

Part 1: Multiple Choice: Chose the single most correct response.

1. Which substance possesses the weakest forces of attraction between molecules?

- A. liquid water
- B. solid table sugar
- C. gaseous carbon dioxide
- D. liquid rubbing alcohol

2. If a substance is cooled down, which statement is true about its particles?

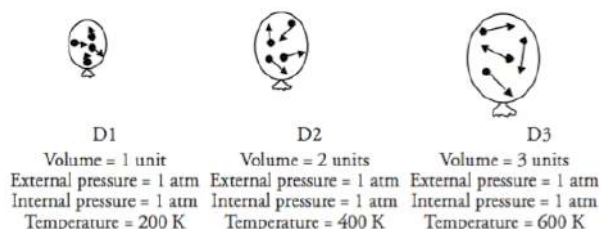
- A. The particles have less kinetic energy.
- B. The particles increase in mass.
- C. The particles are further apart.

3. Gas pressure is caused by ____.

- A. gas molecules colliding with surfaces
- B. gas molecules hitting other gas molecules
- C. gas molecules condensing to a liquid
- D. barometers

4. Which of the following statements does the figure demonstrate?

- A. Volume and temperature are directly related
- B. Temperature and pressure are directly related
- C. Pressure and volume are inversely related
- D. None of the above



5. What happens to the density of a solid when you heat it?

- A. It increases
- B. it stays the same
- C. it decreases

6. Which particles in a liquid are most likely to evaporate?

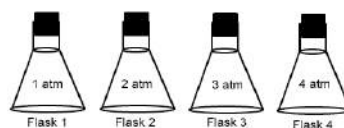
- A. The ones with the highest kinetic energy
- B. The ones on the surface
- C. The ones that vibrate so much that they overcome the attractive forces holding the particles together
- D. all of the above

7. Why does cold water sink to the bottom of the ocean?

- A. its molecules are smaller than hot water
- B. its molecules are closer than hot water
- C. it's attracted to the heat at the bottom of the ocean.
- D. all of the above are true.

8. Each of these flasks is the same size and at the same temperature. Which one contains the fewest molecules?

- A. Flask 1
- B. Flask 4
- C. Flask 3
- D. Flask 2



9. In which of the following substances do the particles have a higher average kinetic energy?

- A. 10 grams of liquid water at 80°C.
- B. 100 grams of liquid water at 70°C.
- C. 10 grams of solid copper at 90°C.
- D. 100 grams of solid copper at 70°C.

10. A block of copper metal is heated at its left side, so that the left side is warmer than the right. Which of the following is true about the two end of the block?

- A. The atoms of the left side are spaced further apart than those on the right.
- B. The atoms of the left side are moving faster than those on the right.
- C. The density of the copper is lower on the left side than on the right
- D. both A and B are true
- E. all of the above are true

11. Which of the following changes to a system will NOT result in an increase in pressure?

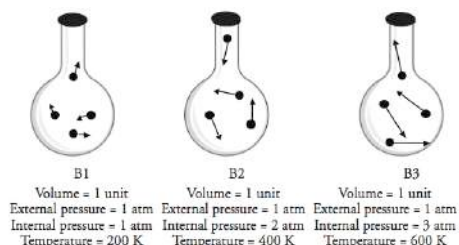
- A. Adding more gas molecules
- B. Raising the temperature
- C. Decreasing the volume of the container
- D. Increasing the volume of the container

12. Absolute zero is ____.

- A. -273.15°C .
- B. the lowest possible temperature.
- C. the temperature at which the average kinetic energy of particles would theoretically be zero.
- D. all of the above

13. Which of the following statements does the figure demonstrate?

- A. Volume and temperature are directly related
- B. Temperature and pressure are directly related
- C. Pressure and volume are inversely related
- D. None of the above



14. The escape of molecules from the surface of a liquid is called ____.

- A. boiling.
- B. evaporation.
- C. sublimation.
- D. condensation.

15. If the volume of a gas is doubled while the Kelvin temperature is held constant, then the pressure of the gas should

- A. remains unchanged.
- B. is doubled.
- C. is reduced by one half.
- D. depends on the kind of gas.

16. As the temperature of the gas in a balloon decreases

- A. the volume increases.
- B. the pressure increases.
- C. the average kinetic energy of the gas particles decreases.
- D. All of the above are true.

17. Which of these would increase the pressure? Circle all that apply.

- A. Adding more gas to the container
- B. Increasing the temperature of the gas in the container.
- C. Increasing the volume of the container

18. Which of the following statements explains the warning label (within the dashed box) on aerosol cans like the one to the right?

- A. Volume and temperature are directly related
- B. Temperature and pressure are directly related
- C. Pressure and volume are inversely related
- D. None of the above



19. Increasing the volume of a given amount of gas at constant temperature causes the pressure to decrease because ____.

- A. the molecules are striking a larger area with the same force.
- B. there are fewer molecules.
- C. the molecules are moving more slowly.
- D. there are more molecules.

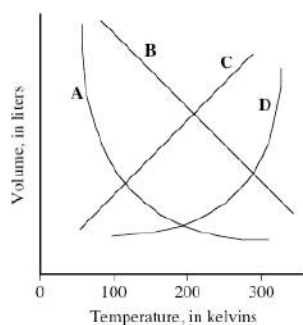
20. Which of these changes would not cause an increase in the pressure of a contained gas?

- A. Another gas is added to the container.
- B. Additional amounts of the same gas are added to the container.
- C. The temperature is increased.
- D. The gas is moved to a larger container.

21. If the temperature of a gas in a closed container increases

- A. the pressure of the gas decreases.
- B. the average kinetic energy of the molecules decreases.
- C. the molecules collide with the walls of the container less frequently.
- D. the pressure of the gas increases.

22. Which of the following graphs represents the relationship between the volume and temperature of an Ideal gas? **C**



23. At constant pressure, the volume of a gas and its Kelvin temperature are said to be ____

A. directly related

B. inversely related

C. unrelated.

D. constant.

24. Which of the following terms best describe the relationship between pressure and temperature at constant volume?

A. inversely related

B. directly related

C. complimentary

D. no relationship

25. Which unit of measurement is directly proportional to the average kinetic energy of particles of a substance?

A. Atmosphere

B. Kelvin

C. Fahrenheit

D. Pascal

26. When using the combined gas law for calculations, correct units for V and T could include which of the following?

A. ml and K

B. L and C

C. atm and K

D. kPa and C

Part 2: Free Response. Be as complete as possible. For all calculation work, show units on all values.

27. Based on the diagram of balloons filled with helium gas at right,

A. Which balloon has a higher temperature? **same temp**

B. Explain your answer to part A:

Length of vector arrows indicate the speed of particles. The vector lengths are the same for both balloons, so the speed and temperature of the particles are the same in each balloon.



E2



E3

C. Which balloon has a higher internal pressure (pressure inside the balloon)? **E2**

D. Explain your answer to part C:

Both balloons are at the same temperature and have the same number of particles. But E2 has a smaller volume than E3. Pressure and volume are inversely related. The balloon with the smaller volume, has a higher internal pressure.

28. The diagram at right shows three balloons filled with helium gas. They may be in different environments: at different temperatures and different external pressures (external pressure is the pressure outside the balloon).

A.

B.

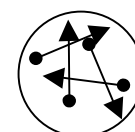
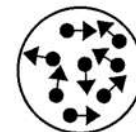
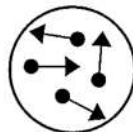
C.

A. In which balloon is the temperature the highest? **C**

B. In which balloon is the temperature lowest? **B**

C. Explain your answers to parts D and E

Length of vector arrows indicate the speed of particles. C has the longest vectors and thus highest temperature. B has the shortest arrows and thus the lowest temperature



29. The combined gas law is given as: $\frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$ Solve that equation symbolically for T1:

$$\frac{P_1 \cdot V_1 \cdot T_2}{P_2 \cdot V_2} = T_1$$

30. 10.0 L of propane gas is released from a container at a pressure of 5.20 atm and 18.0 °C into a different container having a volume of 20.0 L and a pressure of 1.50 atm. What is the temperature of the propane in the new container?

$$\begin{aligned}
 V_1 &= 10.0 \text{ L} & V_2 &= 20.0 \text{ L} & T_2 &= \frac{P_2 \cdot V_2 \cdot T_1}{P_1 \cdot V_1} \\
 P_1 &= 5.20 \text{ atm} & P_2 &= 1.50 \text{ atm} \\
 T_1 &= 18.0^\circ\text{C} & T_2 &= ? \\
 &= \frac{273}{291 \text{ K}} & & & & T_2 = 291 \text{ K} \times \frac{1.50 \text{ atm}}{5.20 \text{ atm}} \times \frac{20.0 \text{ L}}{10.0 \text{ L}} = 168 \text{ K} \\
 & & & & & \text{P decreases, T decreases and V increases}
 \end{aligned}$$

31. A gas in a rigid container exerts a pressure of 75.0 kPa at a temperature of -20.0 °C. At what temperature would it exert a pressure of 112 kPa? Assume the volume remains constant.

$$\begin{aligned}
 P_1 &= 75.0 \text{ kPa} & P_2 &= 112 \text{ kPa} & \frac{P_1}{T_1} &= \frac{P_2}{T_2} & T_2 &= \frac{P_2 \cdot T_1}{P_1} \\
 T_1 &= -20.0^\circ\text{C} & T_2 &= ? \\
 &= \frac{273}{253 \text{ K}} & & & & T_2 = 253 \text{ K} \times \frac{112 \text{ kPa}}{75.0 \text{ kPa}} = 378 \text{ K} \\
 & & & & & \text{As P increases then T increases}
 \end{aligned}$$

32. A balloon full of helium has a volume of 21.0 L at a temperature of 5.0 °C. What will be the volume of the balloon if the balloon is heated to 88.0 °C? Assume the pressure remains constant.

$$\begin{aligned}
 V_1 &= 21.0 \text{ L} & V_2 &= ? & \text{As } T \uparrow \text{ then } V \uparrow & \frac{V_1}{T_1} &= \frac{V_2}{T_2} & V_2 &= \frac{V_1 \cdot T_2}{T_1} \\
 T_1 &= 5.0^\circ\text{C} & T_2 &= 88^\circ\text{C} \\
 &= \frac{273}{278 \text{ K}} & & & & & & & V_2 = 21.0 \text{ L} \times \frac{361 \text{ K}}{278 \text{ K}} = 27.3 \text{ L} \\
 & & & & & & & & \text{As } T \uparrow \text{ then } V \uparrow
 \end{aligned}$$

33. A container of propane is filled with gas at a volume of 1.00 L at a pressure of 5.20 atm. What volume of container would be required to hold the same amount of gas at atmospheric pressure (1.0 atm)? Assume the temperature remains constant.

$$\begin{aligned}
 V_1 &= 1.00 \text{ L} & V_2 &= ? & P_1 V_1 &= P_2 V_2 \\
 P_1 &= 5.20 \text{ atm} & P_2 &= 1.0 \text{ atm} & V_2 &= \frac{P_1 \cdot V_1}{P_2} \\
 & & & & & \text{As } P \downarrow \text{ then } V \uparrow \\
 & & & & & V_2 = 1.00 \text{ L} \times \frac{5.20 \text{ atm}}{1.0 \text{ atm}} = 5.2 \text{ L}
 \end{aligned}$$