City & Guilds

9210-110
Level 6 Graduate Diploma in Civil Engineering
Water and wastewater engineering

Sample Paper

You should have the following for this examination
- one answer book
- non-programmable calculator
- pen, pencil, drawing instruments

No additional data is attached

General instructions
- The examination paper is of **three** hours duration.
- This question paper consists of **seven** questions over two sections.
- Answer **five** questions, selecting at least **two** questions from each section.
- All questions carry equal marks. The maximum marks for each section within a question are given against that section.
- An electronic non-programmable calculator may be used but candidates **must** show clearly the steps prior to obtaining final numerical values.
- Drawings should be clear, in good proportion and in pencil. Do **not** use red ink.

Section A

1 a) i) What is meant by "water borne diseases" and why are those diseases categorized as communicable diseases?
List **three** actions that can be taken to prevent spreading of water borne diseases. (4 marks)

ii) The average per capita water consumption generally varies widely in cities and townships. There are number of factors, which contribute to such variations. List those. (2 marks)

iii) Average demand of water supplied uniformly at all times will not be sufficient to meet the fluctuations, which could happen seasonally, daily or hourly. How is this situation managed in water supply systems? (2 marks)

b) i) Differentiate between 'Confined Aquifer' and 'Unconfined Aquifer 'with the help of a neat figure.
Indicate 'flowing artesian well' and 'perched aquifer' in the figure.
Briefly describe how they are formed. (4 marks)

ii) A 20 cm diameter tube well in an unconfined aquifer is used to draw groundwater for a community water supply. At the test run of pumping, the discharge of the tube well is 100 m^3/hour.
Reduced level (R.L) of original water surface, before pumping started = 142. 0 m
R.L of water in the well at constant pumping = 137.1 m
R.L of water in the observation well = 141. 3 m
R.L of impervious layer = 112.0 m
If the radial distance of the observation well from the tube well is 50 m, determine the field permeability coefficient of the unconfined aquifer. (6 marks)

iii) The basic function of the intake structure is to help withdrawing water safely from the source.
List factors governing locations of the river intakes. (2 marks)

2 a) i) The extent of treatment required to be given to a particular water source depends upon the characteristics and quality of the available water. Draw a flow diagram of a conventional water treatment plant with essential unit processes. (3 marks)

ii) A reservoir which is supposed to be used as a water source for a town water supply is affected by green algae, especially during hot weather.List the pretreatment methods that could be suggested in such situations. (2 marks)

iii) Dissolved gases in water is a common problem in many water treatment plants.
Explain **two** methods that can be used to remove dissolved gases from water. (2 marks)

b) i) The dosage of chemical required for coagulation depends on the quality of water. Generally, the Jar test is employed for determining the optimum dosage of coagulants after pH adjustment. The following table shows the results of a jar test at a water treatment plant, which purifies an average daily flow of 3800 m^3.

JAR No.	Alum dosage (mg/l)	Turbidity (NTU)
1	4	19
2	8	12
3	12	07
4	16	04
5	20	03
6	24	06

What dosage of alum do you recommend for treating this water?
Estimate the daily requirement of alum in Kg/Day. (4 marks)

ii) Under what circumstances are lime and/or soda ash added to water during the coagulation process?
How does a coagulant and coagulant aid support coagulation? What are the common coagulant aids used in water treatment? (5 marks)

iii) How does stirring help the process of flocculation?
Compute the volume of the flocculation basin, if the weir flow rate is 3800 m^3/d and the retention time is 22 minutes. (4 marks)

3 a) i) What is the importance of the sedimentation tank located after the flocculation basin in a water treatment system?
Two rectangular sedimentation tanks each 25 m long, 5.0 m wide, and 3.5 m deep, settle 5800 m^3/day. The total effluent weir length is 50 m.
Calculate the detention time, over flow rate, and weir loading. (7 marks)

ii) Why is disinfection important in water treatment processes? What are the toxic byproducts of chlorination and under what conditions do they form? (3 marks)

iii) What is ozone and how is it generated and applied in a water treatment plant?
Can the use of ozone eliminate the application of chlorine? (2 marks)

b) i) A pilot plant analysis of a filtration unit of a water treatment plant indicates that 12 m/hour will be acceptable to treat 5000 m^3/d. If the surface configuration is 5 m x 8 m, how many filter units will be required?
Allow one unit out of service for backwashing. (4 marks)

ii) If the backwash velocity is 32 m/hour and each backwash needs 20 min, compute the total water usage for backwashing. (2 marks)

iii) If the backwash water of the first 10 minutes is wasted at the filter run, what percentage of water would be wasted during the filtration process? (2 marks)

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4 a) i) Would ordinary tap water from a city water supply be suitable without further treatment for all industrial uses? Explain briefly. (2 marks)

ii) The concentration of dissolved oxygen in a river is an indicator of the general health of the river. All rivers have some capacity of self-purification. When using the DO sag curve to determine the adequacy of wastewater treatment, it is important to use the river conditions that will cause the lowest DO concentration.
Sketch a series of curves that show de-oxygenation, re-aeration and DO sag in a river. (5 marks)

b) i) The equivalent pipe is one, which will replace a given system of pipes with equal head loss for a given flow. How equivalent pipe length is determined when the pipes are (a) in series (b) in parallel?
Selection of a particular material for a pipeline depends on several factors. Explain them briefly. (4 marks)

ii) A town has a population of 40,000 people and an average per capita water demand of 180 L/d. Assuming that the need for equalizing storage is 30% average of the average daily demand and that storage for a fire flow of 60 L/s for a 4h duration is required, compute the required volume of a distribution storage tank for the town. (5 marks)

iii) After water is fully treated at a plant, it becomes necessary to distribute it to the public.
Discuss with the help of diagrams, various methods of laying out the distribution systems.
List common type of valves that can be used in those water distribution systems. (4 marks)

Section B

5 a) i) Why is storm water control an important aspect of urban water management? Give **two** direct impacts of urbanization on storm water runoff. (2 marks)

ii) Estimate the peak rate of storm water from a 1.5 Km^2 drainage basin that has a composite runoff coefficient of 0.5 if the rainfall intensity is 6 cm/h. Rational Formula is given as Q = 0.278CIA with usual notations. If the sewer maintains self-cleansing velocity of 0.6 m/s, compute the size of the storm sewer pipeline. (4 marks)

iii) What would be the causes of blocking flow of a sewer or collapse of the sewer pipes? List the actions that could be taken in such situations. (3 marks)

b) i) List the purposes of having sewer manholes in a sewer system. What is a drop manhole? How does it differ from the inverted siphon type? (3 marks)

ii) When a sewer pipeline is designed, the peak hourly flows are accommodated. Why? Explain briefly. List the types of pumping stations and rising mains used in sewer systems. (3 marks)

iii) A town with a population of 4500 has a daily wastewater flow of 1590 m^3/day with an average BOD of 280 mg/L including industrial waste. The industrial discharges to the municipal sewers are 57 m^3/d at 1800 mg/L BOD from a milk production plant and 76 m^3/d containing 32 Kg of BOD from a soup canning plant. Calculate the per capita contribution of domestic flow and BOD, excluding the food processing wastewater. (5 marks)

6 a) i) Differentiate 'attached growth systems' and 'suspended growth systems' in aerobic wastewater treatment by providing examples of each system. (2 marks)

ii) A trickling filter has a diameter of 20 m and a depth of 2.5 m. It is operated with a direct recirculation ratio of 1.0, and the influent sewage flow rate is 3 ML/d. Influent BOD to the primary tank is 200 mg/L, and the BOD removal efficiency in that tank is 35 percent. Compute both the hydraulic load and the organic load on the trickling filter. (6 marks)

iii) Suppose that the above treatment plant employs an activated sludge system with MLSS of 2500 mg/l. The F/M ratio is to be 0.3. What would be the size of the aeration tank? (2 marks)

b) i) What is meant by self-assimilation capacity of a stream or a river? (1 mark)

ii) A food industry discharges its treated wastewater into a nearby stream. The BOD_5^{20} of the wastewater of the industry is 340 mg/l and it flows at the rate of 1.5 m^3/s. The river has a flow of 12 m^3/s and with BOD_5^{20} of 2 mg/l. Assuming complete mixing at the tributary, estimate the BOD_5^{20} level just downstream of the point of discharge. (4 marks)

iii) An extended aeration plant consists of three oxidation ditches without primary clarification. Each ditch has a volume of 500 m^3 and initial BOD_5 is 340 mg/L. The MLVSS is maintained by wasting at 2200 mg/L. Calculate the liquid detention time, BOD_5 loading and F/M ratio. (5 marks)

$$\frac{F}{M} = \frac{QS_0}{VX}$$

where Q = flow rate
S_0 = initial soluble BOD_5
V = volume
X = mixed liquor volatile suspended solids (MLVSS)

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7 a) i) What is the objective of sludge stabilization?
What are the methods available for sludge stabilization?
What could be the ultimate use of the stabilized sludge? (4 marks)

ii) Why is dewatering of sludge needed?
List methods that can be adopted for dewatering sludge.
What are the general practices adopted for wastewater reuse? Explain briefly. (4 marks)

iii) A wastewater treatment plant generates 400,000 L/d of wastewater with 2 percent of sludge solids. What is the mass of sludge solids removed from the wastewater each day?
If the sludge is thickened to 7% solids, what would be sludge volume and the mass of sludge solids? Assume the density of sludge if needed. (5 marks)

b) i) Low-tech solutions in tertiary wastewater treatment are maturation pond, facultative ponds and aeration lagoons. Differentiate each of them showing how those differ from each other. (4 marks)

ii) Briefly explain advanced treatment methods available for removal of nutrients such as Nitrogen and Phosphorus from wastewater. (3 marks)