General Chemistry 2 Exam 1 Summer 2008

Kingsborough Community College Dept. of Physical Sciences

The first 25 questions are multiple-choice. Each question is valued at 3 points. Mark your answers on the scantron form.

Part 2 (questions 26-28) are free response. Each question is valued at 10 points. Show all of your reasoning on the exam to receive credit.

1. The equilibrium constant expression for the reaction $2BrF_5(g) \rightleftharpoons Br_2(g) + 5F_2(g)$ is

A. $K_c = [Br_2]\,[F_2]/[BrF_5]$
B. $K_c = [Br_2]\,[F_2]^5/[BrF_5]^2$
C. $K_c = [Br_2]\,[F_2]^{2/}[BrF_5]^5$
D. $K_c = [BrF_5]^2/[Br_2][F_2]^5$
E. $K_c = 2[BrF_5]^2/([Br_2] \times 5[F_2]^5)$

2. Which is the correct equilibrium constant expression for the following reaction?
$Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$

A. $K_c = [Fe_2O_3]\,[H_2]^3/[Fe]^2[H_2O]^3$
B. $K_c = [H_2]/[H_2O]$
C. $K_c = [H_2O]^3/[H_2]^3$
D. $K_c = [Fe]^2[H_2O]^3/[Fe_2O_3]\,[H_2]^3$
E. $K_c = [Fe]\,[H_2O]/[Fe_2O_3]\,[H_2]$

3. When the following reaction is at equilibrium, which of these relationships is *always* true?
$2NOCl(g) \qquad 2NO(g) + Cl_2(g)$

A. $[NO][Cl_2] = [NOCl]$
B. $[NO]^2[Cl_2] = [NOCl]^2$
C. $[NOCl] = [NO]$
D. $2[NO] = [Cl_2]$
E. $[NO]^2[Cl_2] = K_c[NOCl]^2$

4. The following reactions occur at 500 K. Arrange them in order of increasing tendency to proceed to completion (least → greatest tendency).

1. $2NOCl \rightleftharpoons 2NO + Cl_2$ $\qquad K_p = 1.7 \times 10^{-2}$
2. $2SO_3 \rightleftharpoons 2SO_2 + O_2$ $\qquad K_p = 1.3 \times 10^{-5}$
3. $2NO_2 \rightleftharpoons 2NO + O_2$ $\qquad K_p = 5.9 \times 10^{-5}$

A. 2 < 1 < 3
B. 1 < 2 < 3
C. 2 < 3 < 1
D. 3 < 2 < 1
E. 3 < 1 < 2

5. Consider the two gaseous equilibria

$$SO_2(g) + (1/2)O_2(g) \rightleftharpoons SO_3(g) \qquad K_1$$
$$2SO_3(g) \rightleftharpoons SO_2(g) + O_2(g) \qquad K_2$$

The values of the equilibrium constants K_1 and K_2 are related by

A. $K_2 = K_1^2$
B. $K_2^2 = K_1$
C. $K_2 = 1/K_1^2$
D. $K_2 = 1/K_1$
E. none of these

6. Calculate K_p for the reaction
$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$
at 400°C if K_c at 400°C for this reaction is 2.1×10^{-2}.

A. 2.1×10^{-2}
B. 1.7×10^{-3}
C. 0.70
D. 1.2
E. 3.8×10^{-4}

7. K_p for the reaction of $SO_2(g)$ with O_2 to produce $SO_3(g)$ is 3×10^{24} . Calculate K_c for this equilibrium at 25ºC. (The relevant reaction is $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.)

A. 3×10^{24}
B. 5×10^{21}
C. 2×10^{20}
D. 5×10^{22}
E. 7×10^{25}

8. On analysis, an equilibrium mixture for the reaction
$2H_2S(g) \rightleftharpoons 2H_2(g) + S_2(g)$
was found to contain 1.0 mol H_2S, 4.0 mol H_2, and 0.80 mol S_2 in a 4.0 L vessel. Calculate the equilibrium constant, K_c, for this reaction.

A. 1.6
B. 3.2
C. 12.8
D. 0.64
E. 0.8

9. 1.25 moles of NOCl were placed in a 2.50 L reaction chamber at 427ºC. After equilibrium was reached, 1.10 moles of NOCl remained. Calculate the equilibrium constant, K_c, for the reaction $2NOCl(g) \qquad 2NO(g) + Cl_2(g)$.

A. 3.0×10^{-4}
B. 1.8×10^{3}
C. 1.4×10^{-3}
D. 5.6×10^{-4}
E. 4.1×10^{-3}

10. Consider the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$, for which $K_c = 0.10$ at 2,000ºC. Starting with initial concentrations of 0.040 M of N_2 and 0.040 M of O_2, determine the equilibrium concentration of NO.

A. 5.4×10^{-3} M
B. 0.0096 M
C. 0.011 M
D. 0.080 M
E. 0.10 M

11. For the following reaction at equilibrium in a reaction vessel, which one of these changes would cause the Br_2 concentration to *decrease*?

$$2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g) \qquad \Delta H^{\circ}_{rxn} = 30 \text{ kJ/mol}$$

A. Increase the temperature.
B. Remove some NO.
C. Add more NOBr.
D. Compress the gas mixture into a smaller volume.

12. For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, $K_c = 50.2$ at 445ºC. If $[H_2] = [I_2] = [HI] = 1.75 \times 10^{-3}$ M at 445ºC, which one of these statements is *true*?

A. The system is at equilibrium, thus no concentration changes will occur.
B. The concentrations of HI and I_2 will increase as the system approaches equilibrium.
C. The concentration of HI will increase as the system approaches equilibrium.
D. The concentrations of H_2 and HI will fall as the system moves toward equilibrium.
E. The concentrations of H_2 and I_2 will increase as the system approaches equilibrium.

13. For the reaction $BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$ at a particular time, $-\Delta[BrO_3^-]/\Delta t = 1.5 \times 10^{-2}$ M/s. What is $-\Delta[Br^-]/\Delta t$ at the same instant?

A. 13 M/s
B. 7.5×10^{-2} M/s
C. 1.5×10^{-2} M/s
D. 3.0×10^{-3} M/s
E. 330 M/s

14. For the overall chemical reaction shown below, which one of the following statements can be rightly assumed?

$$2H_2S(g) + O_2(g) \rightarrow 2S(s) + 2H_2O(l)$$

A. The reaction is third-order overall.
B. The reaction is second-order overall.
C. The rate law is, rate = $k[H_2S]^2 [O_2]$.
D. The rate law is, rate = $k[H_2S] [O_2]$.
E. The rate law cannot be determined from the information given.

15. The reaction $A + 2B \rightarrow$ *products* has the rate law, rate = $k[A][B]^3$. If the concentration of B is doubled while that of A is unchanged, by what factor will the rate of reaction increase?

A. 2
B. 4
C. 6
D. 8
E. 9

16. Appropriate units for a first-order rate constant are

A. M/s.
B. 1/M·s.
C. 1/s.
D. $1/M^2$·s.

17. A certain first-order reaction A $\rightarrow$ B is 25% complete in 42 min at 25°C. What is the half-life of the reaction?

A. 21 min
B. 42 min
C. 84 min
D. 120 min
E. 101 min

18. Nitric oxide gas (NO) reacts with chlorine gas according to the equation
$NO + \frac{1}{2}Cl_2 \rightarrow NOCl$.

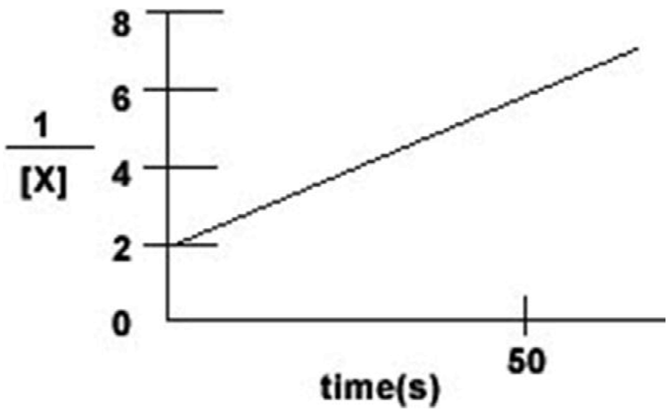
The following initial rates of reaction have been measured for the given reagent concentrations.

Expt. #	Rate (M/hr)	NO (M)	Cl_2 (M)
1	1.19	0.50	0.50
2	4.79	1.00	0.50
3	9.59	1.00	1.00

Which of the following is the rate law (rate equation) for this reaction?

A. rate = k[NO]
B. rate = $k[NO][Cl_2]^{1/2}$
C. rate = $k[NO][Cl_2]$
D. rate = $k[NO]^2[Cl_2]$
E. rate = $k[NO]^2[Cl_2]^2$

19. For the reaction X + Y $\rightarrow$ Z, the reaction rate is found to depend only upon the concentration of X. A plot of 1/X verses time gives a straight line.



What is the rate law for this reaction?

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

20. The reaction $2NO_2(g) \rightarrow 2NO(g) + O_2(g)$ is suspected to be second order in NO_2. Which of the following kinetic plots would be the most useful to confirm whether or not the reaction is second order?

A. a plot of $[NO_2]^{-1}$ vs. t
B. a plot of ln $[NO_2]$ vs. t
C. a plot of $[NO_2]$ vs. t
D. a plot of ln $[NO_2]^{-1}$ vs. t
E. a plot of $[NO_2]^2$ vs. t

21. The Arrhenius equation is $k = A\,e^{-(Ea/RT)}$. The slope of a plot of ln k vs. 1/T is equal to

A. -k.
B. k.
C. E_a.
D. $-E_a$ /R.
E. A.

22. The reaction $C_4H_{10} \rightarrow C_2H_6 + C_2H_4$ has an activation energy (E_a) of 350 kJ/mol, and the E_a of the reverse reaction is 260 kJ/mol. Estimate ΔH, in kJ/mol, for the reaction as written above.

A. -90 kJ/mol
B. +90 kJ/mol
C. 350 kJ/mol
D. -610 kJ/mol
E. +610 kJ/mol

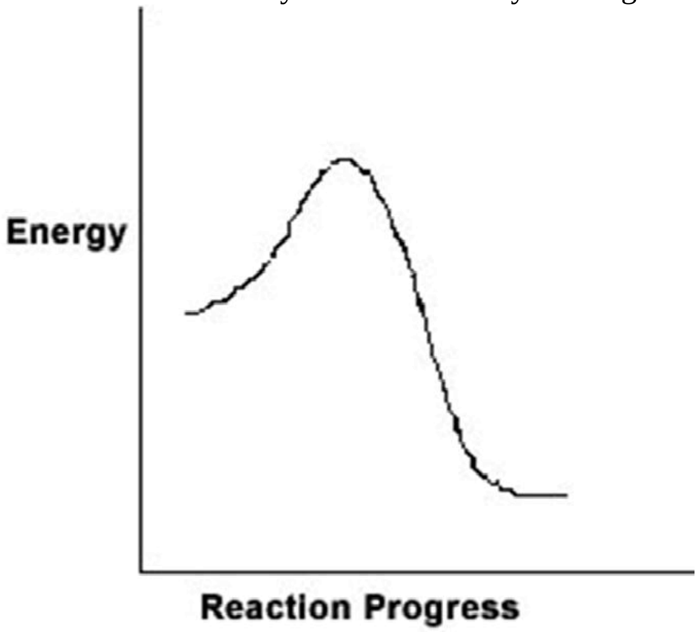
23. The activation energy for the following first-order reaction is 102 kJ/mol.

$$N_2O_5(g) \rightarrow 2NO_2(g) + (1/2)O_2(g)$$

The value of the rate constant (k) is $1.35 \times 10^{-4}\ s^{-1}$ at 35°C. What is the value of k at 0°C?

A. $8.2 \times 10^{-7}\ s^{-1}$
B. $1.9 \times 10^{-5}\ s^{-1}$
C. $4.2 \times 10^{-5}\ s^{-1}$
D. $2.2 \times 10^{-2}\ s^{-1}$
E. none of these

24. For the chemical reaction system described by the diagram below, which statement is *true*?



A. The forward reaction is endothermic.
B. The activation energy for the forward reaction is greater than the activation energy for the reverse reaction.
C. At equilibrium, the activation energy for the forward reaction is equal to the activation energy for the reverse reaction.
D. The activation energy for the reverse reaction is greater than the activation energy for the forward reaction.
E. The reverse reaction is exothermic.

25. The rate law for the reaction $H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$ is rate = $k[H_2O_2][I^-]$. The following mechanism has been suggested.

$H_2O_2 + I^- \rightarrow HOI + OH^-$	*slow*
$OH^- + H^+ \rightarrow H_2O$	*fast*
$HOI + H^+ + I^- \rightarrow I_2 + H_2O$	*fast*

Identify all intermediates included in this mechanism.

A. H^+ and I^-
B. H^+ and HOI
C. HOI and OH^-
D. H^+ only
E. H_2O and OH^-

Part 2. Each question is worth 8 points

26. Consider the reaction between NO_2 and N_2O_4

$2NO_2\,(g) \rightleftharpoons N_2O_4\,(g) \qquad K_c = 1.25$

Suppose that a container of 2.0 L is filled with 0.50 moles of NO_2 and 0.010 moles of N_2O_4. What will the equilibrium concentration of each species be when the system equilibrates?

27. Consider the data given for the dimerization of butadiene at 500 K.

$2C_4H_8$ (g) → C_8H_{12} (g)

Time (s)	**[C_4H_8]**
195	0.016
604	0.015
1246	0.013
2180	0.010
6210	0.0068

Determine the form of the rate law and the rate constant for this reaction. Use graph paper provided.

28. Experimental values for the temperature dependence of the rate constant for the gas-phase reaction: $NO + O_3 \rightarrow NO_2 + O_2$

Are as follows:

T (K)	**k ($M^{-1}s^{-1}$)**
195	1.08×10^9
230	2.95×10^9
260	5.42×10^9
298	12.0×10^9
369	35.5×10^9

Make the appropriate graph using these data and determine the activation energy for this reaction.

ANSWERS TO MULTIPLE CHOICE QUESTIONS EXAM 1 SUMMER 2008

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