(1) Monatomic molecule :-

Average kinetic energy of a molecule

$= \frac{3}{2} KT$

Total Energy of a molecule gas

$$U = \frac{3}{2} KT \times N_A$$

$$U = \frac{3}{2} RT$$

The molar specific heat at constant volume

$$C_V = \frac{dU}{dT}$$

$$C_V = \frac{d}{dT} (U)$$

$$C_V = \frac{d}{dT} \left(\frac{3}{2} RT \right)$$

$$C_V = \frac{3}{2} R$$

Mayer's Relation

$$C_P = C_V + R$$

$$C_P = \frac{3}{2} R + R$$

$$C_P = \frac{3R + 2R}{2}$$

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$C_p = \frac{5}{2} R$

The Ratio of specific heats

$\gamma = \frac{C_p}{C_V}$

$\gamma = \frac{\frac{5}{2} R}{\frac{3}{2} R}$

$\gamma = \frac{5}{2} \times \frac{2}{3}$

$\gamma = \frac{5}{3}$

$\gamma = 1.67$

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(2) Diatomic molecule [Low Temperature]

Average Kinetic Energy

$= \frac{5}{2} KT$

Total energy

$= \frac{5}{2} KT \times N_A$

$= \frac{5}{2} RT$

specific heat at constant volume

$$C_V = \frac{dU}{dT}$$

$$C_V = \frac{d}{dT}(U)$$

$$C_V = \frac{d}{dT}\left(\frac{5}{2} R T\right)$$

$$C_V = \frac{5}{2} R$$

Mayer's Relation

$$C_P = C_V + R$$

$$C_P = \frac{5}{2} R + R$$

$$C_P = \frac{5R + 2R}{2}$$

$$C_P = \frac{7}{2} R$$

$$\gamma = \frac{C_P}{C_V}$$

$$\gamma = \frac{\frac{7}{2} R}{\frac{5}{2} R}$$

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$$\gamma = \frac{7}{\not 2} \times \frac{2}{5}$$

$$\gamma = \frac{7}{5}$$

$$\boxed{\gamma = 1.40}$$

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(3) Diatomic molecule [high temperature]

Average kinetic energy of a diatomic molecule at high temperature and equal $\frac{7}{2} RT$

$$C_V = \frac{dU}{dT}$$

$$C_V = \frac{d}{dT}(U)$$

$$C_V = \frac{d}{dT}\left[\frac{7}{2} RT\right]$$

$$C_V = \frac{7}{2} R.$$

Mayer's Relation

$$C_P = C_V + R$$

$$C_P = \frac{7}{2} R + R$$

$$C_p = \frac{7R+2R}{2}$$

$$C_p = \frac{9R}{2}$$

$$\gamma = \frac{C_p}{C_v}$$

$$\gamma = \frac{\frac{9}{2}R}{7/2 R}$$

$$\gamma = \frac{\frac{9}{2}}{7/2}$$

$$\gamma = \frac{9}{2} \times \frac{2}{7}$$

$$\gamma = \frac{9}{7}$$

$$\gamma = 1.28$$

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(4) Triatomic molecule

a) Linear molecule.

Energy of one mole

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$U = \frac{7}{2} KT \times N_A$

$U = \frac{7}{2} RT$

$C_V = \frac{dU}{dT}$

$C_V = \frac{d}{dT}(U)$

$C_V = \frac{d}{dT}\left(\frac{7}{2} RT\right)$

$C_V = \frac{7}{2} R$

Mayer's Relation

$C_p = C_V + R$

$C_p = \frac{7}{2} R + R$

$C_p = \frac{7R + 2R}{2}$

$C_p = \frac{9R}{2}$

$\gamma = \frac{C_p}{C_V}$

$$\gamma = \frac{\frac{9}{2} \cancel{R}}{\frac{7}{2} \cancel{R}}$$

$$\gamma = \frac{\frac{9}{2}}{\frac{7}{2}}$$

$$\gamma = \frac{9}{\cancel{2}} \times \frac{\cancel{2}}{7}$$

$$\gamma = \frac{9}{7}$$

$$\boxed{\gamma = 1.28}$$

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(5) Triatomic molecule

[Non Linear molecule]

Energy of a mole

$$\frac{6}{2} kT \times N_A$$

$$\frac{6}{2} RT = \frac{\cancel{2} \times 3}{\cancel{2}} RT$$

$$U = 3RT$$

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$$C_V = \frac{dU}{dT}$$

$$C_V = \frac{d}{dT}(U)$$

$$C_V = \frac{d}{dT}(3RT)$$

$$C_V = 3R$$

Mayer's relation

$$C_P = C_V + R$$

$$C_P = 3R + R$$

$$C_P = 4R$$

$$\gamma = \frac{C_P}{C_V}$$

$$\gamma = \frac{4R}{3R}$$

$$\gamma = \frac{4}{3}$$

$$\gamma = 1.33$$

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