General Chemistry 2 Section D02D Fall 2006 Exam 1
Dept. of Physical Sciences Kingsborough CC, CUNY

Directions

When answering questions be sure to write clearly. Be sure to show your thinking as you answer the questions. You must show work in order to receive credit for your answers. For any answers greater than 1000 or less than 0.01 be sure to report the answer using scientific notation or metric prefixes. All answers should include units where appropriate and the correct number of significant figures.

Part 1: Multiple-choice. Choose the **BEST** response. 2 points each.

1. In a study of the reaction described by the equation:

$$2\ CH_4O(g) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 4\ H_2O(g)$$

the rate of consumption of $O_2(g)$ is 0.400 mol L^{-1} s^{-1}. What is the rate of formation of $H_2O(g)$ in the study?

a. 0.300 mol L^{-1} s^{-1}
b. 0.400 mol L^{-1} s^{-1}
c. 0.533 mol L^{-1} s^{-1}
d. 0.800 mol L^{-1} s^{-1}
e. 1.33 mol L^{-1} s^{-1}

2. A reaction has the rate law, rate = $k[A][B]^2$. What is the overall order of the reaction?

a. 2
b. 4
c. 1
d. 3
e. 0

3. For the reaction, $2\ XO + O_2 \rightarrow 2\ XO_2$ data is given below.

run #	[XO]	$[O_2]$	rate, (mol L^{-1} s^{-1})
1	0.010	0.010	2.5
2	0.010	0.020	5.0
3	0.030	0.020	45.0

The rate law is therefore

a. rate = $k[XO]^2\ [O_2]$
b. rate = $k[XO][O_2]^2$
c. rate = $k[XO][O_2]$
d. rate = $k[XO]^2\ [O_2]^2$
e. rate = $k[XO]^2/[O_2]^2$

4. Given the reaction $aA + bB \xrightarrow{C} dD + eE$

where C is a catalyst. If we try, rate = $k[A]^q[B]^r[C]^s$ for a generic rate law statement, which one of the statements below is **false**?

a. The exponents q, r, and s are often integers.
b. The exponent s must be determined experimentally.
c. The exponents q and r are equal to the coefficients a and b, respectively.
d. The overall order of the reaction is q + r + s.
e. The symbol k represents the rate constant.

5. For a first order reaction with a single reactant, after 230.0 seconds, 10.0% of the reactant remains. The rate constant for the reaction is therefore

a. 0.000640 s^{-1}
b. 0.0100 s^{-1}
c. 100 s^{-1}
d. 0.0510 s^{-1}
e. 0.0915 s^{-1}

6. For a chemical reaction, the rate constant at 250.0 ^{o}C is 0.00383 s^{-1}, and the activation energy is 22.40 kilojoules. Calculate the value of the rate constant at 335.0 ^{o}C.

a. 0.00513 s^{-1}
b. 0.00946 s^{-1}
c. 0.00787 s^{-1}
d. 0.0224 s^{-1}
e. 0.000640 s^{-1}

7. A catalyst alters the rate of a chemical reaction by

a. providing an alternate pathway which has a different activation energy
b. changing the products formed in the reaction
c. changing the frequency of collisions between molecules
d. always providing a surface on which molecules react
e. changing the enthalpy of reaction for the reaction

8. The equilibrium constant for the reaction, $R_2 \equiv D_2$ is 6.8×10^{-10}. Which one of the following statements is true?

a. The equilibrium concentration of D_2 is always greater than that of R_2.
b. The equilibrium concentration of R_2 is always greater than that of D_2.
c. Adding more R_2 will increase the value of the equilibrium constant.
d. Adding a catalyst will increase the equilibrium concentration of D_2.
e. Adding a catalyst will increase the value of the equilibrium constant.

9. For a system, $H_2(g) + I_2(g) \equiv 2\ HI(g)$, $K_c = 62.9$ at 750 K.
2.80 moles of HI were placed in a 10.0 liter container and allowed to come to equilibrium. Which situation described below is true at equilibrium?

a. $[HI] = 2 \times [H_2]$
b. $[HI] = [H_2]$
c. $[HI] < [H_2]$
d. $[HI] > [H_2]$
e. $[H_2] > [I_2]$

10. For the reaction, $2\ SO_2(g) + O_2(g) \equiv 2\ SO_3(g)$, at 900.0 K the equilibrium constant, K_c, has a value of 13.0. Calculate the value of K_p at the same temperature.

    a. $97.3 \times 10^3\ atm^{-1}$
    b. $0.176\ atm^{-1}$
    c. $960\ atm^{-1}$
    d. $0.00174\ atm^{-1}$
    e. $0.077\ atm^{-1}$

11. A study of the system, $4\ NH_3(g) + 7\ O_2(g) \equiv 2\ N_2O_4(g) + 6\ H_2O(g)$, was carried out. A system was prepared with $[NH_3] = [O_2] = 3.60$ M as the only components initially. At equilibrium, $[N_2O_4]$ is 0.60 M. Calculate the equilibrium concentration of O_2.

    a, 3.00 M
    b. 2.40 M
    c. 1.50 M
    d. 2.10 M
    e. 3.30 M

12. The equilibrium constant, K_c, for the system, $CaO(s) + CO_2(g) \equiv CaCO_3(s)$, is

    a. $K_c = [CO_2]$
    b. $K_c = [CaCO_3]/([CaO] \times [CO_2])$
    c. $K_c = 1/[CO_2]$
    d. $K_c = [CaCO_3]/[CaO]$
    e. $K_c = ([CaO] \times [CO_2])/[CaCO_3]$

13. Given the reaction, $2\ NO(g) + O_2(g) \equiv 2\ NO_2(g)$, for which the enthalpy of reaction is -118.9 kJ. Which one of the following will cause an increase in the equilibrium concentration of NO in a closed reaction chamber?

    a. adding some more $O_2(g)$
    b. increasing the temperature of the system
    c. removing the NO_2 from the system by absorbing it
    d. increasing the pressure of the system while temperature is kept constant
    e. adding a catalyst

14. Consider the following system, which is at equilibrium,

$$CO(g) + 3\ H_2(g) \equiv CH_4(g) + H_2O(g).$$

The result of removing some $CH_4(g)$ and $H_2O(g)$ from the system is that

    a. more $CH_4(g)$ and $H_2O(g)$ are produced to replace that which is removed
    b. K_c decreases
    c. more $CO(g)$ is produced
    d. more $H_2O(g)$ is consumed to restore the equilibrium
    e. more CH_4 is consumed to restore the equilibrium

15. The system, $H_2(g) + X_2(g) \equiv 2\,HX(g)$ has a value of 24.4 for the constant, K_c. A system being tried in a 3.00 liter reactor was charged with 0.150 moles of H_2, 0.150 moles of X_2, and 0.600 moles of HX. The catalyst was introduced using a remote unit, and the system was allowed to come to equilibrium. Which statement below describes the situation?

a. the reaction goes to the right, $Q < K$
b. the reaction goes to the left, $Q < K$
c. the reaction goes to the right, $Q > K$
d. the reaction goes to the left, $Q > K$
e. it is not possible to predict in which direction the system will travel

16. The nuclear particle which is partially described by the representation, ${}^{0}_{+1}x$, is a(n)

a. alpha particle
b. electron
c. neutron
d. positron
e. proton

17. Identify the missing species in the nuclear equation given

$${}^{55}_{26}Fe + {}^{0}_{-1}e \rightarrow ????$$

a. ${}^{53}_{27}Fe$
b. ${}^{55}_{25}Mn$
c. ${}^{55}_{27}Co$
d. ${}^{55}_{27}Fe$
e. ${}^{55}_{25}Fe$

18. Identify the missing species in the nuclear equation given

$${}^{245}_{96}Cm \rightarrow ???? + {}^{4}_{2}\alpha$$

a. ${}^{249}_{94}Pu$
b. ${}^{241}_{94}Pu$
c. ${}^{249}_{98}Cf$
d. ${}^{241}_{98}Cf$
e. ${}^{247}_{92}U$

19. The nuclear process, $^{37}_{16}S \rightarrow ^{37}_{17}Cl$, is an example of (could be caused by)

a. electron capture by the reactant nucleus
b. ∃-emission from the reactant nucleus
c. ∀-emission from the reactant nucleus
d. proton emission from the reactant nucleus
e. neutron emission from the reactant nucleus

20. If the half-life of a radioactive element is 30.0 years, how long will it take to decay to the point where the activity is 70.0% of the original value?

a. 5.0 years
b. 12.2 years
c. 15.4 years
d. 30.8 years
e. 86.1 years

21. Rhenium-186 is a β-emitter with a half-life of 90.0 hours. How long would it take for the activity in a sample of this nuclide to decay to exactly one-third of its original value?

a. 121 hours
b. 143 hours
c. 158 hours
d. 180 hours
e. 189 hours

22. The conjugate base of HPO_4^{2-} is

a. H_2PO_4
b. H_3PO_4
c. PO_4^{3-}
d. PO_4^{2-}
e. $H_2PO_4^-$

23. The conjugate acid of NH_3 is

a. NH_4
b. NH_3^+
c. H^+
d. H_3O^+
e. NH_4^+

24. For the system

$$\begin{array}{ccccccc} NH_2OH & + & CH_3NH_3^+ & \equiv & CH_3NH_2 & + & NH_3OH^+ \\ 95\% & & 95\ \% & & 5\ \% & & 5\ \% \end{array}$$

the state of equilibrium in the system is described by the numbers given. Which of the species is the strongest acid in the system?

a. NH_2OH
b. $CH_3NH_3^+$
c. CH_3NH_2
d. NH_3OH^+
e. NH_2OH and $CH_3NH_3^+$ are equal in acid strength, and are the strongest acids in the system

25. An aqueous solution at 25.0°C has an H^+ concentration of 4.0×10^{-2} molar. What is the OH^- concentration in the same solution, in moles per liter?

a. 4.0×10^{-2}
b. 4.0×10^{-9}
c. 4.0×10^{-12}
d. 2.5×10^{-13}
e. 25.0

END PART 1

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Part 2. Be sure to show your work for credit.

1. 8 points
Consider the following reaction equation:
$SO_2(g) + NO_2(g) \rightleftharpoons NO(g) + SO_3(g)$ $K_c = 3.1$
The initial concentrations in moles per liter are:
$[SO_2] = 0.50$ $[NO_2] = 0.50$ $[NO] = 0.15$ $[SO_3] = 0.15$

a. Write the expression for K_c for this reaction.
b. Is the system at equilibrium? If not, which direction will it shift to come to equilibrium?
c. If the system is not at equilibrium, calculate the equilibrium concentrations of all species.

$K = \frac{[NO][SO_3]}{[SO_2][NO_2]} = 3.1$ Q = 0.09 so the system is not at equilibrium. Since $Q < K$ the system will shift toward the right side of the equation by producing more products.

The equilibrium concentrations are 0.24 M for SO_2 and NO_2 and 0.41 M for NO and SO_3.

2. 6 points. Consider K/Ar dating: ${}^{40}_{19}K + {}^{0}_{-1}e \rightarrow {}^{40}_{18}Ar$
Suppose that a rock sample contains 12.5 ng potassium-40 and 7.5 ng argon-40. Calculate the age of the rock given that the half-life of
potassium-40 is ($t_{1/2} = 1.3 \times 10^9$ years).

The rate constant is $5.3 \times 10^{-10}\ y^{-1}$
The age of the rock is 8.8×10^8 y

3. 8. points. Consider an aqueous solution of nitric acid (HNO_3). If the concentration of 50.00 mL of nitric acid is 0.025 M calculate:

a. pH 1.60 b. pOH 12.40

c. $[H_3O^+]$ 0.025 M d. $[OH^-]$ 4.0×10^{-13} M

Consider an aqueous solution of potassium hydroxide (KOH). If the concentration of 50.00 ml of KOH solution is 0.025 M calculate:

a. pH 12.40 b. pOH 1.60

c. $[H_3O^+]$ 4.0×10^{-13} M d. $[OH^-]$ 0.025 M

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pico = 10^{-12} nano = 10^{-9} micro = 10^{-6} milli = 10^{-3} centi = 10^{-2}
kilo = 10^{3} mega = 10^{6} giga = 10^{9} tera = 10^{12}

Constants: $N_A = 6.022 \times 10^{23}$/mol R = 8.31 J/Kmol = 0.08206 Latm/Kmol
$T_K = T_C + 273$

$$[A] = -kt + [A]_0$$ Zero-order

$$\ln[A] = -kt + \ln[A]_0$$ First-order

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$ Second-order

$$kt_{1/2} = 0.693$$ first-order

$$\ln k = -\frac{E_A}{RT} + \ln A$$

$K_p = K_c(RT)^{\Delta n}$
$Kw = 1.0 \times 10^{-14}$
$pH = -\log[H_3O^+]$ $pOH = -\log[OH^-]$ $pK = -\log K$
$pH + pOH = 14.00$
$K_aK_b = K_w$ $[H_3O^+][OH^-] = K_w$