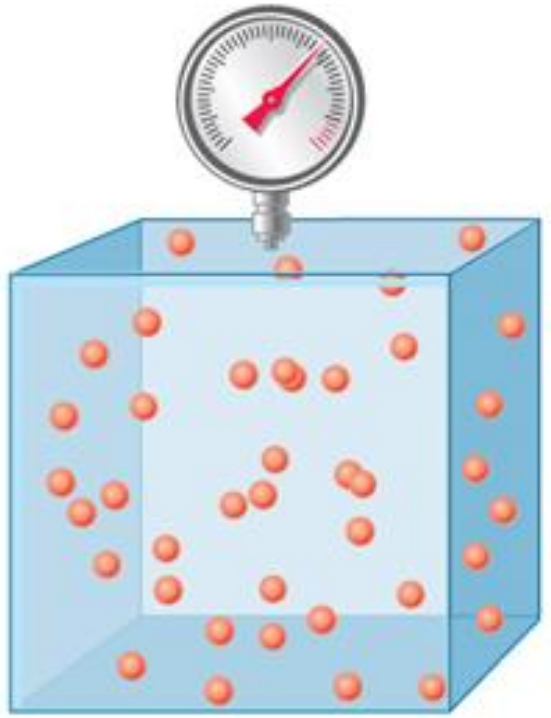
2 The Macroscopic Variables Volume, Pressure, and Temperature

- *The simplest state of matter is a gas, a form of matter that fills any container it occupies*
- *Lets picture a gas as a collection of molecules (or atoms) in continuous random motion, with average speeds that increase as the temperature is raised.*
- *What is the main difference between gases and liquids?*

  Answer: The molecules of a gas are widely separated from one another and unaffected by intermolecular forces



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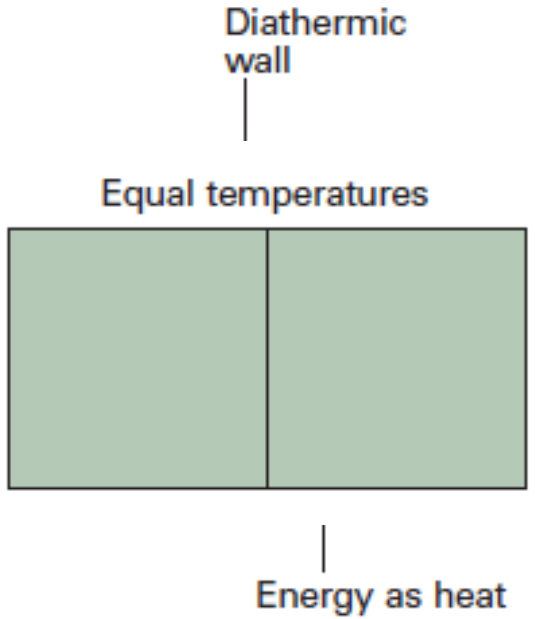
2 The Macroscopic Variables Volume, Pressure, and Temperature

- *What physical association can we make with the temperature T?*

- *Temperature, T, is a property that indicates the direction of the flow of energy through a thermally conducting, rigid wall. If energy flows from A to B when they are in contact, then we say that A has a higher temperature than B*



- *No net transfer of energy as heat*

↓

Thermal equilibrium

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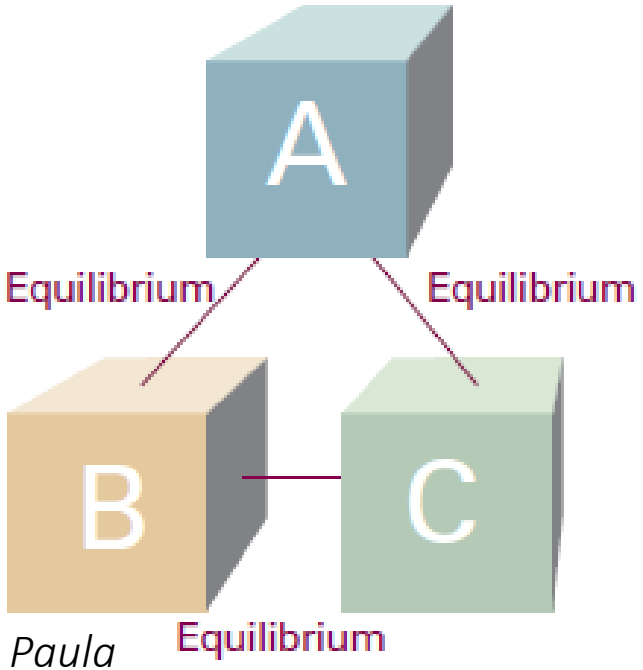
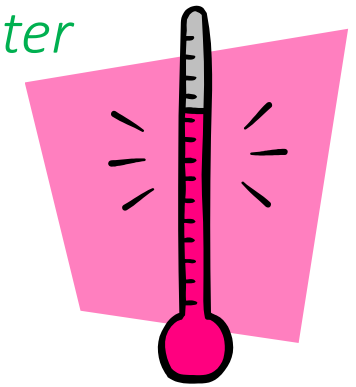
3 Basic Definitions Needed to Describe Thermodynamic Systems

- *Zeroth Law of thermodynamics*

- *If A is in thermal equilibrium with B, and B is in thermal equilibrium with C, then C is also in thermal equilibrium with A*



- *The Zeroth Law justifies the use of a thermometer*



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4 Equations of State and the Ideal Gas Law

- **Each substance is described by an equation of state**

- **Equation of state is a formula that interrelates the variables that describe the substance.**

Boyle's law: $pV = \text{constant}$, at constant n, T

Charles's law: $V = \text{constant} \times T$, at constant n, p

$p = \text{constant} \times T$, at constant n, V

Avogadro's principle:[2] $V = \text{constant} \times n$ at constant p, T

- **Avogadro's principle is commonly expressed in the form "equal volumes of gases at the same temperature and pressure contain the same numbers of molecules"**

4 Equations of State and the Ideal Gas Law

- *Boyle's Law: PV = Constant, at fixed n and T*

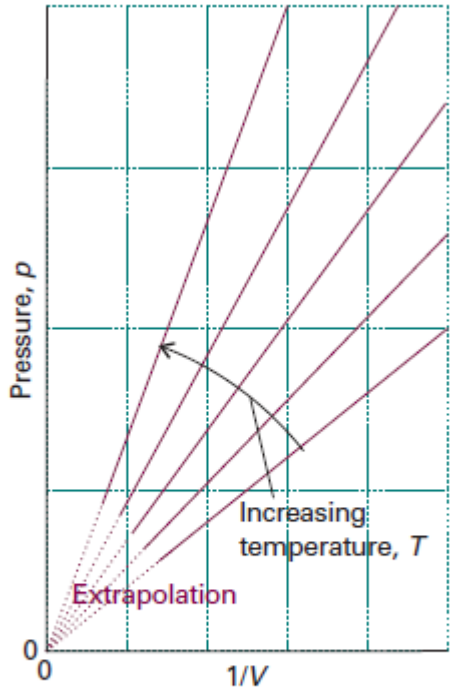

Fig. 1.5 Straight lines are obtained when the pressure is plotted against $1/V$ at constant temperature.

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4 Equations of State and the Ideal Gas Law

- *Charles's Law:* V = Constant X T, at fixed n and P
  P = Constant X T, at fixed n and V

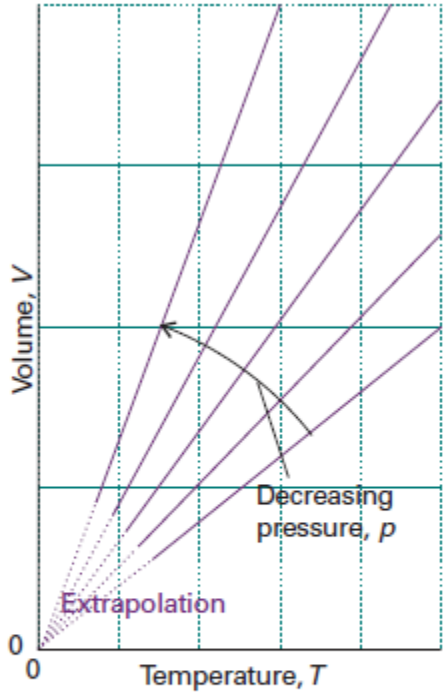

Fig. 1.6 The variation of the volume of a fixed amount of gas with the temperature at constant pressure. Note that in each case the isobars extrapolate to zero volume at $T = 0$, or $\theta = -273°C$.

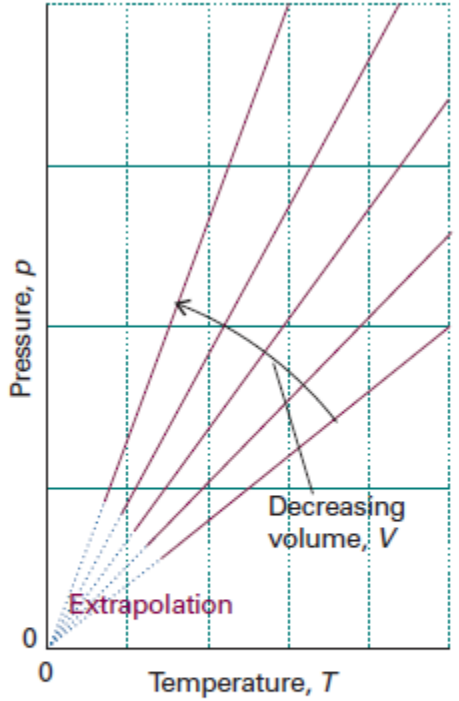

Fig. 1.7 The pressure also varies linearly with the temperature at constant volume, and extrapolates to zero at $T = 0$ (−273°C).

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