

JEE Weightage: High

NEET/JEE • CHEMISTRY • SOLUTIONS • UNIT 1.6.3

Depression of Freezing Point

Why road salt works — and why K_f is always bigger than K_b .

The Cryoscopic Toolkit

Depression of freezing point (ΔT_f) for dilute solutions is directly proportional to molality (m). Use these equations to determine molar mass or freezing point shifts.

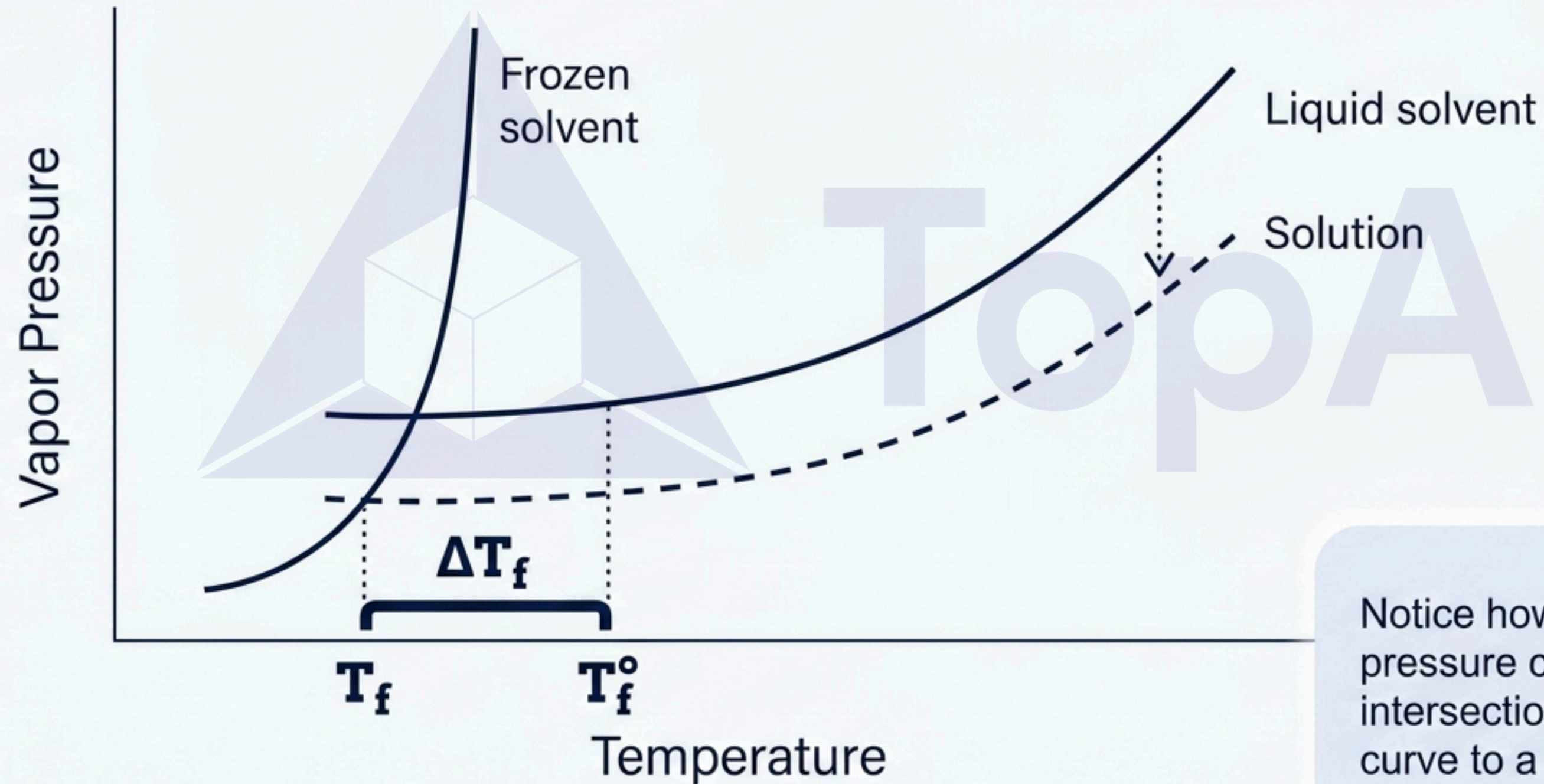
Formula Bank

$$\Delta T_f = K_f \cdot m$$

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

$$K_f = \frac{R \times M_1 \times T_f^2}{1000 \times \Delta_{fus}H}$$

Phase Diagram: Vapor Pressure vs. Temperature



Notice how the lowered vapor pressure curve forces the intersection with the frozen solid curve to a lower temperature.



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$$E=mc^2$$



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Applying the Formula: Unknown Molar Mass

1.00g of a non-electrolyte solute dissolved in 50g of benzene lowered the freezing point by 0.40K. Find M_2 .

$$K_f (\text{benzene}) = 5.12 \text{ K kg mol}^{-1}$$

Step 1. Set up the equation using $M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$

Step 2. Substitute values: $M_2 = \frac{5.12 \times 1.00 \times 1000}{0.40 \times 50}$



Result: **256 g/mol**

Why is K_f typically larger than K_b ?

Looking at Table 1.3, freezing point depression constants are consistently higher than boiling point elevation constants for the same solvent.

Ebullioscopic Constant

$$K_b (\text{water}) = 0.52$$

Depends inversely on Enthalpy of Vaporization ($\Delta_{\text{vap}}H$).
Vaporization requires breaking all intermolecular bonds (large energy).

Cryoscopic Constant

$$K_f (\text{water}) = 1.86$$

Depends inversely on Enthalpy of Fusion ($\Delta_{\text{fus}}H$). Melting requires only partially breaking bonds (much smaller energy).

$$K_f \propto 1 / \Delta_{\text{fus}}H$$

Conceptual Pitfalls



Trap: Assuming K_f and K_b are interchangeable.

Students often confuse the two constants in high-pressure exam scenarios. Remember the math: a smaller $\Delta_{\text{fus}}H$ in the denominator makes K_f consistently larger than K_b . Always check Table 1.3 values in your head to verify your calculations.

Master this trap to avoid easily lost negative marks on theoretical assertions.

Unit 1.6.3 Summary

Key Takeaways

- **Apply** $\Delta T_f = K_f \cdot m$ to solve freezing point depression numericals.
- **Recognize** K_f is typically larger than K_b for the same solvent due to differences in latent heats.
- **Use** freezing-point depression as the more sensitive colligative property for detecting small amounts of solute.



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