#420262

Topic: Mole and equivalent weight

Estimate the fraction of molecular volume to the actual volume occupied by oxygen gas at STP. Take the diameter of an oxygen molecule to be $3\mathring{A}$.

Solution

Diameter (size) of oxygen molecule $= 3\mathring{A}$

Radius of oxygen molecule, $r = \frac{3}{2}\mathring{A} = 1.5 \times 10^{-10} m$

Therefore, volume of 1 mole of oxygen gas at S.T.P

$= \frac{4}{3}\pi r^3 \times N$

$= \frac{4}{3} \times \pi \times (1.5 \times 10^{-10})^3 \times 6.0225 \times 10^{23}$

$= 8.514 \times 10^{-6} m^3 = 8.514 \times 10^{-3}$ litre

Fraction of the molecular volume occupied $= \frac{8.514 \times 10^{-3}}{22.4} = 3.8 \times 10^{-4}$

#422265

Topic: Atomic mass and molecular mass

Calculate the molar mass of the following:

(i) H_2O

(ii) CO_2

(iii) CH_4

Solution

(i) Molar mass of water (H_2O) = 2 × atomic mass of hydrogen + atomic mass of oxygen

Molar mass of water = $2(1\ g/mol) + 16\ g/mol = 18\ g/mol$

(ii) Molar mas of CO_2 = atomic mass of C + 2 × atomic mass of oxygen

Molar mass of $CO_2 = 12\ g/mol + 2(16\ g/mol) = 44\ g/mol$

(iii) Molar mass of methane = atomic mass of carbon + 4atomic mass of hydrogen

Molar mass of methane = $12\ g/mol + 4(1\ g/mol) = 16\ g/mol$

#422266

Topic: Atomic mass and molecular mass

Calculate the molar mass of CO_2.

Solution

Molar mas of CO_2 = atomic mass of C + 2 × atomic mass of oxygen

Molar mass of $CO_2 = 12\ g/mol + 2(16\ g/mol) = 44\ g/mol$

#422268

Topic: Atomic mass and molecular mass

Calculate the molar mass of the following:

CH_4

Solution

Molar mass of methane = atomic mass of carbon + 4 atomic mass of hydrogen

Molar mass of methane = $12\ g/mol + 4(1\ g/mol) = 16\ g/mol$

#422271

Topic: Concentrations

Calculate the mass percent of O present in sodium sulphate $\left(Na_2SO_4\right)$.

Solution

The molar mass of sodium sulphate is $2(23) + 32 + 4(16) = 46 + 32 + 64 = 142\ g/mol$

The mass percentage of sodium in sodium sulphate is the ratio of the mass of sodium present in 1 mole of sodium sulphate to the maolar mass of sodium sulphate multiplied by 100.

The mass percentage of oxygen in sodium sulphate $= \frac{64}{142} \times 100 = 45.07\%$.

#422275

Topic: Percentage composition, empirical and molecular formula

Determine the empirical formula of an oxide of iron which has 69.9% iron and 30.1% dioxygen by mass.

Solution

The iron oxide has 69.9% iron and 30.1% dioxygen by mass.

Thus, 100 g of iron oxide contains 69.9 g iron and 30.1 g dioxygen.

The number of moles of iron present in 100 g of iron oxide are $\frac{69.9}{55.8} = 1.25$.

The number of moles of dioxygen present in 100 g of iron oxide are $\frac{30.1}{32} = 0.94$.

The ratio of the number of oxygen atoms to the number of carbon atoms present in one formula unit of iron oxide is

$\frac{2 \times 0.94}{1.25} = 1.5:1 = 3:2$.

Hence, the formula of the iron oxide is Fe_2O_3.

#422277

Topic: Stoichiometry and calculations based on stoichiometry

Calculate the amount of carbon dioxide that could be produced when

(i) 1 mole of carbon is burnt in air.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

Solution

(i) 1 mole of carbon is burnt in air.

$C + O_2 \rightarrow CO_2$

1 mole of C produces 1 mole of CO_2 which corresponds to 44 g of CO_2.

(ii) 1 mole of carbon is burnt in 16 g of dioxygen.

16 g of dioxygen corresponds to $\frac{16}{32} = 0.5$ moles.

Here, dioxygen is the limiting reagent.

It will produce 0.5 moles of CO_2 which corresponds to $0.5 \times 44 = 22$ g of CO_2.

(iii) 2 moles of carbon are burnt in 16 g of dioxygen.

16 g of dioxygen corresponds to $\frac{16}{32} = 0.5$ moles.

Here, dioxygen is the limiting reagent.

It will produce 0.5 moles of CO_2 which corresponds to $0.5 \times 44 = 22$ g of CO_2.

#422279

Topic: Concentrations

Calculate the mass of sodium acetate (CH_3COONa) required to make 500 ml of 0.375 molar aqueous solution. Molar mass of sodium acetate is 82.0245 g mol^{-1}.

Solution

The mass of sodium acetate $= \frac{\text{volume in mL}}{1000\ mL/L} \times molarity \times \text{molar mass} = \frac{500}{1000} \times 0.375 \times 82.0245 = 15.38$ g.

#422282

Topic: Concentrations

Calculate the concentration of nitric acid in moles per litre in a sample which has a density 1.41 g mL^{-1} and the mass per cent of nitric acid in it being 69%.

Solution

The density of the solution is 1.41 g/mL.

1000 g of the solution will have a volume $= \frac{\text{Mass}}{\text{Density}} = \frac{1000}{1.41} = 709$ ml.

The mass per cent of nitric acid is 69%.

1000 g of the solution will have $1000 \times \frac{69}{100} = 690$ g of nitric acid.

The molarity of solution is $\frac{\text{Mass of nitric acid}}{\text{Molar mass of nitric acid } \times \text{Volume of solution}} = \frac{690}{63 \times 709} = 0.0155$ M.

#422284

Topic: Stoichiometry and calculations based on stoichiometry

How much copper can be obtained from 100 g of copper sulphate ($CuSO_4$)?

Solution

The molar masses of copper and copper sulphate are 63.5 g/mol and 159.6 g/mol respectively.

100 g of copper sulphate will contain $\frac{63.5}{159.6} \times 100 = 39.76$ g of copper.

#422285

Topic: Percentage composition, empirical and molecular formula

Determine the molecular formula of an oxide of iron in which the mass per cent of iron and oxygen are 69.9 and 30.1 respectively.

Solution

The iron oxide has 69.9% iron and 30.1% dioxygen by mass.

Thus, 100 g of iron oxide contains 69.9 g iron and 30.1 g dioxygen.

The number of moles of iron present in 100 g of iron oxide are $\frac{69.9}{55.8} = 1.25^{.}$

The number of moles of dioxygen present in 100 g of iron oxide are $\frac{30.1}{32} = 0.94^{.}$

The ratio of the number of oxygen atoms to the number of carbon atoms present in one formula unit of iron oxide is

$\frac{2 \times 0.94}{1.25} = 1.5:1 = 3:2^{.}$

Hence, the formula of the iron oxide is Fe_2O_3.

#422296

Topic: Atomic mass and molecular mass

Calculate the atomic mass (average) of chlorine using the following data :

	% Natural Abundance	Molar Mass
^{35}Cl	75.77	34.9689
^{37}Cl	24.23	36.9659

Solution

Average atomic mass of chlorine $= \frac{75.77 \times 34.9689 + 24.23 \times 36.9659}{100} = 35.45$ g/mol.

#422301

Topic: Mole and equivalent weight

If 3 moles of ethane $\left(C_2H_6\right)$ are given, calculate the following:

(i) Number of moles of carbon atoms.

(ii) Number of moles of hydrogen atoms.

(iii) Number of molecules of ethane.

Solution

1 mole of ethane (C_2H_6) has 2 moles of carbon and 6 moles of hydrogen.

We are given 3 moles of ethane.

(i) Number of moles of carbon atoms $= 3 \times 2 = 6$

(ii) Number of moles of hydrogen atoms $= 3 \times 6 = 18$

(iii) Number of molecules of ethane $= 3 \times 6.023 \times 10^{23} = 1.8069 \times 10^{24}$

#422303

Topic: Concentrations

What is the concentration of sugar $\left(C_{12}H_{22}O_{11}\right)$ in mol L^{-1} if its 20 g are dissolved in enough water to make a final volume up to $2L$?

Solution

$$\text{Molarity} = \frac{\text{Mass}}{\text{Molar mass} \times \text{Volume}}$$

The concentration of sugar $(C_{12}H_{22}O_{11})$ is $\dfrac{20}{342 \times 2} = 0.029\ mol/L$.

#422306

Topic: Concentrations

If the density of methanol is 0.793 kg L^{-1}, what is its volume needed for making 2.5 L of its 0.25 M solution?

Solution

Mass of methanol required $=$ Volume of solution $\times$ Molariy of solution $\times$ Molar mass of methanol $= 2.5 \times 0.25 \times 32 = 20$ g.

Volume of methanol needed $= \dfrac{mass}{density} = \dfrac{20}{0.793} = 25.22$ mL.

#422312

Topic: Physical quantities and their measurements

Pressure is determined as force per unit area of the surface. The SI unit of pressure, pascal is as shown below:

$1\ Pa = 1\ N\ m^{-2}$

If mass of air at sea level is $1034\ g\ cm^{-2}$, calculate the pressure in pascal.

Solution

Pressure = weight per unit area $= mg = 1034 g/cm^2 \times \dfrac{1kg}{1000g} \times \left(\dfrac{100\ cm}{1m}\right)^2 \times 9.80 m/s^2 \times \dfrac{1N}{kgm/s^2} \times \dfrac{1Pa}{1N/m^2}$

$= 1.013 \times 10^5 Pa$

#422315

Topic: Dimensional analysis (Unit factor method)

What is the SI unit of mass? How is it defined?

Solution

Kilogram is used as SI unit of mass. It is represented by the symbol kg.

It is defined as the mass of platinium-iridium block stored at international bureau of weights and measures in France.

#422323

Topic: Physical quantities and their measurements

Match the following prefixes with their multiples:

List 1

A	micro
B	deca
C	mega
D	giga
E	femto

List 2

1	10^6
2	10^9
3	10^{-6}
4	10^{-15}
5	10

Answer: A ➞ 3, B ➞ 5, C ➞ 1, D ➞ 2, E ➞ 4

Solution

	Prefixes	Multiples
1	micro	10^{-6}
2	deca	10
3	mega	10^6
4	giga	10^9
5	femto	10^{-15}

#422326

Topic: Uncertainty in measurement and significant figures

What do you mean by significant figures?

Solution

In a given number, all the certain digits plus one doubtful digit correspond to significant figures. They depend on the precision of the scale or the instrument used for the measurement. For example, the number 1.587 represents four significant figures (three are certain and one is doubtful).

#422329

Topic: Concentrations

A sample of drinking water was found to be severely contaminated with chloroform, $CHCl_3$, supposed to be carcinogenic in nature. The level of contamination was 15 ppm (by mass).

(i) Express this in percent by mass.

(ii) Determine the molality of chloroform in the water sample.

Solution

(1) 15 parts of chlorofom in 1,000,000 parts of water corresponds to 15 ppm.

Percentage by mass of chloroform $= \frac{15 \times 100}{1,000,000} = 1.5 \times 10^{-3}$ %

(2) The molar mass of chloroform is $12 + 1 + 3 + \;\; \times 35.5 = 119.5$ g/mol.

The number of moles of chloroform are $\frac{1.5 \times 10^{-3} g}{119.5 g/mol} = 1.255 \times 10^{-5}$ mol.

The mass of water is 100 g.

Molality is the number of moles of solute in 1,000 g of solvent.

Hence, the molality of the solution is $\frac{1.255 \times 10^{-5}}{100} \times 1000 = 1.255 \times 10^{-4} m$.

#422337

Topic: Uncertainty in measurement and significant figures

Express the following in the scientific notation:

(i) 0.0048

(ii) 234,000

(iii) 8008

(iv) 500.0

(v) 6.0012

Solution

(i) 0.0048 can be written in scientific notation as 4.8×10^{-3}.

(ii) 234,000 can be written in scientific notation as 2.34×10^{5}.

(iii) 8008 can be written in scientific notation as 8.008×10^{3}.

(iv) 500.0 can be written in scientific notation as 5.000×10^{2}.

(v) 6.0012 can be written in scientific notation as 6.0012.

#422341

Topic: Uncertainty in measurement and significant figures

How many significant figures are present in the following?

(i) 0.0025

(ii) 208

(iii) 5005

(iv) 126,00

(v) 500.0

(vi) 2.0034

Solution

(i) 0.0025 contains 2 significant figures.

(ii) 208 contains 3 significant figures.

(iii) 5005 contains 4 significant figures.

(iv) 126,00 contains 3 significant figures.

(v) 500.0 contains 4 significant figures.

(vi) 2.0034 contains 5 significant figures.

#422346

Topic: Uncertainty in measurement and significant figures

Round up the following upto three significant figures:

(i) 34.216

(ii) 10.4107

(iii) 0.04597

(iv) 2808

Solution

(i) The number 34.216 is rounded to three significant figures as 34.2.

(ii) The number 10.4107 is rounded to three significant figures as 10.4.

(iii) The number 0.04597 is rounded to three significant figures as 0.046.

(iv) The number 2808 is rounded to three significant figures as 2810.

#422367

Topic: Laws of chemical combination

The following data are obtained when dinitrogen and dioxygen react together to form different compounds :

	Mass of dinitrogen	Mass of dioxygen
(i)	14g	16g
(ii)	14g	32g
(iii)	28g	32g
(iv)	28g	80g

(a) Which law of chemical combination is obeyed by the above experimental data? Give its statement.

(b) Fill in the blanks in the following conversions:

(i) 1 km = ___________mm = ___________pm

(ii) 1 mg = ___________kg = ___________ng

(iii) 1 mL = ___________L = ___________dm^3

Solution

(a) When the mass of dinitrogen is 28g , mass of dioxygen combined is 32,64,32, and 80 g . The corresponding ratio is 1:2:1:5. It is a simple whole number ratio .

This illustrates the law of multiple proportions.

It states that, "if two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers.

(b) (i) $1\ km = 1000\ m \times 100\ cm \times 10\ mm$

$\therefore 1\ km = 10^6\ mm$

$1\ km = 1000\ m \times \frac{1\ pm}{10^{-12} m}$

$\therefore 1\ km = 10^{15}\ pm$

Hence, $1\ km = 10^6\ mm = 10^{15}\ pm$

(ii) $1\ mg = 10^{-6}\ kg = 10^6\ ng$

(iii) $1\ ml = 10^{-3}\ l = 10^{-3}\ dm^3$

#422370

Topic: Physical quantities and their measurements

If the speed of light is $3.0 \times 10^8 ms^{-1}$, calculate the distance covered by light in 2.00 ns.

Solution

The distance traveled is the product of speed and time.

Thus, in 2.00 ns, the light will travel a distance of $\frac{3.00 \times 10^8 m/s \times 2.00 ns \times 10^{-9} s}{1 ns} = 0.600 m$

#422373

Topic: Stoichiometry and calculations based on stoichiometry

In a reaction $A + B_2 \rightarrow AB_2$, identify the limiting reagent, if any, in the following reaction mixtures.

(i) 300 atoms of A + 200 molecules of B_2

(ii) 2 mol A + 3 mol B_2

(iii) 100 atoms of A + 100 molecules of B_2

(iv) 5 mol A + 2.5 mol B_2

(v) 2.5 mol A + 5 mol B_2

Solution

(*i*) 200 molecules of B will react with 200 atoms of A and 100 atoms of A will remain unreacted. Hence, B_2 is the limiting reagent.

(*ii*) 2 moles of A will react with 2 moles of B_2 and 1 mole of B_2 will remain unreacted. Thus, A is the limiting reagent.

(*iii*) 100 atoms of A will react with 100 molecules of B_2. Thus, both reagents are present in stoichiometric amounts.

(*iv*) 2.5 mole of B_2 will react with 2.5 mole of A and 2.5 mole of A will remain unreacted. Hence, B_2 is the limiting reagent.

(*v*) 2.5 moles of A will react with 2.5 moles of B_2 and 2.5 moles of B_2 will remain unreacted. Thus, B_2 is the limiting reagent.

#422379

Topic: Stoichiometry and calculations based on stoichiometry

Dinitrogen and dihydrogen react with each other to produce ammonia according to the following chemical equation:

$N_2(g) + H_2(g) \rightarrow 2NH_3(g)$

(i) Calculate the mass of ammonia produced if 2.00×10^3 g dinitrogen reacts with 1.00×10^3 g of dihydrogen.

(ii) Will any of the two reactants remain unreacted?

(iii) If yes, which one and what would be its mass?

Solution

The balanced chemical equation is as follows:

$N_2 + 3H_2 \rightarrow 2NH_3$

The molar masses of nitrogen, hydrogen and ammonia are 28 g/mol, 2 g/mol and 34 g/mol respectively.

28 g of nitrogen reacts with 6 g of hydrogen to form 34 g of ammonia.

2.00×10^3 g of nitrogen will react with $\frac{6}{28} \times 2.00 \times 10^3 = 428.6$ g hydrogen.

However, 1.00×10^3g of dihydrogen are present.

Hence, nitrogen is the limiting reagent.

(i) Mass of ammonia produced $= \frac{34}{28} \times 10^3 = 2428.57$ g

(ii) Hydrogen is the excess reagent. Hence, it will remain unreacted.

(iii) Mass of dihydrogen left unreacted $= 1.00 \times 10^3 - 428.6 = 571.4$ g

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#422382

Topic: Concentrations

How are 0.50 m Na_2CO_3 and 0.50 M Na_2CO_3 different?

Solution

The molar mass of sodium carbonate is $2(23) + 12 + 3(16) = 106$ g/mol.

0.50 moles of sodium carbonate corresponds to 0.5 mol $\times$ 106 g/mol $= 53$ g of Na_2CO_3.

In 0.50 m sodium carbonate solution, 0.5 mol of sodium carbonate is present in 1000 g of water.

In 0.50 M sodium carbonate solution, 0.5 moles of sodium carbonate is present in 1 L of solution.

#422383

Topic: Stoichiometry and calculations based on stoichiometry

If ten volumes of dihydrogen gas reacts with five volumes of dioxygen gas, how many volumes of water vapour would be produced?

Solution

The balanced chemical equation for the reaction is,

$2H_2 + O_2 \rightarrow 2H_2O$.

The volume of a gas is directly proportional to the number of moles.

Thus, 2 volumes of dihydrogen reacts with 1 volume of oxygen to form 2 volumes of water.

Thus, 10 volumes of dihydrogen reacts with 5 volume of oxygen to form 10 volumes of water.

#422385

Topic: Physical quantities and their measurements

Convert the following into basic units:

(i) 28.7 pm

(ii) 15.15 pm

(iii) 25365 mg

Solution

The conversions into basic units are shown below.

(i) 28.7 pm $= 28.7pm \times \frac{1m}{10^{12}pm} = 2.87 \times 10^{-11}m$

(ii) 15.15 pm $= 15.15pm \times \frac{1m}{10^{12}pm} = 1.515 \times 10^{-11}m$

(iii) 25365 mg $= 25365 \times \frac{1kg}{10^{6}mg} = 2.5365 \times 10^{-2}kg$

#422394

Topic: Mole and equivalent weight

Which one of the following will have largest number of atoms ?

(i) 1 g Au (s)

(ii) 1 g Na (s)

(iii) 1 g Li (s)

(iv) 1 g of Cl_2 (g)

Solution

The number of atoms is directly proportional to the number of moles and is inversely proportional to the molar mass. The molar masses of Au, Na, Li and Cl_2 are 197 g/mol , 23 g/mol, 7 g/mol and 71 g/mol respectively.

Since the molar mass of Li is minimum, it will have a maximum number of atoms.

#422395

Topic: Concentrations

Calculate the molarity of a solution of ethanol in water in which the mole fraction of ethanol is 0.040 (assume the density of water to be one).

Solution

The mole fraction of ethanol is equal to the ratio of the number of moles of ethanol to the total number of moles present in the solution.

For dilute solutions, 1 L of water (or 1 L of solution) contains $\frac{1000}{18} = 55.55$ moles of water.

Let n be the number of moles of ethanol. The mole fraction of ethanol is 0.040.

Hence, $0.040 = \frac{n}{n + 55.55}$

$n = 0.040n + 2.222$

$n = \frac{2.222}{1 - 0.040} = 2.31$ moles.

The molarity of the solution is the ratio of the number of moles of solute present in 1 L of solution.

As 1 L of solution contains 2.31 moles of ethanol, the molarity of solution is 2.31 M.

#422418

Topic: Mole and equivalent weight

What will be the mass of one ^{12}C atom in g ?

Solution

The molar mass of C-12 is 12 g/mol.

1 mole of C-12 contains avogadro's number of atoms.

Thus, the mass of 1 C-12 atom will be $\frac{12}{6.023 \times 10^{23}} = 1.9927 \times 10^{-23}g$.

#422425

Topic: Uncertainty in measurement and significant figures

How many significant figures should be present in the answer of the following calculations?

(i) $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$

(ii) 5×5.364

(iii) $0.0125 + 0.7864 + 0.0215$

Solution

(i) The answer of the calculation $\frac{0.02856 \times 298.15 \times 0.112}{0.5785}$ will contain 3 significant figures as 0.112 contains 3 significant figures which is the lowest number of significant figures.

(ii) The answer of the calculation 5×5.364 will contain 4 significant figures as 5.364 contains 4 significant figures which is the lowest number of significant figures. Here, the exact figure 5 is not considered.

(iii) The answer of the calculation $0.0125 + 0.7864 + 0.0215$ will contain 4 significant figures as the result will be reported to 4 decimal places.

#422435

Topic: Atomic mass and molecular mass

Use the data given in the following table to calculate the molar mass of naturally occurring argon isotopes:

Isotope	Isotopic molar mass	Abundance
^{36}Ar	$35.96755\ g\ mol^{-1}$	0.337%
^{38}Ar	$37.96272\ g\ mol^{-1}$	0.063%
^{40}Ar	$39.9624\ g\ mol^{-1}$	99.600%

Solution

The average atomic mass of argon is $\frac{35.96755(0.337) + 37.96275(0.063) + 39.9624(99.60)}{100} = 39.94$ g/mol.

#422440

Topic: Mole and equivalent weight

Calculate the number of atoms in each of the following.

(i) 52 moles of Ar

(ii) 52 u of He

(iii) 52 g of He.

Solution

(i) The number of atoms present in 52 mol of Ar are $52 \times 6.023 \times 10^{23} = 3.13 \times 10^{25}$ atoms.

(ii) 52 u of He will contain $\frac{52}{4} = 13$ atoms.

(iii) 52 g of He will contain $\frac{52}{4} \times 6.023 \times 10^{23} = 7.82 \times 10^{24}$ atoms.

#422443

Topic: Percentage composition, empirical and molecular formula

A welding fuel gas contains carbon and hydrogen only. Burning a small sample of it in oxygen gives 3.38 g carbon dioxide, 0.690 g of water and no other products. A volume of 10.0 L (measured at STP) of this welding gas is found to weigh 11.6 g. Calculate (i) empirical formula, (ii) molar mass of the gas and (iii) molecular formula.

Solution

Since, 3.38 g of carbon dioxide are obtained, the mass of C present in the sample of welding fuel gas is

$\frac{12}{44} \times 3.38 = 0.92$ g.

Since, 0.690 g of water are obtained, the mass of hydrogen present in the welding fuel gas sample is

$\frac{2}{18} \times 0.690 = 0.077$g.

The percentage of C is $\frac{0.92}{0.92 + 0.077} \times 100 = 92.3$ %.

The percentage of H is $\frac{0.077}{0.92 + 0.077} \times 100 = 7.7$%.

(i) The number of moles of carbon $= \frac{92.2}{12} = 7.7$.

The number of moles of hydrogen $= \frac{7.7}{7.7} = 1$.

The mole ratio $C:H = \frac{7.7}{7.7} = 1:1$.

Hence, the empirical formula of the welding fuel gas is CH.

(ii) The weight of 10.0 L of gas at N.T.P is 11.6 g.

22.4 L pf gas at N.T. P will weigh $\frac{11.6}{10.0} \times 22.4 = 26 g/mol$

This is the molar mass.

(iii) Empirical formula mass is $12 + 1 = 13$.

Molecular mass is 26.

The ratio, n of the molecular mass to empirical formula mass is $\frac{26}{13} = 2$.

The molecular formula is $2(CH) = C_2H_2$.

#422452

Topic: Stoichiometry and calculations based on stoichiometry

Calcium carbonate reacts with aqueous HCl to give $CaCl_2$ and CO_2 according to the reaction, $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$.

What mass of $CaCO_3$ is required to react completely with 25 mL of 0.75 M HCl ?

Solution

The mass of HCl is $\frac{0.75 \times 36.5}{1000} \times 25 = 0.684g$.

1 mole of calcium carbonate reacts with 2 moles of HCl.

Hence, the mass of calcium carbonate that will react completely with 0.684 g of HCl is

$\frac{100}{2 \times 36.5} \times 0.684 = 0.937g$.

#422462

Topic: Stoichiometry and calculations based on stoichiometry

Chlorine is prepared in the laboratory by treating manganese dioxide $\left(MnO_2\right)$ with aqueous hydrochloric acid according to the reaction:

$4HCl(aq) + MnO_2(s) \rightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g)$.

How many grams of HCl react with 5.0 g of manganese dioxide ?

Solution

The balanced chemical equation is:

$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + 5Cl_2$.

The molar mass of MnO_2 is $55 + 2 \times 16 = 87$g/mol.

The molar mass of HCl is $1 + 35.5 = 36.5$g/mol.

Hence, 5 g of MnO_2 will react with $\frac{36.5 \times 4 \times 5}{87} = 8.39$ g of HCl.

#422613

Topic: Mole and equivalent weight

Calculate the mass and charge of one mole of electrons.

Solution

Mass of one mole of electrons is $9.11 \times 10^{-31} \times 6.023 \times 10^{23} = 5.486 \times 10^{-7}$kg.

Charge of 1 mole of electrons is $1.602 \times 10^{-19} \times 6.023 \times 10^{23} = 9.647 \times 10^{4} C$.

#422622

Topic: Mole and equivalent weight

Find (a) the total number and (b) the total mass of neutrons in 7 mg of ^{14}C.

(Assume that mass of a neutron =$1.675 \times 10^{-27} kg$)

Solution

Number of neutrons is equal to the difference in the mass number and atomic number.

It is equal to $14 - 6 = 8$.

(a) The number of neutrons present in 7 mg of C-14 is $\frac{6.023 \times 10^{23} \times 8}{14} \times 7 \times 10^{10-3} = 2.4088 \times 10^{21}$ neutrons.

(b) Total mass of neutrons in 7 mg of C-14 is $2.4088 \times 10^{21} \times 1.675 \times 10^{-27} 4.035 \times 10^{-6}$ kg.

#422626

Topic: Mole and equivalent weight

Find (a) the total number and (b) the total mass of protons in 34 mg of NH_3 at STP.

Will the answer change if the temperature and pressure are changed ?

Solution

(a)Number of protons present in 1 molecule of ammonia $= 7 + 3 = 10$.

Number of molecules present in 34 mg of ammonia is $\frac{6.023 \times 10^{23} \times 34 \times 10^{-3}}{17} = 1.2044 \times 10^{21}$.

Total number of protons present in 34mg of ammonia $= 10 \times 1.2044 \times 10^{21} = 1.2044 \times 10^{22}$.

(b) Total mass of protons present in 34 mg of ammonia at STP is $1.6726 \times 10^{-27} \times 1.204 \times 10^{22} = 2.0138 \times 10^{-5}$ kg.

When temperature and pressure is changed, there is no difference in the answer.

#422770

Topic: Mole and equivalent weight

If the diameter of a carbon atom is 0.15 nm, calculate the number of carbon atoms which can be placed side by side in a straight line across length of scale of length 20 cm long.

Solution

The diameter of 1 C atom is $0.15 nm = 0.15 \times 10^{-7} cm$.

In 20 cm length, $\frac{20}{0.15 \times 10^{-7}} = 1.33 \times 10^{9}$ carbon atoms can be placed.

#422772

Topic: Mole and equivalent weight

2×10^{8} atoms of carbon are arranged side by side. Calculate the radius of carbon atom if the length of this arrangement is 2.4 cm.

Solution

The length covered by 1 carbon atom corresponds to its diameter.

The diameter of carbon atom is $\frac{2.4}{2 \times 10^{8}} = 1.2 \times 10^{-8}$ cm.

The radius of carbon atom is $\frac{1.2 \times 10^{-8}}{2} = 0.6 \times 10^{-8} cm = 0.06\ nm$.

#422773

Topic: Mole and equivalent weight

The diameter of zinc atom is $2.6 \overset{\circ}{A}$. Calculate (a) radius of zinc atom in pm and (b) number of atoms present in a length of 1.6 cm if the zinc atoms are arranged side by side lengthwise.

Solution

(i)The diameter of zinc atom is $2.6\overset{o}{A} = 2.6 \times 10^{-10} m$.

The radius of Zn atom is $\frac{2.6 \times 10^{-10}}{2} = 1.3 \times 10^{-10} m = 130 \times 10^{-12} m = 130\ pm$

(ii) The number of Zn atoms present on 1.6 cm of length are $\frac{1.6}{2.6 \times 10^{-8}} = 6.154 \times 10^{7}$.

#422979

Topic: Mole and equivalent weight

Calculate the total number of electrons present in 1.4 g of dinitrogen gas.

Solution

1.4 g of nitrogen corresponds to $\frac{1.4}{28} = 0.05$ moles.

0.05 moles of nitrogen corresponds to $0.05 \times 6.023 \times 10^{23} = 3.011 \times 10^{22}$ molecules.

One molecule of nitrogen contains 14 electrons.

1.4 g of nitrogen will contain $3.011 \times 10^{22} \times 14 = 5.2154 \times 10^{23}$ electrons.

#422980

Topic: Mole and equivalent weight

How much time would it take to distribute one Avogadro number of wheat grains, if 10^{10} grains are distributed each second?

Solution

Avogadro's number is 6.023×10^{23}.

The time required to distribute 6.023×10^{23} grains is $\frac{6.023 \times 10^{23}}{1 \times 10^{10}} sec = 6.023 \times 10^{13}$ seconds.

Convert unit of time from seconds to years.

$\frac{6.023 \times 10^{13}}{3600 \times 24 \times 365} = 1.9096 \times 10^{6}$years.

Note: 1 year is equal to $3600 \times 24 \times 365$ seconds.

#423878

Topic: Percentage composition, empirical and molecular formula

In the estimation of sulphur by Carius method, 0.468 g of an organic sulphur compound afforded 0.668 g of barium sulphate. Find out the percentage of sulphur in the given compound.

Solution

The molar mass of $BaSO_4$ is 233 g/mol.

Thus, 233 g of $BaSO_4$ corresponds to 32 g of sulphur.

0.668 g of $BaSO_4$ will contain $\frac{32 \times 0.668}{233} = 0.0917 g$ of sulphur.

The percentage of sulphur in the given compound is $\frac{0.0917 \times 100}{0.468} = 19.6$ %.

#464270

Topic: Matter : Nature and Classification

Give reasons for the following observation:

The smell of hot sizzing food several metres away, but to get the smell from cold food you have to go close.

Solution

Particles of hot food have more kinetic energy than the particles of cold food. Due to more energy they can travel easily or diffuse through the air very fast and can be reached several metres away. But the particles of cold food are low in energy and the tendency to travel is very less so to get the smell from cold food we need to go close to the food.

#464273

Topic: Matter : Nature and Classification

The mass per unit volume of a substance is called density (density = mass/ volume). Arrange the following in order of increasing density- air, exhaust from chimneys, honey, water, chalk, cotton and iron.

Solution

General order of density of states of matter is gases<liquids<solids. Increasing order of density is:

air < exhaust from chimneys < cotton < water < honey < chalk < iron.

#464275

Topic: Matter : Nature and Classification

(a) Tabulate the differences in the characteristics of states of matter.

(b) Comment upon the following: rigidity, compressibility, fluidity, filled a gas container, shape, kinetic energy and density.

Solution

S.No	Property	Solid	Liquid	Gases
1.	Shape	They have definite shape	They do not have definite shape	They do not have definite shape
2.	Volume	They have definite volume	They do not have definite volume	They do not have definite volume
3.	Density	They have high-density	Liquids have less density than solids	Gases have the least density
4.	Kinetic energy of particles	Least	More than solids	Maximum
5.	Compressibility	Negligible	Low	High

Rigidity: It is the property of matter to resist the change of its shape.

Compressibility: It is the property of matter in which its volume is decreased by applying force.

Fluidity: It is the ability of matter to flow.

Filled a gas container: On filling, a gas takes the shape of the container.

Shape: Having definite boundaries.

Kinetic energy: It is the energy possessed by the particles of matter due to its motion.

Density: It is the ratio of mass with per unit volume

#464279

Topic: Matter : Nature and Classification

Give reasons

(a) A gas fills completely the vessel in which it is kept.

(b) A gas exerts pressure on the walls of the container.

(c) A wooden table should be called a solid.

(d) We can easily move our hand in air but to do the same through a solid block of wood we need a karate expert.

Solution

(a) The particles of gases have low force of attraction between them. The particles are freely moving in the vessel in which it is filled.

(b) The particles of gas has least force of attraction. They are constantly moving randomly. The particle of gas hit the walls of container thereby applying force and hence pressure on the wall.

(c) Wooden table has a definite shape and the definite volume. The particles of wood are closely packed. They do not take the shape of the container. Hence wooden table satisfies the properties of solid.

(d) The particles of air are very loosely bounded. They are far away from each other having a lot of space between them. Hence we can easily move our hands in air. But in a solid block, the particles are tightly held by a strong force of attraction. So there is some or no space between them. Hence we need a karate expert.

#464282

Topic: Matter : Nature and Classification

Liquids generally have lower density as compared to solids. But you must have observed that ice floats on water. Find out why.

Solution

In general, the volume of liquid is more than the volume of solid as the particles of liquids are more free to move thereby more volume. But in case of ice, density of water is maximum at $4^\circ C$. The density of ice is less than that of water. Therefore it floats on water.

#464321

Topic: Matter : Nature and Classification

Give two reasons to justify:

(a) water at room temperature is a liquid.

(b) an iron almirah is a solid at room temperature.

Solution

(a) Water at room temperature is a liquid because it boils at 373 K and the room temperature is nearly $20^\circ C - 25^\circ C$. The solidification point is $0^\circ C$ It will remain in a liquid state. It does not have a definite shape but has a definite volume at room temperature. So these are properties of a liquid state.

(b) An iron almirah is a solid at room temperature because it has a definite shape and definite volume. So the properties mentioned is satisfied by the solid state only.

#464373

Topic: Mixtures and compounds

Classify each of the following as a homogeneous or heterogeneous mixture.

Soda water, wood, air, soil, vinegar, filtered tea.

Solution

A homogeneous mixture has the same uniform composition and appearance.

A heterogeneous mixture consists of visibly different phases or substances.

Soda water is a homogeneous mixture.

Wood is homogeneous mixture.

Air is homogeneous mixture.

Soil is heterogeneous mixture.

Vinegar is homogeneous mixture.

Filter tea is homogeneous mixture.

#464374

Topic: Mixtures and compounds

How would you confirm that a colourless liquid given to you is pure water?

Solution

Take a sample of colourless liquid and put on stove if it starts boiling exactly at 100°C then it is pure water. Any other colourless liquid such as vinegar always have different boiling point. Also observe carefully that after some time whole liquid will convert into vapour without leaving any residue.

#464375

Topic: Mixtures and compounds

Which of the following materials fall in the category of a pure substance?

(*a*) Ice

(*b*) Milk

(*c*) Iron

(*d*) Hydrochloric acid

(*e*) Calcium oxide

(*f*) Mercury

(*g*) Brick

(*h*) Wood

(*i*) Air.

#464380
Topic: Mixtures and compounds

Classify the following into elements, compounds and mixtures.

(*a*) Sodium

(*b*) Soil

(*c*) Sugar solution

(*d*) Silver

(*e*) Calcium carbonate

(*f*) Tin

(*g*) Silicon

(*h*) Coal

(*i*) Air

(*j*) Soap

(*k*) Methane

(*l*) Carbon dioxide

(*m*) Blood

Solution

Classification of the given substances into elements compounds and mixtures

Elements: Sodium, Silver, Tin and Silicon.

Compounds: Calcium carbonate, Methane and carbon dioxide.

Mixtures: Soil, Sugar solution, Coal, Air, Soap and Blood.

#464384
Topic: Percentage composition, empirical and molecular formula

A 0.24g sample of compound of oxygen and boron was found by analysis to contain 0.096g of boron and 0.144g of oxygen. Calculate the percentage composition of the compound by weight.

#464386
Topic: Laws of chemical combination

When 3.0 g of carbon is burnt in 8.00 g oxygen, 11.00 g of carbon dioxide is produced. What mass of carbon dioxide will be formed when 3.00 g of carbon is burnt in 50.00 g of oxygen? Which law of chemical combination will govern your answer?

Solution

$C + O_2 \rightarrow CO_2$

3 g 8 g 11 g

Total mass of reactants = mass of carbon + mass of oxygen = 3 g+8 g=11 g

Total mass of reactants = Total mass of products

Hence, the law of conservation of mass is proved.

Further, it also shows carbon dioxide contains carbon and oxygen in a fixed ratio by mass, which is 3:8.

Thus it also proves the law of constant proportions. 3 g of carbon must also combine with 8 g of oxygen only. This mean that (50-8)=42 of oxygen will remain unreacted.

#464391
Topic: Atomic mass and molecular mass

Calculate the molar mass of the following substances.

(a) Ethyne, C_2H_2

(b) Sulphur molecule, S_8

(c) Phosphorus molecule, P_4(Atomic mass of phosporus $= 31$)

(d) Hydrochloric acid, HCl

(e) Nitric acid, HNO_3

Solution

(a) Ethyne (C_2H_2)=$2 \times Mass\ of\ C\ atom + 2 \times Mass\ of\ H\ atom = 2 \times 12 + 2 \times 1 = 24 + 2 = 26\ g$

(b) Sulphur dioxide (S_8)=$8 \times Mass\ of\ sulphur\ atom = 8 \times 32 = 256\ g$

(c) $P_4 = 4 \times Mass\ of\ P\ atom = 4 \times 31 = 124\ g$

(d) $HCl = 1 \times Mass\ of\ H\ atom + 1 \times Mass\ of\ Cl\ atom = 1 + 35.5 = 36.5\ g$

(e) $HNO_3 = 1 \times Mass\ of\ H\ atom + 1 \times Mass\ of\ N\ atom + 3 \times Mass\ of\ O\ atom$

$= 1 \times 1 + 1 \times 14 + 3 \times 16 = 63\ g$

#464395
Topic: Mole and equivalent weight

What is the mass of-

(a) 1 mole of nitrogen atoms?

(b) 4 moles of aluminium atoms(Atomic mass of aluminium $= 27$)?

(c) 10 moles of sodium sulphite (Na_2SO_3)?

Solution

(a) 1 mole of nitrogen atoms=$1 \times mass\ of\ N = 1 \times 14 = 14\ g$

(b) 4 moles of aluminium atoms=$4 \times 27 = 108\ g$

(c) 10 moles of sodium sulphite(Na_2SO_3)=$10 \times Mass\ of\ Na_2SO_3$.

Mass of $Na_2SO_3 = 2 \times Mass\ of\ Na\ atom +_1 \times Mass\ of\ Satom + 3 \times Mass\ of\ O\ atom$

$= 2 \times 23 + 1 \times 32 + 3 \times 16 = 46 + 32 + 48 = 126\ g$

$\therefore 10\ moles\ of\ Na_2SO_3 = 10 \times 126 = 1260\ g$

#464396
Topic: Mole and equivalent weight

Convert into mole.

(a) 12 g of oxygen gas

(b) 20 g of water

(c) 22 g of carbon dioxide.

Solution

(a) Molecular mass of oxygen in grams = 16 g of oxygen= one mole of oxygen gas

Thus, 12 g of oxygen $= \frac{1}{32} \times 12 = 0.375\ moles$

(b) Molecular mass of water (H_2O) in grams= 2+ 16=18 g=one mole of water

Thus, 20 g of water $= \frac{1}{18} \times 20 = 1.111\ moles$

(c) Molecular mass of carbon dioxide (CO_2) in grams $= 12 + 2 \times 16 = 44\ g =$ one mole of carbon dioxide

Thus, 22 g of carbon dioxide $= \frac{1}{44} \times 22 = 0.5\ moles$

#464398

Topic: Mole and equivalent weight

What is the mass of:

(a) 0.2 mole of oxygen atoms?

(b) 0.5 mole of water molecules?

Solution

(a) The mass of 1 mole of oxygen atoms = 16 g

Thus, the mass of 0.2 mole of oxygen atoms = 16 × 0.2 = 3.2 g

(b) The mass of 1 mole of water molecules = 18 g

Thus, the mass of 0.5 mole of water molecules = 18 × 0.5 = 9.0 g

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#464400

Topic: Mole and equivalent weight

Calculate the number of molecules of sulphur(S_8) present in 16g of solid sulphur.

Solution

Moles of $S_8 = \frac{16}{256} = \frac{1}{16}$

number of molecules$= \frac{N_A}{16} = \frac{6.023 \times 10^{23}}{16} = 3.76 \times 10^{22}$

#464401

Topic: Mole and equivalent weight

Calculate the number of aluminium ions present in 0.051g of aluminium oxide.

Solution

The mass of an ion is the same as that of an atom of the same element. Atomic mass of $Al = 27\ u$.

Moles of $Al_2O_3 = \frac{0.051}{102}$

Number of molecules of $Al_2O_3 = \frac{0.051}{102} \times 6.023 \times 10^{23} = 3 \times 10^{20}$

1 molecule of Al_2O_3 contains 2 aluminium ions

so, $3 \times 10^{20} contains\ 6 \times 10^{20}$ aluminium ions

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#464511

Topic: Atomic mass and molecular mass

If bromine atom is available in the form of, say, two isotopes $^{79}_{35}Br$ (49.7%) and $^{81}_{35}Br$ (50.3%), calculate the average atomic mass of bromine atom.

Solution

Average atomic mass of bromine atom$= 79 \times \frac{49.7}{100} + 81 \times \frac{50.3}{100}$

$= 39.273 + 40.743 = 80.486$

#464512

Topic: Percentage composition, empirical and molecular formula

The average atomic mass of a sample of an element X is $16.2\ u$. What are the percentages of isotopes $^{16}_{8}X$ and $^{18}_{8}X$ in the sample?

Solution

Let the percentage of $^{16}_{8}X$ be A %. Then the percentage of $^{18}_{8}X$ be $(100 - A)$ %.

$\therefore\ 16 \times \dfrac{A}{100} + 18 \times \dfrac{100 - A}{100} = 16.2$

$\implies 1800 - 2A = 1620$

$\implies A = 90$

So the answer is 90% $^{16}_{8}X$ and 10% $^{18}_{8}X$