Thermodynamics Unit - Chpt. 10 - 12

Thermal Expansion of Solids and Liquids

10. A cylindrical brass sleeve is to be shrink-fitted over a brass shaft whose diameter is 3.212 cm at 0°C. The diameter of the sleeve is 3.196 cm at 0°C. (a) To what temperature must the sleeve be heated before it will slip over the shaft if the coefficient of linear expansion for brass is $19 \times 10^{-6}\ °C^{-1}$? (b) Alternatively, to what temperature must the shaft be cooled before it will slip into the sleeve?

11. The New River Gorge bridge in West Virginia is a 518-m-long steel arch. How much will its length change between temperature extremes of –20°C and 35°C if the coefficient of linear expansion for steel is $11 \times 10^{-6}\ °C^{-1}$?

12. A grandfather clock is controlled by a swinging brass pendulum that is 1.3 m long at a temperature of 20°C. (a) What is the length of the pendulum rod when the temperature drops to 0.0°C? (b) Does the change in length of the rod cause the clock to run fast or slow (think pendulums)?

Section 10.4 Ideal Gas PV=nRT

27. One mole of oxygen gas is at a pressure of 6.00 atm and a temperature of 27.0°C. (a) If the gas is heated at constant volume until the pressure triples, what is the final temperature? (b) If the gas is heated so that both the pressure and volume are doubled, what is the final temperature?

28. A Hydrogen gas (H_2) is contained in an 8.0-L vessel at a temperature of 20°C and a pressure of 9.0 atm. (a) Determine the number of moles of gas in the vessel. (b) What is the mass of the hydrogen gas?

29. (a) An ideal gas occupies a volume of 1.0 cm^3 at 20°C and atmospheric pressure. Determine the number of moles of the gas in the container. (b) If the pressure of the 1.0-cm^3 volume is reduced to 1.0×10^{-11} Pa (an extremely good vacuum) while the temperature remains constant, how many moles of gas remain in the container?

Section 10.5 The Kinetic Theory of Gases

37. What is the average kinetic energy of a molecule of oxygen at a temperature of 300 K?

40. The temperature near the top of the atmosphere on Venus is 240 K. Find the rms speed of a hydrogen molecule (H_2) at that point in Venus's atmosphere.

Section 12.1 Work in Thermodynamic Processes

3. A container of volume 0.40 m^3 contains 3.0 mol of argon gas at 30°C. Assuming argon behaves as an ideal gas, find the total internal energy of the gas.

HOMEWORK 1 → QUESTIONS 10 – 12, 27 – 29, 37, & 40
HOMEWORK 2 → QUESTIONS 3, 5 – 8, & 10
HOMEWORK 3 → QUESTIONS 11, 13, 15, 16, 50, 51
HOMEWORK 4 → QUESTIONS 54, 23 – 25, 27 - 29

5. A gas expands from I to F along the three paths indicated in Figure P12.5. Calculate the work done *on* the gas along paths (a) IAF, (b) IF, and (c) IBF.

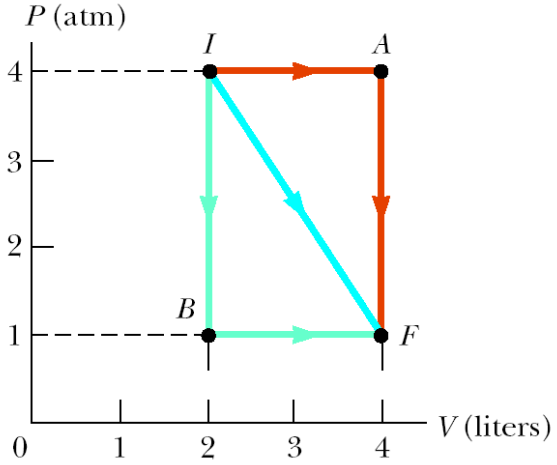

Figure P12.5 (Problems 5 and 15)

6. Sketch a PV diagram of the following processes: (a) A gas expands at constant pressure P_1 from volume V_1 to volume V_2. It is then kept at constant volume while the pressure is reduced to P_2. (b) A gas is reduced in pressure from P_1 to P_2 while its volume is held constant at V_1. It is then expanded at constant pressure P_2 to a final volume V_2. (c) In which of the processes is more work done *by* the gas? Why?

7. Gas in a container is at a pressure of 1.5 atm and a volume of 4.0 m^3. What is the work done *on* the gas (a) if it expands at constant pressure to twice its initial volume? (b) if it is compressed at constant pressure to one-quarter its initial volume?

8. A movable piston having a mass of 8.00 kg and a cross-sectional area of 5.00 cm^2 traps 0.200 moles of an ideal gas in a vertical cylinder. If the piston slides without friction in the cylinder, (a) how much work is done *on* the gas when its temperature is increased from 20°C to 300°C? (b) How much work was done *by* the gas?

10. (a) Determine the work done *on* a fluid that expands from i to f as indicated in Figure P12.10. (b) How much work is done *on* the fluid if it is compressed from f to i along the same path?

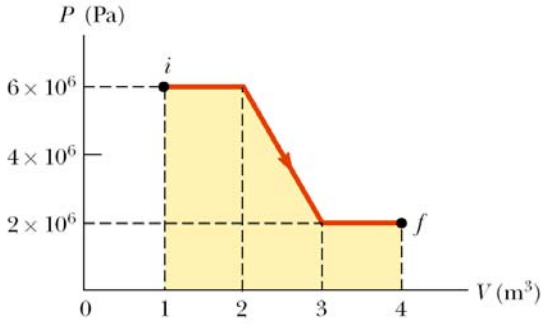

Figure P12.10

Section 12.2 The First Law of Thermo.

11. A container is placed in a water bath and held at constant volume as a mixture of fuel and oxygen is burned inside it. The temperature of the water is observed to rise during the burning. (The water is also held at constant volume. (a) Consider the burning mixture to be the system. What are the signs of Q, ΔU, and W? (b) What are the signs of these quantities if the water bath is considered to be the system?

13. A gas is compressed at a constant pressure of 0.800 atm from 9.00 L to 2.00 L. In the process, 400 J of energy leaves the gas by heat. (a) What is the work done *on* the gas? (b) What is the change in its internal energy?

15. A gas expands from I to F in Figure P12.5. The energy added to the gas by heat is 418 J when the gas goes from I to F along the diagonal path. (a) What is the change in internal energy of the gas? (b) How much energy must be added to the gas by heat for the indirect path IAF to give the same change in internal energy?

16. A gas is taken through the cyclic process described by Figure P12.16. (a) Find the net energy transferred to the system by heat during one complete cycle. (b) If the cycle is reversed—that is, the process follows the path *ACBA*—what is the net energy transferred by heat per cycle?

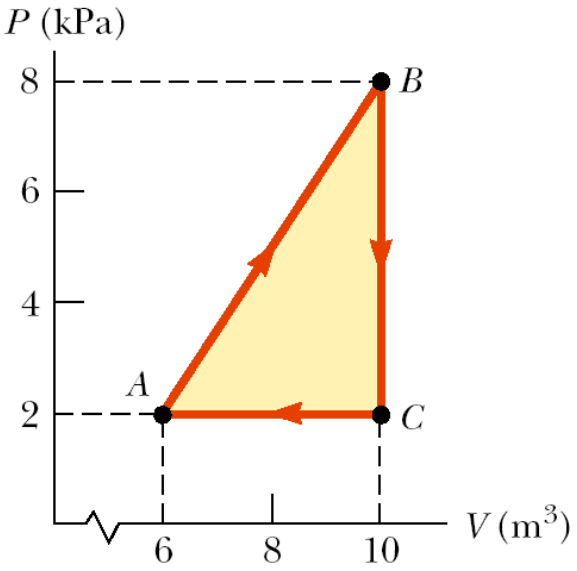

Figure P12.16

50. When a gas follows path 123 on the *PV* diagram in Figure P12.50, 418 J of energy flows into the system by heat and –167 J of work is done *on the gas*. (a) What is the change in the internal energy of the system? (b) How much energy *Q* flows into the system if the gas follows path 143? The work done on the gas along this path is –63.0 J. What net work would be done on or by the system if the system followed (c) path 12341? (d) Path 14321? (e) What is the change in internal energy of the system in the processes described in parts (c) and (d)?

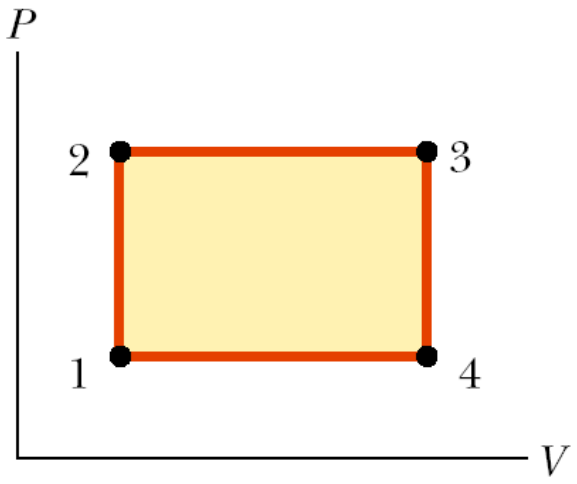

Figure P12.50

51. A substance undergoes the cyclic process shown in Figure P12.51. Work output occurs along path *AB* while work input is required along path *BC*, and no work is involved in the constant volume process *CA*. Energy transfers by heat occur during each process involved in the cycle. (a) What is the work output during process *AB*? (b) How much work input is required during process *BC*? (c) What is the net energy input *Q* during this cycle?

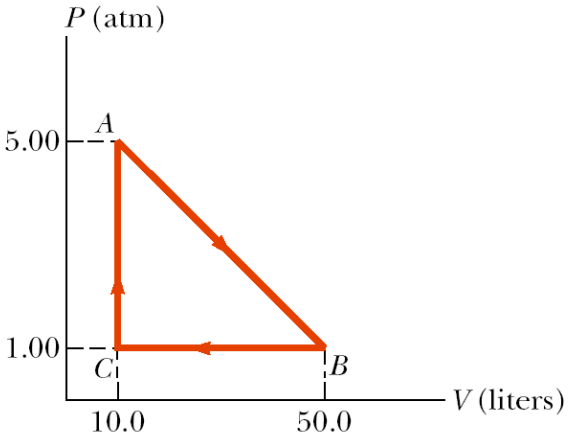

Figure P12.51

54. An ideal gas initially at pressure P_0, volume V_0, and temperature T_0 is taken through the cycle described in Figure P12.54. (a) Find the net work done *by* the gas per cycle in terms of P_0 and V_0. (b) What is the net energy Q added to the system per cycle? (c) Obtain a numerical value for the net work done per cycle for 1.00 mol of gas initially at 0°C. (*Hint:* Recall that the work done by the system equals the area under a PV curve.)

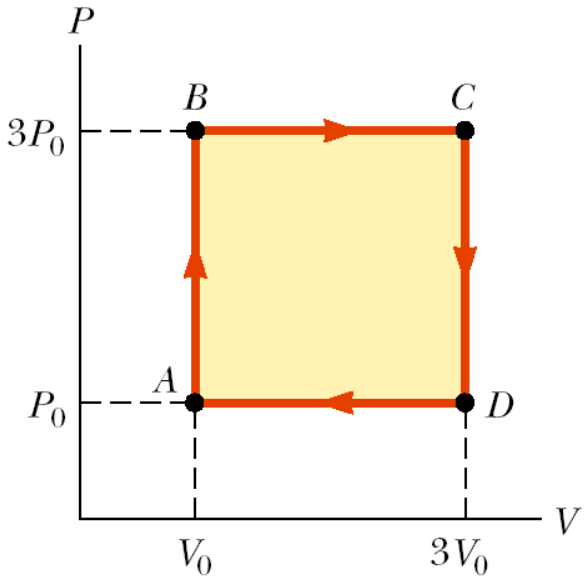

Figure P12.54

Section 12.3 Heat Engines and the Second Law of Thermodynamics

23. A heat engine operates between two reservoirs at temperatures of 20°C and 300°C. What is the maximum efficiency possible for this engine?

24. A steam engine has a boiler that operates at 300°F, and the temperature of the exhaust is 150°F. Find the maximum efficiency of this engine.

25. The energy absorbed by an engine is three times greater than the work it performs. (a) What is its thermal efficiency? (b) What fraction of the energy absorbed is expelled to the cold reservoir?

27. One of the most efficient engines ever built is a coal-fired steam turbine engine in the Ohio River valley, driving an electric generator as it operates between 1 870°C and 430°C. (a) What is its maximum theoretical efficiency? (b) Its actual efficiency is 42.0%. How much mechanical power does the engine deliver if it absorbs 1.40×10^5 J of energy each second from the hot reservoir?

Section 11.5 Energy Tranfer

28. Find the energy transferred in 1.00 h by conduction through a concrete wall 2.0 m high, 3.65 m long, and 0.20 m thick if one side of the wall is held at 20°C and the other side is at 5°C. (the thermal conductivity of concrete is 1.3 J/s·m·°C)

29. A wooden shelter has walls constructed of wooden planks 1.00 cm thick. If the exterior temperature is -20.0°C and the rate of rate of energy loss through the walls is 1000 W, what is the temperature inside? The walls have dimensions or 2.0 m by 2.0 m and the thermal conductivity of wood is 0.10 J/s·m·°C.