Midterm Exam PHYS 1220 Sum09 6/26/2009

____
(your name)

8 problems

You can skip one of the 5 thermodynamics problems. If you work all of the thermodynamic problems, the best 4 grades will count toward the exam grade. You have to work all E&M problems.

Exam Tips:

Ask questions as early as possible.

Full credit only, if the answers are legible, not ambiguous, and the logic is easy to follow and all major steps in a calculation are shown.

*All multiple choice questions **may** have more than one correct answer. In order to get full credit, mark **all** correct answers.*

You may add short comments to each of your multiple choice answers. In case the answer is wrong, I will give partial credit based on your comment.

Make use of the whole exam time. When done solving the problems look for omissions and mistakes.

1- A long copper rod, 1[m] long and of rectangular cross sectional area (side a has length 4[cm] and side b has length 2[cm]), is insulated to the sides and its ends stick in two water baths. One water bath is at 80°C and the rod is at 40°C when thermal equilibrium has been reached.

   a) What is the rate of heat flow, dQ/dt, into the second water bath, if its temperature is 20°C?
      Hint: Use $k_{Cu} = 400[W/mK]$

   b) A lightbulb filament is cylindrical. Its radius is $\frac{1}{\sqrt{\pi}}$[cm] and its length is 2[cm]. How much does the thermal heat radiation of the bulb change when the filament temperature rises from 1000°K to 1200°K, while the temperature of the environment changes from 300°K to 400°K?

      (Assume that the temperature of the environment rises because of the heat radiation of the filament – the bulb is mounted in a small enclosure.)

      Hint: Assume that the filament is a perfect blackbody. Leave the value of the Stefan-Boltzmann constant as σ *in the equation.*

2- An insulated beaker is kept at temperature 30[°C]. It holds 0.4[kg] of hot water, which is initially at 60[°C].

How many kilograms of ice at -20[°C] must be dropped into the tea to make 'ice tea' at 10[°C]?

Hint: Use $c_{wat} = 4200\ [\,]/kgK]$
$c_{ice} = 2100\ [J/kgK]$
$L_{wat\text{-}ice} = 3 \cdot 10^3\ [J/kg]$

Assume that the water will first come to an equilibrium with the beaker and then with the ice.

3- A flask contains H_2O vapor at 120°C.

Hint: the atomic weights of H, O, C and N are 1, 16, 12 and 14, respectively.

a) To what temperature do you have to heat the gas to double v_{rms} of the gas?

b) For which value of v_{rms} would a flask with the same amount of moles of N_2 gas be at the same temperature?

c) What amount of CO gas would be needed at 120°C for it to have the same v_{rms} as the H_2O?

4- pV and pT diagrams

a) Draw the pV and the pT diagram of an ideal gas.

b) Draw a pV diagram of a substance with the following thermodynamic processes (assume that the processes occur in the substance one after the other so that the new process continues at the exact state where the previous process ended):

- There are 4 temperatures, $T_1 < T_2 < T_3 < T_4$
- The first process starts at T_3 at high pressure
- A process, in which the change of internal energy ΔU is equal to the heat produced in the process, takes the substance to T_2
- A process, in which ΔU is equal to the amount of work done, takes the substance to T_1
- A process, in which heat flows in such a way that the thermal equilibrium is not disturbed, takes the substance back to the original pressure
- Finally, an isobaric process takes the substance back to its starting point.

c) Rank the processes for the work done in each process. Include the sign of the work into the ranking.

5- Ideal Gases

a) Two ideal boxes, one of twice the volume than the other, contain ideal gases.

The gas in the smaller box A is at atmospheric pressure and the gas in the other box has twice that pressure. This is all we know about the gases.

What, if anything, can be said about the temperatures, number of molecules, average kinetic energies, v_{rms} of the gases relative to each other? Name the reasons why you can make statements about each of the properties.

b) Which of the following statements about ideal gases are true?

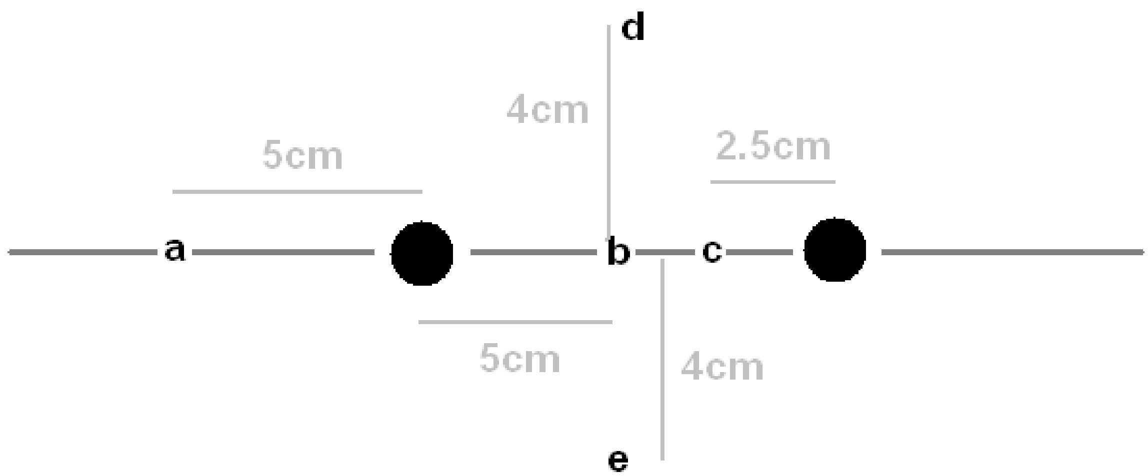
A- When the pressure of the gas is doubled the temperature of the gas must rise
B- When the pressure of the gas is doubled it is possible that the temperature of the gas falls
C- When the product of pressure and volume of the gas is constant the temperature of the gas cannot change under any circumstances
D- When the ratio of pressure and temperature of the gas increases the volume of the gas must increase, as long as the number of gas molecules is constant
E- When the density of an ideal gas is being more and more increased, at some point the gas stops to behave like an ideal gas
F- When the molecule size of the atoms of a gas matter for the gas state properties, the gas cannot be treated as an ideal gas

6 – Electrostatic force and field, conceptual

a) Two charged objects are very far from any other charges. Mark all statements, which complete the sentence correctly: The electric force between them …

A- doubles, if the distance between them is cut in half
B- is cut in half, if the distance between them is cut in half
C- quadruples, if the distance between them is cut in half
D- is ¼ as large, if the distance between them is cut in half
E- doubles, if the charge on one of them is doubled
F- doubles, if the charge on both of them is doubled
G- is cut in half, if the charge on one of them is doubled
H- is cut in half, if the charge on both of them is doubled

b) Two charges are 10[cm] apart. One charge is -2q, the other is +1.5q (see figure). The negative charge is on the left side. Which of the following statements are correct?



A- A test charge put at point **b** will not be accelerated
B- A test charge put at points **d** and **e**, which are vertically 4cm above and below point **b**, experience the same magnitude of force due to the two charges.
C- At point **a** the total electric field due to the two charges points to the right.

D- Exactly one of the five points **a**, **b**, **c**, **d**, **e** experiences a total electric field, which has a positive x-component.

E- If one would double the distance reading in the figure between the two charges as well as all other distances in the figure, for at least one of the points **a**, **b**, **c**, **d**, **e** the value of the electric field drops to exactly half of the original value.

F- If one would double the distance reading in the figure between the two charges as well as all other distances in the figure, for at least one of the points **a**, **b**, **c**, **d**, **e** the value of the electric field does not change

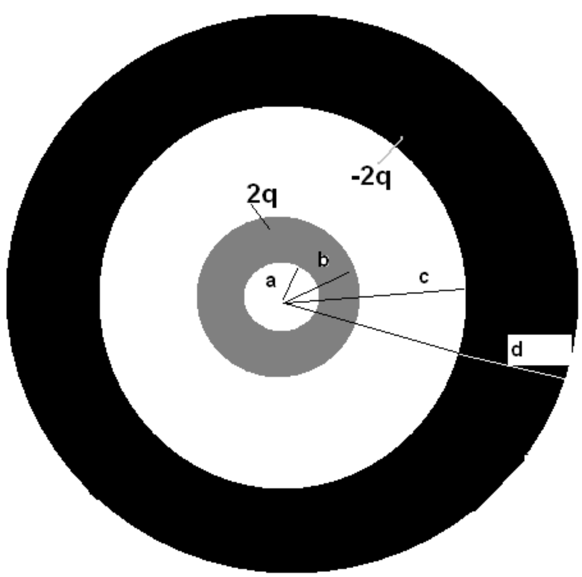
7) Gauss Law, conceptual

a) Explain how the electric field about a conducting sphere differs from that of the electric field about an infinite charged sheet? Alternatively, if you can't remember the field for the sheet, compare the conducting sphere's field to that of an infinite charged cylinder.
Hint: No calculations are necessary for part a)

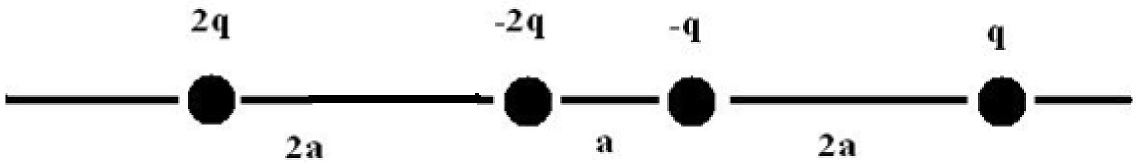
b) Draw the dependence of the electric field E on distance from the center, r, for two conducting shells, which are arranged concentrically around each other for the following two cases:

- with a further point charge –q at their mutual center, r=0 (see figure).
- Without such a central point charge

Draw quantitatively correct axis values in the two diagrams for d = 2b and c = 3/2 b, b=3/2 a.



8- Electrostatic force, numerical



Four point charges are lined up along the x-axis (see figure). The distance from, charge to charge is either 'a' or '2a' as indicated in the figure.

a) **Draw force vector diagrams for each of the four charges. Include for each diagram all force vectors which act on the charge with qualitatively proper proportions and directions.**

b) **Calculate the net forces on the second charge from the left and on the second charge from the right.**

Tip: Use 'k' instead of its numerical value. Simplify the final result for full credit.

Need to put your mind off the test for a minute? Check this out:

An Annotated Thermometer

60 - Californians put on sweaters (if they can find one in their wardrobe)

50 - Miami residents turn on the heat

40 - You can see your breath, Californians shiver uncontrollably, Minnesotans go swimming

35 - Italian cars don't start

32 - Water freezes

30 - Minnesotans put on t-shirts, politicians begin to worry about the homeless, British cars don't start

25 - Boston water freezes, Californians weep pitiably, Minnesotans eat ice cream, Canadians go swimming

20 - You can hear your breath, politicians begin to talk about the homeless, New York City water freezes, Miami residents plan vacation further south

15 - French cars don't start, cat insists on sleeping in your bed with you

10 - Too cold to ski, you need jumper cables to get the car going

5 – UWYO invites CSU for a friendly football game, American cars don't start

0 - Alaskans put on t-shirts, too cold to skate

-10 - German cars don't start, eyes freeze shut when you blink

-15 - You can cut your breath and use it to build an igloo, visiting students from equatorial places at UWYO stick tongue on metal objects to confirm the rumors, Miami residents cease to exist

-20 - Cat insists on sleeping in your pajamas with you, politicians actually do something about the homeless, Minnesotans shovel snow off roof, Japanese cars don't start

-25 - Too cold to think, you need jumper cables to get the driver going

-30 - You plan a two-week hot bath, Wyoming students buy a sweater, Swedish cars don't start

-40 - Californians disappear, Minnesotans button top button, Canadians read up on sweaters, your car wants to stay indoors

-50 - Congressional hot air freezes, Alaskans close the bathroom window