

**THIS QUESTION PAPER MUST BE HANDED-
IN TO THE INVIGILATOR AT THE END OF
THE EXAMINATION**

CRANFIELD UNIVERSITY

Examination

**SCHOOL OF ENERGY, ENVIRONMENT AND AGRIFOOD
Water and Wastewater Engineering
STREAM**

PROCESS SCIENCE AND ENGINEERING

Tuesday 5 January 2016: 13.00 – 15.00

Open Book / Open Note

INSTRUCTIONS TO CANDIDATES:

Answer **ALL** questions

Start each answer on a separate page.

Candidates are allowed a non-programmable calculator.

Watermaths text and annotations in the book only.

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You are expected to answer all questions

Provide the results and the process through which you obtained the results (equations, assumptions ...)

#	Question	Mk
1	A 10 m ³ CSTR treats water flowing at 25 m ³ /h, what is the removal efficiency (1 decimal) when the reaction rate is 0.08 per min?	6
2	A treated effluent has a bacteria count of 100 cfu/mL and a phosphorus concentration of 2 mg/L. Assuming phosphorus is the limiting nutrient, what will be the bacteria concentration after 24 hours of storage if the half saturation coefficient is 11 mg/L and the specific growth rate is 0.035 per min?	4
3	What is the half-life of phenol (C ₆ H ₆ O) in wastewater comprising a concentration of 47 mg/L assuming a second order reaction and a rate constant of 80 L/(mol·day)?	5
4	Water containing 25 mg/l CO ₂ flows at 50 m ³ /h through a stripper fed with 0.05% CO ₂ in air which is flowing at a rate of 75 kg/h. What is the outlet aqueous CO ₂ concentration (in mg/L, 2 decimals) if the off-gas contains 1.2% CO ₂ ? Assume no loss of water by the process and no changes in the CO ₂ /HCO ₃ ⁻ equilibrium.	7
5	A water flow of 20 MLD (megalitres/day) containing 250 mg/L suspended solids is to be clarified to produce treated water containing 50 mg/L total suspended solids and a sludge product of solids concentration 22 g/L.	10
	a) What is the flow rate of the clarified water in m ³ /h (2 decimals)?	5
	b) What percentage of the feedwater solids are recovered in the sludge (1 decimal)?	5
6	Wastewater at 20°C flows through a 5 cm diameter precast concrete pipe at a flow of 5 m ³ /h. Turbulent flow conditions are required to avoid settling of solids in the pipe.	10
	a) Are the conditions adequate?	5
	b) What is the minimum flow (in m ³ /h, 2 decimals) required to obtain turbulent conditions?	5
7	Water at 10°C, initially stored in a tank, is fed through a 50 mm diameter pipe to a treatment unit (at ground level) requiring a flow of 15 L/s. At what height (in m, 2 decimals) should the tank be installed knowing that both the tank and pipe outlet are open to the atmosphere?	7
8	What is the molar concentration (2 decimals) of a ferric chloride solution with a 17% weight concentration (w/w) and a density of 1.4 kg/L?	6
9	The pH of a water is adjusted by adding sulphuric acid (H ₂ SO ₄) at a concentration of 0.005 M.	12
	a) What is the final pH if the initial pH was 7.8?	6
	b) What would be the final pH (2 decimals) if the water contained a bicarbonate concentration of 55 mM?	6
10	Determine the mass transfer coefficient (1 decimal) for oxygen when water at 20°C passes through a 10 mm pipe at a flow rate of 1.3 L/min.	12
11	Oxygen mass transfer takes place across a 3.5 m ² boundary from a solution in equilibrium with air to a non-equilibrated solution with a dissolved oxygen concentration of 1.5 mg/l at a rate of 786 mg/min. If the mass transfer coefficient is 3x10 ⁻⁴ m/s, what is the partial pressure of the equilibrated solution (in atmospheres, 3 decimals)?	6
	Total	85