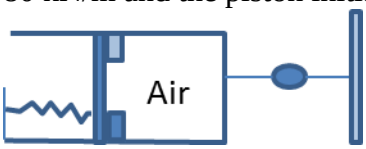
Properties of Pure substances

1. A 1-m3 tank is filled with a gas at room temperature 20°C and pressure 100 kPa. How much mass is there if the gas is a) air, b) neon or c) propane ? Ans. .828, 1.809kg

2. A vacuum pump is used to evacuate a chamber where some specimens are dried at 50°C. The pump rate of volume displacement is 0.5 m^3/s with an inlet pressure of 0.1 kPa and temperature 50°C. How much water vapor has been removed over a 30-min period? Ans. 0.603kg

3. A cylinder is fitted with a 10-cm-diameter piston that is restrained by a linear spring (force proportional to distance) as shown in Fig. P3.16. The spring force constant is 80 kN/m and the piston initially rests on the stops, with a cylinder volume of 1 L.



The valve to the air line is opened and the piston begins to rise when the cylinder pressure is 150 kPa. When the valve is closed, the cylinder volume is 1.5 L and the temperature is 80°C. What mass of air is inside the cylinder? Ans. 0.012kg

4. Determine the mass of methane gas stored in a 2 m^3 tank at –30°C, 3 MPa. Estimate the percent error in the mass determination if the ideal gas model is used. Ans. 53.45 kg, 10.9%

5. A 400-m^3 storage tank is being constructed to hold LNG, liquified natural gas, which may be assumed to be essentially pure methane. If the tank is to contain 90% liquid and 10% vapor, by volume, at 100 kPa, what mass of LNG (kg) will the tank hold? What is the quality in the tank? 152612 kg, x= 4.58e-4

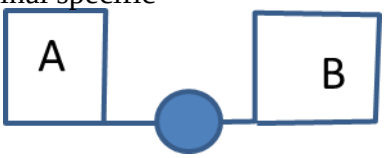
6. A cylinder containing ammonia is fitted with a piston restrained by an external force that is proportional to cylinder volume squared. Initial conditions are 10°C, 90% quality and a volume of 5 L. A valve on the cylinder is opened and additional ammonia flows into the cylinder until the mass inside has doubled. If at this point the pressure is 1.2 MPa, what is the final temperature? Ans. 70.9 C

7. A pressure cooker (closed tank) contains water at 100°C with the liquid volume being 1/10 of the vapor volume. It is heated until the pressure reaches 2.0 MPa. Find the final temperature. Has the final state more or less vapor than the initial state? Ans. 212.4C

8. Water in a piston/cylinder is at 90°C, 100 kPa, and the piston loading is such that pressure is proportional to volume, $P = CV$. Heat is now added until the temperature reaches 200°C. Find the final pressure and also the quality if in the two-phase region. Ans. 1553.8, .118

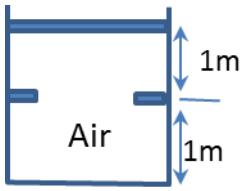
9. A spring-loaded piston/cylinder contains water at 500°C, 3 MPa. The setup is such that pressure is proportional to volume, $P = CV$. It is now cooled until the water becomes saturated vapor. Sketch the *P-v* diagram and find the final pressure. Ans. 2270 kpa

10. Two tanks are connected as shown in Fig. P3.58, both containing water. Tank A is at 200 kPa, $v = 0.5$ m^3/kg, $V_A = 1$ m^3 and tank B contains 3.5 kg at 0.5 MPa, 400°C. The valve is now opened and the two come to a uniform state. Find the final specific volume. Ans. .5746m^3/kg



Work and heat

1. A piston/cylinder arrangement shown in Fig. P4.6 initially contains air at 150 kPa, 400°C. The setup is allowed to cool to the ambient temperature of 20°C.
   Is the piston resting on the stops in the final state?
   a. What is the final pressure in the cylinder?
   b. What is the specific work done by the air during this process? Ans -96.6 kJ/kg

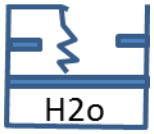


2. The refrigerant R-22 is contained in a piston/cylinder as shown in Fig. P4.7, where the volume is 11 L when the piston hits the stops. The initial state is –30°C, 150 kPa with a volume of 10 L. This system is brought indoors and warms up to 15°C.
   a. Is the piston at the stops in the final state?
   b. Find the work done by the R-22 during this process. Ans. 0.15kJ

3. A balloon behaves such that the pressure inside is proportional to the diameter squared. It contains 2 kg of ammonia at 0°C, 60% quality. The balloon and ammonia are now heated so that a final pressure of 600 kPa is reached. Considering the ammonia as a control mass, find the amount of work done in the process. Ans. 117.5 kJ

4. A cylinder having an initial volume of 3 m^3 contains 0.1 kg of water at 40°C. The water is then compressed in an isothermal quasi-equilibrium process until it has a quality of 50%. Calculate the work done in the process. Assume the water vapor is an ideal gas. Ans. -13.4 kJ

5. Two kilograms of water is contained in a piston/cylinder (Fig. P4.23) with a massless piston loaded with a linear spring and the outside atmosphere. Initially the spring force is zero and $P1 = P_0 = 100$ kPa with a volume of 0.2 m^3. If the piston just hits the upper stops the volume is 0.8 m^3 and $T = 600$°C. Heat is now added until the pressure reaches 1.2 MPa. Find the final temperature, show the P–V diagram and find the work done during the process. Ans. 330 kJ



6. Air at 200 kPa, 30°C is contained in a cylinder/piston arrangement with initial volume 0.1 m^3 . The inside pressure balances ambient pressure of 100 kPa plus an externally imposed force that is proportional to $V^{0.5}$. Now heat is transferred to the system to a final pressure of 225 kPa. Find the final temperature and the work done in the process. Ans. 11.9 kJ

7. A spring-loaded piston/cylinder arrangement contains R-134a at 20°C, 24% quality with a volume 50 L. The setup is heated and thus expands, moving the piston. It is

noted that when the last drop of liquid disappears the temperature is 40°C. The heating is stopped when $T = 130°C$. Verify the final pressure is about 1200 kPa by iteration and find the work done in the process. Ans. 74.7 kJ