Real Science-4-Kids

Kogs-4-Kids

Chemistry Connects to Critical Thinking

Workbook Level I A

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Introduction to Critical Thinking

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I.1 What is critical thinking?

Humans think. You know this. Everyone, whether they seem to or not, thinks. You are thinking at this moment as you read these words. You might be thinking about where the person writing these words (me, the author) is going with this topic on thinking. You might be thinking that this a good way to start a paragraph on thinking—telling you that you think. You might be thinking that this is a lousy way to introduce a topic on thinking because it is obvious you are thinking, and you don’t need anyone to tell you that. You might be thinking that you might learn something new about thinking you never thought about. You might be thinking that you already know all there is to know about thinking, and you might be wondering why you are reading this in the first place. The point is that you are thinking right now. You think because you are human, and humans think.
But how do you think? Yes, there is a “biology of thinking” or a process that is going on in your brain as chemicals are being activated and deactivated as a result of your thinking. However, beyond biology, how do you think, and what do you think? What do you think exactly?

Do you think that you think clearly, or do you get lost in your thinking? Do you sometimes wonder if you are the only one thinking what you are thinking, or do you wonder if everyone thinks the way you think?

Can you think through a problem, or does it seem like thinking through a problem is the problem? Do you think that there are people who are just naturally good thinkers, like Albert Einstein? Do you think that these naturally good thinkers are the only thinkers who think and think, and with all their gifted thinking, discover amazing things? Or do you think that you could ever learn to think like Albert Einstein, and someday, think through and discover your own amazing things?
The fact is that almost anyone can learn to think like Albert Einstein. Yes, some people pick thinking up easily, but everyone can learn to think as well as Albert Einstein. Because everyone can learn to think well, everyone has within him or her new thoughts that could turn into new discoveries that are just as amazing as Albert Einstein’s discoveries.

However, good thinking is hard work. Learning to think clearly and carefully takes training, patience, and practice. Thinking carefully with clarity, depth, precision, accuracy, and logic is thinking critically. Great scientists, like Albert Einstein, who discover amazing things about the world, have trained themselves to think critically. Critical thinking is the process of thinking in a certain way. Critical thinking is the process of thinking clearly, with accuracy and precision; of thinking carefully, with logic and depth; and of thinking open-mindedly, by examining points of view and acknowledging assumptions and biases within a given viewpoint. The point is that everyone can learn how to think critically if the time is taken to learn.

I.2 The tools of critical thinking

So what does it take to think critically? What are the nuts and bolts of critical thinking? Just like math or language or science, critical thinking has necessary tools and a method for using those tools.

There are two main activities we do all the time when we think. The first activity is gathering information or collecting data. As humans, our minds are constantly observing and collecting information about the world around us. We use our five senses to gather information
about the world we live in. We are observing the height, size, weight, color, texture, and odor of the objects around us, and we are observing these qualities in relation to each other.

The second activity we do when we think is *drawing a conclusion* based on the information we’ve collected. We may conclude a building is too high to jump over, or an atom is too small to see with our eyes, or a boulder is too heavy to lift with our hands. However, what separates a critical thinker from a non-critical thinker is how she evaluates both the data she’s collected and the conclusions she’s drawn.
To evaluate both information and conclusions, the critical thinker must use the most important tools in the critical thinking toolbox: questions. To think critically, we must ask questions about the information or data we have collected. “Is it important?” “Is it relevant?” “Is it applicable?” “Is it significant?” But that’s not enough. We must also ask questions about the conclusion we’ve drawn from the information we’ve collected. We need to ask the following types of questions: “Is the conclusion fair?” “Is it logical?” “Is it reasonable?” and “Is it consistent with all the information collected?”

There are different kinds of questions (critical thinking tools) for different activities. There are tools for Getting the Facts, Evaluating the Facts, Drawing a Conclusion, and Evaluating the Conclusion.

### 1.3 Tools for getting the facts

When you first hear a statement or an argument, it is important to get the facts. If an officer has been called to an accident, the very first thing he does is get the facts. Who was involved? How were they...
involved? Which car hit first? Which car hit second? Who was driving? Who wasn’t driving? Exactly how fast was the first car going? When looking at something critically, it is important to collect as many facts as you can.

Tools for **Getting the Facts** include questions like “Who?“ “What?“ “Where?“ “When?“ and “How?“ The facts need to be **accurate, clear,** and **precise.** Questions that get to the **details** of facts, with words like “exactly,“ “how much,” “what time,” etc., help to clarify the facts.

### I.4 Tools for evaluating the facts

Now that you know the facts, it is important to evaluate the facts. When an officer has collected all the facts for the accident, he needs to evaluate the facts. Evaluating facts is not as easy as it sounds because evaluations involve not only facts, but also involve opinions and preferences.

For example, one driver in the accident may claim that because there was a full moon, the accident was the
other driver’s fault. It might be a fact that there was a full moon, but is this fact relevant to the accident? Is it a significant fact concerning the accident? The officer has to evaluate the facts to find out if they are facts that should or should not be used to draw a conclusion.

Tools for Evaluating the Facts include questions that explore the relevance and significance of the facts and questions that explore whether or not the facts are substantial, crucial, or applicable to the conclusion.

### 1.5 Tools for drawing a conclusion—using logic

Now that we have collected the facts and evaluated the facts, we can “draw a conclusion.” A conclusion is a statement that sums up all of the information collected in order to make a point or a decision. But how do you know if the conclusion
you’ve made is valid and consistent, or logically flawed? For example, one driver might not like men in flowered shirts. This driver might want to say that it was not the moon that caused the accident, but that it was the man in the flowered shirt that caused the accident because “men in flowered shirts always cause accidents.” Is this true, or is the driver making a logical error?

Tools for **Drawing a Conclusion** use logic (a method that investigates arguments) to help the critical thinker avoid making errors by exploring **validity**, **consistency**, and **logical flaws**.

### I.6 Tools for evaluating a conclusion

Sometimes it’s not enough to have a logical conclusion. Sometimes it is necessary to evaluate your conclusion. We need to ask the following types of questions: “Is my conclusion fair?” “Has my conclusion taken into
account all the information available? “Is my conclusion reasonable?” and “Is there more information that should be considered?” For example, the officer may conclude that the moon did not cause the accident, and that the man in the flowered shirt did not cause the accident, but that instead, neither man was watching where he was going. One was looking at the moon, and the other was fixing a button on his shirt; so they are both at fault. But does that conclusion take into account all the information available, or is there more information that must be considered before the officer can make a fair conclusion?

Tools for **Evaluating a Conclusion** include questions that explore the **fairness**, **reasonableness**, **depth**, and **breadth** of a conclusion.

### I.7 Putting it all together—critical thinking

In summary, the four main types of critical thinking tools are: **Getting the Facts, Evaluating the Facts, Drawing a Conclusion using Logic**, and **Evaluating a Conclusion**.

As we’ve mentioned, asking questions is the key for critical thinking, and it is important to ask questions that incorporate all of the critical thinking tools we’ve discussed. It is important that we ask questions not just of other people’s thinking, but that we also challenge, and ask questions of, our own thinking.

The critical thinking tools we’ve discussed are different kinds of questions that explore different aspects of the information gathered,
and that explore different aspects of the conclusions drawn from that information. Throughout this workbook, we will be asking questions using all of the critical thinking tools.

Finally, one of the most important questions you can ask another person is, “Let me understand what you are saying. Are you saying...?” Then in different words, repeat what you think the other person is saying, or repeat what you think you are saying in a different way. To admit you may not understand what someone else is saying is a way to open up more critical thinking questions.

I.8 Building a critical thinking lens

We have been talking about “critical thinking tools,” but what exactly do all of these critical thinking tools look like together? One way to envision all of the critical thinking tools is to think about a lens. If our eyes do not function properly, a lens helps us see objects more clearly. In the same way, a critical thinking lens can help you think through problems more clearly.

Constructing a critical thinking lens is not very
difficult. It amounts to asking questions using the four critical thinking tools we have been learning. As you improve your ability to ask good questions, your critical thinking lens will improve. A critical thinking lens can help you decide what kinds of statements are scientifically valid, and what kinds of statements may not be scientifically valid.

I.9 Summary

1. Critical thinking tools are questions.
2. There are four main types of critical thinking tools (questions): Getting the Facts, Evaluating the Facts, Drawing a Conclusion using Logic, and Evaluating a Conclusion.
4. Tools for Evaluating the Facts include the following types of questions: “Is this fact relevant or significant?” “Is this fact substantial, crucial, and applicable?” and “Does it support the conclusion?”
5. Tools for Drawing a Conclusion use logic to help the critical thinker to avoid making errors by asking: “Is this valid and consistent with other information?” and “Are there any logical flaws in this conclusion?”
6. Tools for Evaluating a Conclusion include the following types of questions: “Is this fair and reasonable?” and “Does my conclusion have the necessary depth and breadth?”
I.10 Discussion questions

Look at the following scientific claim:

The moon is made of green cheese.

Look at the critical thinking lens on page 15.

1. Can you pick out two **Getting the Facts** questions?

1. 

2. 

2. Can you pick out two **Evaluating the Facts** questions?

1. 

2. 

3. Based on the critical thinking lens, do you think that the moon is made of green cheese? Why or why not?
4. Have you considered enough information to draw that conclusion? (Does your answer have depth and breadth?). If not, what other information should you consider?
These are the thinking tools (the questions) that, together, make the critical thinking lens.
1. The Atom

1.1 The atom

1.2 Gathering the tools

1.3 Building the critical thinking lens

1.4 Using the critical thinking lens

1.5 Now you try

1.6 Make your own
1.1 The atom

In chapter 1 of Chemistry Level I, you learned all about the atom. You also read about the history of the atom and how atoms were discovered. Now you will construct a critical thinking lens to evaluate this scientific claim:

*Matter is made of atoms.*

[Note: You will need to consider the information you find in your textbook and other resources as “facts” in order to complete this exercise. However, know that the “facts” in your textbook and in other resources are really conclusions that are based on many other facts that have been collected over years of investigation and that have been evaluated by many scientists. As a critical thinker, you are encouraged to examine all “facts” and to evaluate them for yourself, even those facts that have already been evaluated by other scientists.]

1.2 Gathering the tools

First, we need to gather the critical thinking tools. The four types of tools we will be using are as follows:

**Tools for Getting the Facts**

questions regarding clarity, precision, accuracy, and detail

**Tools for Evaluating the Facts**

questions regarding significance, relevancy, and application

**Tools for Drawing Conclusions (using logic)**

questions regarding logical validity, consistency, and flaws

**Tools for Evaluating Conclusions**

questions regarding fairness, depth, breadth, and reasonableness
A. Tools for Getting the Facts

questions regarding clarity, precision, accuracy, and detail

Answer the following Getting the Facts questions for the statement:

*Matter is made of atoms.*

1. Q: Who discovered the atom, and in what year was it discovered?
   A:

2. Q: What are atoms made of?
   A:

B. Tools for Evaluating the Facts

questions regarding significance, relevancy, and application

Answer the following Evaluating the Facts questions for the statement:

*Matter is made of atoms.*

1. Q: Is the fact that the atom was discovered significant to the argument that *matter is made of atoms*?
   A:

2. Q: Is the data that says what atoms are made of relevant to the argument that *matter is made of atoms*?
   A:
C. Tools for Drawing a Conclusion (using Logic)

questions regarding logical validity, consistency, and flaws

In this section, you will learn how to recognize valid arguments and logical fallacies. A logical fallacy is an inaccurate way to formulate an argument. In this chapter, you will be introduced to the logical fallacy called **equivocation**.

**Logical Fallacy:** Equivocation (fallacy of ambiguity)

**Definition:** A word or phrase used in the argument that is not clearly defined, or that changes definition during the argument.

**Example:** Because metal sinks in water, you can’t make a sink from metal.

To prevent committing the logical fallacy of **equivocation**, the definitions of all of the terms in the argument must stay the same. We are using statements of fact to support this argument:

*Matter is made of atoms.*

Write a definition for **matter**.

Write a definition for **atom**.
Look at the following two statements and the *conclusion*.

1. Atoms contain protons, neutrons, and electrons.

Therefore (*conclusion*),

*Matter* is made of atoms.

Determine if the definitions for *matter* and *atom* stay the same.

Q: Does the conclusion that *matter is made of atoms* commit the fallacy of equivocation based on the information you have?

A:  

☐ Yes  ☐ No

**D. Tools for Evaluating the Conclusion**

*questions regarding fairness, depth, breadth, and reasonableness*

Answer the following **Evaluating the Conclusion** questions for the statement: *Matter is made of atoms.*

1. Q: Is the fact that the atom was discovered significant to the argument that *matter is made of atoms*?

A:  


2. Q: Is the data that says what atoms are made of relevant to the argument that *matter is made of atoms*?

A:  


1.3 Building the critical thinking lens

You have gathered the facts, evaluated the facts, checked the conclusion using logic, and evaluated the conclusion:

*Matter is made of atoms.*

Next, put all of the facts, evaluations, and logical checks together to construct a critical thinking lens.

Write the statement you are evaluating in the critical thinking lens.

*Matter is made of atoms.*

Write the two *Getting the Facts* critical thinking questions.

Write the two *Evaluating the Facts* questions.

Write two *Drawing a Conclusion using Logic* statements that don’t commit a logical fallacy.

Write the two *Evaluating the Conclusion* questions.
1.4 Using the critical thinking lens

Look at the critical thinking lens you constructed and think about the answers to the critical thinking questions in your critical thinking lens. Do you think that the statement “matter is made of atoms” is a good scientific argument?

☐ Yes   ☐ No

Why or why not?
1.5 Now you try
You run into a scientist on the street, and you start talking. He tells you his scientific opinion:

*The cow jumped over the moon.*

Evaluate his argument by constructing a critical thinking lens.

**Tools for Getting the Facts**

*Write two questions regarding clarity, precision, accuracy, and detail.*

1. 

2. 

**Tools for Evaluating the Facts**

*Write two questions regarding significance, relevancy, and application.*

1. 

2. 

**Tools for Drawing Conclusions (using logic)**

*Write two questions regarding logical validity, consistency, and flaws.*

1. 

2. 

**Tools for Evaluating Conclusions**

*Write two questions regarding fairness, depth, breadth, and reasonableness.*

1. 

2. 
1.6 Make your own

Using the questions you came up with in section 1.5, construct your own critical thinking lens.

NOTES

The cow jumped over the moon.

1
2

1
2