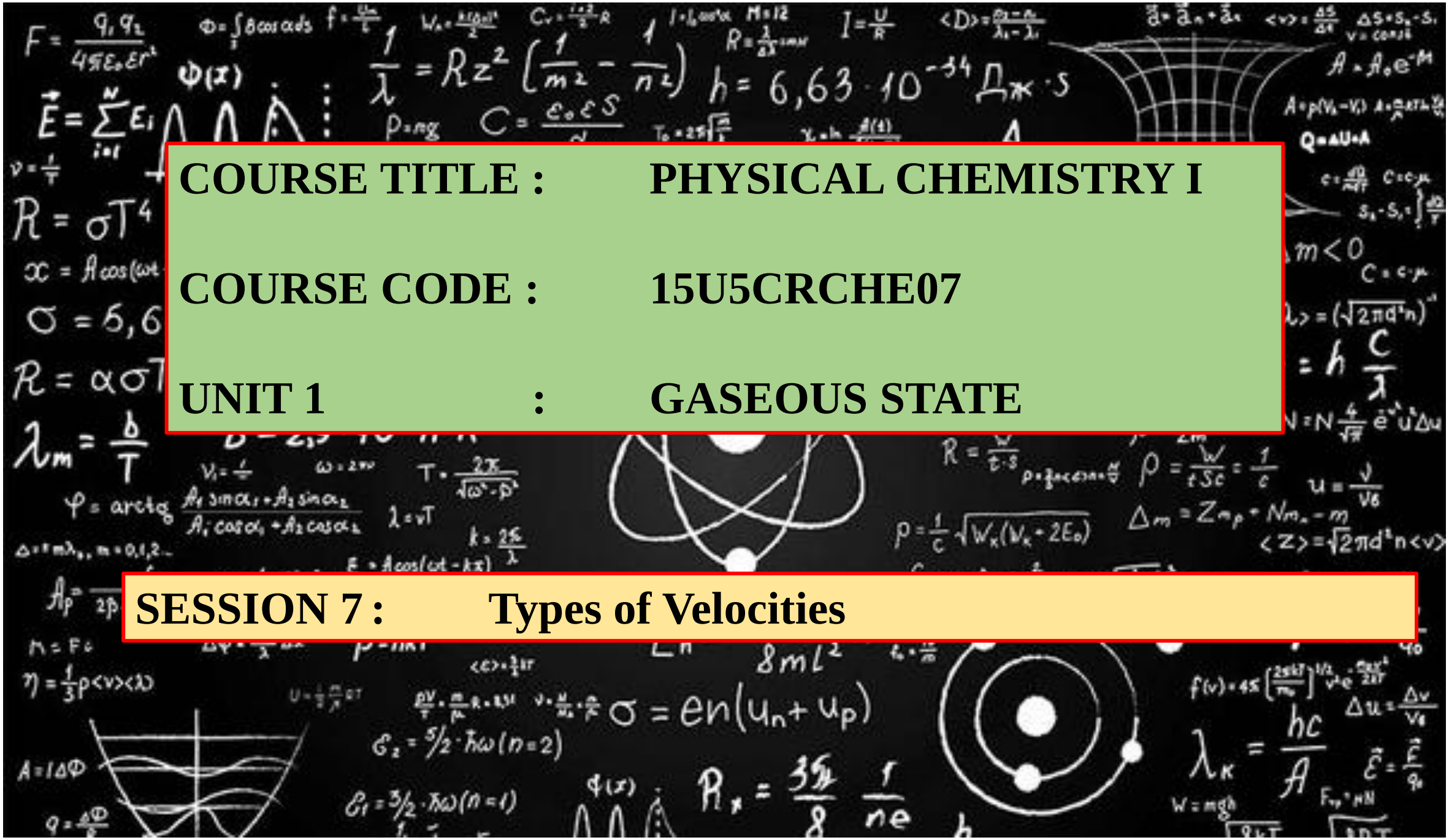


COURSE TITLE : PHYSICAL CHEMISTRY I

COURSE CODE : 15U5CRCHE07

UNIT 1 : GASEOUS STATE

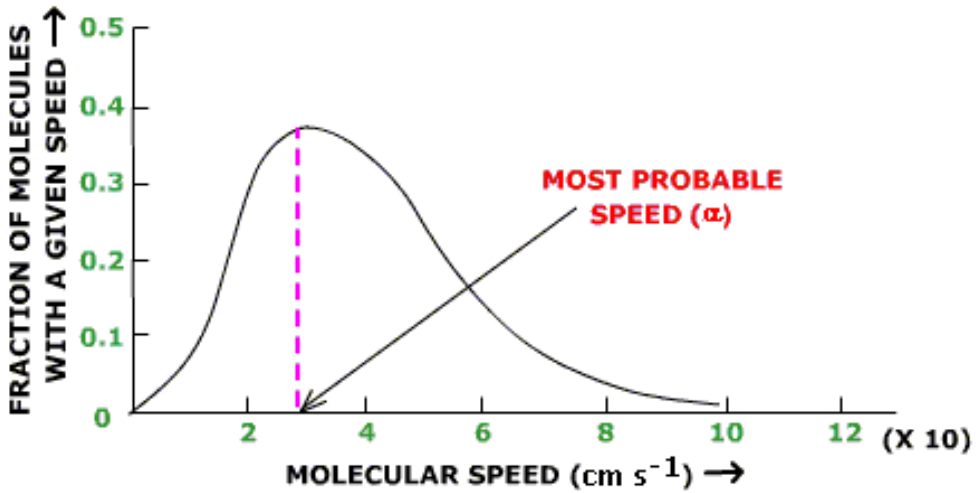
SESSION 7 : Types of Velocities

Most Probable Velocity, α

- Velocity possessed by the maximum number of molecules at a given temperature.

$$\alpha = \sqrt{\frac{2RT}{M}}$$

R – Universal gas constant *M* - Molar mass of the gas T - Temperature



Root Mean Square (RMS) Velocity, u

- The square root of the mean of the squares of the velocities possessed all the molecules at a given temperature.
- Total no. of molecules – N

c_1, c_2, c_3 ..... c_N are the velocities of all N molecules.

Squares of velocities - c_1^2, c_2^2, c_3^2 ..... c_N^2

Mean of square velocities – ($c_1^2 + c_2^2 + c_3^2$ ..... c_N^2)/N

Square root of the mean of the squares of the velocities - u

$$u = \sqrt{\frac{3RT}{M}}$$

Average Velocity, ν:

- The mean of the velocities possessed by all the molecules at a given temperature.
- Total no. of molecules – *N*

c_1, c_2, c_3 ……. c_N are the velocities of all N molecules.

Mean of velocities – (c_1 + c_2 + c_3 ……. c_N)/N

$$\nu = \sqrt{\frac{8RT}{\pi M}}$$

Relationships between Different Types of Velocities

$$\alpha = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2}{3} \cdot \frac{3RT}{M}} = \sqrt{\frac{2}{3}} \cdot \sqrt{\frac{3RT}{M}} = 0.816 \times u$$

$$\nu = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8}{3\pi} \cdot \frac{3RT}{M}} = \sqrt{\frac{8}{3\pi}} \cdot \sqrt{\frac{3RT}{M}} = 0.921 \times u$$

Ratio of the three types of Velocities

$$\alpha : \nu : u = 1 : 1.128 : 1.224$$

PROBLEM:

Calculate the RMS velocity, average velocity and most probable velocity for Nitrogen molecule at 273 K.

SOLUTION:

RMS velocity

$$u = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.3.14 JK^{-1} mol^{-1} \times 273K}{28 \times 10^{-3} kgmol^{-1}}} = 493.14 ms^{-1}$$

$$J = kgm^2 s^{-2}$$

Average velocity

$$\nu = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.3.14 JK^{-1} mol^{-1} \times 273K}{3.14 \times 28 \times 10^{-3} kgmol^{-1}}} = 454.45 ms^{-1}$$

Most probable velocity

$$\alpha = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2 \times 8.3.14 JK^{-1} mol^{-1} \times 273K}{28 \times 10^{-3} kgmol^{-1}}} = 402.65 ms^{-1}$$