Department of Mechanical Engineering
Indian Institute of Technology New Delhi
II Semester -- 2022 – 2023

MCL142 Thermal Science for Electrical Engineers

Problem Set 2: Properties of Substances

Hint: Download steam property App on your smart phone and visit this site for properties of other substances: https://webbook.nist.gov/chemistry/fluid/

Problem1: A sealed rigid vessel has volume of 1 m^3 and contains 2 kg of water.steam at 100°C. The vessel is now heated. If a safety pressure valve is installed, at what pressure should the valve be set to have a maximum temperature of 200°C?

Problem 2: Saturated water vapor at 200 kPa is in a constant pressure piston/cylinder assembly. At this state the piston is 0.1 m from the cylinder bottom. How much is this distance if the temperature is changed to a. 200°C, b. 100°C.

Problem 3: In a refrigerator the working substance (called refrigerant) evaporates from saturated liquid to saturated vapor at -20°C inside a pipe around the freezer. The refrigerant coming out the compressor is sent to another pipe, where it condenses form saturated vapor to saturated liquid at 40°C. For each location find the pressure and the change in specific volume (v) if a. the substance is R-22 b. the substance is ammonia. c. n-Pentane d. Propane and e. Propene.

Problem 4: Two tanks are connected both containing water/steam. Tank A is at 200 kPa, v =0.5 m^3 /kg, V= 1 m^3, and tank B contains 3.5 kg at 0.5 MPa and 400°C. The valve is now opened and the two come to a uniform state. Find the final specific volume.

Problem 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?

Problem 6: 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?

Problem 7: Ammonia at 10°C with a mass of 10 kg is in a piston/cylinder assembly with an initial volume of 1 m^3. The piston initially resting on the stops has a mass such that a pressure of 900 kPa will float it. Now the ammonia is slowly heated to 50°C. Find the final pressure and volume.

Problem 8: A cylinder fitted with a frictionless piston contains butane at 250C, 500 kPa. Can the butane reasonably be assumed to behave as an ideal gas at this state?

Problem 9: A spherical helium balloon 10 m in diameter is at ambient T and p, 15°C and 100 kPa. How much helium does it contain? It can lift a total mass that equals the mass of displaced atmospheric air. How much mass of the balloon fabric and cage can then be lifted?

Problem 10: Is it reasonable to assume that at the given states the substance behaves as an ideal gas? a. Oxygen at 30°C, 3 MPa; b. Methane at 30°C, 3 MPa; c. Water at 30°C, 3 MPa d. R-134a at 30°C, 3 MPa; e. R-134a at 30°C, 100 kPa.