Chemistry (Senior High School)

STUDENTS' WORKSHEET

CHEMICAL EQUILIBRIUM
(concentration factor)

Group's Name:

Class:

Structured Inquiry Worksheet

Students Worksheet Instructions

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This student worksheet aims to train students' conceptual understanding and inquiry abilities on the material of factors that influence the direction of chemical equilibrium shifts. Students' scientific inquiry ability can be understood as their capacity to recognize and analyze problem situations and to find solutions by engaging in processes such as asking questions, planning and conducting investigations, collecting data, thinking critically and logically about the relationship between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments (National Research Council [NRC], 1996).

Students' Inquiry Abilities by Kao and Wu (2008) practiced in this Worksheet are:

1. Questioning
   Asking and identifying questions
2. Experimenting
   Identifying variables and planning experimental procedures
3. Analyzing
   Identifying relevant data and transforming data
4. Explaining
   Making a claim and using evidence

Work Instructions

1. Read each question in this WORKSHEET carefully.
2. Work on this WORKSHEET by discussing with your friend next to you.
3. Write your answer in the answer column provided.
4. Ask the teacher if you have difficulty or are unclear in working on the WORKSHEET

Core Competencies

3.9 Analyze the factors that influence the shift in the direction of equilibrium and their application in industry

4.9 Design, conduct, conclude and present the results of experiments on factors that influence the shift in the direction of equilibrium

Basic Competencies

3.9.1 Students are able to analyze the influence of concentration factors on shifts in the direction of chemical equilibrium based on phenomena in the Worksheet

3.9.2 Students are able to apply chemical equilibrium in industry based on phenomena in the Worksheet

4.9.1 Students are able to conclude the results of the discussion of concentration factors that affect shifts in the direction of chemical equilibrium

4.9.2 Students are able to communicate the results of the discussion regarding concentration factors that affect shifts in the direction of chemical equilibrium

Learning Goals

3.9.1.1 Based on the phenomena in the Worksheet, students are able to determine the experimental variables of the concentration factors that affect the shift in the direction of chemical equilibrium correctly.

3.9.1.2 Based on the phenomena in the Worksheet, students are able to determine the formulation of the problem of the concentration factors that affect the shift in the direction of chemical equilibrium correctly

3.9.1.3 Based on the phenomena in the Worksheet, students are able to develop hypotheses about the concentration factors that affect the shift in the direction of chemical equilibrium correctly

3.9.1.4 Based on the tools and materials that have been presented, students are able to design experimental procedures for concentration factors that affect the shift in the direction of chemical equilibrium correctly.

3.9.1.5 Based on the experimental procedures that have been created, students are able to analyze experiments on concentration factors that affect shifts in the direction of chemical equilibrium correctly

4.9.1.1 Through group discussions, students are able to conclude concentration factors that affect shifts in the direction of chemical equilibrium well

4.9.2.1 Through group discussions, students are able to communicate the results of discussions regarding concentration factors that affect shifts in the direction of chemical equilibrium well

Watch the following video simulation of a chemical equilibrium reaction:

$$Fe^{3+} + SCN^{-} \rightleftharpoons FeSCN^{2+}$$

Video Link: https://youtu.be/0HYGFLtk6hY

Before answering, think about what happens in the system when you add Fe^{3+} or SCN^{-} to the equilibrium mixture.

- What changes do you observe?
- Which variable is being manipulated?
- How does the system respond?

1. After observing the changes in color and concentration when certain substances are added to the equilibrium mixture, what kind of research question can you formulate?

A. How does changing the concentration of Fe^{3+} affect the position of equilibrium in the reaction?
B. What is the molar mass of $FeSCN^{2+}$ in the equilibrium system?
C. How does temperature affect the rate of stirring during the reaction?
D. What is the pH of pure water?

Answer:

2. Which of the following research questions is best aligned with investigating Le Chatelier's Principle based on the video?

A. How much light is absorbed by $FeSCN^{2+}$ at 450 nm?
B. What is the density of iron (III) thiocyanate?
C. What is the color change when more SCN^{-} is added to the equilibrium mixture?
D. How many electrons are in a thiocyanate ion?

Answer:

Initial Prediction

3. How do you think **changing the concentration** of a reactant or product will affect the reaction?

Phenomenon

Solution (a) is a solution of Fe $(SCN)_3$. The equilibrium reaction is as follows:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$$

After adding 5 drops of colorless KSCN to solution (a), which increases the concentration of SCN^-, the color changes to the same as in solution (b). After adding 5 drops of brownish-yellow $FeCl_3$ to solution (a), which increases the concentration of Fe^{3+}, the color changes to the same as in solution (c). After adding a small amount of colorless NaH_2PO_4 to solution (a), which causes the $H_2PO_4^-$ ions to bind tightly to the Fe3+ ions, the color changes to the same as in solution (d).

Note: The video can be accessed at https://www.youtube.com/watch?v=O7zfU-HQuT8 and watch the video from seconds 0:51 – 2:49

4. Observe the chemical equilibrium reaction and the changes occurring upon the addition of different substances. Then, write or answer questions that help explain the phenomenon based on your understanding of Le Chatelier's Principle!

Based on the phenomenon provide, fill in the following questions:

5. Identify the variables in the experiment!

- Control Variables (kept constant):
- Manipulated Variables (what you change):
- Responding Variables (what you observed):

6. Write the experimental procedure for this phenomenon!

7. Write the equilibrium reaction that occurs in the experiment you have done! Write the data for this phenomenon!

Answer:

Reaction:

Before experiment

Material's name	Observed (color)

After experiment

Material's Name	Color Changing

Summary table

Condition	Treatment (adding/ removing substances)	Color Change/ Shift Indication	Direction of Shift
B			
C			
D			

8. Formulate a question based on your observation.

9. Based on your problem formulation, write your hypothesis.

10 What does Le Chatelier's Principle state? And how does this principle explain the shift in reaction direction when concentration is changed?

Reflection

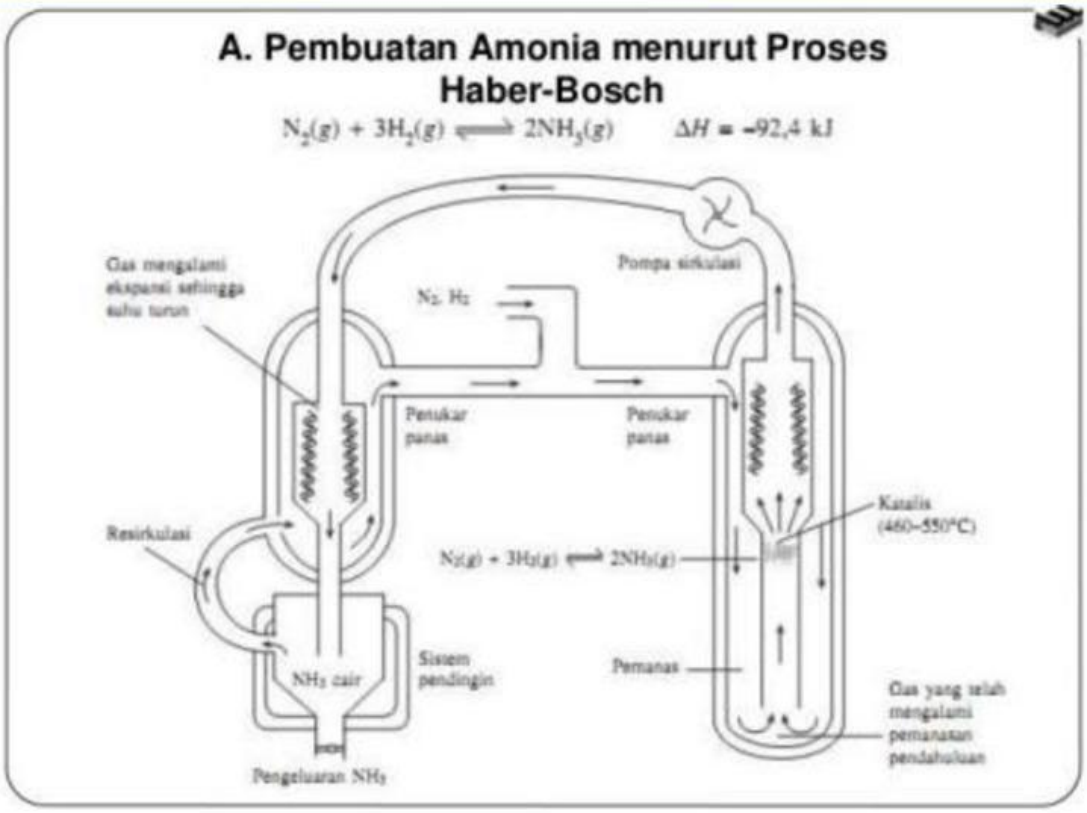

Figure 1. Haber Bosch Process

Ammonia production in Indonesia is carried out at petrochemical plants in Gresik and Kujang. The ammonia production process is carried out through the reaction:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)\ \Delta H = -92\ kJ$$

This process was introduced by Fritz Haber from Germany in 1913. This process is also often called the Haber Bosch process in honor of Karl Bosch, an engineer who developed ammonia production equipment for industrial scale. This ammonia production reaction is an equilibrium reaction. Therefore, to obtain as much ammonia as possible, Le Chaterlier's principle is used in the process.

11 Explain how to obtain as much ammonia as possible based on Le Chaterlier's principle!

12 Write a short paragraph explaining how concentration affects equilibrium in the Haber process!

Reflect on what you observed during the simulation or experiment. Consider how the changes in color and concentration relate to chemical equilibrium, and think about how this concept might apply beyond the classroom. Use clear examples or reasoning in your answers!

13 How did the simulation/experiment help you understand chemical equilibrium?

14 How can this concept be applied in real life or industry?

Teachers' Feedback (Optional)