2 assumption of Ideal Gas

① Negligible intermolecular forces of attraction. (IMF)

vs.

Real Gas : IMF ∝ M_r (molar mass).

In general, the larger gas molecules in the same homologous series, the stronger the IMF, the higher the boiling point.

Recollection : Gas molecules have London Dispersion Forces of attraction.

② Negligible Volume. (see pg. 27).

Since Ideal Gas (does not exist), how can we make Real Gas behave as if they are "Ideal"?

Real Gases.

An ideal gas obeys the gas laws. It obeys $PV = nRT$ ideal gas equation.

Real gases do have some attractive forces between the particles and the particles themselves do occupy some space so they do not obey the laws.

A gas behaves most like an ideal gas at high temp. and low pressures.

IDEAL GAS EQUATION

The different variables for a gas are all related by the ideal gas equation.

$$PV = nRT$$

STP conditions = 273 K and 100 kPa

P = pressure in Pa ($N\,m^{-2}$) 1 atm = 100 kPa (see Chem. data Booklet. 4th Ed.)

T = absolute temp. in K

V = volume in m^3

$1\,dm^3 = 1\,\text{litre} = 1 \times 10^{-3}\,m^3 = 1 \times 10^3\,cm^3$

n = number of moles

R = Gas constant $(R) = 8.31\,J\,K^{-1}\,mol^{-1}$

$$PV = nRT$$

Calculate n

$$n = \frac{PV}{RT}$$ ✓

Calculate M_r

$$n = \frac{m}{M_r}$$

$$PV = \left(\frac{m}{M_r}\right) \cdot RT$$

$$M_r = \frac{m \times R \times T}{P \times V}$$ ✓

m

ρ | V

$$\rho = \frac{m}{V}$$

Calculate density, ρ

$$M_r = \rho \times \frac{R \times T}{P}$$

$$\rho = \frac{M_r \times P}{R \times T}$$ ✓

Q. A canister of gas, of the type used in camping stoves, contains mainly butane under sufficient pressure to cause it to liquefy partially.

0°C = 273 K

C_4H_{10}

(a) What do you understand by the term *ideal gas*? [1]

(b) Would you expect the gas in the canister to behave as an ideal gas? Explain your answer. [2]

(c) Describe how increasing the pressure on a gas can sometimes cause it to liquefy. [2]

(d) Describe the main forces that occur between molecules of butane, and explain how they arise. [2]

(e) A canister was connected to a gas syringe and the valve opened slightly to allow some of the gas into the syringe. It was found that 0.200 g of the gas took up a volume of 96.0 cm^3 at a temperature of 20.0 °C and a pressure of 1.02×10^5 Pa.

20+273

→ ? m^3

Use the general gas equation $pV = nRT$ to calculate the average M_r of the gas mixture. [2]

(f) Suggest a reason why propane is used instead of butane for gas stoves in cold climates in the winter. [1]

(a) An ideal gas is one which obeys the ideal gas equation, $pV = nRT$ exactly. The gas particles have negligible volume and negligible intermolecular forces of attraction.

(b) No, the gas in the canister would not behave as an ideal gas. [This is because butane molecule is not negligible in size ($M_r \approx 58$) and intermolecular forces are significant (it liquefies partially).

(c) As pressure is increased the molecules become closer together, so that intermolecular (London Dispersion Force) have a greater effect, thereby causing the gas to liquefy.

(d) The main forces that occur between molecules of butane are London Dispersion Forces of attraction, which arise due to temporary dipole attraction.

Topic 4: Chemical Bonding.

(e) Using the ideal gas equation,

$$pV = nRT \qquad \text{since } n = \frac{m}{M_r}$$

$$pV = \left(\frac{m}{M_r}\right)RT$$

$$\therefore \quad M_r = \frac{m \times R \times T}{p \times V} = \frac{0.200 \times 8.31 \times (20 + 273)}{1.02 \times 10^5 \times 96.0 \times 10^{-6}}$$

Data Booklet

$1\ dm^3 = 1\ litre = 1 \times 10^{-3}\ m^3 = 1 \times 10^3\ cm^3$ ✓

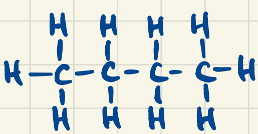
$$= 49.7$$

$$96.0\ cm^3 \times \frac{1 \times 10^{-3}\ m^3}{1 \times 10^3\ cm^3}$$

$$= 96.0 \times 10^{-6}$$

$$= 9.6 \times 10^{-5}$$

$M_r \propto LDF$



$CH_3CH_2CH_2CH_3$

$0.3\ m \Rightarrow \_\ cm$

$1\ m = 100\ cm$

$$0.3\ m \times \frac{100\ cm}{1\ m}$$

(f) Propane is used instead of butane because propane, being a smaller molecule, is more volatile, (lower boiling point), and thus vaporises more easily than butane.

$CH_3CH_2CH_3$