

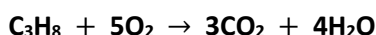
# Mole Calculations – Moderate

## Mark Scheme



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1. The equation for a combustion reaction between propane and oxygen is shown below.



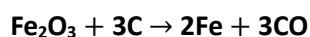
Calculate the number of moles present in 132 g of propane.

|                                                                                                   |                |
|---------------------------------------------------------------------------------------------------|----------------|
| Mr of $\text{C}_3\text{H}_8 = 3(12) + 8(1) = 44$                                                  | 1 mark         |
| Moles of $\text{C}_3\text{H}_8 = \frac{\text{mass}}{\text{Mr}} = \frac{132}{44} = 3 \text{ mols}$ | 1 mark         |
|                                                                                                   | Total: 2 marks |

2. Calculate the number of moles present in 494 g of copper carbonate,  $\text{CuCO}_3$ .

|                                                                                               |                |
|-----------------------------------------------------------------------------------------------|----------------|
| Mr of $\text{CuCO}_3 = 63.5 + 12 + 3(16) = 123.5$                                             | 1 mark         |
| Moles of $\text{CuCO}_3 = \frac{\text{mass}}{\text{Mr}} = \frac{494}{123.5} = 4 \text{ mols}$ | 1 mark         |
|                                                                                               | Total: 2 marks |

3. A student is doing a practical to extract iron from iron oxide using a displacement reaction with carbon.  
The equation for the reaction is:



- a) The student uses 50 grams of iron oxide. Calculate the number of moles in 50 grams of iron oxide.

|                                                                                                         |                |
|---------------------------------------------------------------------------------------------------------|----------------|
| Mr of $\text{Fe}_2\text{O}_3 = 2(56) + 3(16) = 160$                                                     | 1 mark         |
| Moles of $\text{Fe}_2\text{O}_3 = \frac{\text{mass}}{\text{Mr}} = \frac{50}{160} = 0.3125 \text{ mols}$ | 1 mark         |
|                                                                                                         | Total: 2 marks |

- b) What is the ratio of the number of moles of iron oxide to the moles of iron?

|                      |               |
|----------------------|---------------|
| Ratio of moles 1 : 2 | 1 mark        |
|                      | Total: 1 mark |

- c) What is the mass of iron that can be produced from 50 g of iron oxide?

|                                                                                      |                |
|--------------------------------------------------------------------------------------|----------------|
| Mols of Fe = $0.3125 \times 2 = 0.625$                                               | 1 mark         |
| Mass of Fe = mols $\times$ Mr<br>Mass of Fe = $0.625 \times 56$<br>Mass of Fe = 35 g | 1 mark         |
|                                                                                      | Total: 2 marks |

4. A student was doing an electrolysis practical to separate aluminium oxide into aluminium metal and oxygen gas. The student has 153 g of aluminium oxide for this practical. The equation for the reaction is:



- a) Calculate the number of moles in 153 g of aluminium oxide.

|                                                                                                       |                |
|-------------------------------------------------------------------------------------------------------|----------------|
| Mr of $\text{Al}_2\text{O}_3 = 2(27) + 3(16) = 102$                                                   | 1 mark         |
| Moles of $\text{Al}_2\text{O}_3 = \frac{\text{mass}}{\text{Mr}} = \frac{153}{102} = 1.5 \text{ mols}$ | 1 mark         |
|                                                                                                       | Total: 2 marks |

- b) What is the ratio of the number of moles of aluminium oxide to the moles of aluminium?

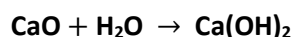
|                                               |               |
|-----------------------------------------------|---------------|
| Ratio of moles 2 : 4 This simplifies to 1 : 2 | 1 mark        |
|                                               | Total: 1 mark |

- c) Calculate the mass of aluminium that can be formed from 153 g of aluminium oxide.

|                                                                                 |                |
|---------------------------------------------------------------------------------|----------------|
| Mols of Al = $1.5 \times 2 = 3$                                                 | 1 mark         |
| Mass of Al = mols $\times$ Mr      Mass of Al = $3 \times 27$ Mass of Al = 81 g | 1 mark         |
|                                                                                 | Total: 2 marks |

5. Calcium oxide reacts with water to produce calcium hydroxide.

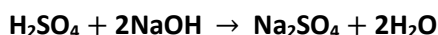
The equation for the reaction is shown below:



What mass of calcium hydroxide is made from 14 g of calcium oxide?

|                                                                                                                   |                |
|-------------------------------------------------------------------------------------------------------------------|----------------|
| Moles of CaO = $\frac{\text{mass}}{\text{Mr}} = \frac{14}{56} = 0.25$                                             | 1 mark         |
| Ratio of mols = 1 : 1                                                                                             | 1 mark         |
| Mass of $\text{Ca(OH)}_2 = \text{mols} \times \text{Mr}$ Mass of $\text{Ca(OH)}_2 = 0.25 \times 74$ Mass = 18.5 g | 1 mark         |
|                                                                                                                   | Total: 3 marks |

6. A student was preparing a sample of sodium sulphate. To produce sodium sulphate the student reacted sulphuric acid with sodium hydroxide. The equation for that reaction is shown below:



- a) Calculate the number of moles in 24.5 g of sulphuric acid.

|                                                                                                        |                |
|--------------------------------------------------------------------------------------------------------|----------------|
| Mr of $\text{H}_2\text{SO}_4 = 2(1) + 32 + 4(16) = 98$                                                 | 1 mark         |
| Moles of $\text{H}_2\text{SO}_4 = \frac{\text{mass}}{\text{Mr}} = \frac{24.5}{98} = 0.25 \text{ mols}$ | 1 mark         |
|                                                                                                        | Total: 2 marks |

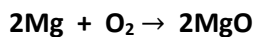
- b) What is the ratio of the number of moles of sulphuric acid to the moles of sodium hydroxide?

|                      |               |
|----------------------|---------------|
| Ratio of moles 1 : 2 | 1 mark        |
|                      | Total: 1 mark |

- c) Calculate the mass of sodium hydroxide that is needed to neutralise 24.5 g of sulphuric acid.

|                                                                                          |                |
|------------------------------------------------------------------------------------------|----------------|
| Mols of NaOH = $0.25 \times 2 = 0.50$                                                    | 1 mark         |
| Mass of NaOH = mols $\times$ Mr      Mass of NaOH = $0.50 \times 40$ Mass of NaOH = 20 g | 1 mark         |
|                                                                                          | Total: 2 marks |

7. Magnesium metal reacts with oxygen gas to produce magnesium oxide.  
The equation for the reaction is:



Calculate the mass of oxygen needed to react 48 g of magnesium to form magnesium oxide.

|                                                                                                        |                       |
|--------------------------------------------------------------------------------------------------------|-----------------------|
| Moles of Mg = $\frac{\text{mass}}{\text{Mr}} = \frac{48}{24} = 2 \text{ mols}$                         | 1 mark                |
| Ratio of mols = 2 : 1                                                                                  | 1 mark                |
| Mass of O <sub>2</sub> = mols × Mr<br>Mass of O <sub>2</sub> = 1 × 32<br>Mass of O <sub>2</sub> = 32 g | 1 mark                |
|                                                                                                        | <b>Total: 3 marks</b> |

8. Magnesium nitrate decomposes when heated to form magnesium oxide, nitrogen dioxide and oxygen gas.

- a) Write the balanced symbol equation for the decomposition of solid magnesium nitrate.  
Include **all** state symbols.

|                                                                                                                             |                       |
|-----------------------------------------------------------------------------------------------------------------------------|-----------------------|
| $2\text{Mg}(\text{NO}_3)_2 (\text{s}) \rightarrow 2\text{MgO} (\text{s}) + 4\text{NO}_2 (\text{g}) + \text{O}_2 (\text{g})$ | 3 marks               |
|                                                                                                                             |                       |
| 1 mark for correct formulae of products and reactants.                                                                      | 1 mark                |
| 1 mark for balanced reactants.                                                                                              | 1 mark                |
| 1 mark for balanced products.                                                                                               | 1 mark                |
|                                                                                                                             | <b>Total: 3 marks</b> |

- b) Calculate the mass of magnesium oxide produced when 0.90 moles of magnesium nitrate decomposes.

|                                                                          |                       |
|--------------------------------------------------------------------------|-----------------------|
| Ratio of mols = 2 : 2      which simplifies to 1 : 1                     | 1 mark                |
| Mass of MgO = mols × Mr<br>Mass of MgO = 0.90 × 40<br>Mass of MgO = 36 g | 1 mark                |
|                                                                          | <b>Total: 2 marks</b> |

- c) Calculate the mass of oxygen gas produced when 0.90 moles of magnesium nitrate decomposes.

|                                                                                                             |                       |
|-------------------------------------------------------------------------------------------------------------|-----------------------|
| Ratio of mols = 2 : 1                                                                                       | 1 mark                |
| Mass of O <sub>2</sub> = mols × Mr<br>Mass of O <sub>2</sub> = 0.45 × 32<br>Mass of O <sub>2</sub> = 14.4 g | 1 mark                |
|                                                                                                             | <b>Total: 2 marks</b> |

- d) Calculate how many molecules of nitrogen dioxide, NO<sub>2</sub>, are produced from the 0.90 moles of magnesium nitrate.

Avogadro's constant is  $6.02 \times 10^{23}$ . Give your answer to 3 significant figures.

|                                                                            |                       |
|----------------------------------------------------------------------------|-----------------------|
| Number of molecules of NO <sub>2</sub> = moles × Avogadro's constant       | 1 mark                |
| Number of molecules of NO <sub>2</sub> = $1.80 \times 6.02 \times 10^{23}$ | 1 mark                |
| Number of molecules of NO <sub>2</sub> = $1.08 \times 10^{24}$             | 1 mark                |
|                                                                            | <b>Total: 3 marks</b> |

9. Sodium reacts with chlorine gas to form sodium chloride.

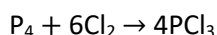
a) Write the balanced symbol equation for this reaction. Include **all** state symbols.

|                                                                     |                |
|---------------------------------------------------------------------|----------------|
| $2\text{Na(s)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NaCl(s)}$ | 2 marks        |
| 1 mark for balanced reactants.                                      | 1 mark         |
| 1 mark for balanced products.                                       | 1 mark         |
|                                                                     | Total: 2 marks |

b) Calculate the maximum mass of sodium chloride that could be formed by reacting 9.20 g of sodium with excess chlorine.

|                                                                                             |                |
|---------------------------------------------------------------------------------------------|----------------|
| Moles of Na = $\frac{\text{mass}}{\text{Mr}} = \frac{9.20}{23} = 0.4$                       | 1 mark         |
| Ratio of mols = 2 : 2 which simplifies to 1 : 1                                             | 1 mark         |
| Mass of NaCl = mol $\times$ Mr<br>Mass of NaCl = $0.4 \times 58.5$<br>Mass of NaCl = 23.4 g | 1 mark         |
|                                                                                             | Total: 3 marks |

10. Phosphorus can exist as tetraphosphorus ( $\text{P}_4$ ) molecules, where four phosphorus atoms are covalently bonded together. Phosphorus trichloride,  $\text{PCl}_3$ , is made in the reaction of tetraphosphorus ( $\text{P}_4$ ), and chlorine as shown in the equation below.



a) Calculate the mass of 2.0 mol of phosphorus.

|                                                                               |                |
|-------------------------------------------------------------------------------|----------------|
| Mr of $\text{P}_4 = 4(31)$ Mr of $\text{P}_4 = 124$                           | 1 mark         |
| Mass of $\text{P}_4 = \text{mol} \times \text{Mr}$                            | 1 mark         |
| Mass of $\text{P}_4 = 2.0 \times 124$<br>Mass of $\text{P}_4 = 248 \text{ g}$ | 1 mark         |
|                                                                               | Total: 3 marks |

b) Calculate the mass of phosphorus trichloride,  $\text{PCl}_3$ , that could be made from 2.0 mol of phosphorus,  $\text{P}_4$ .

|                                                                                                                                           |                |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| Mr of $\text{PCl}_3 = 31 + 3(35.5)$<br>Mr of $\text{PCl}_3 = 137.5$                                                                       | 1 mark         |
| Ratio of mols = 1 : 4 Mols of $\text{PCl}_3 = 2 \times 4 = 8 \text{ mols}$                                                                | 1 mark         |
| Mass of $\text{PCl}_3 = \text{mol} \times \text{Mr}$ Mass of $\text{PCl}_3 = 8.0 \times 137.5$<br>Mass of $\text{PCl}_3 = 1100 \text{ g}$ | 1 mark         |
|                                                                                                                                           | Total: 3 marks |

c) The student reacted the 2.0 mol of phosphorus,  $\text{P}_4$ , with 866.2 g of chlorine,  $\text{Cl}_2$ . Which is the limiting reactant? Explain your answer.

|                                                                                                                                  |                |
|----------------------------------------------------------------------------------------------------------------------------------|----------------|
| First of all calculate what mass of chlorine we'd need to fully react 2.0 mol of phosphorus.                                     | 1 mark         |
| Mass of $\text{Cl}_2 = \text{mol} \times \text{Mr}$ Mass of $\text{Cl}_2 = 2(6) \times 71$ Mass of $\text{Cl}_2 = 852 \text{ g}$ | 1 mark         |
| Limiting reactant: <u>phosphorus</u>                                                                                             | 1 mark         |
| An <u>explanation</u> to include the following:<br>Reacting 2.0 mol of $\text{P}_4$ requires 852 g of $\text{Cl}_2$ .            | 1 mark         |
| Therefore, there would be $\text{Cl}_2$ remaining so we could run out of phosphorus first.                                       | 1 mark         |
|                                                                                                                                  | Total: 4 marks |