PHY 131 Fall 2018

Test #12: *Thermodynamics & Gas Laws*

NAME ____________________________

$\Delta E_{int} = Q - W$ $\Delta E_{int} = \frac{3}{2}nR\Delta T$ $R = 8.314 \frac{\text{J}}{\text{mol}\cdot\text{K}}$

$PV = nRT$ $W = P\Delta V$

SHOW ALL WORK & PUT YOUR ANSWERS IN THE BOXES PROVIDED

1. (50 points) An ideal gas is confined in a container with a piston that can slide or be held fixed. Answer each of the following independently (not cumulative processes from a-e):

a) The gas is heated at constant volume until its internal energy increases by 5000 joules. How much thermal energy was added by heating it?

b) The gas is given 20,000 joules of thermal energy by heating it and then the gas does 5000 joules of work by expanding. What is the change in internal energy of the gas?

c) The gas is cooled until its internal energy drops by 12,500 joules. As it is cooled, 5,000 joules of work is done on it because its volume decreases. How much thermal energy was removed from the gas by cooling it?

d) The gas is both heated and compressed. The heating process adds 10,000 joules of thermal energy and, during the compression process, 6000 joules of work is done on the gas. What is the change in internal energy of the gas?

e) The gas is expanded at constant temperature until it does 8000 joules of work. If a gas is expanded, it must be heated for its temperature to remain constant. What is the amount of thermal energy that was added to the gas by heating it?

a) 5000 J

b) 15,000 J

c) 17,500 J

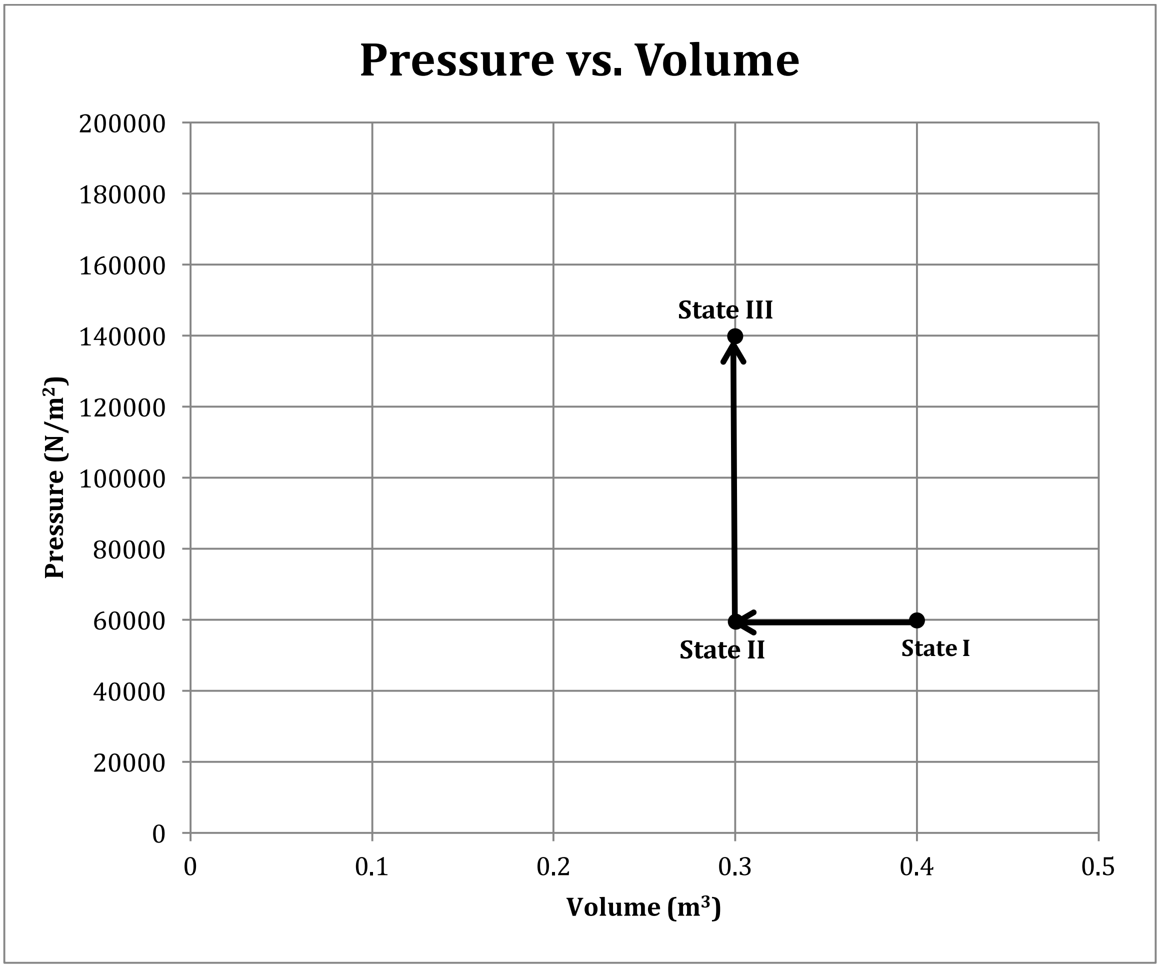
d) 16,000 J

e) 8,000 J

2. (50 points) Five moles of an ideal monatomic gas undergo a process as depicted on the following P-V graph. Using this graph, determine

a) The temperature of the gas in state III. Give your answer in kelvins.

b) The amount of thermal energy (Q) transferred into or out of the gas from state I to state III. Clearly state whether it is *into* or *out of*.



T_f = 1010 K
Q = +21,000 J

The initial temperature can be determined using the Ideal Gas Law.

$$PV = nRT = (60{,}000\ \mathrm{N/m^2})(0.4\ \mathrm{m^3}) = (5\ \text{moles})(8.314\ \mathrm{J/mol\cdot K})T$$

$$T = \frac{(60{,}000\ \mathrm{N/m^2})(0.4\ \mathrm{m^3})}{(5\ \text{moles})(8.314\ \mathrm{J/mol\cdot K})} = 577.3\ \mathrm{K}$$

The work done ON the gas from state I to state II is

$$W = \left(60{,}000\,\frac{\mathrm{N}}{\mathrm{m^2}}\right)(0.1\ \mathrm{m^3}) = 6000\ \mathrm{J}$$

This is an energy “deposit” into the gas because the piston is “kicking” the atoms of the gas as it moves in.

The temperature of state III can be determined using the Ideal Gas Law.

$$PV = nRT = (140{,}000\ \mathrm{N/m^2})(0.3\ \mathrm{m^3}) = (5\ \text{moles})(8.314\ \mathrm{J/mol\cdot K})T$$

$$T = \frac{(140{,}000\ \mathrm{N/m^2})(0.3\ \mathrm{m^3})}{(5\ \text{moles})(8.314\ \mathrm{J/mol\cdot K})} = 1010\ \mathrm{K}$$

The change in the internal energy of the gas from state I to state III is thus

$$\Delta E_{int} = \frac{3}{2}nR\,\Delta T = \frac{3}{2}(5\ \text{moles})(8.314\ \mathrm{J/mol\cdot K})\,(1010.3 - 577.3) = 27{,}000\ \mathrm{J}$$

The piston coming in provided 6000 J of this increase in internal energy, so the thermal energy transfer into the gas is 21,000 J.

Bonus (+3):

Kyle and Brian are playing a game involving coloring a map of Australia. The rules are this:

The guys take turns coloring one of the six states either red or black.

If a player must color bordering states the same color, he loses.

Kyle goes first and colors the state of Victoria **red**.

Brian now has eight possible choices. He can color any of the five remaining states black or he can color Western Australia, Northern Territory or Queensland red. Only one of the eight is the winning move. Which is it?