Q8 Steam at a pressure of 50 bar and temperature 450°C undergoes a non-flow isentropic expansion to 6 bar.

(a) Determine the specific work done.
(b) If internal energy values were not available, it might be possible to calculate the specific work done by assuming a reversible polytropic expansion such that $pv^n = C$. By considering the end state conditions, determine the index n and re-evaluate the specific work done.

(c) Suggest a reason for the difference between the two answers.

From the steam tables at 50 b and 450°C we find
$s_1 = 6.818$ kJ/kg K $v_1 = 0.0632$ m3/kg $u_1 = 3000$ kJ/kg
At 6 bar $s_g = 6.761$ kJ/kg K so the steam is still superheated and we need to interpolate to find u_2

6 bar			
Temp	158.8	θ	200
s	6.761	6.818	6.968
u	2568	u_2	2640
v	0.3156	v_2	0.3522

$\theta = 158.8 + (200 - 158.8)(6.818 - 6.761)/ (6.968 - 6.761) = 158.8 + 11.35$

$u_2 = 2568 + \{11.35/(200 - 158.8)\}\{ 2640 - 2568\} = 2587.8$ kJ/kg

Non Flow Energy Equation

$Q + W = \Delta U$ but $Q = 0$
Specific work = $\Delta u = m(2587.8 - 3000) = -412.2$ kJ/kg

We need to determine v_2 by the same interpolation.
$v_2 = 0.3156 + \{11.35/(200 - 158.8)\}\{ 0.3522 - 0.3156\} = 0.3256$ m^3/kg
If $p_1v_1^n = p_2v_2^n$

$$n = \frac{\log\left(\frac{p_1}{p_2}\right)}{\log\left(\frac{v_2}{v_1}\right)} = \frac{\log(50/6)}{\log(0.3256/0.0632)} = 1.293$$

$$w = \frac{p_2v_2 - p_1v1_2}{n-1} = \frac{6 \text{ x } 10^5 \text{ x } 0.3256 - 50 \text{ x } 10^5 \text{ x } 0.0632}{1.293 - 1} = -411741 \text{ J/kg}$$

w = -411.741 kJ/kg

The errors are due to the fact that the expansion takes place close to the saturated vapour curve.