Answers to selected problems from Essential Physics, Chapter 14

1. When you are several km above the surface of the Earth, the pressure in the plane is substantially lower than it is at ground level. Thus, when you opened the bottle when you were in the plane, and the plane was high above the Earth, and then sealed the bottle again, the pressure inside the bottle was quite a bit lower than standard atmospheric pressure. When you are back at ground level, the atmospheric pressure applies inward directed forces to the bottle that are not balanced by the forces from the lower pressure in the bottle, pushing out, so the bottle tends to collapse. Note that this decrease in volume of the bottle increases the pressure inside the bottle.

3. The pressure is the same on both sides. If the pressure was higher on one side than the other, the piston would not be in equilibrium – it would experience a net force acting to move it toward the side that had lower pressure.

5. The pressure is higher in the lower section of the container. If you draw the free-body diagram of the piston, you can see that the upward force applied on the piston from below, associated with the pressure in the lower section, has to balance the weight of the piston plus the downward force associated with the pressure in the upper section. For everything to balance, the pressure in the lower section must be larger than the pressure in the upper section.

7. (a) $1 = 2 = 3$ (b) $1 > 2 > 3$

9. The average kinetic energy of the gas molecules should stay the same – there is no work being done. This means that we expect the temperature to remain the same. With the temperature remaining the same while the volume doubles, the pressure should be reduced by a factor of 2.

11. $2 > 1 = 3 > 4$

13. $P \times 293/283 = 1.04\ P$

15. $P_{atm} \times 293/373 = 0.79\ P_{atm}$

17. (a) 0.5 (b) 2.9

19. (a) Yes, if the numbers are all the same, such as (2,2,2,2), in which the average is 2 and the rms average is also 2. (b) No, the rms average of a set of numbers is always greater than or equal to the average of that set of numbers.

21. The ranking by pressure does not change with temperature – it just depends on the free-body diagram of the piston. In both Exercise 20 and 21, the ranking by pressure is $1 > 3 > 2$.

23. (a) $2 > 3 > 1$ (b) $2 > 3 > 1$

25. 2 > 3 > 1

27. (a) The pressure is 101.6 kPa (b) The piston's free-body diagram does not change, so the pressure remains the same. The absolute temperature increases by 14%, so the volume increases by 14% (coming from upward movement of the piston).

29. (a) The pressure is 101.0 kPa (b) 1.003 : 1

31. 24.2 cm

33. (a) As the pressure is reduced outside the cylinder, the piston in the cylinder will move up in the cylinder. (b) 47.5 kPa

35. 96.2 kPa

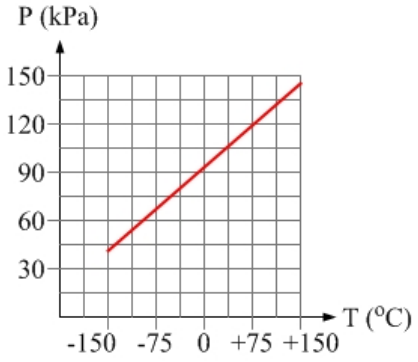
37. 1 : 2.25

39. (a) The pressure is the same in the two cylinders. The pressure is determined by the free-body diagram, which is the same in both cases. (b) The number of moles of gas is the same in each cylinder. The number of moles of gas can be determined by applying the ideal gas law. With the same pressure, volume, and temperature, the number of moles is the same.

41. (a) 7000 Pa (b) 7 : 1

43. (a) The volume decreases, so the work done by the gas is a negative quantity. If the change happens so quickly that there is no time for heat to be transferred, then, by the first law of thermodynamics, the change in internal energy must be a positive value. The change in internal energy is proportional to the temperature change, so the temperature change is positive – the temperature increases. (b) As the piston is moving, the average relative speed between the piston and the gas molecules that collide with the piston increases. The collisions with the piston are elastic, and a property of elastic collisions is that the magnitude of the relative speed between the colliding objects is the same before and after the collision. This means that the gas molecules have a higher speed, after the collision, when they collide with a piston that is moving toward them before the collision, than they do when they collide with a stationary piston. Giving the molecules more kinetic energy is consistent with raising the temperature.

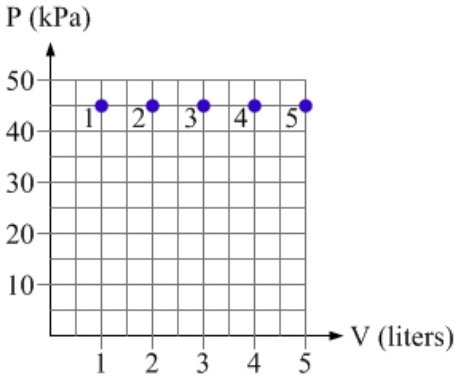
45. (a) 0.089 moles (b)



(c) The slope of the graph is equal to nR/V, which has a value of 346 Pa/K (or 0.346 kPa/K).

47. (a) 1.1 moles (b) 6.7×10^{23} atoms (c) 349 m/s (d) 394 m/s (e) 427 m/s

49. (a) The pressure in all five states is 45 kPa. (b)



(c) One example of a system in which the pressure remains constant is a cylinder that is sealed by a piston which is free to slide up or down without friction. Let's say that the system starts in state 1, with a temperature of 150 K. Heat can then be added to the system – this is done relatively slowly, so that the pressure is almost constant. The more heat is added, the higher the temperature gets.

51. (a) 2 > 3 > 1 > 4

(b) $T_1 = 16$ K, $T_2 = 48$ K, $T_3 = 24$ K, $T_4 = 8$ K

53. The pressures are equal.