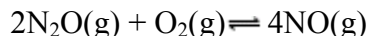|		**BLM 16.5.1**
ASSESSMENT	**Chapter 16 Test**	

Multiple-Choice Questions

Circle the letter for the choice that best completes the statement or answers the question.

1. Which of the following systems, at room temperature and pressure, would be described as being a dynamic equilibrium?
    a) an open flask containing air, water, and water vapour
    b) a stoppered flask containing air, water, and water vapour
    c) a stoppered flask containing $H_2(g)$, $O_2(g)$, and $H_2O(g)$
    d) an open flask containing solid carbon

2. Which of the following would you not observe in a system at equilibrium?
    a) constant colour
    b) constant pH
    c) a constant flow of reactants entering the system and of products leaving it
    d) constant pressure

3. Consider the following equilibrium systems.

    I $ZnO(s) + H_2(g) \rightleftharpoons Zn(s) + H_2O(g)$
    II $Au^{3+}(aq) + 3Ag(s) \rightleftharpoons Au(s) + 3Ag^+(aq)$
    III $Ni^{2+}(aq) + 6NH_3(aq) \rightleftharpoons Ni(NH_3)_6^{2+}(aq)$
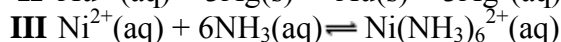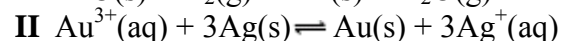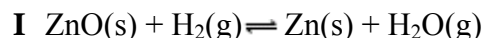
    Which of these systems is heterogeneous?
    a) I only
    b) II only
    c) I and II only
    d) III only

4. Select the equilibrium constant expression for the following system.

$$2N_2O(g) + O_2(g) \rightleftharpoons 4NO(g)$$

   a) $K_c = \dfrac{[N_2O]^2 [O_2]}{[NO]^4}$

   b) $K_c = \dfrac{2[N_2O][O_2]}{4[NO]}$

   c) $K_c = \dfrac{4[NO]^4}{2[N_2O]^2 [O_2]}$

   d) $K_c = \dfrac{[NO]^4}{[N_2O]^2 [O_2]}$

ASSESSMENT   # Chapter 16 Test

5. Select the equilibrium constant expression for the following decomposition reaction.

$$2NaHCO_3(s) \rightleftharpoons Na_2CO_3(s) + CO_2(g) + H_2O(g)$$
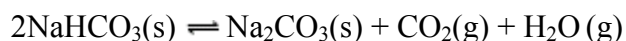
a) $K_c = [CO_2][H_2O]$

b) $K_c = \dfrac{[Na_2CO_3][CO_2][H_2O]}{[NaHCO_3]^2}$

c) $K_c = [Na_2CO_3][CO_2][H_2O]$

d) $K_c = \dfrac{[NaHCO_3]^2}{[Na_2CO_3][CO_2][H_2O]}$

6. Which of the following values for an equilibrium constant indicates a reaction that goes the least far to completion?
   a) 10^6
   b) 10^3
   c) 1
   d) 10^{-3}

7. Which conditions should favour the maximum yield of carbon monoxide in the following reaction.

$$C(s) + CO_2(g) \rightleftharpoons 2CO(g) \qquad \Delta H = +397 \text{ kJ}$$

   a) low temperature and high total pressure
   b) low temperature and low total pressure
   c) high temperature and high total pressure
   d) high temperature and low total pressure

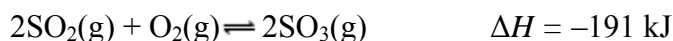8. Which of the following would increase the equilibrium concentration of NO(g) in the system

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -905 \text{ kJ}$$
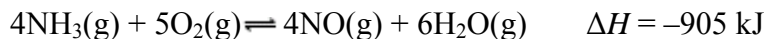
while other variables are held constant?

   I   decreasing the volume
   II increasing the temperature
   III adding $NH_3(g)$

   a) II only
   b) I and II only
   c) III only
   d) I, II, and III

9. Consider the following equilibrium reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -191 \text{ kJ}$$

The addition of a catalyst to this reaction would
   a) increase the concentration of products at equilibrium
   b) increase the amount of heat released by the reaction
   c) increase the amount of heat absorbed by the reaction
   d) increase the rate of both the forward and reverse reactions

10. 1.2 mol/L solutions of each of A and B are mixed. They react slowly, producing C and D according to the following equation.

$$A(aq) + B(aq) \rightleftharpoons C(aq) + 2D(aq)$$
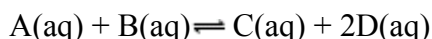
If the equilibrium concentration of D(aq) is 0.80 mol/L, the equilibrium concentration of A is
   a) 0.80 mol/L
   b) 0.60 mol/L
   c) 0.40 mol/L
   d) [A(aq)] cannot be determined because the value of K_c is not given.

11. At a certain temperature the following equilibrium system was analyzed.

$$3NO(g) \rightleftharpoons N_2O(g) + NO_2(g)$$
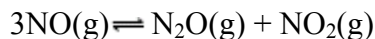
What is the equilibrium constant for this reaction, if the equilibrium concentrations were [NO] = 0.084 mol/L; [N$_2$O] = 0.025 mol/L; [NO$_2$] = 0.040 mol/L.
   a) 1.7
   b) 0.062
   c) 0.059
   d) 0.012

12. At a certain temperature, the equilibrium constant is 3.86 for the reaction

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

If 0.560 mol H$_2$(g) and the same amount of CO$_2$(g) is placed in a 1.00 L container, what is the concentration of CO(g) at equilibrium?
   a) 1.12 mol/L
   b) 0.371 mol/L
   c) 0.445 mol/L
   d) 0.748 mol/L

Chapter 16 Test

13. The three most important buffer systems in the body include the hydrogen carbonate (bicarbonate)/carbonic acid buffer system, the _____ buffer system, and the protein buffer system.
    a) electrolytes
    b) hemoglobin
    c) phosphate
    d) lactic acid

14. For a scuba diver, nitrogen narcosis may result from
    a) nitrogen forming bubbles in the blood
    b) nitrogen affecting the conduction of electrical signals along the nerves
    c) diving after consuming alcohol
    d) lack of oxygen to the brain

15. The Haber process is used to manufacture
    a) methanol
    b) sulfuric acid
    c) syngas
    d) ammonia

Numerical Response Questions

For each numerical response question, record the answer in the following response box.
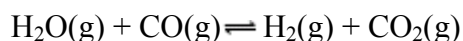
16.	19.
17.	20.
18.	21.

16. For the reaction given below, a 1.0 L container initially contained 3.0 mol/L of A(g) and 2.0 mol/L of B(g).

$$2A(g) + B(g) \rightleftharpoons C(g)$$
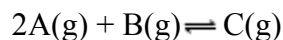
At equilibrium, the concentration of C(g) is 0.80 mol/L. What is the concentration of A(g)?

17. Steam reacts with carbon monoxide gas to form hydrogen gas and $CO_2(g)$.
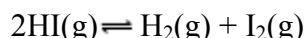
$$H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$$

When equilibrium was established at a certain temperature, the equilibrium concentrations were found to be

$[H_2O(g)] = 0.60$ mol/L; $[CO(g)] = 0.51$ mol/L; $[H_2(g)] = 0.55$ mol/L; $[CO_2(g)] = 0.42$ mol/L

What is the numerical value of the equilibrium constant at this temperature?

18. Hydrogen iodide gas dissociates into hydrogen gas and iodine vapour.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The value of K_c at a certain temperature is 144. Calculate the concentration of $I_2(g)$ at equilibrium if 5.0 mol of HI(g) is placed in an empty 2.0 L container at this temperature.

19. Methane, ethyne, and hydrogen form an equilibrium mixture.

$$2CH_4(g) \rightleftharpoons C_2H_2(g) + 3H_2(g)$$

While studying this reaction, a chemist analyzed a 4.0 L sealed flask containing a mixture of the gases at 1700 °C and found the following amounts: methane = 0.46 mol, ethyne = 0.64 mol, and hydrogen = 0.92 mol. What is the value of K_c for the reaction at 1700 °C?

20. The atmosphere contains 78% $N_2(g)$, 21% $O_2(g)$, and traces of other gases. These gases react at high temperature to form nitrogen monoxide, an important pollutant.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$
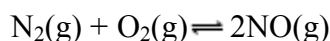
For this reaction at a certain temperature, $K_c = 3.8 \times 10^{-5}$. If the initial concentration of $N_2(g)$ is 0.78 mol/L, and $O_2(g)$ is 0.21 mol/L, what will be the equilibrium concentration of NO(g) at this temperature?

21. At a certain temperature, $K_c = 6.0 \times 10^{-4}$ for the reaction between sulfur trioxide gas and gaseous hydrogen fluoride to produce gaseous sulfur hexafluoride and water vapour.

$$SO_3(g) + 6HF(g) \rightleftharpoons SF_6(g) + 3H_2O(g)$$
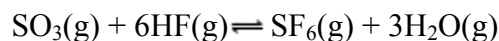
Calculate the equilibrium concentration of sulfur hexafluoride that would result if 1.8 mol of sulfur trioxide was mixed with 5.6 mol of hydrogen fluoride in a 2.1 L container.

Written Response Questions

Answer each question in the space provided. Use complete sentences and diagrams when necessary.

22. Write an equilibrium expression for the redox reaction in aqueous solution.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

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_____
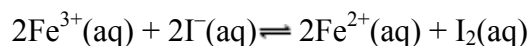
23. Water can be decomposed into $H_2(g)$ and $O_2(g)$ using a Hoffman apparatus that passes an electric current through the water.
   a) Write the chemical equilibrium equation for the decomposition reaction of water.

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   b) What is the equilibrium constant expression for this reaction?

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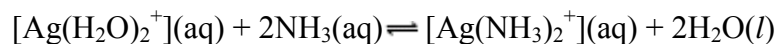
   c) At room temperature, in the absence of a Hoffman apparatus, do you expect the value of K_c to be large or small? Explain your answer.

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24. In aqueous ammonia, complexes of silver(I) ions with different substances are in equilibrium as shown.

$$[Ag(H_2O)_2^+](aq) + 2NH_3(aq) \rightleftharpoons [Ag(NH_3)_2^+](aq) + 2H_2O(l)$$

At room temperature, K_c for this reaction is 1×10^7. Which of the two silver complex ions is more stable? Explain your reasoning.

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25. Liquid bromine vaporizes readily at room temperature to give a red–brown gas. Predict the change in colour of the vapour in a stoppered bottle of liquid bromine when the temperature is lowered.

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26. Household bleach is an aqueous solution containing dissolved chlorine, hypochlorous acid (HOCl(aq)), sodium hydroxide, and sodium chloride. One of the equilibrium systems present is

$$Cl_2(g) + H_2O(l) \rightleftharpoons HClO(aq) + HCl(aq)$$

Bleach containers carry the warning "Dangerous gas formed when mixed with acid." What is the gas formed when bleach is mixed with acid? Briefly explain why the gas is released.

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27. Methanol, CH_3OH, is produced industrially by the reaction of carbon monoxide with hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) + heat$$
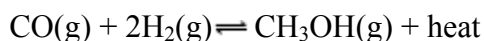
State and explain the effect on the concentration of hydrogen present at equilibrium if more methyl alcohol vapour is introduced into a rigid reaction vessel.

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28. A lake at sea level can contain slightly more dissolved oxygen than mountain streams at the same temperature. Explain this fact, and predict the effect of altitude on the abundance and variety of fish in lakes.

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29. An important step in the contact process for the manufacture of sulfuric acid is the catalyzed reaction between sulfur dioxide and oxygen to form sulfur trioxide. This is a homogeneous gaseous reaction that is exothermic.
   a) Write the chemical equation for this step, showing the sign of ΔH.

_____

b) Describe three changes that would increase the yield of sulfur trioxide.

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c) Explain the fact that the reaction is carried out at a relatively high temperature.

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d) Why is a catalyst (vanadium pentoxide) used?

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