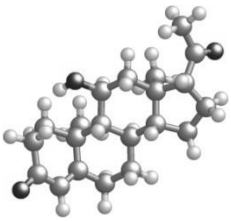

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Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

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^3 and its mass is 13 g. What is the molecular formula of the gas?

2. The complex ion $[Ag(NH_3)_x]^+$ 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 $\mathbf{XY}_2$. 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:

$$2NH_3(g) + 3Cl_2(g) \rightarrow N_2(g) + 6HCl(g)$$

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

5. A gaseous alkane (general formula C_nH_{2n+2}) burns in oxygen according to the following chemical equation:

$$p\ C_nH_{2n+2}(g) + q\ O_2(g) \rightarrow r\ CO_2(g) + t\ H_2O(g)$$

When 28 cm^3 of gaseous alkane were burned in excess oxygen, 84 cm^3 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_2H_5OH, have the same mass as one mole of an oxide of nitrogen, N_2O_x. What is the value of **x**?

7. **P** is a solution containing 3.80 g/dm^3 hydrochloric acid, HCl.
Q is a solution containing 4.24 g/dm^3 of an alkali, **R**OH.
20.35 cm^3 of solution **P** neutralises 20.0 cm^3 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 **M**O_2. What is the relative atomic mass of metal **M**?

10. An organometallic compound, $Mg_xC_yH_z$, was discovered. It is known to contain metal ions, Mg^{2+}, 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_2 and 5.48 g of H_2O. What is the empirical formula of the compound?

11. 20 cm^3 of a hydrocarbon, C_xH_y, was completely burned in an excess of oxygen. A contraction in volume of 100 cm^3 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^3 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^3 of sulfuric acid.
25.0 cm^3 of the resultant solution was pipetted into a conical flask and titrated with 20.50 cm^3 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_2**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:

C = 40.9% H = 4.6% 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^3 of 1.00 mol/dm^3 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^3 bottle of orange juice. She pipetted 25.0 cm^3 of the juice and titrated it with 0.00500 mol/dm^3 of aqueous sodium hydroxide. The volume of aqueous sodium hydroxide required was 11.30 cm^3.

(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^3.

(iii) Calculate the mass of ascorbic acid in the bottle of orange juice.

14. 399 g of $Fe_2O_3(s)$ reacted with 168 dm^3 of CO(g).

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

(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.

$$N_xO_y(g) + z\,H_2(g) \rightarrow x\,NH_3 + y\,H_2O$$

2400 cm^3 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^3 of 1.00 mol/dm^3 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_xO_y.

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_xH_4. 20.0 cm^3 of the hydrocarbon undergoes complete combustion with exactly 60.0 cm^3 of oxygen. Calculate the value of **x** and hence state the formula of the hydrocarbon.

$$C_xH_4(g) + (\mathbf{x} + 1)O_2(g) \rightarrow \mathbf{x}CO_2(g) + 2H_2O(g)$$

18. Hydrated iron(II) sulfate has the formula $FeSO_4 \cdot \mathbf{x}H_2O$. 30.0 g of the iron(II) sulfate were dissolved in distilled water, and the volume made up to 1.00 dm^3 of aqueous solution. In a titration, 25.0 cm^3 of the solution reacted with 27.00 cm^3 of 0.0200 mol/dm^3 potassium manganate(VII). The balanced chemical equation for the reaction is given below:

$$2KMnO_4(aq) + 10FeSO_4(aq) + 8H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2MnSO_4(aq) + 5Fe_2(SO_4)_3(aq) + 8H_2O(l)$$

(a) Calculate the number of moles of $KMnO_4$ that reacted.

(b) Calculate the number of moles of $FeSO_4$ in 25.0 cm^3 of the solution.

(c) Hence determine the number of moles of $FeSO_4$ in 1.00 dm^3.

(d) Calculate the mass of anhydrous $FeSO_4$ in 1.00 dm^3 of solution.

(e) Hence deduce the value of **x** in the formula $FeSO_4 \cdot \mathbf{x}H_2O$.

19. Sodium peroxide, Na_2O_2, reacts with water to produce sodium hydroxide and hydrogen peroxide, H_2O_2, according to the following balanced chemical equation:

$$Na_2O_2(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2O_2(aq)$$

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

(a) Calculate the volume of 1.20 mol/dm^3 hydrochloric acid required to exactly neutralise the sodium hydroxide present in 25.0 cm^3 of the resulting solution.

(b) Calculate the volume of 0.200 mol/dm^3 acidified potassium manganate(VII) required to react exactly with the hydrogen peroxide present in 25.0 cm^3 of the final solution. The balanced chemical equation for the reaction between acidified potassium manganate(VII) and hydrogen peroxide is given below:

$$2KMnO_4(aq) + 3H_2SO_4(aq) + 5H_2O_2(aq) \rightarrow 2MnSO_4(aq) + K_2SO_4(aq) + 8H_2O(l) + 5O_2(g)$$

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

Fe = 51.17% C*l* = 48.83% M_r = 436.2

21. 25.0 cm^3 of a hydrocarbon **Z**, C_xH_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 cm^3. When the mixture was treated with excess aqueous potassium hydroxide, the volume contracted further by 100 cm^3. All volumes were measured at room temperature and pressure (r.t.p.).

(a) Write a chemical equation for the reaction of **Z** with oxygen.

(b) With the use of a balanced chemical equation, explain why the volume of the mixture decreased on treating with excess aqueous potassium hydroxide.

(c) Deduce the formula of hydrocarbon **Z**.

22. When sodium is completely burned in oxygen, a mixture of sodium oxide, Na_2O, and sodium peroxide, Na_2O_2, is formed according to the equation given below:

$$6Na(s) + 2O_2(g) \rightarrow 2Na_2O(s) + Na_2O_2(s)$$

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:

$$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$$

(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 make up to 100 cm^3 to form solution **M**. 25.0 cm^3 of solution **M** was pipetted and titrated with 22.50 cm^3 of 0.0500 mol dm^{-3} of sulfuric acid to reach the end point.
Calculate the total number of moles of sodium hydroxide in 100 cm^3 of solution **M**.

(c) Another 25.0 cm^3 of solution **M** was then titrated with 10.00 cm^3 of 0.0200 mol dm^{-3} acidified potassium manganate(VII), $KMnO_4$. The following reaction occurs:

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$$

(i) Calculate the mass of H_2O_2 in 100 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 g of the fertiliser was warmed with aqueous sodium hydroxide.
The ammonia evolved was bubbled into 100 cm^3 of water to form solution **N**. Solution **N** was neutralised by 15.70 cm^3 of 0.100 mol dm^{-3} hydrochloric acid.

$$NH_4^+(aq) + OH^-(aq) + HCl(aq) \rightarrow NH_4Cl(aq) + H_2O(l)$$

(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 cm^3 of 2.00 g dm^{-3} potassium carbonate solution is added to 40.00 cm^3 of hydrochloric acid. 25.0 cm^3 of the resultant solution is pipetted into a conical flask and titrated with 20.00 cm^3 of 0.0100 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.

25. Nitrosyl chloride, NOC*l*, decomposes on heating according to the equation given below:

$$NOCl(g) \rightleftharpoons NO(g) + {}^{1}/_{2}Cl_2(g)$$

When 225 cm^3 of nitrosyl chloride was placed in a closed container at constant pressure, and heated to a constant temperature, it was found that nitrogen monoxide made up 20% of the equilibrium mixture.

What is the total volume of gases in the equilibrium mixture at the temperature of the reaction?

26. Hydrogen, $H_2(g)$, can be obtained from methane, $CH_4(g)$, by partial oxidation with steam, $H_2O(g)$, as follows:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

When 100 cm^3 of $CH_4(g)$ was reacted with 100 cm^3 of $H_2O(g)$ in a closed container at constant pressure, and heated to a constant temperature, it was found that carbon monoxide, CO(g), made up 20% of the equilibrium mixture.
Taking the decrease in volume of $CH_4(g)$ to be x cm^3, calculate the volume of CO(g) and $H_2(g)$ in the equilibrium mixture.

	$CH_4(g)$	$H_2O(g)$	CO(g)	$H_2(g)$
Initial volume / cm^3	100	100	0	0
Final volume / cm^3	$100 - x$	?	?	?

27. Aluminium chloride reacts with water according to the following balanced chemical equation:

$$2AlCl_3(s) + 3H_2O(l) \rightarrow Al_2O_3(s) + 6HCl(aq)$$

A student added 1.10 g of impure A*l*Cl_3 to 250 cm^3 of distilled water. The mixture was stirred until the reaction between the two chemicals was complete. 25.0 cm^3 of the homogeneous solution were then pipetted into a conical flask and titrated against 0.125 mol dm^{-3} $Na_2CO_3(aq)$ using a suitable indicator.
It was found that 8.00 cm^3 of $Na_2CO_3(aq)$ were required to exactly neutralise the HC*l*(aq).

(a) Construct a balanced chemical equation for the neutralisation reaction.

(b) Calculate the number of moles of HC*l* in 25.0 cm^3 of the solution.

(c) Calculate the mass of pure A*l*Cl_3 added to the distilled water.

(d) Calculate the percentage purity of the $AlCl_3$ that the student used in their experiment.

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

http://www.chemist.sg/mole/assignments/mole_twelve_ans.pdf