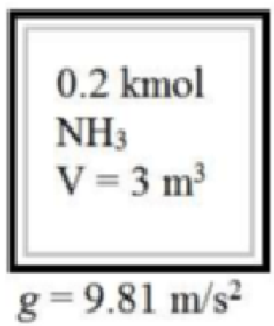
CANKAYA UNIVERSITY
FACULTY OF ENGINEERING AND ARCHITECTURE
MECHANICAL ENGINEERING DEPARTMENT

ME 211 THERMODYNAMICS I

CHAPTER 1
EXAMPLE SOLUTIONS
Fall 2015

11) A closed system consists of 0.2 kmol of ammonia (NH_3) occupying a volume of $3 m^3$. Determine (a) the weight of the system, in N, and (b) the specific volume, in $m^3/kmol$ and m^3/kg. Let $g = 9.81 m/s^2$.

Solution



(a) To determine the weight of a closed system consisting ammonia, proceed as follows:

Write expression for the weight of the system (F_{grav})

$$F_{grav} = mg$$
$$= nMg$$

Here,
Number of kilomoles (n) of ammonia is 0.2 kmol
Molecular weight (M) of ammonia is 17.03 kg/kmol (refer Table A–1)
Acceleration due to gravity (g) is 9.81 m/s^2

Substitute, 0.2 kmol for n, 17.03 kg/kmol for M, and 9.81 m/s^2 for g in the expression of F_{grav}.

$$F_{grav} = (0.2)(17.03)(9.81)$$
$$= 33.41 \text{ N}$$

Thus, the weight of the closed system is $\boxed{33.41 \text{ N}}$

(b) (i) To determine the specific volume $(\overline{v})$ in m^3/kmol, proceed as follows:

Write the expression for specific volume $(\overline{v})$

$$\overline{v} = \frac{V}{n}$$

Here,
Volume (V) occupied by ammonia is $3\ m^3$
Number of kilomoles (n) of ammonia is 0.2 kmol

Substitute, $3\ m^3$ for V and 0.2 kmol for n in the expression of specific volume $(\overline{v})$

$$\begin{aligned}\overline{v} &= \frac{3}{0.2} \\ &= 15\ \text{m}^3/\text{kmol}\end{aligned}$$

Thus, the specific volume $(\overline{v})$ in m^3/kmol is $\boxed{15\ \text{m}^3/\text{kmol}}$

12)A closed system consisting of 2 kg of a gas undergoes a process during which the relation between pressure and volume is $p\forall^n =$ constant. The process begins with $p_1 = 150$ kPa, $\forall_1 = 0.3\,\text{m}^3$ and ends with $p_2 = 450\,\text{kPa}$, $\forall_2 = 0.137\,\text{m}^3$. Determine (a) the value of n and (b) the specific volume at states 1 and 2, each in m^3/kg. (c) Sketch the process on pressure–volume coordinates.

Solution

Solution:

(a) Use the given pressure-volume relationship to write the following relation between initial and final states:

$$p_1 V_1^n = p_2 V_2^n$$

$$\left(\frac{V_1}{V_2}\right)^n = \frac{p_2}{p_1}$$

Substitute $0.3\,\text{m}^3$ for V_1, $0.137\,\text{m}^3$ for V_2, $150\,\text{kPa}$ for p_1 and $450\,\text{kPa}$ for p_2.

$$\left(\frac{0.3}{0.137}\right)^n = \frac{450}{150}$$

Solve above expression to obtain the following value of n:

$$n = 1.4$$

Thus, the value of n is $\boxed{1.4}$.

(b) Use the following relation to determine the specific volume at state 1 (v_1):

$$v_1 = \frac{V_1}{m}$$

Here, m is mass of gas.

Substitute $0.3\ \text{m}^3$ for V_1 and 2 kg for m.

$$v_1 = \frac{0.3\ \text{m}^3}{2\ \text{kg}}$$
$$= 0.15\ \text{m}^3/\text{kg}$$

Thus, specific volume at state 1 is $\boxed{0.15\ \text{m}^3/\text{kg}}$.

Use the following relation to determine the specific volume at state 2 (v_2):

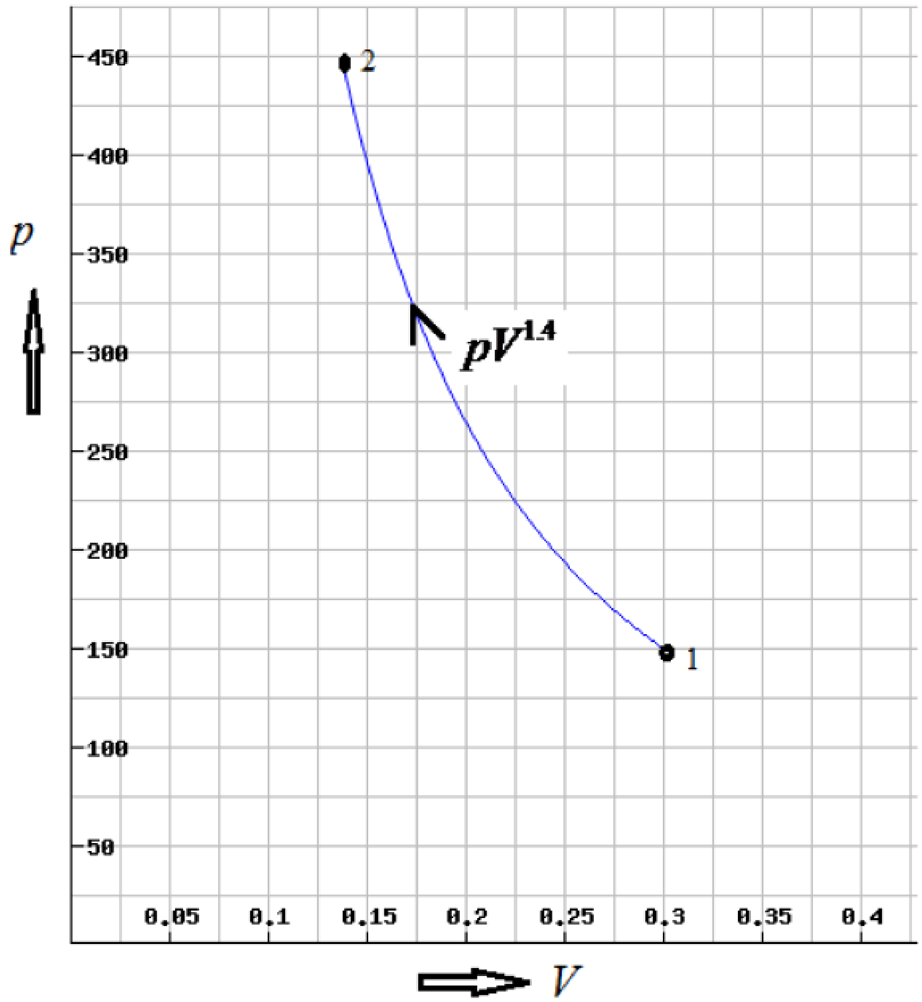
$$v_2 = \frac{V_2}{m}$$

Substitute $0.137\ \text{m}^3$ for V_2 and 2 kg for m.

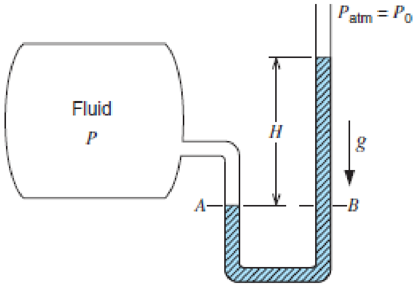
$$v_2 = \frac{0.137\ \text{m}^3}{2\ \text{kg}}$$
$$= 0.0685\ \text{m}^3/\text{kg}$$

Thus, specific volume at state 2 is $\boxed{0.0685\ \text{m}^3/\text{kg}}$.

(c) Sketch a pressure-volume curve for the process as shown below:



13) A mercury (Hg) manometer is used to measure the pressure in a vessel as shown in figure given below. The mercury has a density of 13 590 kg/m^3, and the height difference between the two columns is measured to be 24 cm. We want to determine the pressure inside the vessel.



Solution

The manometer measures the gauge pressure as a pressure difference.

$$\Delta P = P_{gauge} = \rho g H = 13\,590 \text{ kg/m}^3 \times 9.807 \text{ m/s}^2 \times 0.24 \text{ m}$$

$$= 31\,985 \text{ Pa} = 31.985 \text{ kPa}$$

$$= 0.316 \text{ atm}$$

To get the absolute pressure inside the vessel, we have

$$P_A = P_{vessel} = P_B = \Delta P + P_{atm}$$

We need to know the atmospheric pressure measured by a barometer (absolute pressure). Assume that this pressure is known to be 750 mm Hg. The absolute pressure in the vessel becomes

$$P_{vessel} = \Delta P + P_{atm} = 31\,985 \text{ Pa} + 13\,590 \text{ kg/m}^3 \times 0.750 \text{ m} \times 9.807 \text{ m/s}^2$$

$$= 31\,985 + 99\,954 = 131\,940 \text{ Pa} = 1.302 \text{ atm}$$