School of Engineering, University of Edinburgh
Engineering Thermodynamics (Mechanical) 2

THE UNIVERSITY *of* EDINBURGH
School of Engineering

<u>Tutorial 1</u>: Basic Concepts, Pressure, Diagrams, and Properties of a Pure Substance

<u>Conceptual Questions</u>:

1. Describe the following:
(a) Open system
(b) Closed system
(c) What is the thermodynamic state postulate?

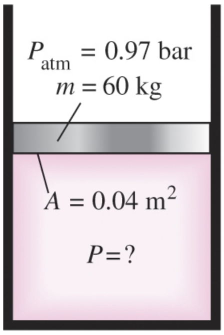
2. Determine whether the following properties are intensive or extensive:
(a) Pressure
(b) Temperature
(c) Mass
(d) Volume
(e) Density
(f) Total energy (E)

<u>Problem Solving Questions</u>:

3) A piston-cylinder device contains a gas at equilibrium. The piston has a mass of 60 kg and a cross-sectional area of 0.04 m^2. The local atmospheric pressure is 0.97 bar (97 kPa), and the gravitational acceleration is 9.81 m/s^2.

(a) Assuming that friction between the piston and the cylinder is negligible, calculate the absolute pressure inside the cylinder in bar and in kPa.

(b) If some heat is transferred to the system and the volume of the gas triples, do you expect the pressure to change?



4) A manometer reading is 100 mmHg (i.e. height of Hg in manometer). A gauge pressure difference using a manometer can be calculated by the following: $\Delta \boldsymbol{P} = \boldsymbol{\rho g h}$ (see lecture 1, slides 38 + 39). Calculate the **gauge** and **absolute** pressure in kPa. The density of mercury is 13,600kg/m^3, gravitational acceleration is 9.81 m/s^2 and atmospheric pressure is 101.3 kPa.

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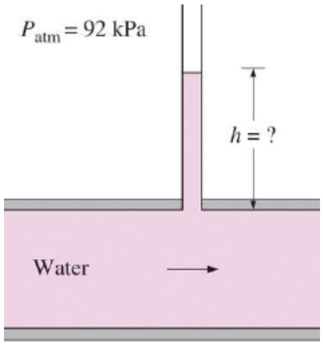
5) A glass tube is attached to a water pipe at a right angle. If the water pressure at the bottom of the tube is 135 kPa and the local atmospheric pressure is 92 kPa, calculate how high the water will rise in the tube (g = 9.81 m/s^2 and the density of water 1000 kg/m^3). Lecture slide material: lecture 1, slides 38 + 39.



6) A spherical balloon 10 m in diameter is filled with helium at a temperature and pressure of 15^{o}C and 100 kPa. The helium behaves as an ideal gas with a mass-based gas constant R_{Helium} = 2.0771 kJ/kgK. Determine the mass of the helium in the balloon.

7) Consider you want to transport an external load by using a large, spherical-shaped balloon. The buoyancy force (expressed below) is the force that suspends the balloon in the air.

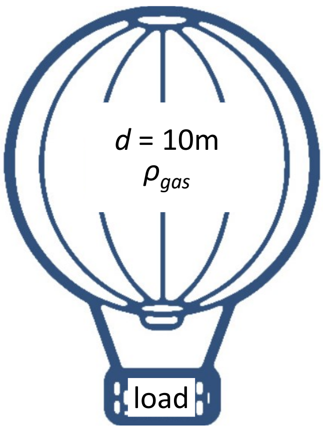
$$F_b = \rho_{air} g V_{balloon}$$

Take the density of air to be 1.16 kg/m^3. Determine the maximum load in kg the balloon can support if the balloon is filled with:

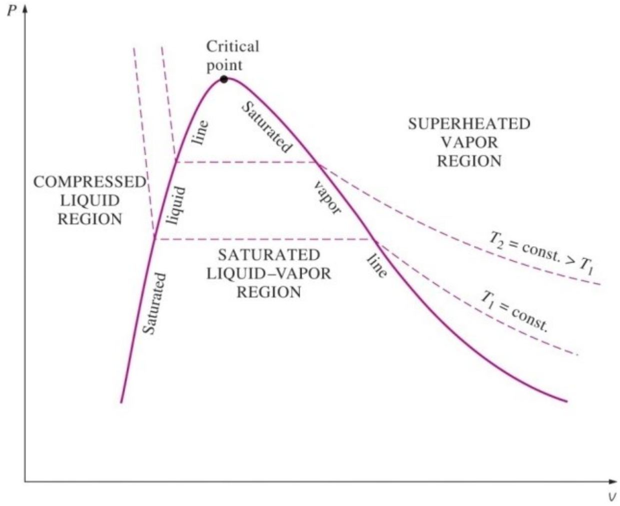
(a) Hot air with ρ_{air} = 0.8 kg/m^3

(b) Helium (ρ_{Helium} = 0.16 kg/m^3)

Hint: do not forget to account for the weight of the balloon gas contents.



8) Plot the following processes in the P-v diagram. Starting points can be arbitrarily placed in the specified regions.



<u>Process 1-2-3-4</u>

- 1→2: linear increase in P & v from compressed liquid to saturated liquid.
- 2→3: *v* increase to superheated vapor under constant T.
- 3→4: P decrease to saturated vapor under constant *v*.

<u>Process A-B-C-D</u>

- A→B: linear P & v decrease from superheated vapor to saturated vapor
- B→C v decrease to saturated mixture with *x* = 50% under constant P & T
- C→D: P increase (& possible *v* decrease) to critical point