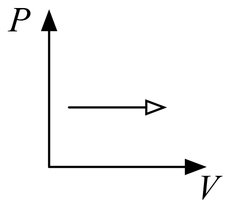
Physics II

Chapter 15 Practice with Answers

Fall 2017

1. When a sample of gas undergoes an isothermal process, there is no change in its
   (a) temperature.
   (b) pressure.
   (c) volume.
   (d) heat.

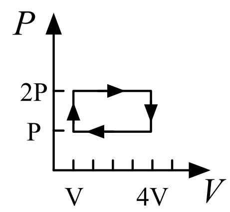


2. The process shown on the PV diagram is an
   (a) isobaric expansion.
   (b) isometric expansion.
   (c) adiabatic expansion.
   (d) isothermal expansion.

3. When a goes undergoes an isochoric process, there is no change in its
   (a) pressure.
   (b) temperature.
   (c) volume.
   (d) internal energy.

4. During an isothermal process, 5.0 J of heat is removed from an ideal gas. What is the change in its internal energy?
   (a) 2.5 J
   (b) zero
   (c) 5.0 J
   (d) 10 J

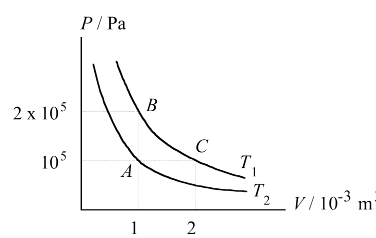
5. A certain amount of a monatomic gas is maintained at constant volume as it is cooled by 50 K. This feat is accomplished by removing 400 J of energy from the gas. How much work is done by the gas?
   (a) -400 J
   (b) 400 J
   (c) zero
   (d) none of the above



6. A gas is taken through the cycle illustrated here. How much work is done during one cycle by an engine operating on this cycle?
   (a) 4PV
   (b) PV
   (c) 3PV
   (d) 2PV

7. If the theoretical efficiency of a Carnot engine is to be 100%, the heat sink must be
   (a) at 0° C
   (b) at 100° K
   (c) infinitely hot.
   (d) at 0 K

8.



The figure above shows two curves for a given mass of gas at temperature T_1 and T_2. If the symbols P, V and T stand for the pressure, volume and absolute temperature of the gas, which of the following statements is FALSE?

   (a) Temperature T_1 is twice the temperature T_2.
   (b) $\dfrac{PV}{T}$ is constant for all the points on the two curves.
   (c) When the gas expands from state B to state C as represented by the curve BC, no energy is transferred from the surroundings to the gas.
   (d) No work is done by the gas when it changes from state A to state B along the line AB.

(e) To take the gas from state A to state C, 100 J of energy is needed.

9. An ideal gas confined in a box initially has pressure P. If the absolute temperature of the gas is doubled and the volume of the box is quadrupled, the pressure is

   (a) $\frac{1}{8}P$

   (b) $\frac{1}{4}P$

   (c) $\frac{1}{2}P$

   (d) P

   (e) $2P$

10. As an ideal gas is compressed at constant temperature,

    (a) heat flows into the gas.

    (b) the internal energy of the gas does not change.

    (c) the work done on the gas is zero.

    (d) both choices (a) and (b)

    (e) both choices (a) and (c)

11. A heat engine runs between reservoirs at temperatures of 300°C and 30°C. What is its maximum theoretical efficiency?

    (a) 10%

    (b) 47%

    (c) 53%

    (d) 90%

    (e) 100%

12. If two different systems are put in thermal contact so that heat can flow from one to the other, then heat will flow until the systems have the same

    (a) energy.

    (b) heat capacity.

    (c) entropy.

    (d) temperature.

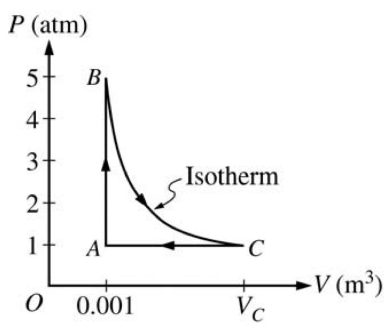
1. How does the kinetic theory of gases explain the fact that a gas cools as it expands into the atmosphere, but a gas does not cool as it expands into the the vacuum of space?

   When gas expands into our atmosphere, it pushes back the air molecules surrounding it. This happens through molecular collisions between our expanding gas particles and air molecules. On net, the expanding gas molecules lose energy as they collide, resulting in a growing volume of our gas. This cools the gas, because average molecular KE is directly proportional to temperature. But in a vacuum there is nothing to push back against, and so there is no cost to the expansion of our gas. Our gas will not cool, because the molecules won't lose energy through collisions with an atmosphere.

2. Describe how an air conditioner works. Include a sketch that shows the compressor, the throttling (expansion) valve, the condenser, and the evaporator. Also discuss what goes on with the "working fluid."

   In this cycle, a circulating refrigerant such as Freon enters the compressor as a vapor. The vapor is compressed (adiabatically) and exits the compressor superheated. The superheated vapor travels through the condenser which cools the vapor as it loses energy to the cooler environment which eventually condenses the vapor into a liquid as additional heat is lost to the environment. The cooler liquid refrigerant then goes through the expansion valve (also called a throttle valve) where its pressure abruptly decreases, causing sudden expansion, flash evaporation, and substantial cooling of, typically, less than half of the liquid. So there is a very cold, low pressure vapor/liquid mixture after the expansion valve does its job. The cold liquid-vapor mixture then travels through the evaporator coils (tubing) and is completely vaporized because of heating by the warmer air (from the space being refrigerated) being blown by a fan across the evaporator coil or tubes. The resulting refrigerant vapor returns to the compressor inlet to complete the thermodynamic cycle.

3. Calculate the total change in entropy of the universe that occurs when 0.2 kg of ice at 0°C melts in a 30° tub of ethanol.



4. A 0.03 mol sample of helium is taken through the cycle shown in the diagram above. The temperature of state A is 400 K.

   (a) For each process in this cycle, indicate in the table below whether the quantities W, Q, and ΔU are positive (+), negative (−), or zero (0). W is the work done by the helium sample on its environment.

Process	W	Q	ΔU
$A \to B$	0	+	+
$B \to C$	+	+	0
$C \to A$	−	−	−

   (b) Explain your response for the signs of the quantities for process $A \to B$.

   For Process $A \to B$ work is zero because there is no change in volume, and so the "area" underneath AB is zero, which means the same thing. ΔU is positive, and this is because $U = \frac{3}{2}PV$. Because PV is greater at B than at A, the total energy of the gas increases in Process $A \to B$.

For Process $B \to C$ there is no temperature change, and that tells us that the total energy of the gas is the same in state B as in state C, so we therefore know that $\Delta U = 0$. Because the gas expands into the surrounding atmosphere, W must be positive; the gas does work on its surroundings. Of course, that means the gas loses energy through this working. After all, its doing the work! But since there is no loss of total energy in the gas, something must be making up for the energy lost in that working. Naturally, Q must be bringing energy into the gas. The gas is gaining energy through heating, and that means $Q > 0$.

Finally in Process $C \to A$ the gas is being compressed, which means that energy is being put into the gas. That is what we define to be *negative* work. We also know that the energy of the gas at A is less than the energy of the gas in state C, don't we! So $\Delta U < 0$ for Process $C \to A$. $\Delta U = Q - W$ shows us that Q must be negative, because W is negative, and ΔU is negative.

(c) Calculate V_C . $P_B V_B = P_C V_C$ because T is the same for states B and C. So if the pressure is cut to one-fifth, the volume must increase by five times in order to maintain a constant PV product. $V_C = 0.005$ m^3.

5. In a certain process, 3200 J of energy is added to an ideal gas by heating. During the same process, 2100 J of work is done on the gas.

   (a) Determine the change in the internal energy of the gas that results from this process. Use First Law of Thermo

   (b) Indicate whether each of the following properties of the gas increases, decreases, or remains the same during the process.

   i. Volume
   Increases / **Decreases** / **Stays the same**
   Justify your answer.

   ii. Temperature
   Increases / **Decreases** / **Stays the same**
   Justify your answer.

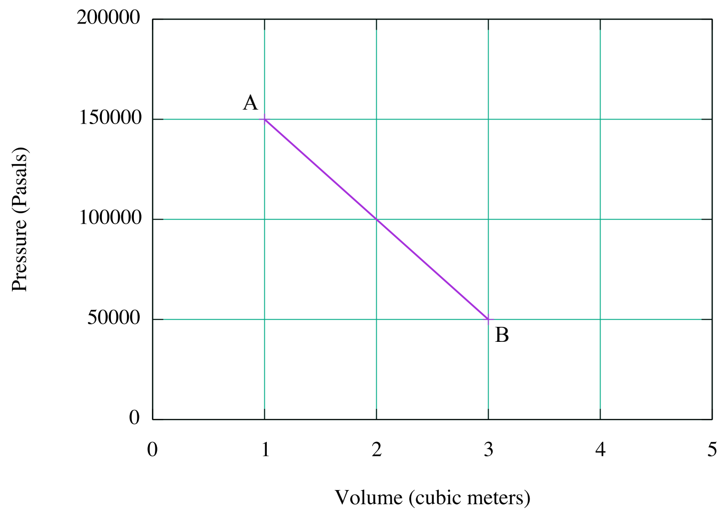
   iii. Pressure
   Increases / **Decreases** / **Stays the same**
   Justify your answer.

   Suppose that in a different process 1800 joules of work is done on the ideal gas at a constant temperature.

   (c) Determine the change in internal energy of the gas during the process. Zero

   (d) Which of the following correctly describes the energy transfer by heating, if any, between the gas and its surroundings?
   There is a heat transfer out of the gas. / **There is a heat transfer into the gas.** / **There is no net heat transfer.**
   Justify your answer.

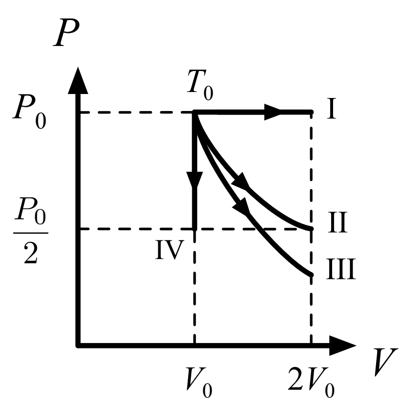
6. One-tenth of a mole of an ideal monatomic gas undergoes a process described by the straight-line path AB shown in the P-V diagram below.



(a) Show that the temperature of the gas is the same at points A and B.Use Ideal Gas Law to show that T's are the same at A and B because PV is the same at A and B.

(b) How much heat is added to the gas during the process described by A→B? Use First Law of Thermo; $\Delta E = 0$ when final temperature is the same as initial temperature. Therefore, $Q = W$ from First Law of Thermo. Work done by the gas in the expansion from A to B can be found from the area under the diagonal line from A to B. It's a combination of a triangle and a rectangle, isn't it. And we know how to calculate those areas, don't we? At any rate, I get $W = 200,000$ J and so $Q = 200,000$ J, too.

(c) What is the highest temperature of the gas during the process described by A→B? [This is not on the test, but you should be able to figure it out. There's only one possible point!] I get about 240000 K. That seems more than a bit ridiculous. What is this data from, a nuclear test site?



7. Four separate samples of an ideal gas are each initially at a pressure P_0, and volume V_0, and a temperature T_0 as shown on the P-V graph above. These samples are taken in separate processes from this initial state to their respective final state I, II, III, and IV. These processes are represented on the P-V graph.

(a) One of the processes is isothermal. Identify which one, and justify your choice.II

(b) One of the processes is adiabatic. Identify which one, and justify your choice. III

(c) In which process or processes does heat flow from the gas to its surroundings? IV

(d) In which process or processes does the gas do work on its surroundings? Justify your choice. I, II, III

(e) In which process or processes does the root-mean-square speed of the gas particles increase? Justify your choice. I