KINETIC THEORY

SPECIFIC HEAT CAPACITY

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General Expression for the Degree of Freedom

The basic formula for the number of ways something can move or behave is shown as follows:

$f = 3A - B$

Where,

A = Number of independent particles

B = Number of independent restrictions

for a monatomic gas

A = Number of independent particles = 1

B = Number of independent restrictions = 0

Therefore, degree of freedom is given as follows,

$f = 3A - B$

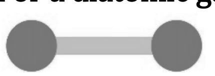
$f = (3 \times 1) - 0$

$f = 3$

At the right temperature, a tiny gas particle will mainly move in a straight line (translation). Because it's really small, we don't worry about it spinning (rotation). And since it's not too hot, we don't need to think about it vibrating, either.

Therefore, $f = 3$ (translational)

For a diatomic gas



A = Number of independent particles = 2
B = Number of independent restrictions = 1
Therefore, the degree of freedom is,

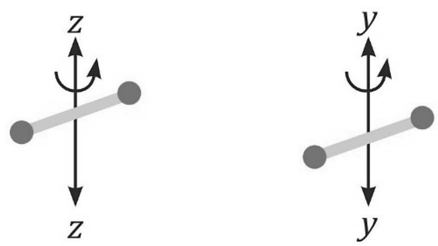
$f = 3A - B$

$f = (3 \times 2) - 1$

$f = 5$

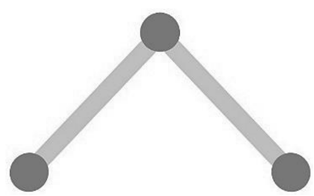
A diatomic gas also has 3 translational motion along x, y, and z-axis.

Also, the molecule can rotate about y and z directions.



Therefore, f = 3 (Translational) + 2 (Rotational)
At high temperature,
f = 3 (Translational) + 2 (Rotational) + 2 (Vibrational)

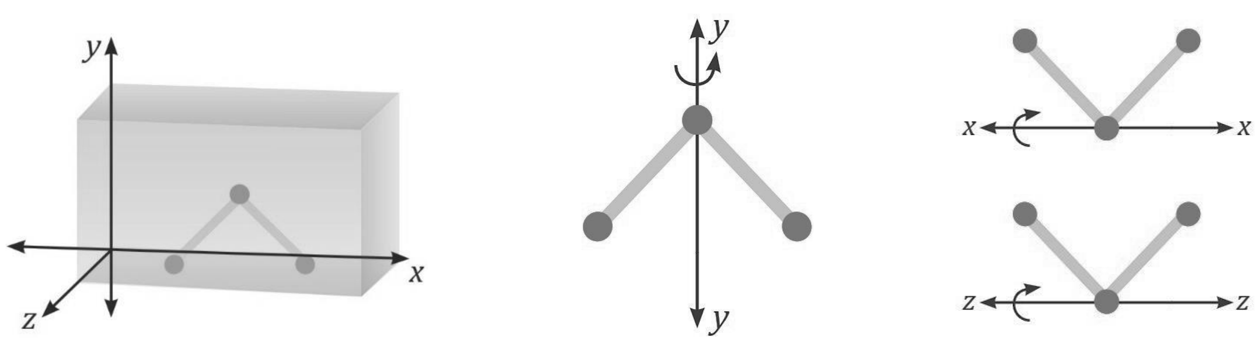
For a triatomic gas (non-linear)



A = Number of independent particles = 3
B = Number of independent restrictions = 3
Therefore, the degree of freedom is,
f = 3A - B
f = (3 × 3) - 3
f = 6

A triatomic gas has 3 translational motions along x, y, and z-axis and three rotational motions about x, y, and z-axis.

Therefore, f = 3 (Translational) + 3 (Rotational)



Specific Heat Capacity of Solids

Solids are a type of material with unique characteristics like strong forces holding their particles together, a rigid structure, and a definite shape. Even though they seem unyielding, they can still be heated, and we can measure their specific heat capacity. The specific heat capacity is measured in Joules per kilogram per degree Celsius (J/kg/°C).

Specific heat capacity for solids tells us how much energy we need to add to a given amount of solid material (usually a kilogram) to raise its temperature by 1°C.

To figure out this specific heat capacity, we use the law of equipartition of energy. This law tells us that, for a substance in thermal balance, there's a certain average amount of energy for each way a particle can move or vibrate.

For instance, in the case of a gas molecule floating in three-dimensional space, it can move in three different directions, so it has three degrees of freedom. This means there's a specific average amount of energy associated with each of these three types of movement.

$$U = 3kbTNA = 3RT$$

We will use the equation for the first law of thermodynamics given below:

$$\Delta Q = \Delta U + P\,\Delta V$$

The first law says that energy can't magically appear or vanish; it just changes from one type to another.

In solids, we can ignore the PV part because they don't change volume much. So, the formula for molar specific heat capacity (which tells us how much heat it takes to change the temperature of one mole of a solid) simplifies to this:

$$C = \Delta Q / \Delta T = \Delta U / \Delta T$$

C = 3R = 24.94 J/K-1 mol -1

C here is the molar specific heat capacity

Q is the heat given and ΔT is the temperature change.

Heat capacity is like a unique trait of a substance. You can find it using a device called a calorimeter. There are two main types of calorimeters: one keeps the volume constant (like a bomb calorimeter), and the other keeps the pressure constant (like a coffee cup calorimeter). They help us figure out how much heat a substance can hold or release.