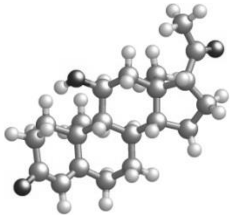

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Name: …………………… (   )

Class: ………………

Date: …… / …… / ……

The Ideal Gas Equation

The greatest difference between gases and solids or liquids is that the particles in a gas are very much further apart. When describing the behaviour of gases, it is assumed that there are no intermolecular forces of attraction between the molecules. A gas in which there are no intermolecular forces of attraction is called an *ideal gas* (sometimes referred to as a *perfect gas*). The behaviour of an ideal gas is described by the *ideal gas equation*. The molecular model of ideal gases has been developed using the kinetic theory of matter. Real gases behave very much like ideal gases under normal conditions of temperature and pressure.

Boyle's law states that the volume (V) of a gas is inversely proportional to its pressure (p) at a constant temperature:

$$\boxed{V \propto {}^{1}/_{p}}$$

Charles's law states that the volume (V) of a gas is directly proportional to its temperature (T) at a constant pressure:

$$\boxed{V \propto T}$$

Combining these expressions gives:

$$\boxed{V \propto {}^{T}/_{p} \quad \text{or} \quad pV \propto T}$$

Adding a constant of proportionality results in the relationship:

$$\boxed{pV = kT}$$

where k is a constant for a fixed mass of a particular gas.

Avogadro's principle shows that the volume of a gas depends on the number of gas molecules. So the volume of a gas is directly proportional to the number of moles of gas that are present, *i.e.* $V \propto n$, where n represents the number of moles of gas. The behaviour of an ideal gas can therefore be described by the *ideal gas equation*:

$$\boxed{pV = nRT}$$

Where R is a constant for all gases called the *gas constant*. Its value in SI units is R = 8.314 $JK^{-1}mol^{-1}$

Note:

It is important to ensure that all of the variable in the ideal gas equation are represented in the correct units.

Pressure (*p*) is measured in pascals (*Pa*). 1 *Pa* = 1 N / m^2

Volume (*V*) is measured in cubic meters (m^3). 1 m^3 = 1 000 000 cm^3.

Temperature (*T*) is measured in *kelvin* (*K*). *K* = °C + 273.

The Kinetic Theory of Gases

An ideal gas follows the gas laws exactly. The *kinetic theory of gases* puts forward a model of gases that explains this behaviour. It makes the general assumptions that an ideal gas is composed of independent molecules that are widely separated from each other, as described by the following four statements:

- The molecules in a gas are in a continuous random motion.
- There are no intermolecular forces of attraction between the gas molecules. The only interactions between the gas molecules are collisions.
- All collisions are *perfectly elastic*. The gas molecules bounce off each other and the walls of their container with no overall change in kinetic energy.
- The gas molecules have no volume. They are considered to be point masses.

Information on the ideal gas equation taken from ***Advanced Chemistry*** by Michael Clugston and Rosalind Flemming. Published by Oxford University Press. Year of publication, 2000.

ISBN, 0–19–914633–0

Questions

Question One:

The equation $pV = nRT$ may be used in the determination of the relative molar mass of a volatile liquid.

Figure 1 shows the apparatus that could be used in this determination. A known mass of volatile liquid is injected through the self-sealing rubber cap into the gas syringe, which is then heated in a boiling water bath for several minutes before the volume of the vapour in the syringe is noted.

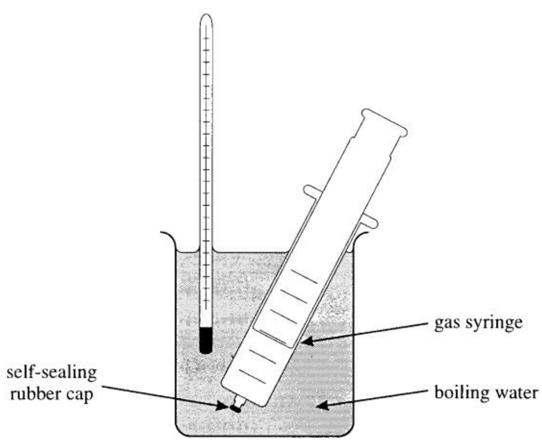

Figure 1. The apparatus that may be used to determine the relative molar mass of a volatile liquid.

(a)

(i) State what is meant by the term *volatile liquid*. Give the name of the equation $pV = nRT$, and state what the symbols n and R represent in this equation.

Volatile liquid: ………………………………………………………………………………………..

Name of the equation: ………………………………………………………………………………………..

"*n*" *represents:* ………………………………………………………………………………………..

"*R*" *represents:* ………………………………………………………………………………………..

(*4 marks*)

(ii) Suggest why it is essential to leave the syringe in the boiling water bath for several minutes before reading the volume of the vapour.

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(*2 marks*)

(iii) State **three** of the basic assumptions made in the kinetic theory of gases regarding the behaviour of gaseous molecules.

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(*3 marks*)

(b) Using apparatus similar to that shown in **Figure 1**, 0.167 g of ethanol, C_2H_5OH, was injected into a gas syringe and the syringe was then placed in a boiling water bath for several minutes. The atmospheric pressure was 101 300 Pa and the temperature of the bath was 100 °C.

(i) Calculate the volume, in cm^3, of ethanol vapour that would have been produced under these conditions.

$$R = 8.314\ JK^{-1}mol^{-1}$$

(*5 marks*)

(ii) Explain why a gas syringe of 100 cm^3 capacity was found to be unsuitable.

………

………

(*1 mark*)

- Scan the QR code below for the answers to this assignment.

http://www.chemist.sg/kinetic_particle_theory/ideal_gas_equation_ans.pdf