PH315 Physics of Contemporary Challenges Winter 2017

Practice Midterm Exam (Not graded)

Time: 50 minutes

Show your working unless the problem states otherwise.

You may use any information on your cheat sheet (single-sided 8.5 x 11" page). You may also use a calculator. Otherwise, the exam is closed book.

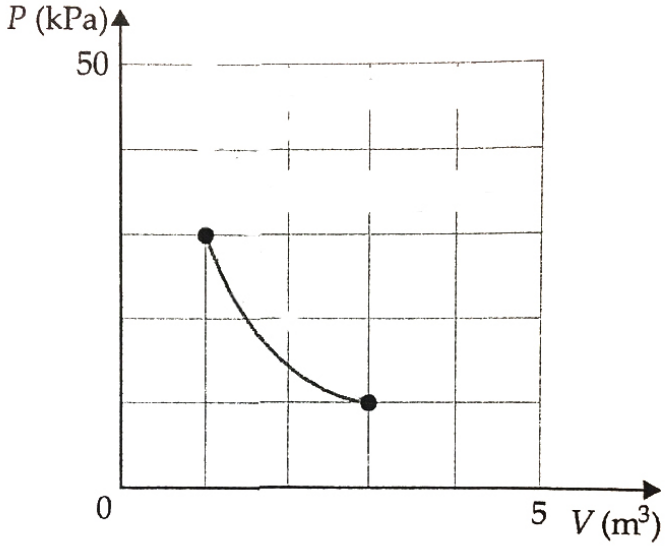
You may ask me any questions you wish. I may or may not answer.

Q1 (10pts)	Q2 (10pts)	Q3 (10pts)	Q4 (10pts)	Q5 (10pts)	Total (50pts)

1. Winter camping

The air temperature inside my sleeping bag is 20 C. The temperature outside the sleeping back is – 10 C. The insulation material of the sleeping bag is 5 cm thick. My body generates heat at a rate of 50 W. Assume that no heat escapes where my head is poking out. Estimate the thermal conductivity of the insulation material. Give your answer in W/(m·°K).

2. Gas process



a) Calculate the work done by this gas during the isothermal expansion shown above. Express your answer in units of kJ.

i) Use an approximate method (area of a geometric shape)

ii) Use an exact method (calculus).

b) How much heat is transferred to or from the gas during this isothermal expansion?

3. Power and energy

Mr. K. wants you to invest in his scheme to harness lightning as an energy source. "It's great!" he says. "Each lightning strike carries around 10^{14} W of power, billions of times what an average person uses. My machine covers one square kilometer and can perfectly capture all the lightning energy hitting it." Assume his statements are correct.

a) A lightning strike lasts for about a microsecond (10^{-6} seconds). How much energy is carried by a lightning strike? Express your answer in Joules.

b) Suppose that there are 100 lightning strikes per square kilometer per year. True or False: Mr. K.'s machine will capture enough energy to supply *one person's* total energy needs.

4. Simplified model for comparing transportation

Compare a motorbike carrying 1 passenger and a train carrying 300 passengers.

For aerodynamic calculations, the effective cross-sectional area of the motorbike (with rider) is 0.5 m^2, and the effective cross-sectional area of a train carrying 300 passengers is 10 m^2.

a) Which method of transportation requires the most "power per passenger" to move people at a velocity v?

b) For these two options, what is the ratio of "power per passenger"? i.e. How many times more power per passenger is required for one option versus the other?

5. Internal energy

a) Consider water in the liquid state at temperature, T, close to room temperature. What is the internal energy per water molecule? Express your answer in terms of T and fundamental constants.

b) Liquid water has a molar heat capacity of 75.2 J/mol·K. In contrast, water vapor has a molar heat capacity of 35.8 J/mol·K. Using the equipartition theorem, and the physical differences between liquid and vapor phases, construct a qualitative argument why water vapor has a lower value than liquid water. (Qualitative means that you don't have to make any calculations).