INSTITUT TEKNOLOGI BANDUNG
FAKULTAS MATEMATIKA DAN ILMU PENGETAHUAN ALAM
PROGRAM STUDI FISIKA
Jl. Ganesha No 10 Bandung 40132 Indonesia

TUTORIAL MODULE 8, ELEMENTARY PHYSICS IB (FI-1102)
1ST SEMESTER, ACADEMIC YEAR 2020-2021
TOPIC : Heat, Kinetic Theory of Gases, Thermodynamics

A. QUESTIONS

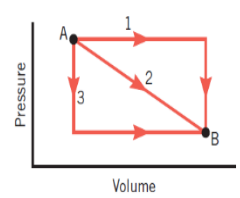
1. Two objects are made of the same material, but they have different masses and temperatures. If the objects are brought into thermal contact, which one will have the greater temperature change? (a) The one with the higher initial temperature (b) The one with the lower initial temperature (c) The one with the greater mass (d) The one with the lesser mass (e) The one with the higher specific heat (f) Not enough information.

2. An ideal gas undergoes an adiabatic expansion, a process in which no heat flows into or out of the gas. As a result, (a) the temperature of the gas remains constant and the pressure decreases. (b) both the temperature and pressure of the gas decrease. (c) the temperature of the gas decreases and the pressure increases. (d) both the temperature and volume of the gas increase. (e) both the temperature and pressure of the gas increase.

3. The atomic mass of a nitrogen atom (N) is 14.0 u, while that of an oxygen atom (O) is 16.0 u. Three diatomic gases have the same temperature: nitrogen (N2), oxygen (O2), and nitric oxide (NO). Rank these gases in ascending order (smallest first), according to the values of their translational rms speeds: (a) O_2, N_2, NO (b) NO, N_2, O_2 (c) N_2, NO, O_2 (d) O_2, NO, N_2 (e) N_2, O_2, NO.

4. Which of the following possibilities could increase the efficiency of a heat engine or an internal combustion engine? (a) Increase the temperature of the hot part of the system and reduce the temperature of the exhaust. (b) Increase the temperatures of both the hot part and the exhaust part of the system by the same amount. (c) Decrease the temperatures of both the hot part and the exhaust part of the system by the same amount. (d) Decrease the temperature of the hot part and increase the temperature of the exhaust part by the same amount. (e) None of the above; only redesigning the engine or using better gas could improve the engine's efficiency.

5. The pressure–volume graph shows three paths in which a gas expands from an initial state A to a final state B. The change in internal energy is the same for each of the paths. Rank the paths according to the heat Q added to the gas, largest to smallest.



(a) 1, 2, 3 (b) 1, 3, 2 (c) 2, 1, 3 (d) 3, 1, 2 (e) 3, 2, 1.

B. PROBLEMS

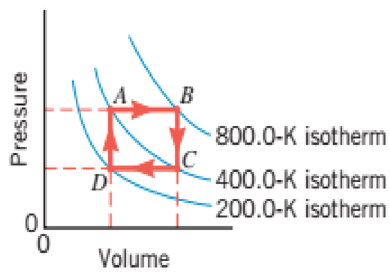
1. Ice at -10.0 ^oC and steam at 130 ^oC C are brought together at atmospheric pressure in a perfectly insulated container. After thermal equilibrium is reached, the liquid phase at 50.0 ^oC is present. Ignoring the container and the equilibrium vapor pressure of the liquid at 50.0 ^oC, find the ratio of the mass of steam to the mass of ice. The specific heat capacity of steam is 2020 J/(kg C^o).

2. A block of material has a mass of 130 kg and a volume of $4.6\text{x}10^{-2}$ m^3. The material has a specific heat capacity and coefficient of volume expansion, respectively, of 750 J/ (kg C^o) and 6.4x $10^{-5}(C^o)^{-1}$. How much heat must be added to the block in order to increase its volume by $1.2\text{x}10^{-5}$ m^3?

3. In an aluminum pot, 0.15 kg of water at 100°C boils away in four minutes. The bottom of the pot is $3{,}1\text{x}10^{-3}$ m thick and has a surface area of 0.015 m^2. To prevent the water from boiling too rapidly, a stainless-steel plate has been placed between the pot and the heating element. The plate is $1.4\text{x}10^{-3}$ m thick, and its area matches that of the pot. Assuming that heat is conducted into the water only through the bottom of the pot, find the temperature at **(a)** the aluminum–steel interface and **(b)** the steel surface in contact with the heating element.

4. Suppose that 31.4 J of heat is added to an ideal gas. The gas expands at a constant pressure of 1,40x10^4 Pa while changing its volume from 3.00 x 10^{-4} m^3 to 8.00 x 10^{-4} m^3. The gas is not monatomic, so the relation $C_p = \frac{5}{2}R$ does not apply. (a) Determine the change in the internal energy of the gas. (b) Calculate its molar specific heat capacity C_p.

5. The drawing refers to one mole of a monatomic ideal gas and shows a process that has four steps, two isobaric (*A* to *B*, *C* to *D*) and two isochoric (*B* to *C*, *D* to *A*). Complete the following table by calculating ΔU, *W*, and *Q* (including the algebraic signs) for each of the four steps.



	ΔU	W	Q
A to *B*			
B to *C*			
C to *D*			
D to *A*			

6. Due to design changes, the efficiency of an engine increases from 0.23 to 0.42. For the same input heat $|Q_1|$, these changes increase the work done by the more efficient engine and reduce the amount of heat rejected to the cold reservoir. Find the ratio of the heat rejected to the cold reservoir for the improved engine to that for the original engine.

7. What is the density (in kg/ m^3) of nitrogen gas (molecular mass 28u) at a pressure of 2.0 atmospheres and a temperature of 310 K?

8. A tire is filled with air at 15°C to a gauge pressure of 230 kPa. If the tire reaches a temperature of 38°C, what fraction of the original air must be removed if the original pressure of 230 kPa is to be maintained?

9. A monatomic ideal gas has an initial temperature of 405 K. This gas expands and does the same amount of work whether the expansion is adiabatic or isothermal. When the expansion is adiabatic, the final temperature of the gas is 245 K. What is the ratio of the final to the initial volume when the expansion is isothermal?

10. Compressed air can be pumped underground into huge caverns as a form of energy storage. The volume of a cavern is 5.6 x10^5 m^3, and the pressure of the air in it is 7.7 x10^6 Pa. Assume that air is a diatomic ideal gas whose internal energy U is given by U = $\frac{5}{2}$nRT. If one home uses 30.0 kW h of energy per day, how many homes could this internal energy serve for one day?

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