AP Physics Study Guide Chapters 13, 14, 15 Thermal Physics Name_____

Write the equation that defines each quantity, **include units for all quantities.**

thermal expansion equation

ideal gas law

pressure – force

heat conduction rate

1st law of thermodynamics

efficiency of a heat engine

Carnot engine (ideal) efficiency

Chapter 13

State the two quantities that comprise the internal energy (U) of a substance.

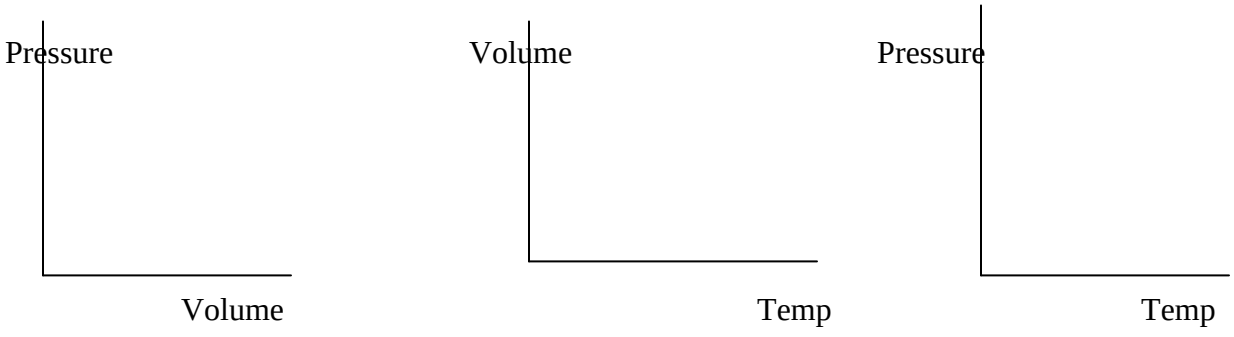
1) 2)

What is the only quantity that the average kinetic energy of molecules in a gas depends on?

Convert the temperature 20°C into the equivalent Kelvin temperature = _____ K

Write the description of an ideal gas:

Draw the shape of the following 3 graphs for an ideal gas



What are standard temperature and pressure for an ideal gas?

The ideal gas law can also be used to calculate P, V or T of a gas as one or more of these quantities is changed from state 1 to state 2. Write that equation here:

Chapter 14

Summarize James Joule's experiment

Explain what heat is, including what it is and the direction involved.

List the three thermal energy transfer mechanisms below along with a brief summary of each.

1)

2)

3)

Which of the mechanisms above require a medium?

Which one does not require a medium?

By examining the heat conduction equation describe 4 ways that the thermal energy transfer rate (Q/t = H) between two points can be INCREASED.

1)

2)

3)

4)

Chapter 15

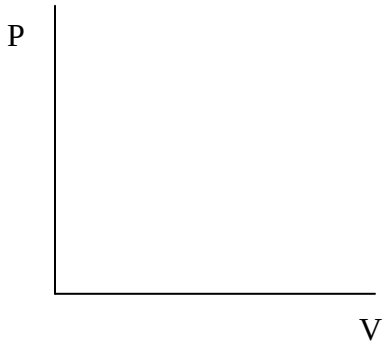
Examine the equation that the 1st law of thermodynamics is based on. When heat is added to the gas the sign of Q is _____. When heat is lost or removed from a gas the sign of Q is_____.

When work is done BY the gas the sign of the work is _____ and when work is done ON the gas by a piston the sign of the work is _____.

State what the internal energy of a gas depends on and write the equation that relates it to temperature, using the universal gas constant R.

Define each of the four thermodynamic processes listed below. Draw AND label a graph of each of the four processes on the P-V diagram at right

Isobaric:



Isothermal:

Isovolumetric:

Adiabatic:

Explain what a heat engine is. In your discussion include a statement of the second law of thermodynamics and a drawing of Figure 15 – 11.

Define the efficiency of a heat engine.

List the four different parts of the Carnot cycle:

1)

2)

3)

4)

Define entropy

Does the total entropy of a system increase or decrease? Explain your answer.

Give an example of how entropy changes for an isolated system

No process is required for these multiple choice questions. Put answers on lines provided.

1.The maximum efficiency of a heat engine that operates between temperatures of 1500 K in the firing chamber and 600 K in the exhaust chamber is most nearly

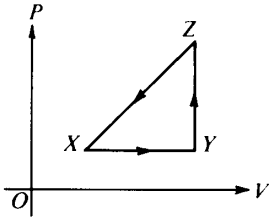
(A) 33% (B) 40% (C) 60% (D) 67% (E) 100% 1)_____

2) Which of the following statements is NOT a correct assumption of the classical model of an ideal gas?

a. The molecules are in random motion.
b. The volume of the molecules is negligible compared with the volume occupied by the gas.
c. The molecules obey Newton's laws of motion.
d. The collisions between molecules are inelastic.
e. The only appreciable forces on the molecules are those that occur during collisions. 2)_____

3. James Joule did much to establish the value of the
   (A) universal gravitational constant
   (B) speed of light
   (C) mechanical equivalent of heat 3)_____
   (D) charge of an electron
   (E) specific heat capacity of helium

Questions 4 – 5



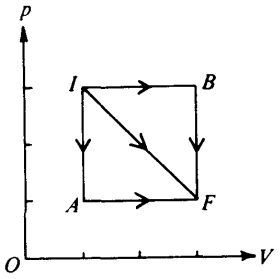
A thermodynamic system is taken from an initial state X along the path XYZX as shown in the PV-diagram above.

4) For the process X→Y, ΔU is greater than zero and 4)_____

(A) Q<0 and W = 0 (B) Q<0 and W>0 (C) Q>0 and W<0
(D) Q>0 and W=0 (E) Q>0 and W>0

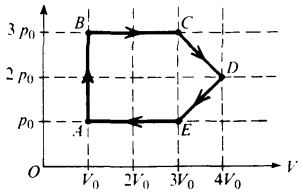
5) For the process Y→Z, Q is greater than zero and 5)_____

(A) W<0 and ΔU=0 (B) W=0 and ΔU<0 (C) W=0 and ΔU>0
(D) W >0 and ΔU=0 (E) W>0 and ΔU>0



6. If three identical samples of an ideal gas are taken from initial state I to final state F along the paths IAF, IF, and IBF as shown in the pV-diagram above, which of the following must be true?
   (A) The work done by the gas is the same for all three paths.
   (B) The heat absorbed by the gas is the same for all three paths.
   (C) The change in internal energy of the gas is the same for all three paths. 6)_____
   (D) The expansion along path IF is adiabatic.
   (E) The expansion along path IF is isothermal.

Questions 7 – 8

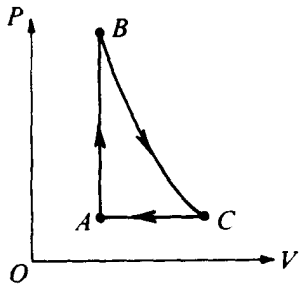


An ideal gas undergoes a cyclic process as shown on the graph above of pressure p versus volume V.

7. During which process is no work done on or by the gas?
   (A) AB (B) BC (C) CD (D) DE (E) EA 7)_____

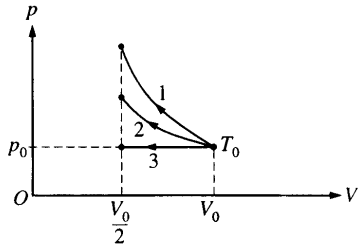
8. At which point is the gas at its highest temperature?
   (A) A (B) B (C) C (D) D (E) E 8)_____

9. If the gas in a container absorbs 275 joules of heat, has 125 joules of work done on it, and then does 50 joules of work, what is the increase in the internal energy of the gas?
   (A) l00 J (B) 200 J (C) 350 J (D) 400 J (E) 450 J 9)_____



10. Gas in a chamber passes through the cycle ABCA as shown in the diagram above. In the process AB, 12 joules of heat is added to the gas. In the process BC, no heat is exchanged with the gas. For the complete cycle ABCA, the work done by the gas is 8 joules. How much heat is added to or removed from the gas during process CA ?
    (A) 20 J is removed. (B) 4 J is removed. (C) 4 J is added.
    (D) 20 J is added. (E) No heat is added to or removed from the gas. 10)_____

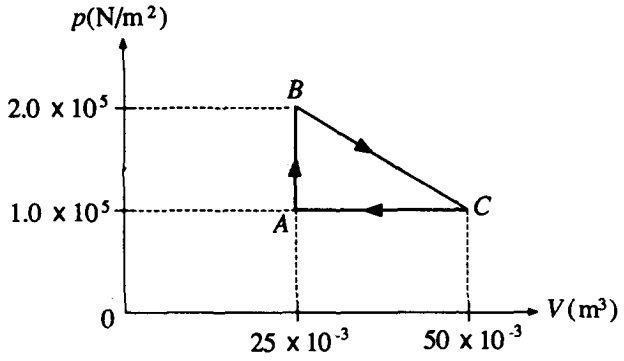
Questions 11 – 12



A certain quantity of an ideal gas initially at temperature T_0, pressure p_0, and volume V_0 is compressed to one-half its initial volume. As shown above, the process may be adiabatic (process 1), isothermal (process 2), or isobaric (process 3).

11. Which of the following is true of the mechanical work done on the gas?
    a. It is greatest for process 1.
    b. It is greatest for process 3.
    c. It is the same for processes I and 2 and less for process 3. 11)_____
    d. It is the same for processes 2 and 3 and less for process 1.
    e. It is the same for all three processes.

12. Which of the following is true of the final temperature of this gas?
    a. It is greatest for process 1. b. It is greatest for process 2. 12)_____
    c. It is greatest for process 3. d. It is the same for processes 1 and 2.
    e. It is the same for processes 1 and 3.



1) One mole of an ideal monatomic gas, initially at point A at a pressure of 1.0×10^5 newtons per meter squared and a volume of $25 \times l0^{-3}$ meter cubed, is taken through a 3-process cycle, as shown in the pV diagram above. Each process is done slowly and reversibly. Determine each of the following:

a. the temperature of the gas at each of the vertices, A, B. and C, of the triangular cycle

a)_____

b. the net work done by the gas for one cycle

b)_____

c. the net heat absorbed by the gas for one full cycle

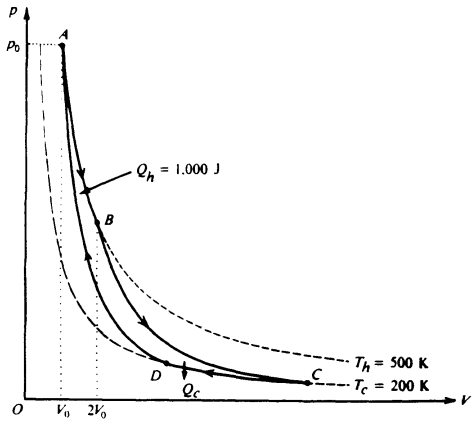
c)_____

d. the heat given off by the gas for the third process from C to A

d)_____

e. the efficiency of the cycle

e)_____



2) The p V-diagram above represents the states of an ideal gas during one cycle of operation of a reversible heat engine. The cycle consists of the following four processes.

Process	**Nature of Process**
AB	Constant temperature (T_h = 500 K)
BC	Adiabatic
CD	Constant temperature (T_c = 200 K)
DA	Adiabatic

During process A B, the volume of the gas increases from V_o to $2V_o$ and the gas absorbs 1,000 joules of heat.

a. The pressure at A is p_o. Determine the pressure at B.

a)_____

b. Using the first law of thermodynamics, determine the work performed by or on the gas during the process A B.

b)_____

c. During the process AB, does the entropy of the gas increase, decrease, or remain unchanged? Justify your answer.

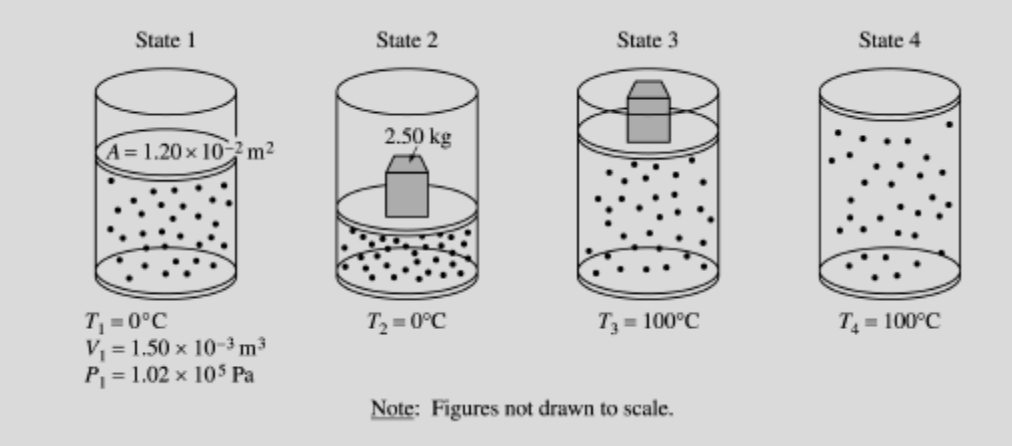
c)_____

d. Calculate the heat Q_c given off by the gas in the process CD.

d)_____

e. During the full cycle ABCDA is the total work the gas performs on its surroundings positive, negative, or zero? Justify your answer.

e)_____



3) A cylinder is fitted with a freely moveable piston of area 1.20 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 1.50 x 10^{-3} m^3, pressure 1.02 x 10^5 Pa, and the cylinder is in contact with a water bath at a temperature of 0^oC. The gas is then taken through the following four-step process.

- A 2.50 kg metal block is placed on top of the piston, compressing the gas to state 2, with the gas still at 0^oC.
- The cylinder is then brought into contact with a boiling water bath, raising the gas temperature to 100^oC at state 3.
- The metal block is removed and the gas expands to state 4 still at 100^oC.
- Finally, the cylinder is again placed in contact with the water bath at 0^oC, returning the system to state 1.

a) Determine the pressure of the gas in state 2

a)_____

b) Determine the volume of the gas in state 2.

b)_____

c) Indicate below whether the process from state 2 to state 3 is isothermal, isobaric or adiabatic.

_____ Isothermal _____Isobaric _____Adiabatic

Explain your reasoning.

d) Is the process from state 4 to state 1 isobaric? _____ Yes _____ No

Explain your reasoning

e) Determine the volume of the gas in state 4

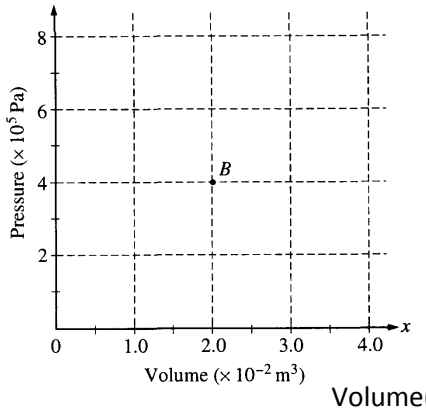
e)_____

4) A cylinder contains 2 moles of an ideal monatomic gas that is initially at state A with a volume of 1.0 x 10^{-2} m^3 and a pressure of 4.0 x 10^5 Pa. The gas is brought isobarically to state B. where the volume is 2.0 x 10^{-2} m^3. The gas is then brought at constant volume to state C, where its temperature is the same as at state A. The gas is then brought isothermally back to state A.

a. Determine the pressure of the gas at state C.

a)_____

b. On the axes below, state B is represented by the point B. Sketch a graph of the complete cycle. Label points A and C to represent states A and C, respectively.



Volume(x10^{-2} m^3)

c. State whether the net work done by the gas during the complete cycle is positive, negative, or zero. Justify your answer.

c)_____

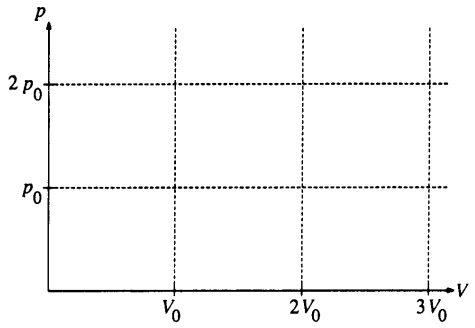
d. State whether this device is a refrigerator or a heat engine. Justify your answer.

d)_____

5) An ideal gas initially has pressure p_o, volume V_o, and absolute temperature T_o. It then undergoes the following series of processes:

I. It is heated, at constant volume, until it reaches a pressure $2p_o$.
II. It is heated, at constant pressure, until it reaches a volume $3\ V_o$.
III. It is cooled, at constant volume, until it reaches a pressure p_o.
IV. It is cooled, at constant pressure, until it reaches a volume V_o.

a. On the axes below
i. draw the p-V diagram representing the series of processes;
ii. label each end point with the appropriate value of absolute temperature in terms of T_o.



b. For this series of processes, determine the following in terms of p_o and V_o.
i. The net work done by the gas

i)_____

ii. The net change in internal energy

ii)_____

iii. The net heat absorbed

iii)_____

c. Determine the heat transferred during process 2 in terms of p_o and V_o.

c)_____