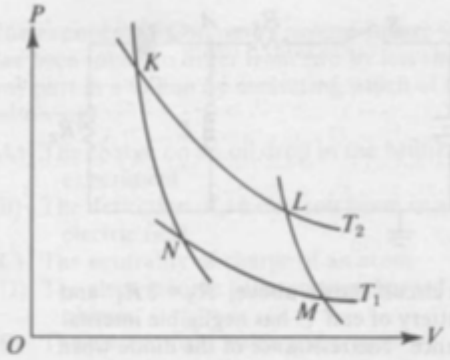
Problem 1:

The energy from electromagnetic waves in equilibrium in a cavity is used to melt ice. If the Kelvin temperature of the cavity is increased by a factor of two, the mass of ice that can be melted in a fixed amount of time is increased by a factor of

(A) 2
(B) 4
(C) 8
(D) 16
(E) 32

Problem 2:



In the cycle shown above, KL and NM represent isotherms, while KN and LM represent reversible adiabats. A system is carried through the Carnot cycle $KLMN$, taking in heat Q_2 from the hot reservoir T_2 and releasing heat Q_1 to the cold reservoir T_1. All of the following statements are true EXCEPT:

(A) $Q_1/T_1 = Q_2/T_2$.
(B) The entropy of the hot reservoir decreases.
(C) The entropy of the system increases.
(D) The work W done is equal to the net heat absorbed, $Q_2 - Q_1$.
(E) The efficiency of the cycle is independent of the working substance.

Problem 3:

A large isolated system of N weakly interacting particles is in thermal equilibrium. Each particle has only 3 possible nondegenerate states of energies 0, ϵ, and 3ϵ. When the system is at an absolute temperature $T >> \epsilon/k$, where k is Boltzmann's constant, the average energy of each particle is

(A) 0 (B) ϵ (C) $\frac{4}{3}\epsilon$ (D) 2ϵ (E) 3ϵ

Problem 4:

In a gas of N diatomic molecules, two possible models for a classical description of a diatomic molecule are:

Which of the following statements about this gas is true?

(A) Model I has a specific heat $c_v = \frac{3}{2}Nk$.
(B) Model II has a smaller specific heat than Model I.
(C) Model I is always correct.
(D) Model II is always correct.
(E) The choice between Models I and II depends on the temperature.

Problem 5:

Two identical 1.0-kilogram blocks of copper metal, one initially at a temperature $T_1 = 0°$ C and the other initially at a temperature $T_2 = 100°$ C, are enclosed in a perfectly insulating container. The two blocks are initially separated. When the blocks are placed in contact, they come to equilibrium at a final temperature T_f. The amount of heat exchanged between the two blocks in this process is equal to which of the following? (The specific heat of copper metal is equal to 0.1 kilocalorie/kilogram °K.)

(A) 50 kcal
(B) 25 kcal
(C) 10 kcal
(D) 5 kcal
(E) 1 kcal

Problem 6:

A three-dimensional harmonic oscillator is in thermal equilibrium with a temperature reservoir at temperature T. The average total energy of the oscillator is

(A) $\frac{1}{2}kT$

(B) kT

(C) $\frac{3}{2}kT$

(D) $3kT$

(E) $6kT$

Problem 7:

A sample of N atoms of helium gas is confined in a 1.0 cubic meter volume. The probability that none of the helium atoms is in a 1.0×10^{-6} cubic meter volume of the container is

(A) 0 (B) $(10^{-6})^N$ (C) $(1 - 10^{-6})^N$
(D) $1 - (10^{-6})^N$ (E) 1