WEEK 14

Physics of Engineer

Chapter 13: ideal gas and pure substance, work and heat

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Outline

- Ideal gas and pure substance
- Introduction
- Ideal gas
- Physical meaning of ideal gas
- Parameter of an ideal gas
- Charles'law
- Boyle 's law
- Application of ideal gas law

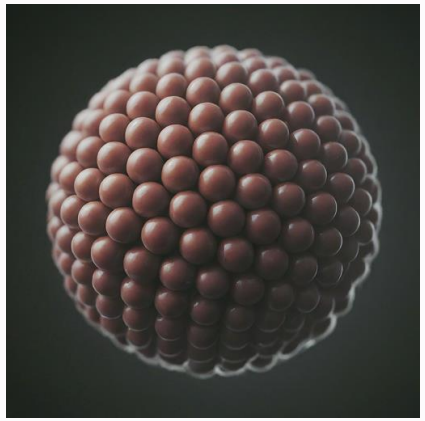
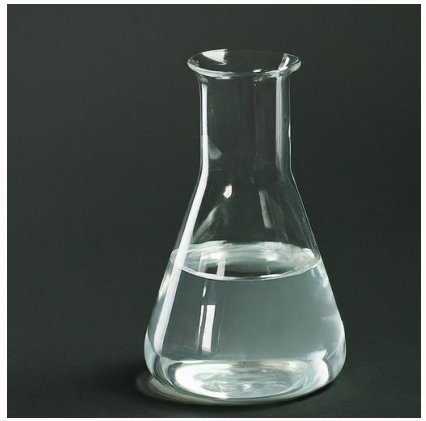
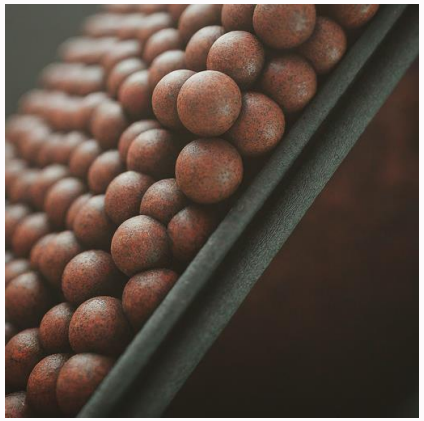
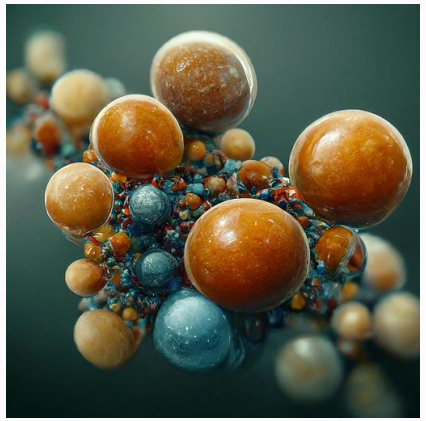
NPRU

Outline

- ❑ Pure substance
- ❑ Properties of pure substances
- ❑ Phase diagrams
- ❑ Application of pure substances
- ❑ Conclusion
- ❑ Exploring Resources and references

NPRU

Ideal Gas and Pure Substance


Introduction



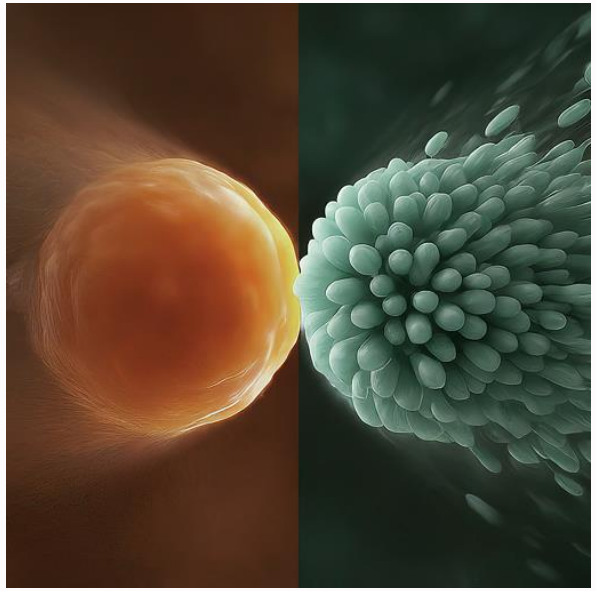
- **Physical Meaning:** Introduction to the concept of matter and its phases (solid, liquid, gas)
- **Definition:** What is a pure substance? A substance with a fixed chemical composition throughout
- What is Thermodynamics?
- Branch of physics concerned with relationships between heat, work, temperature, and energy.
- Focuses on energy transfer and transformations.

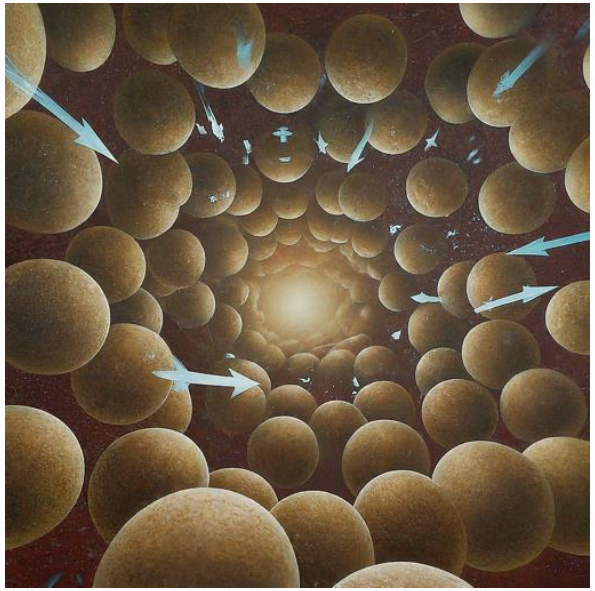
Ideal Gas

- **Definition:** A hypothetical gas that perfectly obeys the ideal gas law
- Theoretical gas that follows the ideal gas law.
- Molecules have negligible volume and no attractive or repulsive forces between them.
- Ideal gas behaviour is a simplification, but it provides a good approximation for real gases under certain conditions.

Physical Meaning of Ideal Gas

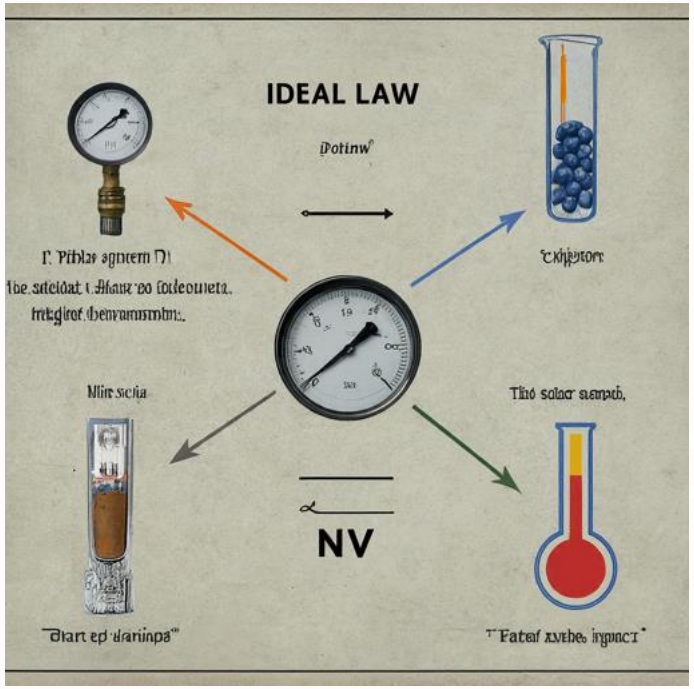
- Ideal gas particles are in constant, random motion.
- Collisions between particles transfer energy but do not result in any loss of kinetic energy.
- Pressure arises due to these collisions with the container walls.





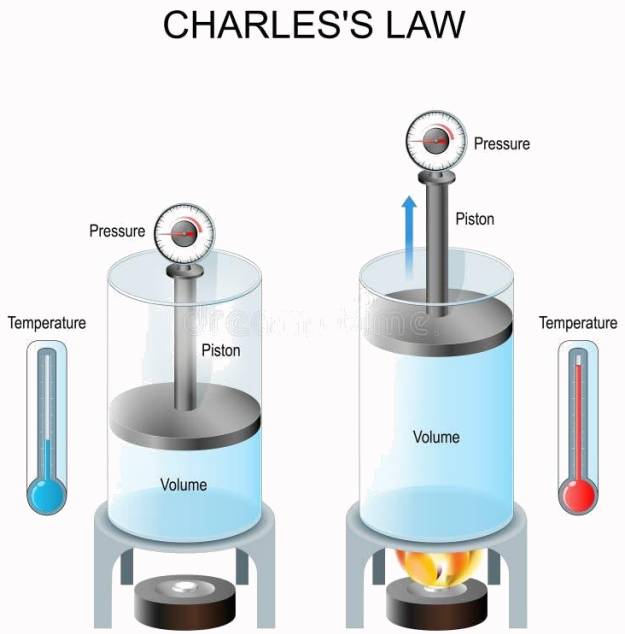
Parameters of an Ideal Gas

- Pressure (P): Force exerted per unit area on the container walls (measured in Pascals, Pa)
- Volume (V): Space occupied by the gas (measured in cubic meters, m^3)
- Temperature (T): Measure of hotness or coldness (measured in Kelvin, K)
- Number of moles (n): Amount of gas present (measured in moles)



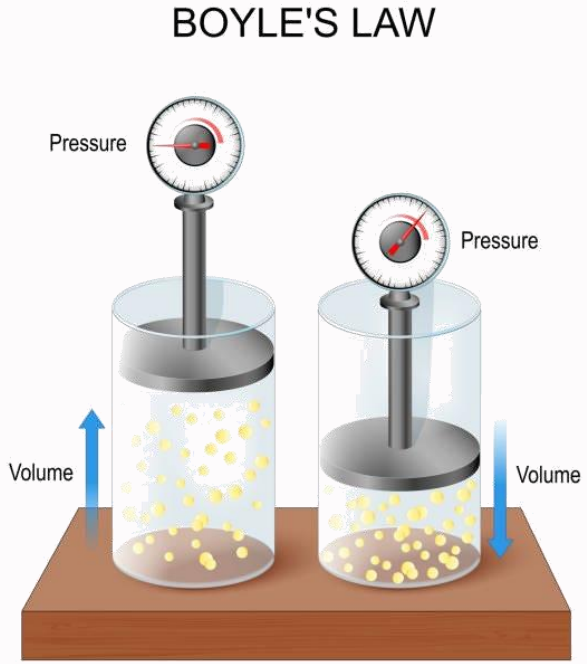
Charles' Law

- **Definition:** At constant pressure, the volume of an ideal gas is directly proportional to its absolute temperature
- **Mathematical Representation:** $V \propto T$ (at constant P)



Boyle's Law

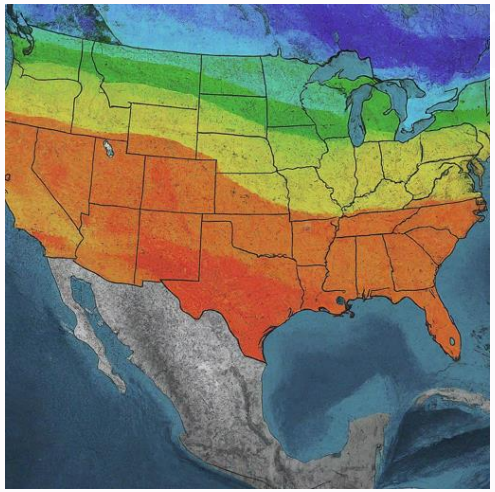
- **Definition:** At constant temperature, the pressure of an ideal gas is inversely proportional to its volume
- **Mathematical Representation:** $P \propto 1/V$ (at constant T)



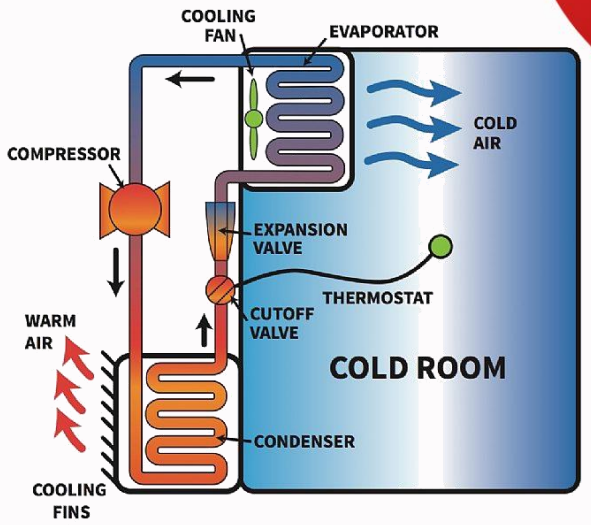
Applications of Ideal Gas Law

- **Airbags:** Ideal gas law principles are used to design airbags. As a car collides, a rapid chemical reaction generates gas that inflates the airbag. The ideal gas law helps determine the amount of gas needed to fill the airbag at the right pressure to cushion the impact.

- **Weather Prediction:** Understanding how pressure, volume, and temperature of air masses behave using the ideal gas law helps meteorologists predict weather patterns. Changes in pressure and temperature can lead to air movement, influencing cloud formation, precipitation, and wind patterns.



Applications of Ideal Gas Law



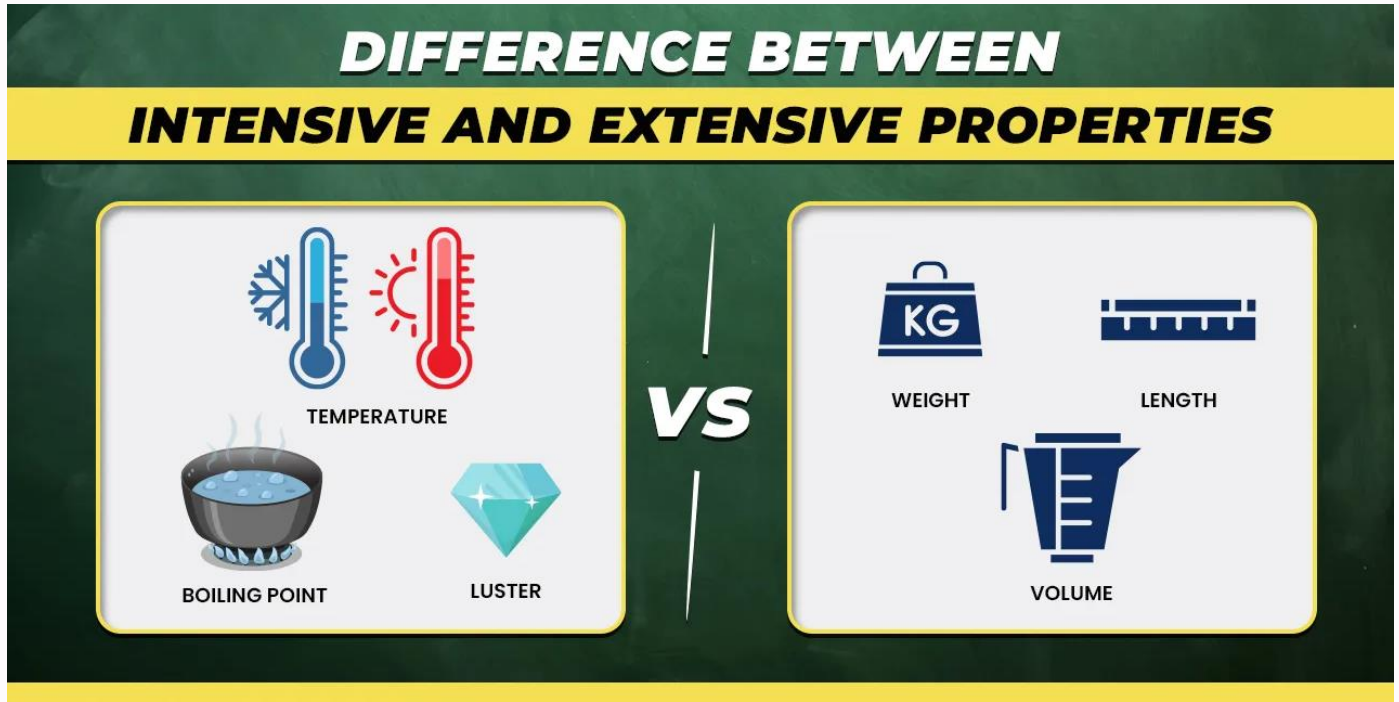
- **Refrigeration Systems:** Ideal gas principles govern the operation of refrigeration systems. Compressing the refrigerant gas (typically a low-boiling-point liquid) increases its pressure and temperature. It then releases heat to the environment as it expands through a valve, lowering its temperature and absorbing heat from the refrigerator compartment.

Pure Substances

- **Definition:** A substance with a fixed chemical composition throughout

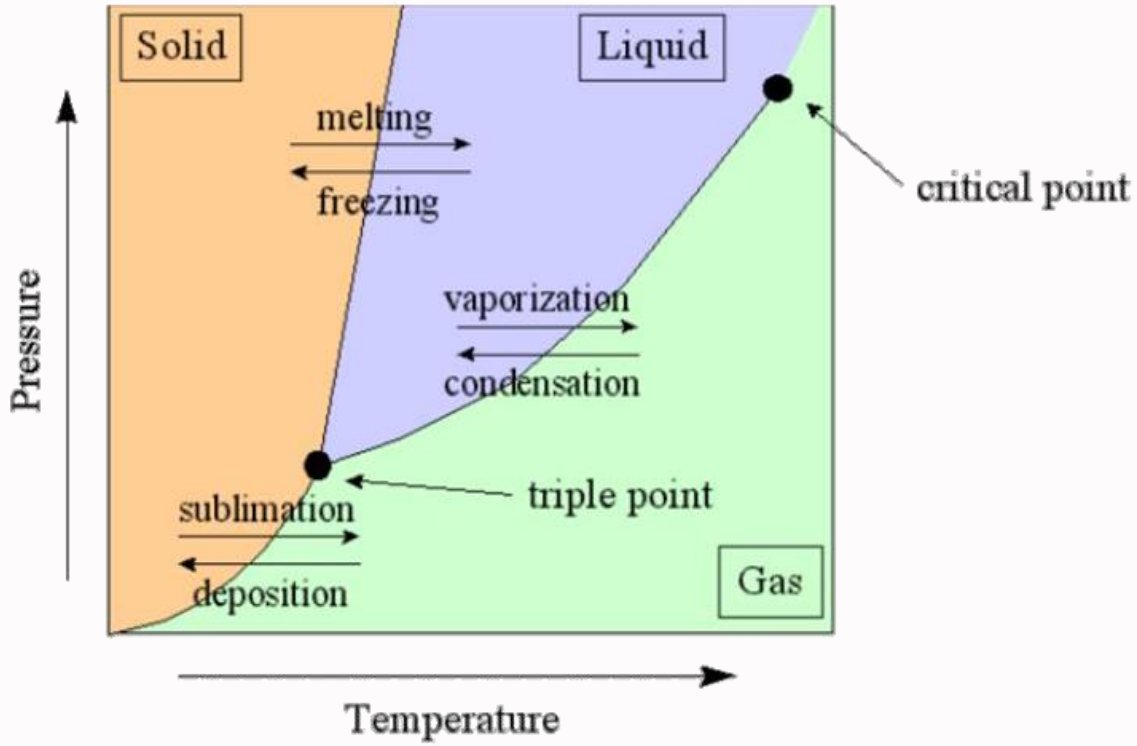
Properties of Pure Substances

- Pure substances exhibit distinct properties in different phases.
- **Intensive Properties:** Independent of the amount of substance (e.g., temperature, pressure)
- **Extensive Properties:** Dependent on the amount of substance (e.g., mass, volume)



Phase Diagrams

- **Definition:** Graphical representation of the conditions (pressure and temperature) under which a pure substance exists in different phases



Applications of Pure Substances

- **Power Generation:** Steam turbines in power plants utilize the phase change of water (liquid to vapor) to generate electricity. By heating water to create high-pressure steam, the steam drives the turbine blades, converting thermal energy into mechanical energy that ultimately produces electricity.

Conclusion

- *Ideal gas and pure substances* are foundational concepts in thermodynamics, providing a framework for understanding the behavior of gases and various materials. The ideal gas law serves as a simplified model for relating pressure, volume, and temperature of ideal gases. It finds applications in diverse fields like airbag design, weather prediction, and refrigeration systems.
- Pure substances, characterized by a uniform chemical composition, exhibit distinct properties in different phases (solid, liquid, gas). Their behavior can be effectively analyzed using phase diagrams. Applications of pure substances are widespread, including power generation through steam turbines.
- In essence, comprehending ideal gases and pure substances equips us to interpret the behavior of matter under various conditions, paving the way for advancements in numerous scientific and engineering fields.

Exploring Resources and References

- **Online Resources:**
  - Khan Academy: Ideal Gas Law (https://www.khanacademy.org/science/ap-chemistry-beta/x2eef969c74e0d802:intermolecular-forces-and-properties/x2eef969c74e0d802:ideal-gas-law/e/ideal-gas-law)
  - MIT OpenCourseware: Thermodynamics Lectures (https://ocw.mit.edu/courses/5-60-thermodynamics-kinetics-spring-2008/)
  - National Institute of Standards and Technology (NIST) Thermophysical Properties: (https://webbook.nist.gov/chemistry/)
- **Interactive Simulations:**
  - PhET Interactive Simulations: Gas Properties (https://phet.colorado.edu/en/simulation/gas-properties) (Explore other relevant simulations offered by PhET)

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