Phys 467/667
Spring 2017
Exam 1
2/16/17
Time Limit: 60 Minutes

Name (Print): _____

Instructor _____

This exam contains 4 pages (including this cover page) and 4 problems. Check to see if any pages are missing. Enter all requested information on the top of this page, and put your initials on the top of every page, in case the pages become separated.

You may *not* use your books, notes, or any calculator on this exam.

You are required to show your work on each problem on this exam. The following rules apply:

- **If you use a "fundamental theorem" you must indicate this** and explain why the theorem may be applied.
- **Organize your work**, in a reasonably neat and coherent way, in the space provided. Work scattered all over the page without a clear ordering will receive very little credit.
- **Mysterious or unsupported answers will not receive full credit**. A correct answer, unsupported by calculations, explanation, or algebraic work will receive no credit; an incorrect answer supported by substantially correct calculations and explanations might still receive partial credit.

Problem	Points	Score
1	10	
2	10	
3	10	
4	20	
Total:	50	

Do not write in the table to the right.

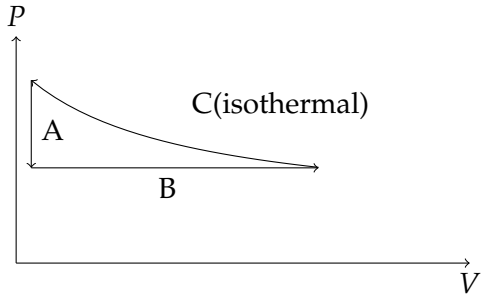
1. (10 points) Explain the following phenomons
    1. N_2(g) has larger heat capacity than He(g) at room termperature
    2. Under thermal equilibrium, H_2(g) molecules are moving faster than N_2(g).
    3. Of the two carbon allotropes, diamond is less stable than graphite at ambient condition, but becomes more stable under high pressure. (hint: diamond has larger density than graphite.)
    4. Scrambling an egg is an irreversible process leading to an increase in total entropy.
    5. Burning gasoline is an irreversible process leading to an increase in total entropy.

2. (10 points) The Gamma function is defined as

$$\Gamma(n+1) = \int_0^\infty x^n e^{-x} dx, \tag{1}$$

prove $\Gamma(n+1) = n!$. (hint: use $\int_0^\infty e^{-ax} dx = 1/a$)

3. (10 points) An ideal gas is made to undergo the cyclic process shown as follows. For each of the steps A, B and C, and total cycle, determin whether each of the following is positive, negative, or zero;
(a) W: the work done on the gas;
(b) Q: the head added to the gas;
(c) U: the total energy change;



4. (20 points) In the atomosphere, consider a horizontal slab of air whose thickness is dz.

   (a) (5 points) Use the ideal gas law to write the density of air in terms of pressure, temperature, and the average mass m of the air molecules. Show that the pressure obeys the differential equation

   $$\frac{dP}{dz} = -\frac{mg}{kT}P, \tag{2}$$

   (b) (5 points) Show that when an ideal gas expands adiabatically, the temperature and pressure are related by the differential equation

   $$\frac{dT}{dP} = -\frac{2}{f+2}\frac{T}{P}, \tag{3}$$

   (c) (5 points) Assuming that the molar mass of air is 29 g/mol, f=5, g = 9.8 N/kg), estimate dT/dz

   (d) (5 points) Assuming that the pressure at sea level is 1 atm, the temperature (T_0) is 300 K. Estimate the temperature (T_1) at Mt. Everest (8850 m), then calcualte the pressure at Mt. Everest by treating temperature as a constant of $(T_0 + T_1)/2$.