Physics

Thermodynamics Homework

1. Name three very different kinds of internal energy that an object can possess.
2. Which has more internal KE, a swimming pool at 22°C or a pot of water at 100°C?
3. Explain the difference between internal KE and external KE.
4. Suppose we decide to use a large, insulated hot air balloon to lift a 4 kg weight. We add 500 calories of heat to the balloon, the heat causes the air inside to expand, and this lifts our weight exactly 10 meters off the ground. If it takes 100 calories to lift a 4kg weight 10 meters into the air, then by how much has the internal energy of the balloon itself increased in the meantime?
5. Inside a steam engine, a piston is forced to move by the expansion of hot water vapor. Suppose that each time this happens, the piston does 1200 calories of useful work (moving the engine forward), and 1000 calories of heat are released to the environment. Does the internal energy of the water vapor change as it expands? If so, by how much? If not, explain why.
6. If you vigorously shake a can of liquid back and forth for more than a minute, will the temperature of the liquid increase, decrease, or stay the same? Explain why.
7. A baseball player on first is trying to steal second base. He's running at full speed, but then slides to a complete stop at second. Where did the external KE go?
8. An electric motor gets warm when you use it. Explain what's happening to the electric potential energy. Is it all going to the same place?
9. When you pump up a tire with a bicycle pump, the cylinder of the pump gets hot. One reason for this is the friction between the piston and the walls of the cylinder. Explain another reason why the cylinder gets hot.
10. Suppose that 20°C air over Sacramento is blown by the wind to Nevada City, approximately 800 meters higher than it was before. Assuming the wind blows fast enough that the air doesn't have time to mix with any other air or exchange any heat with the ground, what will its temperature be now?
11. Imagine a giant dry cleaner's garment bag full of air at a temperature of -10°C floating like a balloon with a string hanging from it 6 km above the ground. If you were able to yank the bag suddenly to the ground, what would its approximate temperature be now?
12. Suppose that during the compression stroke, a diesel engine's piston does 400 calories of work compressing the air/fuel mixture inside the cylinder, and that this is a perfectly adiabatic process. How much heat will be lost to the environment? Will the internal KE of the air/fuel mixture change? If so, by how much?
13. Suppose that during the power stroke in the same engine, 400 calories of chemical energy are converted into internal KE, and that the expanding gas cools to its original temperature (before the compression stroke) as it moves the piston. Assuming this process is also perfectly adiabatic, how much work will the piston do as a result?

14. An air conditioner has two sets of coils, one just after the coolant is compressed and one in which the coolant is expanded. Which set of coils gets hot as a result? Which set gets cold?
15. Explain the direction of heat flow near each set of coils in **Question #14**. Which experiences more (faster) heat flow? What accounts for the difference between them, given the First Law of Thermodynamics?
16. Is it possible to convert mechanical work completely into heat? Is it possible to convert heat energy completely into mechanical work?
17. If in an isolated system 100 Joules of heat energy flowed from a cold object into a nearby hot object, which law(s) would this experiment appear to violate? How about if 100 Joules of kinetic energy were somehow converted into 120 Joules of heat?
18. What is the mechanical efficiency of an internal combustion engine that converts 2500 Joules of chemical energy to heat and then does 1750 Joules of work pumping water?
19. Combustion inside a car engine takes place at about 2000°K. What would the maximum efficiency of such an engine be if the exhaust gases are expelled at 500°K? What would the maximum efficiency be if you ran this engine inside a 2000°K oven?
20. Are cars more efficient on hot days or on cold days? Justify your answer.
21. As the temperature differential between the heat source and the heat sink approaches zero, what does the Carnot efficiency approach?
22. Which is larger, the Carnot efficiency or the actual mechanical efficiency of an expensive and well-designed commercial aircraft's turbofan jet engine?
23. Carefully explain why it's better for the water vapor in a steam engine to be as hot as possible.
24. What essential difference makes a steam turbine system more efficient than a simple steam locomotive? The extra component loses energy due to a phase change, so how could this possibly increase the efficiency?
25. Explain why leaving your refrigerator door open will actually heat up your kitchen.
26. Water placed in your freezer becomes more ordered as it freezes into ice crystals. Does this violate the principle of entropy? Explain why or why not.
27. Give two examples of systems that spontaneously increase their entropy.
28. Give two examples of systems that seem to become more ordered, and explain why neither violates the entropy principle.
29. Suppose you're watching a video of a chef mixing flour and water in a bowl. How can you tell whether the video is being played forward or backward? What does this have to do with entropy?