CHM 2046 Exam 1 Spring 2015

Name _____ **U#**_____

Fill in your name and U# on this test booklet. Fill in and bubble in your name, U#, and section (0901) on the scantron form. Your TEST FORM CODE is "A". Read the items carefully. Mark the best answer after reading all possible choices. Use a #2 pencil and make clean erasures to insure proper scoring. When finished, turn in your scantron. Show this booklet and your USF ID or DL to the proctor and sign the attendance sheet. You may keep this booklet.

The only questions you may ask are related to the legibility of this document or test taking protocol and procedures. Please, refrain from asking questions about content. Any problem with the questions will be addressed only after all students have finished the exam. You may not share materials (including calculators). Please, mute and put away your phone. Good luck.

1. Choose the correct statement. The rate of a chemical reaction:

A. … is a measure of how fast a reaction occurs.
B. … describes the molar ratio in which reactants combine to form products.
C. … describes the changes in energy as a reaction proceeds.
D. … predicts whether reactants or products will be favored at equilibrium.

2. Nitric oxide reacts with hydrogen to form nitrous oxide and water. Use the following data to determine the rate law for the reaction:

$$2NO(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$$

Run #	[NO] mol/L	[H_2] mol/L	Initial rate
1	0.021	0.065	1.46 M/min
3	0.042	0.065	5.84 M/min
2	0.021	0.260	1.46 M/min

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

3. Consider the chemical equation and choose the correct option:

$$CH_3Cl_{(g)} + 3\ Cl_{2(g)} \rightarrow CCl_{4(g)} + 3\ HCl_{(g)}$$

A. $1/3\ \Delta[Cl_2]/\Delta t = 1/3\ \Delta[HCl]/\Delta t$

B. $-\Delta[Cl_2]/\Delta t = -\Delta[CH_3Cl]/\Delta t$

C. CCl_4 is produced three times as fast as HCl

D. Rate of reaction = $-\Delta[CH_3Cl]/\Delta t$

4. Consider the reaction:

$$2\ NO_{2(g)} + F_{2(g)} \rightarrow NO_2F_{(g)}$$

The rate law is given by the following expression:

$$Rate = k\ [NO_2]\ [F_2]$$

A Gen Chem 2 student wants to verify the correctness of this rate law and sets up a kinetics experiment based on the initial concentrations method. If the rate law given above is correct, what would be the predicted values for *y* and *z* in the table below?

[NO_2] (M)	[F_2] (M)	Initial Rate
0.100	0.100	0.026
0.100	0.200	*y*
0.200	0.200	*z*

A. $y = 0.052$, $z = 0.104$ **B.** $y = 0.104$, $z = 0.052$
C. $y = 0.052$, $z = 0.052$ **D.** $y = 0.026$, $z = 0.208$

5. Choose the correct statement: What is the half-life of a reaction?

A. The time it takes a reaction to reach equilibrium.
B. The concentration of the reactant after half of it has reacted.
C. The time it takes to react half of the initial amount of reactant.
D. The change in concentration after half of the reaction time has passed by.
E. Half the time required to reach equilibrium.

6. You are given the following information for a <u>first order reaction</u>:

$$k = 2.90 \times 10^{-4}\ s^{-1}$$
$$[A]_0 = 0.0793\ M$$

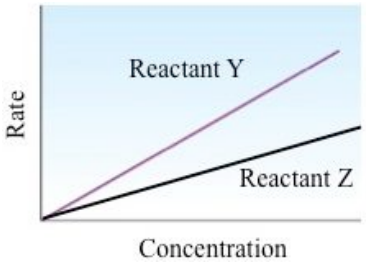
How long will it take for the concentration of A to be **one fourth** of its initial value (that is 0.25 times the initial value)?

A. 100 s **B.** 4.80×10^3 s
C. 8.01×10^{-5} s **D.** 2.90×10^3 s

7. Consider the hypothetical reaction:

$$2\,Y + Z \rightarrow Y_2Z$$

The plot below shows the initial rate of reaction as a function of the initial concentrations of Y and Z:



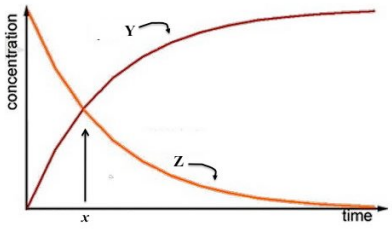
Choose the correct option:

A. The overall order of reaction is 2.
B. The reaction is first order in Z and second order in Y.
C. The reaction is second order in Y and second order in Z.
D. There reaction is first order in Z and zero order in Y.
E. Three molecules react to form the product; therefore the overall order of reaction is 3.

8. At 25°C, the rate constant for the **second-order** decomposition of a pesticide solution is 6.40×10^{-3} $M^{-1}min^{-1}$. If the starting concentration of the pesticide is 0.0310 M, what concentration will remain after 62.0 min at 25 °C?

A. 1.14×10^{-1} M
B. 47.4 M
C. 2.08×10^{-2} M
D. 8.72 M
E. 9.58 M

9. Consider the diagram below and choose the correct answer.

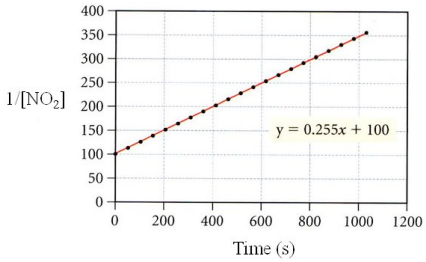


A. The overall rate of reaction is negative.
B. At equilibrium, the concentration of product is greater than the concentration of reactant.
C. Point *x* shows the time at which equilibrium is reached.
D. Both, Y and Z, are reactants.
E. The rate of change in concentration of Y with time, $\Delta[Y]/\Delta t$, is negative

10. A student gathered kinetics information for this reaction:

$$NO_{2(g)} \rightarrow NO_{(g)} + O_{(g)}$$

She used her calculator to plot **1/[NO_2]** versus **t**ime and obtained the graph and equation shown below.



Choose the correct deduction:

A. The integrated rate law indicates this is a second order reaction.
B. The rate constant *k* is - 0.255 mol/L s.
C. The initial concentration is 100 mol/L.
D. From the chemical equation, it follows that the reaction is first order since there is only one molecule of reactant.

11. Choose the correct statement

A. The rate law of chemical reactions can be estimated from the balanced chemical equation.
B. Catalyst, intermediate and activated complex describe the same chemical concept (are synonyms).
C. In a two-step reaction, the rate-determining step has the lowest activation energy.
D. According to the collision model, two molecules that collide with enough energy will react only if properly oriented.

12. A proposed mechanism for the decomposition of nitramide, NO_2NH_2, is shown:

Step 1:

$$NO_2NH_2(aq) + H_3O^+(aq) \rightarrow NO_2NH_3^+(aq) + H_2O(l)$$

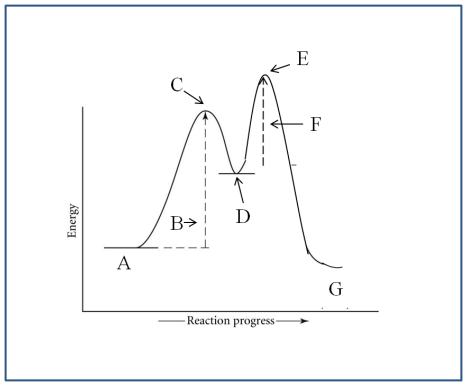
Step 2:

$$NO_2NH_3^+(aq) \rightarrow NO_2(g) + H_3O^+(aq)$$

Which statement is true?

A. $NO_2NH_3^+$ is a catalyst.
B. $NO_2NH_3^+$ and H_3O^+ are both intermediates.
C. H_3O^+ is an intermediate and $NO_2NH_3^+$ is a catalyst
D. $NO_2NH_3^+$ is an intermediate and H_3O^+ is a catalyst.
E. $NO_2NH_3^+$ and H_3O^+ are both catalysts.

13. Consider the energy profile below. The step on the left is the first step; the one on the right is the second step.



Choose the correct statement:

A. The reaction is exothermic **and** there are two intermediates indicated by C and E.
B. The first step is the rate determining step **and** the reaction gives off energy.
C. There are two activated complexes (C and E) **and** two products (D and G)
D. The difference between the two maxima (C and E) corresponds to the activation energy of the reaction.
E. This is a slow reaction since there are two steps in the process.

14. Choose the correct option.
When dynamic equilibrium is established:

A. The concentrations of reactants are equal to the concentrations of products.
B. The equilibrium constant becomes 1.
C. No more reactants are transformed into products.
D. Two opposite reactions occur at the same rate.
E. The activation energy is exhausted and the reaction stops unless heat is added again.

15. Choose the correct option.

A. The equilibrium constant for a given reaction depends on the initial concentrations of reactants and products.
B. The equilibrium constant is an indication of how shifted an equilibrium is towards the products.
C. The equilibrium constant must remain constant when the temperature is changed.
D. The equilibrium constant for the reverse reaction has the same value as that for the forward reaction but with opposite sign.

16. Which is the correct equilibrium expression for the following reaction?

$$Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$$

A. $K_C = \dfrac{[Fe_2O_3][H_2]^3}{[Fe]^2[H_2O]^3}$

B. $K_C = \dfrac{[H_2]}{[H_2O]}$

C. $K_C = \dfrac{[H_2O]^3}{[H_2]^3}$

D. $K_C = \dfrac{[Fe]^2[H_2O]^3}{[Fe_2O_3][H_2]^3}$

E. $K_C = \dfrac{[Fe]^2[H_2O]}{[Fe_2O_3][H_2]}$

17. Given the following reaction at equilibrium, if $K_p = 1.05$ **atm** at 523 **K**, what is the value for K_c?

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

A. 3.90×10^{-6} **mol/L**
B. 2.45×10^{-2} **mol/L**
C. 1.05 **mol/L**
D. 42.9 **mol/L**
E. 45.0 **mol/L**

18. Consider two hypothetical reactions and their corresponding **equilibrium constants**:

(i) N + M → O $K = 1.5 \times 10^{-5}$
(ii) P + Q → R $K = 2.2 \times 10^{+2}$

Choose the correct option:
A. (i) happens at a slower rate than (ii)
B. (i) favors more products than (ii)
C. (ii) reaches equilibrium faster than (i)
D. No kinetic conclusions can be drawn from the information given.

19. Consider the following reaction at equilibrium. What effect will <u>increasing the pressure</u> of the reaction mixture have on the system?

$$2\ H_2S_{(g)} + 3\ O_{2(g)} \rightleftharpoons 2\ H_2O_{(g)} + 2\ SO_{2(g)}$$

A. The equilibrium constant will decrease.
B. The equilibrium constant will increase.
C. The reaction will shift to the right.
D. The reaction will shift to the left.
E. No effect will be observed since all chemicals are in the gas phase.

20. Find the correct values for *j*, *k* and *l* to complete the table below.

	A_2 +	B_2 ⇌	2 AB
initial	**1.5**	**3.0**	*j*
change	**- 0.30**	*k*	*l*
equil.			1.10

A. *j* = 0.50; *k* = -0.30; *l* = +0.08
B. *j* = 3.0; *k* = -0.30; *l* = +0.60
C. *j* = 1.10; *k* = -0.30; *l* = +0.60
D. *j* = 0.50; *k* = +0.30; *l* = +0.60
E. *j* = 0.50; *k* = -0.30; *l* = +0.60

21. At 1300 K, the equilibrium constant for the reaction below is equal to 5.00 (K = 5.00).

$$2\ SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)}$$

If initial concentrations are:
$[SO_2]_0$ =0.100 M, $[O_2]_0$ = 0. 5 M, and $[SO_3]_0$ = 2.00 M,

The system is:
A. Not at equilibrium and will shift to the left to achieve an equilibrium state.
B. Not at equilibrium and will shift to the right to achieve an equilibrium state.
C. Not at equilibrium and will remain in an unequilibrated state.
D. At equilibrium.

22. Consider the reaction:

$$SO_2Cl_{2(g)} \rightleftharpoons SO_{2(g)} + Cl_{2(g)}$$

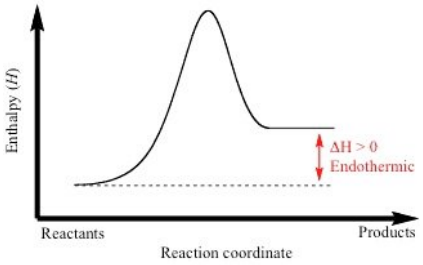
$K_c = 2.99 \times 10^{-7}$ at 227°C.

If a reaction mixture initially contains 0.175 M SO_2Cl_2, what is the equilibrium concentration of Cl_2? (Note: K_c is very, very small and the amount of Cl_2 produced can be assumed negligible compared to the initial amount of reactant.)

	$SO_2Cl_{2(g)}$ ⇌	$SO_{2(g)}$ +	$Cl_{2(g)}$
Initial	0.175 M	0	0
Change			
Equilibrium			*x*

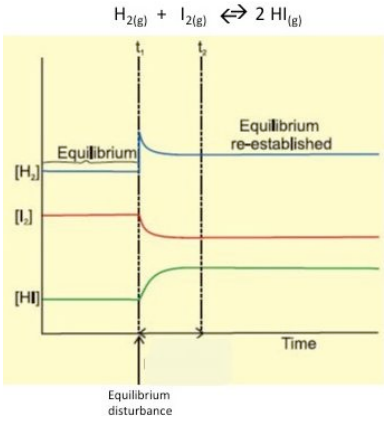
A. 3.67×10^{-7}
B. 2.29×10^{-4}
C. 7.23×10^{-1}
D. 40.8
E. 1.92×10^{2}

23. When heat is added to the chemical reaction represented by the energy profile below:



A. The equilibrium remains unchanged
B. The equilibrium constant remains unchanged
C. The equilibrium shifts towards the products
D. The equilibrium shifts towards the reactants
E. The activation energy is lowered.

24. Consider the chemical reaction and the plot below:



Choose the correct option

A. Ke remains the same after equilibrium is re-established.
B. The disturbance causes a shift towards the products.
C. $[I_2]$ drops in the process of re-establishing equilibrium.
D. The concentration of product after equilibrium is re-established is greater than its concentration before the disturbance.
E. Options A through D are all correct.

25. Consider the equilibrium below and choose the best option:

$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} + OH^-{}_{(aq)}$$

A. HCO_3^- and H_2O are a conjugate pair.
B. H_2O donates an H^+; it is a Bronsted-Lowry base.
C. HCO_3^- and OH^- are a conjugate pair.
D. In this reaction, HCO_3^- is acting as a base.
E. This is not an acid/base reaction.

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USEFUL INFORMATION

Chapter 13

Arrhenius Equation: $k = Ae^{-Ea/RT}$ Linearized form: $\ln k = -(Ea/R)(1/T) + \ln A$

Two-point form: $\ln (k_2/k_1) = (Ea/R)(1/T_1 - 1/T_2)$ Collision Theory: $k = pz\, e^{-Ea/RT}$

Reaction order	Integrated rate Law	Half-life expression
0	$[A]_t = -kt + [A]_0$	$t_{1/2} = [A]_0/2k$
1	$\ln [A]_t = -kt + \ln [A]_0$	$t_{1/2} = 0.693/k$
2	$1/[A]_t = kt + 1/[A]_0$	$t_{1/2} = 1/k[A]_0$

Chapter 14

$R = 0.08206$ **L atm/mol K** $Kp = Kc(RT)^{\Delta n}$
