Kinetics Free Response Practice Problems

1. $A + 2B \rightarrow 2C$

The following results were obtained in experiments designed to study the rate of the reaction above:

Experiment	Initial Concentration (M) [A]	Initial Concentration (M) [B]	Initial Rate of Disappearance of A (M/sec)
1	0.05	0.05	3.0×10^{-3}
2	0.05	0.10	6.0×10^{-3}
3	0.10	0.10	1.2×10^{-2}
4	0.20	0.10	2.4×10^{-2}

(a) Determine the order of the reaction with respect to each of the reactants, and write the rate law for the reaction.
(b) Calculate the value of the rate constant, k, for the reaction. Include the units.
(c) If another experiment is attempted with [A] and [B], both 0.02M, what would be the initial rate of disappearance of A?
(d) The following reaction mechanism was proposed for the reaction above:

$A + B \rightarrow C + D$
$D + B \rightarrow C$

(i) Show that the mechanism is consistent with the balanced reaction.
(ii) Show which step is the rate-determining step, and explain your choice.

2. $2NO(g) + Br_2(g) \rightarrow 2NOBr(g)$

The following results were obtained in experiments designed to study the rate of the reaction above:

Experiment	Initial Concentration (mol/L) [A]	[B]	Initial Rate of Appearance of NOBr (M/sec)
1	0.02	0.02	9.6×10^{-2}
2	0.04	0.02	3.8×10^{-1}
3	0.02	0.04	1.9×10^{-1}

(a) Write the rate law for the reaction.
(b) Calculate the value of the rate constant, k, for the reaction. Include the units.
(c) In experiment 2, what was the concentration of NO remaining when half of the original amount of Br_2 was consumed?
(d) Which of the following reaction mechanisms is consistent with the rate law established in (a)? Explain your choice.

I. $NO + NO \leftrightarrow N_2O_2$ (fast)
$N_2O_2 + Br_2 \rightarrow 2\ NOBr$ (slow)

II. $Br_2 \rightarrow Br + Br$ (slow)
$2\ (NO + Br \rightarrow NOBr)$ (fast)

3. $N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$

Dinitrogen pentoxide gas decomposes according to the equation above. The first-order reaction was allowed to proceed at 40°C and the data below were collected.

$[N_2O_5]$(M)	Time (min)
0.400	0.0
0.289	20.0
0.209	40.0
0.151	60.0
0.109	80.0

(a) Calculate the rate constant for the reaction using the values for concentration and time given in the table. Include units with your answer.

(b) After how many minutes will $[N_2O_5]$ be equal to 0.350 M?

(c) What will be the concentration of N_2O_5 after 100 minutes have elapsed?

(d) Calculate the initial rate of the reaction. Include units with your answer.

(e) What is the half-life of the reaction?

4. $2A+B \rightarrow C+ D$

The following results were obtained in experiments designed to study the rate of the reaction above:

Experiment	Initial Concentration (moles/L) [A]	[B]	Initial Rate of Formation of D (M/min)
1	0.10	0.10	$1.5x10^{-3}$
2	0.20	0.20	$3.0x10^{-3}$
3	0.20	0.40	$6.0x10^{-3}$

(a) Write the rate law for the reaction.

(b) Calculate the value of the rate constant, k, for the reaction. Include the units.

(c) If experiment 2 goes to completion, what will be the final concentration of D? Assume that the volume is unchanged over the course of the reaction and that no D was present at the start of the experiment.

(d) Which of the following possible reaction mechanisms is consistent with the rate law found in (a)?

I. A + B ---> C + E (slow)
A + E ----->D (fast)

II. B ---> C + E (slow)
A + E ----> F (fast)
A + F ---> D (fast)

5. A (g) + B (g) $\rightarrow$ C (g)

The reaction above is second order with respect to A and zero order with respect to B. Reactants A and B are present in a closed container. Predict how each of the following changes to the reaction system will affect the rate and rate constant and explain why.

(a) More gas A is added to the container.
(b) More gas B is added to the container.
(c) The temperature is increased.
(d) The inert gas D is added to the container.
(e) The volume of the container is decreased.

$$A_{(aq)} + 2\ B_{(aq)} \rightarrow 3\ C_{(aq)} + D_{(aq)}$$

6. For the reaction above, carried out in solution of 30°C, the following kinetic data were obtained:

Experiment	Initial Conc. of Reactants (mole·liter^{-1}) A_o	B_o	Initial Rate of Reaction (mole·liter^{-1}·hr^{-1})
1	0.240	0.480	8.00
2	0.240	0.120	2.00
3	0.360	0.240	9.00
4	0.120	0.120	0.500
5	0.240	0.0600	1.00
6	0.0140	1.35	?

(a) Write the rate-law expression for this reaction.

(b) Calculate the value of the specific rate constant k at 30°C and specify its units.

(c) Calculate the value of the initial rate of this reaction at 30°C for the initial concentrations shown in experiment 6.

(d) Assume that the reaction goes to completion. Under the conditions specified for experiment 2, what would be the final molar concentration of C?