DISINFECTION STUDY GUIDE

1. Name two reasons why chlorine is a common disinfectant.

2. Name three important parameters impacting disinfection.

3. Name two physical and two chemical (excluding chlorine) agents that can be used as disinfectants.

4. What are chloramines? How are they formed? Do they have disinfecting power?

5. What is the difference between disinfection and sterilization?

6. What are DBPs? How are they formed? Name 2 common DBPs.

7. State Chick's law.

8. What chemicals are used in place of chlorine gas?

9. What compounds contribute to free residuals and combined chlorine residuals?

10. What are advantages and disadvantages of ozone as a disinfecting agent?

Disinfection By Products (DBPs)

Reaction of Chlorine with Organics in water and wastewater

HOCl + NOM (Natural Organic Matter) = Oxidized NOM + HAA + THM

HAA Haloacetic Acids- mono,di, tri - chloroacetic acid

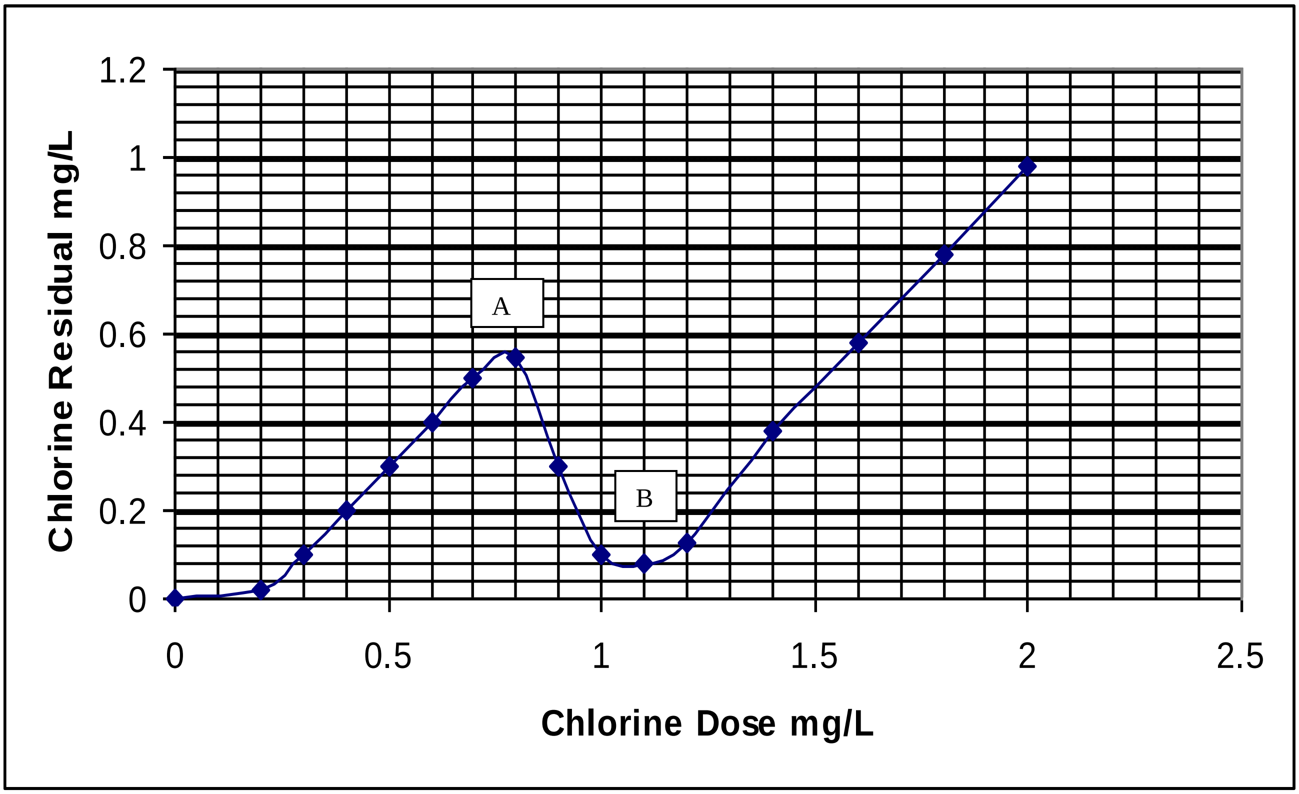
THM Trihalomethanes (carcinogenic The current limit for THMs is 100 ppb)
Choloroform, Bromoform, bromodichloromethane, dibromochloromethane

7. Breakpoint chlorination data for a water is provided below.

a) What is the chlorine dose to reach breakpoint?

b) Determine the chlorine dose required to attain a **total residual** of 0.35 mg/L?

c) What is the chlorine dose required to maintain a free residual of 0.5 mg/L?



d) Why is there no residual at a chlorine dose of 0.1 mg/L?
e) Why does the residual decrease from point A to B?

Chick-Watson's Law

If Chick's Law is combined with the concentration product concept, a relationship dealing with both time, concentration, and degree of lethality can be established. Watson observed that the concentration time product was a function of the degree of disinfection as well as other factors including the microorganism present.

It has been observed that the destruction of microorganisms is a function of the concentration of disinfectant and the time of contact, or,

$$K = C^n t$$

where,

K = constant for a particular disinfectant and microorganism, [mg/L-min or mg/L-sec]
C = disinfectant concentration, [mg/L]
t = contact time, [min or sec] or detention time
n = empirical constant

This relationship holds true only for a given set of conditions, e.g., constant pH, temperature, and a specific microorganism.

For a coagulation plant 0.5 log inactivation of Giardia is needed.
For untreated surface water, a 3 log inactivation is needed

Physical removal of microbes is termed **log removal or inactivation (LR)**

Log inactivation is a measure of the percent of microorganisms that are inactivated during the disinfection process and is defined as:

Log removal or $$\text{Log Inactivation} = \text{Log}\left(\frac{N_o}{N_T}\right)$$

Where,

N_o = initial (influent) concentration of viable microorganisms
N_T = concentration of surviving microorganisms
Log = logarithm to base 10

% removal = $100-100/10^{LR}$

TABLE 6-15

CT values (in mg/L · min) for inactivation of *Giardia* cysts by free chlorine at 10°C

Chlorine concentration (mg/L)	pH = 6.0 Log inactivations						pH = 7.0 Log inactivations						pH = 8.0 Log inactivations						pH = 9.0 Log inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	12	24	37	49	61	73	17	35	52	69	87	104	25	50	75	99	124	149	35	70	105	139	174	209
0.6	13	25	38	50	63	75	18	36	54	71	89	107	26	51	77	102	128	153	36	73	109	145	182	218
0.8	13	26	39	52	65	78	18	37	55	73	92	110	26	53	79	105	132	158	38	75	113	151	188	226
1	13	26	40	53	66	79	19	37	56	75	93	112	27	54	81	108	135	162	39	78	117	156	195	234
1.2	13	27	40	53	67	80	19	38	57	76	95	114	28	55	83	111	138	166	40	80	120	160	200	240
1.4	14	27	41	55	68	82	19	39	58	77	97	116	28	57	85	113	142	170	41	82	124	165	206	247
1.6	14	28	42	55	69	83	20	40	60	79	99	119	29	58	87	115	145	174	42	84	127	169	211	253
1.8	14	29	43	57	72	86	20	41	61	81	[illegible]	[illegible]	[illegible]	[illegible]	90	119	149	179	43	86	130	173	216	259
2	15	29	44	58	73	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	61	91	121	152	182	44	88	133	177	221	265
2.2	15	30	45	59	[illegible]	[illegible]	21	42	[illegible]	85	106	127	31	62	93	124	155	186	45	90	136	181	226	271
2.4	15	30	45	60	75	90	21	43	65	86	108	129	32	63	95	127	158	190	46	92	138	184	230	276
2.6	15	31	46	61	77	92	22	44	66	87	109	131	32	65	97	129	162	194	47	94	141	187	234	281
2.8	16	31	47	62	78	93	22	45	67	89	112	134	33	65	99	131	164	197	49	96	144	191	239	287
3	16	32	48	63	79	95	23	46	69	91	114	137	34	67	101	134	168	201	49	97	146	195	243	292

Source: U.S. EPA, 1991.

athogen that may require inactivation is *Cryptosporidium*. *Cryptospo-* inactivated by chlorine, and either ozone or ultraviolet light (UV) is e processes are discussed in later sections.

ome common in the water industry to express the inactivation credit or physical removal achieved in a plant as *log removal*. This term does not removal of physical particles is a logarithmic process, but rather that the al found at a point in time can be mathematically represented by a log on. Log removal (LR) can be found as:

$$LR = \log\left(\frac{\text{influent concentrations}}{\text{effluent concentrations}}\right) \tag{6-63}$$

oval for a series of data is to be determined, then the averages for the luent concentrations can be used. The percent removal (or inactivation) log removal or inactivation by

$$\%\ \text{removal} = 100 - \frac{100}{10^{LR}} \tag{6-64}$$

A city measured the concentration of aerobic spores in its raw and as an indicator of plant performance. Spores are often plentiful in and are conservative indicators of how well a plant is able to remove m. The city data are as follows:

(spores/L)	
Raw	Finished
200,000	16
145,000	4
170,000	2
150,000	8
170,000	10
180,000	2
180,000	3

g removal and convert that to percent removal.

log removal is found by finding the average raw and finished water and then using Equation 6-63. The average raw concentration is /L and the finished average concentration is 6.43. Therefore,

$$LR = \log\left(\frac{170{,}714}{6.43}\right) = 4.42$$

removal is

$$\% = 100 - \frac{100}{10^{4.42}} = 99.996$$

DISINFECTION CT RULE (Page 337-339)

Learn to Use Table 6-15

a) A water treatment plant is aiming for a log inactivation of 2.5 for Giardia cysts at 10°C and a pH of 7. What is the required time of kill in minutes if the plant uses a chlorine dose of 2 mg/L?

Using table go to pH 7 and log inactivation 2.5. Use the Chlorine dose of 2.0 to find the corresponding Ct value of 103 mg.min/L

Therefore time = 103/2=51.5 minutes

b) A drinking water treatment plant uses a chlorine dose of 1.8 mg/L for a contact period of 45 minutes at a pH of 7 and a temperature of 10oC. What is the Ct value and what is log inactivation for Giardia cysts and % removal?

Ct = 1.8 mg/L * 45 min = 81 mg.min/L

Corresponding Log inactivation is 2.0 from table.

% removal of Giardia = 100-100/10^2 =99%