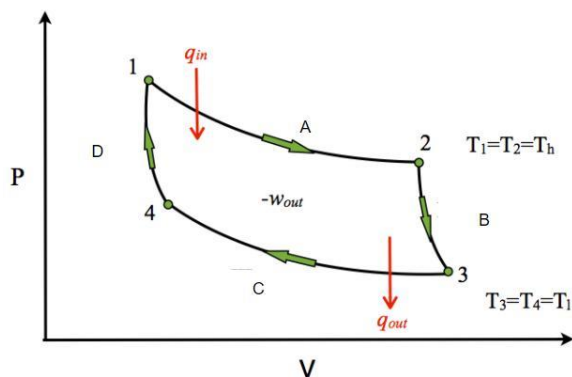


Test Exchange
Thermodynamics (C) Test
Answer Key

Questions are worth between 1 to 3 points. Show calculations for all open-ended math questions in order to receive partial credit.

1. A rigid container contains a gas. The temperature in the container is doubled while the number of molecules triples. Which of the following occurs to the average kinetic energy? (1 point)
 - a. **The average kinetic energy doubles.**
 - b. The average kinetic energy quadruples.
 - c. It increases, but we cannot be sure of how much.
 - d. It is impossible to determine.
2. Which of these is not an assumption made by the kinetic molecular theory? (1 point)
 - a. Gas molecules undergo elastic collisions only
 - b. There are no forces of attraction between particles
 - c. Gases have random, constant motion and have energy in the form of kinetic energy
 - d. **Gas particles are relatively close together and occupy large portions of container volumes**
 - e. All of these are assumptions made by the kinetic molecular theory
3. Sadi Carnot, is known for all of the following achievements except? (1 point)
 - a. Formalized the second law of thermodynamics
 - b. Defined the concept of entropy
 - c. **Assisted in deriving the Gibbs-Free Energy equation**
 - d. Established a thermodynamic model for heat engines
4. The Kelvin temperature scale has been historically defined by which of the following? (1 point)
 - a. Standard temperature and pressure
 - b. **Triple point of water**
 - c. The melting point of helium gas
 - d. Vapor pressure of water at STP

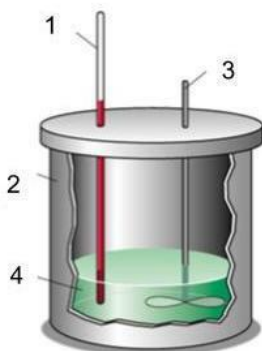
5. Which of the following describes the process that occurs in this diagram at A? (1 point)



- A reversible isothermal gas expansion process
 - A reversible adiabatic gas expansion process
 - A reversible isothermal gas compression process
 - A reversible adiabatic gas compression process
- 2 Write the equation formed by Van der Waals Equation if interparticle interactions are negligible and the common name of this equation. (1 point for equation, 1 point for name)

Ideal Gas Law ($PV=nRT$)

7. Label the parts of this apparatus and in the space below, briefly describe what this device is used for. (1 point each)



- Thermometer
- Insulated container (calorimeter)
- Stirrer
- Sample, liquid, water, etc.

Must mention one of the following: measuring the heat of reactions
Or specific heat capacity

8. Helium gas and nitrogen gas have been added to an excavated container that can hold 1 liter. (4 points total)

- a. Which gas is most likely to exhibit deviation from kinetic molecular theory and why? (1 point)

Nitrogen gas is most likely to exhibit ideal gas deviations because it has a greater molar mass which means that it has more electrons and has greater polarizability or greater London Dispersion forces. With increased interparticle attractions, the particles are more likely to deviate from their constant, random motion.

- b. What is the ratio between the effusion rates of helium to nitrogen gas if a pinhole is cut out of the box? Show calculations. (2 points)

$$\frac{Rate_A}{Rate_B} = \sqrt{\frac{Molar\ Mass_B}{Molar\ Mass_A}}$$

Molar mass of Nitrogen gas: $2 \cdot 14 \text{ g/mol} = 28$
Molar mass of Helium gas: 4 g/mol
Ratio: $\sqrt{7}$

- c. The box is subjected to a constant external temperature. Which gas would you expect to have the greatest average speed? (1 point)

Helium gas. This is because both gases have the same average kinetic energy since they are under the same temperatures. But since Helium gas has less mass than nitrogen gas, the average speed of the helium particles is greater.

9. The number of microstates of a thermodynamic system is 10^{24} . Calculate the entropy of the system (1 point)
- 7.6×10^{-22}
 - 8.6×10^{-24}
 - 2.5×10^{-17}
 - 6.2×10^{-30}
10. Given a hot dry rock system with a thermal conductivity of 1.38 in $\text{W/m}\cdot\text{K}$, a temperature difference of 30 C, and a thickness of 80 m, what is the heat flow in a cross sectional area of 20 square meters. (1 point)
- 10.35 W
 - 12.4 W
 - 9.9 W
 - 29020 W
 - 66420 W
11. Given a reaction, circle spontaneous or nonspontaneous for each reaction. (1 point each)
- Lighting a match: spontaneous/ **nonspontaneous**
 - Iron rusting: **spontaneous**/ nonspontaneous
 - Mercury solidifies at room temperature: spontaneous/ **nonspontaneous**
12. Calculate the actual gas constant for 1 L for 1 mole of hydrogen gas at 2 atm and 20 degrees Celsius. (3 points)

$$\left[P + a \left(\frac{n}{V} \right)^2 \right] \left(\frac{V}{n} - b \right) = RT$$

$$R = 0.00766$$

13. Which material listed below is known for having the most thermal diffusivity? (1 point)

- a. Steel
- b. Gold
- c. Graphite
- d. Inconel
- e. Silicon

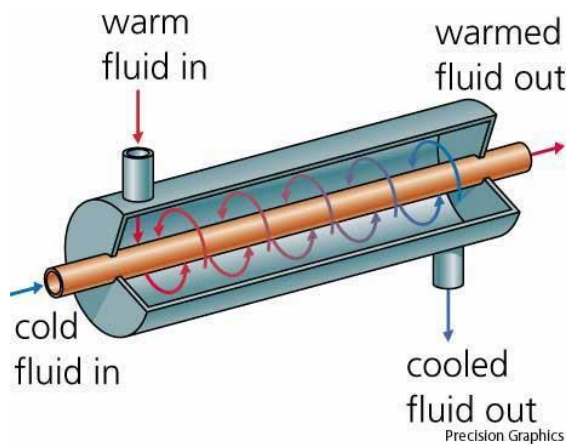
14. Anisotropic heating of materials usually results from which of the following: (1 point)

- a. Point source heating
- b. Tempered variances
- c. Rapid increases in microstates
- d. Non-cubic crystal structures

15. Determine the compressibility of a solid with a volume of 3.24 cubic meters and a volumetric pressure derivative of 35.3 cubic meters per pascal. (1 point)

- a. -114.372
- b. -10.89
- c. -2.74
- d. -1.886

Use the following image for questions 16-18.



16. Which famous scientist developed the basis for the system pictured above? (1 point)

- a. Sadi Carnot
- b. James Maxwell
- c. Josiah Gibbs
- d. Walther Nernst

17. Where would this type of system be found? (1 point)

- a. Space heating
- b. Air conditioning
- c. Petroleum refineries
- d. Sewage treatment
- e. Geothermal heat pumps
- f. All of these

18. Which of the following are ways to optimize such designs? (1 point)

- I. Maximizing the pressure drop
- II. Maximizing the thermal performance
- III. Minimizing the entropy generation

- a. I only
- b. II only
- c. I and III
- d. I and II
- e. II and III

19. Which of the following best describes residual entropy? (1 point)

- s. The remaining entropy after a substance has achieved thermal equilibrium
- t. The difference in entropy between a non-equilibrium state and crystal state of a substance close to absolute zero
- u. The caloric energy count in the system as it approaches absolute zero
- v. None of the above

20. Define sorption calorimetry: (2 points)

Used for the studies of surfactants and complex organic materials that helps to determine qualities of the hydration of various materials and substances.

21. Based on Carnot's theorem, an engine can have a maximum efficiency that is defined by the temperature of its cold and hot reservoir. If the cold reservoir is 300 K and the hot reservoir is 400 K. What is the maximum efficiency? (1 point)
- 0.75
 - 0.3
 - 0.45
 - 0.25**
 - 1
22. What is the driving force behind the piston in a Photo-Carnot engine? (1 point)
- Steam pressure
 - Radiation pressure**
 - Electrical power
 - Rotational momentum
23. A Rijke tube converts **heat** into **sound** using **self-amplifying waves**.
(1 point for each blank)
24. The Delisle temperature scale is one of the only scales that: (1 point)
- Uses three fixed points to calibrate the scale
 - Runs with increasing values for decreasing heat**
 - Utilizes more than 3000 gradations
 - Has an exponentially changing scale
25. How is the BTU defined? (2 points)
- The amount of heat required to raise the temperature of one pound of water through 1 degree Fahrenheit (58.5 F to 59.5 F) at sea level**
26. The Joule-Thomson effect was discovered in **1853**. (1 point)
27. Which of the following thermodynamics pioneers is accredited with the concept of internal energy? (1 point)
- Lord Kelvin
 - Sadi Carnot
 - Max Planck
 - Rudolf J. Clausius**
28. In 1798, Benjamin Thompson began his **cannon-boring** experiments. (1 point)