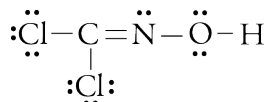


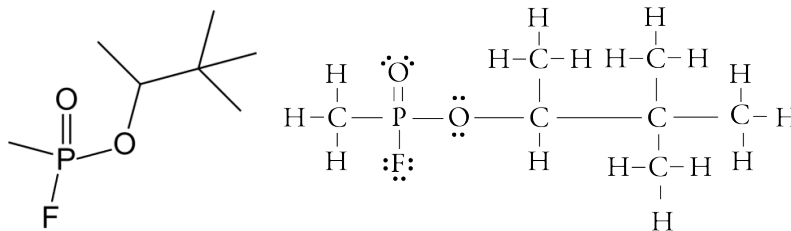
Chemistry Module Quiz Key for Science and Technology NPTS

Fall 2012

- Write the term in the blank that corresponds to the following definitions. (1½ points each)
 - Precursor** With respect to the CWC, any chemical reactant that takes part at any stage in the production by whatever method of a toxic chemical.
 - Binary weapon** A weapon in which the last step in the production of the toxic chemical takes place in the projectile after it is launched (to minimize the danger associated with the storage of the toxic chemical).
 - Schedule 3 chemicals** According to the CWC, chemicals that can be used as chemical weapons or to make chemical weapons but that also have large-scale uses other than chemical weapons.
 - 1925 Geneva Protocol** Protocol on the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare...it banned first use of chemical and biological weapons but not their production and stockpiling.
 - Neurotransmitters** Chemicals that transmit signals from nerve cells (neurons) to a target cell across a synapse.
 - Organisation for the Prohibition of Chemical Weapons (OPCW)** Implementing body of the CWC...given the mandate to achieve the object and purpose of the Convention, to ensure the implementation of its provisions, including those for international verification of compliance with it, and to provide a forum for consultation and cooperation among States Parties.
- Phosgene oxime, or CX, is a chemical weapon with the formula Cl₂CNOH. It is often classified as a vesicant (blister agent), but because it does not cause blisters, it is also called a nettle agent, which produces corrosive skin and tissue injury upon contact, resulting in intense itching and a hive-like rash. Draw a Lewis structure for Cl₂CNOH. All of the atoms should have their most common bonding pattern. (8 Points)



3. The following line drawing represents the nerve agent soman.
- a. Draw a Lewis structure for this agent, including all lone pairs. Note that the phosphorus atom does not have its most common bonding pattern. (8 Points)



- b. On which of the three schedules for the Chemical Weapons Convention would you expect soman to be? Why? (4 Points)

Schedule 1: As a dangerous nerve agent, we wouldn't expect it to have uses other than as a chemical weapon.

- c. Would you expect it to be on part A or part B? Why? (4 Points)

Part A: It's a chemical weapon, not a precursor.

4. Identify each of the following descriptions as associated with chlorine, phosgene, sulfur mustard, hydrogen cyanide, tabun, sarin, soman, or VX. (4 points each)
- Hydrogen cyanide** This volatile liquid is used to make many important chemicals in industry. It disrupts cellular respiration (the conversion of nutrients and oxygen into carbon dioxide, water, and energy) by inhibiting an enzyme in mitochondria.
 - Sulfur mustard** This chemical agent causes damage through both inhalation and skin contact. It is fat-soluble, so it dissolves in the oils in the skin, causing severe chemical burns. It is primarily used to cause medical casualties, but can be lethal when large amounts are inhaled. In Pueblo, Colorado, there is a large amount of this chemical agent stored in different types of projectiles and mortars. It is all scheduled to be destroyed by chemical neutralization.
 - Phosgene** This chemical agent causes suffocation by reacting with proteins in the lungs to disrupt the blood-air barrier. It is used to make important compounds, including pharmaceuticals and plastics. It smells like new-mown hay.
 - VX** This chemical agent was first produced in England in 1954. It disrupts the mechanism by which nerves transfer messages to organs, causing seizures and loss of body control. A small drop on the skin could kill an adult in fifteen minutes. When sprayed on the ground, it remains lethal for up to three weeks, so it is an area denial weapon. The U.S. still has some of this agent stored in Bluegrass, Kentucky. It will be destroyed by chemical neutralization.
5. Write a description of the effects of nerve agents on the body and explain why atropine and 2-PAM act as antidotes. (Your description should include mention of nerve cells, neurotransmitters, acetylcholine, receptor sites, acetylcholinesterase, the on-off mechanism of nerve cells, and competition for receptor sites.) (8 Points)

When the neurotransmitter acetylcholine attaches to its receptor site on a nerve cell (neuron) or muscle cell, it triggers the firing of the neuron or stimulates muscle contraction. Normally, acetylcholine is broken down in the active site of an enzyme, acetylcholinesterase. The acetylcholine can be viewed as the on-switch for the firing of nerve cells and the contraction of muscles and the acetylcholinesterase as the off-switch. Nerve agents form a covalent bond to a serine side chain in the active site of acetylcholinesterase, deactivating it. If acetylcholinesterase is deactivated, the acetylcholine levels remain high, and the switch gets stuck in the "on" position. This leads to a much greater stimulation of the nerve cells, leading to neurological problems, such as seizures, and to excess contraction of muscles, ultimately causing muscle paralysis.

Atropine competes successfully with one type of acetylcholine receptors. It helps relax muscles, and stops the symptoms of nerve agent poisoning, not the cause.

Pralidoxime (2-pyridine aldoxime methyl chloride,) or 2-PAM displaces the nerve agent from the active site of acetylcholinesterase, restoring the enzyme to more normal levels. It is slow to act, so it is administered along with atropine.

See http://preparatorychemistry.com/nerve_agent_sarin.html.

6. Pretend that you are in charge of the chemical weapons program for a country in the Middle East. Your goal is to produce chemical weapons for deterrence and possibly as offensive weapons. You have a well-financed program, a relatively sophisticated chemical industry, a well-developed missile program, and an offer of help from another country with experience in the production of chemical weapons. When answering these questions, keep in mind that there is not one correct answer. If you adequately support your answer, you will be given full credit.
- a. If you were going to put your efforts into creating one chemical agent, would you produce chlorine, hydrogen cyanide, sulfur mustard, or VX as your chemical agent? Give at least four reasons for your choice. Among the factors you might consider are the difficulty in obtaining or making the chemical agent, the ease of transport, the ease of dispersal, the cost, the persistence of the chemical on the ground, the lethality, and the rate at which the physiological effects are manifested. (8 Points)

There's no one correct answer to this question, but VX might be the best choice. Its high lethality makes it a strong deterrent, and its persistence on the ground makes it a powerful battlefield weapon that denies the enemy access to the exposed area for up to weeks. Although the process for making VX is expensive and requires special safety precautions, it is not so different than that used to make organophosphate pesticides, and is within the capability of a well-developed chemical industry.

VX is also odorless, fast acting, damaging through inhalation and skin contact, clings to whatever it hits, and has obvious and frightening effects.

- b. What sort of delivery method would you plan to use? (4 Points)

Because of the great danger in handling and transporting VX, perhaps the best delivery method would be as a binary weapon in which the chemicals that form VX in the last step in production are mixed in the projectile in flight.