12.1 Thermodynamic Systems, States, and Processes

1. **MC** On a p–V diagram, a reversible process is a process (a) whose path is known, (b) whose path is unknown, (c) for which the intermediate steps are nonequilibrium states, (d) none of the preceding. (a)

2. **MC** There may be an exchange of heat with the surroundings for (a) a thermally isolated system, (b) a completely isolated system, (c) a heat reservoir, (d) none of the preceding. (c)

3. **MC** Only initial and final states are known for irreversible processes on (a) p–V diagrams, (b) p–T diagrams, (c) V–T diagrams, (d) all of the preceding. (d)

12.3 Thermodynamic Processes for an Ideal Gas

6. **MC** There is no heat flow into or out of the system in an (a) isothermal process, (b) adiabatic process, (c) isobaric process, (d) isometric process. (b)

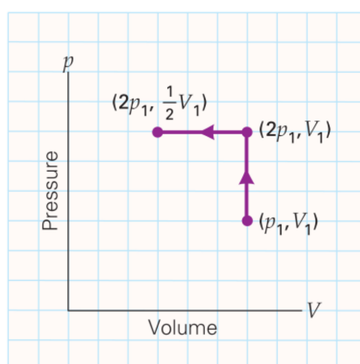
7. **MC** According to the first law of thermodynamics, if work is done on a system, then (a) the internal energy of the system must change, (b) heat must be transferred from the system, (c) the internal energy of the system must change and/or heat must be transferred from the system, (d) heat must be transferred to the system. (c)

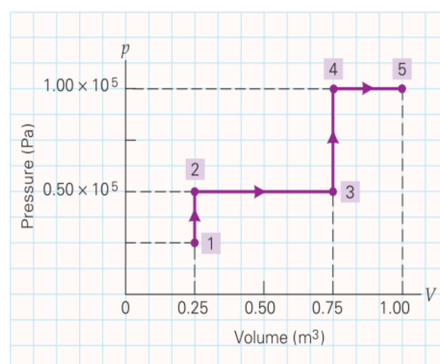
8. **MC** When heat is added to a system of ideal gas during an isothermal expansion process, (a) work is done on the system, (b) the internal energy decreases, (c) the effect is the same as for an isometric process, (d) none of the preceding. (d)

10. **CQ** In ▾ Fig. 12.20, the plunger of a syringe is pushed in quickly, and the small pieces of paper in the syringe catch fire. Explain this phenomenon, using the first law of thermodynamics. (Similarly, in a diesel engine, there are no spark plugs. How can the air–fuel mixture ignite?) see Solutions

16. ● While playing in a tennis match, you lost 6.5×10^5 J of heat, and your internal energy also decreased by 1.2×10^6 J. How much work did you do in the match? 5.5×10^5 J

21. **IE** ●● An ideal gas is taken through the reversible processes shown in >Fig. 12.22. (a) Is the overall change in the internal energy of the gas (1) positive, (2) zero, or (3) negative? Explain. (b) In terms of state variables p and V, how much work is done by or on the gas, and (c) what is the net heat transfer in the overall process? (a) (2) zero (b) $-p_1V_1$ (on the gas) (c) $-p_1V_1$ (out of the gas)





22. ●● A fixed quantity of gas undergoes the reversible changes illustrated in the p–V diagram in >Fig. 12.23. How much work is done in each process? 1–2: 0; 2–3: 2.5×10^4 J; 3–4: 0; 4–5: 2.5×10^4 J

25. **IE** ●● A gas is enclosed in a cylindrical piston with a 12.0-cm radius. Heat is slowly added to the gas while the pressure is maintained at 1.00 atm. During the process, the piston moves 6.00 cm. (a) This is an (1) isothermal, (2) isobaric, (3) adiabatic process. Explain. (b) If the heat transferred to the gas during the expansion is 420 J, what is the change in the internal energy of the gas? (a) (2) isobaric (b) 146 J

26. ●● A monatomic ideal gas $(\gamma = 1.67)$ is compressed adiabatically from a pressure of 1.00×10^5 Pa and volume of 240 L to a volume of 40.0 L. (a) What is the final pressure of the gas? (b) How much work is done on the gas? (a) 1.99×10^6 Pa (b) -8.30×10^4 J

28. **IE** ●●● One mole of ideal gas is compressed as shown on the p–V diagram in ▾ Fig. 12.24. (a) Is the work done by the gas (1) positive, (2) zero, or (3) negative? Why? (b) What is the work done by the gas? (c) What is the change in temperature of the gas? (a) (3) negative (b) -1.8×10^5 J (c) -4.8×10^4 K

12.4 The Second Law of Thermodynamics and Entropy

30. **MC** In any natural process, the overall change in the entropy of the universe could not be (a) negative, (b) zero, (c) positive. (a)

31. **MC** The second law of thermodynamics (a) describes the state of a system, (b) applies only when the first law is satisfied, (c) precludes perpetual motion machines, (d) does not apply to an isolated system. (c)

32. **MC** An ideal gas is compressed isothermally. The change in entropy for this process is (a) positive, (b) negative, (c) zero, (d) none of the preceding. (b)

37. **IE** ● 1.0 kg of ice melts completely into liquid water at 0°C. (a) The change in entropy of the ice (water) in this process is (1) positive, (2) zero, (3) negative. Explain. (b) What *is* the change in entropy of the ice (water)? (a) (1) positive (b) $+1.2\times10^{3}$ J/K

43. **IE ●●** A quantity of ideal gas undergoes a reversible isothermal expansion at 0°C and does 3.0×10^{3} J of work on its surroundings in the process. (a) Will the entropy of the gas (1) increase, (2) remain the same, or (3) decrease? Explain. (b) What is the change in the entropy of the gas? (a) (1) increases, $Q > 0$ (b) +11 J/K

44. **IE ●●** An isolated system consists of two very large thermal reservoirs at constant temperatures of 373 K and 273 K. Assume 1000 J of heat were to flow from the cold reservoir to the hot reservoir spontaneously. (a) The total change in entropy of the isolated system (both reservoirs) would be (1) positive, (2) zero, (3) negative. Explain. (b) Calculate the total change in entropy of this isolated system. (a) (3) negative (b) –0.98 J/K

47. **IE ●●●** A system goes from state 1 to state 3 as shown on the *T*–*S* diagram in ▾ Fig. 12.26. (a) The heat transfer for the process going from state 2 to state 3 is (1) positive, (2) zero, (3) negative. Explain. (b) Calculate the total heat transferred in going from state 1 to state 3. (a) (2) zero, $\Delta S = 0$ (b) 2.73×10^{4} J

12.5 Heat Engines and Thermal Pumps*

50. **MC** For a cyclic heat engine, (a) $\varepsilon > 1$, (b) $Q_h = W_{net}$, (c) $\Delta U = W_{net}$, (d) $Q_h > Q_c$. (d)

51. **MC** A thermal pump (a) is rated by thermal efficiency, (b) requires work input, (c) is not consistent with the second law of thermodynamics, (d) violates the first law of thermodynamics. (b)

52. **MC** Which of the following determines the thermal efficiency of a heat engine? (a) $Q_c \times Q_h$; (b) Q_c/Q_h; (c) $Q_h - Q_c$; (d) $Q_h + Q_c$. (b)

58. ● A gasoline engine has a thermal efficiency of 28%. If the engine absorbs 2000 J of heat per cycle, (a) what is the net work output per cycle? (b) How much heat is exhausted per cycle? (a) 5.6×10^{2} J (b) 1.4×10^{3} J

63. ●● A gasoline engine burns fuel that releases 3.3×10^{8} J of heat per hour. (a) What is the energy input during a 2.0-h period? (b) If the engine delivers 25 kW of power during this time, what is its thermal efficiency? (a) 6.6×10^{8} J (b) 27%

69. ●● An air conditioner has a COP of 2.75. What is the power rating of the unit if it is to remove 1.00×10^{7} J of heat from a house interior in 20 min? 3.0 kW

71. ●●● A gasoline engine has a thermal efficiency of 25.0%. If heat is expelled from the engine at a rate of 1.50×10^{6} J per hour, how long does the engine take to perform a task that requires an amount of work of 3.0×10^{6} J? 6.0 h

12.6 The Carnot Cycle and Ideal Heat Engines

74. **MC** The Carnot cycle consists of (a) two isobaric and two isothermal processes, (b) two isometric and two adiabatic processes, (c) two adiabatic and two isothermal processes, (d) four arbitrary processes that return the system to its initial state. (c)

75. **MC** Which of the following temperature-reservoir relationships would yield the highest efficiency for a Carnot engine: (a) $T_c = 0.15T_h$, (b) $T_c = 0.25T_h$, (c) $T_c = 0.50T_h$, or (d) $T_c = 0.90T_h$? (a)

76. **MC** For a heat engine that operates between two reservoirs of temperatures T_c and T_h, the Carnot efficiency is the (a) highest possible value, (b) lowest possible value, (c) average value, (d) none of the preceding. (a)

83. ● It has been proposed that temperature differences in the ocean could be used to run a heat engine to generate electricity. In tropical regions, the water temperature is about 25°C at the surface and about 5°C at very large depths. (a) What would be the maximum theoretical efficiency of such an engine? (b) Would a heat engine with such a low efficiency be practical? Explain. (a) 6.7% (b) probably not; see Solutions

Comprehensive Exercises

101. When cruising at 75 mi/h on a highway, a car's engine develops 45 hp. If this engine has a thermodynamic efficiency of 25% and 1 gal of gasoline has an energy content of 1.3×10^{8} J, what is the fuel efficiency (in miles per gallon) of this car? 20 mi/gal

* Consider efficiencies to be exact.