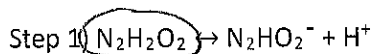
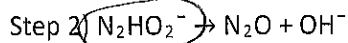


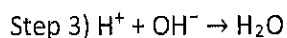
3. Nitramide,  $N_2H_2O_2$ , decomposes slowly in aqueous solution. This decomposition is believed to occur according to the reaction mechanism below.



(fast equilibrium)



★RDS (slow) rate =  $k [N_2HO_2^-]$

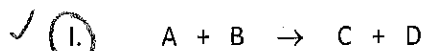


(fast)

Write the rate law for the decomposition of nitramide that is consistent with this mechanism.

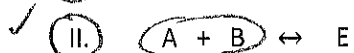
$$\text{rate} = k [N_2H_2O_2]$$

4. The reaction  $A + B \rightarrow C + D$ , obeys the rate law expression  $\text{Rate} = k[A][B]$ . Which of the following proposed mechanisms below that are consistent with this information? Justify your answer.

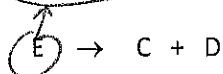


one step

$$\text{rate} = k[A][B]$$



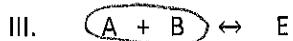
fast, equilibrium



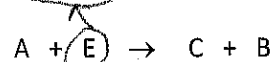
slow ★RDS

$$\text{rate} = k[A][B]$$

Because E is an intermediate, use fast equil step to



fast, equilibrium



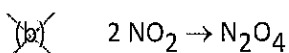
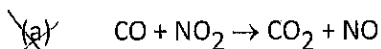
slow ★RDS

$$\text{rate} = k[A]^2[B]$$

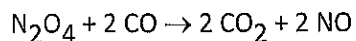
replace [E] w/  $K_{eq}[A][B]$  in rate law!

Both I and II are consistent - they both sum to the overall rxn, and the stoichiometry for both supports the provided rate law (i.e. stoichiometric coefficient of 1 for both A and B, and they're both 1<sup>st</sup> order in the given rate law).

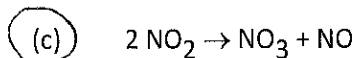
5. The rate law for  $CO + NO_2 \rightarrow CO_2 + NO$  is  $\text{rate} = k [NO_2]^2$ . Which of the following mechanisms is consistent with the data? Justify your choice.



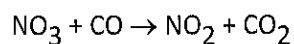
fast



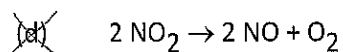
slow



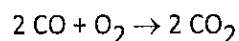
slow



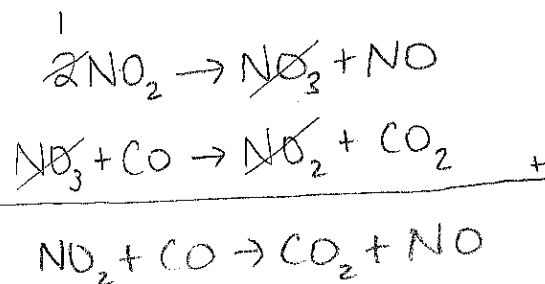
fast



slow



fast



(c) is consistent w/ the data, because the steps sum to the overall rxn, and step 1 is slow and thus the rate-determining step.  $NO_2$  has a stoichiometric coefficient of 2 in that step, and  $NO_2$  is second order in the provided rate law.

## Released AP Free Response Practice – Wheel

1. The following results were obtained when the following reaction was studied at 25°C:  $2A + B \rightarrow C + D$

Experiment	Initial [A]	Initial [B]	Initial Rate of Formation of C (mol L <sup>-1</sup> min <sup>-1</sup> )
1	0.25	0.75	$4.3 \times 10^{-4}$
2	0.75	0.75	$1.3 \times 10^{-3}$
3	1.50	1.50	$5.3 \times 10^{-3}$

a. Determine the order of the reaction with respect to A and to B. Justify your answer.

trials 1+2:  $3 \times [A]$ ,  $[B]$  constant, rate increased by a factor of 3, so the rxn is 1<sup>st</sup> order w/ respect to A.

trials 2+3:  $2 \times [A]$  AND  $2 \times [B]$ , rate increased by a factor of 4; since  $2 \times [A]$  causes  $2 \times$  rate,  $2 \times [B]$  must double rate  $\Rightarrow$  1<sup>st</sup> order w/ respect to B

b. Write the rate law for the reaction. rate =  $k[A][B]$

c. Calculate the value of the rate constant,  $k$ , for the reaction, specifying units.

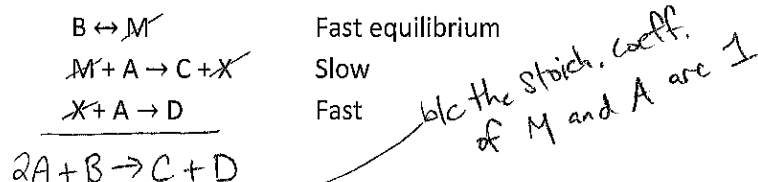
$$k = \frac{\text{rate}}{[A][B]} = \frac{4.3 \text{ E M/min}}{(0.25 \text{ M})(0.75 \text{ M})} = \boxed{0.0023 \text{ M}^{-1} \text{ min}^{-1}}$$

d. Predict the initial rate of the disappearance of A if  $[A]_{\text{init}} = 0.75 \text{ mol L}^{-1}$  and  $[B]_{\text{init}} = 1.50 \text{ mol L}^{-1}$ .

$$\text{rate (of rxn)} = k[A][B] = (0.0023 \text{ M}^{-1} \text{ min}^{-1})(0.75 \text{ M})(1.50 \text{ M}) = 0.0026 \text{ M/min}$$

$$\Rightarrow \text{rate of A consumption} = \overset{\text{stoch. coeff.}}{\downarrow} 2 \times \underset{\text{rxn}}{\text{rate of}} = 2(0.0026 \frac{\text{M}}{\text{min}}) = \boxed{0.0052 \frac{\text{M}}{\text{min}}}$$

e. Is the reaction mechanism represented below consistent with the rate law developed in part (b)? Justify your answer.



Yes, this rxn mechanism is consistent w/ the rate law from part b. The mechanism steps sum to the overall rxn. Also, the rate-determining (slow) step has a rate law =  $k[M][A]$ , but since M is an intermediate, we can use the fast equilibrium step to replace  $[M] = K_{\text{eq}}[B]$ , so the rate law predicted by this mechanism =  $k(K_{\text{eq}}[B])[A] = k[B][A]$ .