Gases: Worksheet 3

Examples:

250 cm^3 of hydrogen gas is at a temperature of 21°C and at a pressure if 180 kPa. Calculate the volume of hydrogen if the temperature is raised to 67°C and the pressure is decreased to 80 kPa.

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

$$\frac{180\ 000(0{,}25)}{(21 + 273)} = \frac{80\ 000.V2}{(67+273)}$$

$15300000 = 23520000V_2$

$V_2 = 0{,}65\ dm^3$

Your questions:

1 The pressure in a car tyre is $2{,}1 \times 10^5$ Pa at 27°C. If the temperature increased to 57°C while the volume of the tyre decreased by 5%, calculate the new pressure of the air in the tyre.

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

When a question like this is asked choose the V1 as 100, then it is very easy to calculate the 5% less for V2

(100 x5% = 5)

Thus V2 = 100 – 5

= 95

$$\frac{2.1x10^5(100)}{(27 + 273)} = \frac{P2.(95)}{(57+273)}$$

*cross multiply first

$6{,}93 \times 10^9 = 2{,}85 \times 10^4$(P2)

Then divide by $2{,}85 \times 10^4$ on both sides

P2 = 243157,89 Pa or $2{,}43 \times 10^5$Pa

2 The pressure of a system is doubled. The temperature changes from 21°C to 47°C and the original volume was $10m^3$. Calculate the final volume if the original pressure was 1 atmosphere.

When choosing the volume to use – just choose V1 as $100dm^3$

Then V2 would be double and thus $200dm^3$

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

The SI unit is either cm^3 or dm^3

dm^3 might be easier since that is also the SI unit in the mole

$$\frac{(100)(10)}{(21+273)} = \frac{(200)(v2)}{(47+273)}$$

320000= 58800V2

V2 = 5,44 m^3

V2 = 5,44 x 10^3

= 5440 dm^3

Exam questions

Oxygen gas occupies a volume of 500 cm^3 at a temperature of 27° C and a pressure of 100 kPa. The gas is heated to 70° C and the pressure of the gas increases to 200 kPa.

1.1 Calculate the new volume that the oxygen gas will occupy at a temperature of 70° C.

V_2=

Ideal gases

Kinetic theory of gases:

- Molecules are in constant motion and collide with each other and the walls of the container
- There are forces of attraction between molecules. Forces are very weak between gas particles.
- Molecules in a gas move at different speeds
- Gas molecules are widely separated
- Gas particles exert a pressure when they surround an object or strike the wall of their container
- The number of molecular impacts per second provides the forces and therefore the pressure.

DEFINITION: *Pressure*

The **pressure** of a gas is a measure of the number of collisions of the gas particles with each other and with the sides of the container that they are in.

DEFINITION: *Temperature*

The **temperature** of a substance is a measure of the **average kinetic energy** of the particles.

So what is an ideal gas:

First of all, they are just theoretical gases which would obey the gas laws under all temperatures and pressures.

- A gas in which the particles are identical and have zero volume
- There are no intermolecular forces between molecules
- A gas in which all collisions of the molecules with themselves or the wall of the container, are perfectly elastic

Which gas behave most like ideal gases: He

Why?

You are looking for a gas with

smallest possible molecules, and the lowest possible intermolecular forces

A helium molecule consists of a small atom, and has weak van der Waals dispersion forces

hydrogen molecule also has weak intermolecular forces

Ideal gases can be quite tricky to understand. Watch the video below to help you

Real gases behave more or less like ideal gases <u>except</u> at **high pressures and low temperature**

Before we go on to look at the gas laws we will first see what happens to gases at high pressures and low temperatures.

When we defined an ideal gas, we said that an ideal gas has identical particles of zero volume and that there are no intermolecular forces between the particles in the gas. We need to look more closely at these statements because they affect how gases behave at high pressures or at low temperatures.

1. *Molecules do occupy volume*

When pressures are very high and the molecules are compressed, the volume of the molecules becomes significant. This means that the total volume available for the gas molecules to move is reduced and collisions become more frequent. This causes the pressure of the gas to be *higher* than what would be expected for an ideal gas (Figure 7.1).

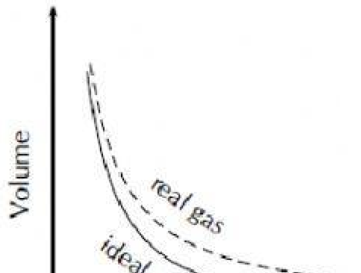


Figure 7.1:

Gases deviate from ideal gas behaviour at high pressure.

2. *Forces of attraction do exist between molecules*

At low temperatures, when the speed of the molecules decreases and they move closer together, the intermolecular forces become more apparent. As the attraction between molecules increases, their movement decreases and there are fewer collisions between them. The pressure of the gas at low temperatures is therefore lower than what would have been expected for an ideal gas (Figure 7.2). If the temperature is low enough or the pressure high enough, a real gas will **liquefy**.

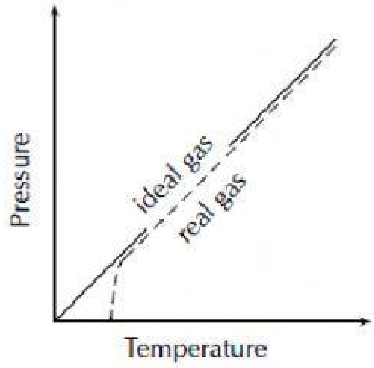


Figure 7.2: Gases deviate from ideal gas behaviour at low temperatures.

There are several laws to explain the behaviour of ideal gases. The first three that we will look at apply under very strict conditions. These laws are then combined to form the general gas equation and the ideal gas equation.

The ideal gas law equation is the following: pV = nRT p – pressure (must be in Pa) V- volume (must be in m^3) n – number of moles R – is a constant, called the universal gas constant (8,31) T – temperature (must be in Kelvin)

Examples:

Calculate the temperature of 5 moles of oxygen which is in a container of 300 dm^3 at a pressure of 75 kPa.

pV = nRT

(75 000)(300÷1000) = 5(8,31)T

T = 541,5 K

Your questions:

1. At what pressure will 56 g nitrogen gas occupy a volume of 20 dm^3 at -73°C?

$n = m \div M$

$= 56 \div 28$

$= 2$ mol

$pV = nRT$

$(p)(20 \div 1000) = 2(8{,}31)(200)$

166200 Pa

2. What volume is occupied at $1{,}6 \times 10^5$ Pa and 47°C by 5,2g of ethyne (C_2H_2) gas? { }

$n = m \div M$

$= 5{,}2 \div 26$

$= 0{,}2$ mol

$pV = nRT$

$(1{,}6 \times 10^5)(V) = 0{,}2(8{,}31)(47 + 273)$

$V = 3{,}32 \times 10^{-3}\ m^3$

3.a 100 g of a certain gas has a volume of 8 dm^3 at 47°C and $1{,}66 \times 10^3$ kPa. Calculate the molar mass of the gas. {$20 g.mol^{-1}$}

b. Name this gas {Ne}

$pV = nRT$

$(1{,}66 \times 10^3 \times 1000)(8 \div 10^3) = n(8{,}31)(47 + 273)$

$n = 4{,}994$ mol

$M = m \div n$

$= 100 \div 4{,}994$

$= 20\ g.mol^{-1}$

Thus the gas is Ne

Exam questions

1.1 Glass tubing is being chosen to produce a neon sign.
The glass must support 250 kPa without breaking. The design for the sign requires the use of 10,5 g Ne gas in a 6,77 dm^3 volume. Operating temperature is expected to reach a maximum of 78 °C.
Will this glass take the strain, or should tubing be sourced?

{This is a 2 step question, write your answer for the first step into block one and then the final answer.}

= {3 decimals}

= {1 decimal}

Will the glass take the strain: yes no

1.2 Gas A and Gas B have the same molecular mass. They are placed in separate sealed containers. The containers are at the same temperature and have the same volume.

Container 1 **Gas A**	Container 2 **Gas B**

The density (number of molecules in a unit volume) of **Gas A** is greater than the density of **Gas B**.

Which gas, **A** or **B**, exerts the greatest pressure on the walls of its container? (1)

A B

The explanation for this answer is below

*Density was last done in gr 8 – so look at this carefully

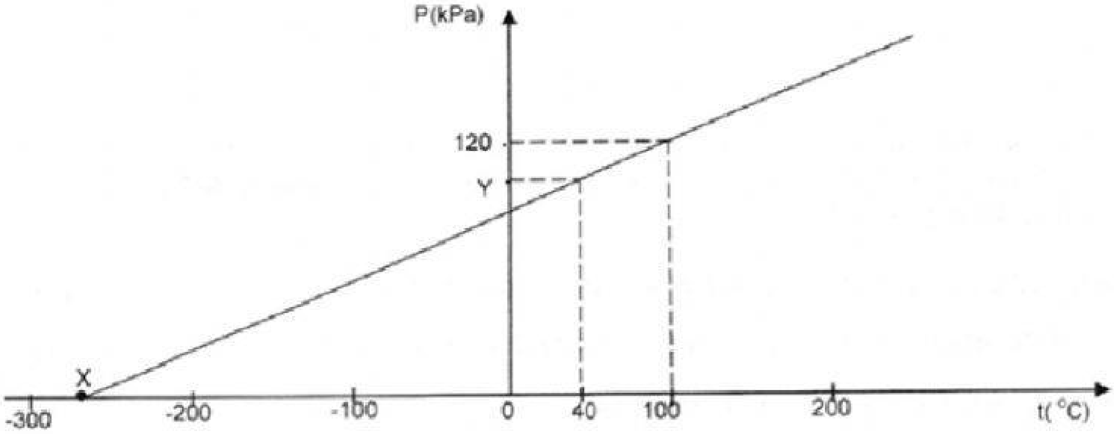
consider $D = \frac{m}{V} = \frac{nM}{V}$ √

If molar mass (M) and volume (V) is the same √ -- then $D \propto n$ √

Gas A has more particles than gas B √ / *Gas A het meer deeltjies as gas B.*
More collisions with sides of container A √ ∴ Exert greater pressure in A.

Question 2

An investigation to find the relationship between pressure and temperature of a given mass of gas was done by a learner using 2,5 moles of an unknown diatomic gas under normal temperature and pressure conditions and the following graph was plotted.



2.1 The graph is extrapolated to intersect the x-axis at X. What is the value of X in degrees Celcius? (1)

2.2 What is point X referred to as? (1)

2.3 What physical quantity is kept constant during this experiment? (1)

2.4 Calculate the volume of the vessel in which the investigation was conducted.

First convert the following into the correct SI unit

Then pick the correct formulae you will use to solve this

V =

T =

Final answer = {3 demical places}

{Write in decimal notation}

Pick the correct formula used:

$p_1.V_1 = p_2.V_2$

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

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

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

pV = nRT

2.5 If 177, 5 g of this gas was used in the investigation, identify the gas. (1)

=

Thus the gas is (just state the element symbol) =