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

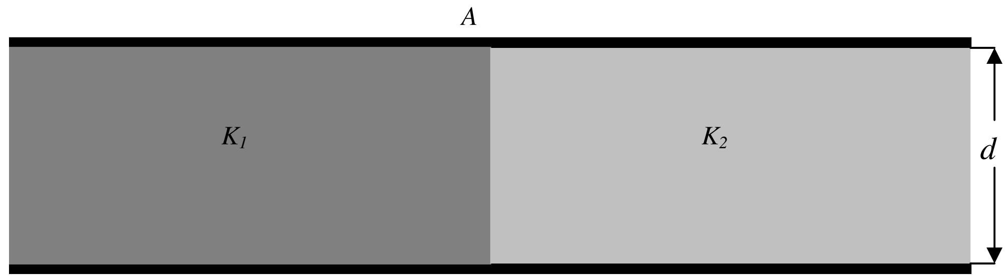
Final Exam
Tuesday, 12/15/07
5:00-8:00 PM

Name______________________________________ Section______________

Fundamental Constants:
Avogadro's number, N_A: 6.02×10^{23} mol^{-1}
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
Elementary charge, e: 1.60×10^{-19} C
Permittivity of free space, $\varepsilon_0(=1/c^2\mu_0)$: 8.85×10^{-12} C^2/N·m^2
Permeability of free space, μ_0: $4\pi\times10^{-7}$ T·m/A
Speed of light, c: 3×10^8 m/s

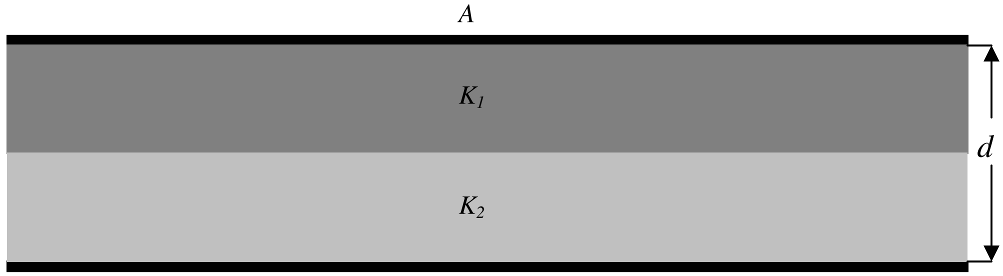
1) (20 pts.) Two different dielectrics each filling half the space between the plates of a parallel plate capacitor, in two different configurations, are shown in a) and b) below. K_1 and K_2 are the dielectric constants. A is the area of the plates and d is separation between them. Determine the capacitance in terms of K_1, K_2, A and d for a) and b). (*Hint*: In each of the two cases, can you consider this capacitor as two capacitors in parallel or series?)

a)



Answer:

b)



Answer:

2) (20 pts.) A gas-tight frictionless piston of small thermal conductivity slides in a thermally insulated cylinder, dividing it into two compartments, *A* and *B*, each containing an equal amount of an ideal monatomic gas (*n* moles). Initially the temperature of the gas is T_0 in compartment *A* and $3T_0$ in *B*. Assume that the system is in mechanical equilibrium at all times and that the mass of the piston and the effect of gravity are negligible. Consider the process by which the system reaches thermal equilibrium:

a) What is the final temperature, T_f?

Answer:

b) What is the ratio of the volume of *A* to that of *B* initially, r_i?

Answer:

c) What is the ratio of the volume of A to that of B after thermal equilibrium is reached, r_f?

Answer:

d) Calculate the change in entropy for A. (Please specify the reversible path that you choose for this calculation.)

Answer:

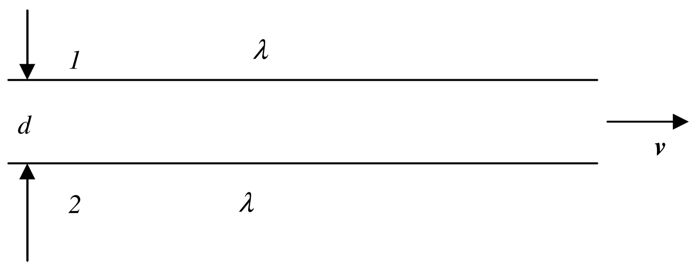
e) Calculate the change in entropy for *B*. (Please specify the reversible path that you choose for this calculation.)

Answer:

f) Calculate the change in entropy for the entire system.

Answer:

3.) (20 pts.) Two infinitely long wires, separated by a distance d are moving at velocity $\boldsymbol{v}$ toward the right. They both carry uniform linear charge density λ.



a) **Derive** the electric field at the second wire produced by the first wire.

Answer:

b) Find the electric force per unit length on the second wire.

Answer:

c) Find the current produced by the first wire.

Answer:

d) **Derive** the magnetic field at the second wire produced by the first wire.

Answer:

e) Find the magnetic force per unit length on the second wire.

Answer: $\boxed{}$

f) At what value of $\boldsymbol{v}$ will the electric and magnetic forces have the same magnitude? (Ignore any special relativistic effects.)

Answer: $\boxed{}$

4) (20 pts.) A doubly charged helium atom whose mass is $m = 6.6 \times 10^{-27}$ kg is accelerated by a voltage of $V_0 = 2100$ V.

a) What will be its radius of curvature, r, if it moves in a plane perpendicular to a uniform field, $\boldsymbol{B} = 0.340$ T?

Formulaic Answer (Use variables; do **NOT** plug in numbers yet):

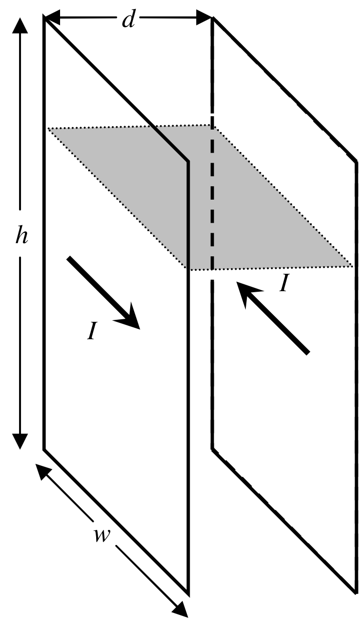
Numerical Answer:

b) What is its period of revolution, *T*?

Formulaic Answer (Use variables; do **NOT** plug in numbers yet.):

Numerical Answer:

5) (20 pts.) An inductor consists of two identical conducting planes, separated by a distance d, each carrying current density, $i = I/h$, where I is the total current. Assume that $d << h, w$.



a) **Derive** the magnetic field between the two planes in terms of the current density, i.

Answer:

b) **<u>Derive</u>** the magnetic field outside the two planes in terms of the current <u>density</u>, i.

<u>Answer:</u>

c) Find the magnetic flux through the surface of the shaded area. (Please specify the direction of the normal for the surface.)

<u>Answer:</u>

d) Calculate the inductance of this inductor.

Answer: