UNIVERSITY OF
NOTRE DAME

Introduction to Chemical Engineering (CBE 20255)

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1 Unsteamed

A 10.0 m^3 tank contains steam at 275 °C and 15.0 bar. You consult a steam table and find that the steam is superheated at this condition, with specific properties $\hat{V} = 0.1610\,m^3\,kg^{-1}$, $\hat{U} = 2741\,kJ\,kg^{-1}$, $\hat{H} = 2982\,kJ\,kg^{-1}$. The tank and its contents are cooled until the pressure drops to 1.8 bar. Some of the steam condenses in the process.

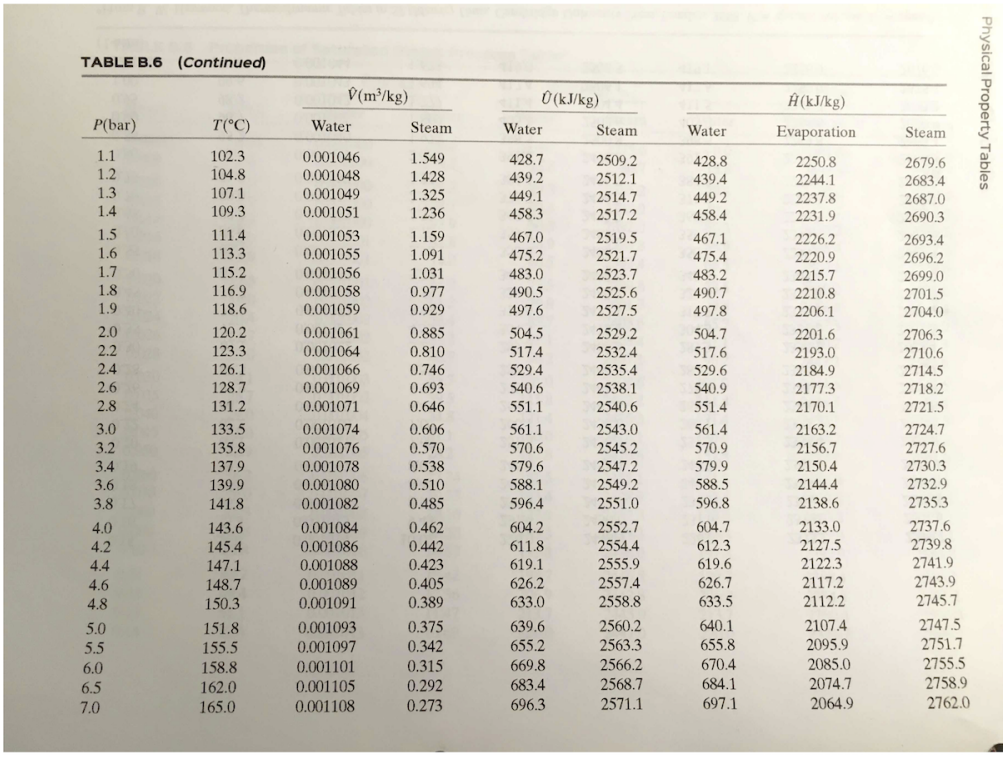

TABLE B.6 (*Continued*)

Physical Property Tables

		$\hat{V}$(m³/kg)		$\hat{U}$(kJ/kg)		$\hat{H}$(kJ/kg)		
P(bar)	*T*(°C)	Water	Steam	Water	Steam	Water	Evaporation	Steam
1.1	102.3	0.001046	1.549	428.7	2509.2	428.8	2250.8	2679.6
1.2	104.8	0.001048	1.428	439.2	2512.1	439.4	2244.1	2683.4
1.3	107.1	0.001049	1.325	449.1	2514.7	449.2	2237.8	2687.0
1.4	109.3	0.001051	1.236	458.3	2517.2	458.4	2231.9	2690.3
1.5	111.4	0.001053	1.159	467.0	2519.5	467.1	2226.2	2693.4
1.6	113.3	0.001055	1.091	475.2	2521.7	475.4	2220.9	2696.2
1.7	115.2	0.001056	1.031	483.0	2523.7	483.2	2215.7	2699.0
1.8	116.9	0.001058	0.977	490.5	2525.6	490.7	2210.8	2701.5
1.9	118.6	0.001059	0.929	497.6	2527.5	497.8	2206.1	2704.0
2.0	120.2	0.001061	0.885	504.5	2529.2	504.7	2201.6	2706.3
2.2	123.3	0.001064	0.810	517.4	2532.4	517.6	2193.0	2710.6
2.4	126.1	0.001066	0.746	529.4	2535.4	529.6	2184.9	2714.5
2.6	128.7	0.001069	0.693	540.6	2538.1	540.9	2177.3	2718.2
2.8	131.2	0.001071	0.646	551.1	2540.6	551.4	2170.1	2721.5
3.0	133.5	0.001074	0.606	561.1	2543.0	561.4	2163.2	2724.7
3.2	135.8	0.001076	0.570	570.6	2545.2	570.9	2156.7	2727.6
3.4	137.9	0.001078	0.538	579.6	2547.2	579.9	2150.4	2730.3
3.6	139.9	0.001080	0.510	588.1	2549.2	588.5	2144.4	2732.9
3.8	141.8	0.001082	0.485	596.4	2551.0	596.8	2138.6	2735.3
4.0	143.6	0.001084	0.462	604.2	2552.7	604.7	2133.0	2737.6
4.2	145.4	0.001086	0.442	611.8	2554.4	612.3	2127.5	2739.8
4.4	147.1	0.001088	0.423	619.1	2555.9	619.6	2122.3	2741.9
4.6	148.7	0.001089	0.405	626.2	2557.4	626.7	2117.2	2743.9
4.8	150.3	0.001091	0.389	633.0	2558.8	633.5	2112.2	2745.7
5.0	151.8	0.001093	0.375	639.6	2560.2	640.1	2107.4	2747.5
5.5	155.5	0.001097	0.342	655.2	2563.3	655.8	2095.9	2751.7
6.0	158.8	0.001101	0.315	669.8	2566.2	670.4	2085.0	2755.5
6.5	162.0	0.001105	0.292	683.4	2568.7	684.1	2074.7	2758.9
7.0	165.0	0.001108	0.273	696.3	2571.1	697.1	2064.9	2762.0

Figure 1: A Fragment of a Saturated Steam Table

1.1 (2 pts) What is the total mass (kg) of H_2O in the tank?

1.2 (2 pts) What is the final temperature of the tank contents?

1.3 (4 pts) How much steam (kg) condensed?

1.4 (4 pts) How much heat (kJ) was transferred from the tank?

2 Keep the water flowing

Water is to be delivered from an elevated reservoir into farm fields. The water is to be delivered at a rate of $4.00\,\mathrm{m^3\,h^{-1}}$ through a pipe with cross-sectional area $40\,\mathrm{cm^2}$, and the end of the pipe is 300 m below the entrance.

The Bernoulli equation might be helpful to remember:

$$\frac{1}{2}\Delta u^2 + g\Delta z + \frac{1}{\rho}\Delta P = 0$$

2.1 (4 pts) What is the pressure difference between the exit and inlet of the pipe?

2.2 (4 pts) How far below the surface of the reservoir is the pipe inlet?

