

Module 7 Summative Assessment

<i>Marks</i>		
<i>Maximum Possible</i>	<i>Earned</i>	<i>%</i>
78		

Lesson 1

1. As a chemical system progresses towards dynamic equilibrium, what happens to the rates of the forward and reverse reactions?

Answer (1 Mark)

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2. Compare macroscopic observations to microscopic observations in a system that has established dynamic equilibrium.

Answer (2 Marks)

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3. Identify three conditions that must be met in order for a system to achieve dynamic equilibrium.

Answer (3 Marks)

View the Virtual Investigation “Evidence of a Reversible Reaction” in Module 7 Lesson 1.1. Use the experimental results to answer Questions 4 -11.

4. When aqueous sodium sulfate is combined with aqueous calcium chloride, describe the empirical evidence that confirms a chemical reaction in the forward direction?

Answer (1 Mark)

5. Record the data from the Virtual Investigation, "Evidence of a Reversible Reaction".

Answer (4 Marks)

DATA TABLE							
Trial	Volume of 0.50 mol/L $\text{Na}_2\text{SO}_4(\text{aq})$ (mL)	Volume of 0.50 mol/L $\text{CaCl}_2(\text{aq})$ (mL)	Limiting Reagent	Excess Reagent	Mass of filter paper (g)	Mass of filter paper and $\text{CaSO}_4(\text{s})$ precipitate(g)	Mass of $\text{CaSO}_4(\text{s})$ precipitate (g)
1	50	25					
2	50	50					
3	50	75					
4	50	100					

6. Based the data recorded in Question 5, explain why the mass of the $\text{CaSO}_4(\text{s})$ precipitate is constant in Trials 2, 3 and 4?

Answer (1 Mark)

7. Identify which ions should be present in each trial's filtrate, assuming that this is a quantitative reaction.

Answer (2 Marks)

Trial	Entities expected in filtrate (if reaction is quantitative)
1	
2	
3	
4	

8. Based on the table in Question 7, predict the results when each trial's filtrate is tested with $\text{Ba}(\text{NO}_3)_2(\text{aq})$ and $\text{Na}_2\text{CO}_3(\text{aq})$. Then record the results of the **actual** precipitate test from the Virtual Investigation.

Answer (8 Marks)

Trial	Predicted results when filtrate was tested with $\text{Ba}(\text{NO}_3)_2(\text{aq})$	Predicted results filtrate was tested with $\text{Na}_2\text{CO}_3(\text{aq})$	Actual results when filtrate was tested with $\text{Ba}(\text{NO}_3)_2(\text{aq})$	Actual results when filtrate was tested with $\text{Na}_2\text{CO}_3(\text{aq})$
1				
2				
3				
4				

9. Does the empirical evidence recorded in Question 8 support the assumption that the reaction between sodium sulfate and calcium chloride is quantitative? Explain your answer.

Answer (2 Marks)

10. How does the data from this virtual investigation support the existence of a forward and a reverse reaction? Explain your answer.

Answer (2 Marks)

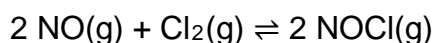
11. In theoretical terms, describe how the forward reaction rate and reverse reaction rate change over time as a chemical system progresses towards dynamic equilibrium. Be sure to discuss changes to the relative number of collisions between reactants and products. To help you answer this question, refer back to the Virtual Investigation "Evidence of a Reversible Reaction" (starting at 7:25 min)

Answer (3 Marks)

Lesson 2

Use the following information to answer the next 5 questions.

A technician places 0.50 mol of nitrogen monoxide gas and 0.20 mol of chlorine gas in a 1.00 L sealed container at 100°C. The following equilibrium is established at 4.5 min.



The technician determines that at equilibrium there are 0.30 mol of NOCl, 0.20 mol of nitrogen monoxide and 0.050 mol of chlorine gas. The technician continues recording data for another 3.5 min, noting no change in the concentrations of any of the entities.

12. Construct a graph that represents the changes in concentrations over time for the three entities involved in the reaction shown in the previous information box.

Answer (4 Marks)



13. Calculate the percent yield for this reaction (refer to page 680 and 792 of your textbook).

Answer (2 Marks)



14. Write the equilibrium law expression for this equilibrium.

Answer (1 Mark)

15. Calculate the equilibrium constant for this reaction.

Answer (3 Marks)

16. Is the forward or reverse reaction favoured? Support your answer with two pieces of evidence.

Answer (3 Marks)

17. Write equilibrium law expressions for each of the following equilibrium systems.

- a) $\text{C}_6\text{H}_6(\text{l}) + \text{Br}_2(\text{l}) \rightleftharpoons \text{C}_6\text{H}_5\text{Br}(\text{l}) + \text{HBr}(\text{l})$
- b) $\text{CH}_3\text{COOH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$
- c) $\text{H}_2\text{O}(\text{g}) + \text{Cl}_2\text{O}(\text{g}) \rightleftharpoons 2 \text{HOCl}(\text{g})$
- d) $4 \text{NH}_3(\text{g}) + 5 \text{O}_2(\text{g}) \rightleftharpoons 4 \text{NO}(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$

Answer (4 Marks)

a)	
b)	
c)	
d)	

18. Consider the following equilibrium law expression

$$K_c = \frac{[\text{ClF}_3(\text{g})]^2}{[\text{Cl}_2(\text{g})][\text{F}_2(\text{g})]^3}$$

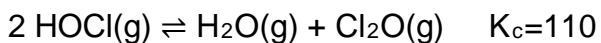
Write the reaction equation that is represented by the above equilibrium law expression.

Answer (2 Marks)

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Use the following information to answer the next question.

Consider the following equilibrium system



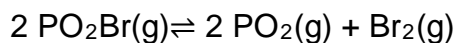
At equilibrium, a technician determined that the 1.00 L sealed reaction vessel contained 0.18 mol of $\text{H}_2\text{O(g)}$ and 0.40 mol of $\text{Cl}_2\text{O(g)}$.

19. Determine the equilibrium concentration of HOCl(g)

Answer (2 Marks)

Use the following information to answer the next question.

A technician placed 4.0 mol of metaphosphoryl bromide ($\text{PO}_2\text{Br(g)}$) in a 2.0 L sealed container. The following equilibrium established



At equilibrium it was determined that the sealed reaction vessel contained 1.8 mol of $\text{Br}_2\text{(g)}$.

20. Calculate K_c for the equilibrium shown in the previous information box. Show all work.

Answer (4 Marks)

Lesson 3

View the Virtual Investigation “Le Châtelier’s Principle and Equilibrium Shifts” in Module 7 Lesson 3.3 and use the results to answer Questions 21 – 27.

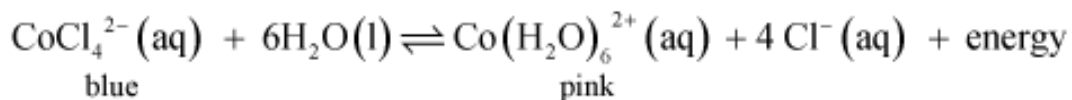
21. Based on the initial equilibrium system solution colour, is the forward or reverse reaction favoured? Provide support for your answer.

Answer (2 Marks)

22. Create a data table to record your observations. Describe the stress that was applied to the cobalt(II) chloride equilibrium system, the initial colour of the equilibrium system (before the stress was applied), and the final colour of the equilibrium system.

Answer (3 Marks)

Use the following additional information to answer the next question.



23. Identify how the following stresses will affect the appearance of this equilibrium system. Will the system turn more pink or more blue in colour?

Answer (3 Marks)

	Stress applied	Direction of shift	Colour
A.	The equilibrium system is placed in an ice water bath.		
B.	Addition of chloride ions		
C.	A desiccating agent is added to remove some of the water from the equilibrium system		

24. Identify a source of error for the experimental design of the cobalt(II) chloride system.

Answer (1 Mark)

25. With respect to the animation of the dinitrogen tetroxide equilibrium system shown in the Virtual Investigation, identify the manipulated, responding, and controlled variables.

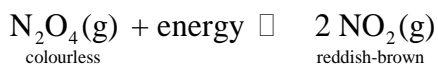
Answer (4 Marks)

Manipulated	
Responding	
Controlled	

26. Create a data table to record your observations regarding the dinitrogen tetroxide portion of the Virtual Investigation. Include the stress that was applied to the dinitrogen tetroxide equilibrium system, the initial colour of the equilibrium system, and final colour of the equilibrium system.

Answer (2 Marks)

Use the following additional information to answer the next question.



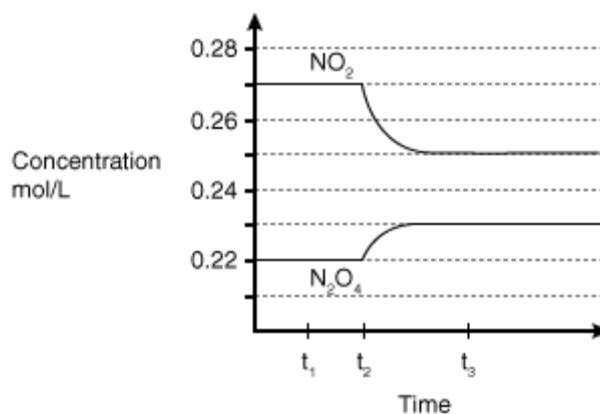
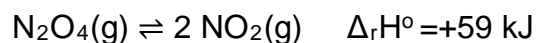
27. Identify how the following stresses will affect the appearance of the dinitrogen tetroxide/nitrogen dioxide equilibrium system. Will the system turn darker brown or lighter brown in colour?

Answer (2 Marks)

	Stress applied	Direction of shift	Colour
A.	The equilibrium system is placed in an ice water bath.		
B.	The equilibrium system is placed in a warm water bath.		

Use the following information to answer Questions 28, 29 and 30.

Consider the following equilibrium system and graph of change equilibrium concentrations.



28. Calculate K_c at time t_1 .

Answer (2 Marks)

29. Calculate K_c at time t_3 .

Answer (2 Marks)

30. Propose a stress that may have been applied at t_2 . Provide support for your suggestion.

Answer (2 Marks)

Lesson 4

31. What effect does a catalyst have on the position of equilibrium in a chemical reaction?

Answer (1 Mark)