



a place of mind

FACULTY OF EDUCATION

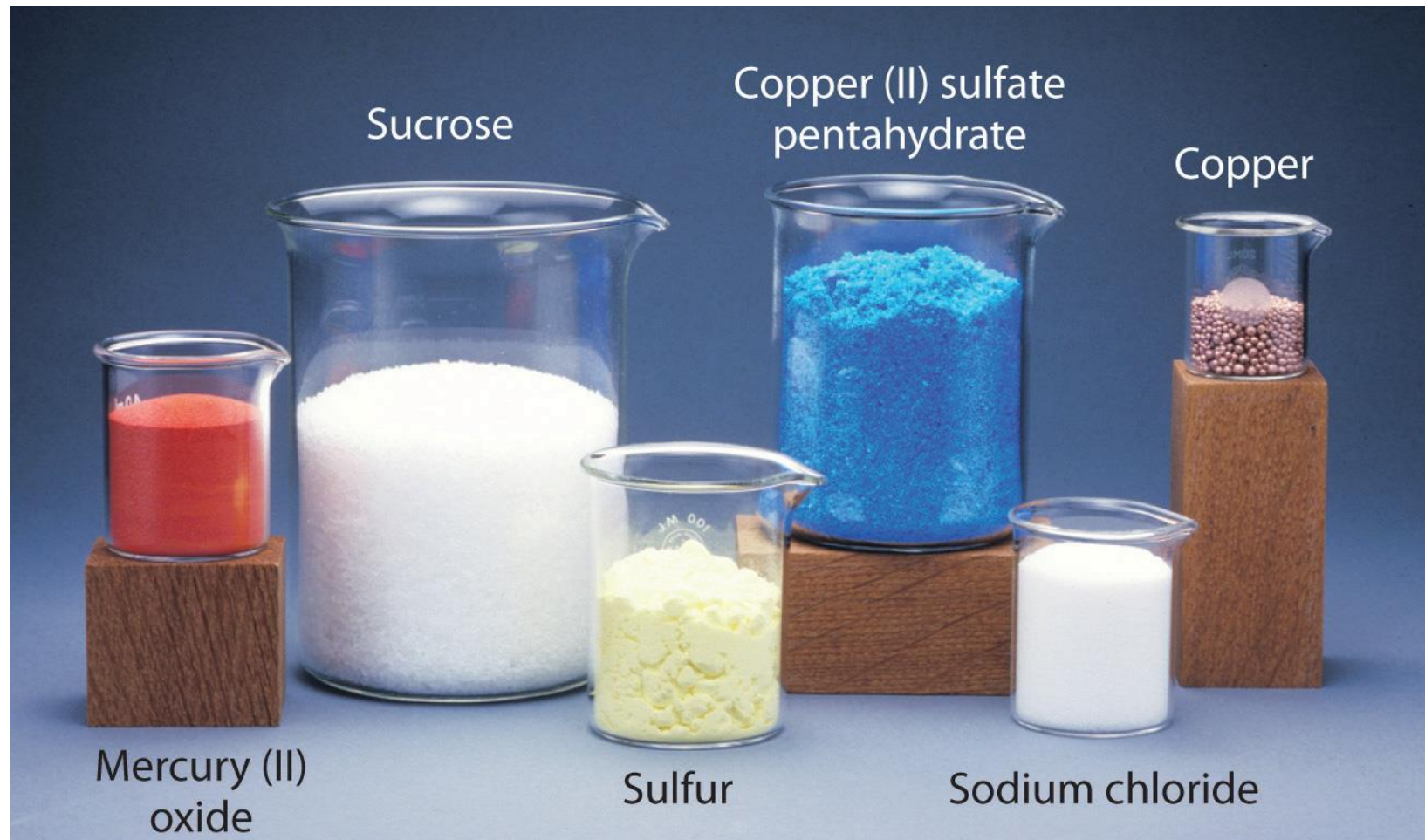
Department of
Curriculum and Pedagogy

Chemistry

Stoichiometry: Moles

Science and Mathematics
Education Research Group

The Mole



The Mole I

Which of the following statements best describes a mole?

A mole is:

- A. a unit of mass of a substance
- B. a quantity of molecules in 1g of a substance
- C. a specific amount of something
- D. the mass of 6.022×10^{23} atoms of a substance
- E. the molar mass of a substance

Solution



Answer: C

Justification: Just like the word “dozen” refers to 12 of something, the word “mole” refers to an amount of something. The difference between a mole and a dozen is that a mole is a much, much bigger number.

B is incorrect because a mole refers to a set number of something, not an amount of something in 1 gram.

A and D are incorrect because they are saying that a mole is a unit of mass, which is incorrect. A mole is a unit-less value that is just used to count the amount of something.

E is incorrect. To get the molar mass you have to use the mole, but the definition of a mole is not molar mass.

The Mole II

What is the value of the Avogadro number?

A. 6.023×10^{22} kg

B. 6.023×10^{22}

C. 6.022×10^{-23}

D. 602,200,000,000,000,000,000,000 (20 zeros after the 2)

E. 6.022×10^{23} kg

Solution

Answer: D

Justification: The Avogadro number tells you how many atoms are needed to make the mass of 1 mole of a substance equal to the atomic mass unit of a single atom, except with the units of grams.

This is the number that the “mole” refers to. It is a VERY large number. Thus, the answer is not C.

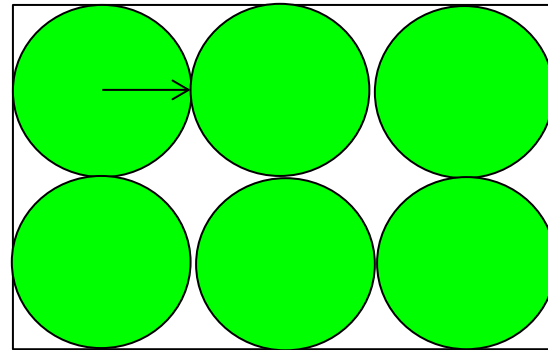
The answer is not A or E because the Avogadro number should be a unit-less number.

The answer is not B because the decimal places and the exponent have been mixed up.

The Mole III

If you have one mole of green peas, how many times could you cover the surface of the earth? The radius of a pea is about 2.5 mm, and the radius of the earth is about 6371 km.

- A. 23 times
- B. 23,000 times
- C. 26,000,000 times
- D. 2.6×10^{19} times
- E. None of the above



Surface area
of a sphere $= 4\pi r^2$

Solution

Answer: B

Justification: The calculation steps are shown below. If you got a similar answer but with a different order of magnitude then you did not convert the units to a common unit (ex. all in mm or all in km). The question gave the radius of a pea in mm and the radius of the earth in km.

$$\frac{\left(\begin{array}{l} \text{Total area that} \\ \text{1 mole of peas} \\ \text{could cover} \end{array} \right)}{\left(\begin{array}{l} \text{Surface area} \\ \text{of the earth} \end{array} \right)} = \frac{\left(\begin{array}{l} \text{Cross} \\ \text{section area} \\ \text{of a pea} \end{array} \right) \left(\begin{array}{l} \text{Avogadro \#} \end{array} \right)}{\left(\begin{array}{l} \text{Surface area} \\ \text{of the earth} \end{array} \right)} = \frac{(\pi r^2)(6.022 \times 10^{23})}{(4\pi R^2)}$$

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Solution

Answer: B

Justification: The answer A does not make logical sense since it is so small. The mole is such a large number, that a mole of peas will cover the earth far more than 23 times.

The answer is not C or D because the Avogadro number was not used. The method used to get these numbers was to divide the surface area of the earth by the cross sectional area of a pea. This tells you amount of peas needed to cover the surface of the earth once.

What does this tell us???

This shows how incredibly small an atom is. 1 mole of salt molecules can easily fit within in a small beaker, but 1 mole of peas (which we consider to be small) will cover the earth 2.6×10^{19} times

The Mole IV

Atomic mass unit (amu) is defined as 1/12 of the mass of 1 carbon atom. A carbon atom consists of 6 protons and 6 neutrons. The masses of a proton and a neutron are almost the same. They are approximately 1.67×10^{-24} g. How many grams are in 1 amu?

A. 12.0 g

B. 1.0 g

C. 1.67×10^{-24} g

D. 1.4×10^{-25} g

E. 1.022×10^{-23} g

Solution

Answer: C

Justification: Similar to how we can figure out the number of grams in a kilogram (1000g/kg) or how many kilograms are in a gram (0.0001kg/g), we can find how many grams are in an amu.

A carbon atom has 6 protons and 6 neutrons. If a proton and a neutron have about the same mass, the total mass of the carbon atom will be 12 times the mass of a single proton/neutron.

If the definition of an amu is $1/12$ the mass of a carbon atom, then an amu is simply the mass of 1 proton/neutron.

The Mole V

What is the mass (in grams) of 1 mole of atomic mass units (amu)?

A. 12.0 g

B. 1.0 g

C. 6.022×10^{23} g

D. 6.022×10^{-23} g

E. 1.67×10^{24} g

Solution

Answer: B

Justification: If 1 amu equals 1.67×10^{-24} g, then to find the mass of 1 mole of amu units, you must multiply the mass of 1 amu by the Avogadro number.

$$6.022 * 10^{23} \times 1.67 * 10^{-24} \text{ g} = 1.0 \text{ g}$$

What does this tell us???

If we weigh 1 mole of any element, the scale will read the atomic mass value in grams. In this example, 1 mole of something with a mass of 1 amu had a total mass of 1 g.

The Mole VI

What is the mass of 1 mole of carbon atoms?

- A. 12.0 g
- B. 24.0 g
- C. 12.0 amu
- D. 12.0 g/mol
- E. None of the above

Solution

Answer: A

Justification: The molar mass of carbon is 12.0 g/mol.

The answer is not B because carbon is not diatomic. Carbon atoms mean just C, not C₂.

One mole of carbon thus has a mass of 12.0 g.

C is incorrect because that is the mass of a single carbon atom, not a mole of carbon atoms.

D is incorrect because the units are not the correct units of mass.

The Mole VII

What is the mass of a nitrogen atom?

- A. 14.0 g
- B. 28.0 g
- C. 2.32×10^{-23} g
- D. 28.0 amu
- E. None of the above

Solution

Answer: C

Justification: The molar mass of a nitrogen atom is 14.0 g/mol.

The answer is not A or B because the mass of a single atom is very small. That is why the unit “amu” (atomic mass unit) is used. A and B are the masses for a mole of the atom N or the molecule N₂.

The answer is not D because while Nitrogen is a diatomic element, you don't need to calculate the mass of N₂ because the question is looking for the mass of a nitrogen atom not a molecule. Thus you would not use the diatomic N₂.

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Solution

Answer: C

Justification: The answer is C because the mass of a nitrogen atom is 14.0 amu. This can also be shown in grams.

If we weigh 1 mole of any element, the scale will read the atomic mass value in grams (also called the molar mass). Thus, if we divide the molar mass by the Avogadro number, you will get the mass of 1 atom (in grams).

$$\frac{14.0 \text{ g}}{6.022 * 10^{23}}$$

The Mole VIII

What is the molar mass of an oxygen molecule?

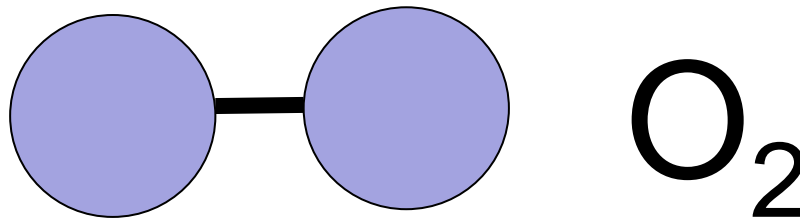
- A. 16.0 g
- B. 32.0 g
- C. 16.0 g/mol
- D. 32.0 amu
- E. None of the above

Solution

Answer: E

Justification: Oxygen is a diatomic element, thus it exists as O_2 . A single oxygen atom has a molar mass of 16.0 g/mol. Thus the molar mass of an oxygen molecule is twice that amount.

None of the listed answers were correct because the units were not correct. The correct answer is 32.0 g/mol.



The Mole IX

What is the molar mass of sucrose ($C_{12}H_{22}O_{11}$)?

- A. 29.0 g/mol
- B. 2.1×10^{26} amu/mol
- C. 540.0 g/mol
- D. 342.0 amu/mol
- E. None of the above

Solution

Answer: B

Justification: To calculate the molar mass, you need to add together the molar masses of all the atoms in the molecule. There are 12 carbon atoms, 22 hydrogen atoms, and 11 oxygen atoms. This comes out to 342.0 g/mol (this answer was not an option).

Answer D is not correct because the units are in amu/mol. However, the value of 342.0 was in g/mol.

Answer B is correct because the 342.0 g/mol was converted to amu/mol by multiplying the mass in grams by the Avogadro number. This is not a normal way of presenting molar mass, however it is technically still correct.