



**EXAM PAPERS PRACTICE**

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2002

**XVIII**

1583

Time allowed  
**63 Minutes**

**Score**

**/53**

**Percentage**

**%**

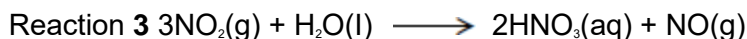
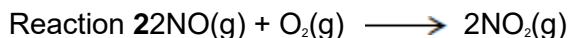
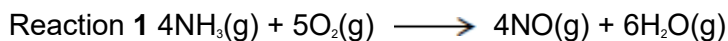
**CHEMISTRY**

**AQA  
AS & A LEVEL**

**Topic Questions**

**3.1 Physical chemistry**

1. Ammonia is used to make nitric acid ( $\text{HNO}_3$ ) by the Ostwald Process.  
Three reactions occur in this process.



- (a) In one production run, the gases formed in Reaction 1 occupied a total volume of  $4.31 \text{ m}^3$  at  $25^\circ\text{C}$  and  $100 \text{ kPa}$ .

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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- (b) In another production run,  $3.00 \text{ kg}$  of ammonia gas were used in Reaction 1 and all of the NO gas produced was used to make  $\text{NO}_2$  gas in Reaction 2.

- (i) Calculate the amount, in moles, of ammonia in  $3.00 \text{ kg}$ .

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(4)

- (ii) Calculate the mass of  $\text{NO}_2$  formed from 3.00 kg of ammonia in Reaction 2 assuming an 80.0% yield. (2)  
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)

- (c) Consider Reaction 3 in this process.



Calculate the concentration of nitric acid produced when 0.543 mol of  $\text{NO}_2$  is reacted with water and the solution is made up to  $250 \text{ cm}^3$ .

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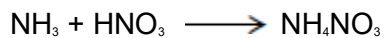
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- ..... (2)
- (d) Suggest why a leak of  $\text{NO}_2$  gas from the Ostwald Process will cause atmospheric pollution.

- ..... (1)
- (e) Give **one** reason why excess air is used in the Ostwald Process.

- ..... (1)
- (f) Ammonia reacts with nitric acid as shown in this equation.

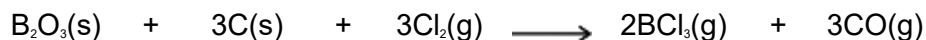


Deduce the type of reaction occurring.

..... (1)  
(Total 14 marks)

2

(a) Boron trichloride ( $\text{BCl}_3$ ) can be prepared as shown by the following equation.



A sample of boron oxide ( $\text{B}_2\text{O}_3$ ) was reacted completely with carbon and chlorine. The two gases produced occupied a total volume of  $5000 \text{ cm}^3$  at a pressure of 100 kPa and a temperature of 298 K.

Calculate the mass of boron oxide that reacted.  
Give your answer to 3 significant figures.

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

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(5)

(b) Boron trichloride can also be prepared from its elements.

Write an equation for this reaction.

Explain why boron trichloride has a trigonal planar shape with equal bond angles.

(Extra space) .....

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(3)

- (c) (i) Boron trichloride is easily hydrolysed to form two different acids as shown in the following equation.



Calculate the concentration, in  $\text{mol dm}^{-3}$ , of hydrochloric acid produced when 43.2 g of boron trichloride are added to water to form  $500 \text{ cm}^3$  of solution. Give your answer to 3 significant figures.

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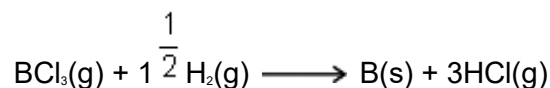
(4)

- (ii) Boric acid ( $\text{H}_3\text{BO}_3$ ) can react with sodium hydroxide to form sodium borate and water. Write an equation for this reaction.

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(1)

- (d) Boron trichloride can be reduced by using hydrogen to form pure boron.



Calculate the percentage atom economy for the formation of boron in this reaction.

Apart from changing the reaction conditions, suggest **one** way a company producing pure boron could increase its profits from this reaction.

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(Extra space) .....

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(3)

- (e) A different compound of boron and chlorine has a relative molecular mass of 163.6 and contains 13.2% of boron by mass.

Calculate the molecular formula of this compound.  
Show your working.

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(4)

(Total 20 marks)

3. The metal lead reacts with warm dilute nitric acid to produce lead(II) nitrate, nitrogen monoxide and water according to the following equation.



- (a) In an experiment, an 8.14 g sample of lead reacted completely with a 2.00 mol dm<sup>-3</sup> solution of nitric acid.

Calculate the volume, in dm<sup>3</sup>, of nitric acid required for complete reaction.  
Give your answer to 3 significant figures

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

(3)

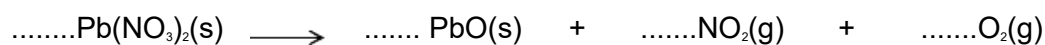


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(3)

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

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



(1)

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

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(1)

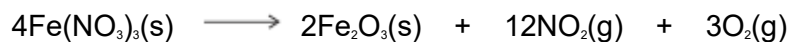
- (iii) Suggest **one** reason why it is difficult to obtain a pure sample of nitrogen dioxide from this reaction.

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(1)

(Total 9 marks)

4. When heated, iron(III) nitrate ( $M_r = 241.8$ ) is converted into iron(III) oxide, nitrogen dioxide and oxygen.



A 2.16 g sample of iron(III) nitrate was completely converted into the products shown.

- (a) (i) Calculate the amount, in moles, of iron(III) nitrate in the 2.16 g sample.

Give your answer to 3 significant figures.

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(1)

- (ii) Calculate the amount, in moles, of oxygen gas produced in this reaction.

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(1)

- (iii) Calculate the volume, in  $\text{m}^3$ , of **nitrogen dioxide** gas at  $293\text{ }^\circ\text{C}$  and  $100\text{ kPa}$  produced from  $2.16\text{ g}$  of iron(III) nitrate.  
The gas constant is  $R = 8.31\text{ JK}^{-1}\text{ mol}^{-1}$ .

(If you have been unable to obtain an answer to part (i), you may assume the number of moles of iron(III) nitrate is  $0.00642$ . This is **not** the correct answer.)

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(4)

- (b) Suggest a name for this type of reaction that iron(III) nitrate undergoes.

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(1)

- (c) Suggest why the iron(III) oxide obtained is pure.  
Assume a complete reaction.

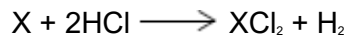
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(1)

(Total 8 marks)

5. In an experiment to identify a Group 2 metal (X), 0.102 g of X reacts with an excess of aqueous hydrochloric acid according to the following equation.



The volume of hydrogen gas given off is 65 cm<sup>3</sup> at 99 kPa pressure and 303 K.  
The gas constant is  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ .

Which is X?

- |          |           |                          |
|----------|-----------|--------------------------|
| <b>A</b> | Barium    | <input type="checkbox"/> |
| <b>B</b> | Calcium   | <input type="checkbox"/> |
| <b>C</b> | Magnesium | <input type="checkbox"/> |
| <b>D</b> | Strontium | <input type="checkbox"/> |

(Total 1 mark)

6. A sample of 2.18 g of oxygen gas has a volume of 1870 cm<sup>3</sup> at a pressure of 101 kPa.

What is the temperature of the gas?  
The gas constant is  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ .

- |          |           |                          |
|----------|-----------|--------------------------|
| <b>A</b> | 167 K     | <input type="checkbox"/> |
| <b>B</b> | 334 K     | <input type="checkbox"/> |
| <b>C</b> | 668 K     | <input type="checkbox"/> |
| <b>D</b> | 334 000 K | <input type="checkbox"/> |

(Total 1 mark)