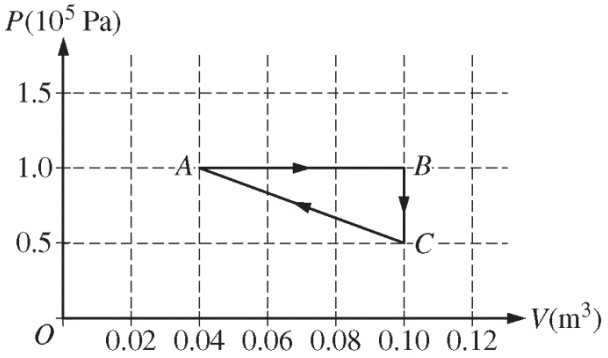
PHYSICS 2
Section II
4 Questions
Time—90 minutes

Directions: Questions 1 and 4 are short free-response questions that require about 20 minutes each to answer and are worth 10 points each. Questions 2 and 3 are long free-response questions that require about 25 minutes each to answer and are worth 12 points each. Show your work for each part in the space provided after that part.



1. (10 points, suggested time 20 minutes)

   Two moles of a monatomic ideal gas are enclosed in a cylinder by a movable piston. The gas is taken through the thermodynamic cycle shown in the figure above. The piston has a cross-sectional area of 5×10^{-3} m^2.

   (a)
   i. Calculate the force that the gas exerts on the piston in state *A*, and explain how the collisions of the gas atoms with the piston allow the gas to exert a force on the piston.

   ii. Calculate the temperature of the gas in state *B*, and indicate the microscopic property of the gas that is characterized by the temperature.

   (b)
   i. Predict qualitatively how the internal energy of the gas changes as it is taken from state *A* to state *B*. Justify your prediction.

   ii. Calculate the energy added to the gas by heating as it is taken from state *A* to state *C* along the path *ABC*.

   (c) Determine the change in the total kinetic energy of the gas atoms as the gas is taken directly from state *C* to state *A*.

2. (12 points, suggested time 25 minutes)

A student is given a glass block that has been specially treated so that the path of light can be seen as the light travels through the glass. The student is asked to design an experiment to measure the index of refraction of the glass. The light source available in the laboratory is a hydrogen lamp that emits red light of a known wavelength.

(a) A linear graph is to be used to determine the index of refraction of the glass. Indicate the quantities that should be graphed and describe how the graph could be used to determine the index of refraction of the glass.

(b) Outline an experimental procedure that could gather the necessary data. Include sufficient detail so that another student could follow your procedure. In addition to the glass block and the hydrogen lamp, the equipment in a typical classroom laboratory is available.

(c) Predict how the path of the light will change as it enters the glass. Support your prediction using a qualitative comparison of the speed of light in glass and the speed of light in air.

(d) Describe the process(es) by which red light from the lamp is produced by hydrogen atoms that are initially in the ground state. Draw and label an energy level diagram that supports the atomic process(es) you describe.