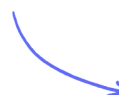


Amount of Substance & Gas Volume

Amount of Substance in Relation to Volumes of Gases

Easy (5 questions)	/29
Medium (6 questions)	/32
Hard (7 questions)	/46
Total Marks	/107

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Easy Questions

1 (a) This question is about gas volumes.

What volume does one mole of any gas occupy at room temperature and pressure?

Give your answer in cm^3 and dm^3 .

.....
..... (2 marks)

(b) What are the temperature and pressure implied with room temperature and pressure?

Room temperature = _____ $^{\circ}\text{C}$

Room pressure = _____ atm

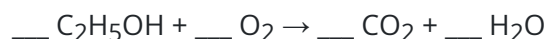
.....
..... (2 marks)

(c) State **one** equation to calculate the amount of gas in moles.

..... (1 mark)

- 2 (a)** Ethanol, $\text{C}_2\text{H}_5\text{OH}$, undergoes complete combustion to form carbon dioxide and water.

Complete the balanced symbol equation for the complete combustion of ethanol.



(2 marks)

- (b)** Which of the chemicals in the reaction equation are gases at room temperature and pressure?

..... **(1 mark)**

- (c)** The complete combustion of ethanol is performed at room temperature and pressure.

Draw a circle around the correct word to complete the sentences.

9 moles of oxygen produce

2 moles
3 moles
6 moles
9 moles

 of carbon dioxide.

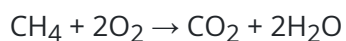
A volume of

24 dm³
72 dm³
144 dm³
24000 cm³

 of carbon dioxide is released.

(2 marks)

3 (a) 0.0625 moles of methane is burnt in air according to the following equation:



How many moles of oxygen are required for this combustion reaction?

Tick (✓) **one** box.

0.03125	
0.0625	
0.125	

..... (1 mark)

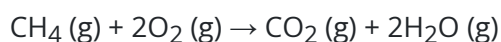
(b) If the reaction is completed at room temperature and pressure, what volume, in dm^3 , of methane is being burned?

..... (2 marks)

(c) If the reaction was completed at room temperature and pressure, what volume, in dm^3 , of carbon dioxide is produced?

..... (1 mark)

(d) Assuming that all the chemicals involved in the reaction are in the gaseous state, the balanced symbol equation is:



Draw a circle around the correct answer to complete the sentence.

Burning 2500 cm^3 of methane produces a **total** volume of

- | |
|--------------------|
| 2500 cm^3 |
| 5000 cm^3 |
| 7500 cm^3 |

..... (1 mark)

4 (a) Helium is a gas at room temperature and pressure.

Calculate the number of moles in a 38.4 g sample of helium.

Relative atomic mass (A_r): He = 4

Use the equation:

$$\text{Moles} = \frac{\text{mass}}{A_r}$$

..... (1 mark)

(b) What volume of gas, in cm^3 and dm^3 , does 38.4 g of helium occupy?

..... (2 marks)

(c) Chlorine, Cl_2 , is a gas at room temperature and pressure.

Calculate the number of moles in a 376.3 g sample of chlorine.

Relative atomic mass (A_r): Cl = 35.5

Use the equation:

$$\text{Moles} = \frac{\text{mass}}{M_r}$$

..... (2 marks)

(d) What volume of gas, in cm^3 and dm^3 , does 376.3 g of chlorine occupy?

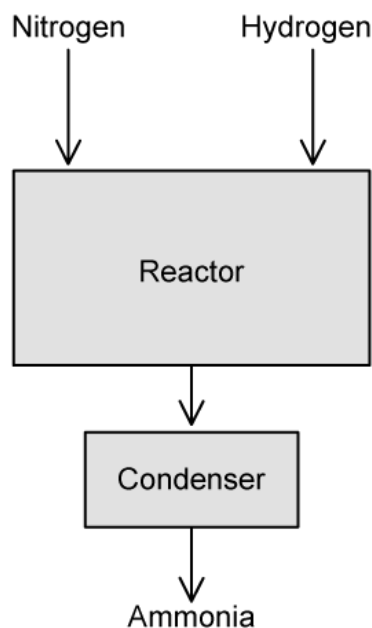
..... (2 marks)

Medium Questions

1 (a) Nitrogen and hydrogen react together in the Haber process to produce ammonia.

Figure 1 shows a flow diagram for the process

Figure 1



A gaseous mixture of NH_3 , N_2 and H_2 leaves the reactor where the ammonia is separated and the hydrogen and nitrogen are recycled back into the reactor. The reactor has a temperature of 450°C and a pressure of 200 atmospheres.

What does Avogadro's Law state about all three gases?

.....
..... (2 marks)

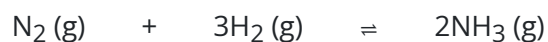
(b) The gases have the following boiling points:

Gas	Boiling Point (°C)
Ammonia	-33
Nitrogen	-196
Hydrogen	-253

Suggest how ammonia can be separated from the other gases.

.....
 (2 marks)

(c) The equation for the Haber process is:



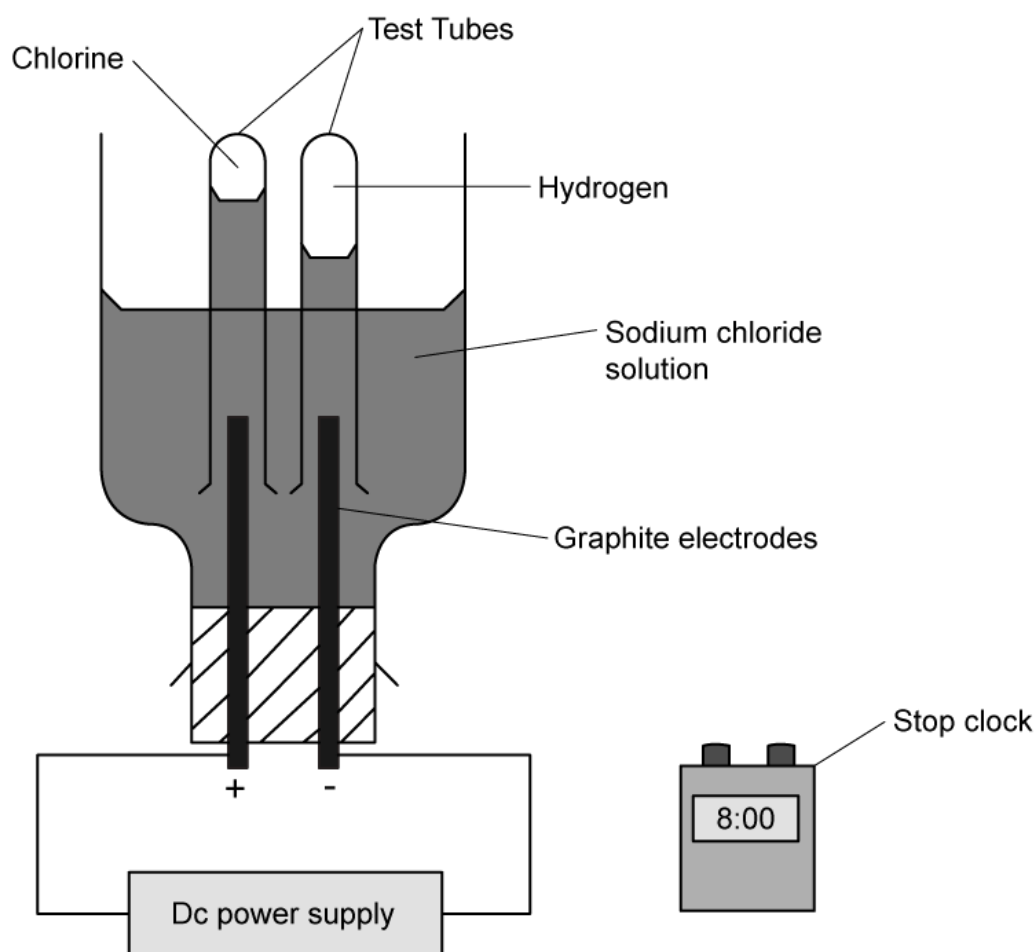
Calculate the volume of ammonia produced from the complete reaction of 795 dm³ of hydrogen.

.....
 (2 marks)

- 2 (a)** A student investigated the electrolysis of a solution of sodium chloride by measuring how the volume of gases produced changes with time.

Figure 1 shows the apparatus used in the investigation.

Figure 1



The student made an error in designing and setting up the apparatus for this investigation.

Identify the error and suggest what needs to be changed.

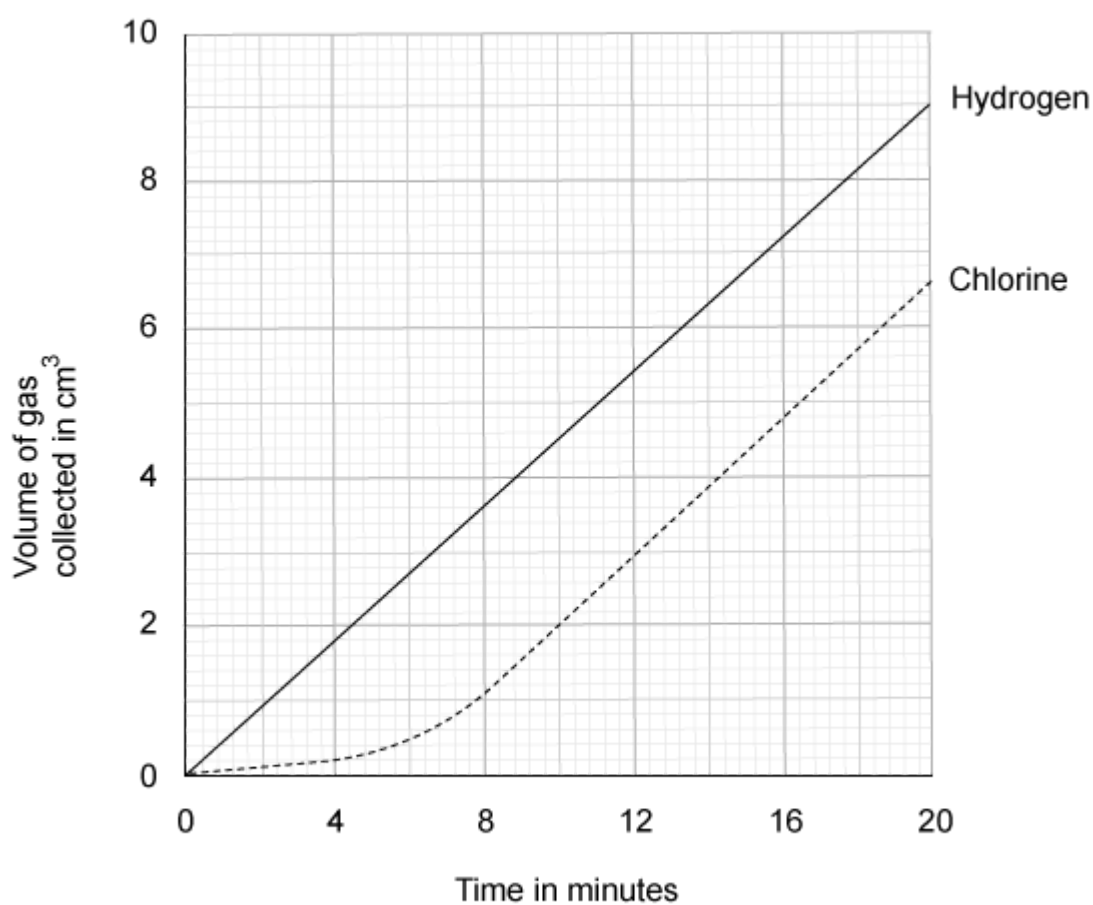
(2 marks)

- (b) The student soon adjusted the apparatus and was able to perform the investigation correctly.

The student measured the volumes of gases produced every minute for 20 minutes and constructed a graph of these results.

Figure 2 shows the graph of the investigation.

Figure 2



Using the graph, describe the trends shown in the results.

..... (3 marks)

- (c) The number of moles of each gas produced at each electrode is the same and no gas escapes from the apparatus however there is a difference in the amount of gas collected.

Suggest **one** reason for the difference in volume of each gas collected.

..... (1 mark)

- (d) Using **Figure 2**, calculate the amount in moles of chlorine collected after 16 minutes.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3

State your answer in standard form.

..... (4 marks)

- 3 What is the volume occupied by 5.6 g of nitrogen gas at RTP?

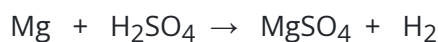
Relative atomic masses (A_r): N = 14

- A. 2.4 dm^3
- B. 4.8 dm^3
- C. 9.6 dm^3
- D. 12 dm^3

(1 mark)

4 (a) This question is about calculating the volumes of gases produced in different reactions.

What volume of hydrogen is produced from the reaction of 2.5 g of magnesium with excess sulfuric acid?



Relative atomic mass (A_r): Mg = 24

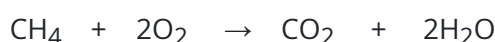
.....

.....

.....

..... (4 marks)

(b) What volume of steam is produced from the combustion of 2.000 kg of methane in excess oxygen?



Relative formula mass (M_r): CH₄ = 16

.....

.....

.....

..... (4 marks)

(c) What mass of iodine is required to react with hydrogen to produce 67.20 dm³ of hydrogen iodide?



Relative atomic mass (A_r): I = 127

.....

.....

(5 marks)

- 5 The reaction between nitrogen and hydrogen produces ammonia.



What volume of ammonia is produced from 565 cm³ of hydrogen?

- A. 1130 cm³
- B. 377 cm³
- C. 283 cm³
- D. 847 cm³

(1 mark)

- 6 A gas cylinder has a volume of 264 dm³.

What mass of hydrogen does it contain?

Relative atomic masses (A_r): H=1

- A. 22 g
- B. 11 g
- C. 24 g
- D. 264 g

(1 mark)

Hard Questions

1 (a) This question is about electrolysis.

In the electrolysis of molten potassium bromide, separate reactions occur at the electrodes.

Write **two** balanced half equations for the reactions that occur at the anode and the cathode.

.....

.....

..... (3 marks)

(b) During the electrolysis of molten potassium bromide, 3.12 g of potassium was formed.

Calculate the number of moles of bromine formed in the reaction.

Relative atomic masses (A_r): K = 39, Br = 80

.....

.....

..... (3 marks)

(c) 11.3% of the bromine produced in the reaction escapes the container.

Calculate the volume, in dm^3 , of bromine in the container.

.....

..... (2 marks)

- (d) When molten sodium chloride was electrolysed, 0.28 g of sodium was formed at one electrode.

Calculate the volume of gas, in cm^3 , that was produced at room temperature and pressure.

Relative atomic masses (A_r): Na = 23, Cl = 35.5

.....

.....

..... (3 marks)

2 (a) This question is about combustion.

A 0.050 mol sample of a hydrocarbon was burned in excess oxygen.

To determine the identity of the hydrocarbon, the type of combustion used is important.

Which type of combustion should be used to determine the identity of the hydrocarbon?
Explain your reasoning.

.....

.....

..... **(3 marks)**

(b) 3.6 dm³ of carbon dioxide were produced during the complete combustion of the 0.050 mol sample of a hydrocarbon.

Calculate the number of moles of carbon dioxide released.

..... **(1 mark)**

(c) When the hydrocarbon was burned 1.204×10^{23} molecules of water were produced.

Calculate the number of moles of hydrogen atoms in 1.204×10^{23} molecules of water.

.....

..... **(2 marks)**

(d) The amount of hydrocarbon burned was 0.050 mol.

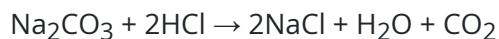
Calculate the molecular formula of the hydrocarbon.

.....

.....

..... **(3 marks)**

3 (a) Sodium carbonate reacts with dilute hydrochloric acid:



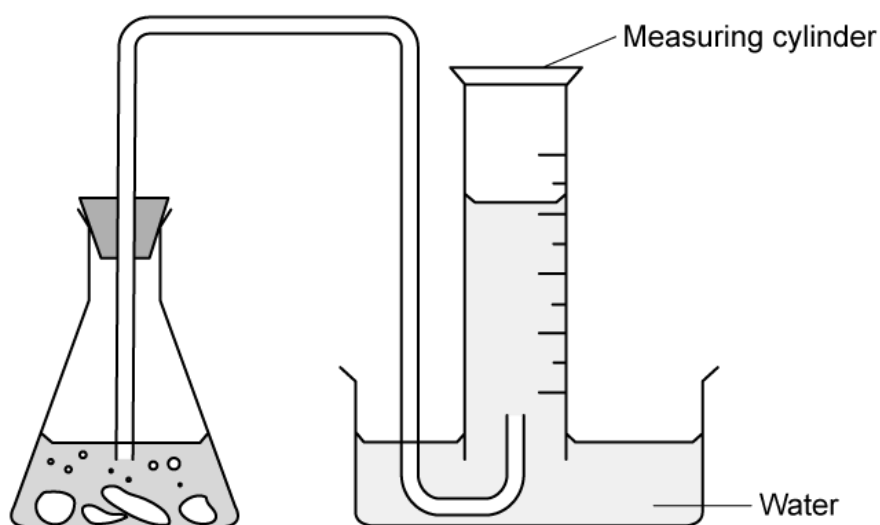
A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm³ of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

The student has set the apparatus incorrectly as shown in **Figure 1**.

Figure 1



Identify the error and describe what would happen if the student used the apparatus.

.....
..... (2 marks)

- (b) The student corrected the error and collected the results shown in **Table 1**.

Table 1

Mass of sodium carbonate in g	0.07	0.12	0.23	0.29	0.34	0.54	0.59	0.65
Volume of carbon dioxide gas in cm³	16.0	27.5	52.0	65.0	77.0	95.0	95.0	95.0

Suggest why the volume of carbon dioxide collected reaches a maximum of 95.0 cm³.

..... (1 mark)

- (c) Describe how the student could accurately determine the minimum mass of sodium carbonate required to produce 95.0 cm³ of carbon dioxide.

..... (3 marks)

- (d) The carbon dioxide was collected at room temperature and pressure.

Calculate the number of atoms of oxygen present in the 95.0 cm³ of carbon dioxide produced.

Give your answer to three significant figures.

..... (3 marks)

- 4 Air bags contain sodium azide (NaN_3) which decomposes on heating to form sodium and nitrogen.



What volume of nitrogen would be produced from 13 g of sodium azide?

Relative atomic mass (A_r): N = 14

Relative formula mass (M_r): NaN_3 = 65

A. 4.8 dm^3

B. 7.2 dm^3

C. 48 dm^3

D. 72 dm^3

(1 mark)

- 5 (a) This question is about power stations.

Coal-fired power stations are being phased out as the supply of coal decreases and greater restrictions on emissions are implemented.

Coal typically contains between 0.2% and 5% sulfur by dry weight.

Calculate the average number of moles of sulfur in 75 tonnes of coal.

Relative atomic mass (A_r): S = 32

1 tonne = $1 \times 10^6 \text{ g}$

.....

.....

..... (3 marks)

- (b) Calculate the volume of sulfur dioxide released from the combustion of 75 tonnes of typical coal.

.....

..... (2 marks)

- (c) Natural gas is replacing coal in some power stations.

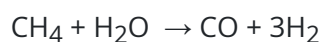
The typical sulphur content of natural gas is $5.5 \times 10^{-6} \text{ g / dm}^3$.

An articulated fuel tanker truck can carry up to 36000 dm^3 of natural gas.

Calculate the volume, in cm^3 , of sulfur dioxide that could be released by combusting the 36000 dm^3 of natural gas carried in the tanker truck.

..... (3 marks)

- 6 Hydrogen can be produced by reacting methane with steam:



What volume would the products occupy at RTP after reacting 32 g of methane with excess steam?

Relative atomic masses (A_r): C = 12 H = 1 O = 16

- A. 24 dm^3
- B. 72 dm^3
- C. 96 dm^3
- D. 192 dm^3

(1 mark)

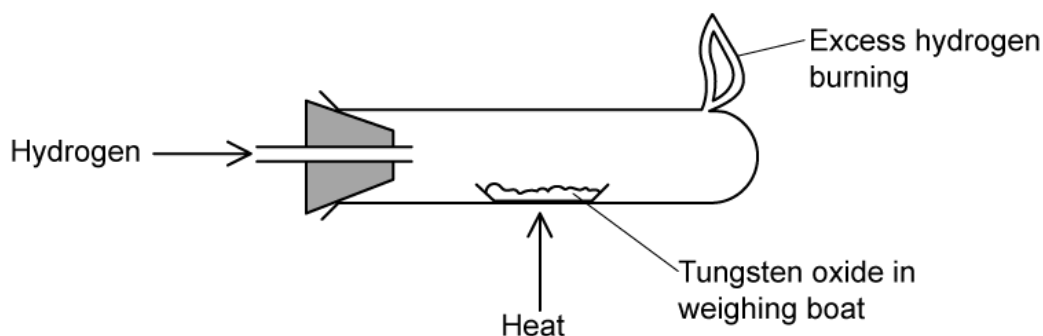
- 7 (a) This question is about the reduction of tungsten oxide, WO_3 .

A teacher reduces tungsten oxide to tungsten using the following method and the equipment shown in **Figure 1**.

- Record the mass of the weighing boat
- Add tungsten oxide and record the mass again

- Heat the weighing boat and tungsten oxide strongly for two minutes and then allow to cool
- Record the mass of the weighing boat and its contents

Figure 1



Write the balanced symbol equation, including state symbols, for the reduction of tungsten oxide by hydrogen.

(2 marks)

- (b) State **one** addition to the method to check that the tungsten oxide has been completely reduced.

(1 mark)

- (c) In industry, tungsten oxide is reduced on a large scale using hydrogen.

Using your equation from part (a), calculate the minimum volume, in dm^3 , of hydrogen that is required to react with 13.92 tonnes of tungsten oxide.

Relative atomic masses (A_r): W = 184, O = 16, H = 1

1 tonne = 1×10^6 g

(4 marks)
