Chemistry Fundamentals

LECTURE 2: Matter and Its Properties

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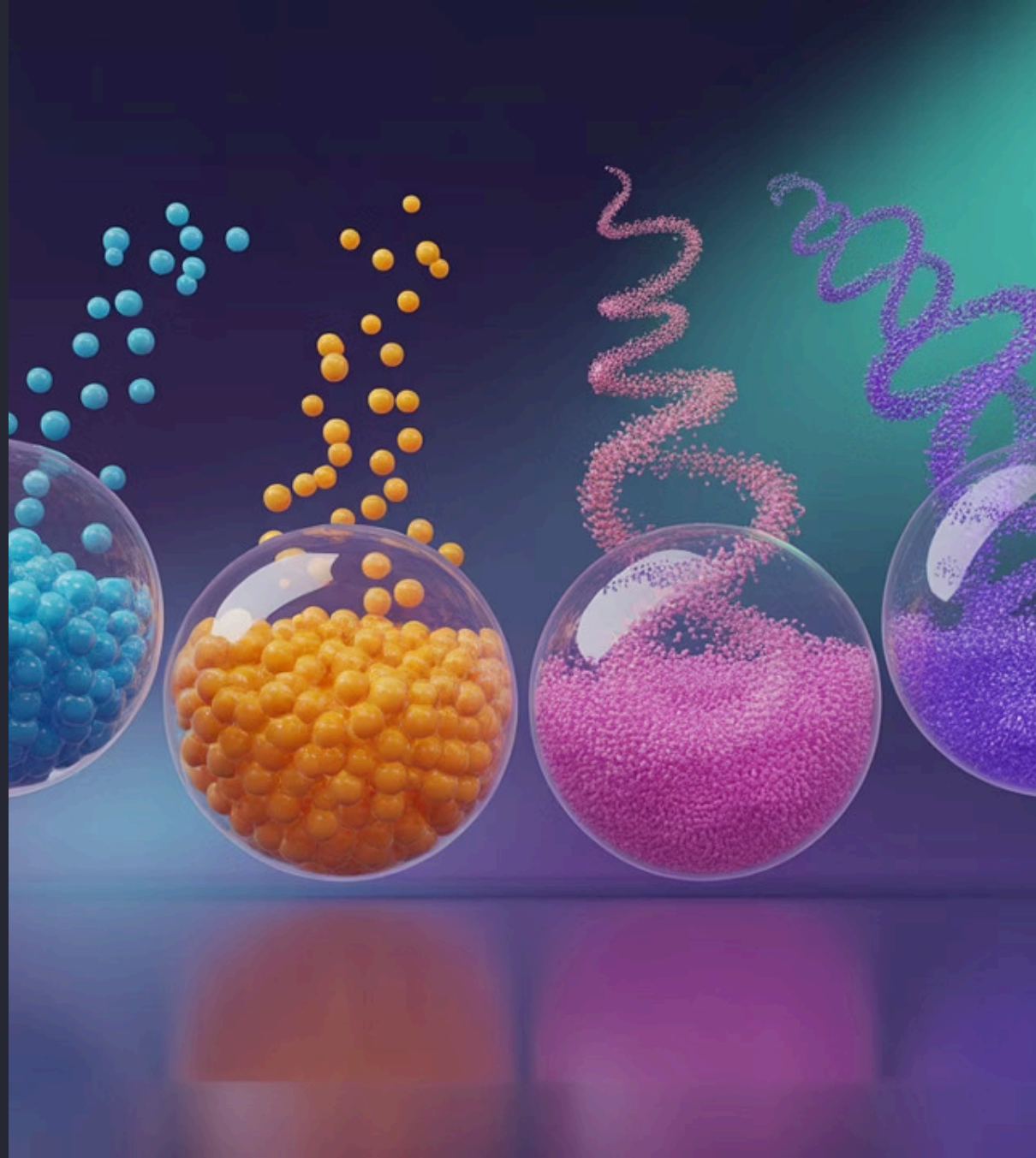
Matter and Its Properties

Welcome to our exploration of matter - the fundamental building blocks of everything around us. we'll examine what matter is, its various states, how it changes, and methods to separate different substances.



Understanding Matter

Fundamental Definition

Matter is anything that has mass and occupies space (has volume).

Mass vs. Weight

Mass: Amount of matter in an object (measured in grams/kilograms)

Weight: Force of gravity acting on mass (varies with location)

Your mass is the same on Earth and Moon, but weight is 1/6 on Moon

What Qualifies as Matter:

- **Solids**: Rocks, metals, ice - definite shape and volume
- **Liquids**: Water, oil, blood - definite volume, takes container shape
- **Gases**: Air, helium, steam - fills entire container

What is NOT Matter:

- **Light**: Electromagnetic radiation (no mass)
- **Heat**: Form of energy (no mass)
- **Sound**: Pressure waves through matter (no mass)
- **Ideas and emotions**: Abstract concepts

States of Matter - The Dance of Particles

1

Solid State

- Tightly packed particles in regular, ordered pattern
- Particles vibrate in fixed positions
- Definite shape, definite volume, incompressible
- Examples: **Ice**, **diamond**, **salt crystals**
- Very strong intermolecular forces

2

Liquid State

- Particles close together but irregular, can slide past each other
- Particles vibrate and translate (move around)
- Definite volume, takes container shape, slightly compressible
- Examples: **Water**, **alcohol**, **mercury**
- Moderate intermolecular forces

3

Gas State

- Particles far apart, completely random arrangement
- Rapid, random movement in all directions
- No definite shape or volume, highly compressible
- Examples: **Air**, **helium**, **water vapor**
- Very weak intermolecular forces

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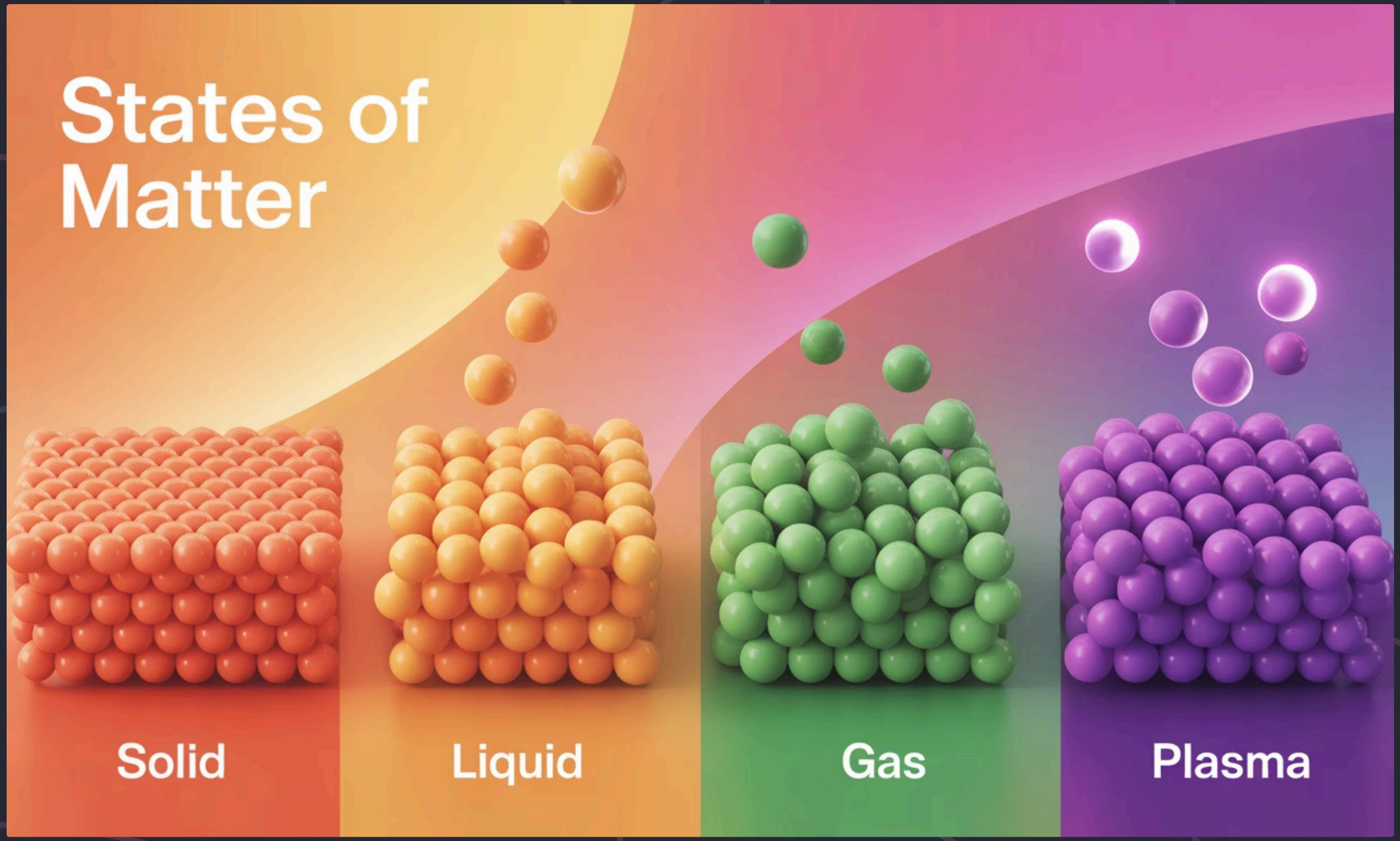
Plasma State

- Extremely high temperature: Electrons stripped from atoms
- Examples: **Stars**, **lightning**, **fluorescent lights**
- Conducts electricity, affected by magnetic fields


States of Matter
Solid
Liquid
Gas
Plasma

Phase Changes - Energy and Molecular Motion

Phase Change Process:

- Energy input/output required to break/form intermolecular forces
- Temperature remains constant during phase change
- Energy goes into breaking bonds, not increasing kinetic energy

1

Melting

Solid → Liquid

Heat of fusion required

Example: Ice to water at 0°C

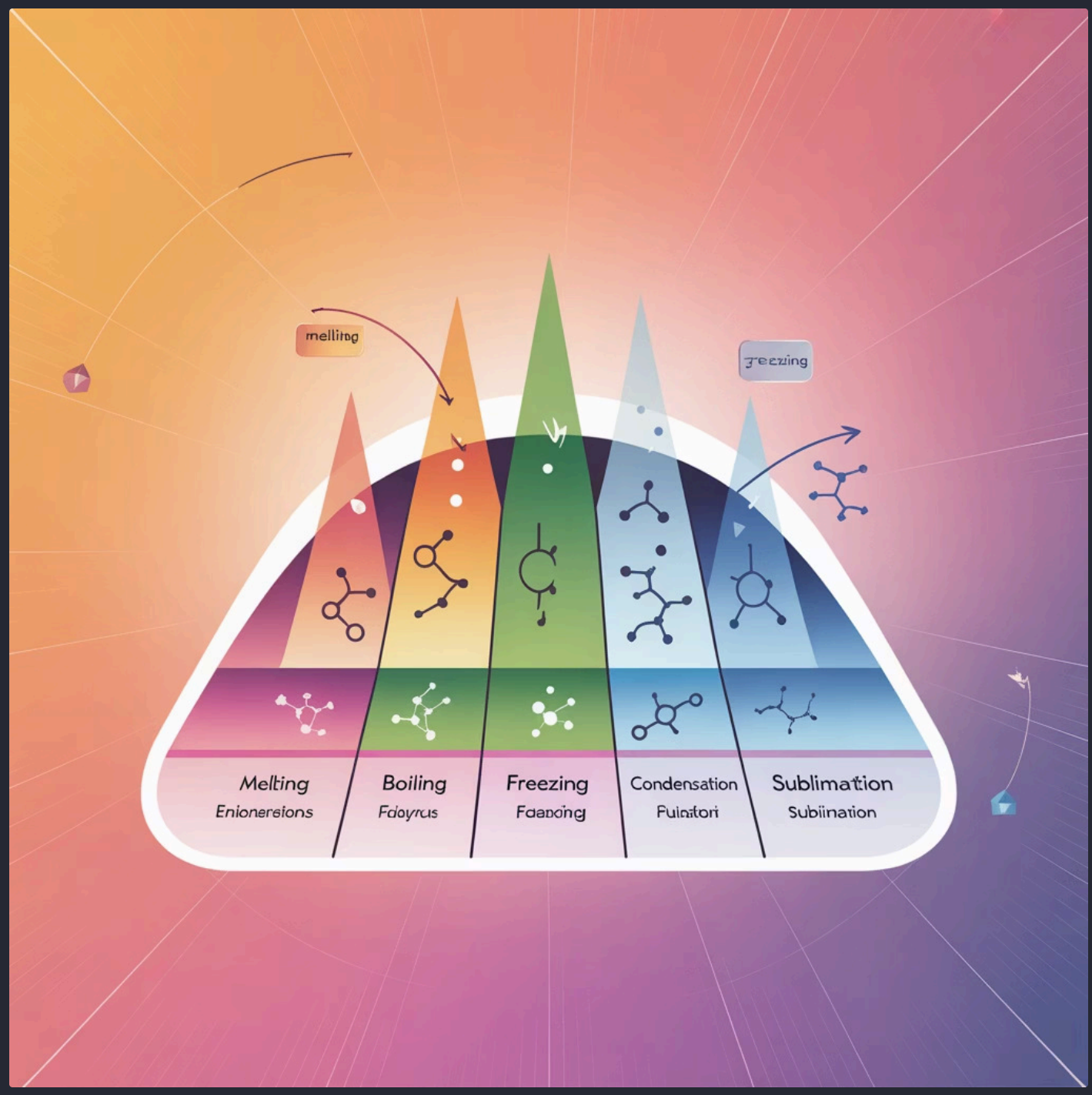
2

Boiling

Liquid → Gas

Heat of vaporization required

Example: Water to steam at 100°C



Special Phase Changes:

- **Sublimation** (Solid → Gas): Dry ice, mothballs, freeze-drying
- **Condensation** (Gas → Liquid): Energy is released, water vapor on cold glass
- **Freezing** (Liquid → Solid): Energy is released, not absorbed

Physical vs Chemical Properties

Physical Properties

Characteristics observed without changing the substance's identity

- **Color**: Due to wavelengths of light absorbed/reflected
- **Density**: Mass per unit volume, helps identify substances
- **Melting**/Boiling point: Temperatures where phase changes occur
- **Solubility**: How well substance dissolves in different solvents
- **Conductivity**: Ability to conduct heat or electricity

Chemical Properties

Characteristics that describe how a substance reacts with other substances

- **Flammability**: Ability to burn in oxygen (combustion reaction)
- **Reactivity with acids**: Some metals react vigorously, others don't
- **Oxidation**: Tendency to lose electrons (rusting is oxidation)
- **pH response**: How substance affects acidity/basicity of solutions

Physical Change:

Ice melting - still **H_2O** molecules, just moving faster

Chemical Change:

Wood burning - cellulose molecules break apart, form **CO_2 and H_2O**

Pure Substances vs Mixtures & Separation Techniques

Pure Substances

Uniform composition throughout

- Elements: One type of atom (Gold, Oxygen)
- Compounds: Elements chemically bonded in fixed ratios (H_2O)

Mixtures

Variable composition

- Homogeneous: Uniform throughout (saltwater, air)
- Heterogeneous: Non-uniform, distinct phases (oil and water)

Separation Techniques

1. **Filtration**

   Separates based on particle size (sand from water, coffee brewing)

2. **Distillation**

   Separates based on different boiling points (purifying water, alcohol)

3. **Chromatography**

   Separates based on different rates of movement (dyes, drug analysis)

4. **Crystallization**

   Separates based on different solubilities (purifying salt, pharmaceuticals)

Next Lecture:

Units in Chemistry & Significant Figures

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