a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Chemistry

Stoichiometry: Conversion Factors

Science and Mathematics Education
Research Group

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Conversion Factors

$$25.0\ \cancel{mL} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{0.150\ \cancel{mol}}{1\ \cancel{L}} \times \frac{58.4\ g}{1\ \cancel{mol}}$$

Best Practices I

Example 1 – Unit conversion: Convert 58 km/h and into m/s

$$\frac{km}{h} = \ldots = \frac{m}{s} \Rightarrow \frac{km}{h} = \frac{\cancel{km}}{\cancel{h}} \times \frac{m}{\cancel{km}} \times \frac{\cancel{h}}{s} = \frac{m}{s}$$

$$58\ \frac{km}{h} = 58\ \frac{\text{km}}{\text{h}} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{h}}{3600\ \text{s}} = \frac{58}{3.6}\ \frac{m}{s} = 16\ \frac{m}{s}$$

Best Practices II

Example 2 – Dimensional analysis: How many molecules are there in 4.5 g of NaCl? The molar mass of NaCl is 58.5 g/mol

$$\text{grams of NaCl} \rightarrow \text{moles of NaCl} \rightarrow \text{molecules of NaCl}$$

$$4.5\ \cancel{\text{g}} \times \frac{1\ \cancel{\text{mol}}}{58.5\ \cancel{\text{g}}} \times \frac{6.022\times10^{23}\ \text{molecules}}{1\ \cancel{\text{mol}}} = 4.6\times10^{22}\ \text{molecules}$$

Conversion Factors I

What is the correct calculation to find the amount of moles in a 12.5 g sample of $CuSO_4$?

A. $12.5\, g \times \frac{1\, mol}{160.\ g}$

B. $12.5\, g \times \frac{159.6\, g}{1\, mol}$

C. $12.5\, g \times \frac{1\, mol}{159.6\, g}$

D. $12.5\, g \times \frac{159.6\, mol}{1\, g}$

E. $1\, mol \times \frac{12.5\, g}{159.6\, g}$

Solution

Answer: C

Justification: The answer is not A, because you shouldn’t round your molar mass before you do the calculation.

The answer is not B because the conversion factor does not cancel out the grams. The conversion factor would need to be flipped to cancel out the grams.

The answer is not D because the conversion factor is wrong. You can’t have 159.6 moles in 1 gram. Rather, the conversion factor should be 159.6 grams in 1 mole.

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Solution

Answer: C

Justification: Though E will give you the correct value for the amount of moles, the steps shown for doing the calculation do not follow good convention for doing mole calculations since the ratio does not show a single conversion factor which you can then cancel out units from.

The answer is C because the units cancel out correctly as shown below:

$$12.5\,\cancel{g} \times \frac{1\,mol}{159.6\,\cancel{g}}$$

Conversion Factors II

Which of the following statement(s) accurately describes one mole of oxygen in one balloon and one mole of ammonia (NH_3) gas in another balloon at STP?

A. The oxygen balloon has a volume of 22.4 L

B. The ammonia balloon has a volume larger than 22.4 L

C. The ammonia balloon has the same mass and volume as the oxygen balloon.

D. A and B

E. A and C

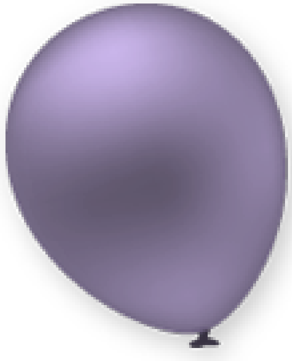
Solution

Answer: A

Justification: We know that for any type of gas, a 1 mol sample at STP (standard temperature and pressure) will have a volume of 22.4 L.

Thus the two different gases would have the same volume at STP, but the masses would be different since they are different molecules.

Conversion Factors III



You now combine the 1 mole of oxygen gas and 1 mole of ammonia gas into a different balloon at STP. What is the volume of this new balloon?

A. It has a volume that is less than 22.4 L

B. It has a volume of 22.4 L

C. It has a volume between 22.4 L and 44.8 L

D. It has a volume of 44.8 L

E. We can’t know the volume because the pressure is not the same in this balloon compared to the previous balloons.

Solution

Answer: D

Justification: We now have 2 moles of a gas at STP, thus the volume is 44.8 L.

(That is one giant balloon.)

Conversion Factors IV

What is the correct calculation to find the mass of a 10.0 L sample of carbon monoxide gas at STP?

A. $10.0\,L \times \frac{1\,mol}{22.4\,L} \times \frac{28.0\,g/mol}{1\,mol}$

B. $10.0\,L \times 22.4\frac{L}{mol} \times 28.0\frac{g}{mol}$

C. $10.0\,L \times \frac{1\,g}{22.4\,L}$

D. $\frac{22.4\,L}{1\,mol} \times \frac{1}{10.0\,L} \times \frac{1\,mol}{28.0\,g}$

E. $10.0\,L \times \frac{1\,mol}{22.4\,L} \times \frac{28.0\,g}{1\,mol}$

Solution

Answer: E

Justification: The answer is not A because the units don't cancel out properly. The molar mass units are written incorrectly and mean something different. $\frac{28.0\ g/mol}{1\ mol} = \frac{28.0\ g}{1\ mol^2}$

The answer is not B because you can't just multiply everything. You need to make sure the units cancel out.

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Solution

Answer: E

Justification: The answer is not C because $\frac{1\ g}{22.4\ L}$ is not a proper conversion factor. g and L are not directly linked in any conversion factors. You need to go through moles first.

The answer is not D because you end up with the units of 1/g instead of g.

The units correctly cancel out in E as shown below:

$$\text{E.}\quad 10.0\ \cancel{L} \times \frac{1\ \cancel{mol}}{22.4\ \cancel{L}} \times \frac{28.0\ g}{1\ \cancel{mol}}$$

Conversion Factors V

What is the concentration of 2.0 g of NaCl dissolved in 25 mL of water?

A. 1.4 M

B. 0.080 g/mL

C. 0.0014 mol/mL

D. 80. g/L

E. All of the above

Solution

Answer: E

Justification: Each answer is a different way of representing concentration with different units.

In chemistry the most common way to describe concentration is with molarity (mol/L).

To calculate a concentration, you need to divide the mass of the solute by the volume of the solvent. Then, you can use conversion factors to convert the grams and mL into mol and L if you want the answer in mol/L. In this case you would do this as shown below:

$$\frac{2.0\ \cancel{g}}{25\ \cancel{mL}} \times \frac{1000\ \cancel{mL}}{1\ L} \times \frac{1\ mol}{58.4\ \cancel{g}}$$

Conversion Factors VI

Saline solution is a sterile salt water (NaCl) solution used to clean contacts. If the solution is 0.150 M, what mass of salt is in a 25.0 mL sample?

A. 219 g

B. 0.219 g

C. 3.75 g

D. 0.00375 g

E. None of the above

Solution

Answer: B

Justification: The correct sequence of solving this problem would be to convert:

mL of NaCl $\longrightarrow$ L of NaCl $\longrightarrow$ mol of NaCl $\longrightarrow$ g of NaCl

$$25.0\ \cancel{mL} \times \frac{1\ \cancel{L}}{1000\ \cancel{mL}} \times \frac{0.150\ \cancel{mol}}{1\ \cancel{L}} \times \frac{58.4\ g}{1\ \cancel{mol}}$$

A is incorrect because mL was not converted to L.

You would have got C and D if you did not include the molar mass in your calculation.

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Solution

Answer: B

Justification: You could also try to answer this question logically by considering each of the answers.

1 mL of water has a mass of 1 g. Thus, 25 mL of the saline solution would weigh just over 25 g.

The salt in the solution then could not possibly weigh 219 g (A).

3.75 g (B) seems too large also (almost a third of the weight of the solution).

0.00375 g (C) seems too small.

This leaves B.

Conversion Factors VII

How many molecules of Na_2SO_4 are in 5.3L of a 2.5M solution?

A. 8.0×10^{24} molecules

B. 1.1×10^{27} molecules

C. 1.9×10^{3} molecules

D. 1.3×10^{1} molecules

E. None of the above

Solution

Answer: A

Justification: The correct sequence of solving this problem would be to convert:

L of Na_2SO_4 $\longrightarrow$ mol of Na_2SO_4 $\longrightarrow$ molecules of Na_2SO_4

The conversion factors that you would thus use need would be:

$$5.3\,\cancel{L} \times \frac{2.5\,\cancel{mol}}{1\,\cancel{L}} \times \frac{6.022 * 10^{23}\,molecules}{1\,\cancel{mol}}$$

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Solution

Answer: A

Justification: It is a common mistake to think that you need to include molar mass for any stoichiometry question. However, for this question it was not needed.

B is not correct because the molar mass was included as an extra conversion factor in the calculation. This is not needed and it does not allow the units to cancel out correctly.

C is incorrect because the answer gives the mass of the sodium sulphate in the sample instead of the amount of molecules. The molar mass was used for this calculation.

D is incorrect because it shows the number of moles present, not the molecules. The final conversion factor was missed.