Name ________________________

Hour _______

AP Physics: Chapter 10
Thermal Physics

Question A:
Two identical cylinders at the same temperature contain the same kind of gas. If cylinder *A* contains three times as much gas as cylinder *B*, what can you say about the relative pressures in the cylinders?

Question B:
A cylinder with a movable piston contains gas at a temperature of 27.0 °C, a volume of 1.50 m^3, and an absolute pressure of .200 x 10^5 Pa. What will be its final temperature if the gas is compressed to .700 m^3 and the absolute pressure increases to .800 x 10^5 Pa?

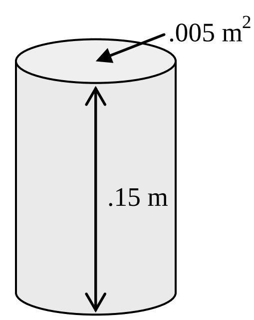
Question C:
Gas is contained in an 8.0 x 10^{-3} m^3 vessel at a temperature of 20 °C and a pressure of 9.0 atm.
a) Determine the number of moles of gas in the vessel.
b) How many molecules are in the vessel?

Question D:
An ideal gas occupies a volume of 1.0 x 10^{-6} m^3 at 20 °C and atmospheric pressure.
a) Determine the number of molecules of gas in the container.
b) If the pressure is reduced to 1.0 x 10^{-11} Pa (an extremely good vacuum) while the temperature and volume remain constant, how many moles of gas remain in the container?

Question E:
The pressure on an ideal gas is cut in half, resulting in a decrease in temperature to three fourths of the original value. Calculate the ratio of the final volume to the original volume of the gas.

Question F:
A 2.0 mol sample of an ideal gas is confined to a .0050 m^3 vessel at a pressure of 8.0 x 10^5 Pa.
a) Calculate the average kinetic energy of a gas molecule.
b) Calculate the total kinetic energy of the sample of gas.

Question G:
The inside of the cylindrical can shown at right has cross-sectional area of 0.0050 m^2 and length 0.15 m. The can is filled with an ideal gas and covered with a loose cap. The gas is heated to 363 K and some is allowed to escape from the can so that the remaining gas reaches atmospheric pressure (1.0 x 10^5 Pa). The cap is now tightened, and the gas is cooled to 298 K.
a) What is the pressure of the cooled gas?
b) Determine the upward force exerted on the cap by the cooled gas inside the can.
c) If the cap develops a leak, how many moles of air would enter the can as it reaches a final equilibrium at 298 K and atmospheric pressure? (Assume that air is an ideal gas.)



AP Physics: Chapter 11
Heat

Question A:
A heavy iron chain of mass *m* drags from the back of a semi truck as it travels down the highway. The coefficient of friction between the chain and the asphalt surface of the road is .65. Assume that one half of the energy generated by friction is absorbed by the chain. Calculate the distance traveled by the truck if the chain increases in temperature by 2.50 °C.

Question B:
Mary is preparing a punch bowl for her New Year's party. She places 300.0 grams of ice at – 5.0 °C in the punch.

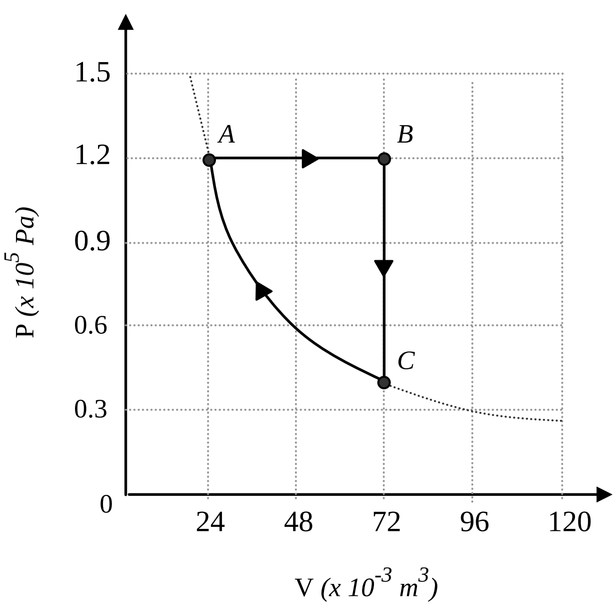
a) Calculate the total energy required to raise the temperature of the ice to 0 °C, melt the ice, and heat the ice (now water) to 10.0 °C
b) Where does the energy required for Part *a* come from?

AP Physics: Chapter 12
Thermodynamics

Question A:
A gas is enclosed in a container fitted with a piston of cross-sectional area .150 m^2. The pressure of the gas is maintained at 6000 Pa as the piston moves inward .20 m.
a) Calculate the work done on or by the gas.
b) If the internal energy of the gas decreases by 8.00 J, find the amount of heat removed from the system during the compression.

Question B:
What is the change in internal energy of 1.5 mol of a monatomic ideal gas if its temperature is increased by 120 K?

Question C:
One mole of an ideal monatomic gas is taken through the cycle *ABCA* shown on the *P-V* diagram at right. Process *CA* is an isothermal process.



What is the temperature of the gas at . . .
a) State *A?*
b) State *B?*
c) State *C?*

What is the change in internal energy of the gas during . . .
d) Process *AB?*
e) Process *BC?*

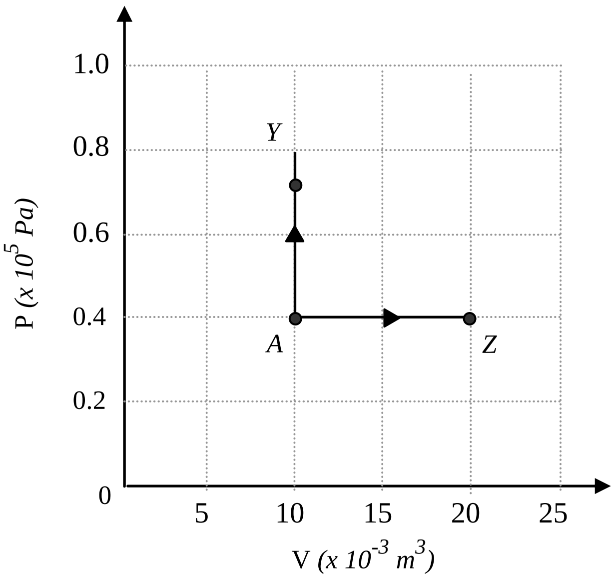
What is the heat added to or removed from the gas during . . .
f) Process *AB?*
g) Process *BC?*

It is found that the work done on the gas during Process *CA* is 3164 J.
h) What is the heat absorbed or given off by the gas during the complete cycle?

Question D:

An ideal gas is initially at State *A*, as shown on the *P*-*V* diagram at right. In one process the gas increases in pressure to State *Y* at a constant volume. In a separate process, the gas expands to State *Z* at a constant pressure.

a) Calculate the change in internal energy of the gas during Process *AY*.
b) Calculate the change in internal energy of the gas during Process *AZ*.
c) Calculate the heat absorbed or given off by the gas during Process *AY*.
d) Calculate the heat absorbed or given off by the gas during Process *AZ*.



Question E:

A gas is enclosed in a container fitted with a 4.0 kg piston of cross-sectional area .015 m^2. The original temperature of the gas is 310 K. Heat is then added to the gas and the piston moves upwards in the cylinder, causing the volume to increase from .00225 m^3 to .00300 m^3.

a) Calculate the new temperature of the gas.
b) Calculate the work done by the gas.
c) Calculate the change in internal energy of the gas.
d) How much heat is required to produce this temperature change?

Question F:

A pitcher containing 1.75 kg of water is placed in a refrigerator, where its temperature decreases by 12.0 °C during a time of 20 minutes. The condenser of the refrigerator must do 1375 J of work to complete this cooling process.

a) Calculate the heat removed from the water pitcher by the refrigerator.
b) Calculate the rate at which energy is given off by the refrigerator into the outside surroundings.

Question G:

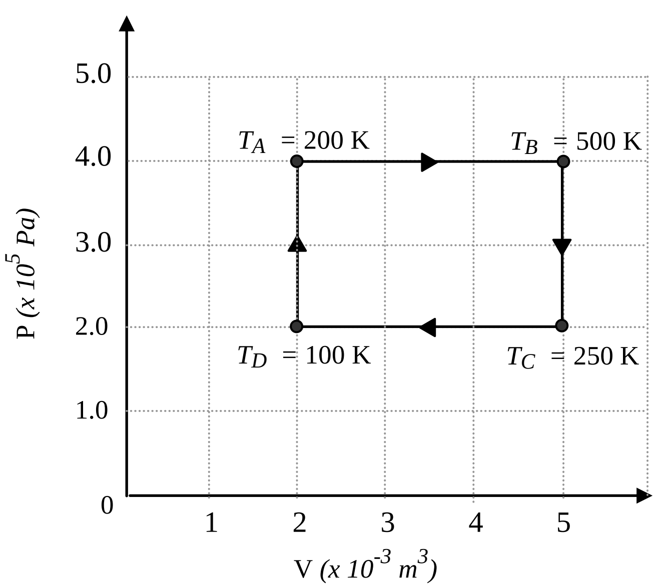
A sample of .48 moles of an ideal monatomic gas is taken through the cycle *ABCDA* shown on the *P*-*V* diagram below.

For Process *AB*, determine the . . .
a) work done on or by the gas.
b) change in internal energy of the gas.
c) heat absorbed or given off by the gas.

For Process *BC*, determine the . . .
d) work done on or by the gas.
e) change in internal energy of the gas.
f) heat absorbed or given off by the gas.

For Process *CD*, determine the . . .
g) work done on or by the gas.
h) change in internal energy of the gas.
i) heat absorbed or given off by the gas.

For Process *DA*, determine the . . .
j) work done on or by the gas.
k) change in internal energy of the gas.
l) heat absorbed or given off by the gas.



Question H:

A heat engine operates using the cyclic process described in Question G above. The efficiency of this heat engine can be found using two methods.

a) Calculate the Carnot efficiency of the engine using the formula $e_c = \dfrac{T_H - T_C}{T_H}$.

b) Calculate the actual efficiency of the engine using the formula $e = \left|\dfrac{W}{Q_H}\right|$.

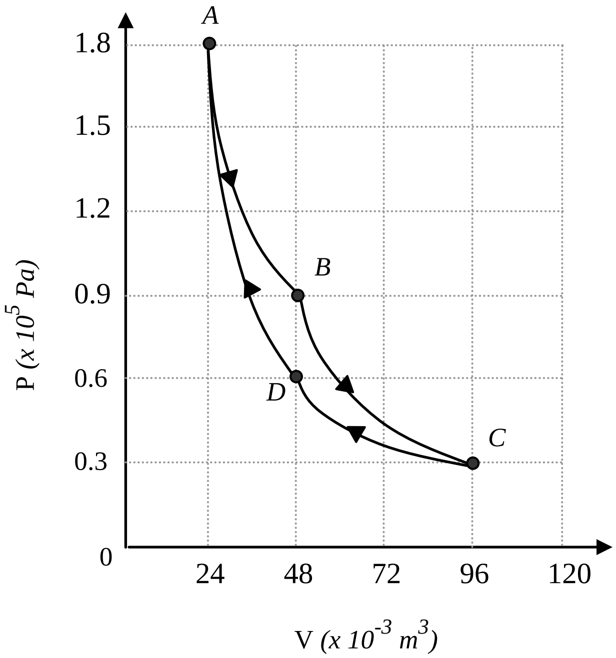
c) How do the answers for *a* and *b* compare? Explain your results.

One mole of an ideal monatomic gas is taken through the Carnot heat engine cycle *ABCDA* shown on the *P-V* diagram below. Processes *AB* and *CD* are isothermal, while Processes *BC* and *DA* are adiabatic. Use the diagram to answer Questions *I* to *K*.

Question I:

Identify any process in which . . .

a) work is done on the gas *(positive W).*
b) work is done by the gas *(negative W).*
c) no work is done on or by the gas *(zero W).*
d) the internal energy of the gas increases *(positive* ΔU*).*
e) the internal energy of the gas decreases *(negative* ΔU*).*
f) the internal energy of the gas remains constant *(zero* ΔU*).*
g) heat is absorbed by the gas *(positive Q).*
h) heat is given off by the gas *(negative Q).*
i) heat is neither absorbed nor given off by the gas *(zero Q).*



Question J:

It is found that the heat absorbed by the gas during Process *AB* is 3000 J and the heat given off by the gas during Process *CD* is – 2000 J.

a) What is the net heat absorbed by the gas during the entire cycle?
b) What is the net work done by the gas during the entire cycle?

Question K:

A heat engine operates using the cyclic process described in Questions I and J above. The efficiency of this heat engine can be found using two methods.

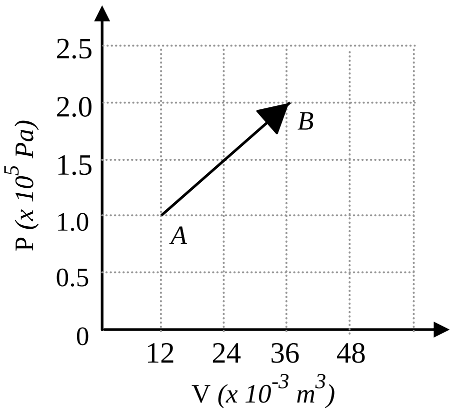
a) Calculate the Carnot efficiency of the engine using the formula $e_c = \dfrac{T_H - T_C}{T_H}$.

b) Calculate the actual efficiency of the engine using the formula $e = \left|\dfrac{W}{Q_H}\right|$.

c) How do the answers for *a* and *b* compare? Explain your results.

Question L:

Calculate the work done on or by the gas for the process shown in the Pressure-Volume graph at right.

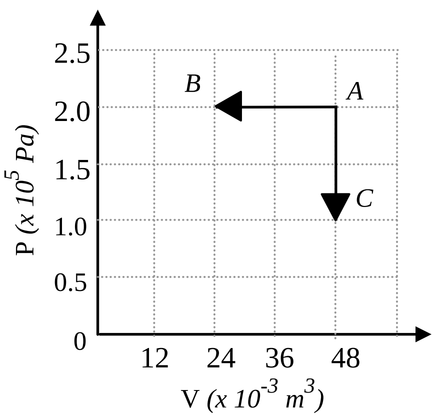


Question M:

In the Pressure-Volume graph shown at right, a gas is initially in State A, with a pressure of 2.0 x 10^5 Pa, volume of 48 x 10^{-3} m^3, and temperature of 500 K. In one process, it is compressed at constant pressure to State B, where its new volume is 24 x 10^{-3} m^3 and temperature is 250 K. In a separate process, the gas is held at constant volume and its pressure decreased to 1.0 x 10^5 Pa at State C, where its temperature is 250 K.

For Process *AB*, determine if the following are positive, negative, or zero:
a) work done on or by the gas.
b) change in internal energy of the gas.
c) heat absorbed or given off by the gas.

For Process *AC*, determine if the following are positive, negative, or zero:
d) work done on or by the gas.
e) change in internal energy of the gas.
f) heat absorbed or given off by the gas.



Question N:

In the Pressure-Volume graph shown above (in *Question #M*), a gas is initially in State A, with a pressure of 2.0 x 10^5 Pa, volume of 48 x 10^{-3} m^3, and temperature of 500 K. In one process, it is compressed at constant pressure to State B, where its new volume is 24 x 10^{-3} m^3 and temperature is 250 K. In a separate process, the gas is held at constant volume and its pressure decreased to 1.0 x 10^5 Pa at State C, where its temperature is 250 K. The sample of gas loses 7200 J of internal energy for both Process *AB* and Process *AC*.

For Process *AB*, calculate the . . .
a) work done on or by the gas.
b) heat absorbed or given off by the gas.

For Process *AC*, calculate the . . .
c) work done on or by the gas.
d) heat absorbed or given off by the gas.

Question O:

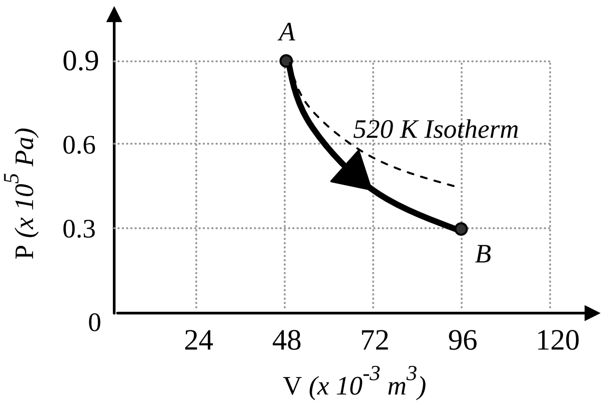
In the Pressure-Volume graph shown below, one mole of an ideal gas is initially in State A, with a pressure of 0.90 x 10^5 Pa, volume of 48 x 10^{-3} m^3, and temperature of 520 K. It is taken in an adiabatic process to State B, where its pressure is 0.30 x 10^5 Pa, volume is 96 x 10^{-3} m^3, and temperature is 347 K. The 520 K isotherm has been added to the graph (with a dashed line) as a reference.

For Process *AB*, determine if the following are positive, negative, or zero:

a) work done on or by the gas.
b) change in internal energy of the gas.
c) heat absorbed or given off by the gas.

Suppose Process *AB* is reversed to create Process *BA*. For Process *BA*, determine if the following are positive, negative, or zero:

d) work done on or by the gas.
e) change in internal energy of the gas.
f) heat absorbed or given off by the gas.



Question P:

In the Pressure-Volume graph shown above (in *Question #O*), one mole of an ideal gas is initially in State A, with a pressure of 0.90 x 10^5 Pa, volume of 48 x 10^{-3} m^3, and temperature of 520 K. It is taken in an adiabatic process to State B, where its pressure is 0.30 x 10^5 Pa, volume is 96 x 10^{-3} m^3, and temperature is 347 K. The 520 K isotherm has been added to the graph (with a dashed line) as a reference. The internal energy of the gas at State A is 6482 J and the internal energy at State B is 4320 J.

For Process *AB*, determine the . . .

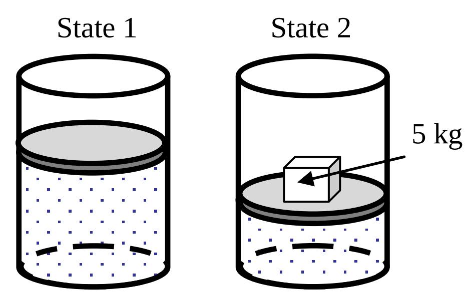
a) heat absorbed or given off by the gas.
b) work done on or by the gas.

For Process *BA*, determine the . . .

c) heat absorbed or given off by the gas.
d) work done on or by the gas.

Question Q:

A cylinder is fitted with a freely moveable piston of area 1.200 x 10^{-2} m^2 and negligible mass. The cylinder below the piston is filled with a gas. At State 1, the gas has volume 1.500 x 10^{-3} m^3, pressure 1.020 x 10^5 Pa, and temperature of 273.0 K. In an adiabatic process, a 5.000 kg metal block is placed on top of the piston, compressing the gas to a volume of 1.460 x 10^{-3} m^3 at State 2.



a) Calculate the temperature of the gas at State 2.
b) Determine the change in internal energy of the gas during the process.
c) Determine the work done on or by the gas during the process.

Question R:

A sample of 1.03 moles of an ideal monatomic gas is taken through the cycle *ABCA* shown on the *P-V* diagram below. The temperature of the gas at States *A* and *B* is 560 K and the temperature at State *C* is 280 K. The total heat absorbed by the gas during Processes *CA* and *AB* is 7195 J.

a) Determine the work done on or by the gas for the cycle.
b) Calculate the Carnot efficiency of the engine.
c) Calculate the actual efficiency of the engine.
d) How do the answers for *b* and *c* compare? Explain your results.