measurement that can be used to compare the relative toxicity of several chemical weapons:
- a. TLV b. IDLH c. LF-100 d. LD₅₀ e. MSM test
33. The dose rate of a nerve agent is highly critical with regard to the body's response. (*True*)
34. Hydrogen cyanide prevents transfer of oxygen to living tissue. (*True*)

Match

- | | |
|---------------|--|
| 35. tabun [d] | a. venomous |
| 36. sarin [g] | b. sulfur impurities removed |
| 37. HD [b] | c. blood agent |
| 38. VX [a] | d. first of the chemical warfare agents developed by the Germans |
| 39. L [f] | e. IDLH |
| | f. blister agent |
| | g. Aum Shinrikyo cult, Japan |
-

- | | |
|---------------------|---|
| 40. miosis [c] | a. excessive tearing of the eyes |
| 41. emesis [e] | b. methamphetamine |
| 42. paranoia [b] | c. constriction of pupil |
| 43. lacrimation [a] | d. shattering effect |
| 44. wheal [f] | e. vomiting |
| 45. atropine [h] | f. evanescent area of edema of the skin |
| | g. excessive bleeding |
| | h. antidote for nerve agent exposure |
-

Short Answer

1. List three 'advantages' to terrorists in using chemical weapons on a populated area.
 - a. Chemical weapons tend to have a long 'shelf life'*
 - b. Responders may not be able to immediately identify the chemical; this will allow time for the perpetrator to escape the area*
 - c. Psychological effects may occur, i.e., panic among the affected population*
 - d. Many chemical agents are persistent after release (e.g., VX)*
 - e. May result in mass casualties*