QUIZ 2A MULTIPLE CHOICE SECTION, PROBLEMS 1-6 [1 POINT EACH]

(1) The amount of heat absorbed during a transition from liquid to gas is the:
(A) latent heat of fusion
(B) latent heat of vaporization
(C) latent heat of sublimation
(D) specific heat

(2) The point at which the saturated liquid and saturated vapor states are identical is called the:
(A) saturation temperature
(B) phase diagram
(C) enthalpy of vaporization
(D) critical point

(3) At what conditions does the ideal gas law have the most accuracy?
(A) near the critical point
(B) at high pressures
(C) at low pressures
(D) as a saturated mixture

(4) For ideal gases, the internal energy is a function of:
(A) the volume
(B) the pressure
(**C) the temperature**
(D) all of the above

(5) If a process involves only a solid substance, which of the following is false?
(A) The change in enthalpy is equal to the change in internal energy.
(B) The specific heat at constant volume and the specific heat at constant pressure are the same value.
(C) We can treat the enthalpy as that of a compressed liquid.
(D) The enthalpy is a function of temperature.

(6) If a system's initial state is the same as the final state, the work done by the system is equivalent to:
(A) The distance travelled by the system
(B) The change in temperature of the system
(C) The net heat added to the system
(D) None of the above

QUIZ 2B MULTIPLE CHOICE SECTION, PROBLEMS 1-6 [1 POINT EACH]

(1) The amount of heat absorbed during a transition from liquid to gas is the:
(A) latent heat of vaporization
(B) latent heat of fusion
(C) latent heat of sublimation
(D) specific heat

(2) The point at which the saturated liquid and saturated vapor states are identical is called the:
(A) saturation temperature
(B) critical point
(C) enthalpy of vaporization
(D) phase diagram

(3) At what conditions does the ideal gas law have the least accuracy?
(A) below the critical point
(B) at high pressures
(C) at low pressures
(D) at standard atmospheric conditions

(4) For ideal gases, the internal energy is a function of:
(A) the volume
(B) the pressure
(C) the temperature
(D) all of the above

(5) If a process involves only a solid substance, which of the following is false?
(A) We can treat the enthalpy as that of a compressed liquid.
(B) The specific heat at constant volume and the specific heat at constant pressure are the same value.
(C) The change in enthalpy is equal to the change in internal energy.
(D) The internal is a function of temperature.

(6) If a system's initial state is the same as the final state, the work done by the system is equivalent to:
(A) The distance travelled by the system
(B) The change in temperature of the system
(C) The net heat added to the system
(D) The pressure multiplied by the change in volume

(7) **[8 POINTS]** A piston-cylinder device contains 0.5 kg of water at an initial volume of 75,000 cm^3 and a temperature of 250^0 C. It is then cooled until the temperature is 35^0 C.

(A) What is the final pressure of the water?
(B) What is the final volume of the water?
(C) What is the final enthalpy (H) of the water?
(D) Draw a P-V diagram of the process.

A) Determine specific volume as your second state variable for state 1.

$$v = \frac{0.075\, m^3}{0.5\, kg} = 0.150 \frac{m^3}{kg}$$

Look at tables, determine that $v > v_{sat}(T)$, so must be superheated. Use Table A-6 to determine pressure

$$P = 1.6\, MPa - \frac{0.15 - 0.1419\, \frac{m^3}{kg}}{0.16356 - 0.1419\, \frac{m^3}{kg}}(0.2\, MPa) = 1.525\, MPa$$

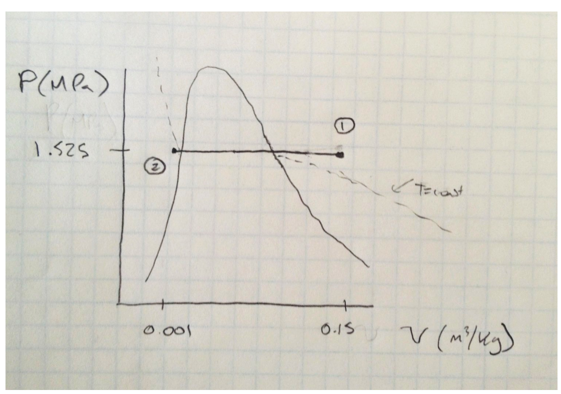
B) Looking at the tables (or just thinking about it), you know that this is a subcooled (compressed) liquid

$$v_2 \cong v_{sat}(T) = 0.001006\, \frac{m^3}{kg}$$
$$V_2 \cong 0.001006 * 0.5kg = 0.0005\, m^3$$

C) Similarly, we know

$$h_2 \cong h_{sat}(T) + \Delta P(v_{sat}(T)) = 146.64\, \frac{kJ}{kg} + (1.52e3\, kPa) * (0.001\, m^3) = 148.2 \frac{kJ}{kg}$$
$$H = (0.5\, kg) * 148.2 \frac{kJ}{kg} = 74.08\, kJ$$

D) Diagram



(8) **[6 POINTS]** A well-insulated (i.e. adiabatic) rigid container with a total volume of 0.085 m^3 is divided into two equal sections by a thin membrane. Initially, one of these chambers is filled with air at 700 kPa and 38^0 C while the other is evacuated (i.e. vacuum).
(A) What is the change of internal energy of the air after the membrane is ruptured and the container reaches equilibrium?
(B) What is the final air pressure in the container?
(C) If the insulation is then removed and heat is exchanged with the surroundings so the temperature decreases by 11^0 C, what is the change in internal energy (U)? You can assume the following values for air are constant: R = 0.2870 kJ/(kg·K), c_p = 1.005 kJ/(kg·K), and c_v = .718 kJ/(kg·K).

A) We know that the boundary work and the heat transfer must both be zero because it is a well-insulated, rigid container. Thus we can write the energy balance equation:

$$\Delta U = Q - W = 0 - 0 = 0$$

B) Because we know that internal energy of an ideal gas is related only to temperature, this implies that the temperature must not change after expansion, since the internal energy does not change. This may be counter-intuitive, since it expands, but because it is expanding *against a vacuum* there is no pressure on it as it expands, and thus it does no work, so does not cool as a result.

With T_1=T_2 we can write

$$P_2 = P_1 \frac{V_1}{V_2} = 700 \frac{1}{2}\ kPa = 350\ kPa$$

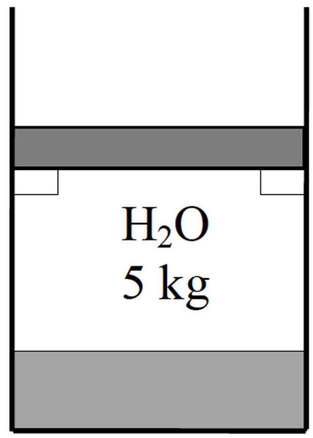
C) Since this is an ideal gas, we can use the assumed constant specific heats given. Since the volume is fixed, we use the specific heat at fixed volume, which, gives us the change in internal energy.

To solve this first we must know the mass. From the ideal gas relation:

$$m = \frac{P_1 V_1}{RT} = \frac{700(0.0425)}{(.2870)(273 + 38)} = 0.3333\ kg$$

$$\Delta U = Q = m c_v \Delta T = (0.333\ kg) * \left(0.718 \frac{kJ}{kg\ K}\right) * (11\ K) = \ 2.632\ kJ$$

(9) **[10 POINTS]** A mass of 5 kg of a saturated liquid-vapor mixture is contained in a piston-cylinder device at 120.90 kPa. Initially, 2 kg of water is in the liquid phase and the rest is in the vapor phase. Heat is then transferred to the water until the piston, which is resting on stops, starts moving when the pressure is 300 kPa. Heat continues to be added to the system until the total volume increases by 20%.



(A) What is the initial temperature?
(B) What is the final temperature?
(C) What is the mass of the liquid water when the piston first starts moving?
(D) What is the work done during the process?
(E) Draw a P-V diagram of the process.

A) Since it is saturated mixture, the pressure defines the temperature. Look at Table A-4, find it to be 100C
B) We need to find our final volume to give us a second state variable to define our second state. We know the increase in volume from V1, so we need to find V1 using the quality of our saturated mixture and Table A-4.

$$v_1 = 0.001047 + -\frac{5-2\ kg}{5}(1.4186 - 0.001047) = 0.8516\ \frac{m^3}{kg}$$

$$v_2 = 1.2v_1 = 1.2(0.8516) = 1.0219\ \frac{m^3}{kg}$$

Looking at the specific volume at temperatures near the saturation pressure of 300kPa, we can tell this value is much larger so we must be superheated. Going to Table A-6 we can interpolate specific volume to find temperature

$$T = 300 + \frac{1.0219 - 0\ .87535\frac{m^3}{kg}}{1.03155 - 0\ .87535\frac{m^3}{kg}}(100) = 393.8\ C$$

C) Consider the state when the piston starts moving: we have a specific volume of v1 and are at 300kPa. Looking at Table A-4, we can tell that for saturation pressures of 270-313kPa, the specific volume is much lower than v1. This tells us that the mixture must be *superheated*, even before it expands, since the specific volume it occupies is greater than the saturation value for that pressure. Thus we know that the mass of liquid water must be zero.

D) The work done happens only when the piston is moving, which is a constant-pressure condition. Thus:

$$W = wm = (P\Delta v)m = (300\ kPa)(1.0219 - 0.8516\frac{m^3}{kg})(5\ kg) = 255.45\ kJ$$

E) Diagram