NOTES:

1. The total possible examination mark is 100.

2. This examination is an OPEN BOOK EXAM.

3. A Casio or Sharp approved calculator is permitted.

4. *If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.*

5. All 11 questions constitute a complete paper.
2. Darcy’s law is expressed as: \[ Q = K \frac{A dh}{dL} \]
Why a minus sign?

10. A sanitary landfill is set in clay having porosity of 50% and if \( K = 1 \times 10^{-7} \) cm/s.
Darcy’s Law: \( Q = -K SA \)
where: \( Q = \) quantity of liquid flowing through area \( A \) per unit of time = \( nVA \)
\( K = \) coefficient of hydraulic conductivity (dependent on soil type)
\( S = \) hydraulic gradient i.e. the change in elevation of the “free” water surface between the two points being considered divided by the distance through which the liquid must travel.
\( A = \) gross cross-sectional area through which the flow passes
\( v = \) velocity at which the liquid travels through the soil
\( n = \) soil porosity i.e. void volume divided by total volume of the soil mass

2.1 How long would it take the leachate to percolate from the bottom of the landfill through the underlying soil to the groundwater table 1.5 m below (assuming that the leachate is not allowed to build up in the landfill and the underlying soil is saturated,?
2.2 How long would it take if the soil had a hydraulic conductivity of \( 1 \times 10^{-8} \) cm/s?
2.3 If the sanitary landfill became filled to overflowing what effect would this have on the liquid time.of travel determined in parts (2.1) and (2.2)?

7. Name 7 factors that influence the composition of municipal solid waste.

10. A mass burning incinerator with heat recovery operates on 400 t/d of municipal solid waste with natural gas as a supplementary fuel. A plan for residential source separation is expected to reduce the amount of paper and cardboard collected by 20%. For the incinerator to maintain steam production, the heating value of the lost combustibles will have to be replaced by natural gas at an average cost of $0.50/m³. Neglecting changes in collecting costs, what price per tonne would need to be received for the paper for the municipality to break even?

6. List some of the major problems with landfilling.

7. The solid wastes from a summer camp with 100 children and a staff of 25 are to be collected once per week. If bottles and cans (representing 20% of the weight) are removed, paper wastes (40%) are burned in the camp incinerator, and only the wastes from the kitchen (30%) and miscellaneous wastes from the cabins (10%) are collected, what volume will be picked up?

8. The town of Dentalfloss is landfilling their municipal solid waste (MSW). The landfill only has enough remaining capacity to handle their MSW for another 3 years. Composting is one option to extend the landfill life. You have been commissioned to prepare a feasibility report about whether or not composting their municipal solid waste is represents a viable solution. Prepare a report index showing major- and associated sub-headings of all factors that you consider to be important for this assignment.

9. Develop a design and an operational plan for landfill.

10. A residential area of 40 ha contains 300 single-family residences and 8 ha with multiple-family units housing 400 people. With two curb-side pick-ups per week, how many trips on each collection day would one packer truck (4 tonne capacity) need to make in order to serve this area? Assume 4 residents/single family unit.

11. Over a three year period, wastes from a population of 100,000 have been placed in a sanitary landfill with a gas recovery system. This practice is to continue into the foreseeable future, so a steady supply of gas with 55% methane (CH₄) is expected. A nearby year-round work camp has 50 oil-heated detached homes for their personnel. The homes use an average of 100 x 10⁶ kJ of heat energy during the year and have a peak demand during the coldest month of 2.5 times the average. Will there be enough landfill gas available to heat these homes? Make and state all your assumptions.

100 total mark