Student ID number ____________________ Name ________________________________

(Write neatly!) (First and Last)

Practice Midterm Exam

Time: 12.00 – 12.50pm

Write your answers in the space underneath each question. If you need extra paper, please ask.

You may use any information on your note card (single-sided 8.5 x 11" page). Otherwise, the exam is closed book.

You may use a calculator. Alternatively, full credit will be given if you use mental arithmetic and make a reasonable effort to get a final answer within ±10%. For example, π can be rounded to 3 if you are using mental arithmetic.

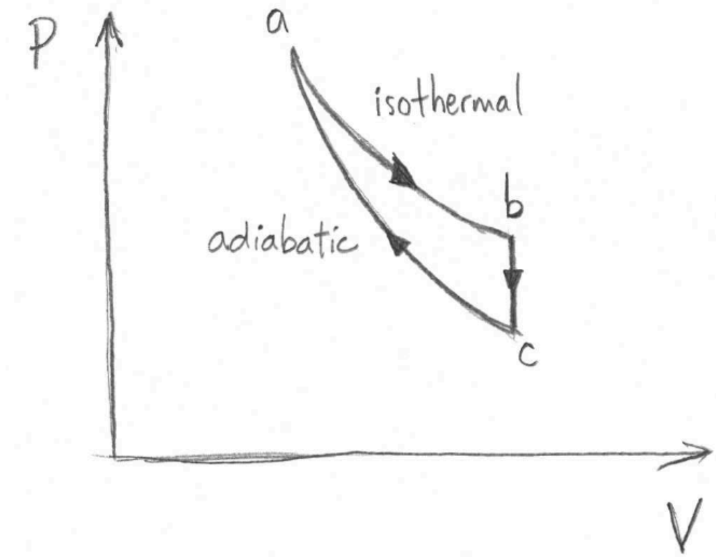
State any assumptions you make to solve the problem. Show the mathematics that you use to solve the problem. Show enough of your working so the grader can distinguish small mistakes from big mistakes. Show units when working with the numerical values of physical quantities. Because time is limited, you are not required/expected to write very many words explaining of your reasoning.

If a question asks for a quantitative answer, do not expect partial credit for a conceptual answer.

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

1. Thermal insulation (10 pts)
Standard window glass transmits thermal energy at a rate of about 10 J/(s·m^2·K). Consider a large window that is made out of a single sheet of this glass. The surface area is 3 m^2. Calculate the rate that thermal energy is transmitted through the glass when the inside temperature is 20°C and the outside temperature is 0°C. Give your answer in units of J/s.

2. Gas cycle (10 pts)
Consider an ideal gas that undergoes the following cycle:



a) Determine the sign of ΔU, Q and W for each step of the process. Fill in the chart below with +, - or 0. Use the standard sign conventional for work

$$W = -\int_i^f P dV$$

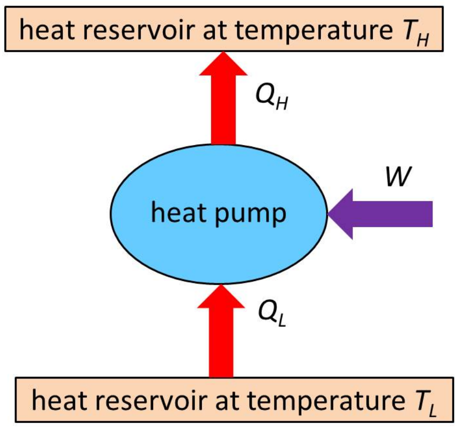
	ΔU	Q	W
a -> b			
b -> c			
c -> d			

b) At what point in the cycle is the temperature of the gas lowest?

c) Is the gas working as a heat engine or a heat pump? Explain how you know.

3. Heat Pump (10 pts)
When a small amount of heat, Q, is added to a large mass of material, the temperature of the material, T, stays practically constant. In a case like this, the change in the entropy of the large material is Q/T.

a) Using the definition of entropy for a large material, and the second law of thermodynamics, find the maximum performance of a heat pump (see diagram below). Express your answer as the ratio Q_H/W.



b) Consider a heat pump that is heating a family home. Choose a realistic outside temperature for a snowy day. Choose a realistic inside temperature for the home. Given your temperature assumptions, what is the maximum possible value of Q_H/W?

4. Heat capacity (10 pts)

Estimate how much energy is required to heat the water each time someone has a bath (the specific heat capacity of water is 4.2 J/g·K). Give your answer in units of kWh.

> *How to do this: You can estimate the amount of water by comparing the bath water to the mass of an adult person. The mass of water will be at least twice the mass of a person. You can estimate the water temperature with a couple reference points: Human body temperature is 37 C (this is too cold for a comfortable bath). Boiling water is 100 C (this is too hot for a bath).*

5. Carnot efficiency (5 pts)
Use the formula for Carnot efficiency to determine the maximum electrical energy you could get from burning 1 kg of coal inside of a heat engine. Express your final answer in Joules.

How to do this: Assume the hottest temperature in the engine is 700 C. Make an appropriate approximation for the lowest temperature inside the engine and the energy density of coal.