University of California, Berkeley
Physics 7B, Fall 2007 (*Xiaosheng Huang*)

Midterm 1
Friday, 10/3/2008
6:00-8:00 PM

Physical Constants:
Avogadro's number, N_A: 6.02×10^{23}
Gas Constant, R: 8.315 J/mol·K
Boltmann's Constant, k_B: 1.38×10^{-23} J/K
Stefan-Boltzmann Constant, σ: 5.67×10^{-8} W/m^2·K^4
Specific heat for water: c=4.19×10^3J/kg·^{o}C
Heat of vaporization for water: L_V=22.6×10^5J/kg
Heat of fusion for water: L_F= 3.33×10^5J/kg

Note: Formulaic answers may only involve the quantities given in a problem and constants.

1) (15 pts.) The mean free path of CO_2 molecules at STP is measured to be about 5.6×10^{-8} m. Estimate the diameter of a CO_2 molecule.

Formulaic Answer:

Numerical Answer:

2) (15 pts.) Five multiple choice questions:

(i) The blackbody radiation of an object depends on its temperature. The total amount of energy radiated is proportional to

a) T.
b) T^2.
c) T^3.
d) T^4.

(ii) When He I (normal He) turns into He II (superfluid He), as seen in the video shown during class, the boiling all of a sudden stops. This is due to the fact that

a) heat conductivity of He increases by a large factor.
b) heat conductivity of He decreases by a large factor.
c) heat capacity of He increases by a large factor.
d) heat capacity of He decreases by a large factor.

(iii) If you throw 1000 coins into the air, the number of throws needed to get all heads is on the order of

a) 10.
b) 100.
c) 1000.
d) none of the above.

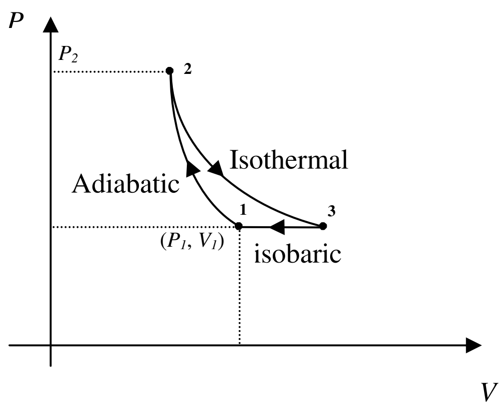
(iv) Which of the following process is irreversible?

a) $p + n \rightarrow {}^2H + \gamma$.
b) One full cycle of a Carnot engine.
c) Free expansion of an ideal gas.
d) Isobaric expansion of an ideal gas.

(v) The coefficient of linear expansion for aluminum is α. A very thin sheet of aluminum has area A_0 at T_0. If the temperature is raised by a small amount ΔT (that is, $\alpha\Delta T << 1$), the area of the sheet will increase by approximately

a) $\alpha\Delta T A_0$.
b) $\alpha^2\Delta T A_0$.
c) $2\alpha\Delta T A_0$.
d) $\alpha\Delta T^2 A_0$.

3) (35 pts.) Consider the following cycle for n moles of a monatomic ideal gas.



Find, in terms of n, P_1, V_1 and P_2, the heat that flows into the gas and the work done by the gas for

a) the adiabatic process;

Answer:

b) the isothermal process;

Answer:

c) the isobaric process.

Answer:

d) The volume coefficient β is defined as $\beta=(1/V)\ (\mathrm{d}V/\mathrm{d}T)$. Find β as a function of temperature for the isobaric process.

Answer:

4) (35 pts.) One mole of water is cooled from T_1=25 ^oC to T_2=0 ^oC and frozen. All the heat taken by the refrigerator, operating at maximum theoretical efficiency (no entropy created) is delivered to a second mole of water at again T_1=25 ^oC, heating it to T_3=100 ^oC and converting a fraction (n' mole) into vapor.

a) Find the total amount of heat ($|Q_1|$) and entropy ($|\Delta S_1|$) that flow out of the first mole of water in terms of T_1 and T_2.

<u>Answer:</u>

b) Find the total amount of heat ($|Q_2|$)entropy ($|\Delta S_1|$) that flow into the second mole of water in terms of T_1, T_2 and n'.

Answer:

c) What is $\Delta S_1 + \Delta S_2$? (Note that there are no absolute value signs around the entropy changes here. *Hint*: Can this process be reversed?)

Answer:

d) Find n'.

Formulaic Answer:

Numerical Answer:

e) How much work must be done by the refrigerator?

Formulaic Answer:

Numerical Answer: