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

B.Sc. DEGREE IN ENVIRONMENTAL HEALTH SCIENCE

MAIN EXAMINATION PAPER 2019

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. State the advantages and disadvantages of providing storage facility in the form of reservoirs and ponds to water.

1B. Describe the advantages and disadvantages of:
- i) horizontal flow roughing filtration ....[3 marks]
- ii) vertical flow roughing filtration. ....[2 marks]

1C. Given the following unit treatment processes, arrange them in the proper sequence in which they are provided in water treatment; i) super chlorination, ii) flash mixing iii) settling iii) plain sedimentation iv) pre-chlorination v) activated carbon vi) de-chlorination viii) coagulation ix) filtration.

1D. What adverse effects are caused by the presence of each of the following chemicals in a water source which is to be treated and subsequently used for potable purposes?

- **i.** Excess concentration of iron and manganese
- **ii.** Low PH of water
- **iii.** Excess concentration of fluoride
- **iv.** Excess concentration of nitrate.

1E. Describe in detail the Nalgonda treatment technique used for the removal of fluoride from water.

QUESTION TWO (Marks are indicated for each question)

2A. For the E-pH diagram of Lead shown below, indicate the areas of corrosion, passivation and immunity. Comment also on the thermodynamic stability of lead in water. Work you answer directly on the diagram below. Detach this paper after writing the answer and include it in your answer sheet. Also write your ID No. on top of this page while submitting it for marking......[10 Marks]
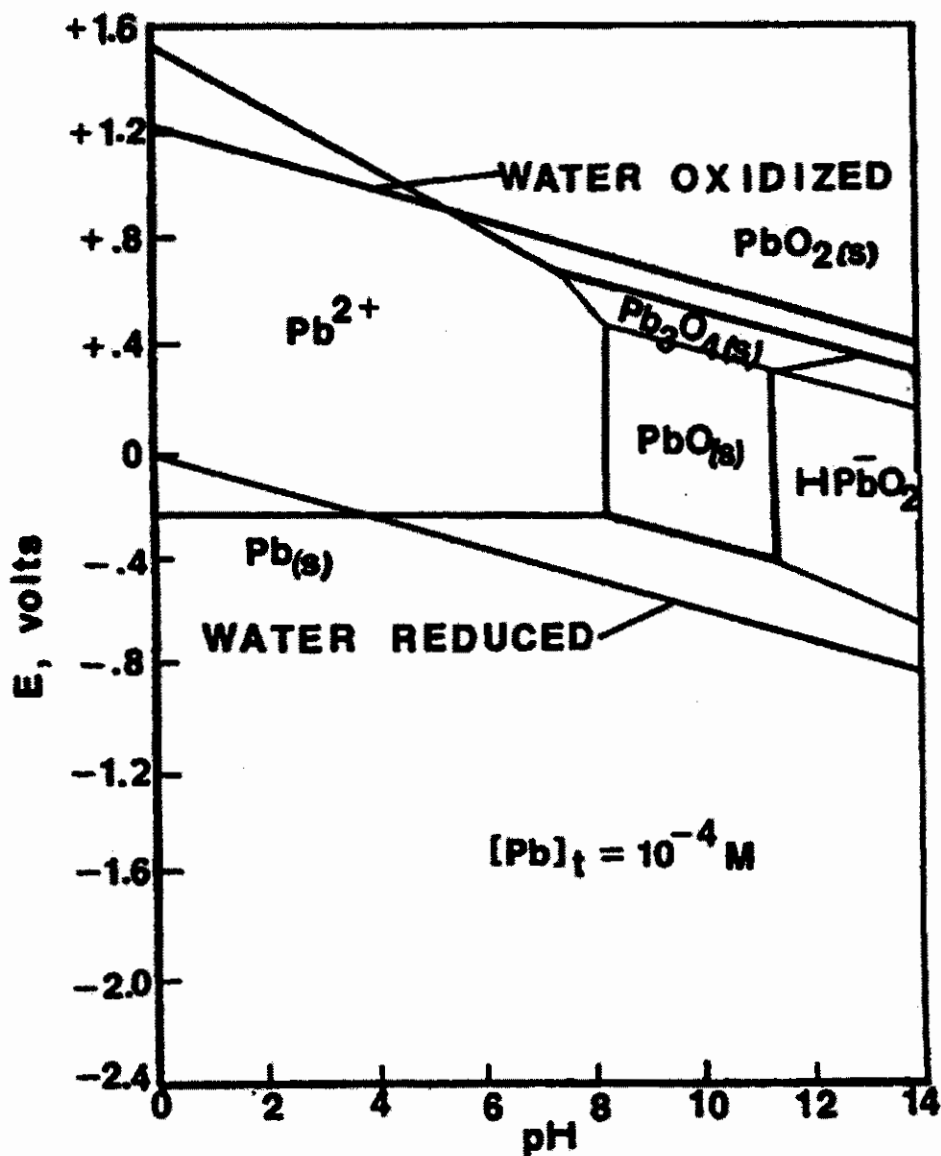
2B. Compare the advantages and disadvantages of i) hydraulic rapid mixing and ii) mechanical rapid mixing. ....[5 Marks]

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. ....[10 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. Describe the roles of i) electro static forces and ii) Van der Waal forces in the formation of stable colloids in water

3C. A coagulation process is to be designed for a water treatment with a flow of 0.25 m^3/sec. A jar test done on a 1.5 litre sample indicated 5ml and 7ml dosages of a 1.5% alum solution gave equally good lowest turbidity. Determine the amount of alum required daily in kg, the alkalinity required and the daily sludge production. State what will happen if the coagulant dose of ferric sulphate is too high beyond the optimum dose?

3D. Answer each of the following related to flocculation;

     i. How do you compare the density of flocs with that of individual particles of clay from which flocs are formed? .... [2 Marks]

     ii. What will happen to the density of flocs when the floc radius is increased? .... [1 Mark]

     iii. Is the rate of settlement of flocs dependent on the depth of tank? Give reasons for your answer. .... [2 Marks]

3E. A designer of a plain sedimentation tank decided to increase the depth of tank to be double the original depth by building up the wall of the tank. The reason for doing so was because the discharge through the tank was doubled. Calculate the new overflow rate and detention time (after the flow rate is doubled and after the designer increased the depth of the tank to be double the original) in terms of the original values and comment on whether the designer's approach was correct.

QUESTION FOUR (5 marks each)

4A. Discuss the principle of operation of a declining rate filter. Indicate the advantages of declining rate filter over a traditional rapid rand filter.

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

4C. Define the following terms:
   i.   Schmutzdecke …………………..…..[1 Mark]
   ii.   Filter run …………………………..…..[1 Mark]
   iii. Media segregation……………………..[1 Mark]
   iv.   Filter break through …………………..[1 Mark]
   v.   Uniformity coeffici……….. …….….…[1 Mark]

4D. List the major possible problems that may be encountered in the course of operating a rapid sand filter.

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 (Marks are indicated for each question)

5A. How do you evaluate ozone (O_3) as a disinfection agent with respect to the following criteria?   ……………………..[5 marks]

      i) Effectiveness in comparison with chlorine

      ii) Ability to leave a residual

      iii) Solubility in water compared with oxygen

      iv) Material of container used for generation of ozone

      v) Means of disposal of excess ozone after disinfection and the danger it pauses if such excess ozone is allowed to escape in to the open air.

5B. The chlorine residuals measured when various dosages of chlorine were added to treated water are given below. Determine

      (i) The breakpoint dosage …………………………………..[7 Marks]

      (ii) The design dosage to obtain a residual of 0.5 mg/lit free available

      chlorine……………………………………………………..[7 Marks]

Dosage, mg/lit	0.1	0.5	1	1.5	2	2.5	3
Residual mg/lit	0.0	0.3	0.6	0.35	0.35	0.8	1.3

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 ……………………………………..…………….[6 marks]

Break point reaction:

$$2NH_3 + 3HOCl \rightarrow N_2 + 3H^+ + 3Cl^- + 3H_2O$$