

Cambridge AS & A Level

CHEMISTRY

Paper 1

Topical Past Paper Questions
+ Answer Scheme

2015 - 2021



Chapter 2

Atoms, molecules and stoichiometry

2.1 Relative masses of atoms and molecules

50. 9701_m21_qp_12 Q: 4

Originally, chemists thought indium oxide had the formula InO . By experiment they showed that 4.8 g of indium combined with 1.0 g of oxygen to produce 5.8 g of indium oxide. The A_r of oxygen was known to be 16.

Which value for the A_r of indium is calculated using these data?

- A** 38 **B** 77 **C** 115 **D** 154
-

51. 9701_w20_qp_11 Q: 1

Which statement is correct?

- A** Cl has a relative isotopic mass of 35.5.
B Cl_2 has a relative molecular mass of 70.
C ICl has a relative molecular mass of 162.4.
D NaCl has a relative molecular mass of 58.5.
-

2.2 The mole and the Avogadro constant

52. 9701_s21_qp_11 Q: 1

Which contains the largest number of hydrogen atoms?

- A** 0.10 mol of pentane
B 0.20 mol of but-2-ene
C 1.00 mol of hydrogen molecules
D 6.02×10^{23} hydrogen atoms
-

53. 9701_s21_qp_12 Q: 1

Which statement about the Avogadro constant is correct?

- A** It is the mass of one mole of any element.
B It is the mass of 6.02×10^{23} atoms of any element.
C It is the number of atoms in one mole of neon.
D It is the number of atoms in 12 g of any element.
-

54. 9701_w21_qp_12 Q: 2

Which statement is correct?

- A** 1.0 g of hydrogen gas contains 3.0×10^{23} atoms.
B 4.0 g of helium gas contains 1.2×10^{24} atoms.
C 16 g of methane gas contains 3.0×10^{24} atoms.
D 44 g of carbon dioxide gas contains 6.0×10^{23} atoms.
-

55. 9701_s20_qp_11 Q: 11

A sample of solid ammonium chloride decomposes on heating.

A total of 2.4×10^{21} molecules of gas is formed.

How many hydrogen atoms are present in the gaseous products?

- A** 1.2×10^{21} **B** 2.4×10^{21} **C** 4.8×10^{21} **D** 9.6×10^{21}
-

56. 9701_w19_qp_11 Q: 2

Diamond is a pure form of carbon. The mass of a diamond can be measured in carats. One carat is 0.200 g of carbon.

Which expression gives the number of carats that contain 6.02×10^{23} carbon atoms?

- A** 0.200×12.0
B $\frac{0.200}{12.0}$
C $\frac{12.0}{0.200}$
D $\frac{0.200}{6.02 \times 10^{23}} \times 12.0$
-

57. 9701_s17_qp_11 Q: 3

A sports medal has a total surface area of 150cm^2 . It was evenly coated with silver by electrolysis. Its mass increased by 0.216g .

How many atoms of silver were deposited per cm^2 on the surface of the medal?

- A 8.0×10^{18} B 1.8×10^{19} C 8.7×10^{20} D 1.2×10^{21}
-

58. 9701_s17_qp_12 Q: 2

Which would contain 9.03×10^{23} oxygen atoms?

- A 0.25 mol aluminium oxide
B 0.75 mol sulfur dioxide
C 1.5 mol sulfur trioxide
D 3.0 mol water
-

2.3 Formulae

59. 9701_m22_qp_12 Q: 3

Compound X contains the elements C, H and O only.

2.00g of X produces 4.00g of carbon dioxide and 1.63g of water when completely combusted.

What is the empirical formula of X?

- A CHO_2 B $\text{C}_2\text{H}_2\text{O}$ C $\text{C}_2\text{H}_4\text{O}$ D CH_2O_2
-

60. 9701_m22_qp_12 Q: 14

Which statement about atoms and molecules is correct?

- A The molecular formula of a compound is the simplest whole number ratio of atoms of each element in the compound.
B One mole of any substance contains 6×10^{23} atoms.
C The relative atomic mass of an element is the ratio of the average mass of one atom of the element to the mass of an atom of carbon-12.
D The relative formula mass of a compound is the sum of the individual atomic masses of all the atoms in the formula.
-

61. 9701_s21_qp_13 Q: 1

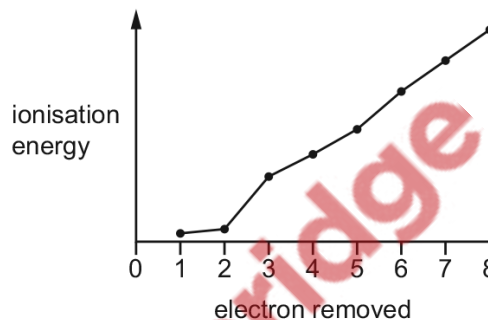
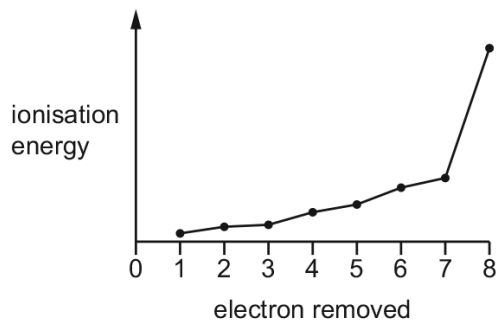
Compound X is an organic compound that contains 30.6% carbon, 3.8% hydrogen, 20.4% oxygen and 45.2% chlorine by mass.

What is the empirical formula of X?

- A** C_2H_3OCl **B** C_2H_4OCl **C** C_3H_4OCl **D** $C_4H_3O_2Cl_2$

62. 9701_s19_qp_12 Q: 3

The first eight successive ionisation energies for two elements of Period 3 of the Periodic Table are shown in the graphs.



What is the formula of the ionic compound formed from these elements?

- A** $MgCl_2$ **B** $CaBr_2$ **C** Na_2S **D** K_2Se

63. 9701_m18_qp_12 Q: 1

What are the shapes of the molecules of water and boron trifluoride?

	H_2O	BF_3
A	linear	pyramidal
B	linear	trigonal
C	non-linear	pyramidal
D	non-linear	trigonal

64. 9701_s18_qp_12 Q: 4

Compound J burns in excess oxygen to give carbon dioxide and water only. When a 3.00 g sample of compound J is burnt in excess oxygen, 4.40 g of carbon dioxide and 1.80 g of water are formed.

What is the empirical formula of J?

- A** CH **B** CHO **C** CH_2 **D** CH_2O

65. 9701_m17_qp_12 Q: 2

Compounds J and K each contain 40% carbon by mass.

What could J and K be?

	J	K
A	a hexose, $C_6H_{12}O_6$	starch, $(C_6H_{10}O_5)_n$
B	a pentose, $C_5H_{10}O_5$	a hexose, $C_6H_{12}O_6$
C	a pentose, $C_5H_{10}O_5$	sucrose, $C_{12}H_{22}O_{11}$
D	starch, $(C_6H_{10}O_5)_n$	sucrose, $C_{12}H_{22}O_{11}$

66. 9701_w17_qp_11 Q: 1

Which formula represents the empirical formula of a compound?

- A** C_2H_4O **B** $C_2H_4O_2$ **C** C_6H_{12} **D** H_2O_2

67. 9701_w17_qp_12 Q: 2

 Two hydrocarbons have the formulae C_WH_X and C_YH_Z . W, X, Y and Z represent different whole numbers.

$$\frac{W}{X} = \frac{Y}{Z}$$

Which row is correct when comparing the two hydrocarbons?

	empirical formula	molecular formula	relative molecular mass
A	different	same	different
B	different	same	same
C	same	different	different
D	same	different	same

68. 9701_w15_qp_11 Q: 1

The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
ionisation energy/ kJ mol^{-1}	950	1800	2700	4800	6000	12300

What could be the formula of a chloride of X?

- A** XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

2.4 Reacting masses and volumes (of solutions and gases)

69. 9701_m22_qp_12 Q: 20

Equal masses of CaCO_3 , $\text{Ca}(\text{NO}_3)_2$, BaCO_3 and $\text{Ba}(\text{NO}_3)_2$ are thermally decomposed. The volume of gas produced in each experiment is measured under the same conditions.

Which compound will produce the greatest volume of gas?

- A** CaCO_3 **B** $\text{Ca}(\text{NO}_3)_2$ **C** BaCO_3 **D** $\text{Ba}(\text{NO}_3)_2$
-

70. 9701_m22_qp_12 Q: 31

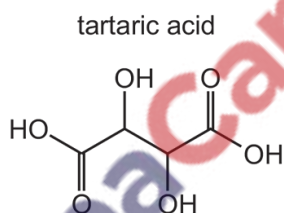
A sample of 2.30g of ethanol is mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture is boiled under reflux for one hour. The required organic product is then collected by distillation. The yield of product is 60.0%.

Which mass of product is collected?

- A** 1.32g **B** 1.38g **C** 1.80g **D** 3.00g
-

71. 9701_m22_qp_12 Q: 32

The structure of tartaric acid is shown.



Four moles of substance X react with one mole of tartaric acid.

What could be substance X?

- A** sodium
B sodium carbonate
C sodium hydrogencarbonate
D sodium hydroxide
-

72. 9701_m21_qp_12 Q: 3

Substance Q is a hydrocarbon. When 1.00 g of Q is completely burned, 3.22 g of carbon dioxide is produced.

What could be the identity of Q?

- A cyclohexene
- B cyclopentane
- C ethene
- D pentane

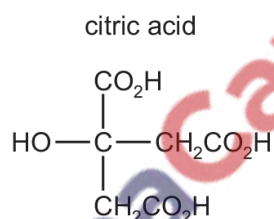
73. 9701_s21_qp_11 Q: 6

What is the minimum mass of oxygen required to ensure the complete combustion of 12 dm³ of propane measured under room conditions?

- A 60 g
- B 80 g
- C 120 g
- D 160 g

74. 9701_s21_qp_11 Q: 27

How many moles of hydrogen, H₂, are evolved when an excess of sodium metal is added to one mole of citric acid?



- A 0.5
- B 1.5
- C 2
- D 4

75. 9701_s21_qp_13 Q: 2

A sample of propane, C₃H₈, with a mass of 9.61 g is completely combusted in an excess of oxygen under room conditions.

Which volume of carbon dioxide gas is produced?

- A 4.89 dm³
- B 5.24 dm³
- C 14.7 dm³
- D 15.7 dm³

76. 9701_w21_qp_11 Q: 15

Anhydrous magnesium nitrate, Mg(NO₃)₂, decomposes when heated, giving a white solid and a mixture of two gases, X and Y.

Y is oxygen.

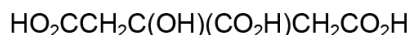
What is the ratio $\frac{\text{mass of X released}}{\text{mass of Y released}}$?

- A $\frac{1}{0.174}$
- B $\frac{1}{0.267}$
- C $\frac{1}{0.348}$
- D $\frac{1}{3.43}$

77. 9701_w21_qp_11 Q: 28

Citric acid is found in lemon juice.

citric acid



Which volume of 0.40 mol dm^{-3} sodium hydroxide solution is required to neutralise a solution containing 0.0050 mol of citric acid?

- A 12.5 cm^3 B 25.0 cm^3 C 37.5 cm^3 D 50.0 cm^3
-

78. 9701_w21_qp_12 Q: 14

A 0.005 mol sample of anhydrous calcium carbonate is completely thermally decomposed to give 100 cm^3 of gas.

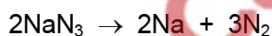
In a separate experiment carried out under the same conditions, a 0.005 mol sample of anhydrous calcium nitrate is completely thermally decomposed. The volume of gaseous products is measured.

What total volume of gaseous products is produced from the calcium nitrate?

- A 50 cm^3 B 100 cm^3 C 200 cm^3 D 250 cm^3
-

79. 9701_m20_qp_12 Q: 7

Sodium azide, NaN_3 , decomposes as shown.



Which volume of nitrogen, measured at room temperature and pressure, will be produced by the decomposition of 150 g of sodium azide?

- A 166 dm^3 B 83 dm^3 C 55 dm^3 D 37 dm^3
-

80. 9701_s20_qp_11 Q: 4

10 cm^3 of ethane is burned in 45 cm^3 of oxygen at a pressure of 101 kPa and a temperature of 200°C . Complete combustion takes place.

What is the total volume of gas present when the reaction is complete, measured under the same conditions?

- A 30 cm^3 B 50 cm^3 C 55 cm^3 D 60 cm^3
-

81. 9701_s20_qp_11 Q: 13

6.90 g of an ammonium salt is heated with an excess of aqueous sodium hydroxide. The volume of ammonia produced, measured under room conditions, is 2.51 dm^3 .

Which ammonium salt is used?

- A ammonium carbonate ($M_r = 96.0$)
 - B ammonium chloride ($M_r = 53.5$)
 - C ammonium nitrate ($M_r = 80.0$)
 - D ammonium sulfate ($M_r = 132.1$)
-

82. 9701_s20_qp_11 Q: 17

0.25 g of anhydrous magnesium nitrate is heated strongly until it completely decomposes.

What is the total volume of gas produced, measured under room conditions?

- A 40 cm^3
 - B 81 cm^3
 - C 101 cm^3
 - D 202 cm^3
-

83. 9701_s20_qp_12 Q: 2

A copper ore contains 3.00% of copper carbonate, CuCO_3 , by mass.

Which mass of copper would be obtained from 1 tonne of the ore?

- A 1.91 kg
 - B 3.71 kg
 - C 15.4 kg
 - D 58.4 kg
-

84. 9701_s20_qp_12 Q: 6

In this question you should assume air contains 21% oxygen.

What is the minimum volume of air required to ensure complete combustion of 10 cm^3 of butane gas, under room conditions?

- A 14 cm^3
 - B 27 cm^3
 - C 65 cm^3
 - D 310 cm^3
-

85. 9701_s20_qp_12 Q: 13

Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, decomposes when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

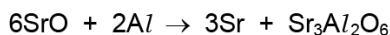
7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

- A 1.5 g
 - B 2.3 g
 - C 3.0 g
 - D 4.6 g
-

86. 9701_w20_qp_11 Q: 2

Strontium metal can be extracted from strontium oxide, SrO, by reduction with aluminium. One of the possible reactions is shown.



What is the maximum mass of strontium metal that can be produced from the reduction of 100 g of strontium oxide using this reaction?

- A 41.3 g B 42.3 g C 84.6 g D 169.2 g

87. 9701_w20_qp_12 Q: 2

An ore of manganese contains 4% by mass of MnO_2 and no other manganese compound.

Which mass of manganese would be obtained from 1 tonne of this ore?

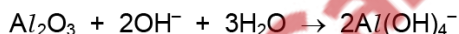
- A 25.3 kg B 40.0 kg C 63.3 kg D 632 kg

88. 9701_w20_qp_12 Q: 5

A white powder is known to be a mixture of magnesium oxide and aluminium oxide.

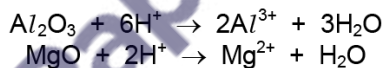
100 cm^3 of 2 mol dm^{-3} NaOH(aq) is just enough to dissolve the aluminium oxide in x grams of the mixture.

The reaction is shown.



800 cm^3 of 2 mol dm^{-3} HCl(aq) is just enough to dissolve **all** of the oxide in x grams of the mixture.

The reactions are shown.



How many moles of each oxide are present in x grams of the mixture?

	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

89. 9701_m19_qp_12 Q: 2

A 3.7 g sample of copper(II) carbonate is added to 25 cm³ of 2.0 mol dm⁻³ hydrochloric acid.

Which volume of gas is produced under room conditions?

- A** 0.60 dm³ **B** 0.72 dm³ **C** 1.20 dm³ **D** 2.40 dm³
-

90. 9701_s19_qp_11 Q: 3

A washing powder contains sodium hydrogencarbonate, NaHCO₃, as one of the ingredients.

In a titration, a solution containing 1.00 g of this washing powder requires 7.15 cm³ of 0.100 mol dm⁻³ sulfuric acid for complete reaction. The sodium hydrogencarbonate is the only ingredient that reacts with the acid.

What is the percentage by mass of sodium hydrogencarbonate in the washing powder?

- A** 3.0% **B** 6.0% **C** 12.0% **D** 24.0%
-

91. 9701_w19_qp_12 Q: 2

In this question it should be assumed that (NH₄)₂CO₃·H₂O(s) dissolves in water without causing an increase in volume.

Which mass of (NH₄)₂CO₃·H₂O(s) should be added to 800 cm³ of water to form a 0.100 mol dm⁻³ solution of NH₄⁺ ions?

- A** 4.56 g **B** 7.13 g **C** 9.12 g **D** 14.3 g
-

92. 9701_w19_qp_12 Q: 9

When lead(II) sulfide, PbS, is heated in air, sulfur dioxide and lead(II) oxide are formed.

What is the equation for the reaction between PbS and oxygen?

- A** $\text{PbS} + 2\text{O}_2 \rightarrow \text{SO}_2 + \text{PbO}_2$
B $\text{PbS} + 2\frac{1}{2}\text{O}_2 \rightarrow \text{SO}_3 + \text{PbO}_2$
C $\text{PbS} + 1\frac{1}{2}\text{O}_2 \rightarrow \text{SO}_2 + \text{PbO}$
D $\text{PbS} + 2\text{O}_2 \rightarrow \text{SO}_3 + \text{PbO}$
-

93. 9701_m18_qp_12 Q: 2

The electronic configuration of the two outermost shells of an atom is $3s^23p^63d^54s^2$.

What is this atom?

- A manganese
 - B phosphorus
 - C strontium
 - D vanadium
-

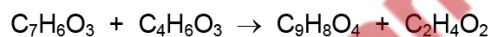
94. 9701_m18_qp_12 Q: 25

Which volume of hydrogen, measured under room conditions, is produced when 0.160 g of methanol reacts with an excess of sodium?

- A 60 cm^3
 - B 120 cm^3
 - C 240 cm^3
 - D 480 cm^3
-

95. 9701_s18_qp_13 Q: 5

Aspirin, $\text{C}_9\text{H}_8\text{O}_4$, $M_r = 180.0$, can be made by a reaction between 2-hydroxybenzoic acid, $\text{C}_7\text{H}_6\text{O}_3$, $M_r = 138.0$, and ethanoic anhydride, $\text{C}_4\text{H}_6\text{O}_3$, $M_r = 102.0$. The balanced equation for the reaction is shown.



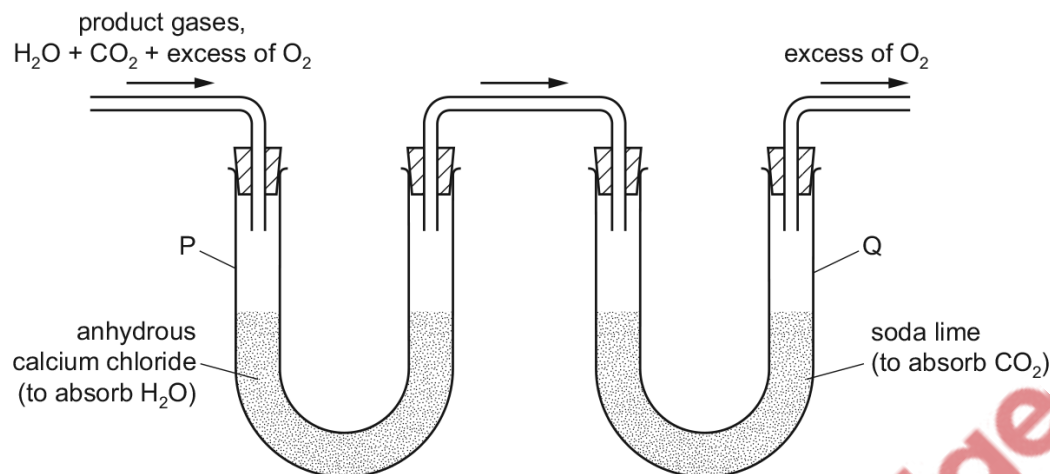
If a reaction mixture consists of 10.0 g of each of the two reactants, what is the maximum mass of aspirin that can be produced?

- A 5.7 g
 - B 10.0 g
 - C 13.0 g
 - D 17.6 g
-



96. 9701_w18_qp_11 Q: 3

A sample of the hydrocarbon C_6H_{12} is completely burned in dry oxygen and the product gases are collected as shown.



The increases in mass of the collecting vessels P and Q are M_P and M_Q , respectively.

What is the ratio M_P / M_Q ?

- A 0.41 B 0.82 C 1.2 D 2.4

97. 9701_s17_qp_12 Q: 19

A chemist took 2.00 dm^3 of nitrogen gas, measured under room conditions, and reacted it with a large volume of hydrogen gas to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.

Which mass of ammonia was formed?

- A 0.213 g B 0.425 g C 1.42 g D 2.83 g

98. 9701_s17_qp_13 Q: 2

A 0.216 g sample of an aluminium compound X reacts with an excess of water to produce a single hydrocarbon gas. This gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 at room temperature and pressure is 108 cm^3 .

What is the formula of X?

- A Al_2C_3 B Al_3C_2 C Al_3C_4 D Al_4C_3

99. 9701_s17_qp_13 Q: 3

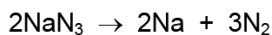
Which equation correctly describes the complete combustion of an alkene, C_nH_{2n} ?

- A $C_nH_{2n} + \frac{3}{2}nO_2 \rightarrow nCO_2 + 2nH_2O$
 B $C_nH_{2n} + \frac{3}{2}nO_2 \rightarrow nCO_2 + nH_2O$
 C $C_nH_{2n} + 2nO_2 \rightarrow nCO_2 + nH_2O$
 D $C_nH_{2n} + 2nO_2 \rightarrow nCO_2 + 2nH_2O$

100. 9701_w17_qp_12 Q: 3

The airbags in cars contain sodium azide, NaN_3 , and an excess of potassium nitrate, KNO_3 .

In a car accident, the reactions shown occur, producing nitrogen. This causes the airbag to inflate rapidly.



How many moles of nitrogen gas are produced **in total** when 1 mol of sodium azide, NaN_3 , decomposes in an airbag?

- A 1.5 B 1.6 C 3.2 D 4.0

101. 9701_s16_qp_11 Q: 3

Tetraethyl lead, $Pb(C_2H_5)_4$, has been used as a petrol additive.

What is the percentage by mass of carbon in tetraethyl lead?

- A 10.2 B 14.9 C 29.7 D 32.0

102. 9701_s16_qp_11 Q: 17

A piece of rock has a mass of 2.00 g. It contains calcium carbonate, but no other basic substances. It neutralises exactly 36.0 cm^3 of $0.500 \text{ mol dm}^{-3}$ hydrochloric acid.

What is the percentage of calcium carbonate in the 2.00 g piece of rock?

- A 22.5% B 45.0% C 72.0% D 90.1%

103. 9701_s16_qp_12 Q: 4

In China, the concentration of blood glucose, $C_6H_{12}O_6$, is measured in $mmol/l$. In Pakistan, the concentration of blood glucose is measured in mg/dl .

The unit l is a litre ($1 dm^3$). The unit dl is a decilitre ($0.1 dm^3$).

A blood glucose concentration of $18.5 mmol/l$ indicates a health problem.

What is $18.5 mmol/l$ converted to mg/dl ?

- A** 33.3 mg/dl **B** 178 mg/dl **C** 333 mg/dl **D** 3330 mg/dl
-

104. 9701_s16_qp_12 Q: 14

A $0.005 mol$ sample of anhydrous calcium carbonate was completely thermally decomposed to give $100 cm^3$ of gas measured at a certain temperature and pressure.

In a separate experiment carried out at the same temperature and pressure, a $0.005 mol$ sample of anhydrous calcium nitrate was completely thermally decomposed. The volume of gaseous products was measured.

What total volume of gaseous products was produced from the calcium nitrate?

- A** $50 cm^3$ **B** $100 cm^3$ **C** $200 cm^3$ **D** $250 cm^3$
-

105. 9701_s16_qp_13 Q: 3

Which mass of urea, $CO(NH_2)_2$, contains the same mass of nitrogen as $101.1 g$ of potassium nitrate?

- A** 22 g **B** 30 g **C** 44 g **D** 60 g
-

106. 9701_w16_qp_12 Q: 3

People are advised to eat less than $6.00 g$ of salt (sodium chloride) per day for health reasons.

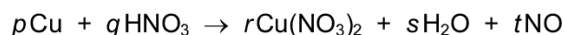
Which mass of sodium is present in $6.00 g$ of sodium chloride?

- A** 0.261 g **B** 2.36 g **C** 3.64 g **D** 3.88 g
-

107. 9701_w16_qp_12 Q: 4

When copper reacts with a 50% solution of nitric acid, nitrogen monoxide is evolved and a blue solution results.

The balanced equation for this reaction is shown.



What are the values of the integers p , q , r , s and t ?

	p	q	r	s	t
A	1	4	1	2	2
B	2	6	2	3	2
C	2	8	2	4	4
D	3	8	3	4	2

108. 9701_s15_qp_12 Q: 2

The shell of a chicken's egg makes up 5% of the mass of an average egg. An average egg has a mass of 50g.

Assume the egg shell is pure calcium carbonate.

How many complete chicken's egg shells would be needed to neutralise 50 cm³ of 2.0 mol dm⁻³ ethanoic acid?

- A** 1 **B** 2 **C** 3 **D** 4

109. 9701_w15_qp_11 Q: 3

Use of the Data Booklet is relevant to this question.

The compound S₂O₇ is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352g of S₂O₇ is hydrolysed?

- A** 12 cm³ **B** 24 cm³ **C** 48 cm³ **D** 96 cm³

110. 9701_w15_qp_12 Q: 2

Arsenic chloride, AsCl_3 , reacts with sodium borohydride, NaBH_4 .



What are the numbers **p**, **q**, **r**, **s** and **t** when this equation is balanced correctly?

	p	q	r	s	t
A	2	3	2	3	1
B	3	3	3	3	2
C	4	3	4	3	3
D	4	4	4	4	3

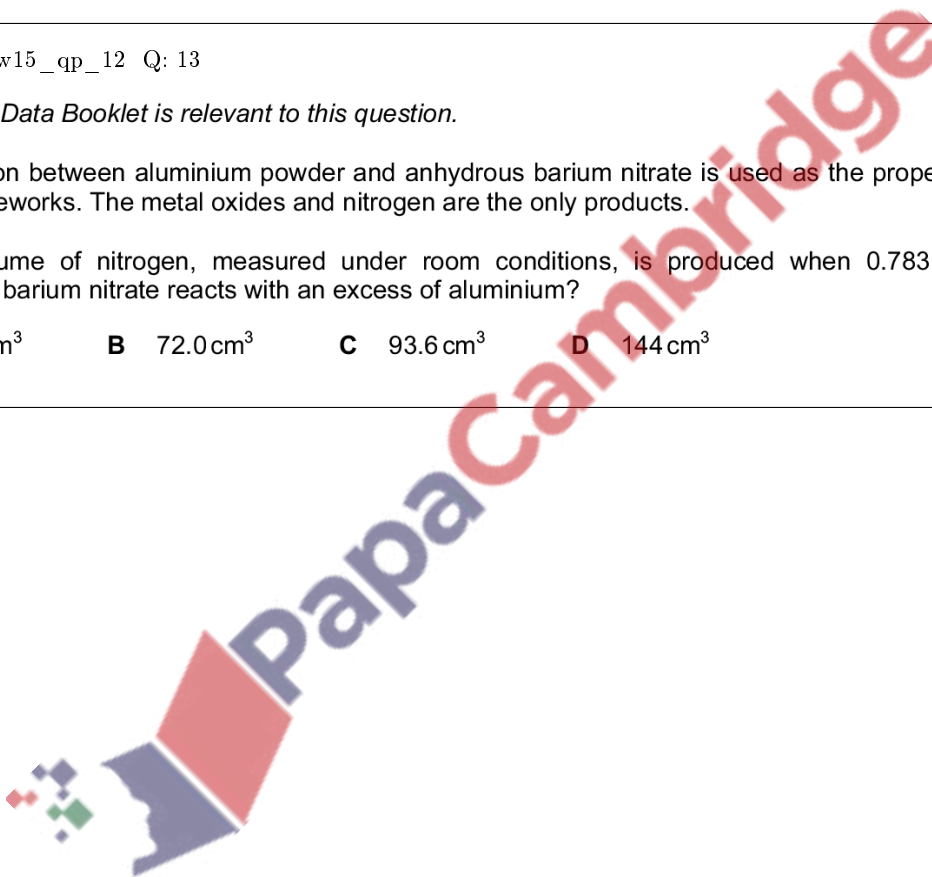
111. 9701_w15_qp_12 Q: 13


Use of the Data Booklet is relevant to this question.

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783g of anhydrous barium nitrate reacts with an excess of aluminium?

- A** 46.8 cm³ **B** 72.0 cm³ **C** 93.6 cm³ **D** 144 cm³



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