# 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.

6.1 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.

6.2 Real gases approach ideal gas behaviour when the molecules

- are identical and have negligible (very small) volume
- have no intermolecular forces between molecules
- have collisions with themselves or the wall of the container, are perfectly elastic

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

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

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).

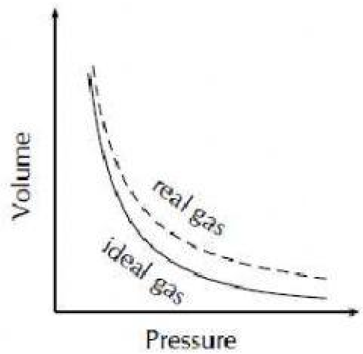



Figure 7.1: Gases deviate from ideal gas behaviour at high pressure.

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**.

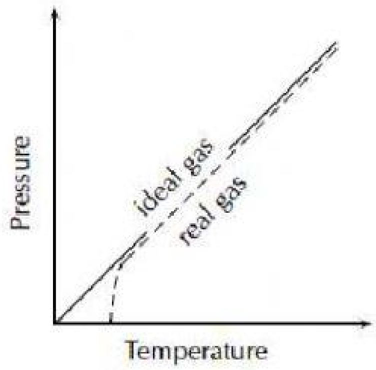



Figure 7.2:
Gases deviate from ideal gas behaviour at low temperatures.

6.4 The temperature of a gas is a measure of the average kinetic energy of the molecules.

6.5 Real gases that best correspond to ideal gas behaviour are: hydrogen and Helium , because they have small molecules and very weak IMF (van der Waals forces London forces).

> 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:

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

n = m÷M

= 56 ÷28

= 2 mol

pV = nRT

(p)(20 ÷1000) = 2(8,31)(200)

166200 Pa

6.7 What volume is occupied at 1,6 x $10^5$ Pa and 47°C by 5,2g of ethyne ($C_2H_2$) gas?

n = m÷M

= 5,2 ÷26

= 0,2 mol

pV = nRT

(1,6 x $10^5$)(V) = 0,2(8,31)(47 +273)

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

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

b) Name this gas {Ne}

pV = nRT

(1,66 x$10^3$x 1000)(8÷$10^3$) = n(8,31)(47 +273)

n = 4,994 mol

M = m÷n

= 100 ÷ 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

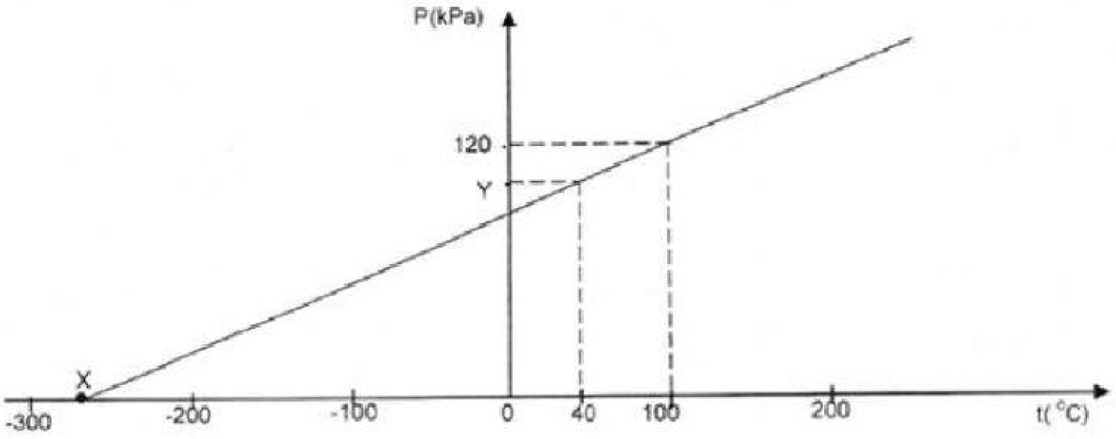
consider $D = \frac{m}{V} = \frac{nM}{V}$ √

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 P = T =

Then pick the correct formulae you will use to solve this

$p_1.V_1 = p_2.V_2$

$pV = nRT$

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

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

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

Final answer: V = {3 demical places; write in DECIMAL notation}

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

$M = \frac{m}{n}$ = g.mol$^{-1}$

Thus the gas is (NAME the diatomic element) :