



Percentage	
Grade	

A Level Chemistry

Mole Calculations

Duration: 1 hour 15 min

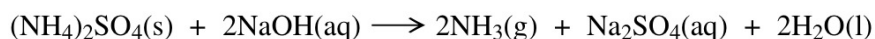
Total Marks: 69

Information for Candidates:

- Use black or blue ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional paper is used, the question number(s) must be clearly shown
- The number of marks is given in brackets [] at the end of each question or part question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

[illegible]

- 2 Ammonium sulfate reacts with sodium hydroxide to form ammonia, sodium sulfate and water as shown in the equation below.



- 2 (a) A 3.14 g sample of ammonium sulfate reacted completely with 39.30 cm³ of a sodium hydroxide solution.

- 2 (a) (i) Calculate the amount, in moles, of (NH₄)₂SO₄ in 3.14 g of ammonium sulfate.

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(2 marks)

- 2 (a) (ii) Hence calculate the amount, in moles, of sodium hydroxide which reacted.

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(1 mark)

- 2 (a) (iii) Calculate the concentration, in mol dm⁻³, of the sodium hydroxide solution used.

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(1 mark)

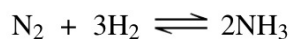
- 2 (b) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and sodium hydroxide.

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(2 marks)



- 2 (c) Ammonia is manufactured by the Haber Process.



Calculate the percentage atom economy for the production of ammonia in this process.

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(1 mark)

- 2 (d) A sample of ammonia gas occupied a volume of $1.53 \times 10^{-2} \text{ m}^3$ at 37°C and a pressure of 100 kPa.
(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

Calculate the amount, in moles, of ammonia in this sample.

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(3 marks)

(Extra space)

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- 2 (e) Glauber's salt is a form of hydrated sodium sulfate that contains 44.1% by mass of sodium sulfate. Hydrated sodium sulfate can be represented by the formula $\text{Na}_2\text{SO}_4 \cdot x\text{H}_2\text{O}$ where x is an integer. Calculate the value of x .

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(3 marks)

(Extra space)

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Turn over ►



- 2** Norgessalpeter was the first nitrogen fertiliser to be manufactured in Norway. It has the formula $\text{Ca}(\text{NO}_3)_2$

- 2 (a)** Norgessalpeter can be made by the reaction of calcium carbonate with dilute nitric acid as shown by the following equation.



In an experiment, an excess of powdered calcium carbonate was added to 36.2 cm^3 of $0.586 \text{ mol dm}^{-3}$ nitric acid.

- 2 (a) (i)** Calculate the amount, in moles, of HNO_3 in 36.2 cm^3 of $0.586 \text{ mol dm}^{-3}$ nitric acid. Give your answer to 3 significant figures.

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(1 mark)

- 2 (a) (ii)** Calculate the amount, in moles, of CaCO_3 that reacted with the nitric acid. Give your answer to 3 significant figures.

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(1 mark)

- 2 (a) (iii)** Calculate the minimum mass of powdered CaCO_3 that should be added to react with all of the nitric acid. Give your answer to 3 significant figures.

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(2 marks)

- 2 (a) (iv)** State the type of reaction that occurs when calcium carbonate reacts with nitric acid.

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(1 mark)



- 2 (b)** Norgessalt peter decomposes on heating as shown by the following equation.



A sample of Norgessalt peter was decomposed completely.

The gases produced occupied a volume of $3.50 \times 10^{-3} \text{ m}^3$ at a pressure of 100 kPa and a temperature of 31°C .

(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

- 2 (b) (i)** Calculate the total amount, in moles, of gases produced.

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(3 marks)

- 2 (b) (ii)** Hence calculate the amount, in moles, of oxygen produced.

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(1 mark)

- 2 (c)** Hydrated calcium nitrate can be represented by the formula $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ where x is an integer.

A 6.04 g sample of $\text{Ca}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ contains 1.84 g of water of crystallisation.

Use this information to calculate a value for x .

Show your working.

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(3 marks)

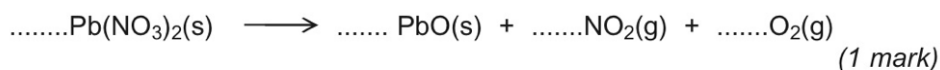


- 6 (b)** In a second experiment, the nitrogen monoxide gas produced in the reaction occupied 638 cm^3 at 101 kPa and 298 K.
Calculate the amount, in moles, of NO gas produced.
(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

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(3 marks)
(Extra space)

- 6 (c)** When lead(II) nitrate is heated it decomposes to form lead(II) oxide, nitrogen dioxide and oxygen.

- 6 (c) (i)** Balance the following equation that shows this thermal decomposition.



- 6 (c) (ii)** Suggest **one** reason why the yield of nitrogen dioxide formed during this reaction is often less than expected.

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(1 mark)

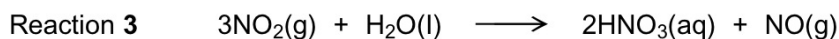
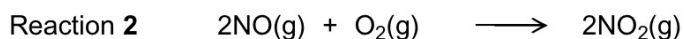
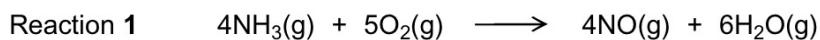
- 6 (c) (iii)** Suggest **one** reason why it is difficult to obtain a pure sample of nitrogen dioxide from this reaction.

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(1 mark)



Section BAnswer **all** questions in the spaces provided.

- 5** Ammonia is used to make nitric acid (HNO_3) by the Ostwald Process. Three reactions occur in this process.



- 5 (a)** In one production run, the gases formed in Reaction 1 occupied a total volume of 4.31 m^3 at 25°C and 100 kPa .

Calculate the amount, in moles, of NO produced.

Give your answer to 3 significant figures.

(The gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)

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(4 marks)

(Extra space)

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5 (b) In another production run, 3.00 kg of ammonia gas were used in Reaction 1 and all of the NO gas produced was used to make NO₂ gas in Reaction 2.

5 (b) (i) Calculate the amount, in moles, of ammonia in 3.00 kg.

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(2 marks)

5 (b) (ii) Calculate the mass of NO₂ formed from 3.00 kg of ammonia in Reaction 2 assuming an 80.0% yield.

Give your answer in kilograms.

(If you have been unable to calculate an answer for part (b) (i), you may assume a value of 163 mol. This is **not** the correct answer.)

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(3 marks)

(Extra space)

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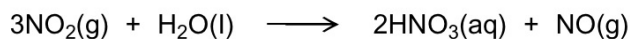
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- 5 (c) Consider Reaction 3 in this process.



Calculate the concentration of nitric acid produced when 0.543 mol of NO_2 is reacted with water and the solution is made up to 250 cm^3 .

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(2 marks)
(Extra space)

- 5 (d) Suggest why a leak of NO_2 gas from the Ostwald Process will cause atmospheric pollution.

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(1 mark)

- 5 (e) Give **one** reason why excess air is used in the Ostwald Process.

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(1 mark)

- 5 (f) Ammonia reacts with nitric acid as shown in this equation.



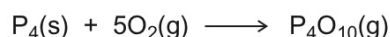
Deduce the type of reaction occurring.

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(1 mark)



- 6** Phosphoric(V) acid (H_3PO_4) is an important chemical. It can be made by two methods. The first method is a two-step process.

- 6 (a)** In the first step of the first method, phosphorus is burned in air at $500\text{ }^\circ\text{C}$ to produce gaseous phosphorus(V) oxide.



220 g of phosphorus were reacted with an excess of air.

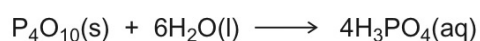
Calculate the volume, in m^3 , of gaseous phosphorus(V) oxide produced at a pressure of 101 kPa and a temperature of $500\text{ }^\circ\text{C}$.

The gas constant $R = 8.31\text{ J K}^{-1}\text{ mol}^{-1}$

Give your answer to 3 significant figures.

[4 marks]

- 6 (b)** In the second step of the first method, phosphorus(V) oxide reacts with water to form phosphoric(V) acid.

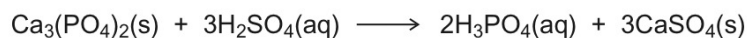


Calculate the mass of phosphorus(V) oxide required to produce 3.00 m^3 of 5.00 mol dm^{-3} phosphoric(V) acid solution.

[3 marks]



- 6 (c)** In the second method to produce phosphoric(V) acid, 3.50 kg of $\text{Ca}_3(\text{PO}_4)_2$ are added to an excess of aqueous sulfuric acid.



1.09 kg of phosphoric(V) acid are produced.

Calculate the percentage yield of phosphoric(V) acid.

[4 marks]

- 6 (d)** Explain whether the first method or the second method of production of phosphoric acid has the higher atom economy.
You are not required to do a calculation.

[1 mark]

END OF QUESTIONS



Answer **all** the questions.

- 1 Tin mining was common practice on Dartmoor in pre-Roman times. Most of the tin extracted was mixed with copper to produce bronze.

(a) The table below shows the sub-atomic particles of an isotope of tin.

isotope	protons	neutrons	electrons
^{118}Sn			

(i) Complete the table. [1]

(ii) In terms of sub-atomic particles, how would atoms of ^{120}Sn differ from atoms of ^{118}Sn ?

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..... [1]

(b) The relative atomic mass of tin is 118.7.

Define the term *relative atomic mass*.

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..... [3]

(c) A bronze-age shield found on Dartmoor contained 2.08 kg of tin.

Calculate the number of tin atoms in this bronze shield.

Give your answer to **three** significant figures.

answer = [2]

- (d) Tin ore, known as cassiterite, contains an oxide of tin. This oxide contains 78.8% tin by mass. Calculate the empirical formula of this oxide. You must show your working.

answer = [2]

[Total: 9]