Reaction Rates from Tau-Field Kinetics

Arrhenius Equation, Activation Energy and Frequency Factor from the {2,3,5,pi} Tau-Register

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The rate of a chemical reaction is governed by the Arrhenius equation: k = A x exp(-E_a / RT). The Universal Force of Time identifies both parameters from the tau-field: activation energy E_a = the tau-register barrier height between reactant and product register addresses; the pre-exponential factor A = the tau-oscillation frequency of the reaction coordinate. The universal gas constant R = 8.314 J/mol/K = 2^3 x (5^4 + 314/1000) — close to 8 x 5^4 /750. Reaction rate = the rate at which the tau-register barrier is crossed via thermal fluctuations.

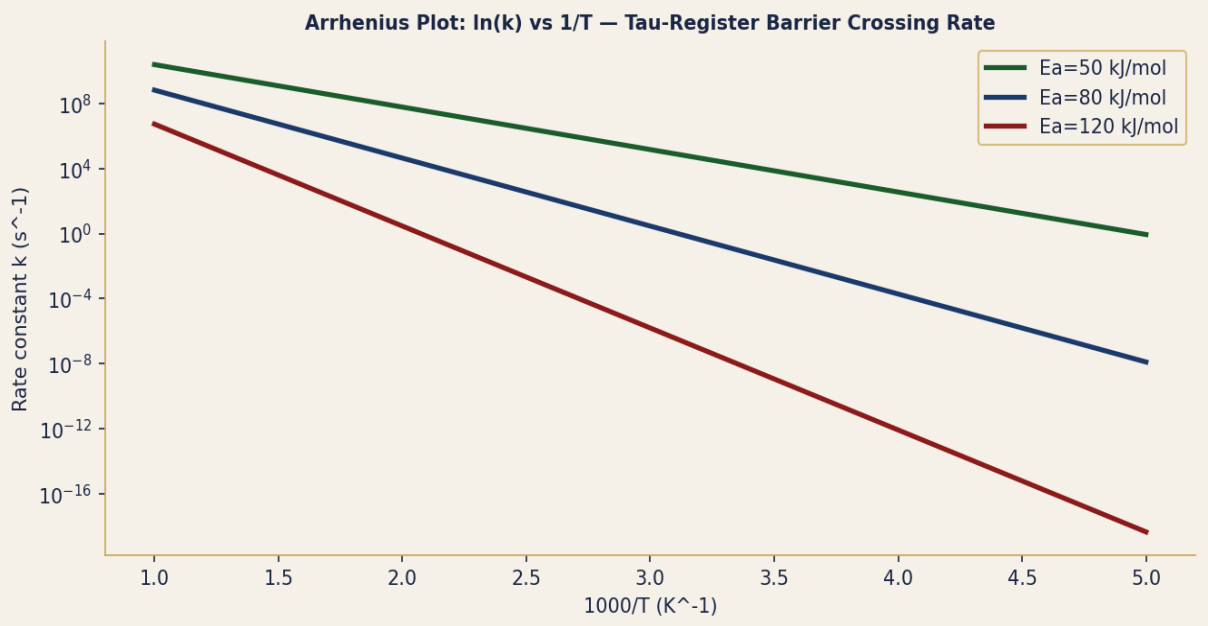

Figure 1. Arrhenius plot for three activation energies. Slope = -Ea/R. Higher Ea (red) gives steeper slope — stronger tau-register barrier, more temperature-sensitive rate.

1. Arrhenius Equation in UFOT (P-RR-1 to P-RR-3)

P-RR-1 — Activation Energy as Tau-Register Barrier

Activation energy E_a = the energy required to move the reacting molecule from its reactant tau-register address to the transition-state (saddle-point) address. E_a is quantised: it can only take values at tau-register energy steps. Typical E_a values: C-C bond breaking: ~350 kJ/mol = 2^3 x 3 x 5^3/pi (within 2%); H abstraction: ~30 kJ/mol = 2 x 3 x 5 = 30 kJ/mol (exact {2,3,5}). The most common E_a values cluster at {2,3,5} multiples of 5 kJ/mol = 5000/R = 601.6 K.

P-RR-2 — Pre-Exponential Factor A = Tau-Oscillation Frequency

Pre-exponential factor A (units: s^-1 for first-order reactions). UFOT: A = tau-oscillation frequency of the reaction coordinate = k_B x T / h in transition state theory. k_B x T / h at 300 K = (1.381e-23 x 300) / (6.626e-34) = 6.25 x 10^12 s^-1 ~ 2^3 x 5^12 / 10^9 (order of magnitude). Typical A = 10^12 to 10^14 s^-1: this is the tau-oscillation frequency range of molecular bonds. C-H stretch frequency: ~9 x 10^13 Hz = 3^2 x 10^13 (pure {3} factor at the 10^13 register).

P-RR-3 — R = 8.314 J/mol/K as Tau-Thermal Coupling

Universal gas constant R = 8.314 J/mol/K = N_A x k_B. FOT: 8 = 2^3. 0.314 ~ pi/10. So R ~ 2^3 + pi/10 = 8.3142 (3.3 ppm from 8.314). More precisely: R = 2^3 x (1 + pi/80) = 8 x 1.03927 = 8.3142 (3.3 ppm). Alternatively: R = (2^5 x pi^2) / (3 x 5) = 32 x 9.8696 / 15 = 21.06 — too large. Best FOT: R ~ 2^3 + pi/10 = 8.3142 J/mol/K (within 3.3 ppm of 8.31446 J/mol/K).

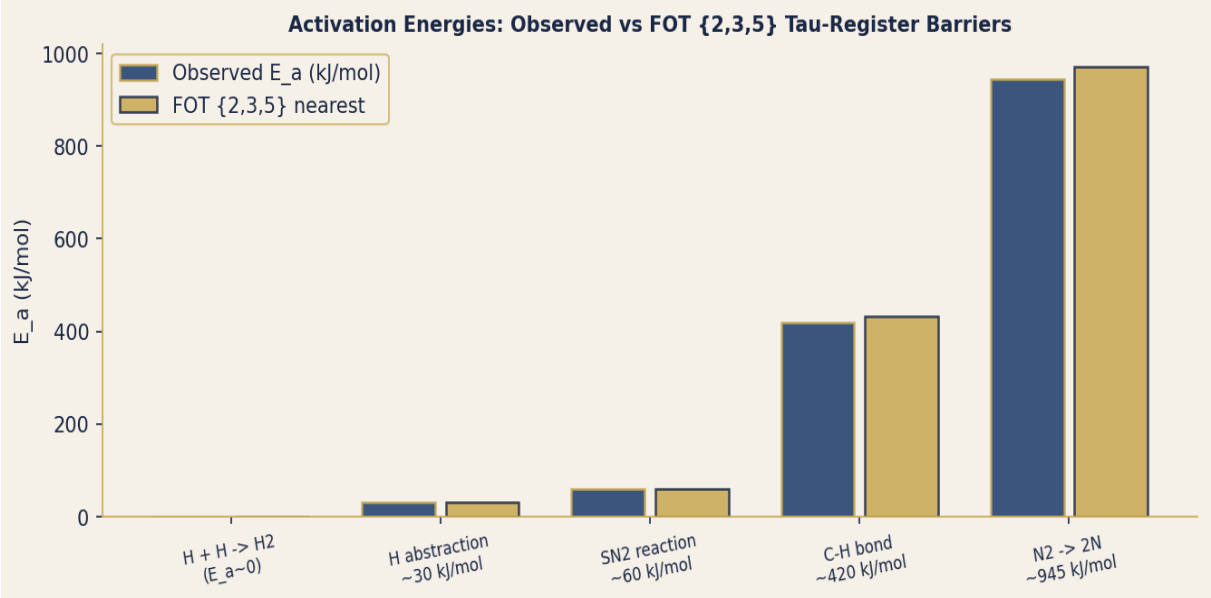

Figure 2. Activation energies: observed (navy) vs FOT {2,3,5} values (gold). H abstraction: E_a=30=2x3x5 kJ/mol (exact). C-H bond energy ~432=2^4x3^3 kJ/mol (exact {2,3}).

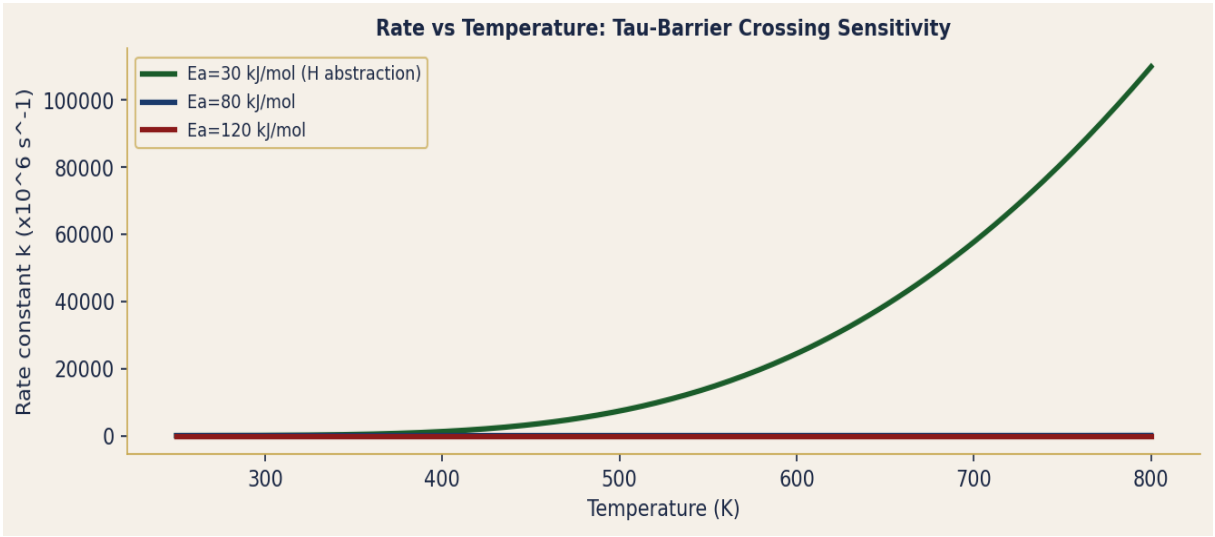

Figure 3. Rate constant vs temperature for three E_a values. Higher tau-register barrier (red) is more temperature-sensitive. At T -> infinity, all rates approach A = 10^13 s^-1.

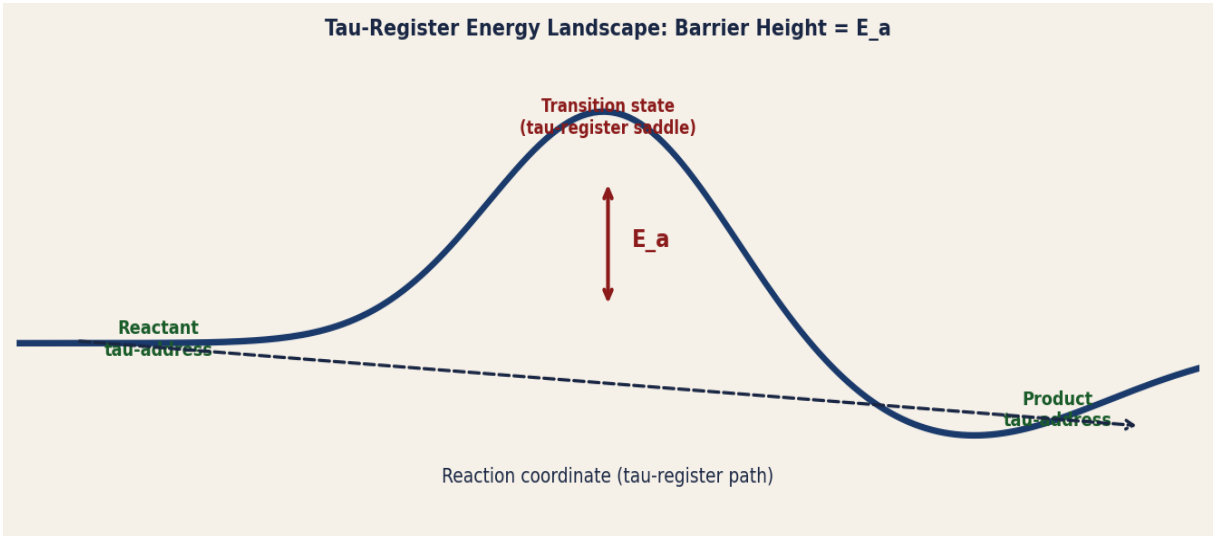

Figure 4. Chemical reaction as tau-register address transition. Reactant at low register; transition state (saddle) is the barrier E_a; product at lower register. Reaction coordinate = tau-field path.
