# CHE 107 EXAMINATION II July 5, 2013

**University of Kentucky Department of Chemistry**

READ THESE DIRECTIONS CAREFULLY BEFORE STARTING THE EXAMINATION!

It is *extremely* important that you fill in the answer sheet EXACTLY as indicated, otherwise your answer sheet may not be processed; ALL entries are to be made on SIDE 1 of the answer sheet. Use a #2 pencil (or softer); fill in the circles completely and firmly. Erasures must be complete. Use only the following categories:

| | |
|---|---|
| NAME: | Print your name starting at the first space, LAST NAME first, then a space, followed by your FIRST NAME, then another space, followed by your MIDDLE INITIAL. Fill in the correct circles below your printed name corresponding to the letters of your name; for the spaces, fill in the top blank circle. |
| STUDENT NUMBER: | This is **VERY IMPORTANT!** Under IDENTIFICATION NUMBER, put in your **8 DIGIT STUDENT ID NUMBER** (**do not use the 9 at the beginning of your number**) beginning in column A and continuing through column H, column I will be blank, (do NOT use column J at this time); be sure to fill in the correct circles (a common error to be avoided is mistaking "0" for "1"). |
| TEST FORM: | Fill in the "1" blank in the J column under IDENTIFICATION NUMBER (to indicate Hour Examination I). |
| SPECIAL CODES: | Use for course and section number; in positions K-P write in the following:<br>Dr. Blue 107-020 |
| SIGNATURE: | You **MUST** sign the examination answer sheet (bubble sheet) on the line directly above your printed name. Use your legal signature. |

Answering Questions:

Starting with answer "1" on SIDE 1, fill in the circle indicating the one best answer for each of the **25 questions** in this examination. Your score is the sum of the appropriate credit for each response. On the day following the examination, an examination key will be posted on Blackboard.

Grading and Reporting:

The examination scores will be posted in Blackboard as soon as possible after the examination. If an error has occurred in scoring your answers, inform your instructor within 48 hours of the posting of your score.

BE SURE THAT YOUR TEST HAS 25 QUESTIONS, A PERIODIC TABLE, AND ONE SHEET OF SCRATCH PAPER. You may NOT use your own scratch paper during this examination. Cell phones, computers, and pagers are to be turned off and out of sight during the exam.

1. Which one of the following statements is **false**?

A. Chemical kinetics is the study of how *far* a chemical reaction goes.

B. Chemical kinetics is the study of how *fast* a chemical reaction occurs.

C. Chemical kinetics measures the *average* change in the concentration of reactants over time.

D. Chemical kinetics measures the *instantaneous* change in the concentration of reactants at a given moment in time.

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2. The concentration of $N_2O(g)$ was monitored in the reaction

$$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g)$$

and found to be 278 atm after 295 seconds. If 325 atm of $N_2O(g)$ was injected into the reaction vessel initially, what is the average rate of the reaction?

A. 0.85 atm/s

B. 0.16 atm/s

C. 0.012 atm/s

D. 0.29 atm/s

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3. If water is consumed at a rate of 0.180 *M*/s at a particular moment in the reaction below, what is the rate of appearance of $H_2(g)$ at the same time?

$$C_3H_8(g) + 3\ H_2O(g) \rightarrow 3\ CO(g) + 7\ H_2(g)$$

A. 1.56 *M*/s

B. 0.745 *M*/s

C. 0.0270 *M*/s

D. 0.420 *M*/s

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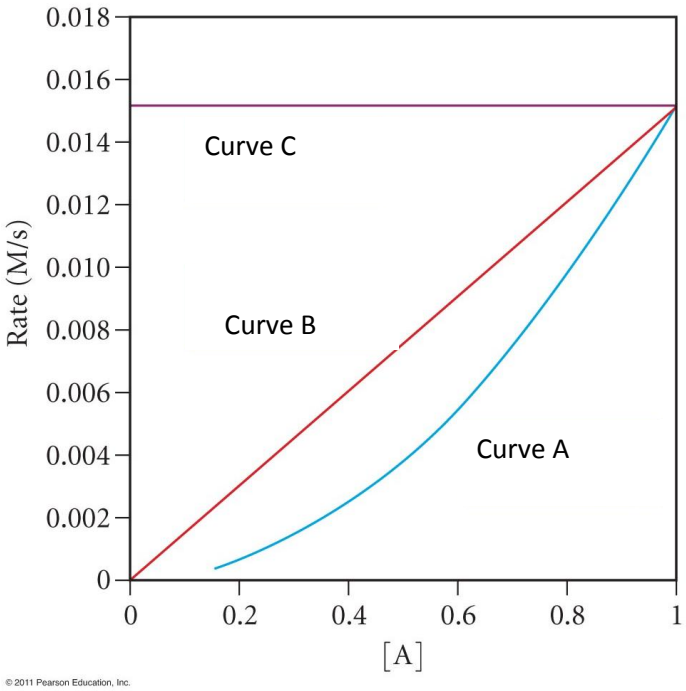
4. The initial rate of the reaction, A → products, was found to be independent of the concentration of A. Which curve below best represents the plot of rate vs. [A] for this reaction?





A. Curve A

B. Curve B

C. Curve C

D. No curves shown represent the plot of rate vs. [A] for the reaction described.

5. The initial rate of the hypothetical reaction A + B → C + D was measured at several different concentrations of the reactants with the following results:

| Experiment | [A] (*M*) | [B] (*M*) | Initial reaction rate (*M*/s) |
|---|---|---|---|
| 1 | 1.40 | 1.00 | $9.80 \times 10^{-3}$ |
| 2 | 1.40 | 2.00 | $3.92 \times 10^{-2}$ |
| 3 | 2.80 | 1.00 | $1.96 \times 10^{-2}$ |

What is the experimental rate law for the reaction?

A. rate = $k$[A][B]

B. rate = $k$[A][B]$^2$

C. rate = $k$[A]$^2$[B]

D. rate = $k$[A][B]$^3$

6. The thermal decomposition of phosphine, $PH_3(g)$, follows first order kinetics. If the initial concentration of $PH_3(g)$ is 0.379 *M*, how much phosphine remains after 10 minutes?

$$PH_3(g) \rightarrow P_4(g) + 6\ H_2(g) \qquad k = 1.98 \times 10^{-2}\ s^{-1}$$

A. $6.48 \times 10^{-6}\ M$

B. $2.02 \times 10^{-5}\ M$

C. $2.62 \times 10^{-6}\ M$

D. $3.92 \times 10^{-7}\ M$

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7. The rate constant for the second-order reaction, $2\ NOBr(g) \rightarrow 2\ NO(g) + Br_2(g)$, is 0.800 $M^{-1}s^{-1}$. Starting with a concentration of 0.200 *M*, what is the $NO_2$ concentration after 34.0 seconds?

A. $3.10 \times 10^{-2}\ M$

B. $1.80 \times 10^{-1}\ M$

C. $2.20 \times 10^{-2}\ M$

D. $4.60 \times 10^{-2}\ M$

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8. The half-life for a first order reaction, A → products, was determined to be 24.0 s. If the initial concentration is $[A]_o = 0.270\ M$, how much of the reactant remains after 83.0 s?

A. $2.70 \times 10^{-3}\ M$

B. $3.29 \times 10^{-4}\ M$

C. $1.84 \times 10^{-1}\ M$

D. $2.46 \times 10^{-2}\ M$

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9. Which one of the following statements is **false** regarding the effect of increasing temperature on the rate constant, *k*?

A. The rate constant increases because the number of effective collisions between reactants increases.

B. The rate constant increases because the fraction of reactant molecules with enough energy to overcome $E_a$ increases.

C. The rate constant increases because the activation barrier, $E_a$, is lowered with increasing temperature.

D. The rate constant increases because the frequency of collisions between reactants increases.

10. When the temperature is increased from 298 K to 348 K, the rate constant for a reaction quadruples (increases by a factor of 4). What is the activation energy, $E_a$, for this reaction?

A. 45.6 kJ/mol
C. 2.42 kJ/mol
B. 23.9 kJ/mol
D. 14.7 kJ/mol

11. The following mechanism has been proposed for the reaction:

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

| | | |
|---|---|---|
| Step 1 | $2\ NO(g) \rightleftharpoons N_2O_2\ (g)$ | (fast) |
| Step 2 | $N_2O_2(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$ | (slow) |
| Step 3 | $N_2O\ (g) + H_2(g) \rightleftharpoons N_2(g) + H_2O(g)$ | (fast) |

Which one of the following is the rate law for the reaction?

A. rate = $k[NO]^2$
C. rate = $k[NO]^2[N_2O_2][H_2]$
B. rate = $k[H_2][NO]^2$
D. rate = $k[N_2O_2][H_2]$

12. The following mechanism has been proposed for the reaction:

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

| | |
|---|---|
| Slow Step | $H_2O_2(aq) + I^-(aq) \rightarrow H_2O(l) + IO^-(aq)$ |
| Fast Step | $H_2O_2(aq) + IO^-(aq) \rightleftharpoons H_2O(l) + O_2(g) + I^-(aq)$ |

What are the functions of $I^-(aq)$ and $IO^-(aq)$ in the reaction mechanism?

A. $I^-$ and $IO^-$ are both an intermediates.

B. $I^-$ and $IO^-$ are both catalysts.

C. $I^-$ is the catalyst and $IO^-$ is an intermediate.

D. $I^-$ is an intermediate and $IO^-$ is the catalyst.

13. Which one of the following statements is **true** of catalysts?

A. Catalysts increase the reaction rate by decreasing the activation energy of the rate-determining step.

B. Catalysts add energy to the reaction.

C. Catalysts are irreversibly destroyed in the reaction.

D. Catalysts must be in the same phase as the reactants.

14. The reaction below has reached a state of dynamic equilibrium. Which one of the following statements about this reaction is **true**?

$$4\ HCl(g) + O_2(g) \rightleftharpoons 2\ Cl_2(g) + 2\ H_2O(g)$$

A. The forward and reverse reactions have stopped.

B. The concentration $HCl(g)$ must be twice the concentration of $Cl_2(g)$.

C. The concentration of the reactants and products is still changing with time.

D. The rates of the forward and reverse reactions are equal.

15. What is the equilibrium constant expression for the following reaction?

$$H_2(g) + N_2(g) + C(s) \rightarrow 2\ HCN(g)$$

A. $K_c = \dfrac{[HCN]^2}{[H_2][N_2]}$

B. $K_c = \dfrac{[H_2][N_2]}{[HCN]^2}$

C. $K_c = \dfrac{[HCN]^2}{[H_2][N_2][C]}$

D. $K_c = \dfrac{[HCN]}{[H_2][N_2][C]}$

16. Initially, 0.759 atm of $CH_4(g)$ and 0.824 atm of $H_2O(g)$ are placed in a reaction vessel. Given the balanced chemical equation and $K_p$, what can be said about the equilibrium concentrations of reactants and products?

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3\ H_2(g) \qquad K_p = 1.25 \times 10^{-25}$$

A. The equilibrium lies far to the right and the partial pressures of the products will be significantly higher than the partial pressures of reactants.

B. The equilibrium lies far to the right and the partial pressures of the reactants will be significantly higher than the partial pressures of products.

C. The equilibrium lies far to the left and the partial pressures of the products will be significantly higher than the partial pressures of reactants.

D. The equilibrium lies far to the left and the partial pressures of the reactants will be significantly higher than the partial pressures of products.

17. Given

$$NO(g) + \tfrac{1}{2}\ O_2(g) \rightleftharpoons NO_2(g) \qquad K_{p1} = 10^2$$
$$N_2O_4(g) \rightleftharpoons 2\ NO_2(g) \qquad K_{p2} = 10^1$$

calculate $K_{p3}$ for the reaction:

$$2\ NO(g) + O_2(g) \rightleftharpoons N_2O_4(g) \qquad K_{p3} = ?$$

A. $10^5$

B. $10^3$

C. $10^1$

D. $10^{-2}$

18. Given

$$2\ NO(g) + Cl_2(g) \rightleftharpoons 2\ NOCl(g) \qquad K_p = 0.27 \text{ at } 700\ K$$

what is the value of $K_c$ at 700K?

A. 0.0087

B. 320

C. 1.3

D. 16

19. Given

$$2\ CH_4(g) \rightleftharpoons C_2H_2(g) + 3\ H_2(g) \qquad K_c = ?\ \text{at } 1973\ K$$

the reaction mixture initially contains $[CH_4] = 0.3250\ M$. At equilibrium, the mixture contains $[H_2] = 0.2169\ M$. What is the value of $K_c$?

A. $4.683 \times 10^{-4}$

B. $1.239 \times 10^{-1}$

C. $2.267 \times 10^{-2}$

D. $8.307 \times 10^{-2}$

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20. Which way will the reaction proceed given the following initial concentrations: $[SO_2] = 0.0125\ M$, $[O_2] = 0.0200\ M$, and $[SO_3] = 0.0272\ M$?

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad K_c = 1.98\ \text{at } 1303\ K$$

A. To the left because $Q > K$

B. To the left because $Q < K$

C. To the right because $Q > K$

D. To the right because $Q < K$

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21. Initially, a 2.00 L reaction vessel contains only 10.0 mol of HBr. What will the concentration of $Br_2(g)$ be at equilibrium?

$$2\ HBr(g) \rightleftharpoons H_2(g) + Br_2(g) \qquad K_c = 4.59 \times 10^{-7}\ \text{at } 730\ °C$$

A. $1.24 \times 10^{-3}\ M$

B. $3.39 \times 10^{-3}\ M$

C. $8.89 \times 10^{-3}\ M$

D. $2.48 \times 10^{-2}\ M$

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22. If the initial concentrations of hydrogen and iodine are both $0.125\ M$, what is the equilibrium concentration of HI?

$$H_2(g) + I_2(g) \rightleftharpoons 2\ HI(g) \qquad K_c = 60.2\ \text{at } 25\ °C$$

A. $3.27 \times 10^{-3}\ M$

B. $1.89 \times 10^{-2}\ M$

C. $9.94 \times 10^{-2}\ M$

D. $1.06 \times 10^{-1}\ M$

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23. A mixture that is 0.257 atm in $N_2(g)$ and 0.742 atm in $O_2(g)$ is allowed to reach equilibrium:

$$N_2(g) + 2\ O_2(g) \rightleftharpoons 2\ NO_2(g) \qquad K_p = 1.00 \times 10^{-18} \text{ at } 298\ K$$

What will the partial pressure of $NO_2(g)$ be at equilibrium?

A. $3.76 \times 10^{-10}$ atm
C. $2.76 \times 10^{-12}$ atm
B. $9.85 \times 10^{-8}$ atm
D. $1.89 \times 10^{-11}$ atm

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24. Given the following reaction

$$2\ Mo(s) + CH_4(g) \rightleftharpoons Mo_2C(s) + 2\ H_2(g) \qquad K_p = 3.55 \text{ at } 973\ K$$

which one of the following will result in the **largest** increase the amount of $H_2(g)$?

A. Add $Mo(s)$ and increase the volume.
B. Add $CH_4(g)$ and increase the volume.
C. Add $Mo_2C(s)$ and decrease the volume.
D. Add $Ar(g)$ and decrease the volume.

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25. Given

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g) \qquad K_p = 1.6 \times 10^{-21},\ \Delta H_{rxn} = +\ 131.3\ kJ/mol$$

which one of the following will result in the **largest** increase the amount of $H_2(g)$?

A. Remove heat and remove $H_2O(g)$.
B. Remove heat and remove $C(s)$.
C. Remove heat and add $CO(g)$.
D. Add heat and remove $CO(g)$.

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**Answer Key**:

1. A
2. B
3. D
4. C
5. B
6. C
7. A
8. D
9. C
10. B
11. B
12. C
13. A
14. D
15. A
16. D
17. B
18. D
19. C
20. A
21. B
22. C
23. A
24. B
25. D