

Physics

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(Chapter 1) (Units and Measurement) (Exercises)

(Class 11)

Question 1.14:

The unit of length convenient on the atomic scale is known as an angstrom and is denoted by Å: $1 \text{ Å} = 10^{-10} \text{ m}$. The size of a hydrogen atom is about 0.5 Å . What is the total atomic volume in m^3 of a mole of hydrogen atoms?

Answer 1.14:

Radius of hydrogen atom, $r = 0.5 \text{ Å} = 0.5 \times 10^{-10} \text{ m}$

Volume of hydrogen atom $= \frac{4}{3} \pi r^3$

$$= \frac{4}{3} \times \frac{22}{7} \times (0.5 \times 10^{-10})^3$$

$$= 0.524 \times 10^{-30} \text{ m}^3$$

1 mole of hydrogen contains 6.023×10^{23} hydrogen atoms.

Volume of 1 mole of hydrogen atoms

$$= 6.023 \times 10^{23} \times 0.524 \times 10^{-30}$$

$$= 3.16 \times 10^{-7} \text{ m}^3$$

Question 1.15:

One mole of an ideal gas at standard temperature and pressure occupies 22.4 L (molar volume). What is the ratio of molar volume to the atomic volume of a mole of hydrogen? (Take the size of hydrogen molecule to be about 1 Å). Why is this ratio so large?

Answer 1.15:

Radius of hydrogen atom, $r = 0.5 \text{ Å} = 0.5 \times 10^{-10} \text{ m}$

$$\text{Volume of hydrogen atom} = \frac{4}{3} \pi r^3 = \frac{4}{3} \times \frac{22}{7} \times (0.5 \times 10^{-10})^3 = 0.524 \times 10^{-30} \text{ m}^3$$

Now, 1 mole of hydrogen contains 6.023×10^{23} hydrogen atoms.

$$\therefore \text{Volume of 1 mole of hydrogen atoms, } V_a = 6.023 \times 10^{23} \times 0.524 \times 10^{-30}$$

$$= 3.16 \times 10^{-7} \text{ m}^3$$

Molar volume of 1 mole of hydrogen atoms at STP, $V_m = 22.4 \text{ L} = 22.4 \times 10^{-3} \text{ m}^3$

$$\therefore \frac{V_m}{V_a} = \frac{22.4 \times 10^{-3}}{3.16 \times 10^{-7}} = 7.08 \times 10^4$$

Hence, the molar volume is 7.08×10^4 times higher than the atomic volume. For this reason, the inter-atomic separation in hydrogen gas is much larger than the size of a hydrogen atom.

Question 1.16:

Explain this common observation clearly: If you look out of the window of a fast moving train, the nearby trees, houses etc. seem to move rapidly in a direction opposite to the train's motion, but the distant objects (hill tops, the Moon, the stars etc.) seem to be stationary. (In fact, since you are aware that you are moving, these distant objects seem to move with you).

Answer 1.16:

Line of sight is defined as an imaginary line joining an object and an observer's eye. When we observe nearby stationary objects such as trees, houses, etc. while sitting in a moving train, they appear to move rapidly in the opposite direction because the line of sight changes very rapidly.

On the other hand, distant objects such as trees, stars, etc. appear stationary because of the large distance. As a result, the line of sight does not change its direction rapidly.

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