Chapter 10+11: Intermolecular Forces

Dec 5, 2022

Chemistry Department, Cypress College

Class Announcements

Lecture

- Short lecture Ch 10 and 11
- Final Exam Dec 10th in Lecture
- Turn in all assignments

Outline

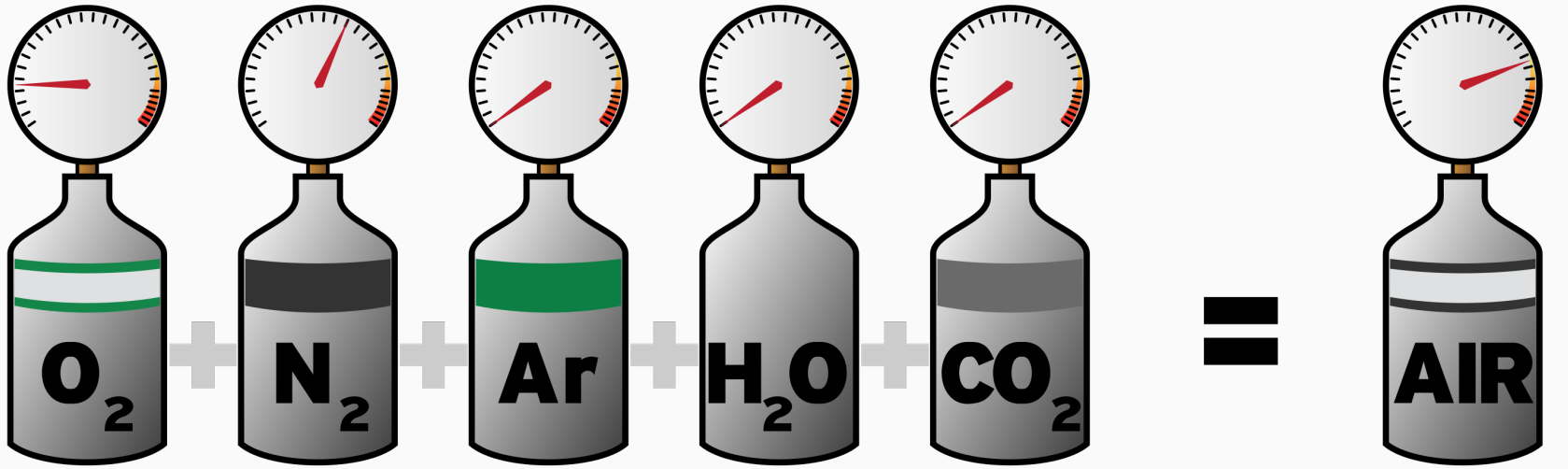
Dalton's Law of Partial Pressures

Gases in a mixture behave independently and exert the same pressure they would exert if they were in a container alone

$$P_{\text{Total}} = P_A + P_B + P_C + \cdots \tag{1}$$

where P_{Total} is the total pressure and $P_A, P_B, \cdots$ are the pressures of the components

Dalton's Law of Partial Pressures



$$P_{\text{Total}} = P_{\text{O2}} + P_{\text{N2}} + P_{\text{Ar}} + P_{\text{H2O}} + P_{\text{CO2}}$$

Mole Fraction

Expressing the relative amounts of substances in a mixture

$$\chi_A = \frac{n_A}{n_{\text{Total}}} \tag{2}$$

where χ_A is the mole fraction of component A, n_A is the amount of moles for A, and n_{Total} is the total amount of moles in the mixture

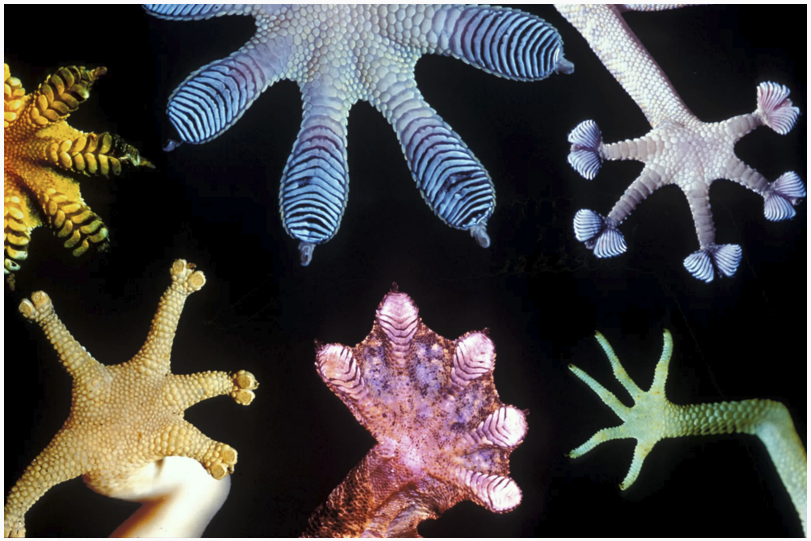
Dalton's Law of Partial Pressure

Since each gas component exert its own pressure, the partial pressure of each component can be expressed by

$$P_A = \chi_A P_{\text{Total}} = \frac{n_A}{n_{\text{Total}}} P_{\text{Total}} \tag{3}$$

Outline

Introduction: Gecko's Sticky Secret

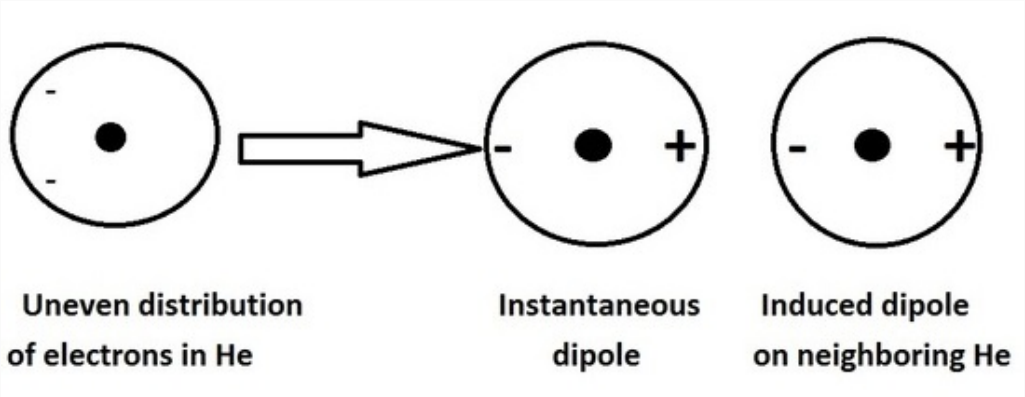


- Quickly turn their feet on/off (literally hanging by their toe hairs)
- Dominated by intermolecular forces
- Gecko-inspired materials e.g. sealing wounds and scaling walls

Defining Intermolecular Forces

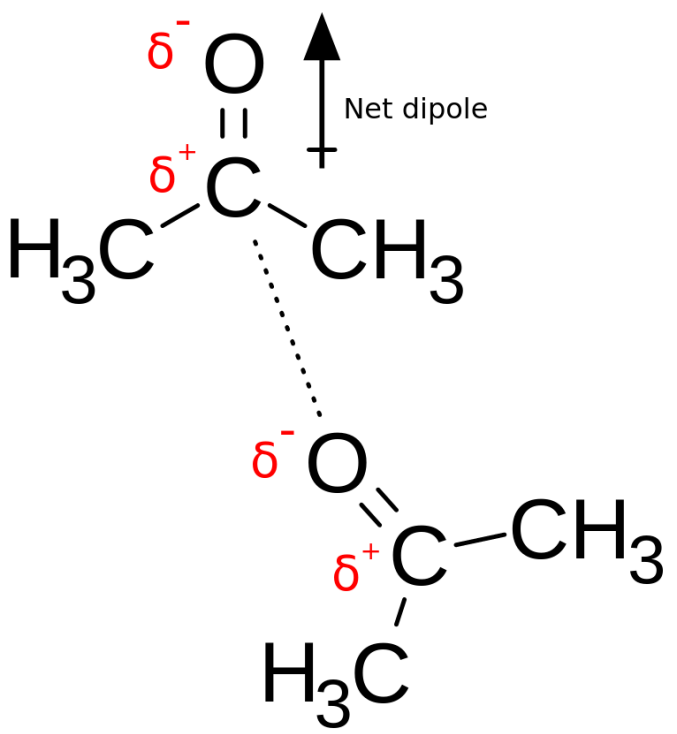
Intermolecular forces - interactions between molecules and significantly weaker than chemical bonds on the order of $\sim 10 - 10^3$ kJ/mol

Types of Intermolecular Forces



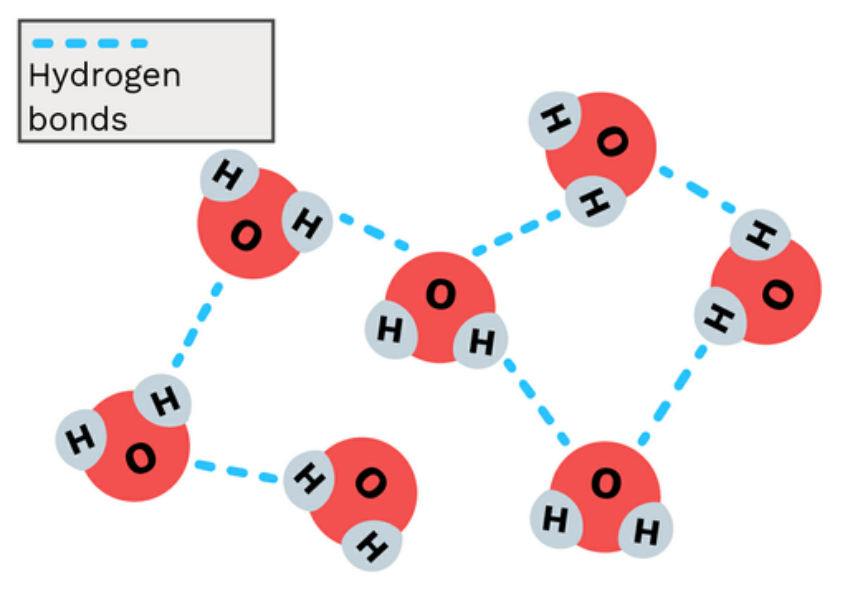
London Dispersion Forces - Spontaneous induced dipoles and weakest intermolecular forces; the heavier the molecule then the stronger these interactions (molar mass dependence)

Types of Intermolecular Forces



Dipole-dipole interactions - attractions between polar molecules; stronger than dispersion

Types of Intermolecular Forces



Hydrogen bonds - when H atoms are bonded to N, O, and F forming strong dipoles due to large electronegativity difference; strongest intermolecular forces

Practice: Identify the Intermolecular Forces

Determine the intermolecular forces present in the following molecules:

CO_2

H_2O

CH_4

PF_4

BH_3

$C_{12}H_{26}$

Practice: Identify the Intermolecular Forces

Based on the answers in the previous slide, rank the molecules from strongest to weakest intermolecular forces

CO_2

H_2O

CH_4

PF_4

BH_3

$C_{12}H_{26}$

Practice: Identify the Intermolecular Forces

Based on the answers in the previous slide, rank the molecules from highest to lowest boiling point

CO_2

H_2O

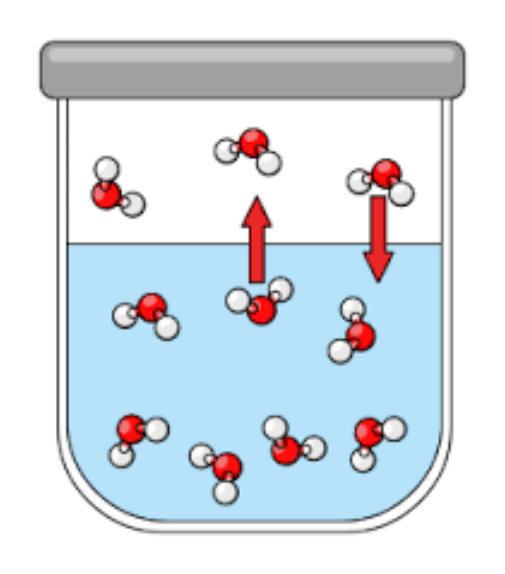
CH_4

PF_4

BH_3

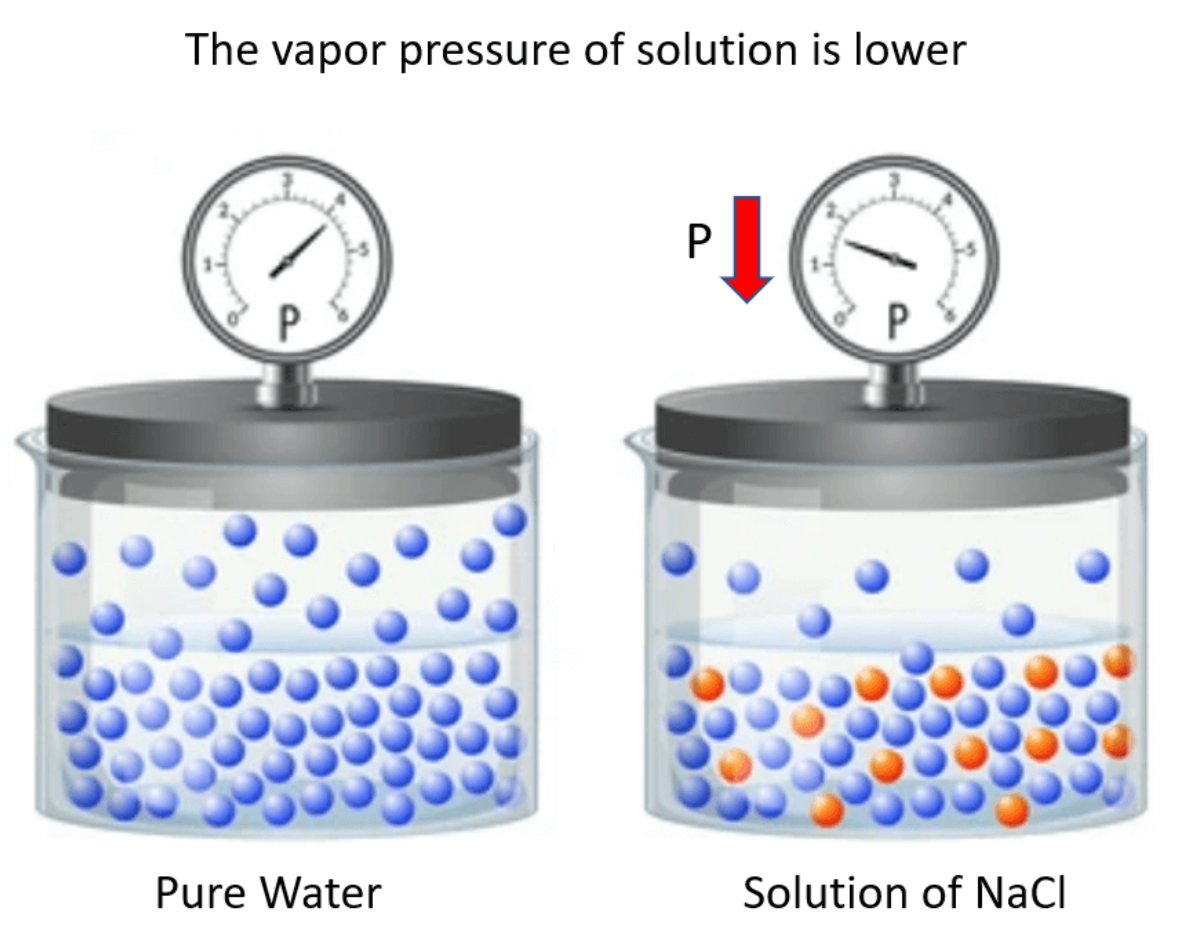
$C_{12}H_{26}$

Relating Vapor Pressure



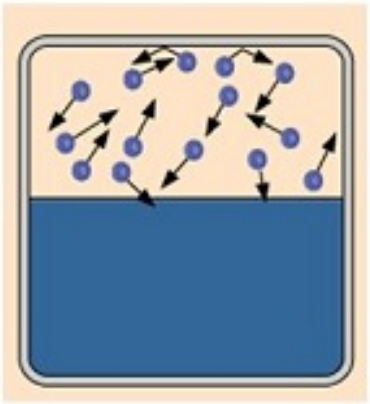
- Equilibrium between gas and liquid phase of the molecule
- Vapor pressure correlates with the strength of the intermolecular forces present in molecules
- **Q**: Determine which has higher vapor pressure: NH_3 or CH_2O

Relating Vapor Pressure



Q: How does the presence of NaCl lower the vapor pressure of water?

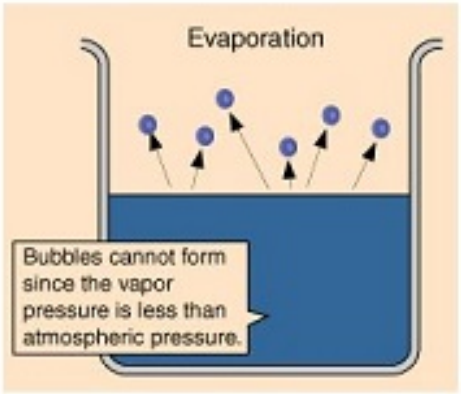
Vapor Pressure and Boiling



25 ºC

Atm Pressure

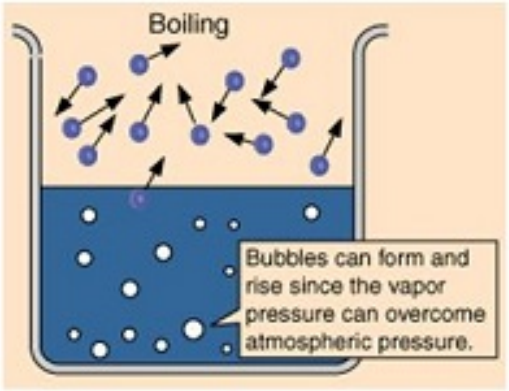
Vapor Pressure



70 ºC

Atm Pressure

Vapor Pressure



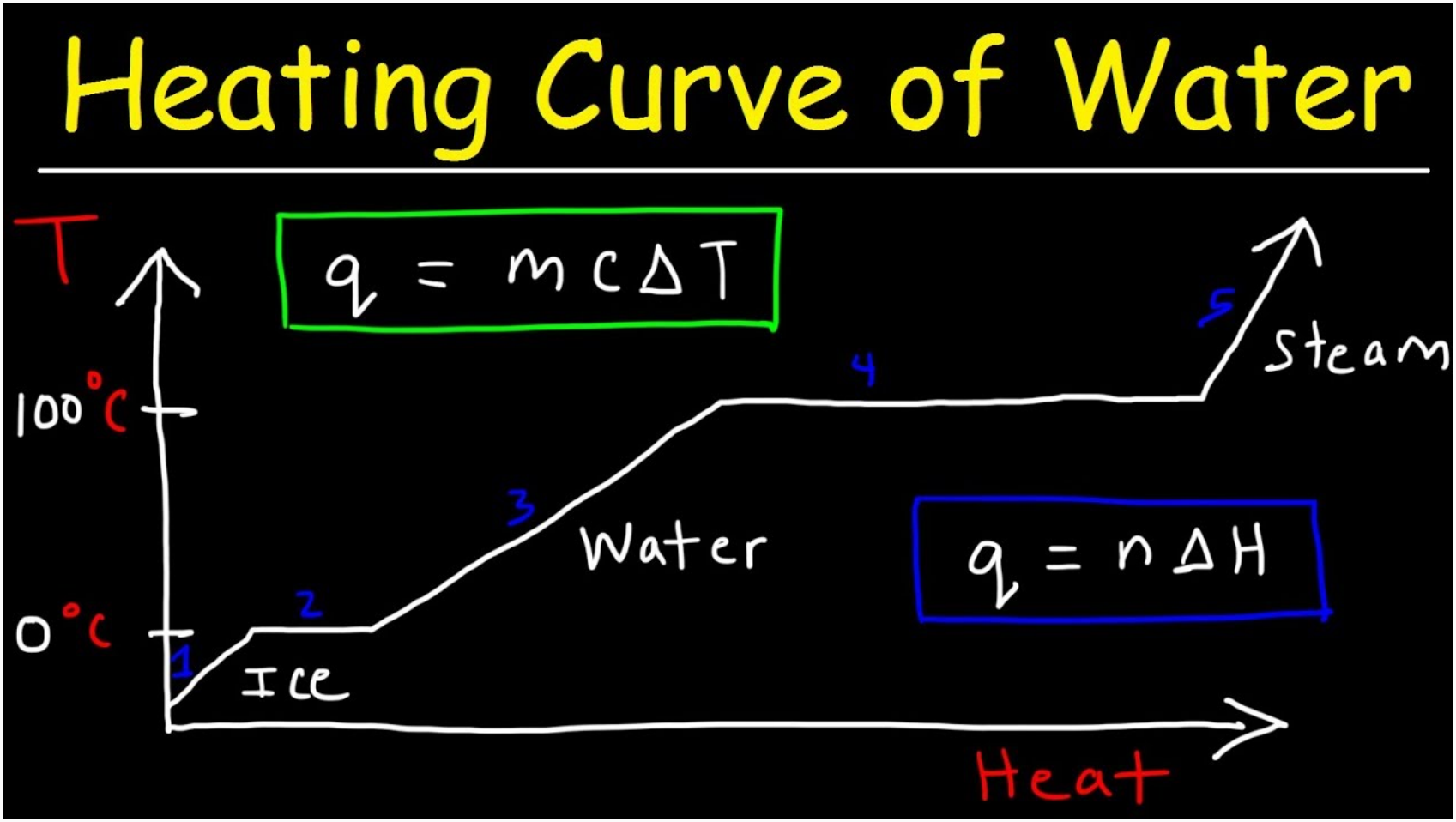
100 ºC

Atm Pressure

Vapor Pressure

Outline

Heating Curves

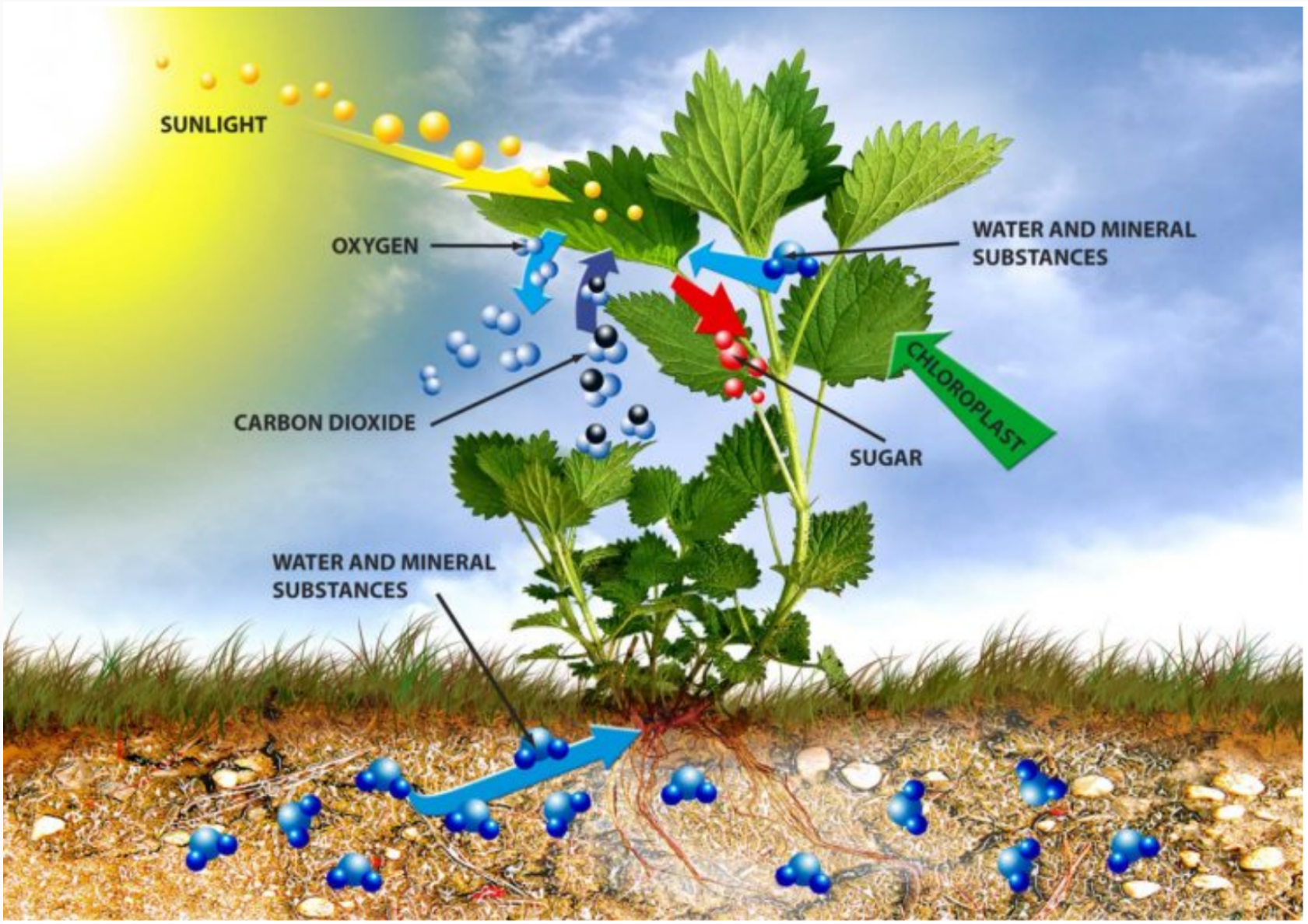


Practice: Heat Energy

Calculate the heat absorbed when 125g $H_2O(s)$ at -10°C is converted to $H_2O(g)$ at 150°C. The specific heats of ice, water, and water vapor are 2.03 J/(g °C), 4.18 J/(g °C), and 2.02 J/(g °C), respectively. the molar heat of fusion of ice is 6,010 J/mol and heat of vaporization of water is 4.07×10^4 J/mol.

Outline

Balanced Chemical Equation: Photosynthesis



Meaning of a Balanced Equation

Photosysnthesis Chemical Equation

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g) \qquad (4)$$

- Balanced chemical equation satisfies the conservation of mass
- Coefficients in front of the molecules represent the relative moles of reactants and products

Practice: Precipitation Reaction

Suppose we want to prepare $BaSO_4(s)$ by adding 0.450 M $K_2SO_4(aq)$ to 130.0mL of 0.250 M $BaCl_2(aq)$. What volume of $K_2SO_4(aq)$ is needed to react completely with the $BaCl_2(aq)$? How many grams of $BaSO_4$ will precipitate?

Practice: Acid-Base Reaction

Suppose a titration is run in which 35.00mL of NaOH(aq) solution of unknown concentration reacts with 25.00mL of 0.100M H_2SO_4(aq). What is the molarity of the NaOH solution?

Practice: Acid-Base Reaction

Suppose you neutralize 50.0mL of 2.5M $H_3PO_4(aq)$ with 1.25M NaOH(aq). Determine the volume of 1.25M NaOH(aq) needed to neutralize $H_3PO_4(aq)$?