CVG 2131

INTRODUCTION TO ENVIRONMENTAL ENGINEERING

Final Examination — Dr. R.L. Droste
December 9, 2003
Time: 3 h —

Open Book Examination. Calculators are permitted.

If an answer requires an iterative solution, only perform 1 iteration and indicate the changes you would make for the next iteration.

<u>You must answer questions 1 and 2 that are each worth 15 marks.</u>

1. A couple of students live in a home with space of 350 m^3 volume that has a 0.25 ach infiltration rate. Each night at 1800 h they cook with two burners on their gas range for 1 hour. They were absent from the home for an extended period of time and the concentrations of all pollutant gases in the home decreased to ambient (outdoor) levels. The ambient level of SO_2 is 0.03 ppm. The decay rate of SO_2 is 0.23/h. The outdoor temperature and pressure are 15^{o}C and 1.0 atm, respectively.

   The students return home on Monday afternoon and resume their regular routine cooking a meal at 1800 h. Find the concentration SO_2 in the home on Tuesday at 1900 h immediately after cooking Tuesday's supper.

2. The concentration of the probable bioaccumulative carcinogen dieldrin in a lake averages 2.0 ppb. What mass of fish caught from this lake can be consumed on a daily basis by a 70 kg person over a period of 65 years to result in a cancer risk of 10^{-6}? The total lifespan of the person is assumed to be 70 years but the person is not assumed to consume fish on a regular basis until the age of 5.

<u>Answer any 7 of the following questions. Each question is worth 10 marks.</u>

3. Biogas is produced from an anaerobic digester at a rate of 200 kg/d. The biogas is to be used in a co-generation process to produce electricity. Variation in the rate of consumption of electricity compared to the generation of biogas requires a storage container that will store 10 days production of biogas. Biogas contains 60% CH_4 and 40% CO_2 by volume. What size container is required for a temperature of 20^{o}C and pressure of 4.0 MPa?

4. In 1977 Ghana had a population of 11.3 million. There were 542,400 births and 192,100 deaths during that year. Assume that the net migration was zero. What is the time for the population to double if the growth rate in 1977 persists into the future?

5. Calculate the BOD reported for a sample for which the following data were taken:

	Dilution		
Sample	1%	2%	3%
Dissolved oxygen decrease (mg/L)	2.7	4.9	7.2

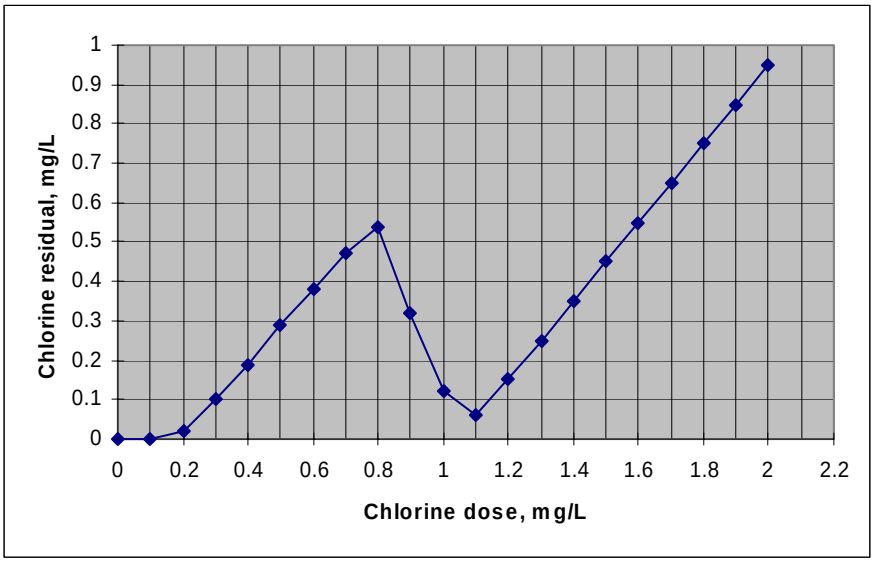
6. How much dichromate would be consumed by a 25 mL sample of water that contains 40 mg/L of acetic acid (CH_3COOH) and 85 mg/L of the amino acid, glycine ($C_2H_5O_2N$) in the standard COD analysis? Remember that N is not oxidized in the COD analysis.

7. On a summer day with moderate insolation and wind speed of 3 m/s, a tank truck loaded with liquid chlorine is involved in an accident that results in a small split in the tank and a leak of 30 kg/min at the top of the tank. (The chlorine escaping is all in vapor form.) The accident occurs on a

throughway through the city and there are very large apartment buildings about 300 m downstream. The threshold limit for chlorine is 3 mg/m^3. In an emergency situation assume for practical and safety purposes that gas density differences can be neglected and the leak is at ground level. Would you give the order to evacuate the apartment buildings?

8. A wastewater is known to have a rate constant of 0.20 d^{-1} (base e) at 20^{o}C. If a sample of this wastewater had a $BOD_{5,20}$ of 160 mg/L and a $BOD_{10,20}$ of 240 mg/L, what was the probable nitrogeneous oxygen demand exerted at 10 days? Nitrogenous oxygen demand was not exerted at 5 days.

9. A chlorine demand curve is shown in the figure below. What is the chlorine dose required to achieve a free residual chlorine concentration of 0.5 mg/L?



10. A water contains the substances listed in the table below. The pH of the water was 6.90. Lime and soda ash at 8.25 meq/L and 0.40 meq/L, respectively, were added to the water. What are the concentrations of dissolved Ca^{2+}, Mg^{2+}, OH^-, HCO_3^-, CO_3^{2-} after precipitation of all possible species?

Substance	Ca^{2+}	Mg^{2+}	HCO_3^-
Concentration, mg/L	94	43	271

What is the acidity of the water as $CaCO_3$?

Molecular Weights

Al- 27, C- 12, Ca- 40, Ce- 140.1, Cl- 35.5, Cr- 52, H- 1, K- 39.1, Mg- 24.3, N- 14, Na- 23, O- 16, P- 31, S- 32