

TOTAL – 60 MARKS

## Chapter 15 Assignment

**Multiple Choice Questions (Value: 24 marks) – Please answer directly on these pages OR on your own paper.**

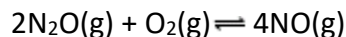
- Decide which of the choices best completes the statement or answers the question.
  - 2 points is awarded for each correct response.
1. Which of the following systems, at room temperature and pressure, would be described as being a dynamic equilibrium?
    - a) an open flask containing air, water, and water vapour
    - b) a stoppered flask containing air, water, and water vapour
    - c) a stoppered flask containing  $\text{H}_2(\text{g})$ ,  $\text{O}_2(\text{g})$ , and  $\text{H}_2\text{O}(\text{g})$
    - 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  $\text{ZnO}(\text{s}) + \text{H}_2(\text{g}) \rightleftharpoons \text{Zn}(\text{s}) + \text{H}_2\text{O}(\text{g})$
    - II  $\text{Au}^{3+}(\text{aq}) + 3\text{Ag}(\text{s}) \rightleftharpoons \text{Au}(\text{s}) + 3\text{Ag}^+(\text{aq})$
    - III  $\text{Ni}^{2+}(\text{aq}) + 6\text{NH}_3(\text{aq}) \rightleftharpoons \text{Ni}(\text{NH}_3)_6^{2+}(\text{aq})$

Which of these systems is heterogeneous?

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

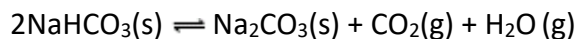
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4. Select the equilibrium constant expression for the following system.



- a)  $K_c = \frac{[\text{N}_2\text{O}]^2 [\text{O}_2]}{[\text{NO}]^4}$
- b)  $K_c = \frac{2[\text{N}_2\text{O}][\text{O}_2]}{4[\text{NO}]}$
- c)  $K_c = \frac{4[\text{NO}]^4}{2[\text{N}_2\text{O}]^2 [\text{O}_2]}$
- d)  $K_c = \frac{[\text{NO}]^4}{[\text{N}_2\text{O}]^2 [\text{O}_2]}$

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



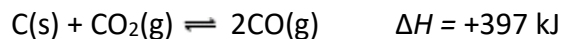
- a)  $K_c = [\text{CO}_2][\text{H}_2\text{O}]$
- b)  $K_c = \frac{[\text{Na}_2\text{CO}_3][\text{CO}_2][\text{H}_2\text{O}]}{[\text{NaHCO}_3]^2}$
- c)  $K_c = [\text{Na}_2\text{CO}_3][\text{CO}_2][\text{H}_2\text{O}]$
- d)  $K_c = \frac{[\text{NaHCO}_3]^2}{[\text{Na}_2\text{CO}_3][\text{CO}_2][\text{H}_2\text{O}]}$

6. Which of the following values for an equilibrium constant indicates a reaction that goes the least far to completion?

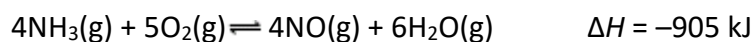
- a)  $10^6$
- b)  $10^3$
- c) 1
- d)  $10^{-3}$

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



- 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



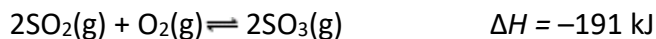
while other variables are held constant?

- I decreasing the volume
- II increasing the temperature
- III adding  $\text{NH}_3\text{(g)}$

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

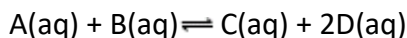
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9. Consider the following equilibrium reaction.



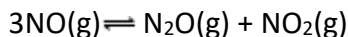
The addition of a catalyst to this reaction would

- 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.



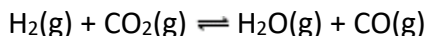
If the equilibrium concentration of D(aq) is 0.80 mol/L, the equilibrium concentration of A is

- 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.



What is the equilibrium constant for this reaction, if the equilibrium concentrations were [NO] = 0.084 mol/L; [N<sub>2</sub>O] = 0.025 mol/L; [NO<sub>2</sub>] = 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



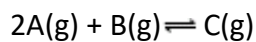
If 0.560 mol H<sub>2</sub>(g) and the same amount of CO<sub>2</sub>(g) is placed in a 1.00 L container, what is the concentration of CO(g) at equilibrium?

- a) 1.12 mol/L
- b) 0.371 mol/L
- c) 0.445 mol/L
- d) 0.748 mol/L

**TOTAL – 60 MARKS****Chapter 15 Assignment****Written Response Questions (Value: 36 marks)**

- Read each question carefully.
- Record your response in the space provided below each question.
- Show all work. Where needed, consider appropriate units and significant digits when expressing final answer.
- Use complete sentences, show problem-solving methods (with formulas), and include diagrams (with labels) when required.
- Point value for each question is as recorded next to each question.

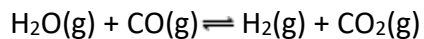
1. For the reaction given below, a 1.0 L container initially contained 3.0 mol/L of A(g) and 2.0 mol/L of B(g).



At equilibrium, the concentration of C(g) is 0.80 mol/L. What is the concentration of A(g)?  
(Value: 3 marks)

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2. Steam reacts with carbon monoxide gas to form hydrogen gas and  $\text{CO}_2(\text{g})$ .



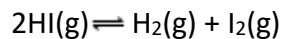
When equilibrium was established at a certain temperature, the equilibrium concentrations were found to be

$$[\text{H}_2\text{O}(\text{g})] = 0.60 \text{ mol/L}; [\text{CO}(\text{g})] = 0.51 \text{ mol/L}; [\text{H}_2(\text{g})] = 0.55 \text{ mol/L}; [\text{CO}_2(\text{g})] = 0.42 \text{ mol/L}$$

What is the numerical value of the equilibrium constant at this temperature?  
(Value: 3 marks)

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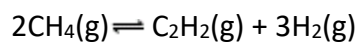
3. Hydrogen iodide gas dissociates into hydrogen gas and iodine vapour.



The value of  $K_c$  at a certain temperature is 148. Calculate the concentration of  $\text{I}_2\text{(g)}$  at equilibrium if 5.0 mol of  $\text{HI(g)}$  is placed in an empty 3.0 L container at this temperature.  
(Value: 4 marks)

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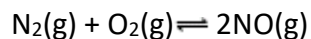
4. Methane, ethyne, and hydrogen form an equilibrium mixture.



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? (Value: 5 marks)

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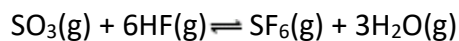
5. The atmosphere contains 78%  $\text{N}_2(\text{g})$ , 21%  $\text{O}_2(\text{g})$ , and traces of other gases. These gases react at high temperature to form nitrogen monoxide, an important pollutant.



For this reaction at a certain temperature,  $K_c = 3.8 \times 10^{-5}$ . If the initial concentration of  $\text{N}_2(\text{g})$  is 0.78 mol/L, and  $\text{O}_2(\text{g})$  is 0.21 mol/L, what will be the equilibrium concentration of  $\text{NO}(\text{g})$  at this temperature? (Value: 5 marks)

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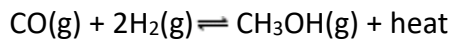
6. At a certain temperature,  $K_c = 6.0 \times 10^{-4}$  for the reaction between sulfur trioxide gas and gaseous hydrogen fluoride to produce gaseous sulfur hexafluoride and water vapour.



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. (Value: 5 marks)

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7. Methanol, CH<sub>3</sub>OH, is produced industrially by the reaction of carbon monoxide with hydrogen.



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. (Value: 3 marks)

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8. 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  $\Delta H$ . (Value: 2 marks)

b) Describe three changes that would increase the yield of sulfur trioxide. (Value: 3 marks)

c) Explain the fact that the reaction is carried out at a relatively high temperature.  
(Value: 2 marks)

d) Why is a catalyst (vanadium pentoxide) used? (Value: 1 mark)