IB Physics Topic B3 Gas Laws; SL & HL

By timthedev07, M25 Cohort

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1 Pressure

Pressure is defined as the force per unit area.

$$P = \frac{F}{A} \tag{1}$$

- **Solid**: The pressure due to the weight W over an area A is given by

$$P = \frac{W}{A} \tag{2}$$

- **Liquid**: The pressure in a liquid at a depth h is given by

$$P = \rho g h \tag{3}$$

  where ρ is the density of the liquid, g is the acceleration due to gravity, and h is the depth.

- **Gas**: Will be discussed later.

1.1 Avogadro's Number and the Mole

The **mole** is the SI unit for the amount of substance. It has been historically defined as the number of atoms in approximately 12 grams of carbon-12. This quantity is known as the Avogadro number, N_A,

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$$

"Every mol is N_A things". For instance, 3 mol of electrons is simply the quantity of $3N_A$ electrons.

1.1.1 Molar Mass

Molar mass is the mass of one mole of a substance, typically given in grams per mole (g/mol). The molar mass of a substance is numerically equal to the atomic mass of the substance in atomic mass units (u). E.g. water has a molar mass of 18.015 g/mol $\equiv$ 18.015 u, and the mass of a single water molecule is $\frac{18.015}{N_A}$.

2 Gas Laws

2.1 Boyle's Law

This states that the pressure of a gas is inversely proportional to its volume at constant temperature. Mathematically, this is

$$P \propto \frac{1}{V}$$

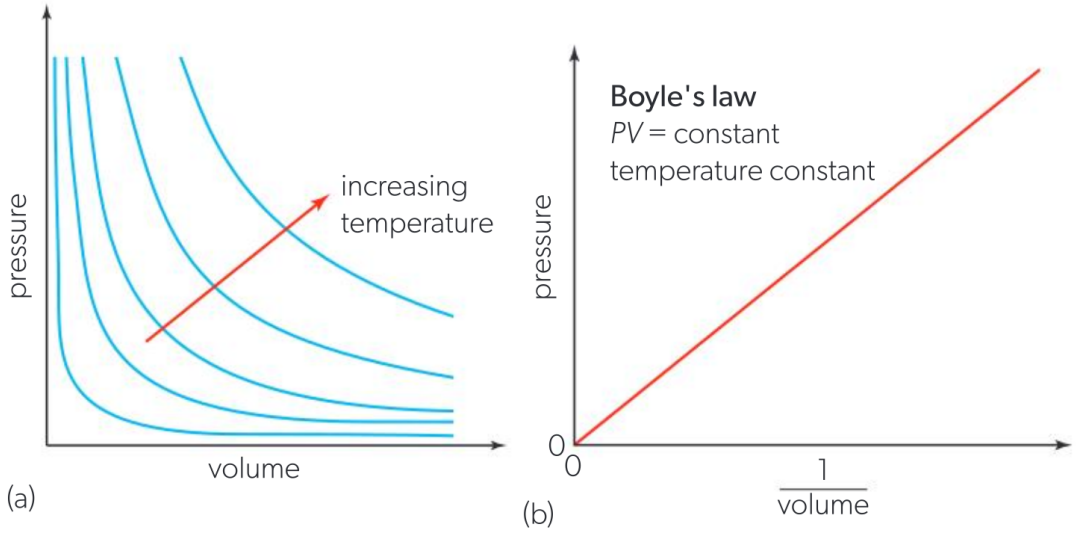

Figure 1: Two graphs that arise from Boyle's Law

- Every one of the curves in (a) is an isothermal curve.
- In the second graph
    1. For a higher temperature and the same mass of gas, the curve is steeper but still linear
    2. For a higher mass of gas and the same temperature, the curve would also be steeper.

2.2 Charles' Law

This states that the **volume** of a gas is **directly proportional** to its **temperature** at **constant pressure**. Mathematically, this is

$$V \propto T$$

2.3 Gay-Lussac's Law

This states that the **pressure** of a gas is **directly proportional** to its **temperature** at **constant volume**. Mathematically, this is

$$P \propto T$$

2.4 Avogadro's Law

This states that the **volume** of a gas is **directly proportional** to the **quantity (in mol)** of the gas at **constant temperature and pressure**. Mathematically, this is

$$V \propto n$$

2.5 The Ideal Gas Law

Derived from the previous laws; they combine to give

$$PV = nRT \quad \text{or} \quad R = \frac{PV}{nT}$$

where R is the ideal gas constant, 8.31 J mol^{-1} K^{-1}.

3 Microscopic Model of Gases

4 Kinetic Model of Ideal Gases

4.1 Temperature

4.2 Ideal vs. Real Gases