## 60 The Pressure Law ♡



In this situation, the volume is fixed (we use a rigid container). The gas is heated, and the pressure increases.

As the temperature of the gas goes up, the average speed and kinetic energy of the molecules increases.

This means that each second, more molecules hit each container wall, and also that on each collision there is a greater velocity (or momentum) change for the molecule, leading to a greater force on the wall.

The equation is

$$\frac{p_{\text{after}}}{T_{\text{after}}} = \frac{p_{\text{before}}}{T_{\text{before}}}$$

where $T$ must be in kelvins.

Example – Starting with some gas at $20.0\,^{\circ}\text{C}$ at a pressure of $101$ kPa and heating it to $100\,^{\circ}\text{C}$, what is the new pressure if the gas' volume is fixed?

1st stage: convert the temperatures to kelvins.

$$20.0\,^{\circ}\text{C} + 273 = 293\text{ K} \qquad 100\,^{\circ}\text{C} + 273 = 373\text{ K}$$

2nd stage: put the numbers into the equation.

$$\frac{p_{\text{after}}}{373\text{ K}} = \frac{101\text{ kPa}}{293\text{ K}}$$

3rd stage: rearrange the equation so that the thing you want to know is the subject, and calculate it.

$$p_{\text{after}} = 101\text{ kPa} \times \frac{373}{293} = 129\text{ kPa}$$

4th stage: put the temperatures back in °C if necessary (not needed here).

60.1 I start with some gas at 30 °C at a pressure of 101 kPa and heat it to 200 °C. What will the new pressure be if I don't let the gas expand?

60.2 I start with some gas at −20 °C, at a pressure of 101 kPa, and heat it until the pressure is 202 kPa without letting it expand. What will the new temperature be?

60.3 A cylinder of compressed gas is at a temperature of 23 °C. It is cooled until it reaches a pressure of 2 000 kPa. It has to be cooled to 90 K before this happens. Calculate the starting pressure of the gas.

60.4 Work out the missing measurements from the following table, where each row is a separate question.

| $P_{\text{before}}$ | $T_{\text{before}}$ | $P_{\text{after}}$ | $T_{\text{after}}$ |
|---|---|---|---|
| 101 kPa | 300 K | (a) | 600 K |
| 101 kPa | −23.0 °C | 505 kPa | (b) |
| 10.1 kPa | (c) | 101 kPa | 300 K |
| (d) | −183 °C | 50.0 kPa | 23.0 °C |

60.5 If gas at atmospheric pressure (101 kPa) and at 300 K is heated at constant volume to increase its pressure by 10%, what is the new temperature?

60.6 What is the percentage decrease in pressure when air at 15 °C is cooled to −5.0 °C at constant volume?

60.7 A rigid container risks rupturing if the pressure of the air within it rises above 230 kPa. It initially contains air at 110 kPa and 15 °C, and is sealed. What is the maximum temperature to which the air can be heated without risk of rupture?

60.8 Give the two reasons why the pressure of a gas goes up when it is heated in a closed container.

60.9 What is the special name for the temperature of −273 °C?