Universal Design for Learning (UDL) in Chemistry for High School Students

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Agenda

- Teaching and university background
- Universal Design (UD) in architecture and environments
- Universal Design for Learning (UDL)
  - CAST https://www.cast.org/ Boston MA USA
- UDL-based instruction used in chemistry studies

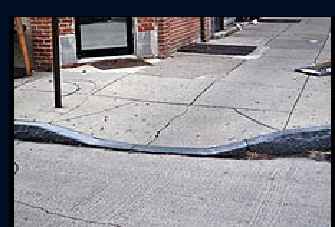
  Convert 8.34 moles of Na_2S to formula units of Na_2S:
- Results from three chemistry studies
- Research and practice implications

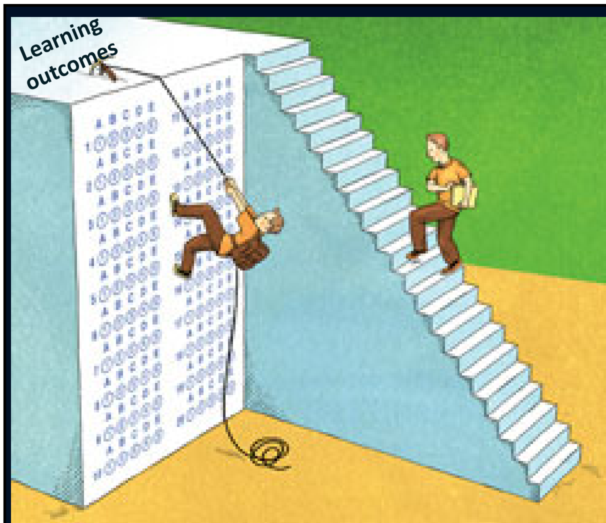
Universal Design

The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.

Source: Bettye Rose Connell, Mike Jones, Ron Mace, Jim Mueller, Abir Mullick, Elaine Ostroff, Jon Sanford, Ed Steinfeld, Molly Story, and Gregg Vanderheiden.

Universal Design





Learning outcomes

- UDL is based on the idea that each learner has variability
- One size curriculum, pedagogy, material, etc. does not fit all
- Designed from the beginning, not added on later
- Increases access opportunities for everyone

UDL in Federal Legislation in the United States

UDL

Higher Education Opportunity Act
2008

National Education Technology Plan
2010

Every Student Succeeds Act
2015

What is UDL?

UDL is a framework for instruction and assessment that is based on three principles

- **Representation**: Information is presented for students in more than one format
- **Engagement**: Students practice content in multiple ways that motivate them
- **Action and Expression**: Options are available for students to show what they know

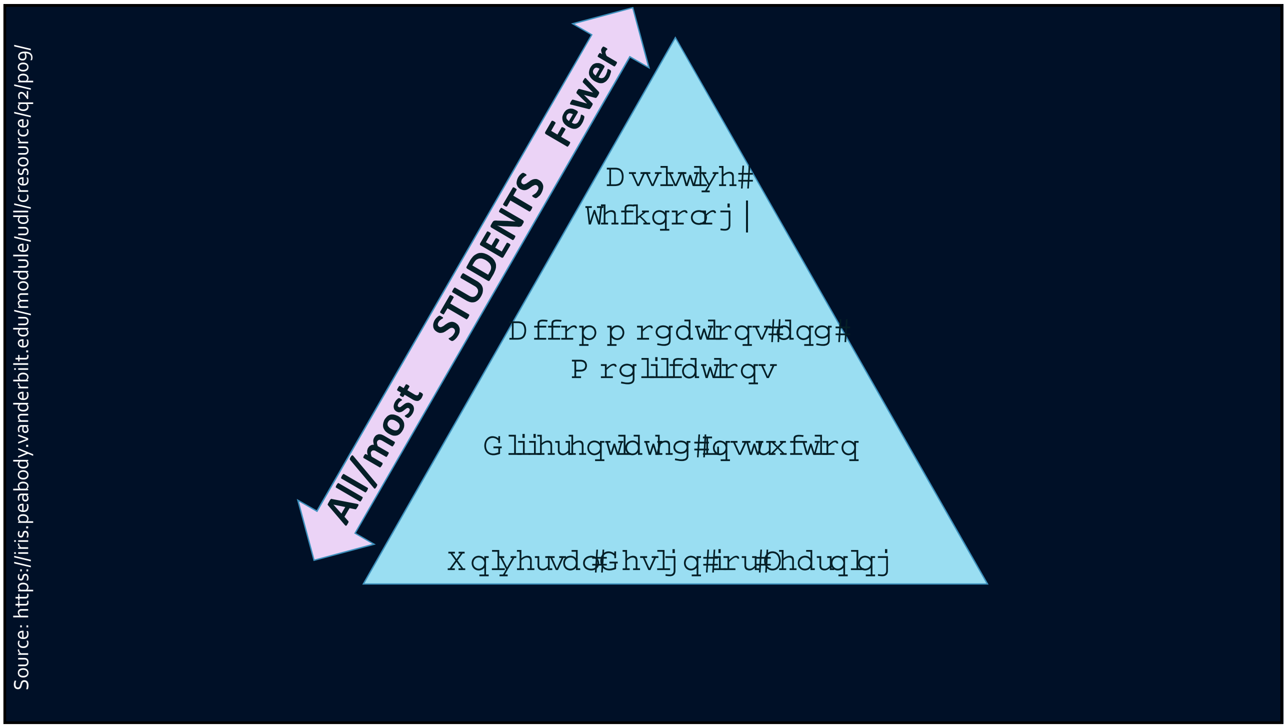
F L E X I B I L I T Y

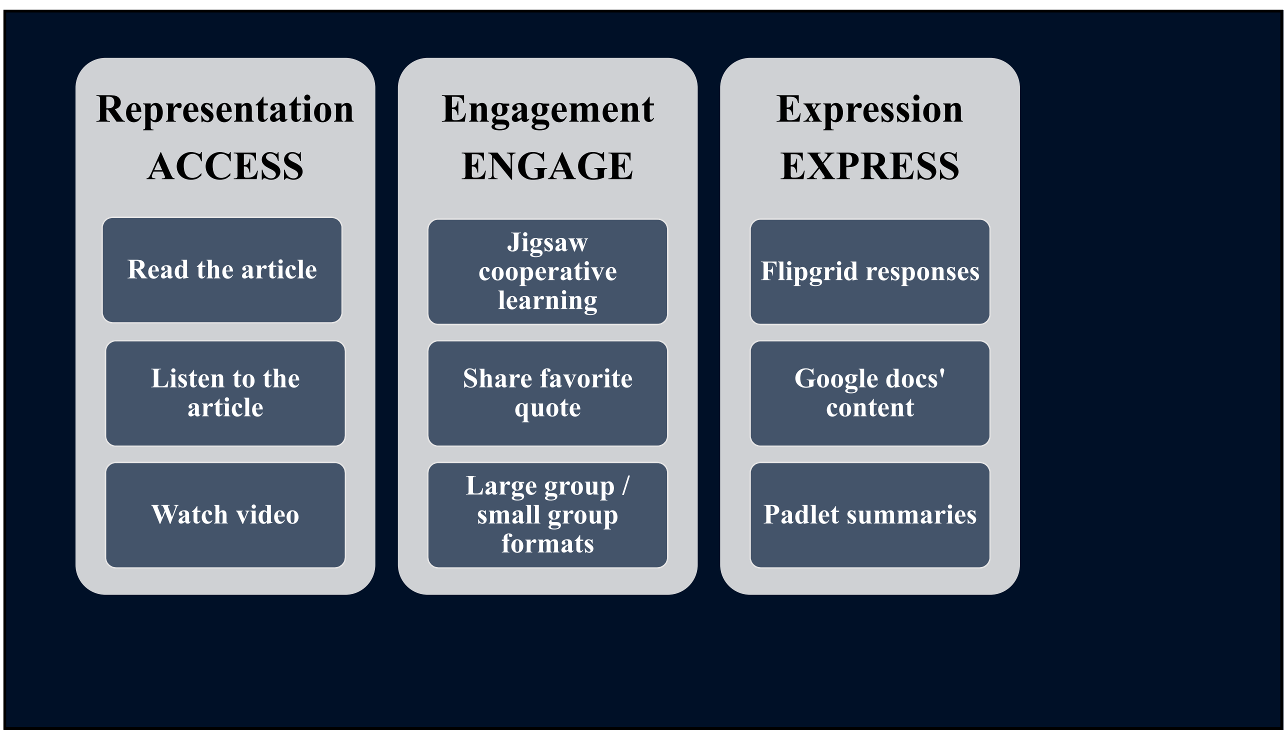
ACCESS

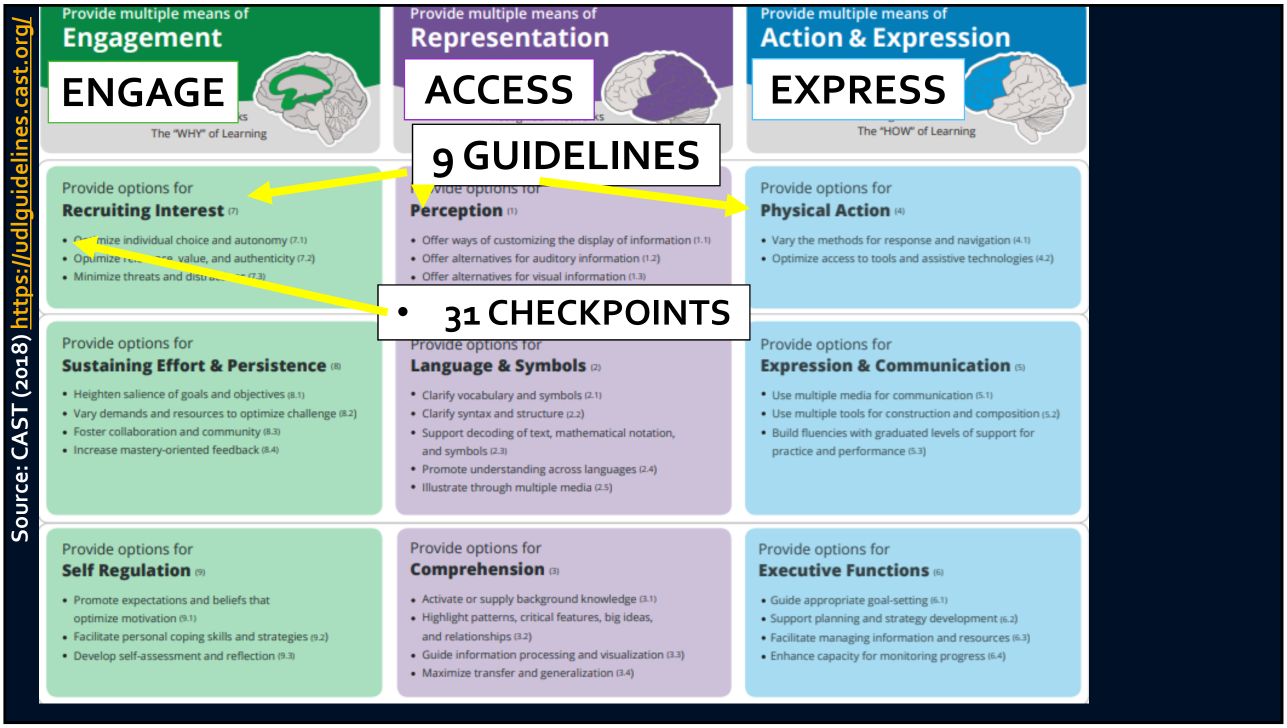
ENGAGE

EXPRESS

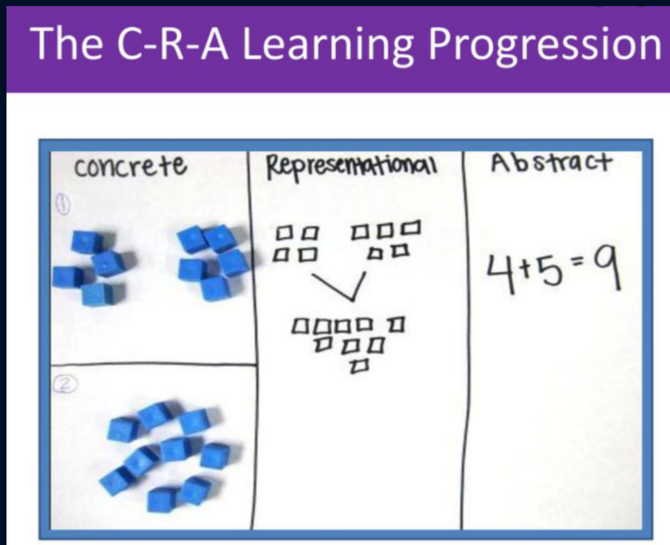
Source: CAST (2018) https://udlguidelines.cast.org/


Source: https://iris.peabody.vanderbilt.edu/module/udl/cresource/q2/p09/
All/most STUDENTS Fewer
Dvvlvwlyh#
Whfkqrorj|
Dffrp prgdwlrqv#dqg#
P rglilfdwlrqv
Gliihuhqwldwhg#Lqvwuxfwlrq
Xqlyhuvdo#Ghvljq#iru#Ohduqlqj


Representation
ACCESS
Read the article
Listen to the article
Watch video
Engagement
ENGAGE
Jigsaw cooperative learning
Share favorite quote
Large group / small group formats
Expression
EXPRESS
Flipgrid responses
Google docs' content
Padlet summaries

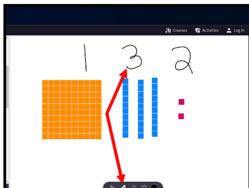


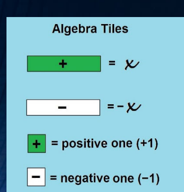
UDL Principle	UDL Mole Module Features: Guidelines and Checkpoints
Representation principle: Options for multiple ways to represent new content	**IDEAS Self-Management Strategy** • Options for mathematical expressions **Strategy Sheet and Mole Equality Organizer** • Options for perception (offer alternatives for auditory and visual information), and comprehension (highlight big ideas) **Multi-Media Mole Video Clips and Scaffolded Practice** • Options for language, mathematical expressions, and symbols and comprehension (highlight patterns, critical features, and relationships, and guide information processing and visualization)
Engagement principle: Options for multiple ways students can engage in practice of new content	**IDEAS Self-Management Strategy** • Options for expression, communication (build fluency with graduated levels of support for practice and performance), and executive functions (support planning, strategy development) **Strategy Sheet and Mole Equality Organizer** • Options for interest (minimize distractions)
Expression principle: Options for multiple ways students can express what they know	**IDEAS Self-Management Strategy** • Options for interest (minimize distractions), and self-regulation (facilitate use of strategy) **Strategy Sheet and Mole Equality Organizer** • Options for executive function (facilitate managing information and resources) **Scaffolded Practice** • Options for expression (build fluency with graduated levels of support for practice and performance)

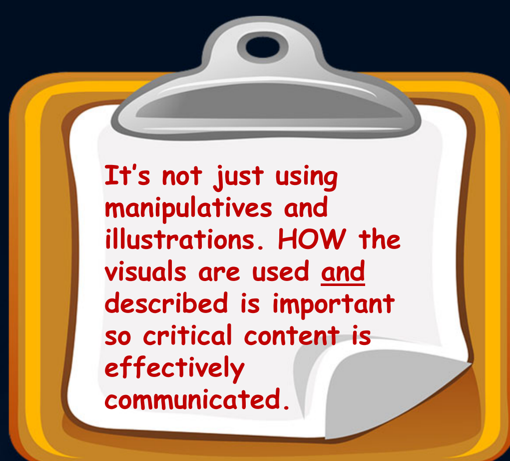


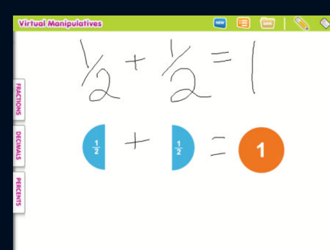
Other options:

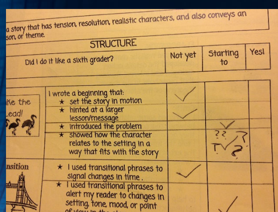
- Video
- Virtual manipulatives
- Relevancy
- Checklist of steps
- Icons for cues

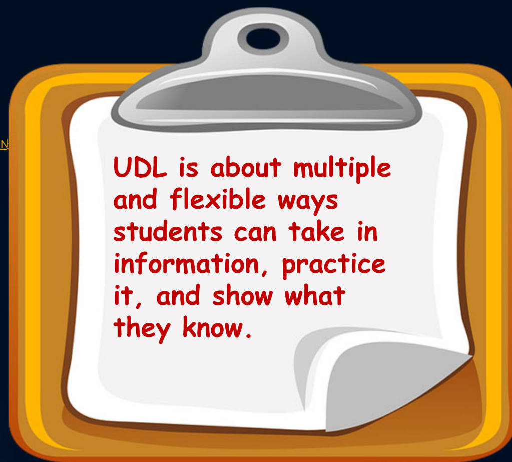


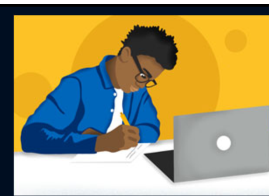


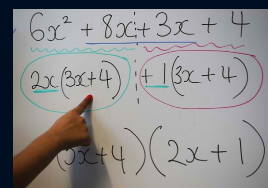












Options for Input / Output

- **Teacher…**
  - Writes on board
  - Uses color to distinguish content
  - Provides visual and auditory input
  - Models decision-making
  - Links content to real-life
  - Uses pictures, illustrations
  - Repeats information in same/different ways
  - Assesses in multiple ways
- **Student…**
  - Uses outline to take notes
  - Highlights critical information
  - Listens using electronic book
  - Practices using multiple examples
  - Illustrates decision-making process
  - Studies with peers
  - Designs a model
  - Watches a demonstration via internet
  - Selects from options how to evidence learning

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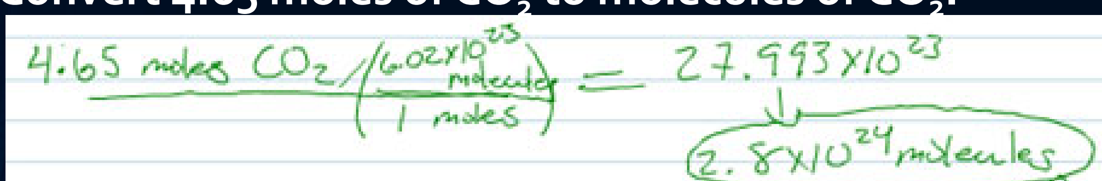
UDL Principle: Representation ACCESS

Mole Treatment Feature	UDL Guidelines and Checkpoints
IDEAS Self-Management Strategy	• **Options for mathematical expressions** *(support decoding of mathematical notations)*
Strategy Sheet (laminated guide) and Mole Equality Organizer (gray box of mole equalities)	• **Options for perception** *(offer alternatives for auditory and visual information)* **and comprehension** *(highlight big ideas)*
Multi-Media Mole Videos and Scaffolded Practice (patterned boxes)	• **Options for language** *(illustrate through multiple media and support decoding of text)* **and comprehension** *(highlight patterns, critical features, and relationships; guide information processing and visualization)*

Chemistry: Molar Conversions

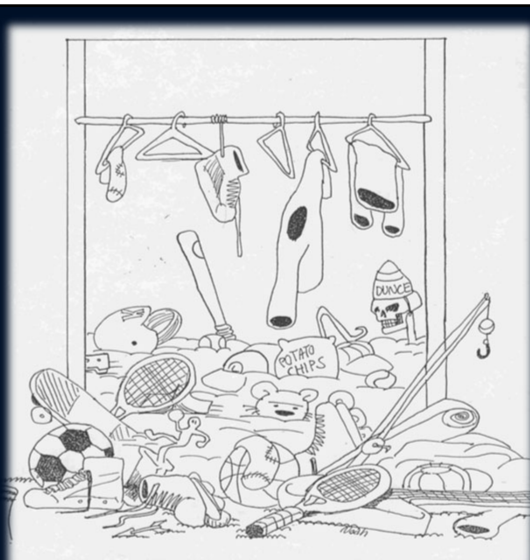
Convert 4.65 moles of CO_2 to molecules of CO_2.

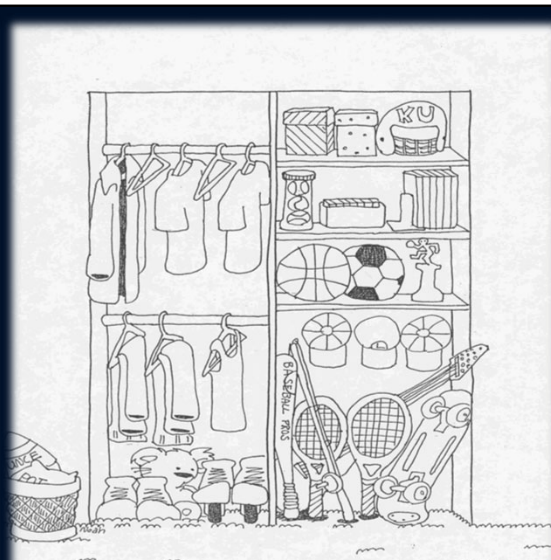


Barriers for students:

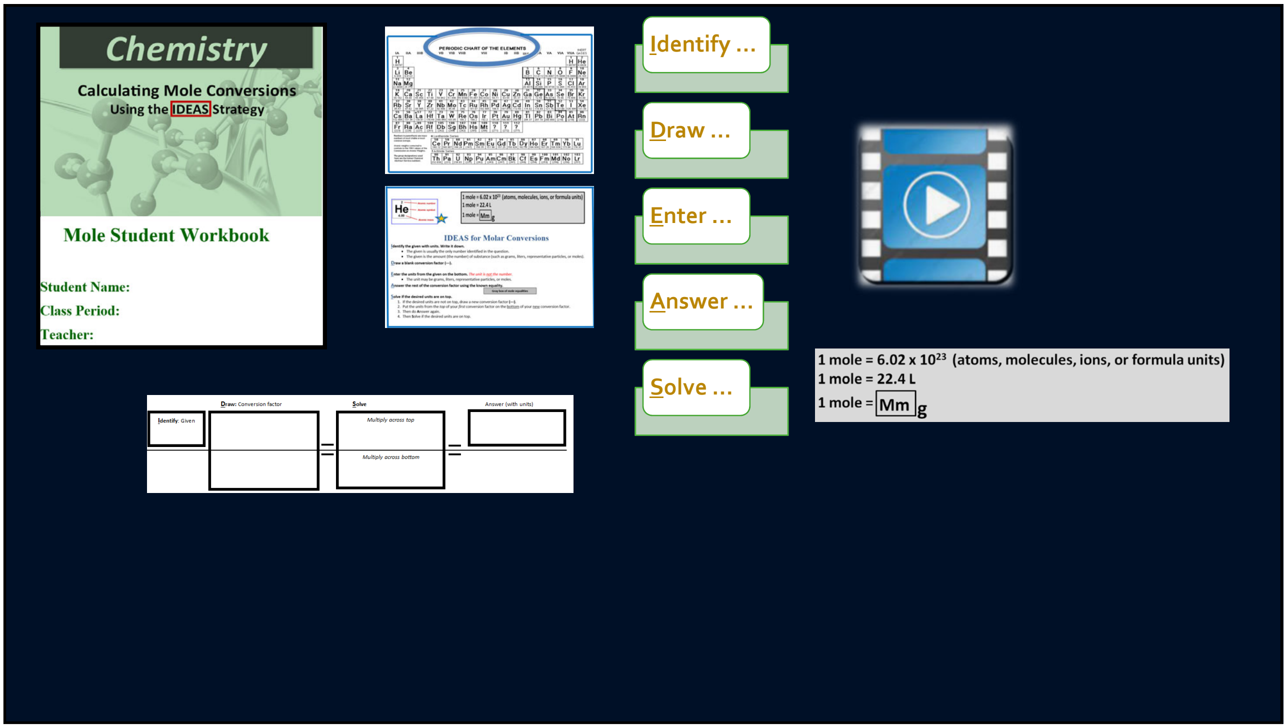
- Vocabulary
- Organization
- Multi-step
  - Sequence
  - Memory
- Algebraic process

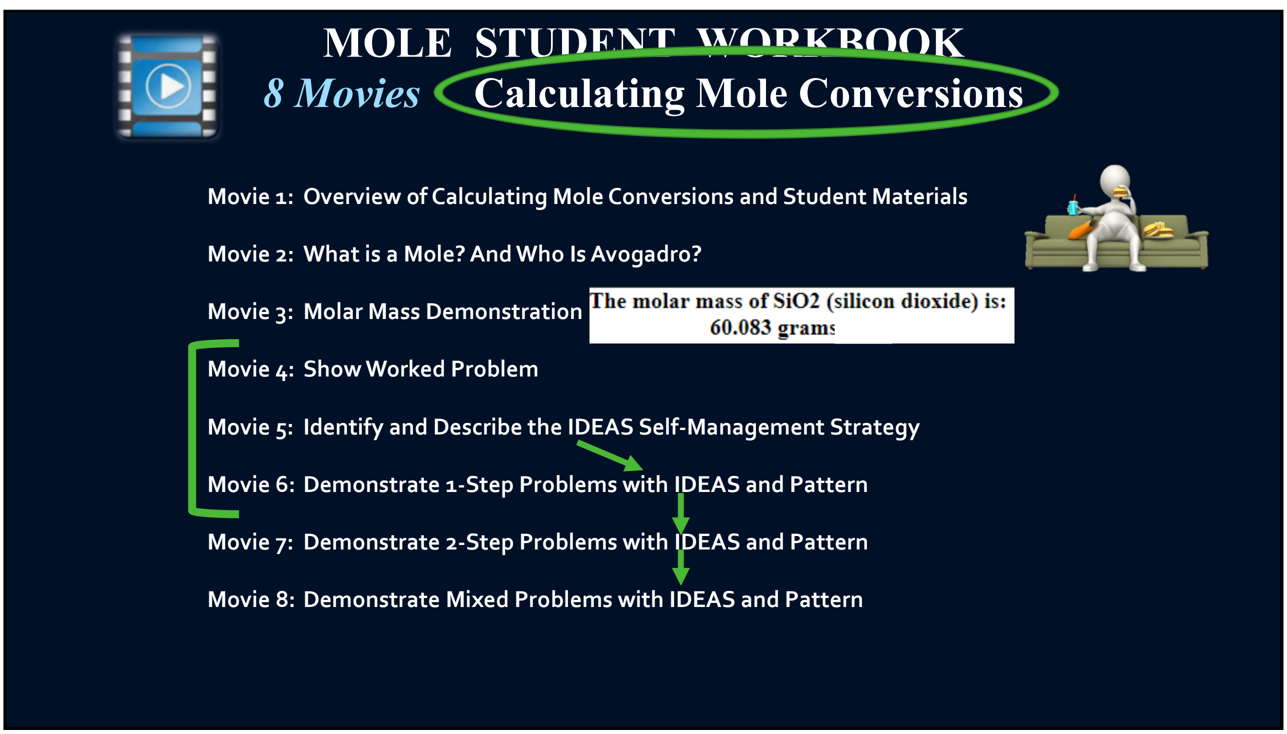
Calculating Mole Conversions

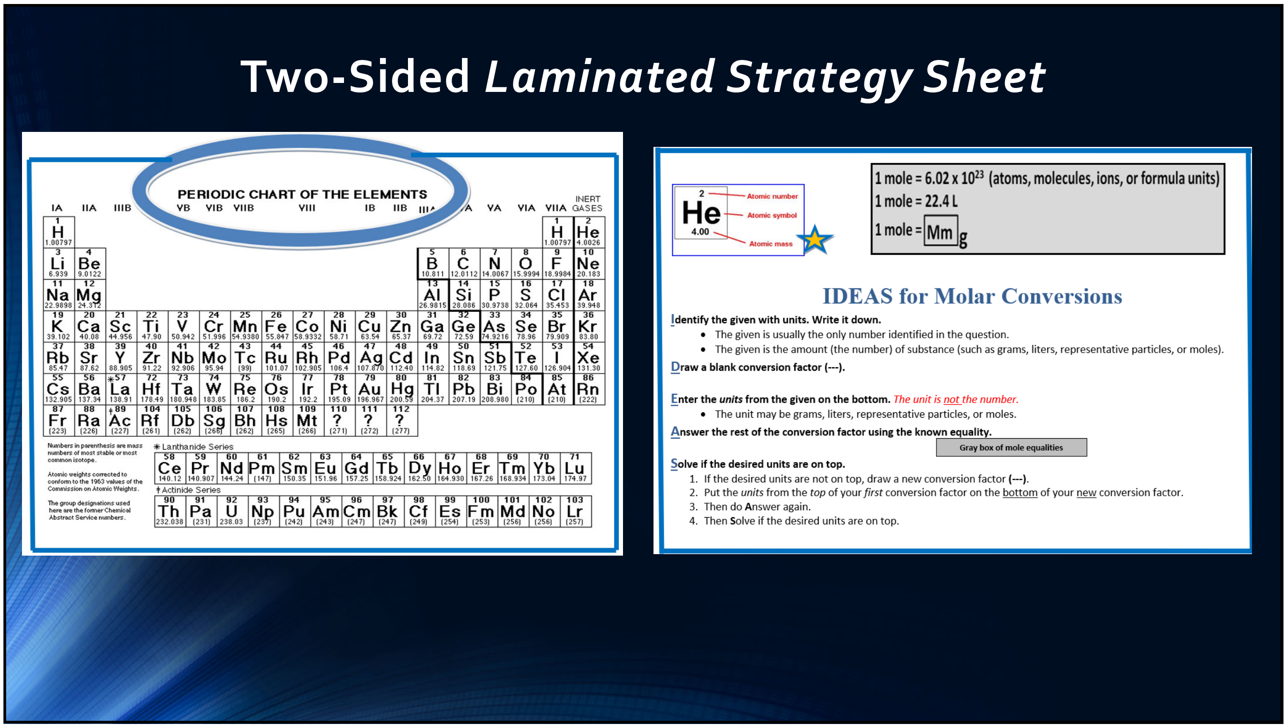


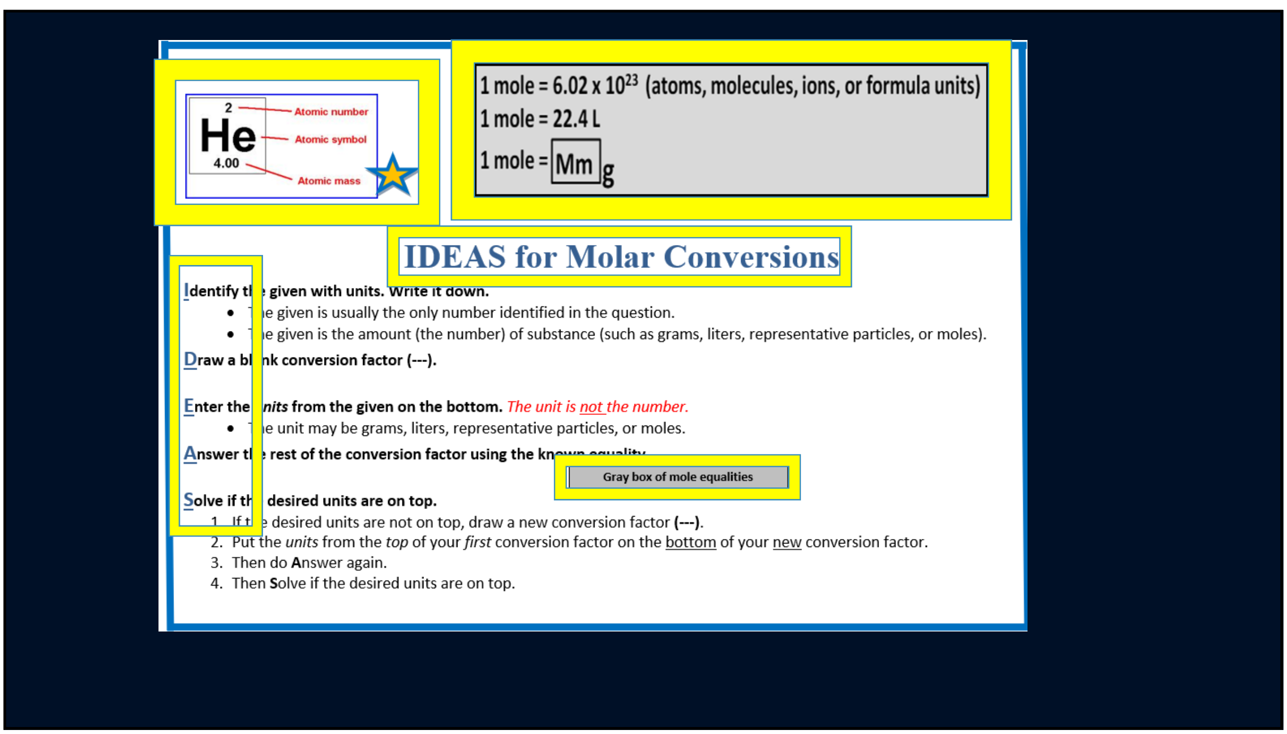


Source: KU-CRL SIM


Chemistry
Calculating Mole Conversions
Using the IDEAS Strategy
Mole Student Workbook
Student Name:
Class Period:
Teacher:
IDEAS for Molar Conversions
Identify ...
Draw ...
Enter ...
Answer ...
Solve ...
1 mole = 6.02 x 10^23 (atoms, molecules, ions, or formula units)
1 mole = 22.4 L
1 mole = Mm g


MOLE STUDENT WORKBOOK
8 Movies
Calculating Mole Conversions
Movie 1: Overview of Calculating Mole Conversions and Student Materials
Movie 2: What is a Mole? And Who Is Avogadro?
Movie 3: Molar Mass Demonstration
The molar mass of SiO2 (silicon dioxide) is: 60.083 grams
Movie 4: Show Worked Problem
Movie 5: Identify and Describe the IDEAS Self-Management Strategy
Movie 6: Demonstrate 1-Step Problems with IDEAS and Pattern
Movie 7: Demonstrate 2-Step Problems with IDEAS and Pattern
Movie 8: Demonstrate Mixed Problems with IDEAS and Pattern


Two-Sided Laminated Strategy Sheet
PERIODIC CHART OF THE ELEMENTS
1 mole = 6.02 x 10^23 (atoms, molecules, ions, or formula units)
1 mole = 22.4 L
1 mole = Mm g
IDEAS for Molar Conversions
Identify the given with units. Write it down.
The given is usually the only number identified in the question.
The given is the amount (the number) of substance (such as grams, liters, representative particles, or moles).
Draw a blank conversion factor (---).
Enter the units from the given on the bottom. The unit is not the number.
The unit may be grams, liters, representative particles, or moles.
Answer the rest of the conversion factor using the known equality.
Gray box of mole equalities
Solve if the desired units are on top.
1. If the desired units are not on top, draw a new conversion factor (---).
2. Put the units from the top of your first conversion factor on the bottom of your new conversion factor.
3. Then do Answer again.
4. Then Solve if the desired units are on top.


2
He
4.00
Atomic number
Atomic symbol
Atomic mass
1 mole = 6.02 x 10^23 (atoms, molecules, ions, or formula units)
1 mole = 22.4 L
1 mole = Mm g
IDEAS for Molar Conversions
Identify the given with units. Write it down.
The given is usually the only number identified in the question.
The given is the amount (the number) of substance (such as grams, liters, representative particles, or moles).
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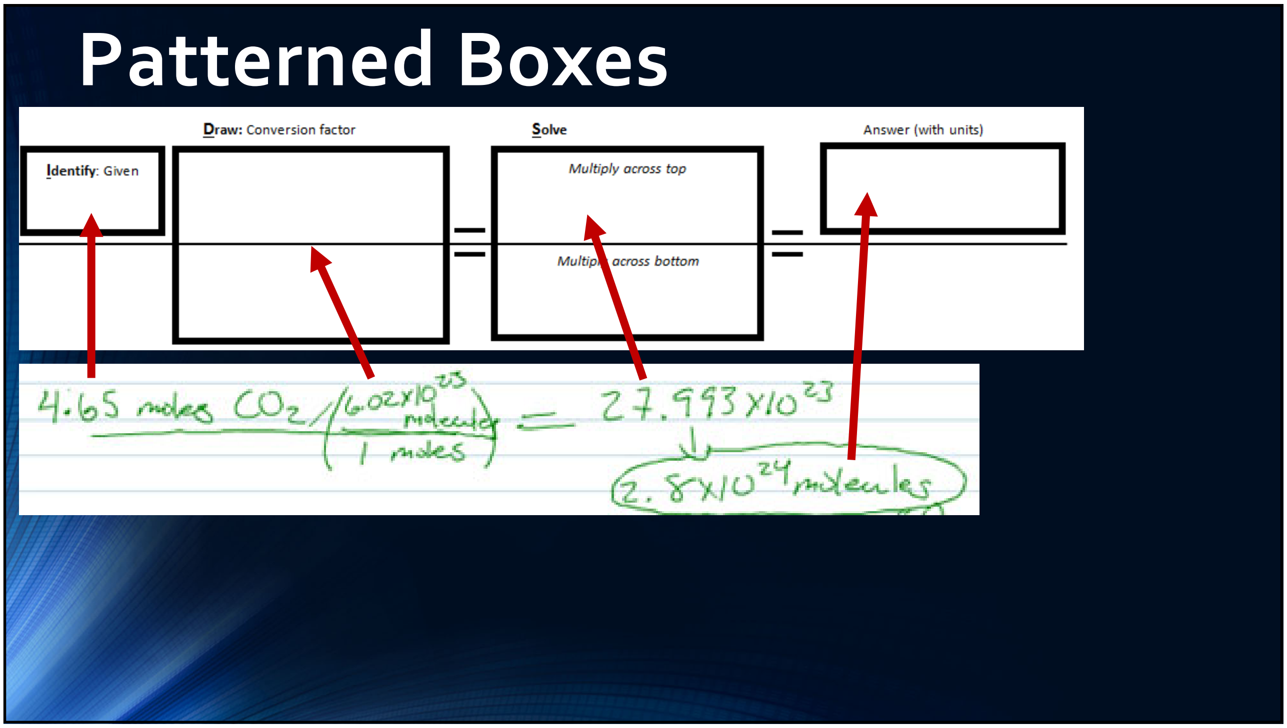
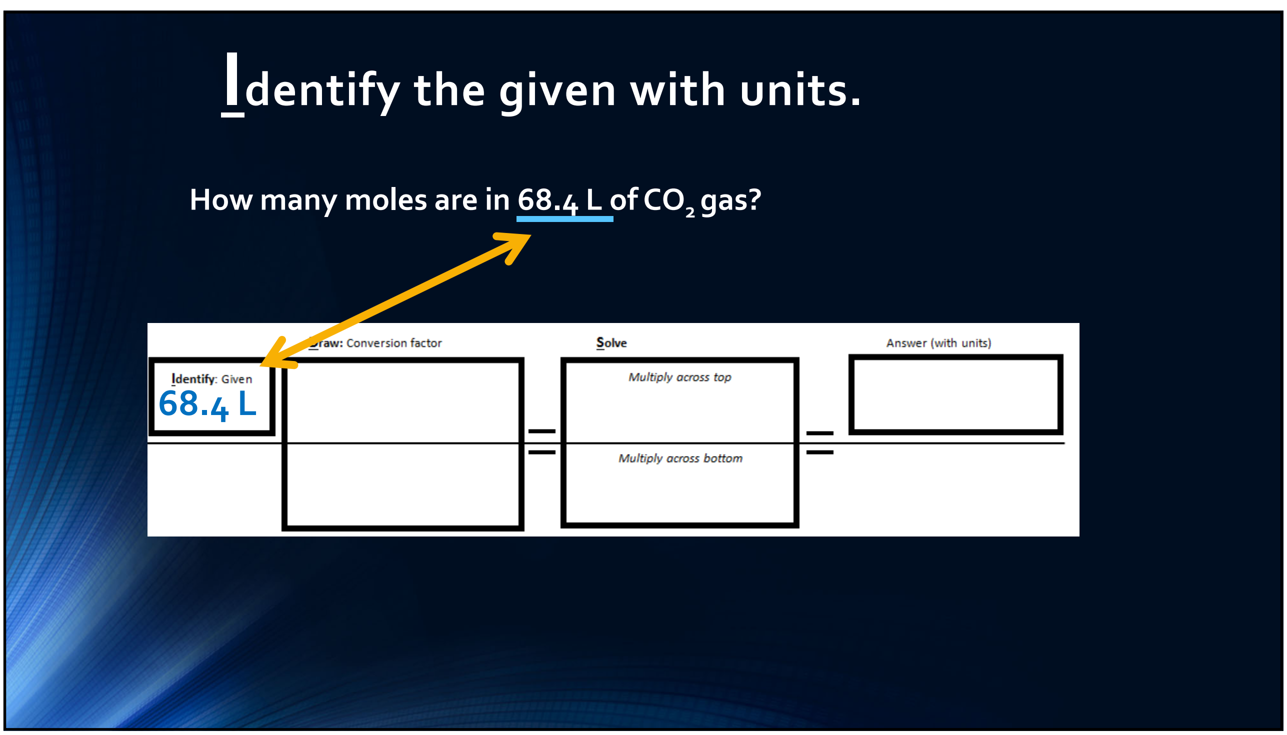
4. Then Solve if the desired units are on top.


Patterned Boxes
Draw: Conversion factor
Solve
Answer (with units)
Identify: Given
Multiply across top
Multiply across bottom
4.65 moles CO2
6.02x10^23 molecules
1 moles
= 27.993x10^23
2.8x10^24 molecules


Identify the given with units.
How many moles are in 68.4 L of CO2 gas?
Draw: Conversion factor
Solve
Answer (with units)
Identify: Given
68.4 L
Multiply across top
Multiply across bottom

Identify the given with units. Write it down.
- The given is usually the only number identified in the question.
- The given is the amount (the number) of substance (such as grams, liters, representative particles, or moles).

1. How many moles are in 5.12×10^{23} molecules of SiO_2?

Identify: Given
5.12×10^{23} molecules

Draw: Conversion factor

Solve
Multiply across top
Multiply across bottom

Answer (with units)

Draw a blank conversion factor (---).

1. How many moles are in 5.12×10^{23} molecules of SiO_2?

Identify: Given
5.12×10^{23} molecules

Draw: Conversion factor
(- - - -)

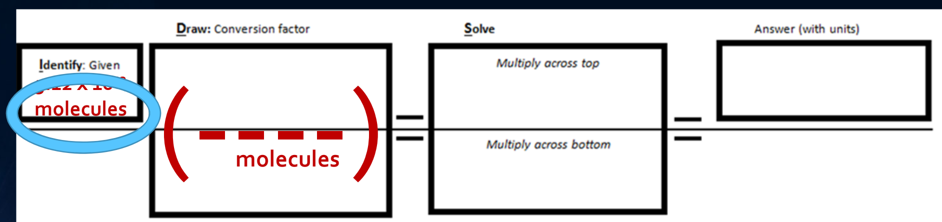
Solve
Multiply across top
Multiply across bottom

Answer (with units)

Enter the *units* from the given on the bottom. *The unit is not the number.*

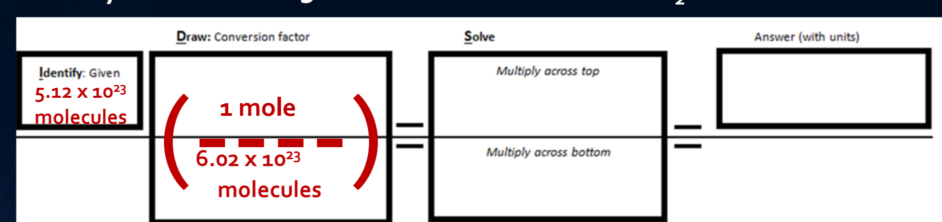
– The unit may be grams, liters, representative particles, or moles.

1. How many moles are in 5.12×10^{23} molecules of SiO_2?



Answer the rest of the conversion factor using the known equality.

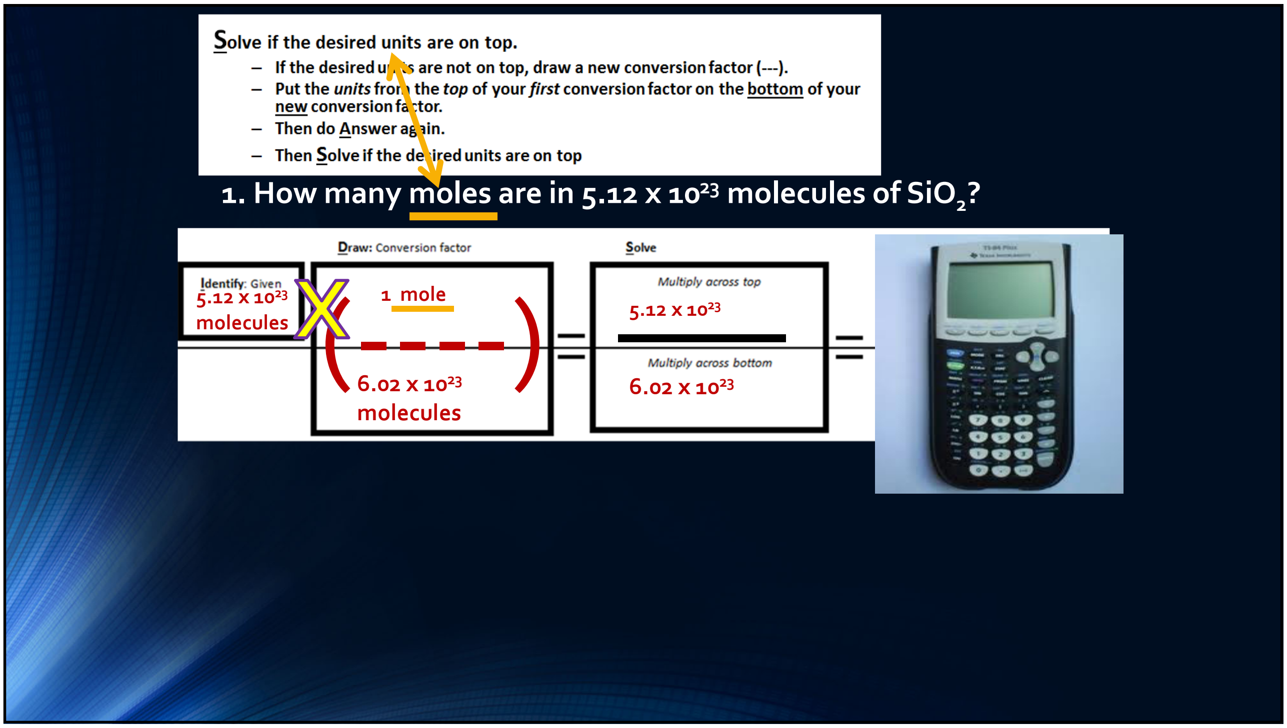
1. How many moles are in 5.12×10^{23} molecules of SiO_2?

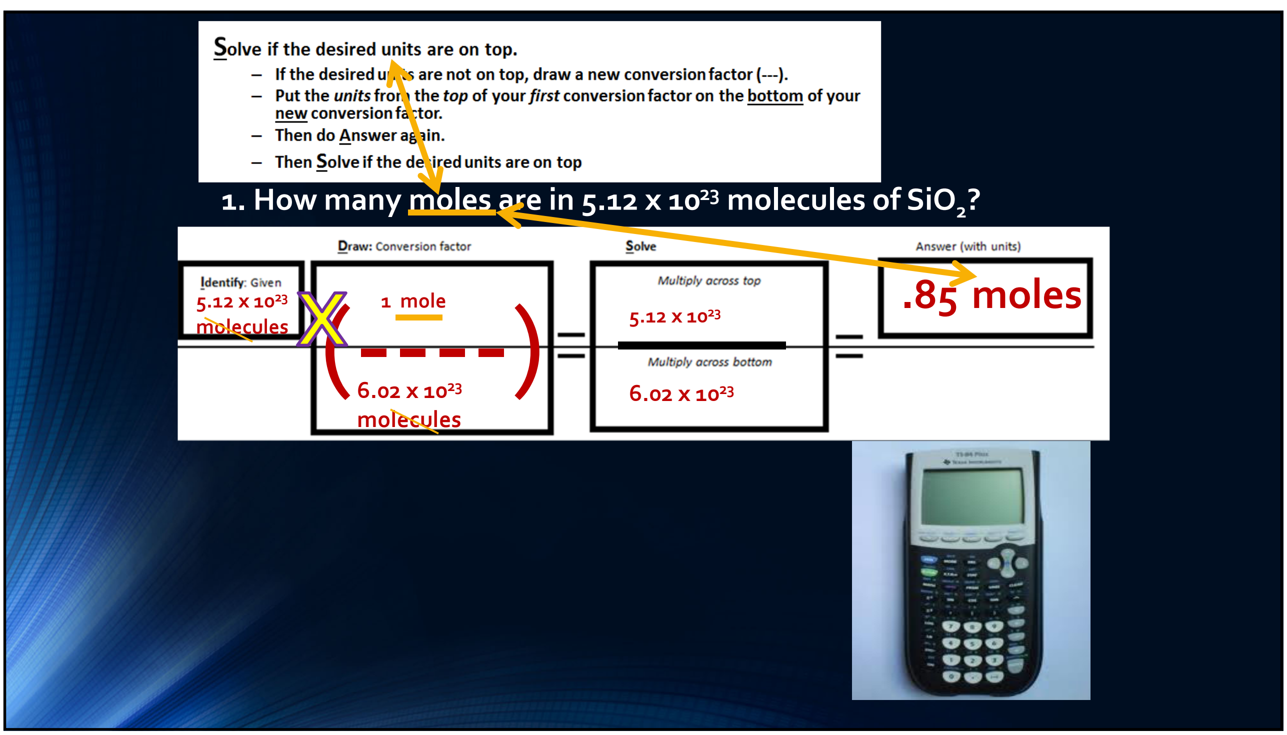


1 mole = 6.02×10^{23} (atoms, molecules, ions, or formula units)

1 mole = 22.4 L

1 mole = Mm g


Solve if the desired units are on top.
– If the desired units are not on top, draw a new conversion factor (---).
– Put the units from the top of your first conversion factor on the bottom of your new conversion factor.
– Then do Answer again.
– Then Solve if the desired units are on top
1. How many moles are in 5.12 x 10²³ molecules of SiO₂?
Draw: Conversion factor
Solve
Identify: Given
5.12 x 10²³ molecules
1 mole
6.02 x 10²³ molecules
Multiply across top
5.12 x 10²³
Multiply across bottom
6.02 x 10²³


Solve if the desired units are on top.
– If the desired units are not on top, draw a new conversion factor (---).
– Put the units from the top of your first conversion factor on the bottom of your new conversion factor.
– Then do Answer again.
– Then Solve if the desired units are on top
1. How many moles are in 5.12 x 10²³ molecules of SiO₂?
Draw: Conversion factor
Solve
Answer (with units)
Identify: Given
5.12 x 10²³ molecules
1 mole
6.02 x 10²³ molecules
Multiply across top
5.12 x 10²³
Multiply across bottom
6.02 x 10²³
.85 moles

If you did not know the IDEAS self-management strategy,
you would be solving all of this problem from memory,
with no guidance (except your memory) of which steps to do when.

How many moles are in 5.12×10^{23} molecules of SiO_2?

5.12×10^{23} molecules X $\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right) = \frac{5.12 \times 10^{23}}{6.02 \times 10^{23}} =$ .85 moles

Students who do not know the IDEAS self-management strategy:

1) forget the steps
2) mix up the order of steps
3) are not sure what to do next
4) are more likely to calculate incorrectly

If you did not know the pattern for using the
IDEAS self-management strategy, you create the pattern on your own.

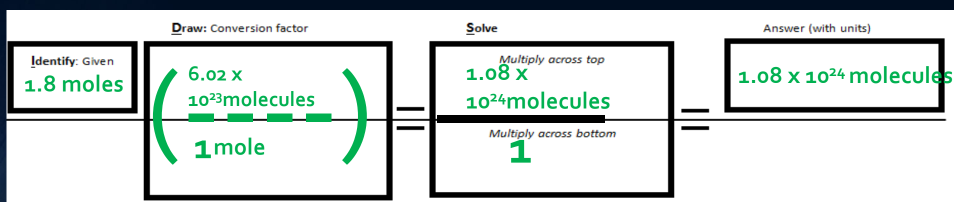
How many moles are in 5.12×10^{23} molecules of SiO_2?

Identify: Given	Draw: Conversion factor		Solve		Answer (with units)
5.12×10^{23} molecules	$\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ molecules}}\right)$	=	Multiply across top: 5.12×10^{23} / Multiply across bottom: 6.02×10^{23}	=	.85 moles

When you DO LEARN the IDEAS self-management strategy and the patterns, you solve problems from memory.

How many moles are in 5.12×10^{23} molecules of SiO_2?

Convert 1.8 moles of CCl_4 to molecules.



Chemistry Study 1

- Pretest
- Prepare high school chemistry co-teachers
  - Day 1 (90 min)
  - Day 2 (90 min)
  - Day 3 (90 min)
- Posttest
- Delayed Posttest (4 weeks later; maintenance)

Source: King-Sears et al., 2015

Chemistry Study 1

- Two schools
- Special education co-teachers delivered UDL intervention
- Two co-taught classes per school
- Random assignment class to UDL
  - One class received UDL-based instruction (UDL)
  - One class received business as usual (BAU: control)
- Students with and without disabilities in co-taught classes

Source: King-Sears et al., 2015

Chemistry Study 1

	Pretest	Day 1	Day 2	Day 3	Post-test	Delayed post-test
UDL	O		X		O	O
Control	O				O	O

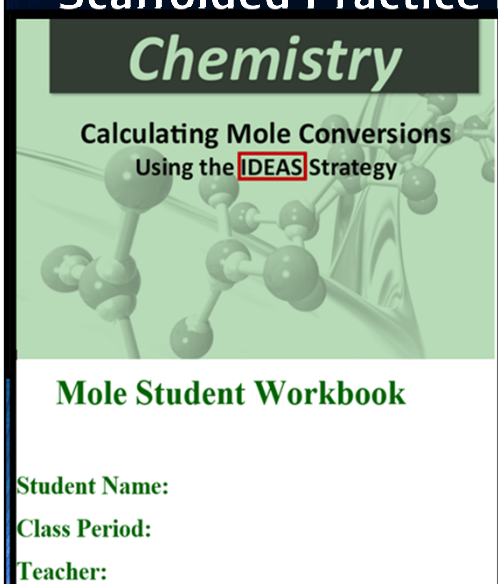
Pre / Post / Delayed Test Examples

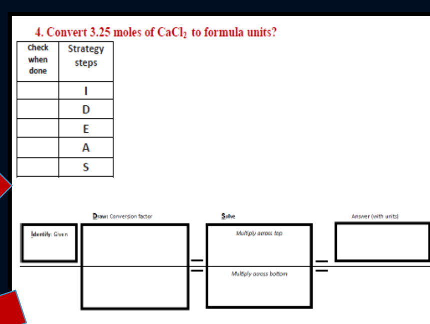
9. Convert 8.34 moles of Na_2S to formula units of Na_2S:

10. What is the volume of 6.54×10^{22} molecules of Cl_2 gas?

11. What is the mass of 4.8 moles of $Mg(ClO_3)_2$?

Scaffolded Practice Problems

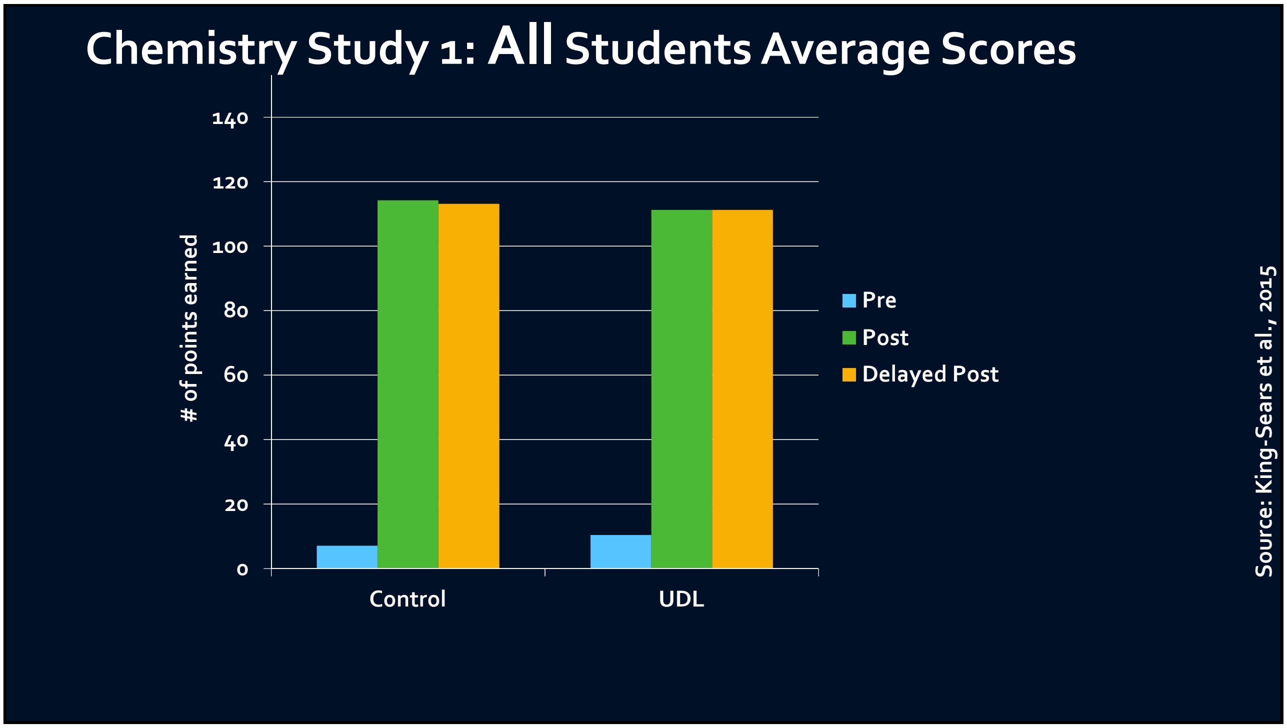


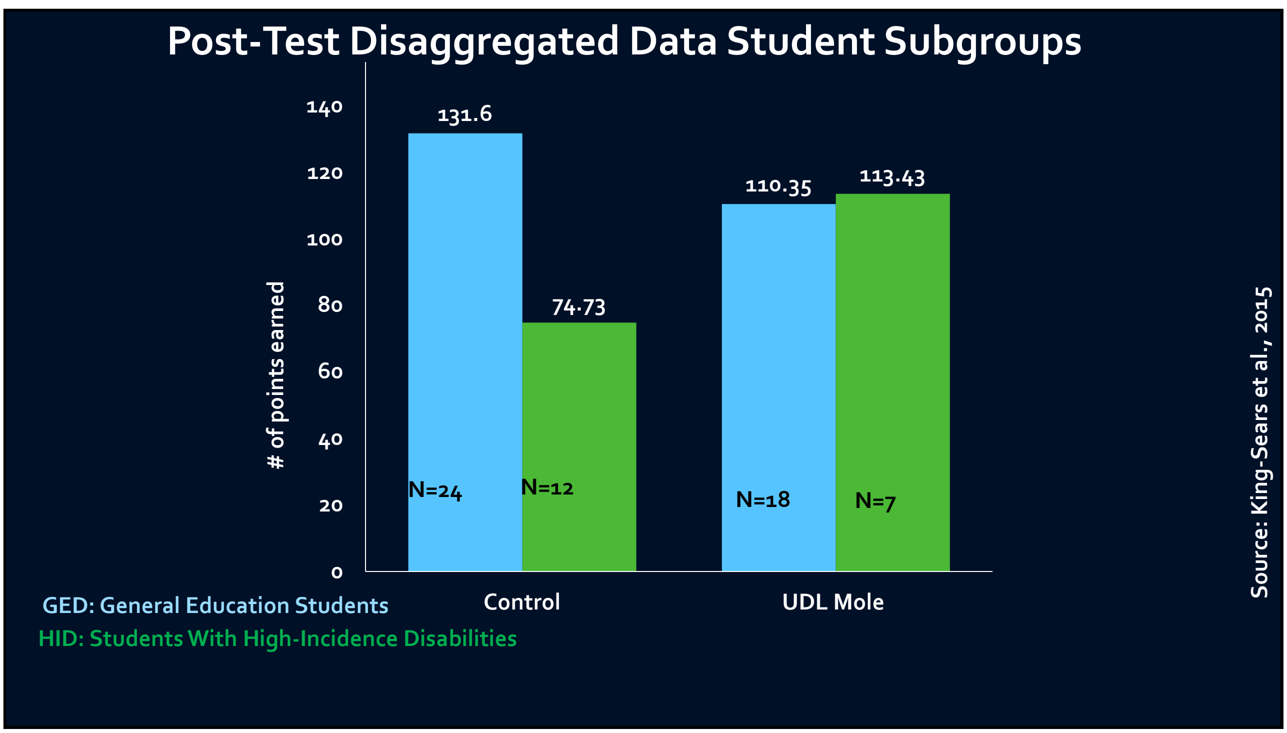

4. Convert 3.25 moles of $CaCl_2$ to formula units?

Check when done	Strategy steps
	I
	D
	E
	A
	S

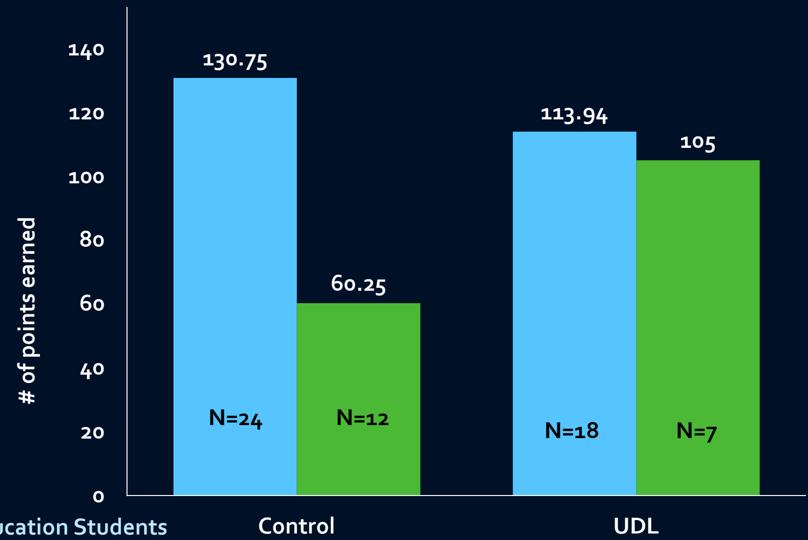
Identify: Given | Draw: Conversion factor | Solve: Multiply across top / Multiply across bottom | Answer (with units)

12. How many grams are in 1.92 moles of $FeCl_3$?


Chemistry Study 1: All Students Average Scores
# of points earned
140
120
100
80
60
40
20
0
Control
UDL
Pre
Post
Delayed Post
Source: King-Sears et al., 2015


Post-Test Disaggregated Data Student Subgroups
# of points earned
140
120
100
80
60
40
20
0
131.6
74.73
110.35
113.43
N=24
N=12
N=18
N=7
Control
UDL Mole
GED: General Education Students
HID: Students With High-Incidence Disabilities
Source: King-Sears et al., 2015

Delayed Post-Test 4 *weeks later*



GED: General Education Students

HID: Students With High-Incidence Disabilities

Source: King-Sears et al., 2015

Take-Aways from the 2015 UDL Chemistry

- Fidelity was an issue; prepare teachers better
- Technology didn't always work; bypass the schools' WiFi
- Use more sophisticated platform for multimedia
- Keep all materials as is
  - Student feedback
- Replicate and disaggregate

Chemistry Study 2 and Study 3

- Pretest
- Prepare high school chemistry co-teachers (Study 2) and self-contained chemistry teacher (Study 3)
  - Day 1 (90 min)
  - Day 2 (90 min)
  - Day 3 (90 min)
    - Day 4 (90 min) for self-contained chemistry class (Study 3)
- Posttest

Source: King-Sears et al., 2015

Chemistry Study 2 and Study 3

- One school
- Three co-taught chemistry classes
  - Two taught on same day were UDL
- One self-contained chemistry class – UDL

- Researcher delivered Days 1 and 2 instruction; co-teachers and self-contained teacher delivered remaining day(s) instruction
- Students with and without learning disabilities (LD) in co-taught and self-contained classes
- Absences in co-taught classes; could not disaggregate data

Source: King-Sears et al., 2015

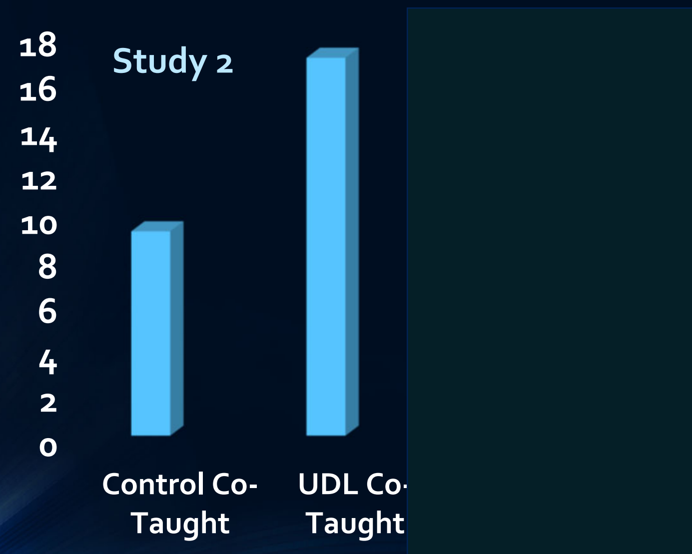
Chemistry Study 2

Convenience assign class to UDL	Pretest	Day 1	Day 2	Day 3	Post-test
UDL	O		X		O
Control	O				O

Chemistry Study 3

One self-contained spec ed class	Pretest	Day 1	Day 2	Day 3	Day 4	Post-test
UDL	O		X			O

Replication of Chemistry UDL-Based Instruction Post-Test Scores



Source: King-Sears & Johnson, 2020

Take-Aways from the 2020 UDL Chemistry

- Teachers demonstrate, then support and monitor
- Transfer videos to iPads / other devices; students pace their practice
- Many students learning English and receiving free/ reduced lunch
- Replicate and disaggregate

Feedback from Students

	Strongly Agree to Agree
1. I believe learning how to do mole conversions using IDEAS improved my learning.	83%
2. Using IDEAS helped me have confidence that I could calculate mole conversions correctly.	84%
3. I would recommend IDEAS to other students.	77%
4. IDEAS helped me remember the steps to calculate mole conversions.	82%

Source: King-Sears & Johnson, 2020

	Strongly Agree Agree
5. I learned how to do the mole conversions better when my teacher demonstrated how to do it using patterned boxes.	79%
6. The IDEAS laminated strategy sheet [procedural facilitator] was helpful.	95%
7. The Mole Student Workbook was helpful.	89%
8. The gray box of mole equalities was helpful.	84%
9. I learned how to do the mole conversions better when my teacher demonstrated with the video clips.	87%

Source: King-Sears & Johnson, 2020

"The movies were helpful for me because it allowed me to see step by step how to solve mole conversions"

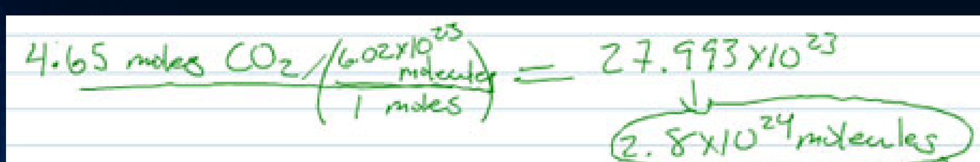
"The IDEAS strategy was quite beneficial for me. It helped me stay organized and remember mole equalities"

"It wasn't exactly the IDEAS strategy that helped me, it was the pattern boxes that helped me remember what to do"

"It's helpful [the laminated guide] because you're not all over the place and it's pretty easy to remember the IDEAS"

"It [the student workbook] helped because after doing so many mole conversions** [gray box of mole equalities] **you got the hang of it after a while. And it was good that they laid some of the problems out for you"

Convert 4.65 moles of CO_2 to molecules of CO_2.



Barriers for students:

- Vocabulary
- Organization
- Multi-step
- Algebraic process

Proactive design and implementation of accessible features that

- **minimize the need for accommodations,**
- **benefit students who need the supports, and**
- **maximize students' opportunities to master complex information.**

Takeaways on UDL for Chemistry

- Identify anticipated barriers students may have based on curriculum (complexity of content; known issues) and learning characteristics
- Plan to minimize or remove barriers by designing multiple and flexible ways students can access, practice, and show what they know
- Monitor progress of students in varied subgroups
  - Formative – during instruction
  - Summative – usually a unit test
  - Caution re: reliance on the class average

What are the implications for practice or research from this presentation?

- UDL should be used more by teachers
- Further research is needed, with students' disaggregated data, to more firmly establish UDL's research base

References

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