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# Marine Science Lesson 1.2 - Solubility (Outline)

Generated Study Guide

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# WATER SOLUBILITY STUDY GUIDE
## Grade 11 Chemistry - Intermediate Level

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## 🎯 LEARNING OBJECTIVES

By the end of this unit, you should be able to:
1. Define solubility and explain factors that affect it
2. Distinguish between saturated, unsaturated, and supersaturated solutions
3. Interpret and create solubility curves
4. Apply solubility rules to predict precipitation reactions
5. Calculate solubility using Ksp expressions
6. Explain the relationship between molecular structure and water solubility

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## I. FUNDAMENTAL CONCEPTS OF SOLUBILITY

### A. 🔴 ESSENTIAL: Basic Definitions and Concepts

#### 1. Key Definitions
📋 **KEY TERM BOX:**
- **Solubility**: Maximum amount of solute that dissolves in a given amount of solvent at specific temperature
- **Solute**: Substance being dissolved (usually present in smaller amount)
- **Solvent**: Substance doing the dissolving (water in aqueous solutions)
- **Solution**: Homogeneous mixture of solute and solvent

#### 2. Types of Solutions
- **Saturated**: Contains maximum amount of dissolved solute at given temperature
- **Unsaturated**: Contains less than maximum amount of solute
- **Supersaturated**: Contains more solute than normally possible (unstable)

🔍 **QUICK CHECK:** What happens when you add more solute to a saturated solution?

### B. 🟡 IMPORTANT: "Like Dissolves Like" Principle

#### 1. Polar vs. Nonpolar Interactions
- Water is polar → dissolves polar and ionic substances
- Nonpolar solvents → dissolve nonpolar substances
- Hydrogen bonding enhances solubility in water

💡 **CONNECTION POINT:** This relates to intermolecular forces you learned earlier!

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## II. FACTORS AFFECTING SOLUBILITY

### A. 🔴 ESSENTIAL: Temperature Effects

#### 1. Solids in Liquids
- Most solids: ↑ Temperature → ↑ Solubility
- Exception: Some salts (e.g., $Li_2SO_4$) show inverse relationship

#### 2. Gases in Liquids
- All gases: ↑ Temperature → ↓ Solubility
- Reason: Increased kinetic energy helps gas escape

🔍 **QUICK CHECK:** Why does soda go flat faster when warm?

### B. 🔴 ESSENTIAL: Pressure Effects (Henry's Law)

#### 1. Henry's Law Formula
**$C = kP$**
- C = concentration of dissolved gas
- k = Henry's law constant
- P = partial pressure of gas

#### 2. Applications
- Deep-sea diving (nitrogen narcosis)
- Carbonated beverages
- Gas solubility in blood

### C. 🟡 IMPORTANT: Surface Area and Agitation
- Increased surface area → faster dissolving (not more total solubility)
- Stirring increases rate of dissolution

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## III. SOLUBILITY CURVES AND CALCULATIONS

### A. 🔴 ESSENTIAL: Reading Solubility Curves

#### 1. Graph Interpretation

```
Solubility (g/100g H₂O)
↑
| /
| / ← Typical curve for most solids
| /
| /
|_/_________→ Temperature (°C)
```

#### 2. Using Curves to Determine:
- Maximum solubility at any temperature
- Whether a solution is saturated/unsaturated
- Amount of precipitate formed upon cooling

🔍 **QUICK CHECK:** If 80g of $KNO_3$ dissolves in 100g water at 50°C, and the curve shows 85g max, what type of solution is this?

### B. 🟡 IMPORTANT: Solubility Calculations

#### 1. Basic Calculations
- g solute/100g $H_2O$ (standard units)
- Converting between different amounts of water
- Determining mass of precipitate

📋 **CALCULATION EXAMPLE:**
If solubility = 40g/100g $H_2O$ at 20°C
In 250g $H_2O$: 40g × 2.5 = 100g can dissolve

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## IV. SOLUBILITY RULES AND PREDICTIONS

### A. 🔴 ESSENTIAL: Common Solubility Rules

#### 1. Always Soluble:
- Group 1 (alkali metals) compounds
- Nitrates ($NO_3^-$)
- Acetates ($CH_3COO^-$)
- Most chlorides, bromides, iodides

#### 2. Generally Insoluble:
- Carbonates ($CO_3^{2-}$) - except Group 1
- Phosphates ($PO_4^{3-}$) - except Group 1
- Sulfides ($S^{2-}$) - except Group 1, 2, $NH_4^+$

📋 **KEY TERM BOX:**
**Precipitation Reaction**: Formation of insoluble solid when two solutions mix

### B. 🟡 IMPORTANT: Predicting Precipitation

#### 1. Double Displacement Method
1. Write possible products by switching ions
2. Apply solubility rules
3. Identify any insoluble products (precipitates)

🔍 **QUICK CHECK:** Will AgCl precipitate when $AgNO_3$ and NaCl solutions mix?

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## V. ADVANCED CONCEPTS

### A. 🔴 ESSENTIAL: Solubility Product Constant (Ksp)

#### 1. Ksp Expression
For $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$
**$K_{sp} = [Ag^+][Cl^-]$**

#### 2. Relationship to Solubility
- Larger Ksp = more soluble
- Can calculate solubility from Ksp and vice versa

### B. 🟡 IMPORTANT: Common Ion Effect

#### 1. Definition
Presence of common ion reduces solubility of ionic compound

#### 2. Application
Adding NaCl to saturated AgCl solution reduces AgCl solubility

💡 **CONNECTION POINT:** This applies Le Châtelier's Principle!

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## VI. MOLECULAR STRUCTURE AND SOLUBILITY

### A. 🟡 IMPORTANT: Structural Factors

#### 1. Functional Groups Affecting Water Solubility
- **Increase solubility**: -OH, -COOH, -$NH_2$, -C=O
- **Decrease solubility**: Long hydrocarbon chains

#### 2. Size Considerations
- Small molecules generally more soluble
- Branching can affect solubility

### B. 🟢 SUPPORTING: Biological Applications
- Drug solubility and bioavailability
- Nutrient absorption
- Waste elimination

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## 🎯 EXAM PREPARATION CHECKLIST

### Essential Formulas to Memorize:
- [ ] Henry's Law: C = kP
- [ ] Ksp expressions for common salts
- [ ] Solubility calculation conversions

### Key Processes to Master:
- [ ] Reading solubility curves
- [ ] Predicting precipitation reactions
- [ ] Calculating Ksp from solubility data
- [ ] Applying solubility rules

### Common Exam Question Types:
1. **Graph Analysis**: "Using the solubility curve, determine..."
2. **Prediction**: "Will a precipitate form when..."
3. **Calculation**: "Calculate the mass of precipitate..."
4. **Explanation**: "Explain why solubility increases/decreases..."

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## 🔍 FINAL QUICK CHECK QUESTIONS

1. What happens to gas solubility as temperature increases?
2. Name three always-soluble ion groups.
3. How does the common ion effect relate to Le Châtelier's Principle?
4. What does a larger Ksp value indicate?
5. Why do alcohols with short carbon chains dissolve in water?

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## 📝 STUDENT NOTES SECTION

*Use this space to add your own examples, practice problems, and connections*

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💡 **STUDY TIP:** Create flashcards for solubility rules and practice reading different solubility curves daily. Focus on understanding WHY things happen, not just memorizing facts!