

Introduction to Marine Chemistry

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Key concepts, processes, and significance for ocean science

1. What Is Marine Chemistry?

Aspect	Description
Definition	The study of the chemical composition, reactions, and cycles that occur in seawater, sediments, and marine organisms.
Scope	- Seawater chemistry (major, minor, trace elements, gases) - Biogeochemical cycles (carbon, nitrogen, phosphorus, silica, sulfur) - Chemical oceanography (physical/chemical interactions, water masses) - Anthropogenic impacts (pollution, acidification, eutrophication)
Why It Matters	Controls marine productivity, climate regulation, nutrient availability, and the health of marine ecosystems.

2. Major Components of Seawater

Component	Typical Concentration (average ocean)	Role
Water (H ₂ O)	~96.5% by mass	Solvent for all dissolved substances
Salts (major ions)	~3.5% (35‰) • Na⁺ 10.8 g/kg¹ • Mg²⁺ 1.29 g/kg¹ • Ca²⁺ 0.41 g/kg¹ • K⁺ 0.39 g/kg¹ • Cl⁻ 19.4 g/kg¹ • SO₄²⁻ 2.7 g/kg¹	Determines density, conductivity, and freezing point
Major ions		Charge balance, buffering, biological functions
Minor & trace elements	Fe, Mn, Cu, Zn, Co, Ni, etc. (μg/kg ¹ –ng/kg ¹)	Micronutrients, catalytic centers in enzymes
Dissolved gases	CO ₂ (~2 mmol/kg ¹), O ₂ (~200 μmol/kg ¹), N ₂ , Ar, CH ₄	Gas exchange, respiration, photosynthesis, climate feedbacks

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Component	Typical Concentration (average ocean)	Role
Organic matter	Dissolved organic carbon (DOC) ~0.7 mmol kg ⁻¹	Carbon reservoir, substrate for microbes

3. Fundamental Physical/Chemical Properties

Property	Symbol	Typical Oceanic Value	Controlling Factors
Temperature	T	-2°C (deep polar) to 30°C (tropics)	Solar radiation, currents
Salinity	S	33–37‰ (practical salinity units, PSU)	Evaporation, precipitation, river input
Density	ρ	1020–1030 kg m ⁻³	T, S, pressure
pH	—	8.07 (average surface)	CO ₂ system, buffering
Alkalinity	A _T	2.3 mmol kg ⁻¹ (~2300 μeq kg ⁻¹)	Bicarbonate/carbonate, borate, hydroxide
Partial pressure of CO ₂	pCO ₂	380–420 μatm (surface)	Air–sea exchange, biological activity

Note: The **CO₂–carbonate system** (CO₂ ⇌ H₂CO₃ ⇌ H