



# Chem!stry

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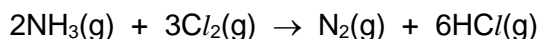
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## Mole Calculations – Assignment Twelve

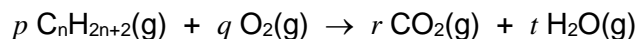
1. A gas is 46.2% carbon and 53.8% nitrogen. Under conditions of room temperature and pressure (r.t.p.) the volume of the gas is 6 dm<sup>3</sup> and its mass is 13 g. What is the molecular formula of the gas?
2. The complex ion [Ag(NH<sub>3</sub>)<sub>x</sub>]<sup>+</sup> contains 76% silver by mass. What is the value of x?
3. 5 g of element **X** reacted with 8 g of element **Y** to form a compound with the formula **XY**<sub>2</sub>. Given that the relative atomic mass of **Y** is 80, what is the relative atomic mass of **X**?

4. Ammonia reacts with chlorine according to the equation given below:



Calculate the total volume of the resulting mixture when 90 cm<sup>3</sup> of ammonia reacts with 150 cm<sup>3</sup> of chlorine. Assume that all measurements are taken at room temperature and pressure.

5. A gaseous alkane (general formula C<sub>n</sub>H<sub>2n+2</sub>) burns in oxygen according to the following chemical equation:



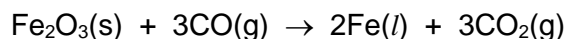
When 28 cm<sup>3</sup> of gaseous alkane were burned in excess oxygen, 84 cm<sup>3</sup> of carbon dioxide gas were formed (all volumes measured at room temperature and pressure). What is the molecular formula of the alkane?

6. Two moles of ethanol, C<sub>2</sub>H<sub>5</sub>OH, have the same mass as one mole of an oxide of nitrogen, N<sub>2</sub>O<sub>x</sub>. What is the value of x?
7. **P** is a solution containing 3.80 g/dm<sup>3</sup> hydrochloric acid, HCl.  
**Q** is a solution containing 4.24 g/dm<sup>3</sup> of an alkali, ROH.  
20.35 cm<sup>3</sup> of solution **P** neutralises 20.0 cm<sup>3</sup> of solution **Q**.  
What is the possible identity of **R**?

8. 4 g of hydrogen and 4 g of oxygen react together explosively. What is the mass in grams of water that is formed at room temperature and pressure?
9. 2.75 g of metal **M** combines with 1.6 g of oxygen to form an oxide with an empirical formula of **MO<sub>2</sub>**. What is the relative atomic mass of metal **M**?
10. An organometallic compound, **Mg<sub>x</sub>C<sub>y</sub>H<sub>z</sub>**, was discovered. It is known to contain metal ions, **Mg<sup>2+</sup>**, that bind to an organic hydrocarbon component. When 5.00 g of the compound was burnt, the hydrocarbon component underwent combustion to form 10.7 g of **CO<sub>2</sub>** and 5.48 g of **H<sub>2</sub>O**. What is the empirical formula of the compound?
11. 20 cm<sup>3</sup> of a hydrocarbon, **C<sub>x</sub>H<sub>y</sub>**, was completely burned in an excess of oxygen. A contraction in volume of 100 cm<sup>3</sup> occurred when the gaseous product was cooled. On treating the remaining gaseous product with aqueous sodium hydroxide, a further contraction in volume of 80 cm<sup>3</sup> took place. Deduce the values of **x** and **y**. Assume that all volumes are measured at room temperature and pressure.
12. 0.400 g of magnesium carbonate was completely dissolved in 100 cm<sup>3</sup> of sulfuric acid. 25.0 cm<sup>3</sup> of the resultant solution was pipetted into a conical flask and titrated with 20.50 cm<sup>3</sup> of 0.400 g/dm aqueous sodium hydroxide.
- (a) Construct chemical equations, with state symbols, for the two reactions described above.
- (b) Calculate the number of moles of sulfuric acid used in the titration with aqueous sodium hydroxide.
- (c) Calculate the number of moles of sulfuric acid that reacted with the magnesium carbonate.
- (d) Hence, calculate the concentration of the sulfuric acid used in the reaction with magnesium carbonate.
13. Ascorbic acid, represented by the chemical formula of **H<sub>2</sub>A**, is used as a vitamin supplement and an antioxidant in some brands of orange juice.
- (a) Ascorbic acid has the following composition by mass:
- $$\text{C} = 40.9\% \quad \text{H} = 4.6\% \quad \text{O} = 54.5\%$$
- (i) Calculate the empirical formula of ascorbic acid.
- (ii) A sample of 4.00 g of ascorbic acid requires 22.70 cm<sup>3</sup> of 1.00 mol/dm<sup>3</sup> of aqueous sodium carbonate for complete reaction. Calculate the molecular formula of ascorbic acid.

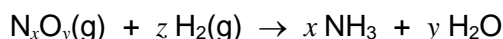
- (b)** A student performed an experiment to determine the mass of ascorbic acid in a 750 cm<sup>3</sup> bottle of orange juice. She pipetted 25.0 cm<sup>3</sup> of the juice and titrated it with 0.00500 mol/dm<sup>3</sup> of aqueous sodium hydroxide. The volume of aqueous sodium hydroxide required was 11.30 cm<sup>3</sup>.
- (i)** Calculate the number of moles of aqueous sodium hydroxide used in the titration.
- (ii)** Calculate the concentration of ascorbic acid in the orange juice in mol/dm<sup>3</sup>.
- (iii)** Calculate the mass of ascorbic acid in the bottle of orange juice.

- 14.** 399 g of Fe<sub>2</sub>O<sub>3</sub>(s) reacted with 168 dm<sup>3</sup> of CO(g).



- (a)** By calculation, identify the limiting reagent hence calculate the mass of Fe(l) produced.
- (b)** Calculate the mass of iron(III) oxide remaining at the end of the reaction.

- 15.** To establish the formula of an oxide of nitrogen, a known volume of the pure gas was mixed with hydrogen and passed over a catalyst at a suitable temperature. A 100% conversion of the oxide to water and ammonia took place.



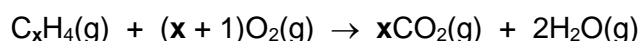
2400 cm<sup>3</sup> of the nitrogen oxide, measured at room temperature and pressure (r.t.p.), produced 7.20 g of water. The ammonia produced was neutralised by 200 cm<sup>3</sup> of 1.00 mol/dm<sup>3</sup> hydrochloric acid.

- (a)** Calculate the number of moles of nitrogen oxide used.
- (b)** Calculate the number of moles of water and ammonia produced.
- (c)** Determine the formula of the nitrogen oxide, N<sub>x</sub>O<sub>y</sub>.

- 16.** Organic acids contain carbon, hydrogen and oxygen. When 10.4 g of an unknown organic acid are completely burned, 21.2 g of carbon dioxide and 6.50 g of water are produced.

- (a)** Calculate the empirical formula of the organic acid.
- (b)** If the relative molecular mass of the organic acid is 86.0, then calculate the molecular formula of the organic acid.

- 17.** A hydrocarbon has the formula C<sub>x</sub>H<sub>4</sub>. 20.0 cm<sup>3</sup> of the hydrocarbon undergoes complete combustion with exactly 60.0 cm<sup>3</sup> of oxygen. Calculate the value of **x** and hence state the formula of the hydrocarbon.

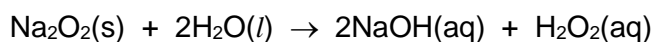


**18.** Hydrated iron(II) sulfate has the formula  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$ . 30.0 g of the iron(II) sulfate were dissolved in distilled water, and the volume made up to  $1.00 \text{ dm}^3$  of aqueous solution. In a titration,  $25.0 \text{ cm}^3$  of the solution reacted with  $27.00 \text{ cm}^3$  of  $0.0200 \text{ mol/dm}^3$  potassium manganate(VII). The balanced chemical equation for the reaction is given below:



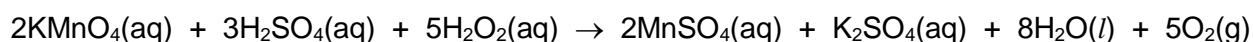
- Calculate the number of moles of  $\text{KMnO}_4$  that reacted.
- Calculate the number of moles of  $\text{FeSO}_4$  in  $25.0 \text{ cm}^3$  of the solution.
- Hence determine the number of moles of  $\text{FeSO}_4$  in  $1.00 \text{ dm}^3$ .
- Calculate the mass of anhydrous  $\text{FeSO}_4$  in  $1.00 \text{ dm}^3$  of solution.
- Hence deduce the value of  $x$  in the formula  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$ .

**19.** Sodium peroxide,  $\text{Na}_2\text{O}_2$ , reacts with water to produce sodium hydroxide and hydrogen peroxide,  $\text{H}_2\text{O}_2$ , according to the following balanced chemical equation:



11.7 g of sodium peroxide were added to  $100 \text{ cm}^3$  of distilled water, and the mixture stirred until the reaction was complete.

- Calculate the volume of  $1.20 \text{ mol/dm}^3$  hydrochloric acid required to exactly neutralise the sodium hydroxide present in  $25.0 \text{ cm}^3$  of the resulting solution.
- Calculate the volume of  $0.200 \text{ mol/dm}^3$  acidified potassium manganate(VII) required to react exactly with the hydrogen peroxide present in  $25.0 \text{ cm}^3$  of the final solution. The balanced chemical equation for the reaction between acidified potassium manganate(VII) and hydrogen peroxide is given below:



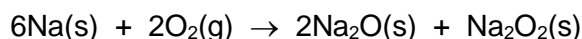
**20.** Calculate the formula of the chloride of iron given the information below:

$$\text{Fe} = 51.17\% \quad \text{Cl} = 48.83\% \quad M_r = 436.2$$

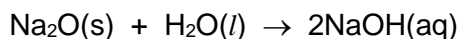
**21.**  $25.0 \text{ cm}^3$  of a hydrocarbon **Z**,  $\text{C}_x\text{H}_y$ , was exploded with an excess of oxygen to produce carbon dioxide and steam. After cooling to room temperature and pressure, the volume of the gaseous mixture contracted by  $100 \text{ cm}^3$ . When the mixture was treated with excess aqueous potassium hydroxide, the volume contracted further by  $100 \text{ cm}^3$ . All volumes were measured at room temperature and pressure (r.t.p.).

- Write a chemical equation for the reaction of **Z** with oxygen.
- With the use of a balanced chemical equation, explain why the volume of the mixture decreased on treating with excess aqueous potassium hydroxide.
- Deduce the formula of hydrocarbon **Z**.

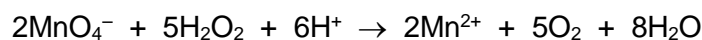
22. When sodium is completely burned in oxygen, a mixture of sodium oxide,  $\text{Na}_2\text{O}$ , and sodium peroxide,  $\text{Na}_2\text{O}_2$ , is formed according to the equation given below:



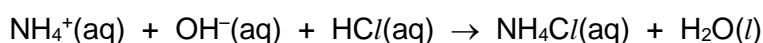
Sodium peroxide reacts with water to form sodium hydroxide and hydrogen peroxide, while sodium oxide reacts with water to form sodium hydroxide only, according to the following equation:



- (a) Write a balanced chemical equation for the reaction between sodium peroxide and water.
- (b) The mixture obtained by burning a sample of sodium was dissolved in distilled water and made up to  $100\text{ cm}^3$  to form solution **M**.  $25.0\text{ cm}^3$  of solution **M** was pipetted and titrated with  $22.50\text{ cm}^3$  of  $0.0500\text{ mol dm}^{-3}$  of sulfuric acid to reach the end point. Calculate the total number of moles of sodium hydroxide in  $100\text{ cm}^3$  of solution **M**.
- (c) Another  $25.0\text{ cm}^3$  of solution **M** was then titrated with  $10.00\text{ cm}^3$  of  $0.0200\text{ mol dm}^{-3}$  acidified potassium manganate(VII),  $\text{KMnO}_4$ . The following reaction occurs:



- (i) Calculate the mass of  $\text{H}_2\text{O}_2$  in  $100\text{ cm}^3$  of solution **M**.
- (ii) Calculate the number of moles of sodium oxide and sodium peroxide formed during the burning of the sodium sample.
- (iii) Calculate the mass of sodium burned in oxygen.
23. A fertiliser contains ammonium sulfate and potassium sulfate. A sample of  $0.225\text{ g}$  of the fertiliser was warmed with aqueous sodium hydroxide. The ammonia evolved was bubbled into  $100\text{ cm}^3$  of water to form solution **N**. Solution **N** was neutralised by  $15.70\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$  hydrochloric acid.



- (a) Calculate the volume of ammonia evolved at room temperature and pressure (r.t.p.).
- (b) Calculate the percentage, by mass, of ammonium sulfate in the fertiliser.
24.  $23.50\text{ cm}^3$  of  $2.00\text{ g dm}^{-3}$  potassium carbonate solution is added to  $40.00\text{ cm}^3$  of hydrochloric acid.  $25.0\text{ cm}^3$  of the resultant solution is pipetted into a conical flask and titrated with  $20.00\text{ cm}^3$  of  $0.0100\text{ mol dm}^{-3}$  nitric acid.
- (a) Write a balanced chemical equation for **one** of the reactions described above.
- (b) Write the ionic equation for the chemical reaction chosen in **24. (a)**.
- (c) Calculate the total number of moles of potassium carbonate used.
- (d) Calculate the number of moles of potassium carbonate that did **not** react with the hydrochloric acid.
- (e) Hence calculate the concentration of hydrochloric acid used in the reaction with potassium carbonate.

- Scan the QR code below for the answers to this assignment.



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