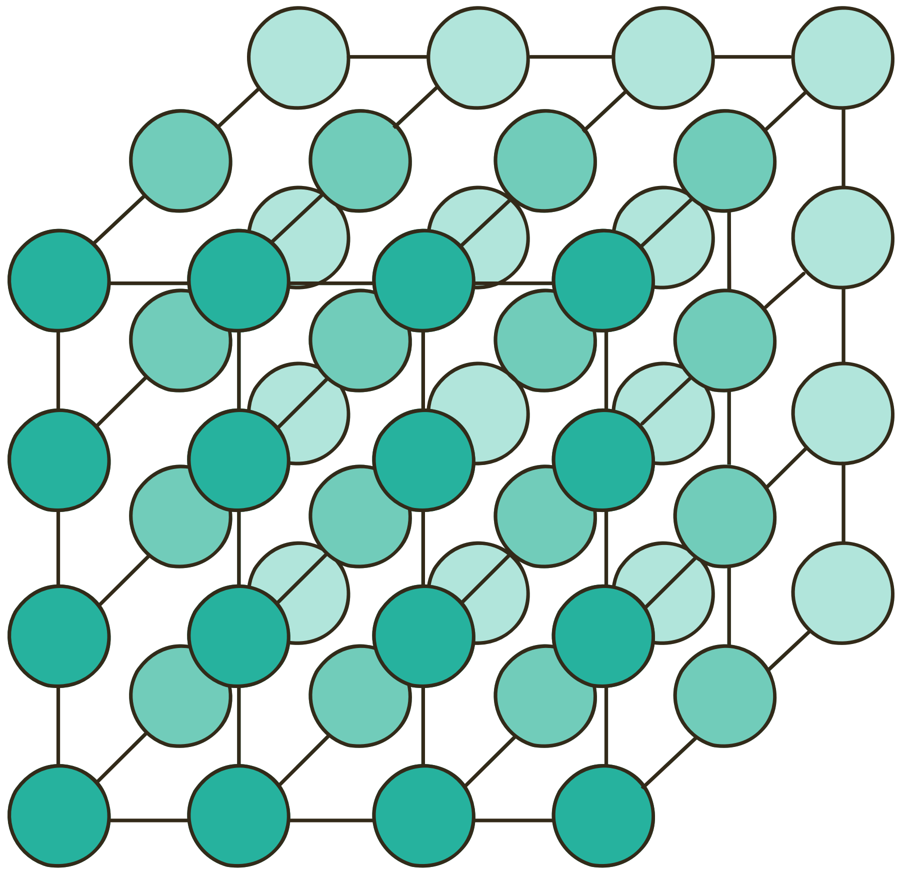
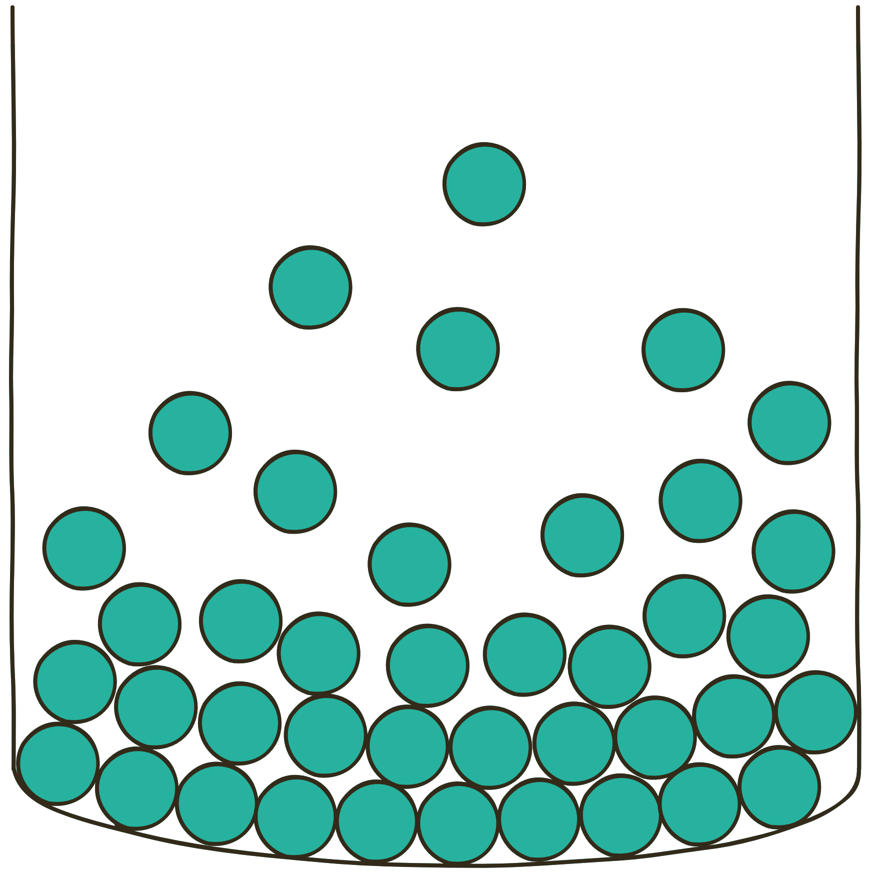
Chapter 2

Kinetic Particle Model Of Matter

Syllabus 2023-2025





2 Thermal physics

2.1 Kinetic particle model of matter

2.1.1 States of matter

1 Know the distinguishing properties of solids, liquids and gases

2 Know the terms for the changes in state between solids, liquids and gases (gas to solid and solid to gas transfers are **not** required)

2.1.2 Particle model

1 Describe, qualitatively, the particle structure of solids, liquids and gases, relating their properties to the forces and distances between particles and to the motion of the particles (atoms, molecules, ions and electrons)

2 Describe the relationship between the motion of particles and temperature, including the idea that there is a lowest possible temperature (–273 °C), known as absolute zero, where the particles have least kinetic energy

3 Describe the pressure and the changes in pressure of a gas in terms of the forces exerted by particles colliding with surfaces, creating a force per unit area

4 Explain qualitatively, in terms of particles, the relationship between:

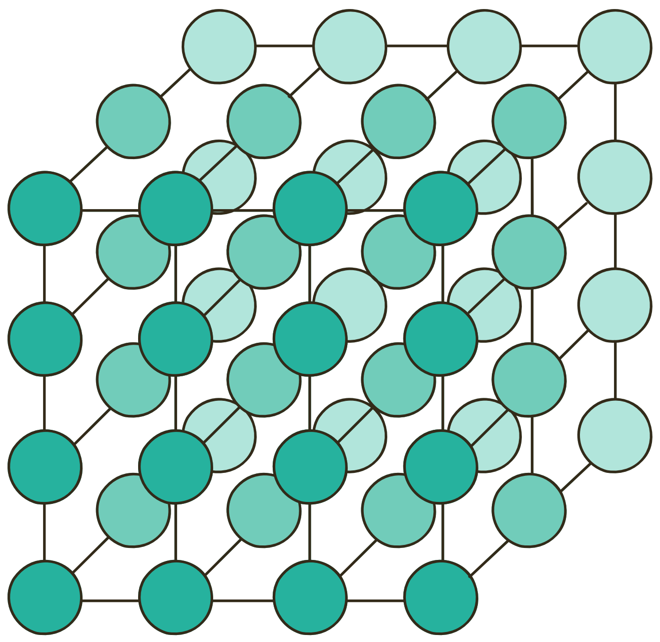
(a) pressure and temperature at constant volume

(b) volume and temperature at constant pressure

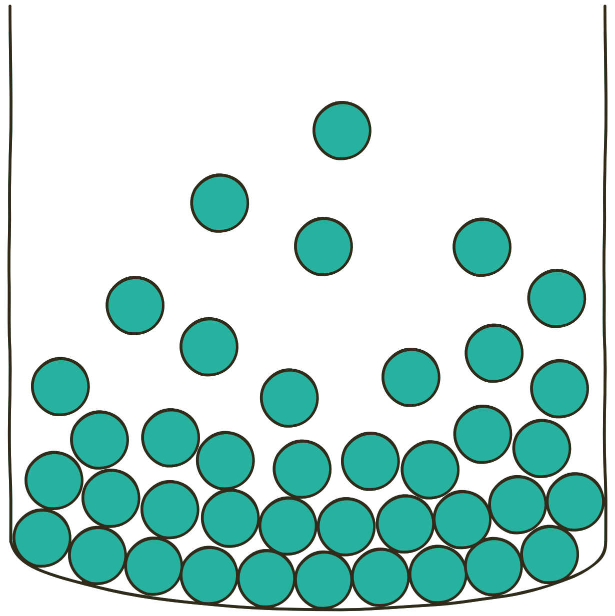
(c) pressure and volume at constant temperature

5 Recall and use the equation $p_1V_1 = p_2V_2$, including a graphical representation of the relationship between pressure and volume for a gas at constant temperature

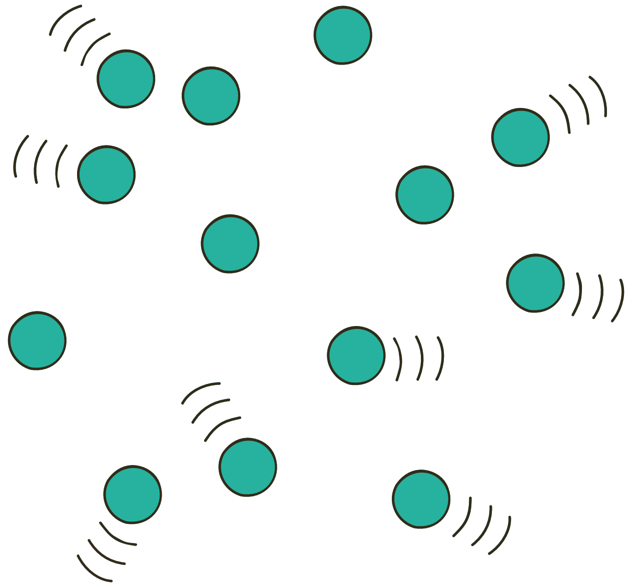
States of matter



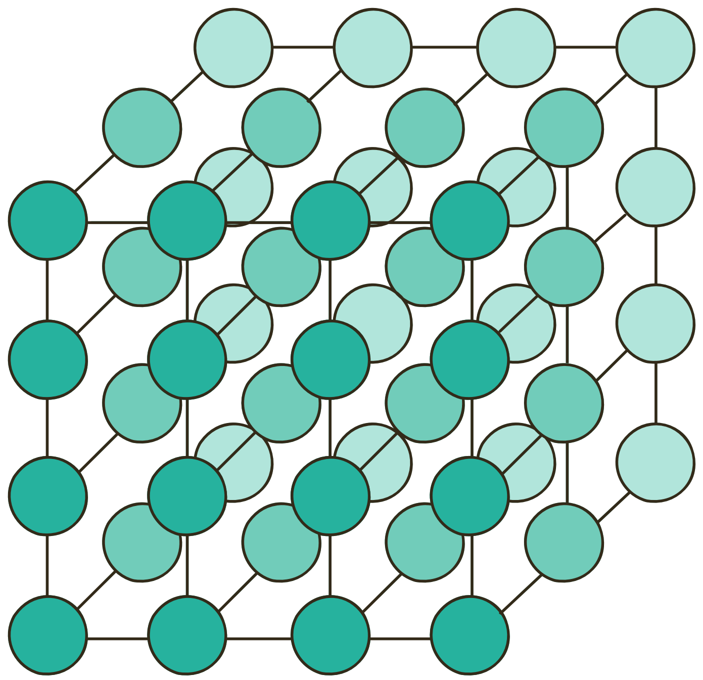
Solid



Liquid



Gas

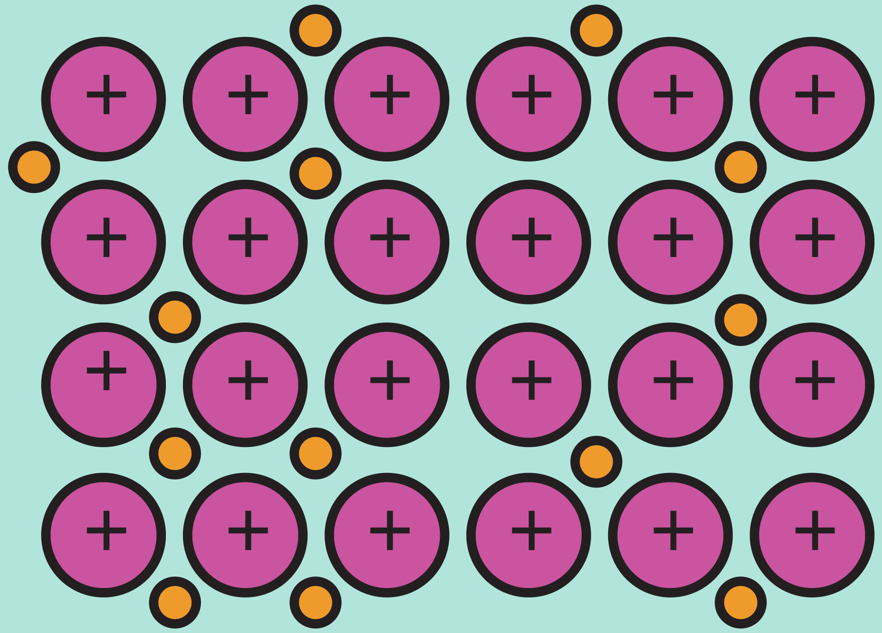


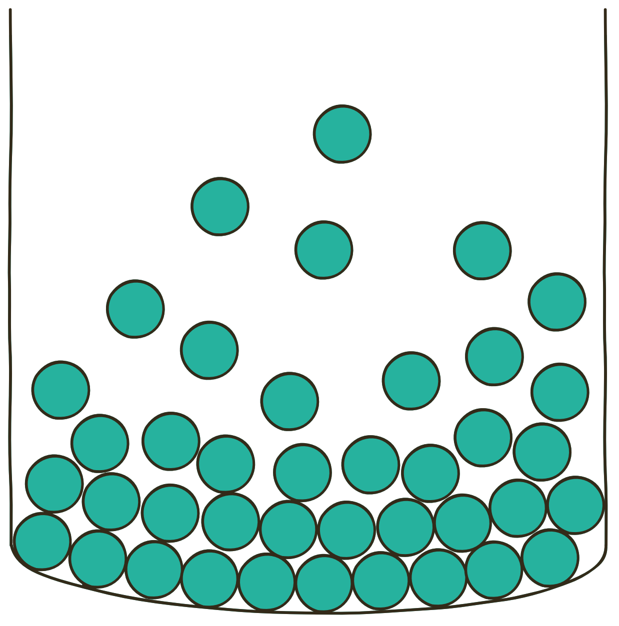
Solid

- The **Intermolecular forces** between particles in solid are **very strong.**
- This causes the particles to be **very close together** and **arranged** in a **regular pattern.**
- The particles in a solid can only **vibrate** about **fixed positions**.
- Solid have **definite shape** and a **definite volume**, because its particles cannot move freely and are **not easily compressible**

What is Intermolecular forces?

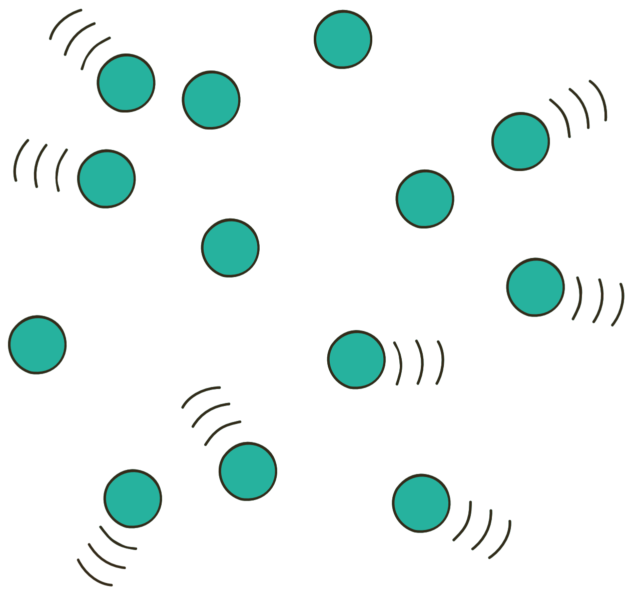
The forces of attraction between the particles





Liquid

- The **Intermolecular forces** between particles in liquid are **slightly weaker** than those in solid**.**
- This causes the particles to be **very close together** and **arranged** in a **irregular pattern.**
- The particles in a liquid can **move** and **slide past each other.**
- Liquid have **no definite shape** but do have **definite volume**, because its particles can **flow** to take the shape of the container, but they are **not easily compressible**



Gas

- The **Intermolecular forces** between particles in gas are **very weak**.

- This causes the particles in a gas to be **far apart**

- The particles in a gas can **move around randomly** at **high speed.**

- Gas have **no definite shape and no definite volume**, because its particles can move freely to take the shape of the container, and are **highly compressible**.

Internal Energy of matter

Internal energy is the sum of kinetic energy and potential energy of the molecules

Internal Energy = KE + PE

Kinetic energy

- **Kinetic energy** of the particle is **depend on its temperature**

- The **higher** the **temperature**, the higher the kinetic energy. which mean the **particle** moves **faster**

Kinetic energy ∝ Temperature

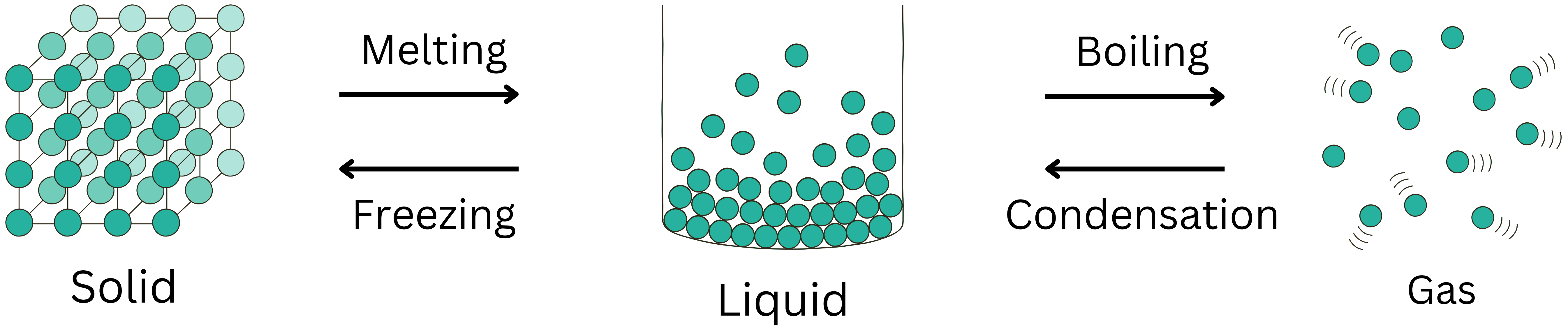
Potential energy

- Potential Energy depends on the **space between molecule**

- When the **separation** between the **molecule increases**, the **potential energy increases**.

Potential energy ∝ Distance between 2 molecules

Change states of matter



Melting

- When Solid **absorb heat** energy to **break** its **intermolecular forces** and **separate** the molecules, therefore **potential energy increases.**
- While the **temperature remain constant**, The **kinetic energy** remain **constant.**
- In conclusion **internal energy increases.**

Freezing

- is a process where **heat energy** is **removed from liquid, create intermolecular forces**, and **reduce** the **separation between molecules**, therefore the **potential energy decreases**
- Temperature **remain constant** , **kinetic energy remain constant**
- Internal energy **decreases**

Boiling

- When liquid **absorb heat** energy to **break** its **intermolecular forces** and **separate** the molecules, therefore **potential energy increases.**
- While the **temperature remain constant**, The **kinetic energy** remain **constant.**
- **Internal energy increases.**

Condensation

- is a process where **heat energy** is **removed from gas,** to **create intermolecular forces**, and **reduce** the **separation between molecules**, therefore the **potential energy decreases**
- Temperature **remain constant** , **kinetic energy remain constant**
- Internal energy **decreases**

Heating vs cooling

No change in states

Heat energy is added

Kinetic energy increases

Internal energy increases

Heat energy is removed

Kinetic energy decreases

Internal energy decreases

In a process of **heating or cooling** where **no change in states** the **separation** between **molecules** remain **constant**, therefore **potential energy** remain **constant**

Absolute scale of temperature

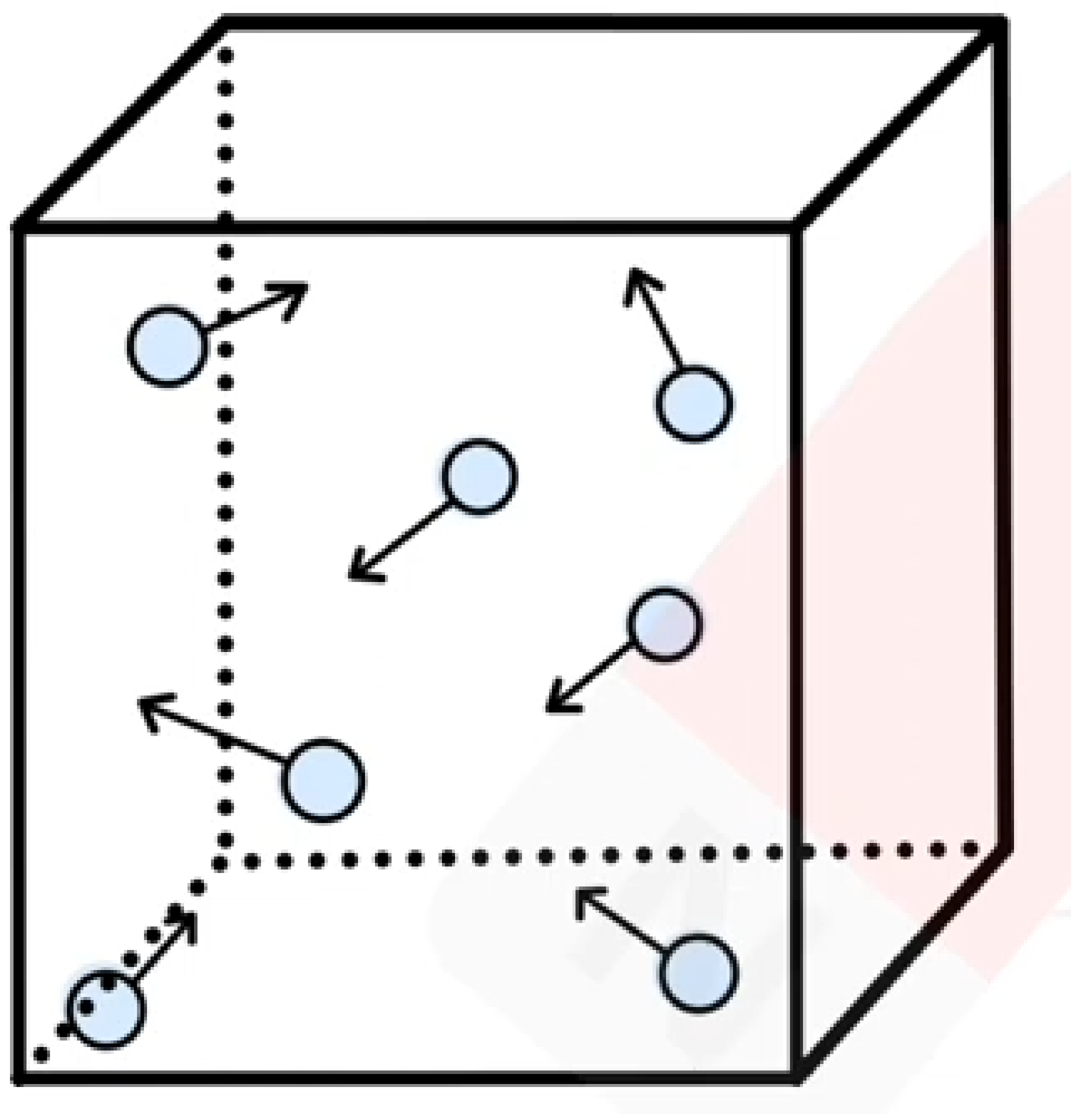
Kelvin scale

- **Absolute zero** is **0K**, **equivalent** to **-273°C**.
- It is **not possible** to have **temperature lower** than **0K**
- At absolute zero, is where there is **no heat energy** , therefore, the particles have **0 kinetic energy**.

To convert temperature °C to Kelvin

$$T(\text{in kelvin}) = T(\text{in °C}) + 273$$

How does **gas** exert **pressure** on the **container**



- The **pressure** of gas is **produced** by the **collisions** of **gas molecules** on the **surface of the wall**.
- When the **molecule hits** the **surface of the wall**, it **bounces off** the wall creating a **change in momentum** as the molecule change its direction of velocity.
- By relating to newton 2nd law, **Force is directly proportional to the rate of change in momentum**.
- When **force** is exert, therefore, the **pressure** is exert as pressure is defined by **force per unit area** (P=F/A)

Pressure and volume

(fixed mass and temperature)

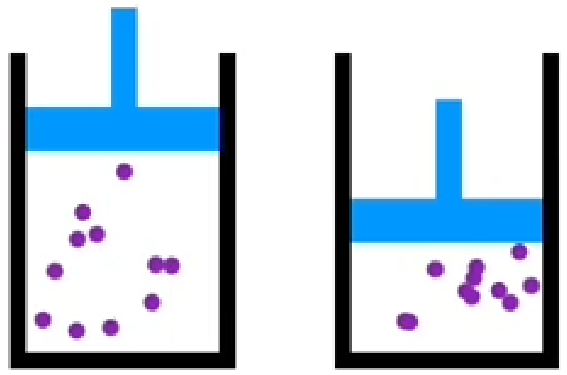
$$p \propto \frac{1}{V}$$

- Pressure is inversely proportional to the volume of the gas
- Which mean the higher the volume, the lower the pressure and vice versa.

$$P_1V_1 = P_2V_2$$

P1 - initial pressure
P2 - Final pressure
V1 - Initial volume
V2 - Final volume

When volume decreases

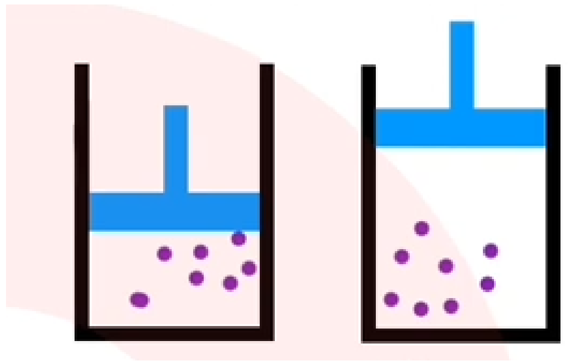


The gas molecule moving closer together

Gas molecule collides with the wall more frequent

Total force per unit area increases

When volume Increases



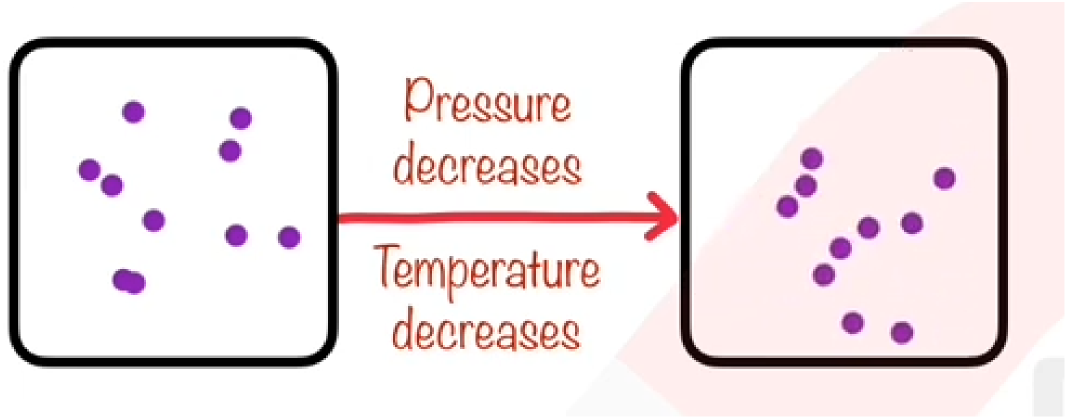
The gas molecule moving further apart

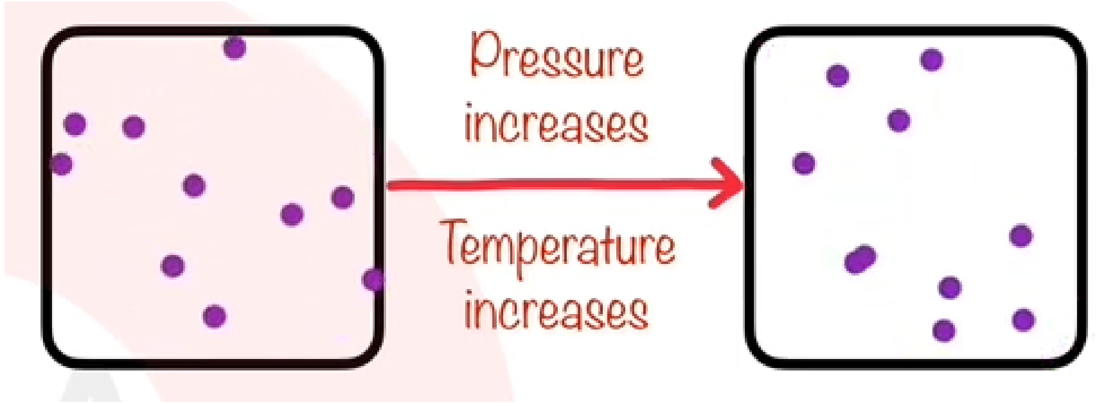
Gas molecule collides with the wall more less frequent

Total force per unit area decreases

Pressure and temperature

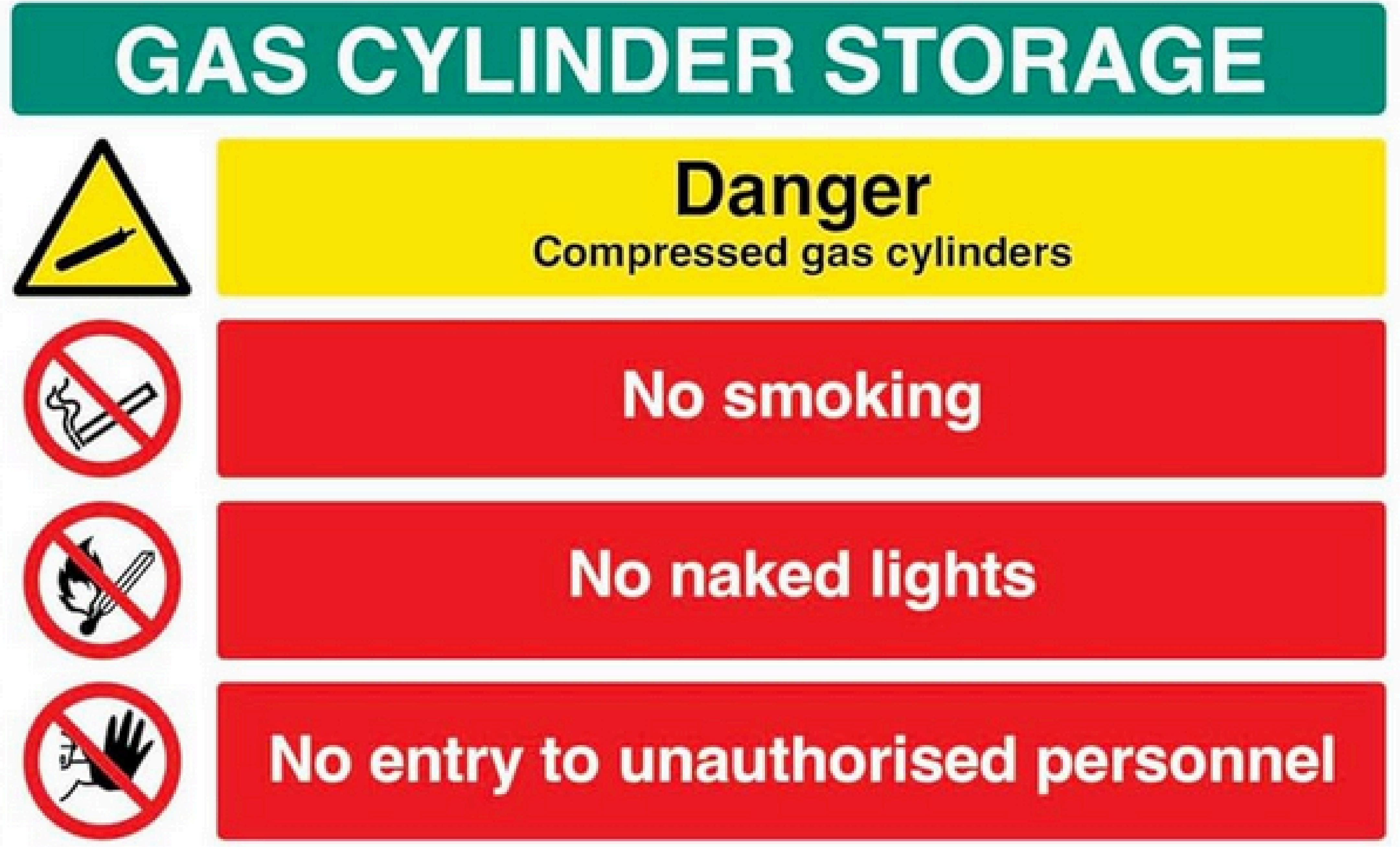
(fixed mass and volume)





- When the temperature decreases, the pressure also decreases
- This is because the speed of molecule decreases.
- The collision of between the molecule and the wall is less frequent and less force
- Therefore, the total force per unit area decreases.

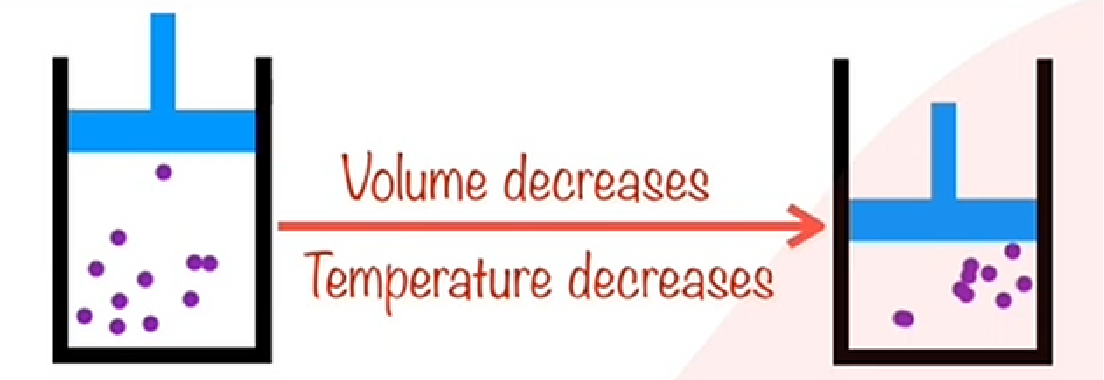
- When the temperature increases, the pressure also increases
- This is because the speed of molecule increases.
- The collision of between the molecule and the wall is more frequent and more force
- Therefore, the total force per unit area increases.


GAS CYLINDER STORAGE
Danger
Compressed gas cylinders
No smoking
No naked lights
No entry to unauthorised personnel

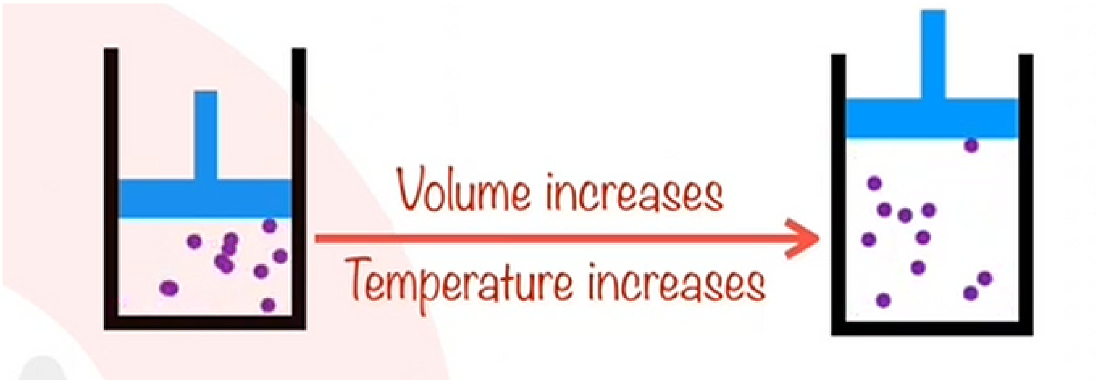

NEW
glade
2X

Temperature and volume

(fixed mass and Pressure)



- When the **temperature decreases**, the **volume** also **decreases.**
- This causes the **molecule** to **collide** with the wall **less often**.
- The **pressure** inside the container will **decrease** and become **lower** than **atmospheric pressure**.
- The **difference in pressure** will cause the **piston moving inward** until the pressure equalize.
- Therefore, **volume decreases.**



- When the **temperature increases**, the **volume also increases**.
- This causes the **molecule** to **collide** with the **wall more often**.
- The **pressure inside** the container will **increase** and become **higher** than **atmospheric pressure**.
- The **difference** in pressure will cause the **piston moving upward** until the pressure equalize.
- Therefore, **volume increase**.