MULTIPLE CHOICE SECTION, PROBLEMS 1-3 [2 POINTS EACH]
Please select one answer for each question.

(1) When a thermodynamic system has undergone a cyclic process,
(A) the net change in the internal energy of the system is always zero.
(B) the net work done must be zero
(C) the system and surroundings must have returned to their initial state.
(D) all of the above

(2) A general approximation is to treat a compressed liquid as a saturated liquid at the given
(A) Pressure
(B) Temperature
(C) Specific Volume
(D) Enthalpy

(3) A rigid tank contains an ideal gas at 1227°C and 200 kPa gage. The gas is cooled until the gage pressure reads 50 kPa. If the atmospheric pressure is 100 kPa, the final temperature of the gas is
(A) 102 °C
(B) 307 °C
(C) 477 °C
(D) 614 °C

$PV = mRT$

$\frac{V}{mR} = \frac{T}{P}$

T constant

$\left(\frac{V}{mR}\right)_1 = \left(\frac{V}{mR}\right)_2$

$\frac{T_1}{P_1} = \frac{T_2}{P_2}$

$T_2 = \frac{P_2}{P_1} T_1$

$P_1 = 200 + 100 = 300\,kPa\ (abs)$

$P_2 = 50 + 100 = 150\,kPa\ (abs)$

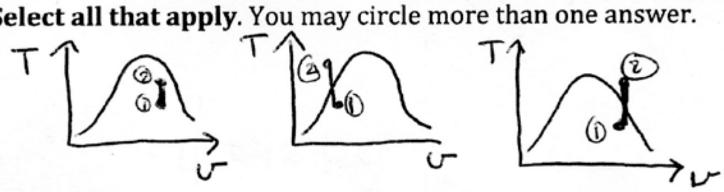
$T_1 = 1227C + 273 = 1500K$

$T_2 = \left(\frac{150\,kPa}{300\,kPa}\right) 1500K = 750K$

$T_2 = 750K - 273 = 477C$

SELECT ALL THAT APPLY SECTION, PROBLEMS 4-5 [2 POINTS EACH]
Select all answers that are correct. You may circle more than one answer.

(4) A rigid tank contains a saturated mixture initially. Heat is transfer to the tank, what will be the final state? **Select all that apply**. You may circle more than one answer.
(A) Superheated vapor
(B) Saturated mixture
(C) Compressed liquid
(D) None of the above



(5) Which of the following is able to cross the boundary of a closed system? **Select all that apply**. You may circle more than one answer.
(A) Mass
(B) Work
(C) Heat
(D) None of the above

1-5	
6	
7	
Total	

Please do not write in this table.

(6) [10 points total] A hydro-pump storage is used for storing excess energy generated by a wind turbine. From the wind turbine, 400kW of electric power was used to pump 500kg/s of water to an elevation of 75 m.

a) **[8 points]** Calculate the efficiency of the pump unit. Gravity $9.8 m/s^2$, 1 kJ/kg = 1000 m^2/s^2

b) **[2 points]** Next day the stored water flows down a turbine-generator unit to produce electricity. If the efficiency of the turbine-generator is 85%, what is the overall efficiency of the hydro-pump storage?

a) $$\Delta \dot{E}_{mech} = \left[\dot{m}\left(\cancel{\frac{P}{\rho}} + \cancel{\frac{V^2}{2}} + gz\right)\right]_{out} - \left[\dot{m}\left(\cancel{\frac{P}{\rho}} + \cancel{\frac{V^2}{2}} + gz\right)\right]_{in}$$

$$\Delta \dot{E}_{mech} = \dot{m} g \Delta z$$

$$\Delta \dot{E}_{mech} = (500\,kg/s)(9.8\,m/s^2)(75\,m)$$

$$\Delta \dot{E}_{mech} = \left(\frac{367500\,kg \cdot m^2}{s^3}\right)\left(\frac{1\,kJ/kg}{1000\,m^2/s^2}\right) = 367.5\,kJ/s$$

$$\Delta \dot{E}_{mech} = 367.5\,kW$$

$$\eta_{pump} = \frac{\Delta \dot{E}_{mech}}{\dot{W}_{in}} = \frac{367.5\,kW}{400\,kW} = 0.919$$

$$\boxed{\eta_{pump} = 91.9\%}$$

b) $$\eta_{overall} = \eta_{pump}\,\eta_{turbine\text{-}generator}$$

$$\eta_{overall} = (0.919)(0.85) = 0.781$$

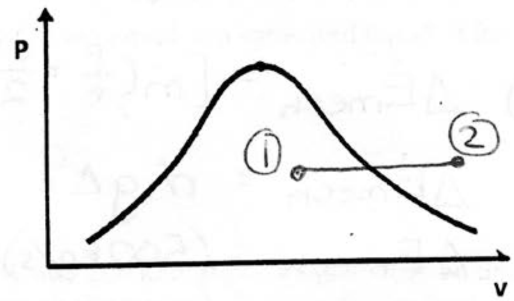
$$\boxed{\eta_{overall} = 78.1\%}$$

(7) **[10 points total]** A piston-cylinder device contains 0.005 m^3 of liquid water and 0.9 m^3 of water vapor in equilibrium at 600 kPa. Heat is transferred at constant pressure until the temperature reaches 200 °C.

a) **[2 points]** What is the initial temperature of the water?

b) **[5 points]** Calculate the final volume.

c) **[3 points]** Show the process on a P-v diagram with respect to saturation lines on the plot provided below. Label the initial and final states. Show the process between the states.



a) Initially, we have a saturated mixture (both liquid and vapor co-exist in equilibrium)

$T_1 = T_{sat}(P = 600\,kPa)$

Table A-5

$\boxed{T_1 = 158.83 C}$

b) At the final state:

$P_2 = 600\,kPa \Rightarrow$ Table A-6 $\Rightarrow v_2 = 0.35212\,m^3/kg$

$T_2 = 200\,C$

$V_2 = m v_2$

$m_f = \frac{V_f}{v_f} = \frac{0.005\,m^3}{0.001101\,m^3/kg} = 4.543\,kg$

$m_g = \frac{V_g}{v_g} = \frac{0.9\,m^3}{0.3156\,m^3/kg} = 2.852\,kg$

$m = m_f + m_g$

$m = 7.395\,kg$

$V_2 = (7.395\,kg)(0.35212\,m^3/kg)$

$\boxed{V_2 = 2.604\,m^3}$