Thermodynamics – Division C – Answer Key

Graders: Award 20% of point value on numeric responses that are incorrect but have work shown on the exam. Do not award any partial credit if only work provided is an equation (work needs to be shown).

_/6 1) a) 70 J b) -70 J c) 0 J *+1 for each correct response, +1 for correct sig figs*

_/8 2) 42.9 K *+6 for correct numeric response, +1 for correct unit (K), +1 for correct sig figs*

_/4 3) T^2L^1 *+2 for each correct portion of response (i.e. +2 for T2, +2 for L1); accept "T2L"*

_/6 4) 527.67 °R 6.6 °N *+3 for each correct response*

_/5 5) Ice water and ammonium chloride *All or nothing credit*

_/8 6) a) T_A 200 K T_B 400 K T_C 200 K b) Isothermal compression *+1 for each correct number in part A, +1 for correct units; all or nothing credit for part B (4 points)*

_/2 7) 20% *All or nothing credit; accept "0.2"*

_/8 8) 1→2) Adiabatic 2→3) Isothermal 3→4) Adiabatic 4→1) Isothermal *+2 per correct response*

_/2 9) 2 and 4 *+1 for each correct response*

_/5 10) 282 kJ *+4 for answer, +1 for units and sig-figs*

_/5 11) James Joule *All or nothing credit*

_/4 12) Hermann von Helmholtz *All or nothing credit*

_/5 13) Parmenides *All or nothing credit*

_/6 14) a) 20 Pa b) 4 sq m *+3 for each correct response; no credit for incorrect units*

_/4 15) Evangelista Torricelli *All or nothing credit*

_/4 16) -40° *All or nothing credit; accept answers without units or answers in C and/or F*

_/4 17) Leonhard Euler *All or nothing credit*

_/4 18) Deposition *All or nothing credit*

_/4 19) 66.1°C *+2 for correct numeric response, +1 for correct units and +1 for correct sig figs*

_/6 20) 17 °C 290 K 520 °R *+2 for each correct response*

Exam instructions: **Answer the following questions to the best of your ability. Use correct significant figures unless otherwise stated. Answers not using correct sig figs will suffer deduction of points. Express all answers in SI Units unless otherwise specified. Show all work in the space provided for credit. Partial credit will be awarded for correct work shown; it is to your advantage to show all work whenever possible. Good Luck!**

1. A thermodynamically isolated system does 80 J of work while simultaneously experiencing 100 J of work done on it and a net heat flow of 11.9503 calories into the system. Compute:
    a. The change in internal energy (ΔU) of the isolated system

    b. The change in internal energy (ΔU) of the environment

    c. The change in internal energy (ΔU) of the universe

2. A sphere has a radius of 5.00 cm and thermal expansion coefficient β of $1.40*10^{-4}$ K^{-1}. After changing the temperature of the sphere you observe the radius has increased to 5.01 cm. By how much did the temperature change?

3. Supposed in an experiment you discover a new quantity *B* such that $B = \frac{k_b T^3}{PN}$ where k_b is the Boltzmann constant (1.38×10^{-23} m^2 kg s^{-2} K^{-1}), T is temperature, P is pressure, and N is number of atoms. What are the dimensions of *B*?

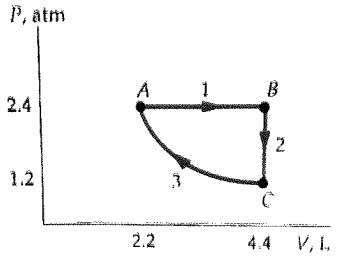
4. The water in a beaker is 20°C. What is this in °R and °N?

5. The initial Fahrenheit scale was first proposed in 1724 and used the temperature of what mixture to define 0 °F?

6. 0.32 mol of a monoatomic ideal gas follows the cyclic process below.

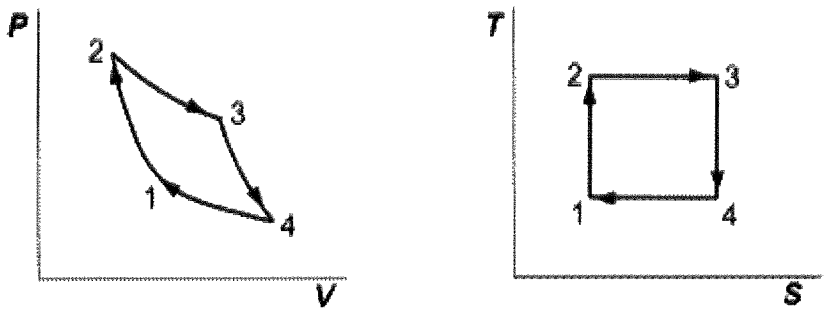
(A) What is the temperature of the gas at A, B, and C?

(B) What kind of process does the gas undergo from C to A?

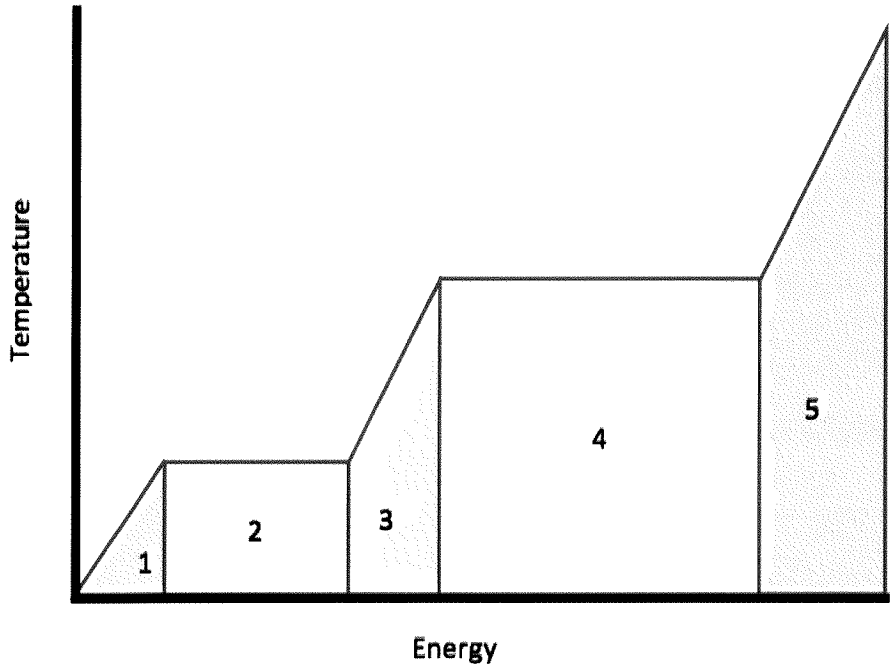


7. A certain heat engine absorbs 200J of energy from a hot reservoir and does work while releasing 160J to a cold reservoir. What is the efficiency of this engine?

8. What kind of processes are occurring from 1 → 2, 2 → 3, 3 → 4, and 4 → 1 in the Carnot cycle below? Be sure you have given four responses.



9. Which number(s) correspond to a phase change in the diagram below? (list all that apply).



10. A mixture contains 50g of water and 50g of ice. How much energy is required to convert this to steam? (Use 334 J/g, 4.186 J/g°C, and 2230 J/g for the latent heat of fusion, specific heat, and latent heat of vaporization for water, respectively).

11. This scientist contributed significantly to the field of thermodynamics, but arguably his greatest contribution was the proof of the interrelation between work and heat, now called "mechanical equivalent of heat."

12. This scientist's first major contribution to research was a treatise on conservation of energy in 1847. He proposed that light, heat, magnetism, electricity, and mechanical force were all manifestations of the same basic energy that changed forms. He also contributed significantly to our understanding of nerve physiology.

13. This ancient Greek philosopher proposed that "nature abhors a vacuum," a statement that greatly influenced thermodynamics and the invention of several devices, including the steam engine and the barometer.

14. A 200 N force is applied to a 10 square meter piston head.
    (A) State the pressure experienced by the piston.
    (B) State the piston head area required to ensure a 50 Pa pressure is experienced by the piston head if the same 200 N force is applied.

15. Who is credited with inventing the world's first Mercury barometer and then using it to prove atmospheric pressure exists?

16. At what temperature do the Fahrenheit and Celsius scales equal?

17. This student of Johann Bernoulli helped devise a mathematical definition of entropy as a state function. He also contributed substantially to other fields of mathematics.

18. What is the process of a gas transitioning to a solid called?

19. You measure a calorimeter of 520. grams water (specific heat 4.184 J/(g K)) to be at 55.0 ˚C and a piece of aluminum (specific heat 0.921 J/(g K)) to have mass .250 kg. After placing the Aluminum in the water, you notice the water rise to 62.0˚C. What was the initial temperature of the aluminum?

20. You measure a beaker of water to be 63 ˚F. What is this temperature in ˚C, K, and ˚R?