Physics 201 – Exam IV

Fall 2008, §531–538

(Melkonian, TTh 5:30–6:45pm)

Name (printed): ___________________________ Section Number: ____________

Signature: _____________________________

§531  Th 8:00 10:50 am (Kyle Damborsky)  §532  Th 9:35 12:25 am (Matthew Springer)
§533  Th 11:10 2:00 pm (Dongyuan Ying)  §534  Th 12:45 3:35 pm (Matthew Springer)
§535  Th 2:20 5:10 pm (Kyle Damborsky)  §536  Th 6:55 9:45 pm (Clement Sofka)

§538 F 9:10 12:00 pm (Shuai Yang)

You may use any type of handheld calculator and should refer to the last page which lists all formulae/constsants/conversions you will need for the problems in this exam (feel free to detach it).

This exam consists of two parts:

1. Two (2) conceptual and three (3) multiple choice questions worth a total of 25%; and
2. Three (3) free-response problems worth a total of 75%.

The free-response problems in Part 2 require you to show your work; you will not get credit for simply writing down the answer, whether it is correct or not.
Part 1

Short Answer/Multiple Choice:

1. [5 pts] Roughly sketch how temperature varies with time as a constant amount of heat is added to a block of ice initially at a temperature below 0°C until the temperature is a little above 100°C, and label where the two phase changes occur.

2. [5 pts] Some amount of heat, $Q$, added to a mole of an ideal monatomic gas in a rigid container raises the temperature an amount $\Delta T$. Explain, on the microscopic level, why it takes more heat to raise temperature of a diatomic ideal gas the same amount; where is the extra energy going?

3. [5 pts] A transverse periodic wave on a string has an amplitude of 2.00 cm, a frequency of 120 Hz, and is travelling in the negative direction with a speed of 50 m/s. The displacement of the string at $x = 0.600$ m when $t = 1.00$ s is closest to:

(a) $-0.74$ cm
(b) $+0.74$ cm
(c) $+0.84$ cm
(d) $+1.36$ cm

4. [5 pts] The root-mean-square velocity of the atoms making up an ideal gas is $501$ m/s when at a temperature of $120^\circ$C. The mass of one of these atoms is:

(a) $1.98 \times 10^{-26}$ kg
(b) $2.53 \times 10^{-26}$ kg
(c) $6.49 \times 10^{-26}$ kg
(d) $3.25 \times 10^{-23}$ kg
(e) none of the above

5. [5 pts] An ideal gas initially at $20^\circ$C expands to twice its original volume and the pressure drops by a factor of three. The final temperature of the gas is:

(a) $-77.7^\circ$C
(b) $13.3^\circ$C
(c) $30.0^\circ$C
(d) $167^\circ$C
(e) there is not enough information to be able to calculate the final temperature
Part 2

Problem 1 *Standing waves* [25 pts]: The Phantom of the Opera is creepily playing fugues one evening when the temperature is 12°C so that the speed of sound in the air is 338 m/s.

(a) [7 pts] The fundamental frequency of one of the stopped pipes of the organ is 24.500 Hz. What is the length of this stopped pipe?

Ans: __________________________

(b) [9 pts] What would be the wavelength of the second harmonic, $\lambda_2$, of an open pipe which has a length of 2.5 m?

Ans: __________________________

(c) [9 pts] What decibel level would a fly on the wall 30 m away be exposed to if the organ put out 10 W of power as the Phantom played? Assume the sound is emitted as a hemisphere (which is half of a three-dimensional sphere).

Ans: __________________________
Problem 2 *Calorimetry* [25 pts]: A mother is making hot chocolate for her daughter. The 0.220 kg of boiling (100°C) water is poured into a 0.050 kg ceramic mug which is at room temperature (20°C).

For this problem, you will need to know that the heat capacities for water, ice and ceramic are 4190, 2010 and 800 J/(mol-K) respectively, and the latent heat of fusion for water is $3.34 \times 10^5$ J/kg. (In what follows, assume that the mug is a thermodynamically isolated system while it is coming to equilibrium; in part (c) you are asked about the non-isolated radiative transport of energy after the system has equilibrated).

(a) [5 pts] What is the temperature of the system once the water and mug have come to thermal equilibrium?

Ans: _____________________________

(b) [15 pts] How much (what mass of) ice initially at $-10^\circ$C should the mother add to bring the system down to $50^\circ$C after thermal equilibrium has been reached so that the daughter doesn’t burn her mouth drinking it?

Ans: _____________________________

(c) [5 pts] How many times more quickly is energy radiated away by the mug when no ice is added (part (a)’s equilibrium temperature – use 100°C here if you didn’t answer (a)) compared to when it is (part (b)’s equilibrium temperature)? *i.e.* what is $H_{\text{without ice}}/H_{\text{with ice}}$?

Ans: _____________________________
Problem 3 *Thermal Processes*: [25 pts] One mole of an ideal gas initially at point A on the $PV$ curve of the figure to the right has an internal energy of 90.0 J. In its final state at point D, the internal energy of the gas is 150.0 J.

(a) [10 pts] For the path $A \rightarrow B \rightarrow D$, find the work done by the gas and the net energy transferred to the gas by heat in the process.

Ans: ________________________________

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(b) [10 pts] For the path $A \rightarrow C \rightarrow D$, find the work done by the gas and the net energy transferred to the gas by heat in the process.

Ans: ________________________________

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(c) [5 pts] For the adiabatic (meaning $Q = 0$) path $A \rightarrow D$, find the work done by the gas and the net energy transferred to the gas by heat in the process.

Ans: ________________________________

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