

Temperature Considerations for Combining Remedies with Thermal Treatment

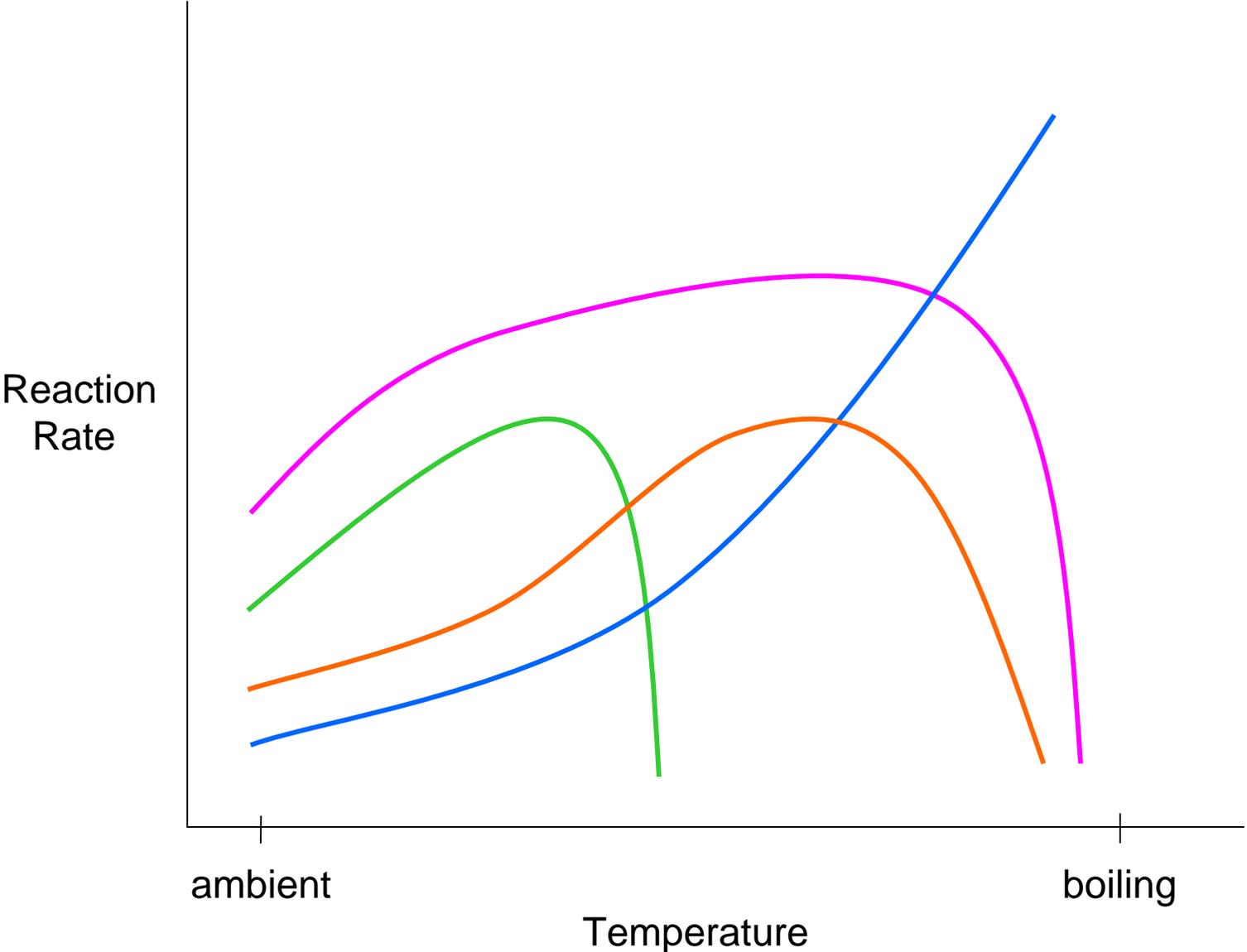
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Effect of Temperature on Reactions

- Reaction rates change as a function of temperature.
- Biological reaction rates increase with increasing temperature to a maximum and then rapidly decrease.
 - Some bacteria have maximum 30-40C (dechlorination) (green line).
 - Thermophiles have maximum above 50C (some hydrocarbon degraders) (purple line).
- Rate of reduced iron or other catalyzed processes increase with temperature, but may also reach a maximum and then decrease (orange line).
- Hydrolysis reactions continue increasing with temperature (blue line).

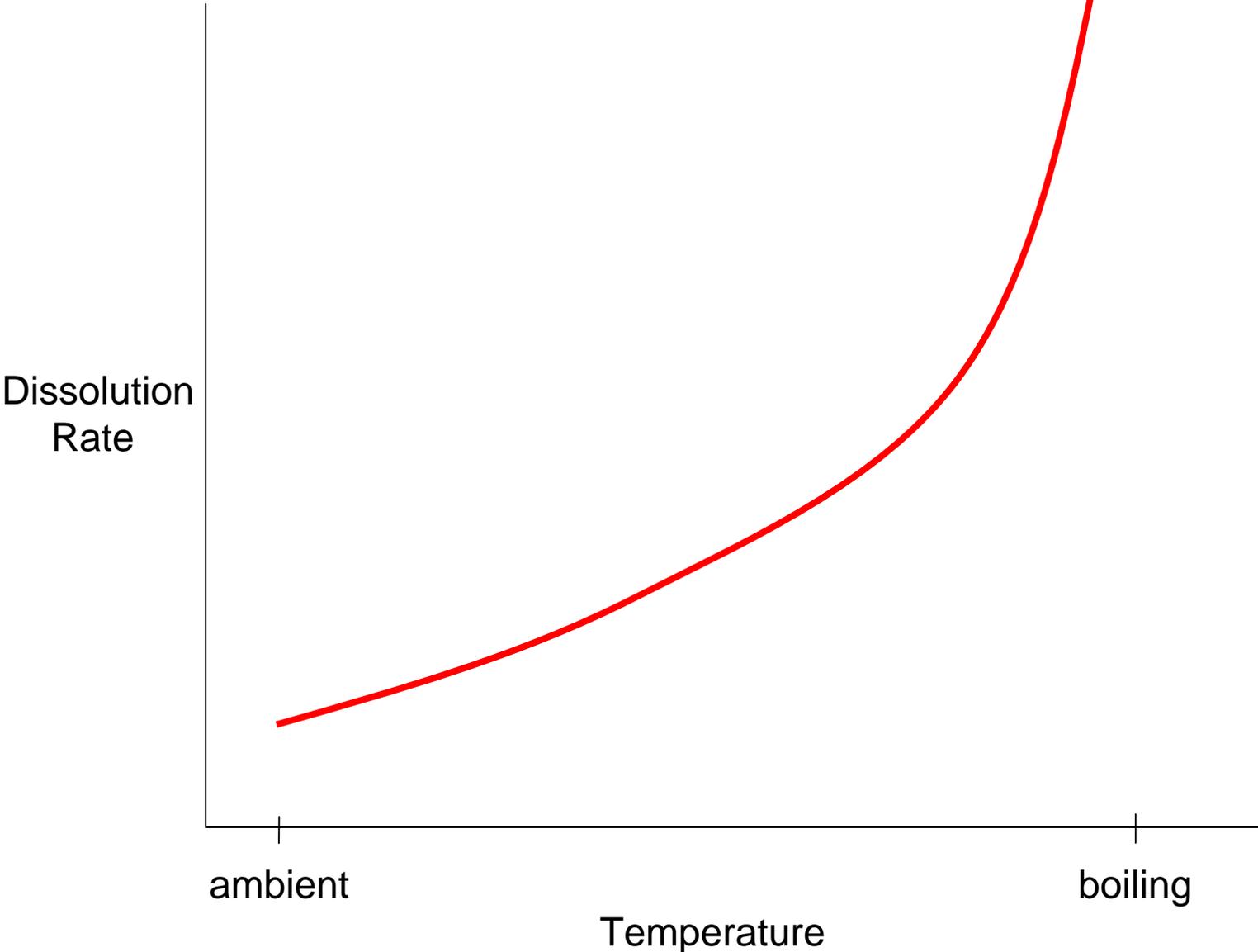
Effect of Temperature on Reactions During Heating



Effect of Temperature on Mass Transfer

- Mass transfer through diffusion, volatilization, or dissolution increases with temperature.
- As temperature approaches boiling rate of volatilization increases dramatically and any reactions would likely be less important because the compound would be readily extracted.
 - Different compounds have different boiling points
 - Boiling of DNAPL in water occurs below water boiling temperature

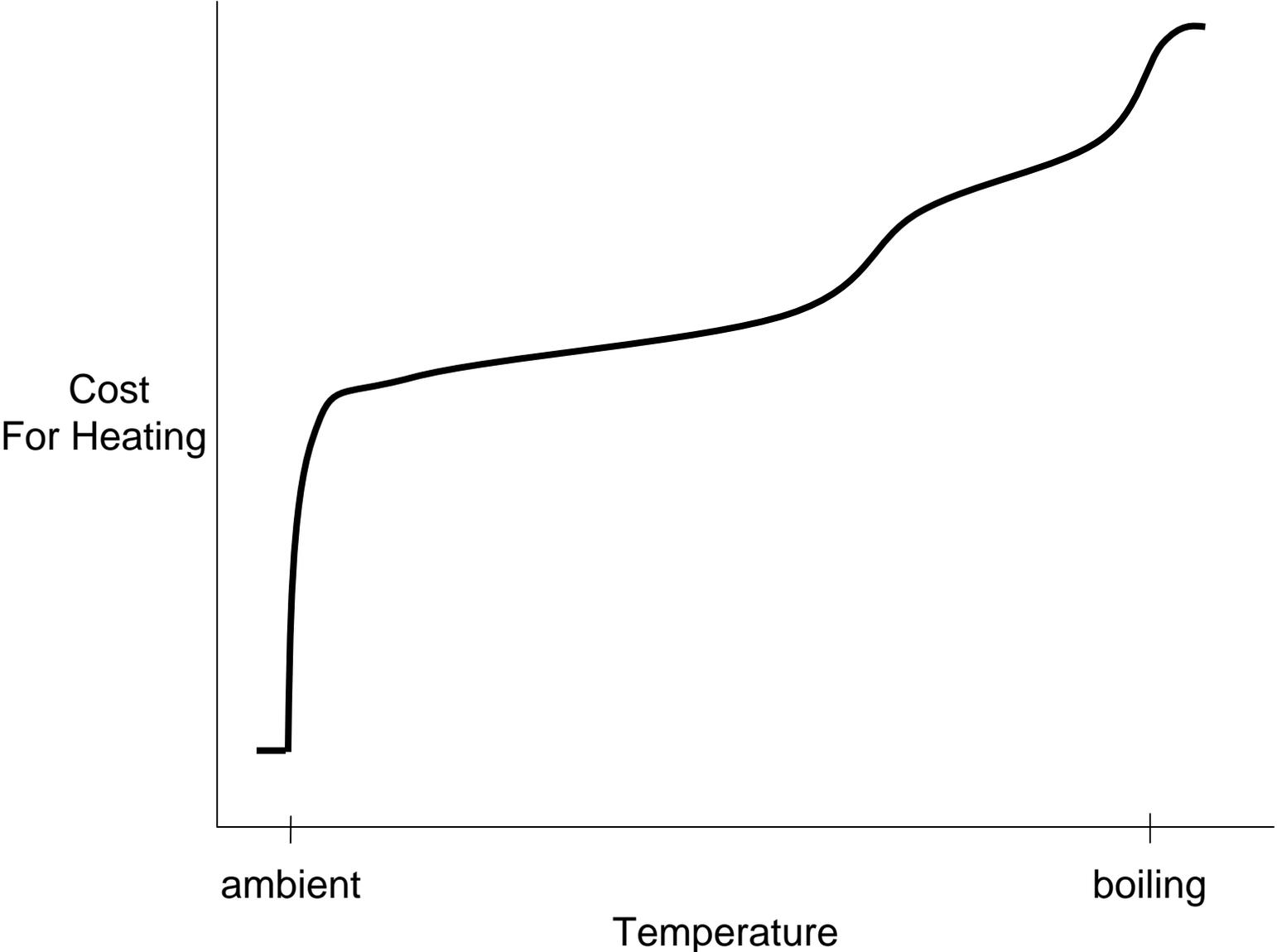
Effect of Temperature on Dissolution During Heating



Cost of Heating

- Cost for heating is dependent on temperature.
- Initial cost for infrastructure.
- Incremental cost increases for higher temperatures.
- Different heating methods may be needed depending on temperature.

Cost of Heating



Overall Benefit of Heating on Reactions

- Overall contaminant degradation rate a combination of reaction rate and mass transfer rate.
- Approaching boiling, reactions may be less beneficial compared to just extracting the contaminant.
- Need to consider all of the temperature effects to find the “sweet spot” with the best overall benefit to remediation.

Finding the "Sweet Spot"

