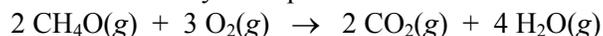


Directions

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:



the rate of consumption of  $\text{O}_2(g)$  is  $0.400 \text{ mol L}^{-1} \text{ s}^{-1}$ . What is the rate of formation of  $\text{H}_2\text{O}(g)$  in the study?

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

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

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

3. For the reaction,  $2 \text{XO} + \text{O}_2 \rightarrow 2 \text{XO}_2$  data is given below.

run #	[XO]	[O <sub>2</sub> ]	rate, (mol L <sup>-1</sup> s <sup>-1</sup> )
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.  $\text{rate} = k[\text{XO}]^2 [\text{O}_2]$
- b.  $\text{rate} = k[\text{XO}][\text{O}_2]^2$
- c.  $\text{rate} = k[\text{XO}][\text{O}_2]$
- d.  $\text{rate} = k[\text{XO}]^2 [\text{O}_2]^2$
- e.  $\text{rate} = k[\text{XO}]^2/[\text{O}_2]^2$

4. Given the reaction  $a\text{A} + b\text{B} \xrightarrow{\text{C}} d\text{D} + e\text{E}$

where C is a catalyst. If we try,  $\text{rate} = k[\text{A}]^q[\text{B}]^r[\text{C}]^s$  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.  $0.000640 \text{ s}^{-1}$
- b.  $0.0100 \text{ s}^{-1}$
- c.  $100 \text{ s}^{-1}$
- d.  $0.0510 \text{ s}^{-1}$
- e.  $0.0915 \text{ s}^{-1}$

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

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

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,  $\text{R}_2 \rightleftharpoons \text{D}_2$  is  $6.8 \times 10^{-10}$ . Which one of the following statements is true?

- a. The equilibrium concentration of  $\text{D}_2$  is always greater than that of  $\text{R}_2$ .
- b. The equilibrium concentration of  $\text{R}_2$  is always greater than that of  $\text{D}_2$ .
- c. Adding more  $\text{R}_2$  will increase the value of the equilibrium constant.
- d. Adding a catalyst will increase the equilibrium concentration of  $\text{D}_2$ .
- e. Adding a catalyst will increase the value of the equilibrium constant.

9. For a system,  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g})$ ,  $K_c = 62.9$  at  $750 \text{ K}$ .

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.  $[\text{HI}] = 2 \times [\text{H}_2]$
- b.  $[\text{HI}] = [\text{H}_2]$
- c.  $[\text{HI}] < [\text{H}_2]$
- d.  $[\text{HI}] > [\text{H}_2]$
- e.  $[\text{H}_2] > [\text{I}_2]$

10. For the reaction,  $2 \text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2 \text{SO}_3(g)$ , 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.
- $97.3 \times 10^3 \text{ atm}^{-1}$
  - $0.176 \text{ atm}^{-1}$
  - $960 \text{ atm}^{-1}$
  - $0.00174 \text{ atm}^{-1}$
  - $0.077 \text{ atm}^{-1}$
11. A study of the system,  $4 \text{NH}_3(g) + 7 \text{O}_2(g) \rightleftharpoons 2 \text{N}_2\text{O}_4(g) + 6 \text{H}_2\text{O}(g)$ , was carried out. A system was prepared with  $[\text{NH}_3] = [\text{O}_2] = 3.60 \text{ M}$  as the only components initially. At equilibrium,  $[\text{N}_2\text{O}_4]$  is 0.60 M. Calculate the equilibrium concentration of  $\text{O}_2$ .
- 3.00 M
  - 2.40 M
  - 1.50 M
  - 2.10 M
  - 3.30 M
12. The equilibrium constant,  $K_c$ , for the system,  $\text{CaO}(s) + \text{CO}_2(g) \rightleftharpoons \text{CaCO}_3(s)$ , is
- $K_c = [\text{CO}_2]$
  - $K_c = [\text{CaCO}_3]/([\text{CaO}] \times [\text{CO}_2])$
  - $K_c = 1/[\text{CO}_2]$
  - $K_c = [\text{CaCO}_3]/[\text{CaO}]$
  - $K_c = ([\text{CaO}] \times [\text{CO}_2])/[\text{CaCO}_3]$
13. Given the reaction,  $2 \text{NO}(g) + \text{O}_2(g) \rightleftharpoons 2 \text{NO}_2(g)$ , 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?
- adding some more  $\text{O}_2(g)$
  - increasing the temperature of the system
  - removing the  $\text{NO}_2$  from the system by absorbing it
  - increasing the pressure of the system while temperature is kept constant
  - adding a catalyst
14. Consider the following system, which is at equilibrium,  
$$\text{CO}(g) + 3 \text{H}_2(g) \rightleftharpoons \text{CH}_4(g) + \text{H}_2\text{O}(g).$$
The result of removing some  $\text{CH}_4(g)$  and  $\text{H}_2\text{O}(g)$  from the system is that
- more  $\text{CH}_4(g)$  and  $\text{H}_2\text{O}(g)$  are produced to replace that which is removed
  - $K_c$  decreases
  - more  $\text{CO}(g)$  is produced
  - more  $\text{H}_2\text{O}(g)$  is consumed to restore the equilibrium
  - more  $\text{CH}_4$  is consumed to restore the equilibrium

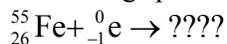
15. The system,  $\text{H}_2(\text{g}) + \text{X}_2(\text{g}) \rightleftharpoons 2 \text{HX}(\text{g})$  has a value of 24.4 for the constant,  $K_c$ . A system being tried in a 3.00 liter reactor was charged with 0.150 moles of  $\text{H}_2$ , 0.150 moles of  $\text{X}_2$ , and 0.600 moles of  $\text{HX}$ . 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,  ${}^0_{+1}\text{x}$ , is a(n)

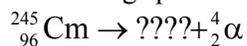
- a. alpha particle
- b. electron
- c. neutron
- d. positron
- e. proton

17. Identify the missing species in the nuclear equation given



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

18. Identify the missing species in the nuclear equation given



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

19. The nuclear process,  ${}_{16}^{37}\text{S} \rightarrow {}_{17}^{37}\text{Cl}$ , is an example of (could be caused by )
- electron capture by the reactant nucleus
  - $\beta$ -emission from the reactant nucleus
  - $\gamma$ -emission from the reactant nucleus
  - proton emission from the reactant nucleus
  - 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?
- 5.0 years
  - 12.2 years
  - 15.4 years
  - 30.8 years
  - 86.1 years
21. Rhenium-186 is a  $\beta$ -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?
- 121 hours
  - 143 hours
  - 158 hours
  - 180 hours
  - 189 hours
22. The conjugate base of  $\text{HPO}_4^{2-}$  is
- $\text{H}_2\text{PO}_4$
  - $\text{H}_3\text{PO}_4$
  - $\text{PO}_4^{3-}$
  - $\text{PO}_4^{2-}$
  - $\text{H}_2\text{PO}_4^-$
23. The conjugate acid of  $\text{NH}_3$  is
- $\text{NH}_4$
  - $\text{NH}_3^+$
  - $\text{H}^+$
  - $\text{H}_3\text{O}^+$
  - $\text{NH}_4^+$

24. For the system



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

- NH<sub>2</sub>OH
  - CH<sub>3</sub>NH<sub>3</sub><sup>+</sup>
  - CH<sub>3</sub>NH<sub>2</sub>
  - d.** NH<sub>3</sub>OH<sup>+</sup>
  - NH<sub>2</sub>OH and CH<sub>3</sub>NH<sub>3</sub><sup>+</sup> are equal in acid strength, and are the strongest acids in the system
25. An aqueous solution at 25.0°C has an H<sup>+</sup> concentration of 4.0 x 10<sup>-2</sup> molar. What is the OH<sup>-</sup> concentration in the same solution, in moles per liter?
- 4.0 x 10<sup>-2</sup>
  - 4.0 x 10<sup>-9</sup>
  - 4.0 x 10<sup>-12</sup>
  - d.** 2.5 x 10<sup>-13</sup>
  - 25.0

END PART 1

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

1. 8 points

Consider the following reaction equation:



The initial concentrations in moles per liter are:

$$[\text{SO}_2] = 0.50 \quad [\text{NO}_2] = 0.50 \quad [\text{NO}] = 0.15 \quad [\text{SO}_3] = 0.15$$

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

$$K = \frac{[\text{NO}][\text{SO}_3]}{[\text{SO}_2][\text{NO}_2]} = 3.1 \quad Q = 0.09$$
 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  $\text{SO}_2$  and  $\text{NO}_2$  and 0.41 M for  $\text{NO}$  and  $\text{SO}_3$ .

2. 6 points. Consider K/Ar dating:  ${}^{40}_{19}\text{K} + {}^0_{-1}\text{e} \rightarrow {}^{40}_{18}\text{Ar}$

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  $5.3 \times 10^{-10} \text{ y}^{-1}$

The age of the rock is  $8.8 \times 10^8 \text{ y}$

3. 8. points. Consider an aqueous solution of nitric acid ( $\text{HNO}_3$ ). If the concentration of 50.00 mL of nitric acid is 0.025 M calculate:

- |                             |         |                    |                                 |
|-----------------------------|---------|--------------------|---------------------------------|
| a. pH                       | 1.60    | b. pOH             | 12.40                           |
| c. $[\text{H}_3\text{O}^+]$ | 0.025 M | d. $[\text{OH}^-]$ | $4.0 \times 10^{-13} \text{ M}$ |

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

- |                             |                                 |                    |         |
|-----------------------------|---------------------------------|--------------------|---------|
| a. pH                       | 12.40                           | b. pOH             | 1.60    |
| c. $[\text{H}_3\text{O}^+]$ | $4.0 \times 10^{-13} \text{ M}$ | d. $[\text{OH}^-]$ | 0.025 M |

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

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

$$[A] = -kt + [A]_0 \quad \text{Zero-order}$$

$$\ln[A] = -kt + \ln[A]_0 \quad \text{First-order}$$

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

$$kt_{1/2} = 0.693 \quad \text{first-order} \quad \ln k = -\frac{E_A}{RT} + \ln A$$

$$K_p = K_c(RT)^{\Delta n}$$

$$K_w = 1.0 \times 10^{-14}$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$\text{pH} + \text{pOH} = 14.00$$

$$K_a K_b = K_w$$

$$\text{pOH} = -\log[\text{OH}^-]$$

$$[\text{H}_3\text{O}^+][\text{OH}^-] = K_w$$

$$\text{pK} = -\log K$$