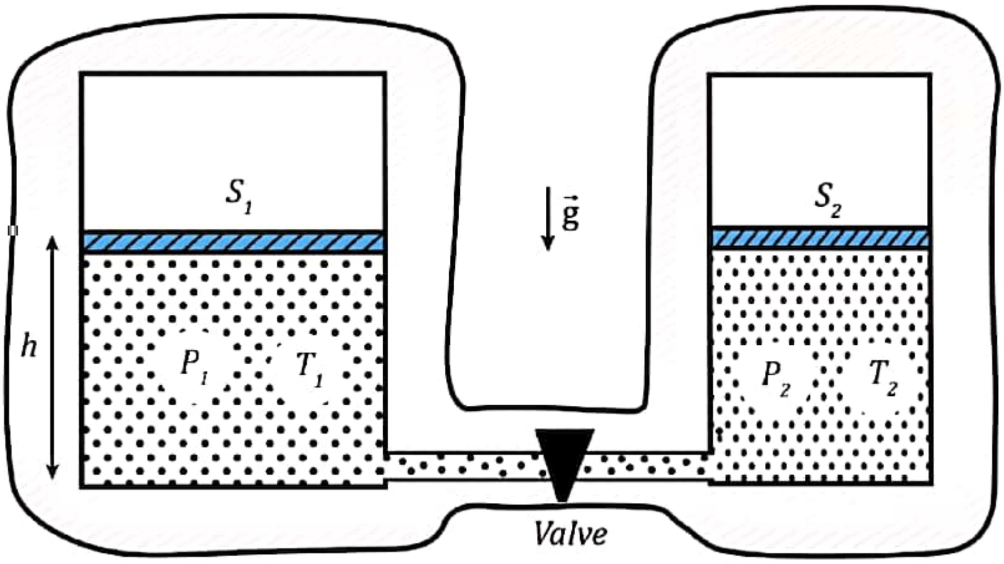
Problem 3

Two cylindrical vessels are filled with monatomic ideal gas. Both of the vessels are thermally insulated and connected with a thin tube. Initially, that tube is closed, while gas conditions in both vessels are characterized with temperatures $T_1 = 400\ K$, $T_2 = 300\ K$ and pressures $P_1 = 1.0 \cdot 10^3 Pa$, $P_2 = 2.0 \cdot 10^3 Pa$ respectively. At the initial equilibrium position, both pistons are at the same height $h = 0.1\ m$ from the bottom of vessels, while space above pistons is empty



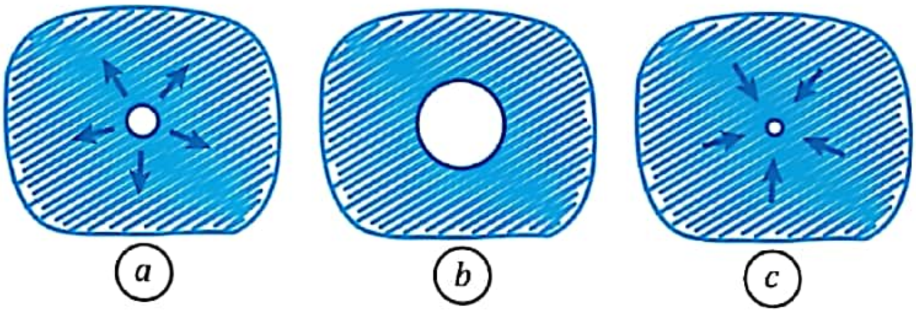
At some moment of time, valve between the cylinders is quickly opened. Determine final equilibrium temperature of the gas T_f, if in that state no gas leaked to the space above pistons. Also assume that friction between the pistons and walls of the vessels is negligibly small. Cross-sectional areas of the pistons are $S_1 = 0.01\ m^2$ and $S_2 = 0.02\ m^2$

$T_f =$ Your answer K

Problem 8

Sonoluminescence (SL) is the phenomenon of emission of light from imploding small bubbles in a liquid, which occurs from excitation of the bubbles by sound waves. The collapsing bubble heats the gas inside the bubble to extremely high temperatures. The goal of this problem is to estimate upper limit of temperature inside the bubble T_c after its collapse

SL process can be described with three main steps:



a) Under negative pressure effect from ultrasonic wave in the fluid, a bubble expands isothermally from initial radius $r_a = 5.0 \cdot 10^{-6}\ m$ to the radius $r_b = 50.0 \cdot 10^{-6}\ m$. Ambient temperature of the fluid is $T_0 = 300\ K$

b) After sound wave is passed by, pressure in the fluid again becomes equal to the normal atmospheric pressure, causing bubble collapse from the radius r_b to r_c

c) Bubble implodes extremely fast, to the small radius $r_c = 1.0 \cdot 10^{-6}\ m$ controlled by van der Waals hard core parameters of the gas. At this moment gas temperature inside the bubble becomes so hot, that bubble emits light

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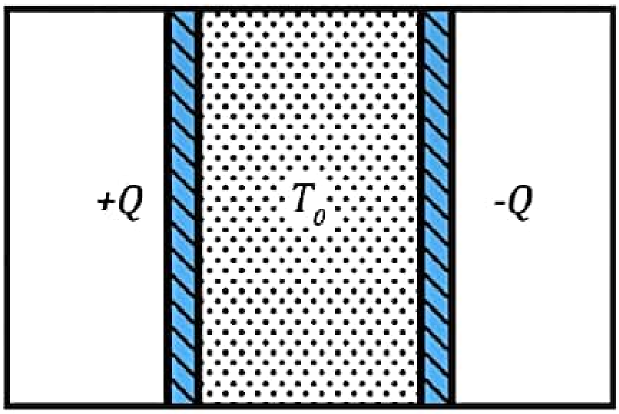
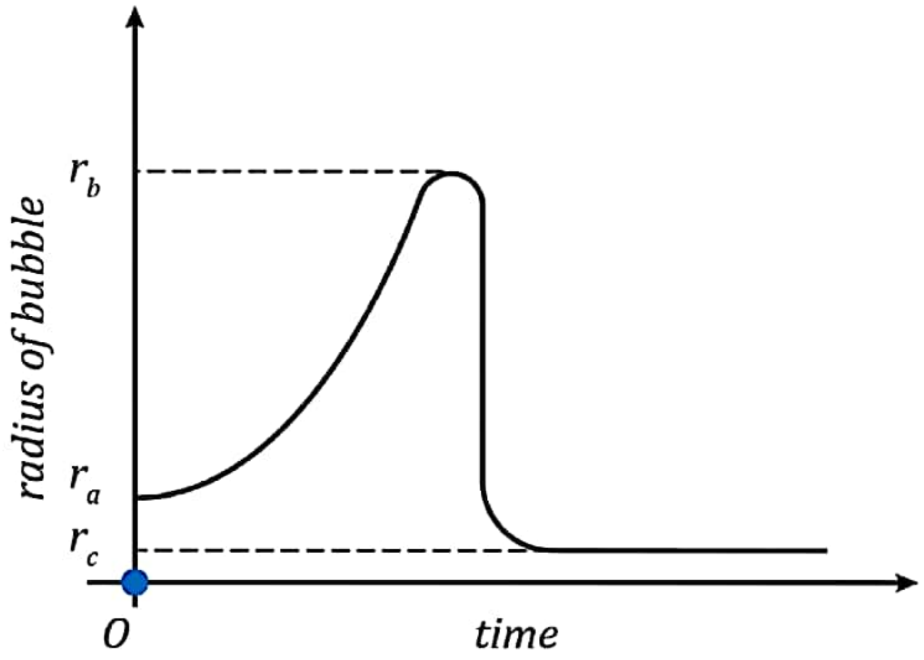
Problem 6

A monatomic gas is kept inside a thermally insulated vessel, between two charged pistons with charges $+Q$ and $-Q$



Initial temperature of the gas is $T_0 = 300\ K$. Pistons can move without friction inside the vessel. Air outside the pistons is pumped out, so that space is close to vacuum. At a certain instant, magnitude of charges of the pistons is suddenly doubled. What will be temperature of the gas T_1 for a new equilibrium state? Assume that at any moment of time, the distance between pistons, is much smaller than their linear dimensions

$T_1 =$ 660.00 K



Typical collapse velocity of the bubble is extremely large, reaching 4 times of the speed of sound in the gas, so regular equation for quasistatic adiabatic process should be used with caution

Estimate temperature inside the bubble at the collapse state T_c, assuming the process $(b) - (c)$ as non-quasistatic. At the same time, even for the collapsed state with a very small radius can be assumed that ideal gas law for the gas inside the bubble is applied. Also assume that gas inside the bubble is mainly pure oxygen and Laplace surface tension effect is much smaller than atmospheric pressure

$T_c =$ Your answer $\cdot 10^3\ K$

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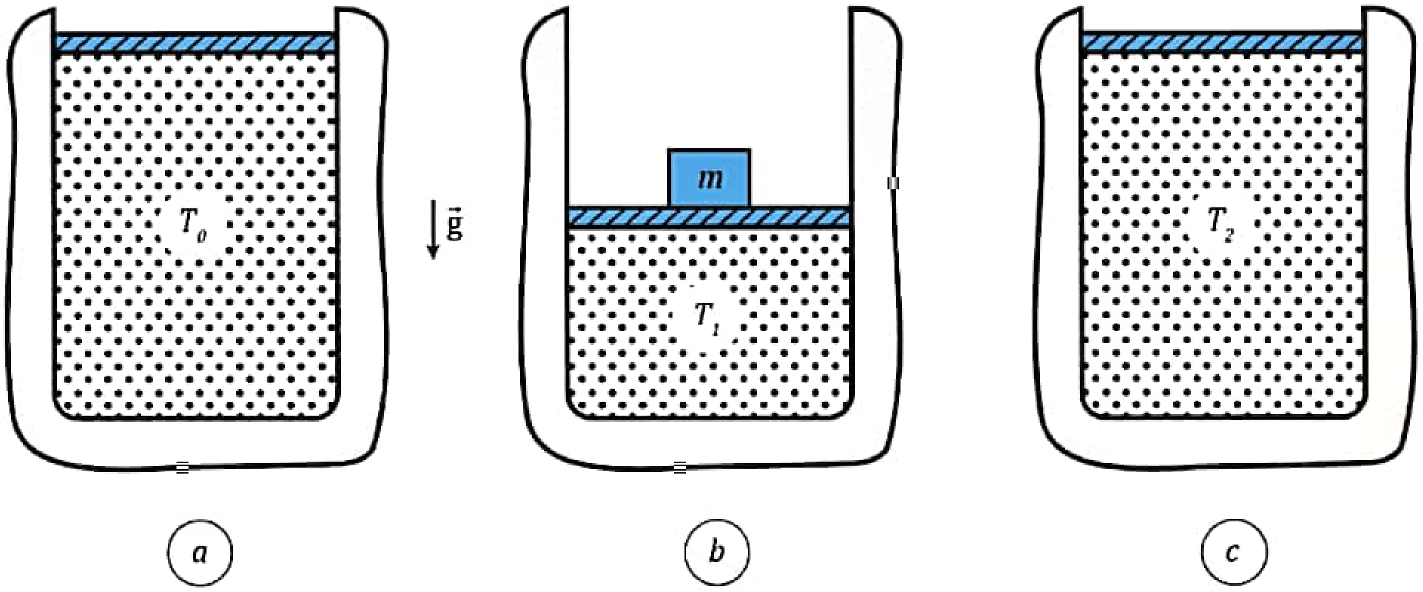
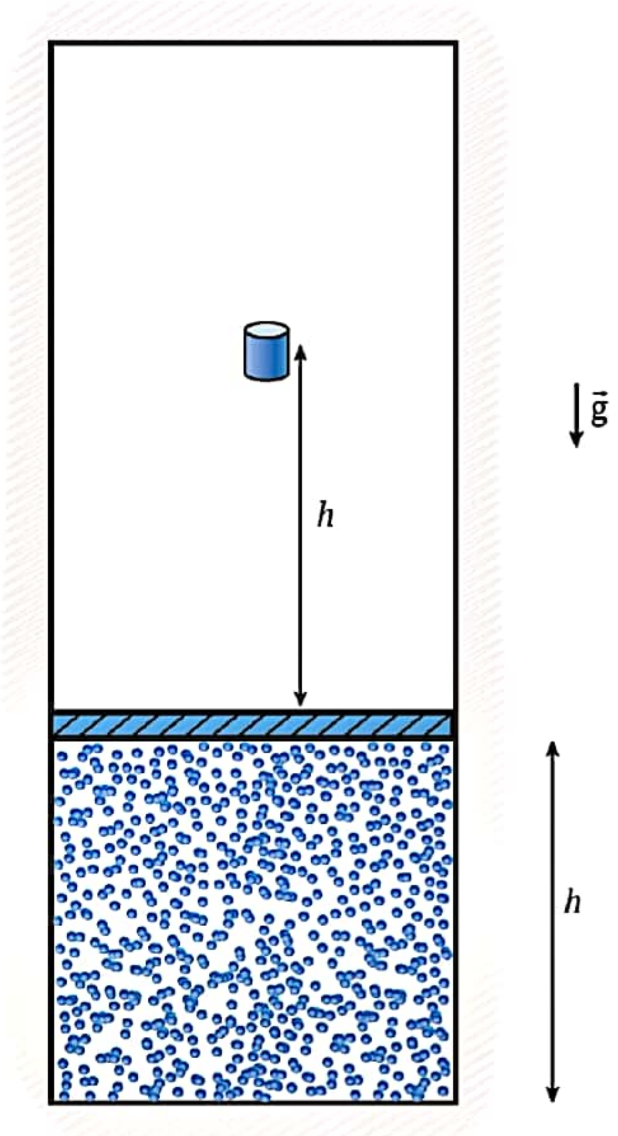
Example 1

A monatomic gas at initial temperature T_0 is kept under a piston of mass M, which can move vertically without friction inside thermally insulated vessel. An experimenter puts a weight with mass m at the top of the piston and waits for a new equilibrium position (b). What is the final temperature of the gas T_2 in equilibrium position (c), after the weight is removed? Assume that piston is heavy, so atmospheric pressure can be neglected



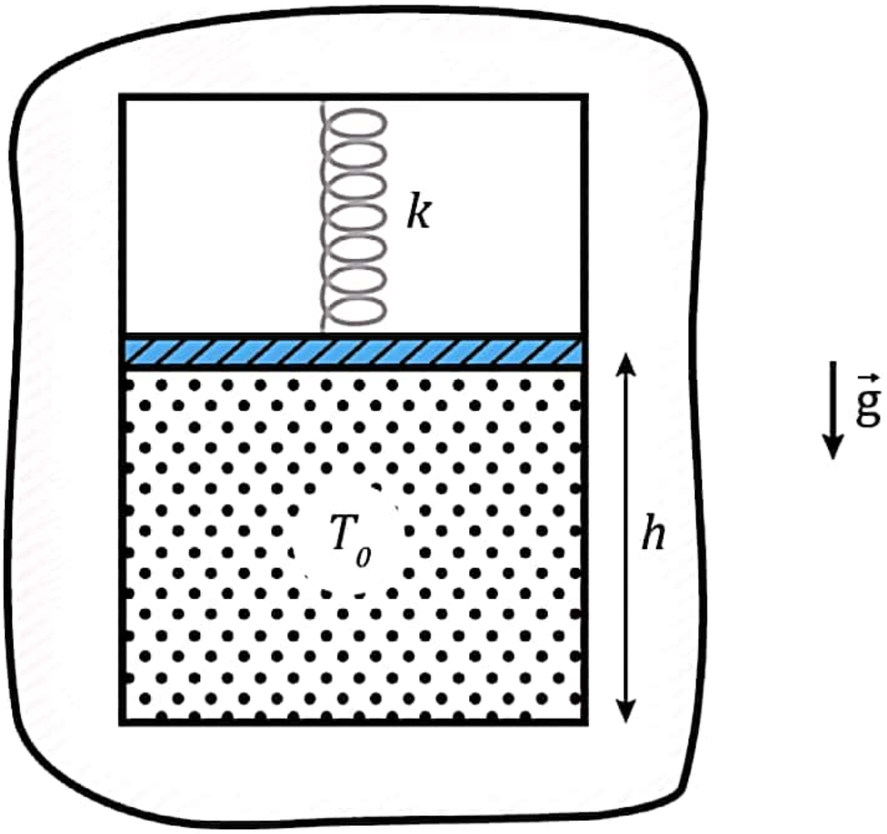
Problem 5

A small piece of malleable material with mass $m = 1.0\ kg$ is initially located at the height $h = 1.0\ m$ above flat piston with mass $M = 2m$. The piston is initially at equilibrium, being at cap for vertical cylinder with monatomic gas. Initial distance between face of the piston and bottom of the cylindrical vessel with gas is also equal to $h = 1.0\ m$. After release of the malleable material, it falls in the gravity of the Earth with acceleration due to gravity $g = 9.8\ m/s^2$



Problem 2

One mole of monatomic gas with initial temperature $T_0 = 300\ K$ is kept in thermally insulated vessel under a thin piston, which is attached to the spring with rigidity $k = 200\ N/m$. Initially, the spring is neither stretched, nor compressed, while the height of the piston above bottom of the vessel is $h = 1.0\ m$

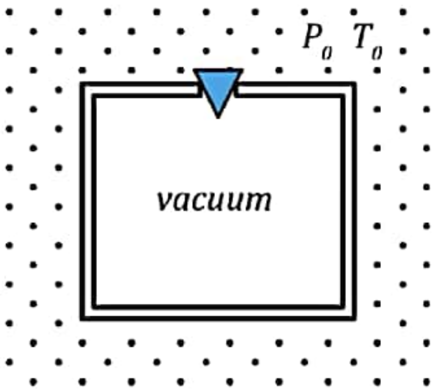


After piston was released, at a new equilibrium position, distance between the piston and bottom of the vessel has decreased by a half. Find temperature T_1 of the gas for a new equilibrium state. Assume that there is no friction between the piston and walls of the vessel

$T_1 =$ Your answer K

Problem 7

A thermally insulated vessel is pumped out of air to the condition very close to vacuum (a). Outside temperature of the air is $T_0 = 300\ K$. At some moment of time, a plug is removed from the empty chamber, so air fills the vessel. Find temperature of the gas T_1 inside the chamber, at the moment (b), when pressure inside the vessel will become equal to the atmospheric pressure P_0. Assume that process of filling the vessel with air is very fast and air can be considered as diatomic gas



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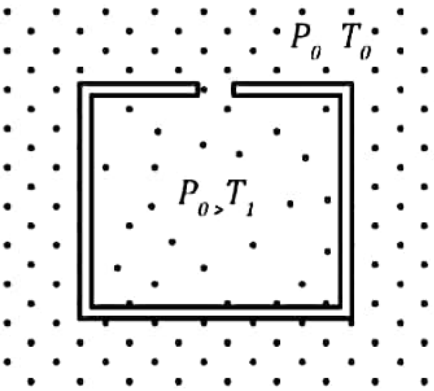

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$T_1 =$ Your answer K

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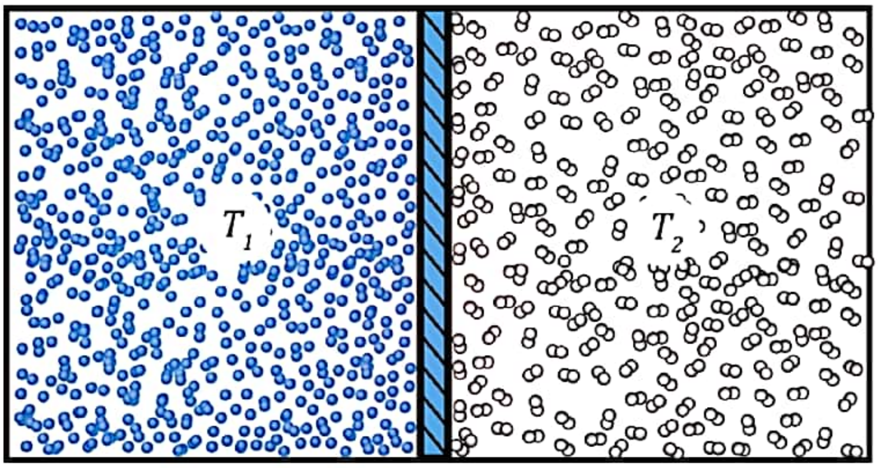
Problem 1

A heat insulated container is divided by a thin partition, which splits the vessel at two sections of equal volumes. Initially, the right part of the vessel is filled with monatomic gas under temperature $T_1 = 300.0\ K$, while the left section is filled with diatomic gas at temperature $T_2 = 400.0\ K$. It is also known that initial pressures at both sections of the vessel were equal



Then partition is quickly removed, with a thin gap in the vessel being sealed instantaneously, so that no gas leaves the container during removal of the partition. Determine final temperature T_f of the mixture of gases after a long period of time. Assume that vessel is kept heat insulated from outside environment after removal of the partition

$T_f =$ Your answer K

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Determine height H of the piston above bottom of the vessel in a new equilibrium, assuming that collision with the piston occurs during a short period of time and that collision is perfectly inelastic. The vessel is thermally insulated, with vacuum above the piston. Heat capacity and thermal conductivity of the vessel and piston can be neglected. Motion of the piston inside cylinder occurs without friction

$H =$ Your answer m

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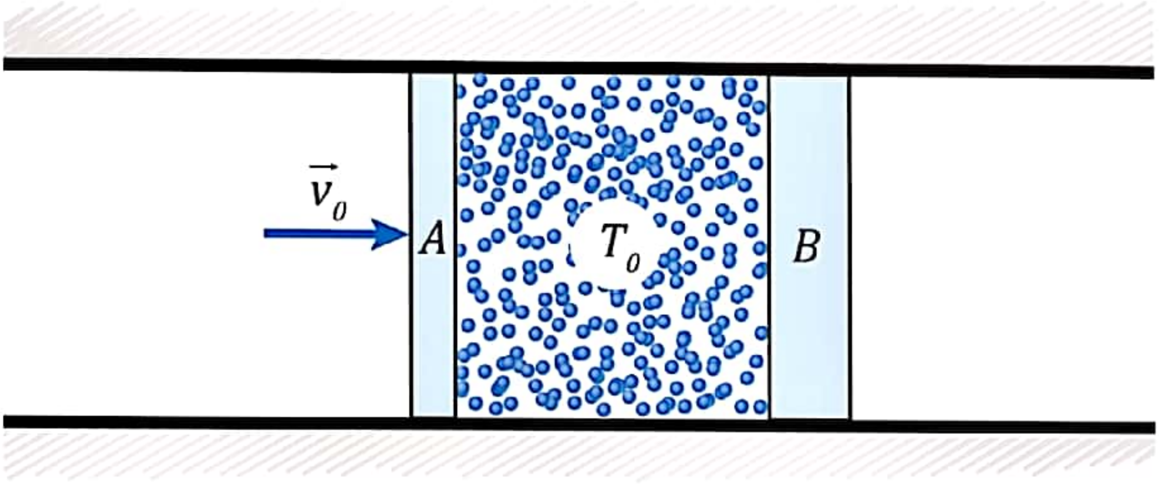
Problem 4

One mole of monatomic gas is kept between two heavy pistons A and B at initial temperature $T_0 = 300.0\ K$. Those pistons can move without friction inside a long heat insulated cylindrical tube. At initial moment of time, piston A has velocity $v_0 = 10.0\ m/s$, while piston B is at rest. Determine maximum temperature T_{max} of gas in the system, if known that piston A has mass $m = 10.0\ kg$, while piston B is two times heavier than piston A. Assume that pistons do not transfer heat and friction with air can be neglected



$T_{max} =$ Your answer K

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