

**Chemistry Module Final Exam Key for Science and Technology NPTS
Fall 2012**

The following is a snip from the beginning of an article in the 2 December, 2012 issue of the Guardian.

Turkey has asked for Nato Patriot missile defenses to be deployed on its territory after receiving intelligence that the Syrian government was contemplating the use of missiles, possibly with chemical warheads, Turkish officials have told the Guardian.

The officials said they had credible evidence that if the Syrian government's aerial bombardment against opposition-held areas failed to hold the rebels back, Bashar al-Assad's regime could resort to missiles and chemical weapons in a desperate last effort to survive.

The Turks believe that the regime's Soviet-era Scuds and North Korean SS-21 missiles would be aimed principally at opposition areas but could easily stray across the border, as Syrian army artillery shells and mortars have done.

A missile, especially with a chemical warhead, would represent a far greater threat to Turkish border communities, and so Ankara decided last month to ask Nato to supply Patriot missile defense systems, which can spot an incoming missile and intercept it.

"We have intelligence from difference sources that the Syrians will use ballistic missiles and chemical warheads," a senior Turkish official said. "First they sent the infantry in against the rebels and they lost a lot of men, and many changed sides. Then they sent in the tanks, and they were taken out by anti-tank missiles. So now it's air power. If that fails it will be missiles, perhaps with chemical warheads. That is why we asked Nato for protection."

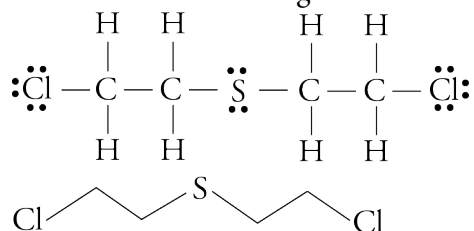
The Syrian regime is believed to have stocks of mustard gas, sarin nerve gas and possibly VX, another nerve agent. Western governments have warned Assad that any use of these weapons would trigger direct military intervention against him. So far, western officials say there are no signs of the regime taking the final steps of preparing chemical artillery shells, missiles or aircraft bombs for use.

Let's pretend that you have been asked to help draft a briefing paper for the group evaluating Turkey's request for Patriot missiles.

1. The first thing you do is provide a glossary of terms relating to the issue. Write the term in the blank that corresponds to the following definitions. (1 points each)
 - a. **Chemical Weapons Convention (CWC)** An arms control agreement that bans the production, stockpiling, transferring, and use of chemical weapons. Approved by the U.N. General Assembly in November, 1992.
 - b. **Organization 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.
 - c. **Precursor** According to the CWC, any chemical reactant that takes part at any stage in the production by whatever method of a toxic chemical.
 - d. **Schedule 1 chemicals** According to the CWC, chemicals that have few or no uses other than as chemical weapons or to make chemical weapons.
 - e. **Blister agents** Compounds that cause severe skin, eye, and mucus membrane pain and irritation. They cause severe chemical burns and painful water blisters.
 - f. **Nerve agents** Phosphorus-containing organic compounds that disrupt the process by which nerves transfer messages to organs. Tabun, Sarin, Soman, and VX are examples.
2. To evaluate the danger of each of Syria's chemical weapons, you decide that the group should know more about each. You start with mustard agent.
 - a. On which CWC schedule is mustard agent found? Why? Is it part A of part B? Why? (3 points)

Schedule 1 Part A...it is a chemical that has no uses other than as a chemical weapon. It is the actual weapon (Part A) not a precursor (Part B).

- b. The condensed formula for sulfur mustard (H or HD) is $\text{ClCH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{Cl}$. Write the Lewis structure and line drawing for sulfur mustard. (4 points)



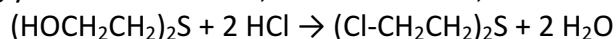
c. Give two examples of how it was used as a chemical weapon in the past. (3 points)

- Used first by Germans in WWI in 1917.
- Captured mustard gas shells used by Allies in 1917.
- 1919: United Kingdom against the Red Army
- 1921-27: Spain and France against insurgents in Morocco
- 1930: Italy in Libya
- 1934, 1936-37: Soviet Union in China
- 1935-40: Italy against Abyssinia (now Ethiopia)
- 1937-45: Japanese against China
- 1963-67: Egypt against North Yemen
- 1983-88: Iraq against Iran and the Kurds
- 1995, 1997: Possibly Sudan against insurgents in their civil war

d. Describe the relative difficulty of the synthesis of sulfur mustard compared to other chemical weapons. (3 points)

Relatively easy to make and conceal.

Thiodiglycol and concentrated hydrochloric acid react to form sulfur mustard. Because thiodiglycol is a schedule 2, Part B chemical, it is difficult to obtain.



Does not require sophisticated equipment.

e. Describe how it acts on the body. (3 points)

It is fat-soluble, so it dissolves in the oils in the skin, causing severe chemical burns and blisters.

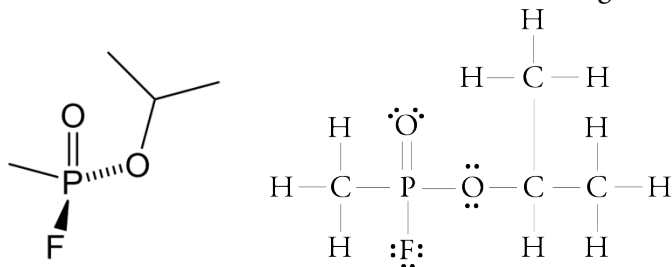
Sulfur mustard forms a sulfonium ion, which attaches to the guanine nucleotide of DNA, disrupting cell division and function. This can lead to cellular death or cancer.

f. Describe the treatment for exposure. (3 points)

Early rinsing of the exposed area with Betadine (povidone-iodine) dissolved in glycofural will reduce symptoms. Can limit the formation of blisters by applying household bleach or a solution called DS2 (2% sodium hydroxide, NaOH, 70% diethylamine, $\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3$, and 28% ethylene glycol monomethyl ether, $\text{CH}_3\text{OCH}_2\text{CH}_2\text{OH}$). After initial treatment, the patient is treated in the same way that any burn victim would be treated.

3. The following questions would help you to develop your description of sarin.

a. Draw the Lewis structure for sarin. Its line drawing is below. (3 points)



- b. Give an example of how it was used as a chemical weapon in the past. (2 points)
- Iraq used sarin against Iran and the Kurds in the 1980s.
 - Used in the Tokyo Subway attack by Aum Shinrikyo
- c. Describe the relative difficulty of the synthesis of sarin compared to other chemical weapons. (3 points)
- Because of sarin's toxicity, its production requires special care.
 - Most easily prepared from methylphosphonyl difluoride and isopropyl alcohol.
- $$\text{CH}_3\text{P}(\text{O})\text{F}_2 + (\text{CH}_3)_2\text{CHOH} \rightarrow [(\text{CH}_3)_2\text{CHO}]\text{CH}_3\text{P}(\text{O})\text{F} + \text{HF}$$
- Three technical hurdles
 - Involves corrosive hot hydrochloric acid, HCl, and hydrogen fluoride, HF, so need corrosion resistant equipment, e.g. vessels and pipes of an alloy that is 40% nickel...Monel and Hastalloy.
 - To make $\text{CH}_3\text{P}(\text{O})\text{F}_2$ (schedule 1, part b), alkylation reaction in which methyl, $-\text{CH}_3$, group is added to the phosphorus atom is technically difficult.
 - Distillation necessary to produce high-purity necessary for long storage.
- d. Describe how it acts on the body. (4 points)
- Sarin forms 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 that triggers the contraction of muscles gets stuck in the "on" position.
 - For skeletal muscles: uncontrolled spasms, followed by paralysis
 - For involuntary muscles: pupil contraction, excessive salivation, intestinal cramps, vomiting, and constriction of bronchial tubes
 - For central nervous system: overstimulates the brain, causing seizures
 - Causes glands to be overactive, secreting excess nasal mucus, saliva, and sweat
 - Causes death by asphyxiation through constriction of bronchial tubes, suppression of the respiratory center of the brain, and paralysis of the breathing muscles
4. The hope is that Syria's chemical weapons will be destroyed. Describe three techniques for the disposal or destruction of chemical weapons. (3 points)
- Disposal at sea...no longer done
 - Incineration
 - Chemical neutralization - Chemical weapons can be converted into safer substances by combining them with a concentrated solution of sodium hydroxide, NaOH. The reaction is called hydrolysis, in which water, H_2O , divides into H, which combines with one part of a molecule, and OH, which combines with another part of the molecule, splitting the molecule into two parts.