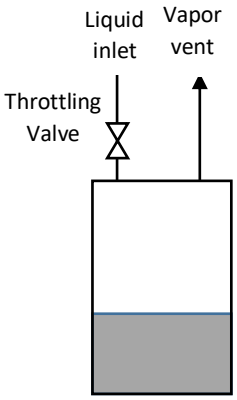
Thermodynamics - 2

A flash tank is used in industrial heating systems to reduce the pressure of high temperature liquid water. A flash tank is illustrated in the adjacent diagram. The tank has a volume of 0.4 m^3 and is initially empty. Liquid water at 25 bar and 200°C flows into the tank through a throttling valve at a steady rate of 0.5 kg/s. The pressure in the tank is 1 bar. Some of the water evaporates and saturated vapor is vented to the atmosphere at 1 bar. The rest of the water accumulates in the tank until the tank is full. Heat is transferred from the tank to the surroundings at a rate of 15 kW. The surroundings are at 27°C.



(a) **[60 pts]** Starting with the relevant governing equations, determine a mathematical expression for the time it takes for the tank to completely fill with liquid.

(b) **[15 pts]** Solve the expression for the time it takes for the tank to completely fill with liquid.

(c) **[25 pts]** Determine the rate of entropy generation as water flows through the throttling valve.

Press., bar	Temp., °C	Specfic Vol, m^3/kg	Internal Energy, kJ/kg	Enthalpy, kJ/kg	Entropy, kJ/kg-K
25	200	1.1555	849.9	852.8	2.3294

Press., bar	Temp., °C	Specfic Vol, m^3/kg		Internal Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/kg-K	
		v_f	v_g	u_f	u_g	h_f	h_{fg}	h_g	s_f	s_g
1	99.63	0.0010432	1.694	417.36	2506.1	417.46	2258.0	2675.5	1.3026	7.3594