Homework #21 – one of these FRQs will be the FRQ on your test…



1. A cylinder with a movable frictionless piston contains an ideal gas that is initially in state 1 at 1 × 105 Pa, 373 K, and 0.25 m3. The gas is taken through a reversible thermodynamic cycle as shown in the *PV* diagram above.

a. Calculate the temperature of the gas when it is in the following states.

i. State 2

ii. State 3

b. Calculate the net work done on the gas during the cycle.

c. Was heat added to or removed from the gas during the cycle?

Added \_\_\_\_\_ Removed \_\_\_\_\_ Neither added nor removed \_\_\_\_\_

Justify your answer.



2. The diagram above of pressure *P* versus volume *V* shows the expansion of 2.0 moles of a monatomic ideal gas from state *A* to state *B. As* shown in the diagram, *PA = PB = 600* N/m2, *V*A *=* 3.0 m3, and *V*B *=* 9.0 m3.

1. i. Calculate the work done by the gas as it expands.

ii. Calculate the change in internal energy of the gas as it expands.

iii. Calculate the heat added to or removed from the gas during this expansion.

b. The pressure is then reduced to 200 N/m2 without changing the volume as the gas is taken from state *B* to state

*C*. Label state *C* on the diagram and draw a line or curve to represent the process from state *B* to state *C*.

c. The gas is then compressed isothermally back to state *A*.

i. Draw a line or curve on the diagram to represent this process.

ii. Is heat added to or removed from the gas during this isothermal compression?

\_\_\_\_\_\_\_added to \_\_\_\_\_\_\_removed from

Justify your answer.



3. An experiment is performed to determine the number *n* of moles of an ideal gas in the cylinder shown above. The cylinder is fitted with a movable, frictionless piston of area *A*. The piston is in equilibrium and is supported by the pressure of the gas. The gas is heated while its pressure P remains constant. Measurements are made of the temperature *T* of the gas and the height *H* of the bottom of the piston above the base of the cylinder and are recorded in the table below. Assume that the thermal expansion of the apparatus can be ignored.



a. Write a relationship between the quantities *T* and *H,* in terms of the given quantities and fundamental constants, that will allow you to determine *n.*

b. Plot the data on the axes below so that you will be able to determine *n* from the relationship in part (a). Label the axes with appropriate numbers to show the scale.



c. Using your graph and the values A = 0.027 m2 and P = 1.0 atmosphere, determine the experimental value of *n.*



4. The cylinder represented above contains 2.2 kg of water vapor initially at a volume of 2.0 m3 and an absolute pressure of 3.0 × 105 Pa. This state is represented by point *A* in the *PV* diagram below. The molar mass of water is 18 g, and the water vapor can be treated as an ideal gas.



a. Calculate the temperature of the water vapor at point *A*.

The absolute pressure of the water vapor is increased at constant volume to 4.0 × 105 Pa at point *B*, and then the volume of the water vapor is increased at constant pressure to 2.5 m3 at point *C*, as shown in the *PV* diagram.

b. Calculate the temperature of the water vapor at point *C*.

c. Does the internal energy of the water vapor for the process *A*→*B*→*C* increase, decrease, or remain the same?

\_\_\_\_Increase \_\_\_\_Decrease \_\_\_\_Remain the same

Justify your answer.

d. Calculate the work done on the water vapor for the process *A*→*B*→*C*.



5. One mole of an ideal monatomic gas is taken through the cycle abca shown on the diagram above. State a has volume Va = 17 × 10–3 cubic meter and pressure Pa = 1.2 × 105 pascals, and state c has volume Vc = 51 ×10–3 cubic meter. Process ca lies along the 250 K isotherm. Determine each of the following.

a. The temperature Tb of state b

b. The heat Qab added to the gas during process ab

c. The change in internal energy Ub - Ua

d. The work Wbc done by the gas on its surroundings during process bc

The net heat added to the gas for the entire cycle 1,800 joules. Determine each of the following.

e. The net work done on the gas by its surroundings for the entire cycle

f. The efficiency of a Carnot engine that operates between the maximum and minimum temperatures in this cycle