

DW Module 24:  
Gas Chlorination  
**Answer Key**



Exercise: Using the graph in Fig. 1.1, fill in the data points that are missing in the above table.

Answer: (In bold)

Curve Data	
Temp. (°F)	Press. (psig)
-29.29	<b>0</b>
-10	8.29
<b>0</b>	13.81
20	27.84
40	46.58
60	70.91
80	<b>101.76</b>
100	<b>140.20</b>
120	<b>186.95</b>
140	243.33
160	310.35
180	389.17
<b>200</b>	480.97
220	587.13



Exercise

1. What is the purpose of chlorination?

**Ans:** Disinfection and oxidation in water treatment.

2. What are the two different forms of chlorine?

**Ans:** liquid chlorine and gaseous chlorine.

3. What are four of the nine properties of liquid chlorine?

**Ans:** Any four of the nine answers in this table will be acceptable.

Critical Temperature	144°C; 291.2°F
Critical Pressure	1118.4 psia
Critical Density	38.77 lbs/ cu ft
Density (at 32°F & 1 atm)	91.67 lbs/cu ft
Specific Gravity (at 68°F)	1.41 (water = 1)
Boiling Point	-34.5°C; -30.1°F
Freezing Point	-100.98°C; -149.76°F
Viscosity (at 68°F)	0.342 centipoise (approx 0.35 x water)
1 pound liquid (at 32°F & 1 atm)	4.98 cu ft gas

4. What are the specific gravity and solubility in water of gaseous chlorine?

**Ans:** The correct answers are in bold type.

Density (at 32°F & 1 atm)	0.2006 lbs/ cu ft
<b>Specific Gravity (at 32°F &amp; 1 atm)</b>	<b>2.482 (air = 1)</b>
Liquefying Point (at 1 atm)	-30.1 °F
Viscosity (at 68°F)	0.01325 centipoise
<b>Solubility in Water</b>	<b>60.84 lbs/1000 gal</b>

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### Health Hazards



Using the sample MSDS in the workbook, answer the following questions about chlorine hazards:

1. What effect does liquid chlorine have on the skin and eyes?

**Ans:** It is corrosive to skin and eyes and can cause frostbite burns. Skin contact may result in skin irritation with discomfort or a rash. Eye contact can cause eye irritation with discomfort, tearing or blurred vision. Permanent eye damage is possible as well as blindness.

2. What effect does gaseous chlorine have on the nose, throat and lungs?

**Ans:** It is extremely irritating to the nose, throat and lungs. Gross overexposure can cause death.

3. What effect does exposure to gaseous chlorine have on heartbeat and pulse?

**Ans:** It may temporarily alter the electrical activity of the heart with irregular pulse, palpitations or inadequate circulation. Gross overexposure could result in death.

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**Exercise for Unit 2 – Chlorine Handling and Storage.**

1. Explain the meaning of a MSDS.

**MSDS stands for Material Safety Data Sheet and is provided for every chemical by the manufacturer. It contains very important information concerning the chemical and should be kept in a file near where the chemical is used.**

2. List two undesirable health effects from Chlorine exposure.

**Answers may include: skin irritation, eye irritation, nausea, headache, breathing difficulties, irregular pulse and others as listed in the MSDS including death in severe cases.**

3. List two ways of detecting Chlorine leaks.

**Answers could include: your sense of smell, chlorine detection equipment, or a rag saturated with strong ammonia solution will indicate leaks by the presence of white fumes.**

4. What are three types of storage containers for Chlorine?

**Answers are cylinders (100 and 150 lb.), ton containers, and railroad tank cars.**

5. List at least three characteristics of an appropriate storage facility for Chlorine.

**Answers could include: clean, cool, well ventilated area. Storage rooms should be free of combustible materials and should be away from heat sources. Cylinder storage and chemical feed operations should be in separate rooms. Other possible answers are listed in the text for Unit 2.**

6. What are the two basic types of Chlorine Scrubbers?

**The two types of chlorine scrubbers are caustic solution and solid media types.**

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**Example:**

Calculate the CT product, or Contact Time, for a ground water supply not under the influence of surface water intrusion. Assume that the concentration C is 0.25 mg/L and that the time T is 25 minutes.

**Answer:**  $C \times T = \text{Concentration} \times \text{Time}$

$$C \times T = 0.25 \text{ mg/l} \times 25 \text{ min.}$$

$$C \times T = 6.25 \text{ mg} \times \text{min} / \text{l}$$

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### Exercise

1. What is produced when chlorine reacts with organic matter in the water?

**Ans:** Chlororganics and chloramines.

2. Explain what breakpoint chlorination is.

**Ans:** Breakpoint chlorination is the addition of chlorine until all chlorine demand has been satisfied. It is used to determine how much chlorine is required for disinfection.

3. A water treatment plant operating at 750,000 gallons per day adds 3.0 mg/l of chlorine for disinfection. After a 30 minute contact period, the chlorine residual is measured at 1.35 mg/l. Compute the chlorine demand of this water.

**Ans:** Compute the chlorine demand in mg/l.

$$\text{Chlorine Demand (mg/l)} = \text{Chlorine Dose (mg/l)} - \text{Chlorine Residual (mg/l)}$$

$$\text{Chlorine Demand (mg/l)} = 3.0 \text{ mg/l} - 1.35 \text{ mg/l}$$

$$\text{Chlorine Demand (mg/l)} = 1.65 \text{ mg/l}$$

4. What is the definition of chlorine residual?

**Ans:** Chlorine Residual = Chlorine Dose – Chlorine Demand

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Exercise for Unit 3.

1. What is the percentage of inactivation for a 2 log and a 4 log process?

**Ans:** 2 log = 99%

4 log = 99.99%

2. Explain the meaning of chlorine demand.

**Ans:** Chlorine Demand = Chlorine Dose – Chlorine Residual

3. Chlorine can be provided in 150 pound cylinders.

4. A 150 pound cylinder can provide chlorine at a maximum rate of about 1.5 pounds per hour.

5. Gas detectors can find chlorine leaks of 1 mg/l or less and should be used in storage and feed rooms.

6. A start-stop operation of a chlorinator is typical for chlorination of well water where a well pump does not operate continuously.

7. Low chlorine residual would be considered to be an example of abnormal operation.

8. A chlorine residual of a minimum of 0.02 mg/l must be maintained at the most distant points of a distribution system.

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### Exercise

1. List two alternate chlorine chemical compounds and explain the purpose of each.

**Ans:** chloramines and chlorine dioxide.

2. List three types of chloramines.

**Ans:** monochloramine, dichloramine and trichloride (trichloramine)

3. What are two advantages of using chlorine dioxide?

**Ans:** Chlorine dioxide is not affected by ammonia and does not form carcinogenic compounds. It can also be used to control taste and odor problems.

4. List the dechlorination reactants.

**Ans:** Chlorine, sulfur dioxide, sodium bisulfite, sodium sulfite and sodium thiosulfate.