Get some extra practice…

…working out moles, concentrations, and dilutions

1. What is the molarity (in mol L^{-1}), of 5.32 mL of a solution containing 0.163 g of hydrogen peroxide?

2. What amount of sodium carbonate, Na_2CO_3, is present in 129 kg?

3. What is the concentration, in mol L^{-1}, of 0.326 mL of solution containing 0.024 mg of ethanoic (acetic) acid?

4. How many atoms are present in 1.639 mol of methane?

5. How many atoms are present in 3.512 mmol of nitric acid?

6. A sample of water contains 6.585×10^{20} atoms. How much water (in mol) is present?

7. What is the volume (in mL) of a solution containing 0.11 g of nitric acid at a concentration of 2.62 M?

8. What is the volume (in mL) of a solution containing 0.028 g of ammonia at a concentration of 18.7 mM?

9. By what factor have we diluted 0.2 mL of a sodium chloride solution if we add 3.8 mL of water?

10. If 73.5 mL of water is added to 25.1 mL of 0.696 M potassium nitrate, what will be the concentration of the final solution?

Scroll to the following pages to check your answers.

Answers

1. What is the molarity (in mol L^{-1}), of 5.32 mL of a solution containing 0.163 g of hydrogen peroxide?

First, we need to calculate the number of moles present in 0.163 g of hydrogen peroxide. To do this, we use the relationship:

$$\text{number of moles (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})}$$

The molar mass of hydrogen peroxide (H_2O_2) is 34 g mol^{-1}

So the number of moles of hydrogen peroxide present = $\frac{0.163 \text{ g}}{34 \text{ g mol}^{-1}} = 0.0048 \text{ mol}$

We then calculate the molarity of the solution by using the relationship:

$$\text{molarity (mol L}^{-1}) = \frac{\text{amount present (mol)}}{\text{volume of solution (L)}}$$

keeping in mind that this relationship asks us to express the volume of solution (in this case, 5.32 mL) in litres:

$$\text{molarity (mol L}^{-1}) = \frac{0.0048 \text{ mol}}{5.32 \times 10^{-3} \text{ L}} = 0.90 \text{ mol L}^{-1}$$

2. What amount of sodium carbonate, Na_2CO_3, is present in 129 kg?

To answer this question, we can use the following relationship:

$$\text{amount (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})}$$

First, note that we need to express the mass in g not kg, so we convert kg to g: $129 \times 1000 = 12.9 \times 10^4$ g.

We then calculate the molar mass of Na_2CO_3 by adding the molar masses of its composite atoms: $((2 \times 23) + 12 + (3 \times 16)) = 106$ g mol^{-1}

We can now feed these values into our equation:

$$\text{amount (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})}$$

$$= \frac{12.9 \times 10^4 \text{ g}}{106 \text{ g mol}^{-1}} = 1217 \text{ mol} = 1.217 \times 10^3 \text{ mol}$$

3. What is the concentration, in mol L^{-1}, of 0.326 mL of solution containing 0.024 mg of ethanoic (acetic) acid?

First, we need to calculate the number of moles present in 0.024 mg of ethanoic acid. To do this, we use the relationship:

$$\text{amount (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})}$$

The molar mass of ethanoic acid (CH_3CO_2H) is 60 g mol^{-1}. (We sum the molar masses of each of its composite atoms.)

We need to note that the equation above expressed mass in g, but the question cites the mass in mg. So we need to convert mg to g by multiplying by 10^{-3}:

$0.024 \text{ mg} \times 10^{-3} = 2.4 \times 10^{-5}$ g.

We can now calculate the amount of ethanoic acid present:

$$\text{amount (mol)} = \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1})} = \frac{2.4 \times 10^{-5} \text{ g}}{60 \text{ g mol}^{-1}} = 4 \times 10^{-7} \text{ mol}$$

We then calculate the concentration of the solution by using the relationship:

$$\text{concentration (mol L}^{-1}) = \frac{\text{amount present (mol)}}{\text{volume of solution (L)}}$$

keeping in mind that this relationship asks us to express the volume of solution (in this case, 0.326 mL) in litres:

$$\text{concentration (mol L}^{-1}) = \frac{4 \times 10^{-7} \text{ mol}}{0.326 \times 10^{-3} \text{ L}} = 0.00123 \text{ mol L}^{-1} = 1.23 \times 10^{-3} \text{ mol L}^{-1}$$

4. How many atoms are present in 1.639 mol of methane?

1 mol of anything contains 6×10^{23} entities, so 1.639 mol of methane contains $(1.639 \times (6\times10^{23}))$ molecules of methane – that is, 9.834×10^{23} molecules.

Each molecule of methane (CH_4) contains 5 atoms, so 9.834×10^{23} molecules of methane contains $(9.834 \times 10^{23}) \times 5$ atoms = **4.917×10^{24} atoms.**

5. How many atoms are present in 3.512 mmol of nitric acid?

3.512 mmol = (3.512×10^{-3}) mol (because 1 mmol equals 0.001 mol).
1 mol of nitric acid contains 6×10^{23} molecules, so 3.512×10^{-3} mol contains $((3.512 \times 10^{-3}) \times (6 \times 10^{23}))$ molecules = 2.107×10^{21} molecules.

Now, each molecule of nitric acid (HNO_3) contains 5 atoms. So 2.107×10^{21} molecules of nitric acid contains $(2.107 \times 10^{21}) \times 5$ atoms = **1.05×10^{22} atoms.**

6. A sample of water contains 6.585×10^{20} atoms. How much water (in mol) is present?

A molecule of water contains 3 atoms. So 6.585×10^{20} atoms make up

$\frac{6.585 \times 10^{20}}{3}$ molecules = 2.195×10^{20} molecules.

There are 6×10^{23} entities in one mole. So, 2.195×10^{20} molecules is equivalent to

$\frac{2.195 \times 10^{20}}{6 \times 10^{23}}$ mol

= 3.66×10^{-4} mol.

7. What is the volume (in mL) of a solution containing 0.11 g of nitric acid at a concentration of 2.62 M?

To answer this question we can use the relationship:

$$\text{volume (L)} = \frac{\text{amount (mol)}}{\text{concentration (mol L}^{-1}\text{)}}$$

To be able to use this relationship, however, we need to know how many moles of nitric acid are present. We calculate this by using the relationship:

Amount present (mol) $= \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$

The molar mass of nitric acid (HNO_3) is the sum of the molar masses of each composite atom = (1 + 14 + (3×16)) = 63.

So the amount present = $= \frac{0.11\text{ g}}{63\text{ g mol}^{-1}}$ = 1.75 × 10^{-3} mol

We can now return to the relationship:

volume (L) $= \frac{\text{amount (mol)}}{\text{concentration (mol L}^{-1}\text{)}}$

and enter our known values:

volume (L) $= \frac{1.75 \times 10^{-3}\text{ mol}}{2.62\text{ mol L}^{-1}}$ = 0.668 × 10^{-3} L (= 0.668 mL)

8. What is the volume (in mL) of a solution containing 0.028 g of ammonia at a concentration of 18.7 mM?

For this question, we use the same strategy as that employed for question 7. So, first, we calculate the amount (in mol) of ammonia present:

Amount present (mol) $= \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}}$

The molar mass of ammonia (NH_3) is (14 + 3) = 17

We have 0.028 g of ammonia, so:

Amount present (mol) $= \frac{\text{mass (g)}}{\text{molar mass (g mol}^{-1}\text{)}} = \frac{0.028\text{ g}}{17\text{ g mol}^{-1}}$ = 1.65 × 10^{-3} mol

We can now return to the relationship:

volume (L) $= \frac{\text{amount (mol)}}{\text{concentration (mol L}^{-1}\text{)}}$

and enter our known values:

volume (L) $= \frac{1.65 \times 10^{-3}\text{ mol}}{18.7 \times 10^{-3}\text{ mol L}^{-1}}$ = 0.088 L (= 88 mL)

Notice that, in the question, the concentration of ammonia is cited in mmol, but the relationship we are using requires the concentration to be cited in mol. So we have multiplied by 10^{-3} to convert from mmol to mol.

9. By what factor have we diluted 0.2 mL of a sodium chloride solution if we add 3.8 mL of water?

We start with a volume of 0.2 mL and end with a total volume of 4 mL (the 0.2 mL we started with plus the 3.8 mL we have added). We then divide our final volume by our initial volume to determine the factor by which the volume has increased:

$$\frac{\text{final volume}}{\text{initial volume}} = \frac{4}{0.2} = 20$$

So we have diluted the solution by a factor of 20: it is a 1:20 dilution.

10. If 73.5 mL of water is added to 25.1 mL of 0.696 M potassium nitrate, what will be the concentration of the final solution?

To find our answer, we can use the following relationship:

$$C_1 \times V_1 = C_2 \times V_2$$

Our unknown quantity is C_2, the final concentration, so we need to rearrange the above equation to isolate C_2:

$$C_2 = \frac{C_1 \times V_1}{V_2}$$

We then need to remember that we have added 73.5 mL of water to a starting volume of 25.1 mL, so our final volume, V_2, is 98.6 mL. We also need to remember that concentrations are expressed in mol L^{-1}, not mol mL^{-1} so we need to convert our volumes accordingly (by multiplying by 10^{-3}).

We now feed our known values into the above equation:

$$C_2 = \frac{0.696 \text{ mol L}^{-1} \times (25.1 \times 10^{-3})\text{L}}{(98.6 \times 10^{-3})\text{L}} = 0.177 \text{ mol L}^{-1}.$$

So our final concentration is 0.177 mol L^{-1}.