SECTION I:

Question 1 (5 points):

In fluids at rest, pressure on a surface inside the fluid depends on:

(a) Surface orientation.
(b) Geometry of the surface.
(c) Surface elevation.
(d) (a) and (c).
(e) (a), (b), and (c).

Question 2 (5 points):

Which list contains only intensive properties:

(a) volume, temperature, pressure.
(b) specific volume, mass, volume.
(c) pressure, temperature, specific volume.
(d) mass, temperature, pressure.
(e) None of the above.

Question 3 (5 points):

Which of the following statements is **true** for an isolated system:

(a) Its mass remains constant.
(b) Its temperature may change.
(c) Its pressure may change.
(d) All of the above.

Question 4 (5 points):

Which of the following statements is **true**:

(a) Triple point marks the lowest pressure at which a liquid phase can exist.
(b) Critical temperature is the highest temperature at which a liquid phase can exist.
(c) You can change the boiling temperature by changing the pressure.
(d) All of the above.
(e) None of the above.

Question 5 (5 points):

Which of the following statements is **false**:

(a) The compressibility factor, Z, is < 1 when attractive forces are dominant.
(b) For a given pressure, if $T < T_{saturated\text{-}vaporization}$ then we have a subcooled liquid.
(c) Ideal gas law can be considered to be valid for liquids at low pressures.
(d) All of the above.
(e) None of the above.

Question 6 (5 points):

Which of the following statements is **true**:

(a) Enthalpy is an extensive property.
(b) Heat depends on the path of a given process.
(c) Work doesn't depend on the path of a given process.
(d) Heat capacity is an intensive property.
(e) For ideal gases, internal energy is a function of temperature only.
(f) All of the above.
(g) (a) and (b) only.
(h) (c) and (d) only.
(i) (a), (b), and (e) only.
(j) (c), (d), and (e) only.

American University of Beirut, Fall 2018 Monday October 15, 2018
MECH-310 (1) Thermodynamics I

Question 7 (20 points):

With Eq. 1.11, the pressure at the oil-water interface is

$$P_a = P_{atm} + \rho_o g L$$

Expressed as a gage pressure, this is

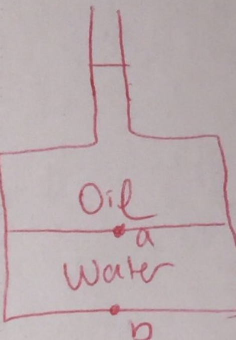
$$[P_a - P_{atm}] = \rho_o g L$$

Calculating,

$$P_a(\text{gage}) = \left(55 \frac{lb}{ft^3}\right)\left(32.2 \frac{ft}{s^2}\right)(17 ft)\left|\frac{1 lbf}{32.2 lb\cdot ft/s^2}\right|\left|\frac{1 ft^2}{144 in^2}\right|$$

(rounded)

$$= 6.49 \frac{lbf}{in^2} \text{ (gage)}$$



(a)

$$P_a(\text{gauge}) = \rho_{oil} g h_{oil} = 880 \frac{kg}{m^3} \times 9.81 \frac{m}{s^2} \times 5m = 43{,}164 \frac{kg}{ms^2}$$

$$= 43{,}164 \text{ Pa}$$

$$= 43.164 \text{ kPa}$$

The pressure at the bottom of the tank is

$$P_b = P_a + \rho_w g L' = [P_{atm} + \rho_o g L] + \rho_w g L'$$

$$\Rightarrow P_b(\text{gage}) = \rho_o g L + \rho_w g L'$$

$$= 6.49 \frac{lbf}{in^2} + \left(62 \frac{lb}{ft^3}\right)\left(32.2 \frac{ft}{s^2}\right)(3 ft)\left|\frac{1 lbf}{32.2 lb\cdot ft/s^2}\right|\left|\frac{1 ft^2}{144 in^2}\right|$$

$$= (6.49 + 1.29) \frac{lbf}{in^2} \text{ (gage)}$$

$$= 7.78 \frac{lbf}{in^2} \text{ (gage)}$$

(b)

$$P_b = P_a + \rho_{water}\, g\, h_{water}$$

gauge

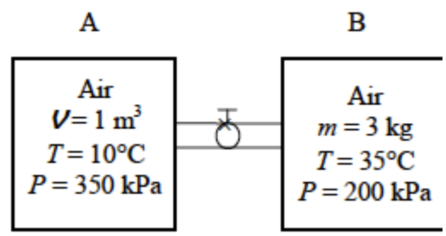
$$= 43{,}164 + 1000 \frac{kg}{m^3} \times 9.81 \frac{m}{s^2} \times 1m$$

$$= 43{,}164 + 9{,}810 \frac{kg}{ms^2}$$

$$= 52{,}974 \text{ Pa}$$

$$= 52.974 \text{ kPa}$$

Question 8 (25 points):



$$V_B = \left(\frac{m_1 R T_1}{P_1}\right)_B = \frac{(3\ \text{kg})(0.287\ \text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(308\ \text{K})}{200\ \text{kPa}} = \mathbf{1.326\ m^3}$$

$$m_A = \left(\frac{P_1 V}{R T_1}\right)_A = \frac{(350\ \text{kPa})(1.0\ \text{m}^3)}{(0.287\ \text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(283\ \text{K})} = 4.309\ \text{kg}$$

Thus,

$$V = V_A + V_B = 1.0 + 1.326 = 2.326\ \text{m}^3$$
$$m = m_A + m_B = 4.309 + 3 = 7.309\ \text{kg}$$

Then the final equilibrium pressure becomes

$$P_2 = \frac{mRT_2}{V} = \frac{(7.309\ \text{kg})(0.287\ \text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(293\ \text{K})}{2.326\ \text{m}^3} = \mathbf{264\ kPa}$$

Question 9 (25 points):

Properties The initial properties of steam are (Table A-4)

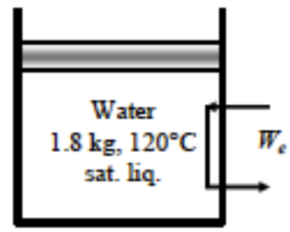
$$\left.\begin{array}{l} T_1 = 120^\circ\text{C} \\ x_1 = 0 \end{array}\right\} \begin{array}{l} v_1 = 0.001060\ \text{m}^3/\text{kg} \\ h_1 = 503.81\ \text{kJ/kg} \\ P_1 = 198.67\ \text{kPa} \end{array}$$

Analysis (*a*) We take the contents of the cylinder as the system. This is a closed system since no mass enters or leaves. Noting that the volume of the system is constant and thus there is no boundary work, the energy balance for this stationar closed system can be expressed as

$$\underbrace{E_{in} - E_{out}}_{\substack{\text{Net energy transfer} \\ \text{by heat, work, and mass}}} = \underbrace{\Delta E_{system}}_{\substack{\text{Change in internal, kinetic,} \\ \text{potential, etc. energies}}}$$

$$W_{e,in} - W_{b,out} = \Delta U = m(u_2 - u_1) \quad (\text{since } Q = \text{KE} = \text{PE} = 0)$$

$$W_{e,in} = W_{b,out} + \Delta U = \Delta H = m(h_2 - h_1)$$



since

$$W_{b,out} + \Delta U = \Delta H \text{ for a constant-pressure process.}$$

The initial and final volumes are

$$V_1 = mv_1 = (1.8\ \text{kg})(0.001060\ \text{m}^3/\text{kg}) = 0.001909\ \text{m}^3$$

$$V_2 = 4(0.001909\ \text{m}^3) = \mathbf{0.007634 m^3}$$

(b) Now, the final state can be fixed by calculating specific volume

$$v_2 = \frac{V_2}{m} = \frac{0.007634\ \text{m}^3}{1.8\text{kg}} = 0.004241\ \text{m}^3/\text{kg}$$

The final state is saturated mixture and both pressure and temperature remain constant during the process. Other properti are

$$\left.\begin{array}{l} P_2 = P_1 = 198.67\ \text{kPa} \\ v_2 = 0.004241\ \text{m}^3/\text{kg} \end{array}\right\} \begin{array}{l} T_2 = T_1 = \mathbf{120^\circ C} \\ h_2 = 511.68\ \text{kJ/kg} \\ x_2 = 0.00357 \end{array} \quad (\text{Table A-4 or EES})$$

(*c*) Substituting,

$$W_{e,in} = (1.8\ \text{kg})(511.68 - 503.81)\text{kJ/kg} = 14.16\ \text{kJ}$$

Finally, the power rating of the resistor is

$$\dot{W}_{e,in} = \frac{W_{e,in}}{\Delta t} = \frac{14.16\text{kJ}}{10 \times 60\ \text{s}} = \mathbf{0.0236kW}$$