Quizzes Section 2

Thermal Expansion

1. In an ordinary thermometer that uses a liquid in a reservoir connected to a small tube, which coefficient of expansion is relevant?
(a) Coefficient of linear expansion α .
(b) Coefficient of volume expansion β .

Heat Capacity

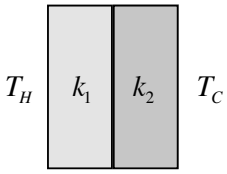
2. True or False: Given two different objects, the one with the higher temperature contains more heat.
(a) T
(b) F

3. You place equal weights of ice (at 0 ^{o}C) and boiling water (at 100 ^{o}C) into a well-insulated container. What is the final temperature?
(a) 0 ^{o}C
(b) Between 0 ^{o}C and 50 ^{o}C
(c) 50 ^{o}C
(d) Between 50 ^{o}C and 100 ^{o}C
Note: The latent heat of ice melting is 333 J/g, and the specific heat of water is 4.186 J/(g ^{o}C).

Thermal Conductivity

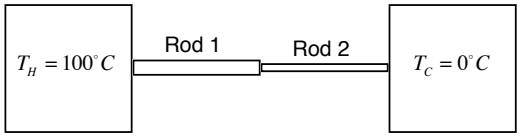
4. Two rods of the same length and made of the same material are connected in parallel between a high-temperature heat reservoir and a low-temperature reservoir. One rod has twice the diameter of the other. The cold reservoir is removed and the temperature is monitored on the end of each rod where the cold reservoir used to be. Assume perfect insulation everywhere except when and where connected to a reservoir. The temperature on the end of the larger rod
(a) increases more slowly than the temperature on the end of the smaller rod.
(b) increases at the same rate as the temperature on the end of the smaller rod.
(c) increases more rapidly than the temperature on the end of the smaller rod.

5. Two slabs with equal thicknesses are made of different materials. The slabs are placed together, and heat flows through the combined construct as shown in the figure. The heat conductivity in the first slab is greater than the conductivity in the second: $k_1 > k_2$. When equilibrium flow is achieved, the power flowing through the first slab will be



(a) less than the power flowing though the second.
(b) equal to the power flowing through the second.
(c) greater than the power flowing though the second.

6. Two rods made of the same material and having equal lengths are connected end to end with good thermal contact. Rod 1 has twice the diameter of Rod 2. Rod 1 is connected to a reservoir at temperature 100^{o}C and Rod 2 is connected to a reservoir at temperature 0^{o}C as shown in the figure. The rods are insulated except on their ends. After steady heat flow is achieved, the temperature where the two rods meet will be

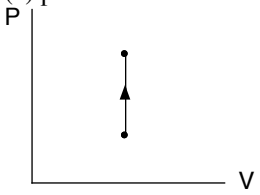


(a) less than 50^{o}C.
(b) equal to 50^{o}C.
(c) greater than 50^{o}C.

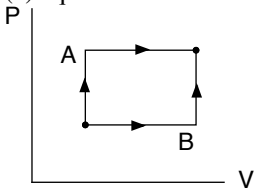
1st Law

7. In the path shown below, the work done on the gas is
(a) negative.
(b) zero.

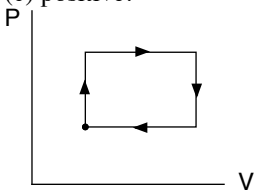
(c) positive.



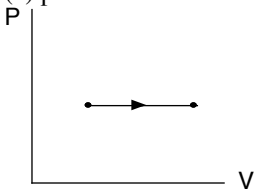
8. In which of the two paths below is the most work done BY the gas?
(a) path A.
(b) path B.
(c) equal amounts of work done for both paths.



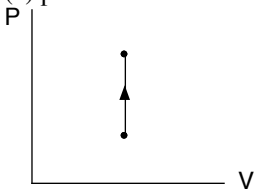
9. In the path shown below, the gas returns to its original state. The net work done ON the gas along this path is
(a) negative.
(b) zero.
(c) positive.



10. In the path shown below, the heat Q put into the gas is
(a) negative.
(b) zero.
(c) positive.

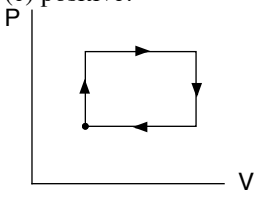


11. In the path shown below, the change of internal energy of the gas is
(a) negative.
(b) zero.
(c) positive.



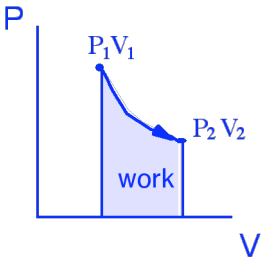
12. In the path shown below, the gas returns to its original state. The change in internal energy of the gas is
(a) negative.

(b) zero.
(c) positive.

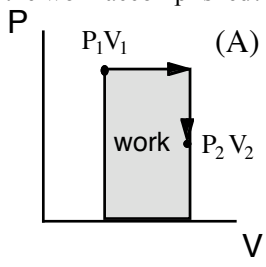


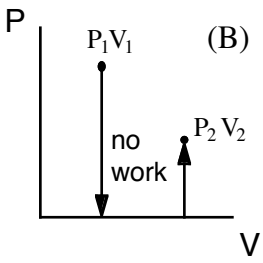
13. A piston is rapidly pushed into a cylinder of gas causing the volume to decrease. There is no time for heat to flow into or out of the gas. The temperature of the gas
(a) decreases.
(b) remains the same (i.e. pressure increases the same as volume decreases: PV=nRT).
(c) increases.

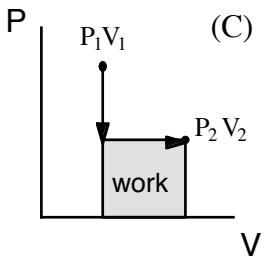
14. The PV diagram represents a constant-temperature expansion of an ideal gas from V_1 to V_2. The area under the curve represents the work accomplished (say, on a piston that allows the expansion).



Now consider gas confined to a volume V_1 behind a membrane which suddenly bursts so that the gas freely expands into vacuum to achieve the same final volume of V_2. Temperature does not change during this process, so the final state looks identical to the final state in the previous case. Which of the following diagrams best represents the work accomplished?

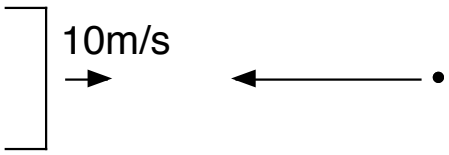






Kinetic Theory of Gases

15. A piston moves inward at 10m/s and a gas molecule moves toward the piston. After bouncing elastically from the piston, the speed of the molecule will be
(a) the same as it was before.
(b) 10m/s faster than before.
(c) 20m/s faster than before.



Cv, Cp, Adiabatic

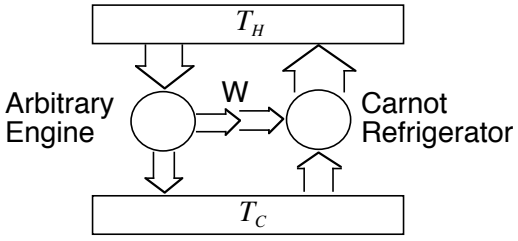
16. A container holds 1mol of an ideal gas. To increase the temperature of the gas, more heat will be required
(a) if the volume is held constant
(b) if the pressure is held constant
(c) Both (a) and (b) require the same amount of heat.
(d) There is insufficient information given to answer this problem.

17. Two gases in separate containers have *equal volumes*, *equal numbers of molecules*, and the *same internal energy* E_{int}. However, one gas is monatomic and the other is diatomic. The pressure of the diatomic gas is
(a) less than that of the monatomic gas.
(b) the same as that of the monatomic gas.
(c) greater than that of the monatomic gas.

18. Warm air can accommodate more water vapor than cool air? Why then do we often see thunderstorms in the afternoon during the warmest part of the day?
(a) The wind moves new clouds in from a distance.
(b) Clouds come and rain at random intervals, and it is only an impression that they come more often in the afternoon.
(c) Thunderstorms form due to adiabatic expansion.
(d) Thunderstorms form due to adiabatic compression.

Carnot Engine

19. Consider an arbitrary engine whose work output is connected to a Carnot engine running in reverse as a refrigerator.
(a) It is possible for the engine to extract less heat from the hot reservoir than is deposited by the Carnot refrigerator.
(b) It is possible for the engine to deposit less heat into the cold reservoir than is extracted by the Carnot refrigerator.
(c) Both (a) and (b) are possible.
(d) The Carnot refrigerator cannot deposit more heat into the hot reservoir than is extracted by the engine.



Heat Engines and Refrigerators

20. The door of an operating kitchen refrigerator is left open for a long time in a well-insulated room. The temperature inside the room will
(a) decrease.
(b) remain the same.
(c) increase.

Entropy

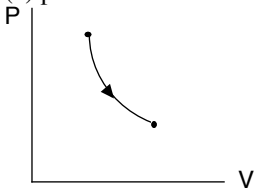
21. Choose the sentence that is <u>not</u> a statement of the <u>second</u> law of thermodynamics:
(a) Heat flows spontaneously from hot objects to cold objects.
(b) The entropy of a closed system never decreases.
(c) The internal energy of a system increases when heat is added and decreases when work is accomplished.
(d) None of the above is <u>not</u> the second law.

22. The entropy in a cylinder of gas changes by -10J/K. Choose the correct statement:
(a) The surrounding environment must be at a higher temperature than the cylinder of gas.
(b) The process may have been adiabatic.
(c) The entropy of the environment does not increase by more than 10J/K.
(d) None of the above.

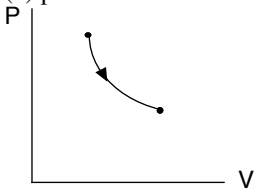
23. A membrane partitions a certain volume of gas from additional empty space. The membrane bursts and the gas expands freely and occupies the new larger volume. During this process,
(a) the temperature decreases and entropy does not change.
(b) both temperature and entropy remain unchanged.
(c) the temperature does not change but entropy increases.
(d) None of the above.

Miscellaneous

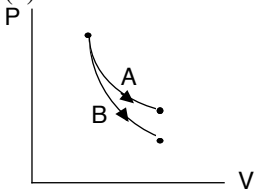
24. The path shown below is adiabatic (Q=0). The change in internal energy of the gas is
(a) negative.
(b) zero.
(c) positive.



25. The path shown below is isothermal (ΔT=0). The change in internal energy of the gas is
(a) negative.
(b) zero.
(c) positive.



26. One of the P-V curves below is for an isothermal process. The other is for an adiabatic process. Which is adiabatic?
(a) A
(b) B



27. Two identical containers hold equal amounts of the same gas at the same temperature. In each case, a piston compresses the gas to half the original volume. In one container the process takes place adiabatically, and in the other container it takes place at constant temperature in contact with a heat reservoir. The piston must do more work in the case of
(a) the adiabatic compression.
(b) the constant-temperature compression.
(c) In both processes the amount of work is the same.

28. Gas in a piston expands its volume at constant temperature. Choose the correct statement:
(a) The internal energy of the gas increases.
(b) The entropy of the gas increases.
(c) The work done by the gas exceeds the amount of heat injected into it.
(d) The heat injected into the gas exceeds the work done by it.

29. A container holds 1mol of an ideal gas. 500J of heat are added to the gas. The temperature increases most
(a) if the volume is held constant.
(b) if the pressure is held constant.
(c) Both (a) and (b) give the same increase in temperature.
(d) There is insufficient information given to make a determination.

30. A pipe organ is manufactured near sea level with barometric pressure of P=760torr. It is then transported to a region well above sea level with a barometric pressure of P=670torr. Assuming the organ is housed in a room at the same temperature, the frequency of individual pipes will be

(a) less than before

(b) greater than before

(c) the same as before

HINT: Recall that the speed of sound in air is $v = \sqrt{\gamma P/\rho}$ and the frequency is $f = v/2L$ (or $v/4L$ if a closed pipe).

Answers

1. (b) It is a change in the liquid's volume that forces it to overflow from the rigid container into the small tube.
2. (b) For a given amount of heat in a material, the temperature depends on the material's capacity to absorb the heat.
3. (b) If 1g of boiling water cools from 100 ^{o}C to 0 ^{o}C, it will give up 418.6J, which exceeds the heat needed to melt 1g of ice. The hot water cools until the ice is melted, and the system settles on a temperature between 0 ^{o}C and 50 ^{o}C.
4. (b) Although more heat flows through the larger-diameter rod, the heat capacity goes up in the same proportion (according to the cross-sectional area).
5. (b) If the power is not the same, heat would accumulate (or be created) between the slabs.
6. (c) There will be a smaller temperature difference across Rod 1 to compensate for the greater cross-sectional area. Otherwise, the power flowing through each rod would not match.
7. (b) If the volume doesn't change, no work can be done since nothing is pushing out.
8. (a) The piston must push harder at the higher pressure. There is more area under path A.
9. (a) The gas is doing work on the piston, so there is negative work done on the gas.
10. (c) To get the volume to increase at constant pressure, heat must be added.
11. (c) To get the pressure to increase at constant volume, heat must be added, which increases internal energy.
12. (b) Each point on the P-V diagram presents a unique pressure-volume combination (with its associated temperature). The internal energy must return to the same value as well.
13. (c) It takes energy in the form of work to push the piston in, and that energy goes into the gas. More energy means a higher temperature.
14. (b) When the membrane bursts and the gas expands freely, but no work is done (and no heat is transferred). This process cannot be represented on a PV diagram unless you say that there is zero pressure during the expansion.
15. (c) In the rest frame of the piston, the molecule approaches and leaves with an extra speed of 10m/s. To return to the original frame, we add the speed of the piston to get 20m/s.
16. (b) To keep the pressure constant, a piston will do work as it moves at constant force. Since the gas loses internal energy to do work, more heat must be added for the same temperature increase.
17. (a) For the monatomic gas, all energy is associated with translational momentum of the molecules. For the diatomic gas, part of the energy goes into molecular tumbling, leaving less for translational momentum. This gives less pressure on the container walls and a lower temperature.
18. (c) Air near the earth's surface is warmed and expands. Buoyant forces cause upwards convection leading to further expansion wherein work is accomplished on the surrounding atmosphere being pushed away. Because of the large volumes, there is no time for heat exchange with surrounding air and temperature drops.
19. (d) Extracting less heat from the hot reservoir and depositing less heat into the cold reservoir to perform the same work would make the arbitrary engine more efficient than the Carnot engine (refrigerator). In this case, the combined system would cause heat to flow from cold to hot, in violation of the second law. Because the Carnot engine can run in reverse, no other engine can be more efficient.
20. (c) The temperature in the room will increase corresponding to the amount of work required to operate the refrigerator. More heat will be deposited to the outer refrigerator coils than will be removed from the interior of the refrigerator, the difference being the work injected.
21. (c) Conservation of energy is the 1st law of thermodynamics.
22. (d) The process is not adiabatic since heat is transferred. Heat flows out of the container to an environment that must be at the same or a lower temperature. Therefore, the entropy of the environment increase by 10J/K or more.
23. (c) Temperature cannot change since there is no heat flow or work done. However, entropy increases because the process is irreversible and disorder has increased.
24. (a) Since the gas does work with no heat added, it gives up internal energy.
25. (b) Since the temperature does not change, the internal energy cannot change. Heat is added to balance the work accomplished.
26. (b) As the gas expands and does work, no heat is added, so it cools and drops in pressure faster.
27. (a) Adiabatic compression has a steeper curve on the PV diagram with more area under the curve. Since no heat can escape, the gas heats up during the adiabatic compression causing a higher pressure.

28. (b) Internal energy remains unchanged as the heat injected balances the work done. Entropy increases as heat is injected.
29. (a) To keep the pressure constant, the piston does work as the volume increases. Since the gas loses internal energy to do work, the temperature does not increase as much.
30. (c) The ideal gas law shows that density of the air to be proportional to the pressure: $PV = NkT \Rightarrow \rho \propto \frac{N}{V} = \frac{P}{kT}$. Therefore, the velocity of sound in air doesn't change.