science Study Guide - flashcards

AI-Generated Study Guide

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AICE Physical Science Study Guide: Water Properties
Chapter 1 - Density and Pressure Concepts

Section A: Fundamental Water Properties

Q: What is the density of pure water at 4°C and standard atmospheric pressure?

A: 1.00 g/cm^3 or 1000 kg/m^3. This is the maximum density of water and serves as the reference point for relative density calculations.

Q: Explain why water has its maximum density at 4°C rather than at 0°C.

A: At 4°C, water molecules are optimally packed. Below this temperature, hydrogen bonding causes molecules to arrange in a more open structure, decreasing density. Above 4°C, increased molecular motion reduces packing efficiency.

Q: Define specific gravity and calculate it for a substance with density 850 kg/m^3.

A: Specific gravity is the ratio of a substance's density to water's density at 4°C. Specific gravity = 850 kg/m^3 ÷ 1000 kg/m^3 = 0.85 (dimensionless).

Q: How does temperature affect water density, and why is this significant for aquatic ecosystems?

A: Water density decreases as temperature increases (except 0-4°C). This creates thermal stratification in lakes, with warmer, less dense water floating on cooler, denser water, affecting oxygen distribution and marine life.

Section B: Pressure Concepts

Q: State the relationship between hydrostatic pressure and depth in a fluid.

A: Hydrostatic pressure increases linearly with depth: $P = \rho gh$, where ρ is fluid density, g is gravitational acceleration (9.81 m/s^2), and h is depth.

Q: Calculate the gauge pressure at a depth of 15 meters in fresh water.

A: $P = \rho gh = (1000 \text{ kg/m}^3)(9.81 \text{ m/s}^2)(15 \text{ m}) = 147{,}150 \text{ Pa} = 147.15 \text{ kPa}$

Q: Distinguish between absolute pressure, gauge pressure, and atmospheric pressure.

A: Absolute pressure = gauge pressure + atmospheric pressure. Gauge pressure measures pressure relative to atmospheric pressure. Atmospheric pressure at sea level = 101.3 kPa.

Q: Why does atmospheric pressure decrease with altitude?

A: The weight of the air column above decreases with altitude. Less air mass above means less gravitational force pressing down, resulting in lower atmospheric pressure.

Section C: Buoyancy and Archimedes' Principle

Q: State Archimedes' Principle and explain its relationship to density.

A: The buoyant force on a submerged object equals the weight of fluid displaced. An object floats if its average density is less than the fluid's density; it sinks if denser.

Q: A wooden block with density 600 kg/m^3 floats in water. What fraction of the block is submerged?

A: Fraction submerged = $\rho_{object}/\rho_{fluid}$ = 600/1000 = 0.6 or 60% of the block is underwater.

Q: Explain why ice floats on liquid water and discuss the environmental significance.

A: Ice density (917 kg/m^3) < water density (1000 kg/m^3), so ice floats. This insulates water below, preventing complete freezing and allowing aquatic life to survive winter.

Q: Calculate the buoyant force on a 2.0 m^3 object completely submerged in water.

A: Buoyant force = $\rho_{fluid} \times V_{displaced} \times g$ = $(1000\ kg/m^3)(2.0\ m^3)(9.81\ m/s^2)$ = 19,620 N

Section D: Fluid Statics and Applications

Q: Explain Pascal's Principle and provide a practical application.

A: Pressure applied to a confined fluid is transmitted equally in all directions. Application: Hydraulic systems (car lifts, brakes) use this principle to multiply force.

Q: In a hydraulic press, a 50 N force is applied to a 0.01 m² piston. What force is produced on a 0.5 m² piston?

A: $P_1 = P_2$, so $F_1/A_1 = F_2/A_2$. $F_2 = F_1(A_2/A_1)$ = 50 N × (0.5/0.01) = 2500 N

Q: Describe how a barometer measures atmospheric pressure.

A: A mercury column in an evacuated tube rises until the weight of mercury equals atmospheric pressure. Standard atmospheric pressure supports 760 mm of mercury.

Q: Why is mercury used in barometers instead of water?

A: Mercury is 13.6 times denser than water, requiring a much shorter column (760 mm vs. 10.3 m) for the same pressure measurement, making the instrument practical.

Section E: Advanced Concepts and Problem-Solving

Q: A submarine is at 200 m depth. Calculate the total pressure on its hull and explain the engineering implications.

A: P_total = P_atm + ρgh = 101,300 + (1000)(9.81)(200) = 2,063,300 Pa = 2.06 MPa. Hull must withstand pressure 20 times atmospheric pressure.

Q: Explain the concept of pressure head and its units.

A: Pressure head is pressure expressed as height of fluid column: h = P/(ρg). Units are length (meters). It represents the height of fluid that would create the given pressure.

Q: A U-tube manometer contains mercury. If one side is 15 cm higher than the other, what is the pressure difference?

A: $\Delta P = \rho_{Hg} \times g \times \Delta h = (13{,}600\ kg/m^3)(9.81\ m/s^2)(0.15\ m) = 20{,}016\ Pa = 20.0\ kPa$

Q: Describe the relationship between water pressure and the design of dams.

A: Water pressure increases with depth, so dam walls must be thicker at the base. The triangular profile of gravity dams reflects this pressure distribution, providing maximum strength where pressure is greatest.

Q: Calculate the density of an unknown liquid if an object with density 800 kg/m³ floats with 90% submerged.

A: For floating equilibrium: $\rho_{object} = (\text{fraction submerged}) \times \rho_{liquid}$
$800 = 0.90 \times \rho_{liquid}$
$\rho_{liquid} = 800/0.90 = 889\ kg/m^3$

Study Tips for AICE Success:
- Practice unit conversions between Pa, kPa, and mmHg
- Remember that density problems often involve ratios
- Always check if pressure questions ask for gauge or absolute pressure
- Sketch diagrams for buoyancy problems to visualize forces
- Review significant figures rules for calculations