EXAM-3 – v1

PHYS 201 (Spring 2004), 04/20/04

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!

No.	Points
1	
2	
3	
4	
5	
6	
Sum	

1.) *Multiple Choice* (18 pts.)

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

(a) At temperature T=300°K, oxygen and nitrogen molecules have the same average *kinetic energy*. (The masses of oxygen and nitrogen molecules are m_{O_2}=32u and m_{N_2}=28u).

TRUE FALSE

(b) At temperature T=300°K, oxygen and nitrogen molecules have the same average *speed*. (The masses of oxygen and nitrogen molecules are m_{O_2}=32u and m_{N_2}=28u).

TRUE FALSE

(c) For a thermodynamic system to do (positive) work, the volume of that system has to increase.

TRUE FALSE

(d) The amount of work extracted from a Carnot heat engine increases if the cold reservoir is at a higher temperature (with the hot reservoir at constant temperature).

TRUE FALSE

(e) If you heat an originally straight bimetallic strip (brass on the left side, steel on the right side), it will bend to the left.
(The thermal expansion coefficients for brass and steel are, respectively, α_{brass}=19×$10^{-6}/C^{\circ}$ and α_{steel}=12×$10^{-6}/C^{\circ}$).

TRUE FALSE

(f) Spontaneous heat flow always increases the total entropy of the universe.

TRUE FALSE

2.) *Buoyant Force* *(14 pts.)*

A transporter vessel (length $l = 180m$, width $b = 40m$) sinks $6m$ deep into the water when unloaded ($\rho_{seawater} = 1025kg/m^3$).

(a) What is the total mass of the (unloaded) vessel (in $tons$; $1ton$=$1000kg$)?

(b) How many cars ($m_{car} = 1500kg$) can it accommodate before reaching its maximally allowed cruising depth of $6.5m$?

3.) *Ideal Gas Law* *(24 pts.)*

Two moles of Carbon-Dioxide ($= CO_2$, $m_{CO_2} = 44u$, $1u = 1.66 \cdot 10^{-27} kg$) are kept at a pressure $P = 3 \cdot 10^5 Pa$ in a box of volume $V = 1.5625 \cdot 10^{-2} m^3$ ($= (25cm)^3$). In the following, approximate CO_2 as a monatomic ideal gas.

(a) What is the temperature of the gas in $^\circ K$?

(b) Calculate the average kinetic energy and speed of a CO_2 molecule in the gas.

(c) How long does it take a CO_2 molecule to traverse one box length, assuming that it does not undergo a collision?

(d) Keeping the volume and amount of CO_2 constant, the gas temperature is increased by $35 C^\circ$. By how much do pressure and internal energy of the gas increase?

4.) *Stefan-Boltzmann Law* *(9 pts.)*

A black-coated object is left in the sun, completely absorbing the radiation power of $1000W/m^2$ provided by the sun ($1W$=$1J/s$). What is the equilibrium temperature that the object reaches?

5.) *Refrigerator* *(21 pts.)*

A person puts $5kg$ of water (originally at room temperature of $20°C$) into the freezer of a refrigerator which has a coefficient of performance of 2.5.

(a) How much heat needs to be extracted from the water/ice to chill it down to -30$°C$? (specific heat capacities of ice and water are $c_{ice} = 2000 J/kgC°$ and $c_{water} = 4186 J/kgC°$, latent heat of fusion is $L_f = 3.35 \cdot 10^5 J/kg$)

(b) How much work does the refrigerator do in the process?

(c) If the power company charges 25 cents for providing an energy of $1KWh = 3.6 \cdot 10^6 J$, how many cents does the cooling process cost?

6.) *Heat Flow and Entropy* *(14 pts.)*

You pour yourself a drink of 0.4 $liters$ water (=400$grams$) at room temperature (20°C). To cool it, you throw in two ice cubes (each of mass 20$grams$ and at temperature -10°C). Neglect any heat exchange with the environment.

(a) What is the final (common) temperature of your drink?
(specific heat capacities of ice and water are $c_{ice} = 2000 J/kgC^{\circ}$ and $c_{water} = 4186 J/kgC^{\circ}$, latent heat of fusion is $L_f = 3.35 \cdot 10^5 J/kg$)

(b) By how much did the entropy of the 20$grams$ of (initial) ice increase, and by how much did the entropy of the initial water decrease?
(*hint*: use the average temperatures for the heating/cooling process)