

EXAM-4 – v1

PHYS 201 (Fall 2007), 11/27/07

Name:

Lab-Sect. no.:

Signature:

Duration: 75 minutes

Show all your work for full/partial credit!

Include the correct units in your final answers for full credit!

Unless otherwise stated, quote your results in SI units!

1.) *Multiple Choice*

(18 pts.)

For each statement below, circle the correct answer (TRUE or FALSE, no reasoning required).

- (a) If the intensity of a sound source decreases by a factor of 100, the corresponding intensity level decreases by $20dB$.
TRUE FALSE
- (b) Longitudinal waves cannot form standing waves.
TRUE FALSE
- (c) If two substances are in thermal equilibrium with each other, the temperatures of the two substances must be identical.
TRUE FALSE
- (d) The kinetic theory of ideal gases states that, at a fixed temperature, the average kinetic energy of a gas molecule decreases with the mass of that molecule.
TRUE FALSE
- (e) Spontaneous heat flow increases the total entropy of the universe.
TRUE FALSE
- (f) In a reversible process, the total entropy of the universe increases.
TRUE FALSE

No.	Points
1	
2	
3	
4	
5	
6	
Sum	

2.) *Doppler Effect*

(15 pts.)

An Aggie student is driving in his car on a highway at a speed of 70mph . In front of him, a police car (at a speed of 95mph) is drawing away, while behind him a fire truck (at a speed of 55mph) is trailing him. All vehicles move straight ahead in the same direction. Both the police car and fire truck have their sirens on, both of which emit a pure tone of frequency 750Hz . (speed of sound: $v = 340\text{m/s}$; $1\text{m/s}=2.25\text{mph}$)

- (a) With what frequency does the student hear the police car?
- (b) With what frequency does the student hear the fire truck?
- (b) What is the beat frequency the student hears?

3.) *Stefan Boltzmann Radiation Law*

(12 pts.)

The Sun has a radius of $R_S = 7 \cdot 10^8 m$ and a surface temperature of $R_S = 6000^\circ K$. The distance from Sun to Earth is $R_{SE} = 1.5 \cdot 10^{11} m$. Assume the Sun to be an ideal blackbody radiator. (the surface area of a sphere is $S = 4\pi R^2$)

- (a) How much total power does the Sun radiate from its surface?
- (b) Assuming the Sun's power output to propagate spherically into space without losses, what is the intensity of its radiation on the Earth's surface (assume that no radiation is absorbed in the atmosphere)?
- (c) What is the equilibrium temperature on the Earth surface facing the Sun (neglect again the atmosphere and assume the Earth surface to be a blackbody)?

4.) *Ideal Gas Law and 1. Law of Thermodynamics*

(20 pts.)

The p - V diagram below illustrates an isothermal expansion of an ideal gas at temperature $T = 320^\circ K$.

- (a) How many moles of the gas are involved?
- (b) What is the volume of the gas at the initial point a ?
- (c) How much work is done by the gas from a to b ?
- (d) By how much did the internal energy of the gas change?

5.) *Heat Extraction and Refrigerator*

(15 pts.)

A freezer has a coefficient of performance of 3.2. A person puts 2.5kg of water at an initial temperature of 20°C into that freezer whose inside temperature is at a constant -8°C .

($c_{\text{water}} = 4.19 \cdot 10^3 \text{ J}/(\text{kg} \cdot \text{K}^\circ)$, $c_{\text{ice}} = 2.01 \cdot 10^3 \text{ J}/(\text{kg} \cdot \text{K}^\circ)$, $L_f^{\text{H}_2\text{O}} = 3.34 \cdot 10^5 \text{ J}/\text{kg}$)

- (a) How much heat must be removed from the water to convert it into ice at -8°C ?
- (b) How much electrical energy does the freezer need for the process?
- (c) How much excess heat does the freezer dump into its environment?

6.) *Heat Pump and Entropy*

(20 pts.)

During winter time (outside air temperature $T_{out} = 25^\circ F$), a person would like to heat his living room from $55^\circ F$ to $75^\circ F$ using his Carnot heating system. The room, which has a volume of $120m^3$, is filled with air of density $\rho_{air} = 1.3kg/m^3$. Treat the inside air as an ideal monatomic gas with a molar mass of $32g$ at constant volume. Be sure to use *SI* units in your calculations.

- (a) How many moles of air are in the room? *(recall: density=mass per volume)*
- (b) How much heat needs to be added to the room to achieve the desired increase in temperature?
- (c) Calculate the efficiency of the heating system using the average temperature of the inside air during the heating process.
- (d) Using the efficiency from part (c), calculate the work required by the heating system to heat up the room.
- (e) Calculate the entropy change of: (i) the air inside the room; (ii) the outside reservoir; (iii) the universe.