PHYSICS 7B, Lecture 2 – Spring 2014
Midterm 1, C. Bordel
Tuesday, February 25, 2014
6pm-8pm

Physical constants

$g = 9.8\ m/s^2$; $k_B = 1.38\times10^{-23}\ J/K$; $R = 8.31\ J/K.mol$; $\mathcal{N}_A = 6.02\times10^{23}$.

Conversions

$1\ L = 10^{-3}\ m^3$; $T(K) = T(°C) + 273$; $1\ atm = 1.013\times10^5\ Pa$

Make sure you show all your work, justify your answers, and always write your symbolic solution before the numerical solution!

Problem 1 – Thermal expansion (20 pts)

A gold sphere of radius R is stored at temperature T_0 in a cubic plexiglas case of inner dimension L, which provides some extra space. What is the maximum temperature T_m allowing the sphere to fit in its case?

$\alpha_{Au} > \alpha_{plexi}$

Problem 2 – Phase change (20 pts)

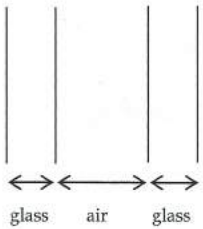
200 g of ice at -10°C is added to 1 kg of water at 15°C. Is there enough ice to cool the water to 0°C? Determine how much of each constituent is present when thermal equilibrium is reached. Explain without any calculation how the entropy changes over the course of this transformation, assuming that water and ice form a closed system.

$C_{water} = 4.186\ kJ/kg.K$
$C_{ice} = 2.100\ kJ/kg.K$
$L_{fusion} = 333\ kJ/kg$

Problem 3 – Conductive heat transfer (20 pts)

Quantitatively compare the daily heat loss of a house by conduction through a single-pane and a double-pane (see cross-section below) window of same surface area (2 m^2). The temperature is assumed to be 20°C inside and 15°C outside. The glass slabs are 3 mm thick and the air layer of the double-pane window is 4 mm thick.

$k_{glass} = 0.84\ J/m.s.K$
$k_{air} = 0.023\ J/m.s.K$



Problem 4 – Ideal gas (20 pts)

1 mole of a polyatomic (non linear) ideal gas undergoes a reversible thermodynamic process from pressure and volume (P_a, V_a) to volume $V_b=2V_a$, following the curve $TV=const$. Assume $T \in [100 - 1000\ K]$.

a) Draw the corresponding path on a P-V diagram, along with the isothermal and adiabatic processes between the same volumes V_a and V_b for comparison.
b) Calculate the work done by the gas from a to b, and represent it graphically on the P-V diagram.
c) Calculate the change in internal energy, the heat gained by the gas.
d) Calculate the change in entropy of the gas from a to b, and determine, without any calculation, the total change in entropy of the closed system {gas + environment}.

Problem 5 – Molecular speed distribution (20 pts)

A sampling of a neon gas is carried out to approximate the behavior of the whole system ($N=10^{23}$ molecules). The experiment provides the following data:

Number of molecules	Middle value of speed range (m/s)
1	200
3	400
6	600
4	800
2	1000
2	1200
1	1400

Assuming a Maxwell speed distribution, find the temperature and internal energy of the whole system.
How would the internal energy and temperature be affected if the gas was actually diatomic instead of monatomic, assuming the same speed distribution and molecular mass?

$m_{Ne} = 20\ amu$
$1\ amu = 1.66\times10^{-27}\ kg$