Chapter 4 Review Questions

Solutions can be found in Chapter 12.

Section I: Multiple Choice

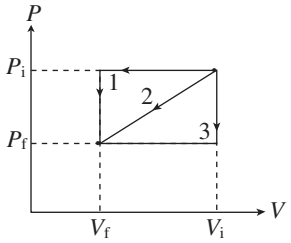
1. A container holds a mixture of two gases, CO_2 and H_2, in thermal equilibrium. Let K_C and K_H denote the average kinetic energy of a CO_2 molecule and an H_2 molecule, respectively. Given that a molecule of CO_2 has 22 times the mass of a molecule of H_2, the ratio K_C / K_H is equal to

   (A) 1/22
   (B) 1
   (C) $\sqrt{22}$
   (D) 22

2. If the temperature and volume of a sample of an ideal gas are both doubled, then the pressure

   (A) decreases by a factor of 2
   (B) increases by a factor of 2
   (C) increases by a factor of 4
   (D) remains unchanged

3. In three separate experiments, a gas is transformed from state P_i, V_i to state P_f, V_f along the paths (1, 2, and 3) illustrated in the figure below:



   The work done on the gas is

   (A) greatest for path 1
   (B) least for path 2
   (C) greatest for path 2
   (D) the same for all three paths

4. An ideal gas is compressed isothermally from 20 m^3 to 10 m^3. During this process, 5 J of work is done to compress the gas. What is the change of internal energy for this gas?

   (A) –10 J
   (B) –5 J
   (C) 0 J
   (D) 5 J

5. An ideal gas is confined to a container whose volume is fixed. If the container holds n moles of gas, by what factor will the pressure increase if the absolute temperature is increased by a factor of 2 ?

   (A) $2/(nR)$
   (B) 2
   (C) $2nR$
   (D) $2/n$

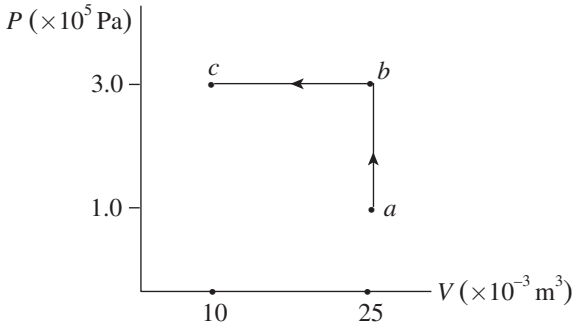
6. Two large glass containers of equal volume each hold 1 mole of gas. Container 1 is filled with hydrogen gas (2 g/mol), and Container 2 holds helium (4 g/mol). If the pressure of the gas in Container 1 equals the pressure of the gas in Container 2, which of the following is true?

   (A) The temperature of the gas in Container 1 is lower than the temperature of the gas in Container 2.
   (B) The temperature of the gas in Container 1 is greater than the temperature of the gas in Container 2.
   (C) The rms speed of the gas molecules in Container 1 is lower than the rms speed of the gas molecules in Container 2.
   (D) The rms speed of the gas molecules in Container 1 is greater than the rms speed of the gas molecules in Container 2.

7. Through a series of thermodynamic processes, the internal energy of a sample of confined gas is increased by 560 J. If the net amount of work done on the sample by its surroundings is 320 J, how much heat was transferred between the gas and its environment?

   (A) 240 J absorbed
   (B) 240 J dissipated
   (C) 880 J absorbed
   (D) 880 J dissipated

8. What's the total work performed on the gas as it's transformed from state *a* to state *c,* along the path indicated?



(A) 1,500 J
(B) 3,000 J
(C) 4,500 J
(D) 9,500 J

9. In one of the steps of the Carnot cycle, the gas undergoes an isothermal expansion. Which of the following statements is true concerning this step?

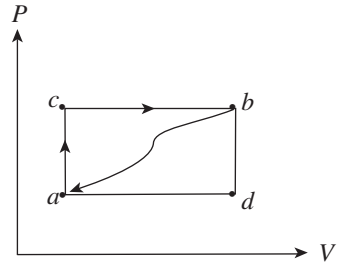
(A) No heat is exchanged between the gas and its surroundings, because the process is isothermal.
(B) The temperature decreases because the gas expands.
(C) The internal energy of the gas remains constant.
(D) The internal energy of the gas decreases due to the expansion.

10. A cup of hot coffee is sealed inside a perfectly thermally insulating container. A long time is allowed to pass. Which of the following correctly explains the final thermal configuration within the box?

(A) The coffee has not changed temperature because the box is perfectly insulating.
(B) The coffee has gotten warmer and the air in the box has gotten cooler because of an exchange of thermal energy between the air and the coffee.
(C) The coffee has gotten cooler and the air in the box has gotten warmer because of an exchange of thermal energy between the air and the coffee.
(D) The coffee has gotten cooler but the air in the box has not changed its temperature. The energy from the coffee has caused an increase in entropy within the box.

Section II: Free Response

1. When a system is taken from state *a* to state *b* along the path *acb* shown in the figure below, 70 J of heat flows into the system, and the system does 30 J of work.



(a) When the system is returned from state *b* to state *a* along the curved path shown, 60 J of heat flows out of the system. Does the system perform work on its surroundings or do the surroundings perform work on the system? How much work is done?

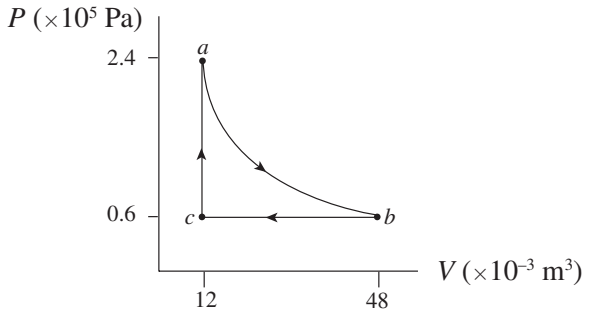
(b) If the system does 10 J of work in transforming from state *a* to state *b* along path *adb*, does the system absorb or does it emit heat? How much heat is transferred?

(c) If $U_a = 0$ J and $U_d = 30$ J, determine the heat absorbed in the processes *db* and *ad*.

(d) For the process *adbca*, identify each of the following quantities as positive, negative, or zero:

$W =$ _____ $Q =$ _____ $U =$ _____

2. A 0.4 mol sample of an ideal diatomic gas undergoes slow changes from state *a* to state *b* to state *c* and back to *a* along the cycle shown in the *P*–*V* diagram below:



Path *ab* is an isotherm, and it can be shown that the work done by the gas as it changes isothermally from state *a* to state *b* is given by the equation

$$W_{ab} = -nRT \times \ln \frac{V_b}{V_a}$$

The molar heat capacities for the gas are C_V = 20.8 J/mol·K and C_p = 29.1 J/mol·K.

(a) What's the temperature of

(i) state *a*?

(ii) state *b*?

(iii) state *c*?

(b) Determine the change in the internal energy of the gas for

(i) step *ab*

(ii) step *bc*

(iii) step *ca*

(c) How much work, W_{ab}, is done by the gas during step *ab*?

(d) What is the total work done over cycle *abca*?

(e) (i) Is heat absorbed or discarded during step *ab*?

(ii) If so, how much?

(f) What is the maximum possible efficiency (without violating the Second Law of Thermodynamics) for a cyclical heat engine that operates between the temperatures of states *a* and *c*?