

Thermodynamics B/C

Rank: _____

Points: _____

Science Olympiad North Regional
Tournament at the University of Florida



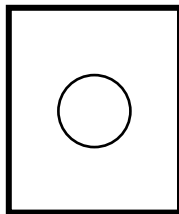
Name(s): _____

Team Name: _____

School Name: _____

Team Number: _____

1. True/False: Boyle's Law relates the volume to the temperature of an ideal gas under isobaric conditions.
2. True/False: Newton's law of cooling applies to cooling by conduction, convection, and radiation.
3. True/False: The first law of thermodynamics states that the sum of the entropy of interacting thermodynamic systems always increases.
4. True/False: James Joule first stated the first and second laws of thermodynamics.
5. True/False: The ideal gas law requires temperature to be in the SI unit of degrees Celsius.
6. True/False: The Gay-Lussac Law relates the pressure to the temperature of an ideal gas under isovolumetric conditions.
7. At what temperature are Fahrenheit and Celsius the same? _____
8. 350 K is equal to how many degrees Fahrenheit? _____
9. Convert 350°C to degrees Rankine. _____
10. Convert 212°F to Kelvin. _____
11. If a steel rectangular plate with a circular hole cut in the center of it is heated from -20°C to 150°C, how does the diameter of the hole change?



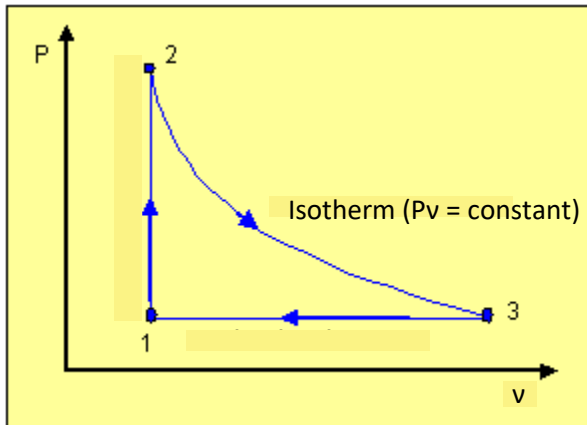
- a. The diameter of the hole increases
- b. The diameter of the hole decreases
- c. The diameter does not change
- d. None of the above
- e. All of the above

12. If a 500 kilocalorie (Calorie) muffin is eaten, how high could a 70 kg man climb stairs with perfect efficiency only burning the energy from the muffin. (use $g = 9.81 \text{ m/s}^2$)

- a. 1052 m
- b. 3045 m
- c. 4026 m
- d. 4532 m

13. Calculate the specific heat capacity of titanium if a 43.56 g sample absorbs 0.476 kJ as its temperature changes from 20.13°C to 41.06°C. (express answer in J/g °C) _____

Use the following figure for questions 14, 15, and 16:



The cycle above is performed on 1 kg of air, assumed to be an ideal gas. The line connecting points 2 and 3 is an isotherm. The y axis is pressure, with point 2 existing at 5 bar and points 1 and 3 existing at 1 bar. The x axis is specific volume, with points 1 and 2 existing at $1 \text{ m}^3/\text{kg}$ and point 3 existing at $5 \text{ m}^3/\text{kg}$. The specific internal energy of air at point 1 is 1432 kJ/kg. The specific internal energy of air at point 3 is 249.2 kJ/kg.

- 14. What is the heat input into the cycle? _____ (kJ/kg)
- 15. What is the work output of the cycle? _____ (kJ/kg)
- 16. What is the thermal efficiency of the cycle? _____

A rigid well insulated tank consists of two compartments each having the same volume separated by a valve.

Initially one of the compartments is evacuated and the other is filled with air at 350 K and 2 bar. The valve is then opened and the gas eventually comes to equilibrium filling the entire tank. Find the final equilibrium temperature and pressure of the gas in the entire tank. Take the ambient temperature and pressure as 300 K and 1 bar, and use the ideal gas model for air.

17. Final temperature of the gas _____ (K).
18. Final pressure of the gas _____ (bar).

19. What is the change in temperature in Fahrenheit if 75 calories are applied to 10 grams of water? (assume no boiling or freezing)
 - a. 13.5°F
 - b. 7.5°F
 - c. 45.5°F
 - d. None of the above

20. Disorder in the universe increases because
 - a. Local entropy decreases are balanced by distant unrelated entropy increases that are greater
 - b. Work in a system always produces waste heat, which leaves a system
 - c. Work acting on a thermodynamic system directly increases the entropy of the system
 - d. All of the above

21. A fluid flowing through an ideal nozzle experiences a
 - a. Pressure increase and velocity increase
 - b. Pressure decrease and velocity increase
 - c. Pressure increase and velocity decrease
 - d. Pressure decrease and velocity decrease

22. A diffuser is the opposite of a

- a. Turbine
- b. Pump
- c. Nozzle
- d. Piston

23. How many Joules are in 220 Calories?

- a. 920
- b. 9.2×10^9
- c. 9.2×10^3
- d. 9.2×10^6
- e. None of the above

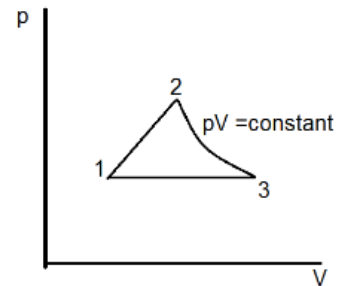
Use this cycle for questions 24-27:

A system with 2 kg of air undergoes the cycle as shown in order:

- (a) 1 to 2- linear variation of pressure with volume process
- (b) 2 to 3- $pV = \text{constant}$ process
- (c) 3 to 1- constant pressure process

Where:

$$p_1 = p_3 = 1\text{bar}; p_2 = 2\text{bar}; V_1 = 1\text{m}^3; V_2 = 2\text{m}^3$$



- 24. What is the work from 1 to 2? _____ (kJ)
- 25. What is the work from 2 to 3? _____ (kJ)
- 26. What is the work from 3 to 1? _____ (kJ)
- 27. What is the work per cycle in kJ?