# CASE WESTERN RESERVE UNIVERSITY
## Case School of Engineering

**ECHE 225: Fall 2024**

**Homework #2: Properties of pure substances, closed systems**

**Due: September 12**

1. [Chapter 4] Complete this table for water.

| $T$ $(°C)$ | $P$ $(kPa)$ | $v$ $(m^3/kg)$ | $u$ $(kJ/kg)$ | $x$ (if applicable) | Phase description |
|---|---|---|---|---|---|
| 50 | | 7.72 | | | Saturated mixture |
| | 400 | | | | Saturated vapor |
| 110 | 350 | | | | |
| 250 | 500 | | | | |

2. [Chapter 4] One kilogram of water fills a 150 L rigid container at an initial pressure of 2 MPa. The container is then cooled to 40°C. Determine the initial temperature and the final pressure of the water.

3. [Chapter 4] Water initially at 300 kPa and 250°C is contained in a piston-cylinder device fitted with stops. The water is allowed to cool at constant pressure until it exists as a saturated vapor and the piston rests at the stops. Then the water continues to cool until the pressure is 100 kPa. On a $T - v$ diagram, sketch the process curve passing through the first, second, and third states. Label the $T$, $P$, and $v$ values for the states. Find the overall change in the internal energy between the first and third states per unit mass of water.
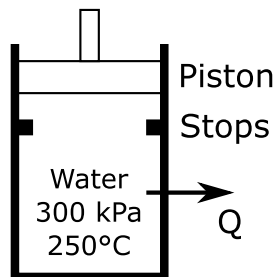
4. [Chapter 4] A 20 m$^3$ tank contains nitrogen (a near ideal gas) at 23°C and 600 kPa. Some nitrogen is allowed to escape until the pressure in the tank drops to 400 kPa. If the temperature at this point is 20°C, determine the amount of nitrogen that has escaped.

5. [Chapter 5] A piston-cylinder device contains helium gas intially at 150 kPa, 20°C, and 0.5 m$^3$. The helium is now compressed in a polytropic process ($PV^n$ = constant) to 400 kPa and 140°C. Determine the heat loss or gain during the process.

1.

| $T\ (°C)$ | $P\ (kPa)$ | $v\ (m^3/kg)$ | $u\ (kJ/kg)$ | $x$ (if applicable) | Phase description |
|---|---|---|---|---|---|
| 50 | 12.352 | 7.72 | 1643 | 0.642 | Saturated mixture |
| 143.61 | 400 | 0.46242 | 2553.1 | 1 | Saturated vapor |
| 110 | 350 | 0.00105 | 461 | N/A | Compressed liquid |
| 250 | 500 | 0.47443 | 2723.8 | N/A | Superheated vapor |

2. 395°C and 7.385 kPa

3. 1566 kJ/kg

4. 44.6 kg

5. 11 kJ loss