UNIVERSITY OF SWAZILAND
Faculty of Health Sciences
Department of Environmental Health Science

B.Sc. DEGREE IN ENVIRONMENTAL HEALTH SCIENCE

MAIN EXAMINATION PAPER 2018

TITLE OF PAPER   URBAN WATER TREATMENT

COURSE CODE   EHS 222

DURATION   2 HOURS

MARKS   100

INSTRUCTIONS   READ THE QUESTIONS & INSTRUCTIONS CAREFULLY

ANSWER **ANY FOUR** QUESTIONS

EACH QUESTION **CARRIES 25** MARKS.

WRITE NEATLY & CLEARLY

NO PAPER SHOULD BE BROUGHT INTO THE EXAMINATION ROOM.

BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER.

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION IS GRANTED BY THE INVIGILATOR.

QUESTION ONE (5 Marks each)

1A. A rectangular plain sedimentation tank was modified by constructing an extra bottom in the middle of the tank as shown in Figure Q1-1. Originally the tank has plan area A, depth H and the flow rate is Q.

    i.   Plot the trajectory of solid particles in this new design. .....[3 marks]

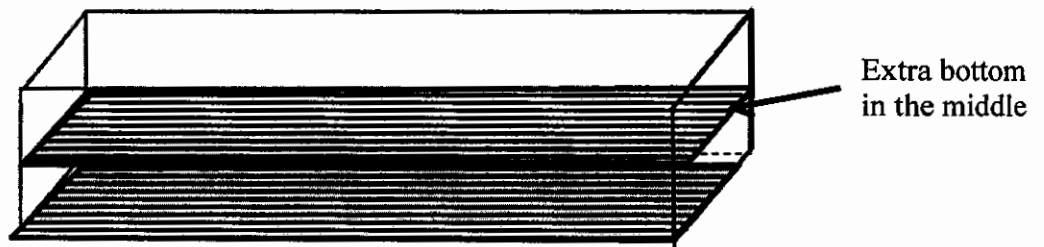   ii.   Compare the settling velocity of particles of this modified tank with that of the original.   ....[2 marks]

Extra bottom in the middle

Figure Q1-1

1B. Describe the advantages and disadvantages of:

    i)   horizontal flow roughing filtration ....[3 marks]

    ii)   vertical flow roughing filtration. ....[2 marks]

1C. What water treatment methods are available for the removal of organic matter in water?

1D. Figure Q1-2 below shows the plan and vertical cross section, respectively, of an intake structure.

    i.   State the function of piles and large boulders shown on the vertical cross section.

    ii.   State the reason for providing curved wall on the upstream wing wall of the intake shown on the plan drawing.

    iii.   The intake is oriented at right angle to the direction of flow. State the advantages and disadvantages of such orientation and suggest possible improvement to such design.

    iv.   Why are multiple screens provided on the intake and in what respect are these several multiple screens differ from each other?
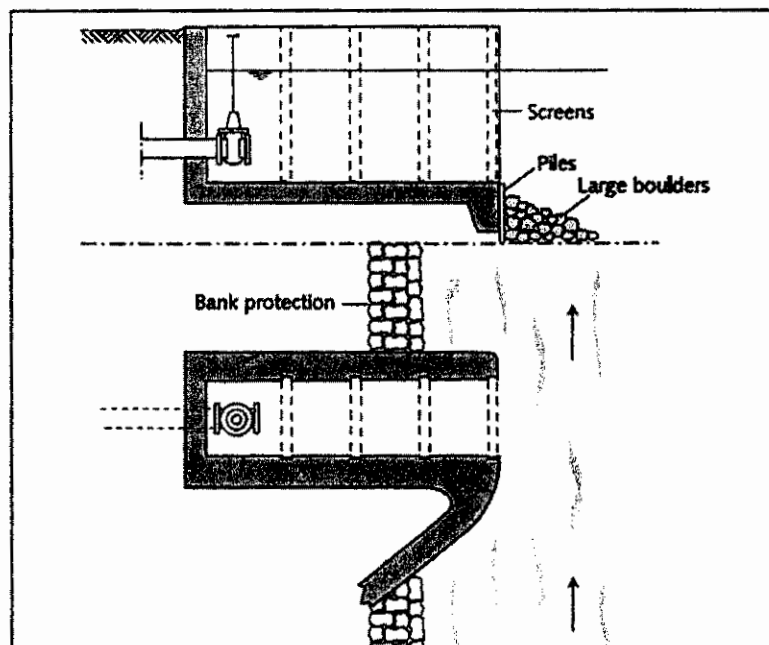

Figure Q1-2

1E. For the PE-pH diagram of iron shown in Figure Q1-3 below, indicate the areas of corrosion, immunity and passive protection. State also whether iron is corroded spontaneously in water. Detach this paper and include it in your answer sheer after answering on the diagram. Write also your ID. Number on top.
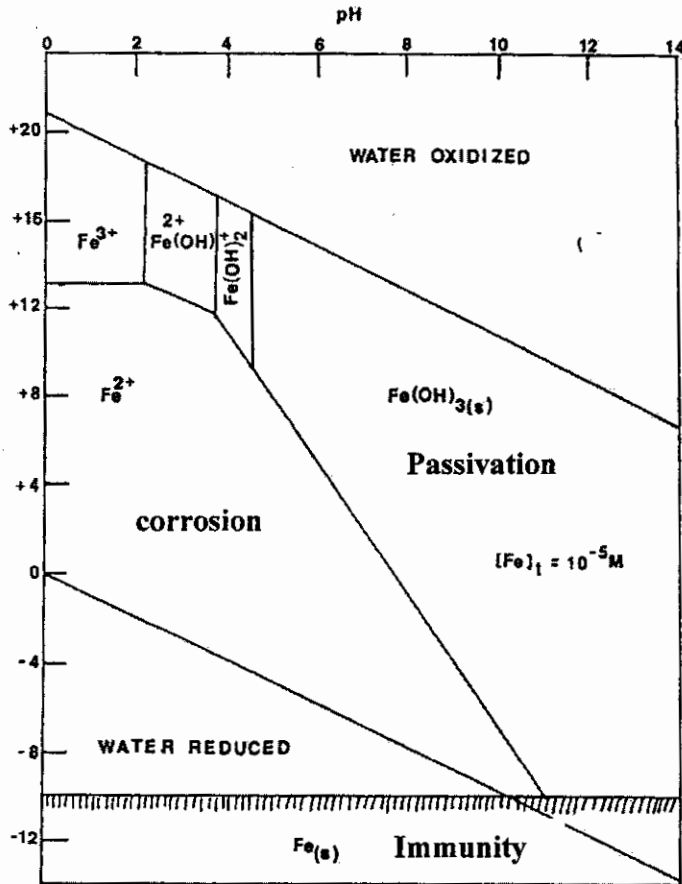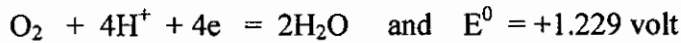

Figure Q1-3

QUESTION TWO (Marks are indicated for each question)

2A. Consider the following two oxidation and reduction reactions given below. According to the calculation given, state the ranges within which water will remain stable, water will be oxidised and water will be reduced. ....[5 marks]

$$O_2 + 4H^+ + 4e = 2H_2O \quad \text{and} \quad E^0 = +1.229 \text{ volt}$$

$$Pe^0 = \frac{nFE^0}{2.3RT} = \frac{4 * \left(\frac{23,061 Cal}{mole - volt}\right) * +1.229 \, volt}{\left(\frac{2.381.98 cal}{Kelvin - mole}\right) * (273 + 25C^0) Kelvin} = +83.52$$

$$2H_2O + 2e = H_2 + 2OH^- \quad \text{and } E^0 = -0.828 \text{ volt}$$

$$Pe^0 = \frac{nFE^0}{2.3RT} = \frac{2 * \left(\frac{23,061 Cal}{mole - volt}\right) * -0.828 \, volt}{\left(\frac{2.381.98 cal}{Kelvin - mole}\right) * (273 + 25C^0) Kelvin} = -28.13$$

2B. List the four mechanisms by which corrosion of water distribution metal pipes can be prevented. ....[5 marks]

2C. Calculate the Langelier saturation index of a water having the following characteristics. Comment on the stability of this water sample based on your results. ....[15 marks]

- pH = 7.4
- Calcium 300 mg/L as $CaCO_3$,
- Alkalinity= 250 mg/L as $CaCO_3$.

Use the formula given below and assume that γ_m =0.89 and that $Pk_2 - Pk_s = 2.4$

$$pH_s = pK_2 + pCa^{2+} - Pk_s - Log(2[Alk]) - Log(\gamma_m)$$

QUESTION THREE (5 marks each)

3A. Describe the four mechanisms of destabilisation of colloidal suspension in water.

3B. Compare the stability of clay colloids of equal concentration in i) pure distilled water and ii) salty water containing high concentration of sodium chloride.

3C. State what will happen if the coagulant dose of ferric sulphate is too high beyond the optimum dose?

3D. Discuss the effectiveness of i) perikinetic flocculation and ii) orthokinetic flocculation on i) very small flocs and i) large diameter flocs.

3E. List the advantages of ferrous salts over aluminium sulphate for the coagulation of water. What may be the disadvantage of using iron salts for coagulation..?

QUESTION FOUR (5 marks each)

4A. What is the dominant mechanism of particle removal in slow sand filters?

4B. Describe the causes and adverse effects of media stratification in rapid sand filters.

4C. Describe the advantages slow sand filters compared to rapid sand filters.

4D. Discuss the operational features of declining rate filters including their advantages and disadvantages.

4E. Discuss the effect of positioning of the wash water trough in rapid sand filter. In other words state what will happen:
  i.   If the wash water trough is located too high relative to the sand bed level.

[2.5 marks]
  ii.   The wash water trough is located too low relative to the sand bed level.

.........[2.5 marks]

QUESTION FIVE (5 marks each)

5A. Discuss the importance of the ratio Cl_2/NH_3 in the chloramination process for the disinfection of water. Indicate the optimum ratio Cl_2/NH_3 and give reasons for your choice.

5B. Discuss the advantages and disadvantages of excess chlorination beyond the break point.

5C. Determine the break point chlorination dosage required for a water sample that contains 0.015 milli-mol/L of ammonia in addition to organic matter that has a chlorine demand of 0.01 milli-mol/L. the free residual chlorine required beyond break point is 0.3 mg/L

Break point reaction:
$$2NH_3 + 3HOCl \rightarrow N_2 + 3H^+ + 3Cl^- + 3H_2O$$
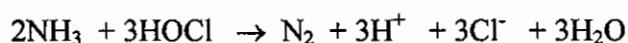
5D. A treated water after disinfection has 40% OCl^- and 60% HOCl. The concentration versus contact time for 99% inactivation of *E.coli* is given in Figure Q5-1 below. For a contact time of 5 minutes, determine the total amount of chlorine that will have to be added to water to achieve the desired inactivation, i.e., 99% inactivation of *E.coli*.
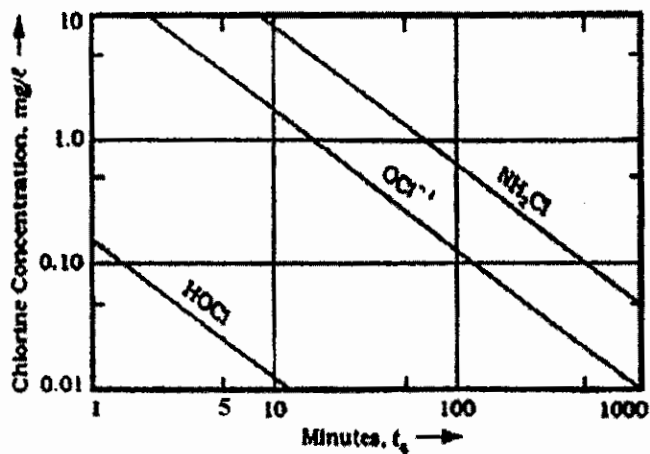

Figure Q5-1

5E. Compare the advantages and disadvantages of ozone as a disinfectant with that of chlorine.