In the diagram above a fixed amount (mol) of gas is trapped in round-bottomed flask. The flash, which is submerged in a beaker of ice is then taken out and placed into a beaker of hot water. The pressure change is recorded.

3.1 monometer is a devide used to measure gas pressures

3.2 atmospheric pressure (called 1 atm) = 101,325 kPa

3.3 As the temperature on the round-bottomed flask increases the pressure on the gas will increase

Thus the temperature (in Kelvin) is directly proportional to the pressure on the gas.

3.4 T α P

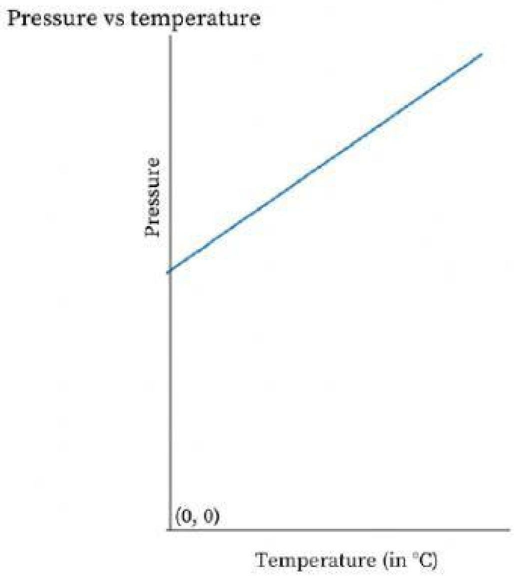
3.5 This can true if the volume and no of mol of gas remains constant.

3.6 stated above

Graph:

Temperature (°C)	Pressure (kPa)
0	67.1
50	77,5
100	88

3.7



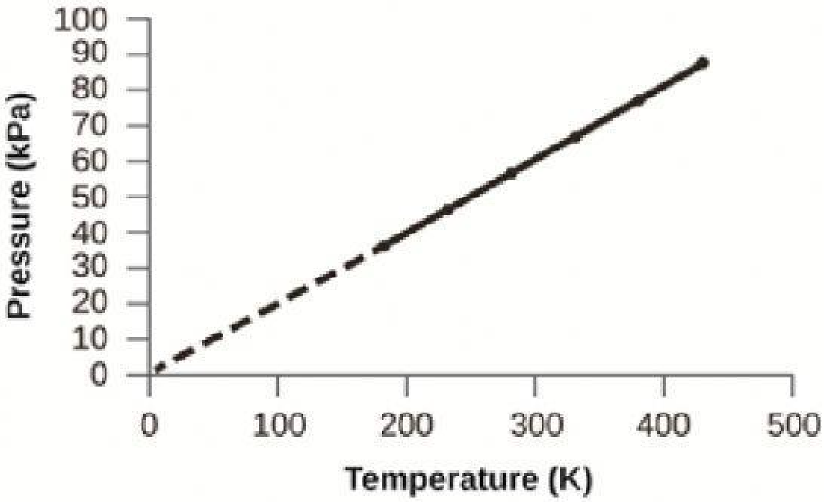
3.8 If the graph is extrapolated back to the x-axis it meets the axis at -273°C.

As you can see the above graph is not a directly proportional relationship, but rather just a linear relationship.

3.9 Now complete the table from 2.7 again, but convert the temperature to Kelvin.

Temperature- T (K)	Temperature -t (°C)	Pressure (kPa)	$\frac{p}{T}$
273	0	67.1	0,25 (if pressure kept in kPa)
323	50	77,5	0,24
373	100	88	0,24

3.10



This temperature is known as **absolute zero**. It is the temperature at which all particle motion stops. It is known as zero Kelvin.

So technically the graph shows a direct proportional relationship between pressure and temperature (when it is measured in Kelvin.)

Thus from now on any temperature we take, should be converted to Kelvin.

How do we convert from temp in °C (t) to temperature in Kelvin (T)?

-273°C = 0 K T = temperature in Kelvin t = temperature in degrees Celsius Thus to convert to Kelvin: T = t + 273 Thus to convert to Celsius: t = T - 273

Thus we can say that $\frac{p1}{T1} = \frac{p2}{T2}$

We can use this to solve problems:

Examples

1. The pressure of a gas in a container is 180 kPa at a temperature of 50°C. Calculate the pressure of the gas if the temperature is increased to 90°C.

$$\frac{p1}{T1} = \frac{p2}{T2}$$

$$\frac{180\ 000}{(50+273)} = \frac{p2}{(90+273)}$$

*remember that in this chapter temperature must be converted to Kelvin

65340000 = 323 p_2

<u>p_2 = 202291,02 Pa</u>

Your questions:

1. The pressure in a car tyre is 200 kPa at 7°C.

a) Is this pressure higher, lower or equal to atmospheric pressure?

b) State two methods by which you can reduce the pressure in the tyre.

c) If the tyre does not stretch, what will the pressure become if the temperature of the tyre is raised to 28 °C.

a) higher

b) cool the tyre down

open the valve and let some air escape

$$\frac{p1}{T1} = \frac{p2}{T2}$$

$$\frac{200\ 000}{(7+273)} = \frac{p2}{(28+273)}$$

P_2 = 2,15 x 105 Pa or 215 000 Pa

2 The tank of a steam engine is fitted with a safety valve which will allow gas to escape at a pressure of 2 x 10^3 kPa. At 17°C the pressure of the gas is 5 x 10^2 kPa. At what temperature will the safety valve open to allow gas to escape if heated?

$$\frac{p1}{T1} = \frac{p2}{T2}$$

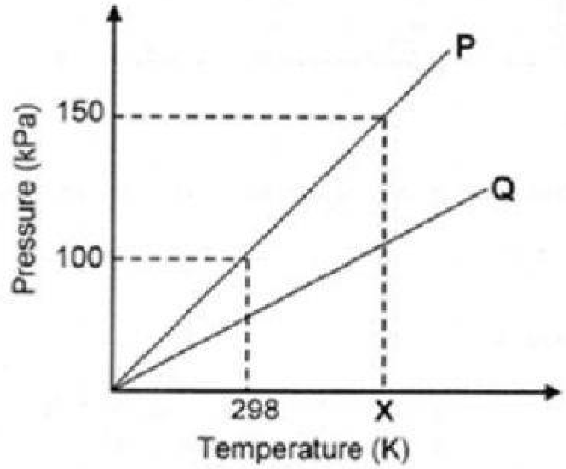
$$\frac{5\,x10^2\,x\,1000}{(17+273)} = \frac{2x10^3\,x\,1000}{T2}$$

T_2 = 1160 K

Exam questions

Two learners investigate the relationship between the temperature and the pressure of an enclosed gas. The learners use different samples of the same gas in two identical containers of fixed volumes.

Graph **P** and Graph **Q** below represent the results obtained by the learners.



1.1 State which saw is being investigated here:

1.2 Use the law in QUESTION 5.2.1 to determine the value of temperature **X**, shown on the graph, in °C.

1.3 Which substance, P or Q represents a gas with a smaller mass?
(Consider what the gradient represents before answering)

1.4 A certain gas with a mass of 2,2 g occupies a volume of 0,831 dm^3 at 27 °C and pressure 150 kPa.

1.4.1 Calculate the molar mass of the gas. Assume that the gas behaves like an ideal gas.

answer to step 1=

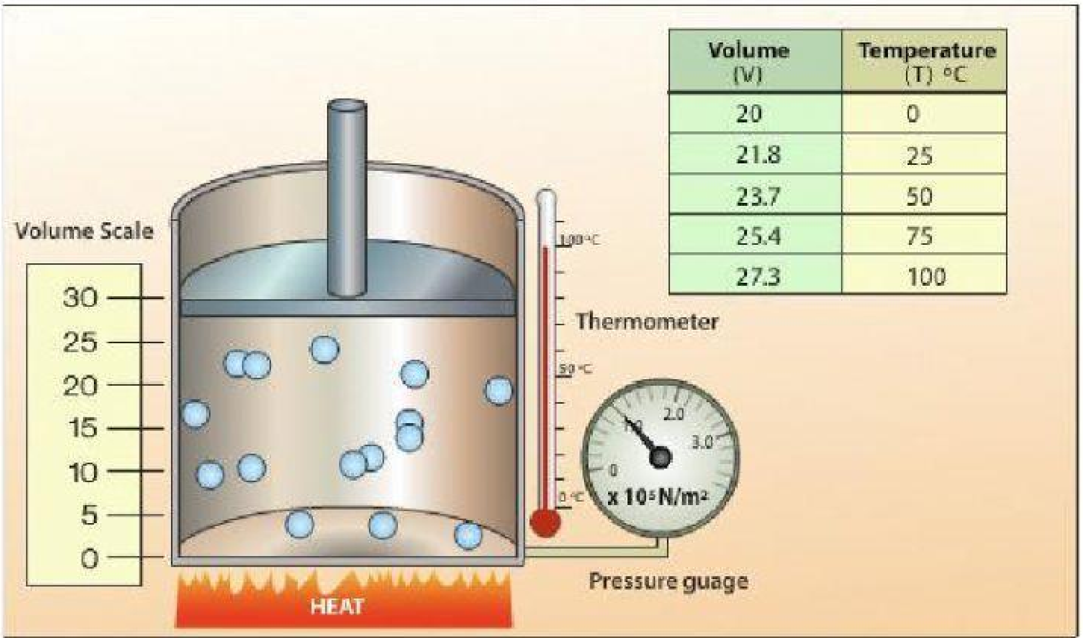
final answer =

1.4.2 Write down the MOLECULAR FORMULA of the gas in QUESTION 1.4.1

***Hint this is a tricky one – it's not just one element from the periodic table – if is a combination of elements**

<u>Temperature and volume</u>

Charles' Law: The temperature of an enclosed gas is directly proportional to the volume it occupies at constant pressure.



Volume (V)	Temperature (T) °C
20	0
21.8	25
23.7	50
25.4	75
27.3	100

In the diagram above a fixed amount (mol) of gas is trapped in a pressurised container.

The container is then heated.

4.3 As the temperature of the gas increases the volume of the gas inside will also increase.

4.4 Temperature is thus directly proportional to volume.

4.5 V α T

4.6 Stated above

4.7 The pressure and no of moles of gas are the constant variables.

4.8 The SI unit for volume is cm^3 but dm^3 is accepted

4.9

Temp (t) in °C	Temp (T) in Kelvin	V (cm^3)	$\frac{V}{T}$
0	273	20	0,07
25	298	21,8	0,07
50	323	23,7	0,07
75	348	25,4	0,07
100	373	27,3	0,07

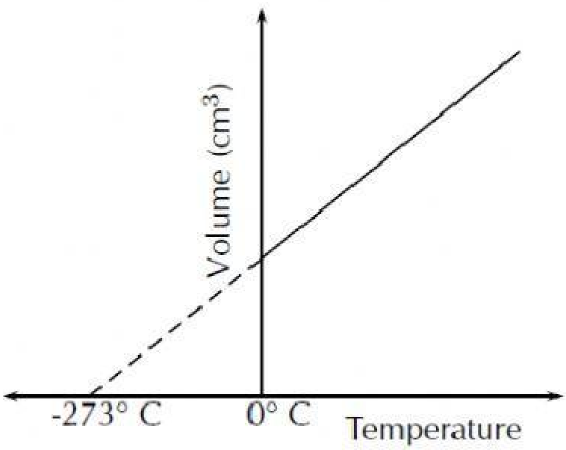
4.10 What do you notice about the third column (the ratio of $\frac{V}{T}$): it is a constant value

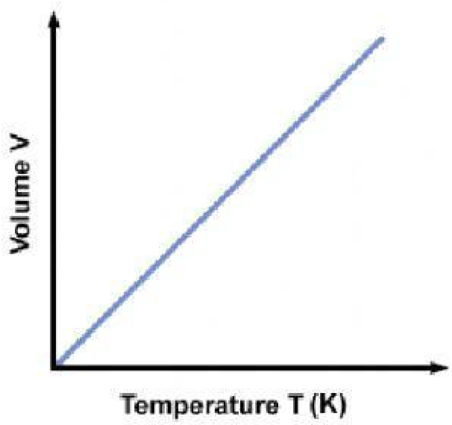
We can thus say that the ratio of $\frac{V}{T}$ stays constant

Thus

$$\frac{V1}{T1} = \frac{V2}{T2}$$

4.11 Graph:





Examples:

The temperature on a fixed amount of gas which occupies a volume of 20 cm^3 is increased from 20 °C to 200 °C. Calculate the new volume which the gas will occupy.

$$\frac{V1}{T1} = \frac{V2}{T2}$$

$$\frac{0{,}02}{293} = \frac{V2}{473}$$

$V_2 =$ 0,03 dm^3

Your questions:

1. In a tube containing a bead of mercury trapping a fixed mass of gas, the volume is 0,11 cm^3 at 27°C. To what temperature must the gas be heated at constant pressure so as to have a volume of 0,165 cm^3?

$$\frac{V1}{T1} = \frac{V2}{T2}$$

$$\frac{0{,}11}{27+273} = \frac{0{,}165}{T2}$$

Cross multiply first

0,11(T2) = 49,5

$$\frac{0{,}11(T2)}{0{,}11} = \frac{49{,}5}{0{,}11}$$

Then divide by the number with T_2 on both sides

T_2 = 450 K

2. A balloon, filled with air at 27°C was placed in the sun. Assuming that the pressure remained constant find at what temperature the volume would be 12% greater than the original volume.

$$\frac{V1}{T1} = \frac{V2}{T2}$$

When a question like this is asked choose the V1 as 100, then it is very easy to calculate the extra 12% for V2

(100 x12% = 12)

Thus V2 = 112

$$\frac{100}{27+273} = \frac{112}{T2}$$

Cross multiply first

100(T2) = 33600

$$\frac{100(T2)}{100} = \frac{33600}{100}$$

Then divide by 100 on both sides

T2 = 336 K

Watch the video example below of Charles' Law

General gas equation

Now put all 3 formulae together :

$p_1.V_1 = p_2.V_2$

$$\frac{p1}{T1} = \frac{p2}{T2}$$

$$\frac{V1}{T1} = \frac{V2}{T2}$$

And make one big equation, called the **general gas equation**.

$$\frac{P1.V1}{T1} = \frac{P2.V2}{T2}$$

Watch the video example below of the general gas equation below