SECTION A

QUESTION ONE

a) One of the tasks of an environmental Engineer is protecting the environment from further degradation. Give one example on how she/he can achieve this

b) Make a clear distinction between Environmental Engineering and Environmental Health Engineering

c) Why is the classification of environmental diseases according to the environment in which they thrive and flourish?

d) One group of diseases within the water related diseases is the water washed. Briefly explain an intervention measure that an environmental Engineer can put in place to address the situation.

e) One category within the environmental classification of communicable disease is "Housing-Related Diseases". Give one example on how housing can impact on the health of a community

f) The city of Livingstone like many other cities in Zambia faces numerous challenges in the area of water supply. You as an Environmental Engineer equipped with generally accepted definition of environmental engineering, demonstrate your role in addressing the challenges of providing water supply in a modern urban setting in Zambia. Use examples and illustration where appropriate. It is expected that the issues of access to water, water sources and water treatment.

[3+4+3+3+3+9]

QUESTION TWO

a) Give two advantage and two disadvantage of using chloramines in water disinfection instead of chlorine.

b) Explain why effectiveness of disinfection process with chlorine decreases with increasing pH values

c) Describe the relationship between Residual Chlorine, Chlorine Demand and Chlorine Dose

d) Discuss the following unit operations in a water treatment plant

i. Flocculation/Coagulation

ii. Filtration

iii. Chlorination

[4+4+5+12]

QUESTION THREE

a) Explain why one of the conditions for a suspended particle to settle is for it to have a size greater than that of colloids

b) Explain how vertical convection currents can affect the efficiency of the sedimentation process

c) Why does the bactericidal effectiveness of chlorine decrease with increasing pH?

d) Draw a distinction between Free available chlorine and combined available chlorine.

Scanned with CamScanner

e) Give two reasons for treating water meant for drinking. **[5+5+5+5+5]**

— removal of unwanted consistitent
— disinfection.

SECTION B

QUESTION FOUR

a) Why is organic matter content high in pure sewage?

b) Sanitation aims at breaking the chain between the host and hazard. How can this be achieved with respect to excreta in a residential area.

c) A technician in the Environmental Engineering Laboratory receives a wastewater water sample where he conducts the analyses for faecal coliforms, total coliforms, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The following were the results:

- Total Coliforms = 1.26×10^5/100ml
- Faecal Coliforms = 1.8×10^6/100ml
- BOD = 453mg/l
- COD = 395mg/l

— feacal coliform must always be less than total coliform which is not the case.
— COD must always be greater than BOD which is not the case
The fe client can not pay such results

When presented with these results, the client rejected them and refused to pay for them. State and explain two possible reasons, based on the results, why his refusal to pay is justified.

d) How does raw sewage discharged into a surface water body promote eutrophication?

e) Briefly explain why it is imperative (important) that wastewater is prevented from promoting formation of sludge banks in the receiving water bodies?

[4 + 5 + 6 + 5 + 5]

END OF TEST
GOOD LUCK

JMT-AAP/TEST/CEE4412/2016

— ~~fecal~~ feacal coliforms must less be total coliforms

— ~~BOD~~ COD > BOD

{ COD > BOD
~~FE~~
TC > F.E }

Scanned with CamScanner

SUPPLY – TRANSPORT

SECTION A

QUESTION ONE

a) As a fresh graduate who has taken part in the commissioning of a new water treatment plant, you have observed that the filters did not perform optimally immediately after commissioning. Explain the background to this "ripening period" for both the removal of suspended solids and ammonium.

b) How water-related infections classified and what is the rationale behind that classification?

c) Reservoirs are usually an integral part of the water distribution system. State any two types of reservoirs and give two disadvantages a distribution system without reservoirs would have.

d) Distinguish between "water demand" and "water demand pattern".

[6 + 6 + 4 + 4]

QUESTION TWO

a) Water-related infections may be viral, bacterial, protozoal, nematodal, etc. in origin. In environmental engineering, however, it is rarely useful to classify the infections based on the etiological agents. Why is that?

b) How are water-related infections classified and what is the rationale behind that classification?

c) Illustrate how the classification of water-related infections is useful to engineers involved in the control of transmission of water-related infections

d) With the aid of examples, discuss the four factors that must be present for the transmission of communicable infections.

e) Discuss three immediate aims and benefits of water supply improvements?

[3 + 5 + 4 + 4 + 4]

Scanned with CamScanner

PPLY – TRANSPORT &

TION

storage → 2 100 (2018 → 2020)

QUESTION THREE

a) Briefly explain what alkalinity is and also explain its significance in the following processes:-
   i) Coagulation/Flocculation
   ii) Anaerobic sludge digestion

b) Briefly discuss the causes of; and explain one significance of hardness of water.

c) With respect to water treatment, what is the meaning of the term "unit operation".

d) Give one advantage and one disadvantage of using chloramines in water disinfection instead of chlorine.

advantage
residuals of chloramines are more stable than

disadvantage
- the disinfection power is less than the chlorine i.e less effective

e) Explain why the effectiveness of the disinfection process with chlorine decreases with increasing pH values.

residuals of chl

[6 + 4+ 2 + 2 + 6]

advantages
- residuals of chloramines are more stable than chlorine

disadvantages
- disinfection power is less i.e less eff.

$Cl_2 + H_2O \rightarrow HOCl$
HCl.

Why effect of chlorine decreases with increasing pH – at high pH

OCl^- prevents and [illegible]

HOCl (hypochlorous acid). [illegible]

but hypochlorous is free available chlorine.

20
20

Scanned with CamScanner

TRANSPORT

SECTION B

QUESTION FOUR

a) Explain one major function of the biological treatment stage in a conventional wastewater treatment plant.

b) You have collected an effluent wastewater sample on which Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) tests have been conducted. After analysis, two sets of results are presented to you as follows:

i) A = 300mg O_2/l

ii) B = 450mg O_2/l

Which amongst the two results refers to COD? Give an explanation for your answer.

c) Mr. Lemekezani, an Engineer working for Nkana Water and Sewerage Company limited has been managing the Nkana Wastewater Treatment plant for five years. The plant treats a consistent average of 2,500m^3 of wasterwater per day throughout the year. Over the years, he has observed that the efficiencies of both the primary sedimentation tanks and trickling filters significantly improve during the period September to March when the average ambient temperature is 35°C as compared to the period April to August when the average ambient temperature is 21.4°C.

i) With respect to the primary sedimentation tanks, explain one possible reason for this observation.

ii) Give and briefly explain one reason why this is so for the trickling filter.

d) Sewage from Chambeshi mining area, a residential area on the Copperbelt Province o f Zambia, has an organic matter concentration of 300mg/l. This sewage is treated using a conventional sewage treatment plant which has the following units:

- Two (2 No.) screens;
- A grit removal chamber;
- Three (3 No.) primary sedimentation tanks each with a diameter of 35m and a depth of 2.5m;
- Four (4 No.) trickling filters each with a diameter of 28m and a depth of 2m; and
- Three (3 No.) secondary sedimentation tanks each with a diameter of 21m and a depth of 2.0m.

Given that the flow rate to the plant is 0.4m^3/s, compute:

i) The hydraulic surface loading rate to each of the primary sedimentation tanks.

ii) The Volumetric Organic Loading Rate to each of the trickling filters. Any assumptions made should be clearly presented and explained.

[3 + 3 + 5 + 9]

QUESTION FIVE

$HSLR = Q/A$

$V_r = LQ/V$ $\quad L = BOD$

Scanned with CamScanner

a) Discuss one way in which on-site sanitation systems differ from off-site sanitation systems?

b) Odour and flies are some of the major challenges associated with pit latrines. However, in a Ventilated Improved Pit Latrine, the nuisance of odour and flies has been effectively averted. Discuss how each of these has been addressed in a VIP Latrine.

c) In conventional wastewater collection and conveyance systems, it is required that the minimum nominal diameter of sewer pipes is at least 100mm with a slope big enough to generate velocities of at least 0.6m/s but not exceeding 3m/s. However, where small bore sewers are used, smaller pipes (i.e. 75mm) can be used and velocities can be in the vicinity of 0.3m/s.

i) Explain why is it important that the maximum velocity in a conventional sewerage system is maintained below 3m/s.

ii) Explain why it is possible to effectively convey the wastewater in smaller pipes and at lower velocities in small bore sewers.

d) Mr. Madalitso., a Civil Engineer working for Excel Consultants is constructing a house to accommodate 20 people. The house is located in Kamwala south which is a medium cost area with an average daily per capita water consumption of 150 liters. The annual per capita sludge generation rate is 0.06m^3/year. Due to absence of a sewerage system in the area, a septic tank discharging into a soakaway will be used to service the household. Design the septic tank if it is required that at inception, the tank should have a hydraulic retention time of 5 days. Assumptions should be stated and explained.

[3 +3 + 6 +8]

QUESTION SIX

a) Conventional wastewater treatment plant deals with several pollutants in wastewater including suspended solids, colloidal matter, dissolved substances and microorganisms. Which of these parameters is not effectively addressed in a conventional wastewater treatment plant? State one way in which you would enhance its removal.

b) The normal COD removal efficiency in the facultative pond which has been observed over the past 10 years is 90%. Recently, the algae in the pond was strained out (removed). It was immediately observed that the COD removal efficiency declined to 18%. Discuss one possible reason for this reduction in the treatment efficiency.

c) List and briefly explain any two treatment processes that contribute to the removal of microorganisms in maturation ponds.

d) In a conventional treatment plant, discuss why it is critical to control the sludge feeding rate into the digester where sludge treatment is through anaerobic processes.

[4 + 6 + 4 + 6]

Scanned with CamScanner

- TRANSPORT 4

QUESTION SEVEN

a) Solid waste characterisation is an important component in the process of solid waste management. Discuss one reason why this is so

b) Discuss why a compactor truck would not be an appropriate means of collecting and transporting solid waste from peri-urban areas of developing countries like Zambia

c) The composition of solid waste from Chalala area is presented in Table 1 below

Table 1

Constituent	Composition by weight (Percent)
Organic constituents (Putrescibles)	0.4
Paper	0.6
Metal	0.1
Glass	0.4
Textile	1.8
Others (Soil, ash)	96.5
Total	100

Engineer Mbulo who is tasked with implementing a solid waste management programme for the area decides that the best way of handling this solid waste is by disposal at a landfill. Discuss whether or not Engineer Mbulo's proposal is justified and give your reasons.

d) With reference to solid waste management, what does secondary storage imply? Also state one condition under which secondary storage is necessary

e) Give and discuss two ways in which a dump site differs from a sanitary landfill

[4 + 4 + 4 + 4 + 4]

END OF EXAMINATION

Scanned with CamScanner

QUESTION ONE

a) State two conditions under which composite sampling would be ideal.

b) Mpongwe district has a population of 1200 inhabitants which is increasing linearly at a rate of 3 percent per annum. The district only has residential areas which are all exclusively medium cost. Due to anticipated economic activities in the district, a water treatment plant with a lifespan of 20 years is to be constructed. It is expected that all the design work will be undertaken in 2018 while construction works will be implemented in the years 2019 and 2020. Unaccounted for water in the system is expected to be 30%. Water demand usage variations according to the month of the year and day of the week is as summarised in the Table below.

Month of the year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Peak Factor	0.9	0.8	0.8	1.0	0.6	0.5	0.8	1.0	1.2	2	1.2	1.0

Day of the Week	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Peak Factor	1.2	1.1	0.8	0.8	0.8	0.9	1.4

Given that the per capita water demand is estimated at 150 liters, determine the design capacity of the water treatment plant.

c) The settling characteristics of the suspended particles in a raw water to be treated can be described by the equation

$$V_h = \frac{gd^2(S-1)}{18\upsilon}$$

It is desired to have an effluent with a turbidity of not more than 10NTU for effective slow sand filtration. It has been established experimentally that for the effluent to have a turbidity of less than 10NTU, all particles with relative density of 1.002 and size 0.8mm should be removed.

i. Given that the ratio between the length and width of the sedimentation tank is 4, determine the length and width of the tank if the flow is 300m^3/h and the water has a kinematic viscosity of $1*10^{-6}m^2/s$.

ii. If the effective depth of the tank is 2.5m, compute the retention time

[3 + 12 + 10]

QUESTION TWO

a) A Jar Test carried out on water from the Mwambashi Stream, which is the raw water source for the Chambishi District Water Treatment Plant, yielded the results presented in the Table below.

Turbidity (NTU)	Dosage of Aluminum Sulphate (ml)
60	0
20	3
10	6
12	9
20	12
35	15

If the treatment plant treats $600m^3/h$,

i. Determine the optimum coagulant dosage given that the concentration of the coagulant (Aluminium Sulphate) used in the Jar Test had a concentration of 10g/l.

ii. If the coagulant is packaged in 50kg bags, how many of these bags are required for water treatment on a daily basis assuming the raw water quality remains constant.

b) A water supply system is designed for an average water demand of $375.65m^3/h$. The water losses in the system are estimated at 20%. Based on the water demand pattern of the supply area, Table 1 below was computed to calculate the required storage.

$$Q_a = \frac{Q_d}{1 - L}$$

P.T.O

Scanned with CamScanner

HOUR	PEAK FAC	Qconsumption	Qleak	Qdel	Delta V	Sum V
1	0.48	180.31	45.08	225.39	244.17	244.17
2	0.32	120.21	30.05	150.26	319.30	563.48
3	0.3	112.70	28.17	140.87	328.69	892.17
4	0.28	105.18	26.30	131.48	338.09	1230.25
5	1.1	413.22	103.30	516.52	-46.96	1183.30
6	1.6	601.04	150.26	751.30	-281.74	901.56
7	1.4	525.91	131.48	657.39	-187.83	713.74
8	1.2	450.78	112.70	563.48	-93.91	619.82
9	1	375.65	93.91	469.56	0.00	619.82
10	0.8	300.52	75.13	375.65	93.91	713.74
11	0.95	356.87	89.22	446.08	23.48	737.21
12	1.45	544.69	136.17	680.87	-211.30	525.91
13	1.32	495.86	123.96	619.82	-150.26	375.65
14	1.1	413.22	103.30	516.52	-46.96	328.69
15	1.02	383.16	95.79	478.95	-9.39	319.30
16	0.65	244.17	61.04	305.22	164.35	483.65
17	0.73	274.22	68.56	342.78	126.78	610.43
18	1.3	488.35	122.09	610.43	-140.87	469.56
19	1.35	507.13	126.78	633.91	-164.35	305.22
20	1.3	488.35	122.09	610.43	-140.87	164.35
21	1.2	450.78	112.70	563.48	-93.91	70.43
22	1.2	450.78	112.70	563.48	-93.91	-23.48
23	1.2	450.78	112.70	563.48	-93.91	-117.39
24	0.75	281.74	70.43	352.17	117.39	0.00

Based on the information provided and data given in the Table above,

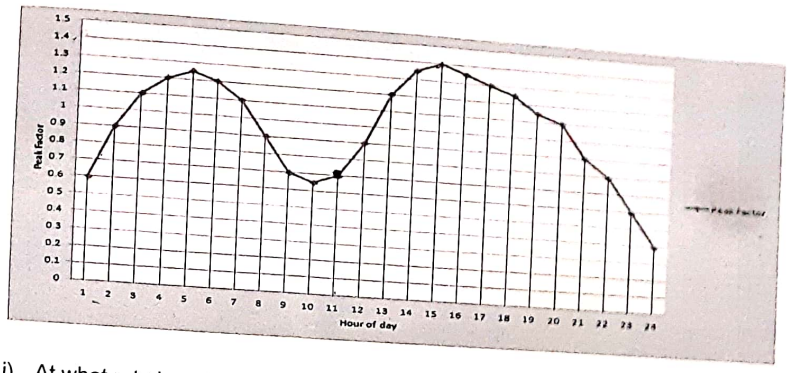
i) Computed the required tank volume to take care of water demand variations in the system.

ii) How much volume is required to provide a reserve of three (3) hours?

c) The average water demand for Luaombo community is 200m^3/hour. The water demand pattern for the community is as presented in the Figure below.

P.T.O

Scanned with CamScanner



i) At what rate is water drawn from the system at the 11th hour of the day.

ii) If this water is flowing in a Galvanized iron pipe and the maximum velocity observed in the in the pipe over the 24 hour period is 1.1m/s, what is the diameter of the pipe?

[10 + 7 + 8]

QUESTION THREE

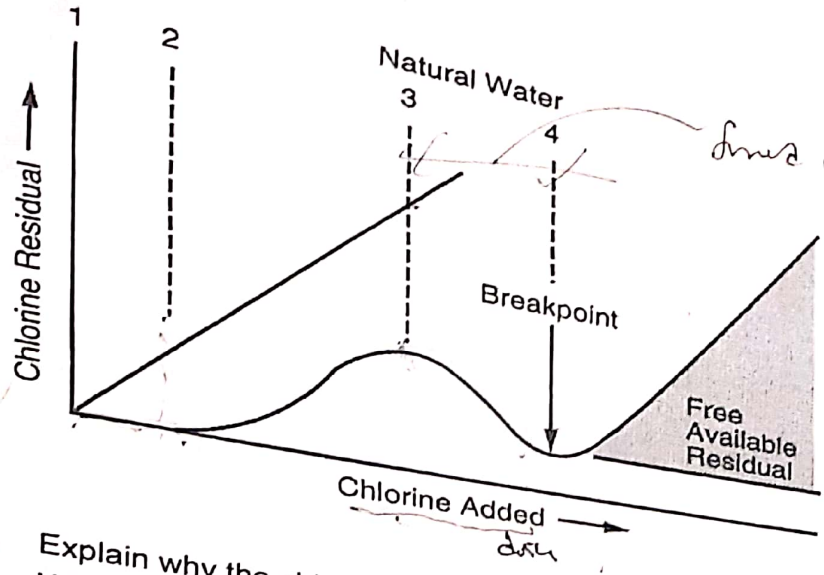
a) Define the term "Free Available Chlorine" is it applies to the Chlorination unit operation in water treatment.

b) Water in a treatment plant is disinfected using HTH which has an effectiveness of 70 percent. Laboratory analysis of the water at the plant has revealed that the water exerts a chlorine demand of 1.0mg/l. The required residual chlorine in the water is 0.3mg/l. Given that the plant treats water at a rate of 200m^3/h, how much HTH is required for water treatment in the plant on a daily basis?

c) The graph below presents a plot of chlorine residual against chlorine dosage in water at the Kamuchanga Water Treatment Plant. Preliminary analysis of the water indicates that the water contains some organics, ammonia, nitrites, phosphates, chlorides, nitrates and a few heavy metals.

P.T.O

Scanned with CamScanner



i. Explain why the chlorine residual remains at 0mg/l between points 1 and 2.

ii. Why does the graph show a reduction of chlorine residual between points 3 and 4.

d) Mr. Sela works as a technician at the Ndazi Water Treatment Plant. He has observed that for the same amount of chlorine added to water, he gets better results in terms of microbiological quality of the water when he chlorinates water at a pH of 6.8 as opposed to chlorinating at pH 8.1. Explain this observation.

QUESTION FOUR

[4 + 9 + 7 + 5]

a) Why is dissolved oxygen concentration nil or very low in raw sewage?

b) Sanitation aims at breaking the chain between the host and hazard. State two ways in which this may be achieved with respect to excreta in a residential area.

c) A technician in the Environmental Engineering Laboratory receives a wastewater water sample where he conducts the analyses for faecal coliforms, total coliforms, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The following were the results:

- Total Coliforms = 1.26×10^5/100ml
- Faecal Coliforms = 1.1×10^6/100ml
- BOD = 453mg/l
- COD = 395mg/l

Scanned with CamScanner