Welcome to our CHEM 4 lecture

- Go to LearningCatalytics.com **Session ID = 17273222**
- While we wait, please start on the review question below.

Review clicker question: Covers material from last class

1) Calculate the atomic mass of Sb with the correct number of digits, given that Sb has two isotopes: Sb-121 (120.904 amu, 57.21%) and Sb-123 (122.904 amu, 42.79%).

A) 120 amu
B) 1.2×10^2 amu
C) 122 amu
D) 121.8 amu
E) 121.76 amu
F) 121.760 amu

Answer:

6sf *4sf* *6sf* *4sf*

atomic mass = (120.904)(0.5721) + (122.904)(0.4279)

100ths *100ths*

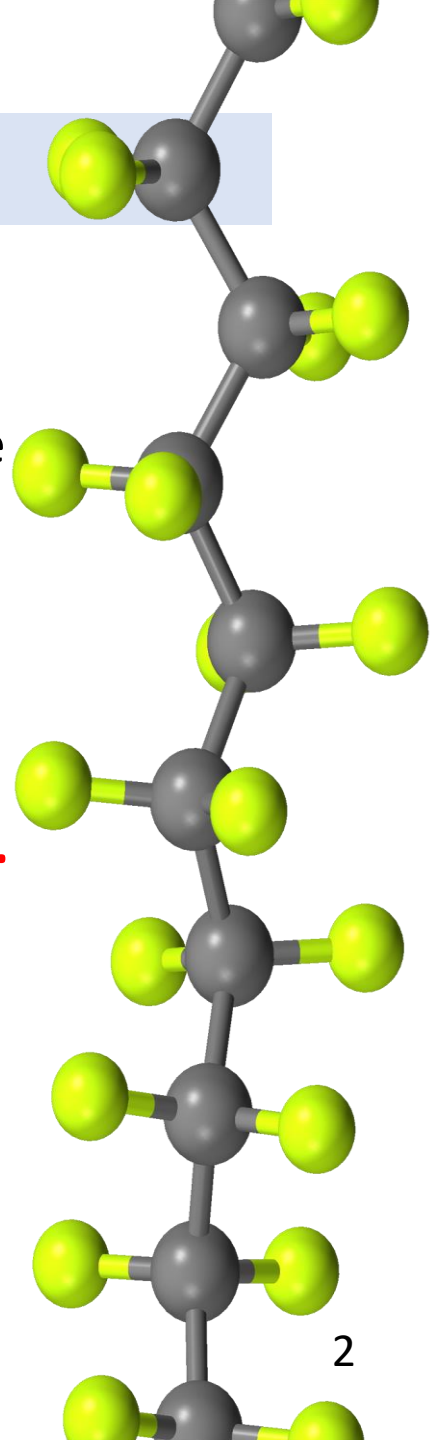
= 69.1691784 + 52.5906216

= 121.7598 *Round off to 100ths place*

= 121.76 amu

Key to Success in CHEM 4

- ✓ Visit our CHEM 4 website regularly: tinyurl.com/SacStateChem4
- ✓ Attend every lecture having completed the assigned reading.
- ✓ Review our PowerPoint slides and/or lecture recordings after each class (they are posted on the above website in the calendar section)
- ✓ Keep up with daily homework. **However, all students will automatically receive full credit for all late homework this semester.**
- ✓ Complete all of the practice exams.
- ✓ **Talk to your Commit to Study peer mentor about how you are doing in CHEM 4.**
- ✓ Get help when needed:
  - ✓ Put together a weekly study group.
  - ✓ Jeff's office hours: MWF 9 – 9:30 am and 11 – 11:30 am; and by appointment.
  - ✓ PAL office hours: link is on our CHEM 4 website.



Prerequisites for CHEM 1A/1E

Students can meet the *chemistry prerequisite* in any of the following ways:

- ~~Having a Chemistry Diagnostic Score of 35 or higher.~~ (not available during COVID)
- Completed CHEM ALEKS (CARA) with 85% of the topics completed.
- Passing CHEM 4 or CHEM 6A with a grade of C or better.
- Having obtained D to a C- in CHEM 4 AND completing 85% or the topics successfully in CARA.

Students can meet the *math prerequisite* in any of the following ways:

Math Prerequisite for CHEM 1A:	**Math Prerequisite for CHEM 1E:**
• A Math ALEKS PPL Score of 61 or higher • Successful completion of Math 12 or the equivalent • Current enrollment in Math 26A, Math 29 or a higher • Score of a 3 or higher on AB or BC Calculus AP Test • Ability to enroll in Math 26A or Math 29	• A Math ALEKS PPL score of 76 or higher • Successful completion of Math 29 or equivalent • Enrollment in a math course of Math 30 or higher • Score of a 3 or higher on AB or BC Calculus AP Test

- Questions can be directed to **Dr. Susan Crawford (crawford@csus.edu)** or **Dr. Roy Dixon (rdixon@csus.edu)**
- Chem department: https://www.csus.edu/college/natural-sciences-mathematics/chemistry/
- Math dept ALEKS PPL: https://www.csus.edu/college/natural-sciences-mathematics/math-placement-exam/

CHEM 4 lecture

Monday – October 12, 2020

Sec 2.5 – 2.6

Metric prefixes and conversions factors

Reading clicker question: Covers material from today's assigned reading

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2) Which of the following statements is false?

A) The English system of units is used in the United States and includes units such as inches, pounds, and gallons.

B) The meter, kilogram, and second are SI units for length, mass, and time, respectively.

C) The prefix *milli-* (symbol, m) indicates 10^3 and the prefix *kilo-* (symbol, k) indicates 10^{-3}.

D) Any unit of length, when cubed, becomes a unit of volume.

E) Conversion factors are used to convert from one unit of measurement to another.

F) Conversion factors are fractions that are always equal to 1.

Chemistry Application: Mars Climate Orbiter (LA Times, 1999)

- NASA lost its $125-million Mars Climate Orbiter because spacecraft engineers failed to convert from English to metric measurements when exchanging vital data before the craft was launched, space agency officials said Thursday.
- A navigation team at the Jet Propulsion Laboratory used the metric system of millimeters and meters in its calculations, while Lockheed Martin Astronautics in Denver, which designed and built the spacecraft, provided crucial acceleration data in the English system of inches, feet and pounds.
- “That is so dumb,” said John Logsdon, director of George Washington University’s space policy institute. “There seems to have emerged over the past couple of years a systematic problem in the space community of insufficient attention to detail.”

Mars Probe Lost Due to Simple Math Error

Background: Metric system handout from class website

	Prefix	Symbol		Exponent
Larger than base unit →	tera	1 T ___*	=	10^{12} ___ *
	giga	1 G ___	=	10^{9} ___
	mega	1 M ___	=	10^{6} ___
	kilo	1 k ___	=	10^{3} ___
Smaller than ← base unit	deci	1 d ___	=	10^{-1} ___
	centi	1 c ___	=	10^{-2} ___
	milli	1 m ___	=	10^{-3} ___
	micro	1 μ ___	=	10^{-6} ___
	nano	1 n ___	=	10^{-9} ___
	pico	1 p ___	=	10^{-12} ___
	femto	1 f ___	=	10^{-15} ___

* These blanks can be filled with any unit. **Important metric units include: gram (g), meter (m), liter (L), second (s).**

For example, if we need to convert between Gm ↔ m, we can start with:

1 G ___ = 10^{9} ___

Filling in the unit gives: 1 Gm = 10^{9} m

This equality can then be used to make useful conversion factors:

$$\frac{1\ \text{Gm}}{10^{9}\ \text{m}} \quad \text{or} \quad \frac{10^{9}\ \text{m}}{1\ \text{Gm}} = 1$$

Background: Metric system

	Prefix	Symbol		Exponent
Larger than → base unit	tera	1 T ___*	=	10^{12} ___*
	giga	1 G ___	=	10^{9} ___
	mega	1 M ___	=	10^{6} ___
	kilo	1 k ___	=	10^{3} ___
Smaller than ← base unit	deci	1 d ___	=	10^{-1} ___
	centi	1 c ___	=	10^{-2} ___
	milli	1 m ___	=	10^{-3} ___
	micro	1 μ ___	=	10^{-6} ___
	nano	1 n ___	=	10^{-9} ___
	pico	1 p ___	=	10^{-12} ___
	femto	1 f ___	=	10^{-15} ___

Write the conversion factors that can be used to convert between the following:

1) pL ↔ L 1 pL = 10^{-12} L

$$\frac{1\ \text{pL}}{10^{-12}\text{L}} \quad \text{or} \quad \frac{10^{-12}\text{L}}{1\ \text{pL}}$$

2) km ↔ m 1 km = 10^{3} m

$$\frac{1\ \text{km}}{10^{3}\text{m}} \quad \text{or} \quad \frac{10^{3}\text{m}}{1\ \text{km}}$$

3) fs ↔ s 1 fs = 10^{-15} s

$$\frac{1\ \text{fs}}{10^{-15}\text{s}} \quad \text{or} \quad \frac{10^{-15}\text{s}}{1\ \text{fs}}$$

Conversions *within* the metric system are definitions (exact numbers) and do not limit sf (the 1 and 10^{-3} in the above have ∞ sf).

Background: Converting between metric prefixes

Example: How many mL are in 3.5 L?

1) Flowchart: L → mL
2) Write conversion factor for each step in flowchart: $\frac{1\ \text{mL}}{10^{-3}\text{L}}$ or $\frac{10^{-3}\text{L}}{1\ \text{mL}}$

3) Perform calculation. Use the units to determine if you need to flip your conversion factor.

$$3.5\ \cancel{\text{L}}\left(\frac{1\ \text{mL}}{10^{-3}\cancel{\text{L}}}\right) = 3500\ \text{mL}$$

2 sf *∞ sf*

4) Label and determine correct sig figs.

Keep 2sf. Use scientific notation to avoid ambiguous zeros

= 3.5 x 10^3 mL

5) Re-read the question. Did you answer the question? Does the answer make sense?

Our answer has the right units and "mL" are smaller than "L", so there should be a lot of them in 3.5 L.

Progress clicker question: Covers material we are learning now
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3) How many meters are there in 5.20×10^9 μm?

A) 520 m
B) 5200 m
C) 5.2×10^3 m
D) 5.20×10^3 m
E) 5.200×10^3 m
F) 5.2×10^{15} m
G) 5.20×10^{15} m
H) 5.200×10^{15} m

Answer:

1) Flowchart: μm → m

2) Conversion factors: $\frac{1\,\mu m}{10^{-6}\,m}$ or $\frac{10^{-6}\,m}{1\,\mu m}$

3) Calculation: $(5.20 \times 10^9\ \cancel{\mu m})\left(\frac{10^{-6}\ m}{1\ \cancel{\mu m}}\right) = 5200\ m$ = **5.20×10^3 m**

4) Sig figs: *3 sf* *∞ sf*

Keep 3sf. Use scientific notation to avoid ambiguous zeros

5) Check answer: *Our answer has the correct units. "m" are larger than "μm".*

Background: Converting within the English system and from metric ↔ English

Length	Volume
1 m = 39.37 in. = 1.094 yd	1 L = 1000 cm^3 = 1.057 qt
1 in. = 2.54 cm (exactly, ∞ sf)	1 gal = 4 qt = 8 pt = 128 fluid ounces = 3.785 L
1 mile = 5280 ft = 1.609 km	
3 ft = 1 yd	

Mass	Energy and Temperature
1 kg = 2.205 lb	1 cal = 4.184 J (exactly, ∞ sf)
1 lb = 16 oz = 453.6 g	1 Cal = 1000 cal = 1 kcal = 1 "nutritional calorie"
1 ton = 2000 lb	
1 g = 6.022 x 10^{23} amu	°C = (°F – 32)/1.8 (*∞ sf on 32 and 1.8*)
	K = °C + 273.15

Be able to make conversion factors out of any of these equalities. **Examples:**

$$\frac{1\text{ mile}}{5280\text{ ft}} \quad \text{or} \quad \frac{5280\text{ ft}}{1\text{ mile}}$$

$$\frac{1\text{ L}}{1000\text{ cm}^3} \quad \text{or} \quad \frac{1000\text{ cm}^3}{1\text{ L}}$$

$$\frac{16\text{ oz}}{453.6\text{ g}} \quad \text{or} \quad \frac{453.6\text{ g}}{16\text{ oz}}$$

$$\frac{4\text{ qt}}{3.785\text{ L}} \quad \text{or} \quad \frac{3.785\text{ L}}{4\text{ qt}}$$

Background: Converting within the English system and from metric ↔ English

Unlike conversions within a given system of units (typically definitions with ∞ sf), when we convert between systems of units, they are measurements (with limited sf).

Type of conversion	Description
metric* ↔ metric	Defined = ∞ sf
English ↔ English	Defined = ∞ sf
metric ↔ English	Measured = limited sf #

* Important metric units include: gram (g), meter (m), liter (L), second (s).

important exception:
1 in. = 2.54 cm

Length

1 m* = 39.37 in. = 1.094 yd

1 in. = 2.54 cm* (exactly, ∞ sf)#

1 mile = 5280 ft = 1.609 km*

3 ft = 1 yd

Volume

1 L* = 1000 cm^3* = 1.057 qt

1 gal = 4 qt = 8 pt = 128 fluid ounces = 3.785 L*

Mass

1 kg* = 2.205 lb

1 lb = 16 oz = 453.6 g*

1 ton = 2000 lb

1 g* = 6.022×10^{23} amu

Background: Converting within the English system and from metric* ↔ English

Examples:

$$\frac{1 \text{ mile}}{5280 \text{ ft}}$$

English ↔ English
defined = ∞ ***sf***

$$\frac{16 \text{ oz}}{453.6 \text{ g}^{*}}$$

English ↔ metric
measured = ***4 sf***

Note: The whole number part of any metric ↔ English conversion has ∞ sf. It is the decimal part that limits the sig figs.

$$\frac{1^{*} \text{ L}}{1000 \text{ cm}^3}$$

metric ↔ metric
defined = ∞ ***sf***

$$\frac{4 \text{ qt}}{3.785 \text{ L}^{*}}$$

English ↔ metric
measured = ***4 sf***

Progress clicker question: Covers material we are learning now
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4) Which of the following is the largest volume?

A) 2.0 qt

B) 2.0 x 10^8 nL

C) 2.0 x 10^2 fluid ounces

D) 2.0 L

Answer: Hint: convert them all to "L" and compare.

A) $(2.0\ \text{qt})\left(\frac{3.785\ \text{L}}{4\ \text{qt}}\right) = 1.8925\ \text{L} = 1.9\ \text{L}$ *(keep 2 sf)*

(2 sf; 4 sf)

B) $(2.0 \times 10^8\ \text{nL})\left(\frac{10^{-9}\ \text{L}}{1\ \text{nL}}\right) = 0.20\ \text{L}$ *(keep 2 sf)*

(2 sf; ∞ sf)

C) $(2.0 \times 10^2\ \text{fl oz})\left(\frac{3.785\ \text{L}}{128\ \text{fl oz}}\right) = 5.9140625\ \text{L} = 5.9\ \text{L}$ *(keep 2 sf)*

(2 sf; 4 sf)

D) 2.0 L