

Lecture 4 CH101 A1 (MWF 9:05 am) Fall 2017 Copyright © 2017 Dan Dill dan@bu.edu

[TP] Which of the following contains the **smallest number of atoms**?

25% 1. 187 g of liquid mercury, Hg  
 25% 2. 1400 u of uranium, U  
 25% 3.  $6 \times 10^{24}$  atoms of sodium, Na  
 25% 4. 2 mol of hydrogen gas, H<sub>2</sub>

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 Wednesday, September 13, 2017

For today ...

- Complete: Isotopes → atomic weight
- Chemist's dozen: The mole

Next lecture: Begin ch3: Naming things. Molecular mass spectra; mass spectra of compounds with Br (or Cl); light; infrared (IR) spectra

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[TP] For our hypothetical class, average weight of a CH101 student is 144 lbs. Which of the following statements is true for this class?

0% 1. The weight of each student is 144 lbs  
 0% 2. No student weighs 144 lbs  
 0% 3. Neither of the statements is true.

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Average mass of an atom of K

Two isotopes: K-39 and K-41  
 How many protons and how many neutrons in each?

sodium	22.98976928
19	
K	
potassium	39.0983
37	

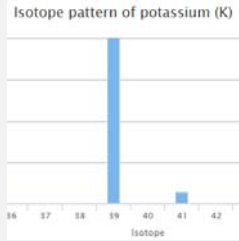
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### Average mass of an atom of K

Two isotopes: K-39 and K-41  
 K-39 peak at 38.9637 u, height 933  
 K-41 peak at 40.9618 u, height 67

Write and then evaluate the expression whose value is the **average mass in u** of an atom of K.

$$f_{39} 38.9637 \text{ u} + f_{41} 40.9618 \text{ u} = 39.098 \text{ u}$$


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### Average mass of an atom of K

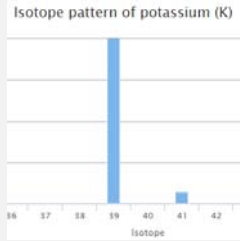
Two isotopes: K-39 and K-41  
 K-39 peak at 38.9637 u, height 933  
 K-41 peak at 40.9618 u, height 67

The average mass **in g** of an atom of K is

$$= 39.098 \text{ u}$$

$$= 39.098 \times (1/12) \times 12 \text{ g} \times (1/N_A)$$

$$= 39.098 \text{ g} / N_A$$

$$= 6.4923 \times 10^{-23} \text{ g}$$


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### Average mass of any **atom**

The average mass of an atom of K is  $39.098 \text{ g} / N_A$   
 The average mass of an atom of Br is  $79.904 \text{ g} / N_A$   
 The average mass of an atom of H is  $1.008 \text{ g} / N_A$

The **average mass of any atom in g /  $N_A$**  is the number given on the periodic table.

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### Molar mass of any **element**

**Molar mass** is the mass of  $N_A$  "average" atoms of an element.

The average mass of an atom of K is  $39.098 \text{ g} / N_A$   
 The molar mass of K is  $N_A \times (39.098 \text{ g} / N_A) = 39.098 \text{ g}$   
 The molar mass of Br is  $79.904 \text{ g}$   
 The molar mass of H is  $1.008 \text{ g}$

The **molar mass of any element in g** is the number given on the periodic table.

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**Atomic weight = magnitude of average mass**

The atomic weight of K is 39.098 (no units!)

The atomic weight of Br is 79.904

The atomic weight of H is 1.008

The atomic weight of an element is the number given on the periodic table.



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**[TP]** The periodic table indicates that “C” has a mass of 12.011. Which of the following statements is true?

- 14% 1. All carbon atoms have mass 12.011 g
- 14% 2. All carbon atoms have mass 12.011 u
- 14% 3. No carbon atoms have mass 12.011 g
- 14% 4. No carbon atoms have mass 12.011 u
- 14% 5. (1) and (2) are correct
- 14% 6. (3) and (4) are correct
- 14% 7. None of the above



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**[Quiz]** The molar mass of Cl is 35.453 g.  $^{37}\text{Cl}$  has a natural abundance of 24.24%. Which of the following statements is true?

- 0% 1. The mass of one atom of naturally occurring Cl is 35.453 g divided by Avogadro's number
- 0% 2. The mass of one atom of naturally occurring Cl cannot be 35.453 g divided by Avogadro's number.
- 0% 3. Neither of the statements is true.



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**Terms to distinguish****Relative atomic mass,  $A_r$ :** ratio of mass of an isotope relative to mass of 1/12 of one  $^{12}\text{C}$  atom $A_r$  of  $^{13}\text{C}$  is 13.00335 (unitless)**Atomic mass unit, u:** 1/12 mass of one  $^{12}\text{C}$  atom $1 \text{ u} = (1/12) \times (12 \text{ g}) / N_A = \text{g} / N_A = 1.66054 \times 10^{-24} \text{ g}$ **Atomic weight:** average of **relative atomic masses** of the isotopes of an element

Atomic weight of C is 12.01 (unitless)

**Molar mass,  $M$ :** Mass in grams numerically equal to atomic weight; that is, the mass in grams of  $N_A$  “average atoms” of an element

Molar mass of C is 12.01 g



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Chemist's dozen: mole → counting by weighing



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## Mole: Count by weighing

The mass in g of 1 mol of any element is called its **molar mass**

Number of particles in 1 mol is  $N_A = 6.022140857 \times 10^{23}$

Each of these **amounts** contains the **same number** of atoms



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- 25% 3.  $6 \times 10^{24}$  atoms of sodium, Na
- 25% 4. 2 mol of hydrogen gas, H<sub>2</sub>



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[Quiz] Which of the following contains the **largest number of atoms**?

- 25% 1. 187 g of liquid mercury, Hg
- 25% 2. 1400 u of uranium, U
- 25% 3.  $6 \times 10^{24}$  atoms of sodium, Na
- 25% 4. 2 mol of hydrogen gas, H<sub>2</sub>



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