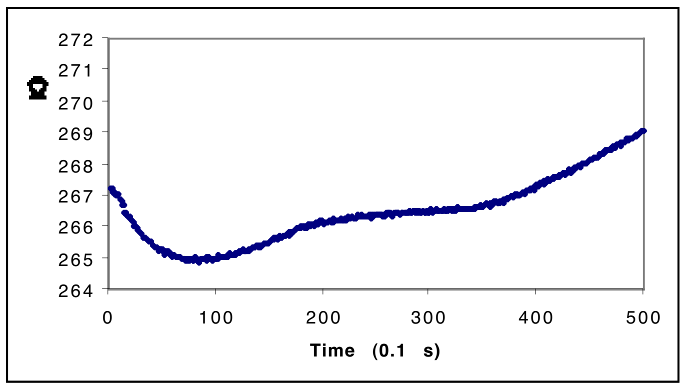
Physics 2110 Final Exam **Name:**
December 13, 1999

For all multiple choice questions **circle the letter corresponding to the best answer.**

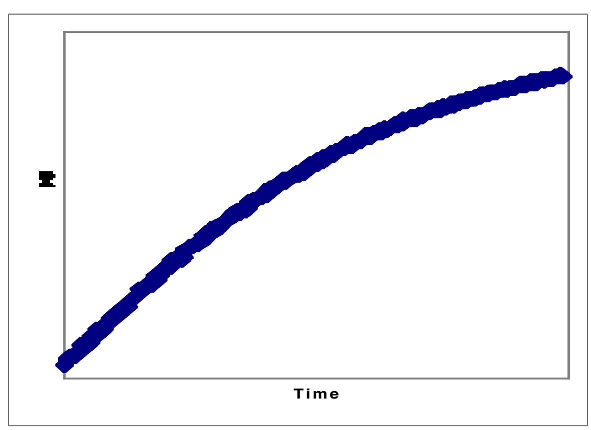
Question 1-7 refer to the Lab "Thermal Equilibrium"

1. One room temperature cylinder and one cold cylinder are placed in thermal contact—but **not** inside the Styrofoam container. The initial temperatures of the cylinders are measured to be 20˚C and 0˚C, respectively. The temperature at which the two cylinders come into equilibrium will be (a) about 10˚C, (b) a few degrees above 10˚C, (c) a few degrees below 10˚C, (d) none, because the two cylinders will never come into equilibrium if they are not in the Styrofoam container.

2. Equation (1) of the instructions states that $C_A \Delta T_A = -C_B \Delta T_B$. This is because (a) the entropy loss of A equals the entropy gain of B, (b) the internal energy loss of A equals the internal energy gain of B, (c) the process involved is adiabatic, (d) the process involved is isothermal.

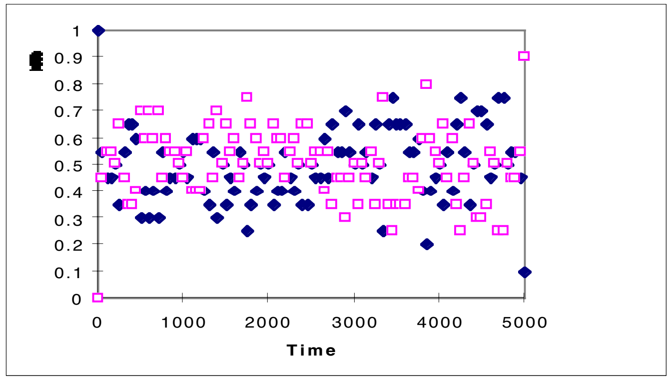


3. A warm and a cold cylinder are placed inside the Styrofoam container and temperature probes are then inserted. The figure to the right shows the record of one of the probes for the first 50 seconds after contact with its cylinder. (Note: temperature is in kelvins.) Which of the following best explains the shape of the curve? (a) The temperature reading is for the cold cylinder; the reading goes down at first because the temperature probe is initially warmer than the cylinder. (b) The temperature reading is for the cold cylinder; the reading goes down at first because heat flows from this cylinder to the warm cylinder for about ten seconds. (c) The temperature reading is for the warm cylinder; the reading rises after about ten seconds because heat flows into the container from the room. (d) The temperature reading is for the warm cylinder; the reading goes down at first farther than expected because the temperature probe is initially colder than the cylinder.

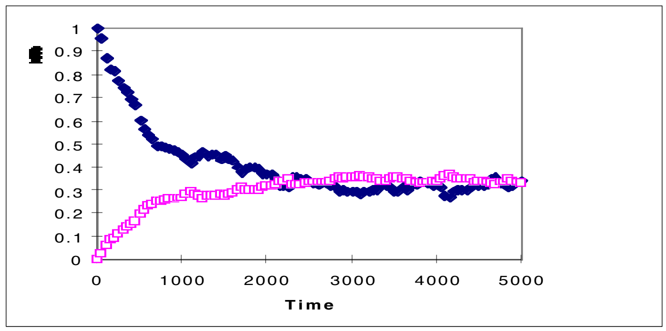


4. The figure to the right shows the total entropy of two cylinders that are in thermal contact as a function of time. What can be said about the temperatures of the two cylinders at the latest time shown? (a) They are equal because the slope of the curve at that time is positive. (b) They are equal because the area under the curve is positive. (c) They are **not** equal because the slope of the curve at that time is not zero. (d) Nothing, because entropy is unrelated to the temperatures of the cylinders.

5. The graph to the right shows output from HeatSim for a given simulation condition. Which of the following **best** describes what is seen? (a) The simulation used too many atoms for equilibrium to be reached in the time shown. (b) The fluctuations shown are very much like those seen in the actual measurement part of the lab. (c) Bodies A and B must have started at the same average energy per atom. (d) The simulation used a very small number of atoms.



6. The graph to the right shows another simulation using HeatSim. Which of the following **best** describes what is seen?
(a) Body A and body B both had about 200 atoms. (b) Body A (hot) had about 200 atoms and body B about 400 atoms.
(c) Body A (hot) had about 400 atoms and body B about 200 atoms. (d) Body A and body B both had about 400 atoms.



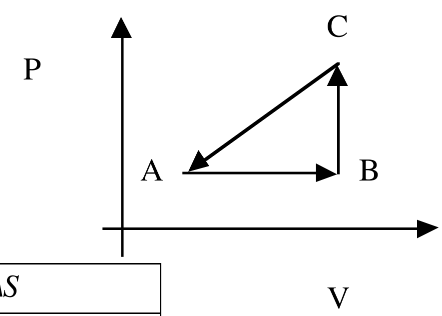
7. Body A and body B are in thermal contact and are in thermal equilibrium. Which of the following is true? In thermal equilibrium, (a) the total amount of energy due to atomic motion is the same in A as it is in B, (b) each of the atoms in A and in B have exactly the same amount of energy, at any instant, (c) the atoms in both A and B stop moving, (d) the average amount of energy transferred by atomic collisions from A to B is the same as the average amount transferred from B to A from instant to instant.

8. Two closed containers both contain 1 mole of the same ideal gas. The gas in container A has a volume of 1 liter and a pressure of 1 atm. The gas in container B has a volume of 1/2 liter and a pressure of 2 atm. When the containers are placed in good thermal contact with each other which of the following changes occur? (a) The pressure in A increases. (b) The pressure in B increases. (c) There are no changes in either container. (d) There isn't enough information to determine what happens.

9. The Zeroth Law of Thermodynamics concerns bodies A, B, and C, and the relation "is in thermal equilibrium with." Suppose each of the following relations is substituted for "is in thermal equilibrium with." For which relation will the Zeroth Law fail? (a) "communicates via email with," (b) "is as tall as," (c) "works in the same building with," (assume one job for each), (d) "owns the same model car as" (assume one car for each).

10. A closed system interacts with its surroundings. For which of the following is $\Delta U > 0$?
(a) $W = -500$ J, $Q = 0$, (b) $W = +500$ J, $Q = +300$ J, (c) $W = +100$ J, $Q = +100$ J,
(d) $W = -100$ J, $Q = -100$ J.

11. The figure to the right shows a *P-V* diagram in which an ideal gas goes from state A to state A in a reversible cycle via the processes A→B, B→C, C→A. In each entry of the following table insert +, –, or 0 to indicate the sign of the associated quantity.



	ΔU	Q	W	ΔS
A→B				
B→C				
C→A				
Total				

12. You want to raise the temperature of an ideal gas to a maximum value with a fixed Q joules of heat. Which of the following is the best process for doing so? (a) Hold the volume constant. (b) Hold the pressure constant. (c) Hold the internal energy constant. (d) Is doesn't matter because all processes will yield the same final temperature.

13. Two different reversible processes connect the same two equilibrium states. Which of the following **must** be the same for the two processes? (a) ΔU and ΔT, (b) Q and W, (c) Q and ΔT, (d) ΔU and W.

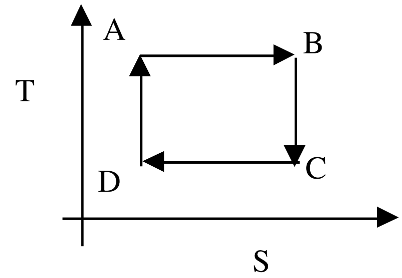
14. In the following table check (√) the boxes of those quantities that **must** be zero in the respective reversible process. Assume the system is an ideal gas.

	isobaric	isothermal	isochoric	adiabatic
ΔU				
ΔT				
ΔP				
ΔV				
ΔS				
Q				
W				

15. A heat engine extracts 60,000 J of heat from a reservoir at temperature 600 K, does 45,000 J of work, and delivers 15,000 J of heat to a reservoir at temperature 300 K. This engine (a) 75% efficient, (b) is 50% efficient, (c) violates the First Law of Thermodynamics, (d) violates the Second Law of Thermodynamics.

16. A heat engine extracts 60,000 J of heat from a reservoir at temperature 600 K, does 15,000 J of work, and delivers 45,000 J of heat to a reservoir at temperature 300 K. This engine (a) is a Carnot engine, (b) operates in an irreversible cycle, (c) violates the First Law of Thermodynamics, (d) violates the Second Law of Thermodynamics.

Questions 17-20 refer to: The figure to the right is a *T-S* diagram for a Carnot cycle. During A→B, the *magnitude* of the heat flow is 10,000 J. During C→D the *magnitude* of the heat flow is 6,000 J. The temperature of state A is 500 K and the entropy of state A is 100 J/K.



17. The entropy of state B is (a) 200 J/K, (b) 120 J/K, (c) 80 J/K, (d) 20 J/K.

18. The net work done per cycle by this engine is (a) 10,000 J, (b) 6,000 J, (c) 4,000 J, (d) 500 J.

19. The temperature of state D is (a) 200 K, (b) 300 K, (c) 500 K, (d) 833 K.

20. The entropy change per cycle of the engine substance plus the two heat reservoirs is (a) 0, (b) +20 J/K, (c) +40 J/K, (d) −20 J/K.

21. An ideal gas in an insulated container undergoes a **free expansion**. During this process which **one** of the following is **not** zero for the gas? (a) Q, (b) W, (c) ΔU, (d) ΔS.

22. Living cells constitute a low entropy state of matter. Living cells (a) violate the Second Law of Thermodynamics, (b) can exist because they help increase the entropy of the rest of the universe, (c) are not subject to physical laws like thermodynamics, (d) demonstrate that the laws of thermodynamics are incomplete.

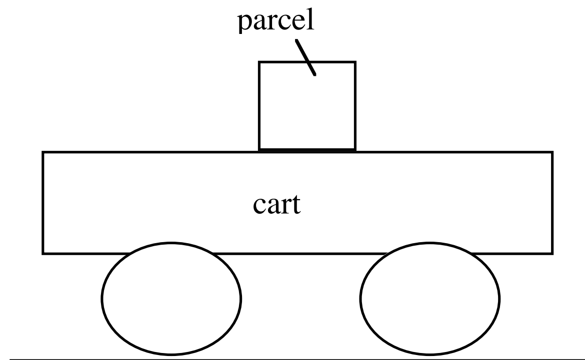
23. A car weighing 10,000 N initially traveling at 30 m/s crashes into a 100 N garbage can, initially at rest, sending it flying. During the time the car is in contact with the can it exerts a force of 3000 N on the can. During the time of contact the can exerts (a) a force of 3000 N on the car, (b) a force considerably less than 3000 N on the car, (c) a force considerably greater than 3000 N on the car, (d) no force on the car.

24. A 50 kg astronaut in orbit can give a 10 kg wrench a speed of 10 m/s by throwing it. The speed the astronaut will recoil with after doing so will be (a) 0 m/s, (b) 2 m/s, (c) 10 m/s, (d) 50 m/s.

25. A mass weighing 10 N is initially at rest on a vertical spring that is compressed by 0.1 m. When released, the mass accelerates upward, leaves the spring and eventually reaches a height of 0.9 m above the spring. The work done by the spring on the mass is (a) −10 J, (b) +1 J, (c) +9 J, (d) +10 J.

26. The Space Shuttle orbits the Earth in a circular orbit at an altitude of 300 km. The Shuttle's mass is 10^6 kg. The period of the orbit is about 5000 s. The radius of the Earth is $6.4\text{x}10^3$ km and its mass is $6\text{x}10^{24}$ kg. The acceleration of the Shuttle is (a) zero because its speed is constant, (b) about 0.01 m/s^2, (c) about 10 m/s^2, (d) about $8\text{x}10^3$ m/s.

27. A cart carries a parcel as shown in the figure to the right. The parcel is not lashed down. The mass of the parcel is M and the mass of the cart is $5M$. The cart is traveling to the right and is slowing down. As the cart slows, the parcel doesn't slip over the surface of the cart.



Draw free body diagrams for the parcel and for the cart, labeling each force and the body that is responsible for the force. The relative sizes of the forces should be qualitatively correct.

parcel

cart

28. In the following problem, assume that Q_{in}, Q_{out}, and W are all positive numbers. In each cycle, engine A receives Q_{in} amount of heat, does W amount of work, and rejects Q_{out} amount of heat. In each cycle, engine B receives $5Q_{\text{in}}$ amount of heat, does $3W$ amount of work, and rejects $2Q_{\text{out}}$ amount of heat. Which engine has the higher efficiency? (The engines don't necessarily operate between the same sets of reservoirs.) To answer fill in the following parts. **For full credit show all steps.**

(a) What is the internal energy change of engine A in one cycle?

(b) Using the First Law of Thermodynamics, express W (the work done by A) in terms of Q_{in} (heat into A) and Q_{out} (heat out of A).

Therefore, $W =$

(c) What is the internal energy change of engine B in one cycle?

(d) Using the First Law of Thermodynamics, express $5W$ (the work done by B) in terms of $3Q_{\text{in}}$ (heat into B) and $2Q_{\text{out}}$ (heat out of B).

Therefore, $5W =$

(e) Solve the equations in (b) and (d) simultaneously to show that $Q_{\text{in}} = 3W$.

(f) Determine a numerical value for the efficiency of A. (A fraction will do.)

(g) Determine a numerical value for the efficiency of B. (A fraction will do.)