CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

2 ATOMS, MOLECULES AND STOICHIOMETRY

SCORE	PERCENTAGE
/	%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at cambridgeinternational.org before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

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

STEMUP.CO.UK

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.

$$\text{solid ammonium chloride} \rightarrow \text{ammonia gas} + \text{hydrogen chloride gas}$$

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 $\dfrac{0.200}{12.0}$

C $\dfrac{12.0}{0.200}$

D $\dfrac{0.200}{6.02 \times 10^{23}} \times 12.0$

---

57. 9701_s17_qp_11 Q: 3

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

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.

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

What is the empirical formula of X?

A CHO_2 **B** C_2H_2O **C** C_2H_4O **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.

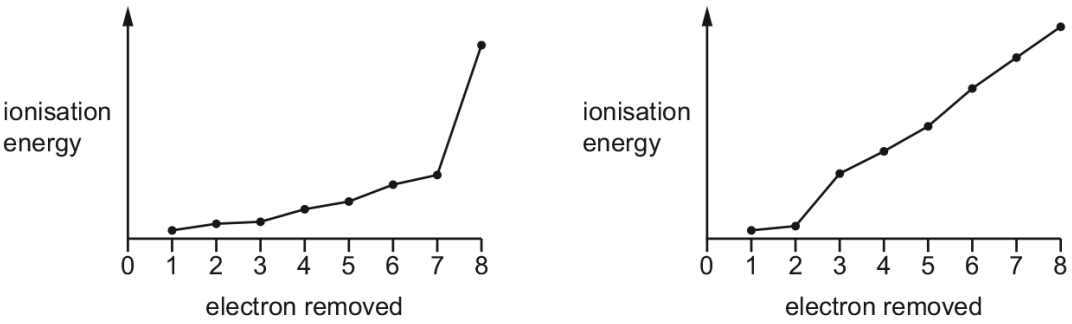
What is the empirical formula of X?

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 $CaCO_3$, $Ca(NO_3)_2$, $BaCO_3$ and $Ba(NO_3)_2$ 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** $Ca(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

---

70. 9701_m22_qp_12 Q: 31

A sample of 2.30 g 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?

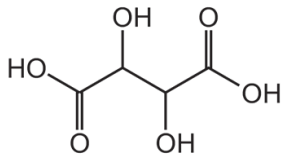
A 1.32 g **B** 1.38 g **C** 1.80 g **D** 3.00 g

---

71. 9701_m22_qp_12 Q: 32

The structure of tartaric acid is shown.

tartaric acid



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 dm^3 of propane measured under room conditions?

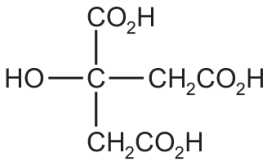
A 60 g **B** 80 g **C** 120 g **D** 160 g

---

74. 9701_s21_qp_11 Q: 27

How many moles of hydrogen, H_2, are evolved when an excess of sodium metal is added to one mole of citric acid?

citric acid



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

---

75. 9701_s21_qp_13 Q: 2

A sample of propane, C_3H_8, 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 dm^3 **B** 5.24 dm^3 **C** 14.7 dm^3 **D** 15.7 dm^3

---

76. 9701_w21_qp_11 Q: 15

Anhydrous magnesium nitrate, $Mg(NO_3)_2$, 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

$HO_2CCH_2C(OH)(CO_2H)CH_2CO_2H$

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.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

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, $Mg(NO_3)_2$, 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.

$$6SrO + 2Al \rightarrow 3Sr + Sr_3Al_2O_6$$

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.

$$Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2Al(OH)_4^-$$

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.

$$Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$$
$$MgO + 2H^+ \rightarrow Mg^{2+} + H_2O$$

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 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

Which volume of gas is produced under room conditions?

A 0.60 dm^3 **B** 0.72 dm^3 **C** 1.20 dm^3 **D** 2.40 dm^3

---

90. 9701_s19_qp_11 Q: 3

A washing powder contains sodium hydrogencarbonate, $NaHCO_3$, as one of the ingredients.

In a titration, a solution containing 1.00 g of this washing powder requires 7.15 cm^3 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 $(NH_4)_2CO_3.H_2O(s)$ dissolves in water without causing an increase in volume.

Which mass of $(NH_4)_2CO_3.H_2O(s)$ should be added to 800 cm^3 of water to form a 0.100 mol dm^{-3} solution of NH_4^+ 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 $PbS + 2O_2 \rightarrow SO_2 + PbO_2$

B $PbS + 2\frac{1}{2}O_2 \rightarrow SO_3 + PbO_2$

C $PbS + 1\frac{1}{2}O_2 \rightarrow SO_2 + PbO$

D $PbS + 2O_2 \rightarrow SO_3 + PbO$

---

93. 9701_m18_qp_12 Q: 2

The electronic configuration of the two outermost shells of an atom is $3s^2 3p^6 3d^5 4s^2$.

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, $C_9H_8O_4$, M_r = 180.0, can be made by a reaction between 2-hydroxybenzoic acid, $C_7H_6O_3$, M_r = 138.0, and ethanoic anhydride, $C_4H_6O_3$, M_r = 102.0. The balanced equation for the reaction is shown.

$$C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$$

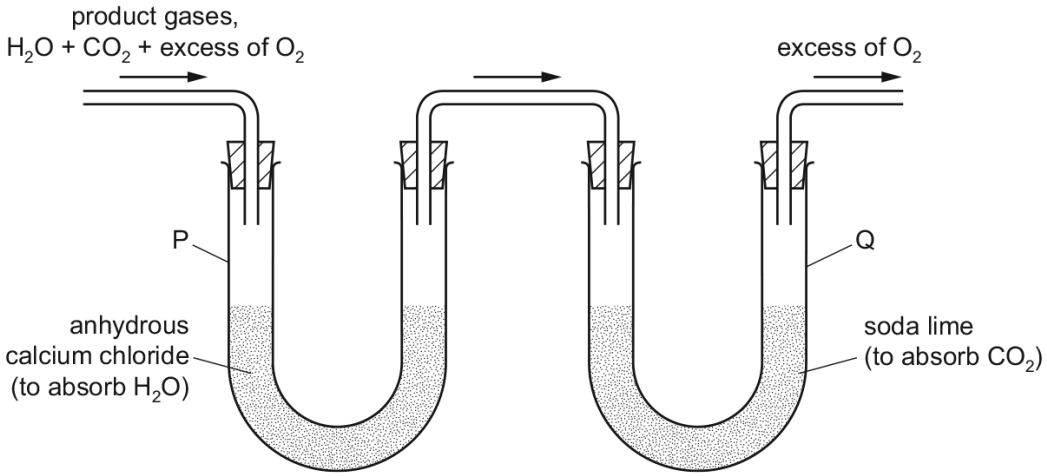
If a reaction mixture consists of 10.0 g of each of the two reactants, what is the maximum mass of aspirin that can be produced?

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.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

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 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.

$$p\text{Cu} + q\text{HNO}_3 \rightarrow r\text{Cu(NO}_3)_2 + s\text{H}_2\text{O} + t\text{NO}$$

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 50 g.

Assume the egg shell is pure calcium carbonate.

How many complete chicken's egg shells would be needed to neutralise 50 cm^3 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 S_2O_7 is hydrolysed by water to produce sulfuric acid and oxygen only.

Which volume of oxygen, measured at room temperature and pressure, is evolved when 0.352 g of S_2O_7 is hydrolysed?

A 12 cm^3 **B** 24 cm^3 **C** 48 cm^3 **D** 96 cm^3

---

110. 9701_w15_qp_12 Q: 2

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

$$\mathbf{p}AsCl_3 + \mathbf{q}NaBH_4 \rightarrow \mathbf{r}AsH_3 + \mathbf{s}NaCl + \mathbf{t}BCl_3$$

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 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

A 46.8 cm^3 **B** 72.0 cm^3 **C** 93.6 cm^3 **D** 144 cm^3

Chapter 1

Atoms, molecules and stoichiometry

STEMUP.CO.UK

1.1 Reacting masses and volumes (of solutions and gases)

1. 9701_s17_qp_21 Q: 1

Combustion data can be used to calculate the empirical formula, molecular formula and relative molecular mass of many organic compounds.

(a) Define the term *relative molecular mass*.

.....

.....

.....

..... [2]

(b) **T** is an alcohol, C_xH_yO. A gaseous sample of **T** occupied a volume of 20 cm^3 at 120 °C and 100 kPa.

The sample was completely burned in 200 cm^3 of oxygen (an excess). The final volume, measured under the same conditions as the gaseous sample, was 250 cm^3.

Under these conditions, all water present is vaporised. Removal of the water vapour from the gaseous mixture decreased the volume to 170 cm^3.

Treating the remaining gaseous mixture with concentrated alkali, to absorb carbon dioxide, decreased the volume to 110 cm^3.

The equation for the complete combustion of **T** can be represented as shown.

$$C_xH_yO + zO_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

(i) Use the data given to calculate the value of *x*.

x = ... [1]

(ii) Use the data given to calculate the value of *y*.

y = ... [1]

If you were unable to calculate values for x and y then use $x = 4$ and $y = 10$ for the remaining parts of this question. These are **not** the correct values.

(iii) Complete the equation for the complete combustion of the alcohol, **T**.

..... + ...O_2 → .....CO_2 + ...H_2O

[1]

(iv) Give the skeletal formulae for two possible structures of **T**.

Name each alcohol.

.....	.....

[2]

(v) Use the general gas equation to calculate the mass of **T** present in the original 20 cm^3 gaseous sample, which was measured at 120 °C and 100 kPa.

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

mass = ... g [3]

[Total: 10]

2. 9701_m16_qp_22 Q: 2

Spathose is an iron ore that contains iron(II) carbonate, $FeCO_3$. The percentage of iron(II) carbonate in spathose can be determined by titration with acidified potassium dichromate(VI) solution using a suitable indicator.

The ionic equation is shown below.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

(a) A 5.00 g sample of spathose was reacted with excess concentrated hydrochloric acid and then filtered.
The filtrate was made up to 250 cm^3 in a volumetric flask with distilled water.

A 25.0 cm^3 sample of the standard solution required 27.30 cm^3 of 0.0200 mol dm^{-3} dichromate(VI) solution for complete reaction.

(i) Calculate the amount, in moles, of dichromate(VI) ions used in the titration.

amount = ... mol [1]

(ii) Use your answer to **(i)** to calculate the amount, in moles, of Fe^{2+} present in the 25.0 cm^3 sample.

amount = ... mol [1]

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of Fe^{2+} present in the 250 cm^3 volumetric flask.

amount = ... mol [1]

(iv) Use your answer to **(iii)** to calculate the mass of iron(II) carbonate present in the sample of spathose.

mass = ... g [2]

(v) Calculate the percentage of iron(II) carbonate in the sample of spathose.

percentage of iron(II) carbonate = ... % [1]

(b) Iron ores containing iron(III) compounds can be analysed using a similar method.

A standard solution of an aqueous iron(III) compound is reacted with aqueous tin(II) chloride. Aqueous tin(IV) chloride and aqueous iron(II) chloride are the products of this reaction.

(i) Write an **ionic** equation for this reaction. Do not include state symbols.

..... [2]

(ii) Any excess tin(II) chloride can be removed by reaction with $HgCl_2(aq)$. A white precipitate of Hg_2Cl_2 is produced.

Complete the equation for this reaction.

$$.....(.....) + ...HgCl_2(aq) \rightarrow SnCl_4(.....) + Hg_2Cl_2(.....)$$

[2]

[Total: 10]

3. 9701_w16_qp_21 Q: 1

A 0.17 g sample of a Group 14 chloride, **X**Cl_4, reacted with water to produce an oxide, **X**O_2, and HCl.

equation 1 $\quad$ **X**Cl_4(s) + 2H_2O(l) $\rightarrow$ **X**O_2(s) + 4HCl(aq)

The HCl produced was absorbed in 100 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution (an excess).

In a titration, the unreacted sodium hydroxide solution required 30.0 cm^3 of 0.20 mol dm^{-3} hydrochloric acid for complete neutralisation.

(a) Calculate the amount, in moles, of hydrochloric acid used in the titration to neutralise the unreacted sodium hydroxide solution.

amount = ... mol [1]

(b) Write the equation for the reaction between hydrochloric acid and sodium hydroxide.

..... [1]

(c) Calculate the amount, in moles, of sodium hydroxide neutralised in the titration.

amount = ... mol [1]

(d) Calculate the amount, in moles, of sodium hydroxide that reacted with the HCl produced by the reaction in equation 1.

amount = ... mol [1]

(e) Calculate the amount, in moles, of HCl produced by the reaction in equation 1.

amount = ... mol [1]

(f) Calculate the amount, in moles, of **X**Cl_4 in the original 0.17 g sample.

amount = ... mol [1]

(g) Calculate the molecular mass, M_r, of **X**Cl_4.

M_r = ... [1]

(h) Calculate the relative atomic mass, A_r, of **X** and suggest its identity.

A_r of **X** = ...

identity of **X** .....
[2]

[Total: 9]

---

4. 9701_w16_qp_22 Q: 1

A 0.50 g sample of a Group 2 metal, **M**, was added to 40.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid (an excess).

equation 1 $\mathbf{M}(s) + 2HCl(aq) \rightarrow \mathbf{M}Cl_2(aq) + H_2(g)$

(a) Calculate the amount, in moles, of hydrochloric acid present in 40.0 cm^3 of 1.00 mol dm^{-3} HCl.

amount = ... mol [1]

(b) When the reaction had finished, the resulting solution was made up to 100 cm^3 in a volumetric flask.

A 10.0 cm^3 sample of the solution from the volumetric flask required 15.0 cm^3 of 0.050 mol dm^{-3} sodium carbonate solution, Na_2CO_3, for complete neutralisation of the remaining hydrochloric acid.

(i) Write the equation for the complete reaction of sodium carbonate with hydrochloric acid.

..... [1]

(ii) Calculate the amount, in moles, of sodium carbonate needed to react with the hydrochloric acid in the 10.0 cm^3 sample from the volumetric flask.

amount = ... mol [1]

(iii) Calculate the amount, in moles, of hydrochloric acid in the 10.0 cm^3 sample.

amount = ... mol [1]

(iv) Calculate the total amount, in moles, of hydrochloric acid remaining after the reaction shown in equation 1.

amount = ... mol [1]

(v) Use your answers to **(a)** and **(b)(iv)** to calculate the amount, in moles, of hydrochloric acid that reacted with the 0.50 g sample of **M**.

amount = ... mol [1]

(vi) Use your answer to **(v)** and equation 1 to calculate the amount, in moles, of **M** in the 0.50 g sample.

amount = ... mol [1]

(vii) Calculate the relative atomic mass, A_r, of **M** and identify **M**.

A_r of **M** = ...

identity of **M** = ...
[2]

[Total: 9]

Appendix A

Q1.

Examiner's Use

6 A compound, **A**, has the following composition by mass.

C, 66.7%; H, 11.1%; O, 22.2%.

It has an M_r of 72.

(a) Calculate the molecular formula of **A**.

[2]

Q2.

2 Compounds of phosphorus have many uses in everyday life, e.g. fertilisers, matches and in water softeners.

(a) State the full electronic configuration of phosphorus.

.....[1]

(b) Phosphoric acid, H_3PO_4, is used in the manufacture of phosphate fertilisers.

Deduce the oxidation number of phosphorus in H_3PO_4.

.....[1]

(c) The salt sodium phosphate, Na_3PO_4, is a water-softening agent.

(i) Write the equation for the complete neutralisation of phosphoric acid with aqueous sodium hydroxide.

.....

STEMUP.CO.UK

Sodium phosphate was prepared from 50.0 cm^3 of 0.500 mol dm^{-3} H_3PO_4 and an excess of aqueous sodium hydroxide.

(ii) How many moles of H_3PO_4 were used?

(iii) Use your equation in **(c)(i)** to calculate how many moles of sodium hydroxide are required.

[3]

(d) Phosphorus sulphide, P_4S_3, is used in small amounts in the tip of a match. On striking a match, this compound burns.

(i) Construct an equation for this reaction.

.....

(ii) Both oxides formed in **(i)** dissolve in water to give acidic solutions. Construct an equation for the reaction of each oxide with water.

.....

.....[4]

[Total : 9]

Q3.

STEMUP.CO.UK

(c) 1.20 dm^3 of ammonia gas were dissolved in water to form 200 cm^3 of aqueous alkali at room temperature and pressure.

(i) Use the *Data Booklet* to calculate how many moles of $NH_3(g)$ were dissolved.

(ii) Write the equation for the neutralisation of aqueous ammonia by dilute sulphuric acid.

.....

(iii) Calculate the volume of 0.50 mol dm^{-3} sulphuric acid that is required to neutralise the 200 cm^3 of aqueous ammonia.

[3]

Q4.

STEMUP.CO.UK

Hydrogen sulphide burns with a blue flame in an excess of oxygen to form sulphur dioxide and water.

(d) **(i)** Write a balanced equation for the complete combustion of H_2S.

.....

(ii) What is the change in the oxidation number of sulphur in this reaction?

from ..... to .....

(iii) What volume of oxygen, measured at room temperature and pressure, is required for the complete combustion of 8.65 g of H_2S? Give your answer to two decimal places.

[5]

Q5.

1 Mohr's salt is a pale green crystalline solid which is soluble in water. Mohr's salt is a 'double salt' which contains

two cations, one of which is Fe^{2+},

one anion which is SO_4^{2-},

and water of crystallisation.

(a) The identity of the second cation was determined by the following test.
Solid Mohr's salt was heated with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.

(i) What is the gas?

.....

(ii) What is the formula of the second cation identified by this test?

.....

(iii) In this test, a grey/green solid residue was also formed.

Suggest a name **or** formula for this solid.

.....

[3]

STEMUP.CO.UK

(b) The identity of the anion present in Mohr's salt was confirmed by adding dilute hydrochloric acid followed by aqueous barium chloride to an aqueous solution of Mohr's salt. A white precipitate was formed.

Suggest the identity of the white precipitate.

.....[1]

(c) When a double salt such as Mohr's salt is made, the two individual salts are mixed together in a 1:1 molar ratio, dissolved in water and the solution crystallised.

(i) Give the formula of **each** of the two salts that would be mixed to make the double salt, Mohr's salt.

salt 1 .....

salt 2 .....

(ii) Calculate the relative formula mass of **each** of the salts present in Mohr's salt.

salt 1

relative formula mass of salt 1 .....

salt 2

relative formula mass of salt 2 .....

(iii) The crystals of the double salt contain water of crystallisation.

The relative formula mass of Mohr's salt is 392. Use your answers to **(ii)** to calculate the number of moles of water of crystallisation present in one mole of Mohr's salt.

[6]

[Total: 10]

STEMUP.CO.UK

Q6.

(c) In some countries, ethyne is manufactured from calcium carbide, CaC_2, which is produced by heating quicklime and coke together at 2300 K.

$$CaO + 3C \longrightarrow CaC_2 + CO$$

When water is added to the CaC_2, calcium hydroxide, $Ca(OH)_2$, and ethyne, C_2H_2, are produced.

(i) Construct a balanced equation for the formation of ethyne from calcium carbide.

.....

(ii) Use this equation and your answer to part **(b)** to calculate the mass of CaC_2 which will react with an excess of water to produce enough ethyne to fill 100 cylinders of the gas.

[3]

Q7.

(b) When CH_2Cl_2 is heated under reflux with an excess of NaOH(aq), a compound **W** is formed.

W has the following composition by mass: C, 40.0%; H, 6.7%; O, 53.3%.

Use this information and the *Data Booklet* to show that the empirical formula of **W** is CH_2O.

[2]

Q8.

STEMUP.CO.UK

Titanium also reacts with chlorine.

(d) When an excess of chlorine was reacted with 0.72 g of titanium, 2.85 g of a chloride **A** was formed.

(i) Calculate the amount, in moles, of titanium used.

(ii) Calculate the amount, in moles, of chlorine atoms that reacted.

(iii) Hence, determine the empirical formula of **A**.

(iv) Construct a balanced equation for the reaction between titanium and chlorine.

.....

[4]

Q9.

4 An organic compound, **E**, has the following composition by mass:
C, 48.7%; H, 8.1%; O, 43.2%.

(a) Calculate the empirical formula of **E**.

[2]

STEMUP.CO.UK

(b) When vaporised in a suitable apparatus, 0.130 g of **E** occupied a volume of 58.0 cm^3 at 127 °C and 1.00 × 10^5 Nm^{-2}.

(i) Use the expression $pV = \frac{mRT}{M_r}$ to calculate M_r of **E**,

where m is the mass of **E**.

(ii) Hence calculate the molecular formula of **E**.

[4]

Q10.

A third polycarboxylic acid present in unripe fruit is a colourless crystalline solid, **W**, which has the following composition by mass: C, 35.8%; H, 4.5%; O, 59.7%.

(d) **(i)** Show by calculation that the empirical formula of **W** is $C_4H_6O_5$.

(ii) The M_r of **W** is 134. Use this value to determine the molecular formula of **W**.

[3]

Q11.

STEMUP.CO.UK

(c) In a redox reaction, 0.83 g of lithium reacted with water to form 0.50 dm^3 of aqueous lithium hydroxide.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

(i) Calculate the amount, in moles, of lithium that reacted.

(ii) Calculate the volume of hydrogen produced at room temperature and pressure.

(iii) Calculate the concentration, in mol dm^{-3}, of the LiOH(aq) formed.

[5]

Q12.

STEMUP.CO.UK

(c) In this section, give your answers to <u>one</u> decimal place.

The flight path from Beijing to Paris is approximately 8195 km.
A typical intercontinental jet airliner burns 10.8 kg of kerosene for each kilometre covered.

(i) Calculate the mass, in tonnes, of $C_{14}H_{30}$ burnt on a flight from Beijing to Paris.
[1 tonne = 1 000 kg]

(ii) Use your equation in **(b)** to calculate the mass, in tonnes, of CO_2 produced during this flight.

[4]

Q13.

In an experiment to determine K_c a student placed together in a conical flask 0.10 mol of ethanoic acid, 0.10 mol of an alcohol ROH, and 0.005 mol of hydrogen chloride catalyst.
The flask was sealed and kept at 25 °C for seven days.
After this time, the student titrated all of the contents of the flask with 2.00 mol dm^{-3} NaOH using phenolphthalein indicator.
At the end-point, 22.5 cm^3 of NaOH had been used.

STEMUP.CO.UK

(b) (i) Calculate the amount, in moles, of NaOH used in the titration.

(ii) What amount, in moles, of this NaOH reacted with the hydrogen chloride?

(iii) Write a balanced equation for the reaction between ethanoic acid and NaOH.

(iv) Hence calculate the amount, in moles, of NaOH that reacted with the ethanoic acid.

[4]

Q14.

Use

1 Methanoic acid, HCO_2H, was formerly known as formic acid because it is present in the sting of ants and the Latin name for ant is *formica*. It was first isolated in 1671 by John Ray who collected a large number of dead ants and extracted the acid from them by distillation.

In this question, you should give all numerical answers to <u>two</u> significant figures.

At room temperature, pure methanoic acid is a liquid which is completely soluble in water.

When we are stung by a 'typical' ant a solution of methanoic acid, **A**, is injected into our skin.

Solution **A** contains 50% by volume of pure methanoic acid.

A 'typical' ant contains 7.5×10^{-6} dm^3 of solution **A**.

STEMUP.CO.UK

(a) (i) Calculate the volume, in cm^3, of solution **A** in one ant.

volume = ... cm^3

(ii) Use your answer to **(i)** to calculate the volume, in cm^3, of pure methanoic acid in one ant.

volume = ... cm^3

(iii) Use your answer to **(ii)** to calculate how many ants would have to be distilled to produce 1 dm^3 of pure methanoic acid.

number = ...

[3]

STEMUP.CO.UK

When we are stung by an ant, the amount of solution **A** injected is 80% of the total amount of solution **A** present in one ant.

The density of pure methanoic acid is 1.2 g cm^{-3}.

(b) (i) Calculate the volume, in cm^3, of **pure** methanoic acid injected in one ant sting.

volume = ... cm^3

(ii) Use your answer to **(i)** to calculate the mass of methanoic acid present in one ant sting.

mass = ... g
[3]

Bees also sting us by using methanoic acid. One simple treatment for ant or bee stings is to use sodium hydrogencarbonate, $NaHCO_3$.

(c) (i) Construct a balanced equation for the reaction between methanoic acid and sodium hydrogencarbonate.

.....

(ii) In a typical bee sting, the mass of methanoic acid injected is 5.4×10^{-3} g. Calculate the mass of $NaHCO_3$ needed to neutralise one bee sting.

mass = ... g
[3]

[Total: 9]

Q15.

STEMUP.CO.UK

2 Ammonium sulfate, $(NH_4)_2SO_4$, is widely used as a fertiliser. 5

In order to determine its percentage purity, a sample of ammonium sulfate fertiliser was analysed by reacting a known amount with an excess of NaOH(aq) and then titrating the unreacted NaOH with dilute HC*l*.

(a) Ammonium sulfate reacts with NaOH in a 1 : 2 ratio.
Complete and balance the equation for this reaction.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow \text{.....}NH_3 + \text{.....} + \text{.....}$$

[2]

(b) A 5.00 g sample of a fertiliser containing $(NH_4)_2SO_4$ was warmed with 50.0 cm^3 (an excess) of 2.00 mol dm^{-3} NaOH.

When all of the ammonia had been driven off, the solution was cooled.

The remaining NaOH was then titrated with 1.00 mol dm^{-3} HC*l* and 31.2 cm^3 were required for neutralisation.

(i) Write a balanced equation for the reaction between NaOH and HC*l*.

.....

(ii) Calculate the amount, in moles, of HC*l* in 31.2 cm^3 of 1.00 mol dm^{-3} HC*l*.

(iv) Use your answers to **(i)**, **(ii)** and **(iii)** to calculate the amount, in moles, of NaOH used up in the reaction with $(NH_4)_2SO_4$.

STEMUP.CO.UK

(v) Use your answer to **(iv)** and the equation in **(a)** to calculate the amount, in moles, of $(NH_4)_2SO_4$ that reacted with NaOH.

Exa

(vi) Use your answer to **(v)** to calculate the mass of $(NH_4)_2SO_4$ that reacted with NaOH.

(vii) Hence, calculate the percentage purity of the ammonium sulfate fertiliser.

[7]

[Total: 9]

Q16.

(e) The food additive E330 is another organic compound which occurs naturally in fruit. E330 has the following composition by mass: C, 37.5 %; H, 4.17 %; O, 58.3 %. Calculate the empirical formula of E330.

[3]

Q17.

STEMUP.CO.UK

2 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$.

A student wished to determine the value of x by carrying out a titration, with the following results.

> 5.13 g of washing soda crystals were dissolved in water and the solution was made up to 250 cm^3 in a standard volumetric flask.
>
> 25.0 cm^3 of this solution reacted exactly with 35.8 cm^3 of 0.100 mol dm^{-3} hydrochloric acid and carbon dioxide was produced.

(a) (i) Write a balanced equation for the reaction between Na_2CO_3 and HC*l*.

.....

(ii) Calculate the amount, in moles, of HC*l* in the 35.8 cm^3 of solution used in the titration.

(iii) Use your answers to **(i)** and **(ii)** to calculate the amount, in moles, of Na_2CO_3 in the 25.0 cm^3 of solution used in the titration.

(iv) Use your answer to **(iii)** to calculate the amount, in moles, of Na_2CO_3 in the 250 cm^3 of solution in the standard volumetric flask.

STEMUP.CO.UK

(v) Hence calculate the mass of Na_2CO_3 present in 5.13 g of washing soda crystals.

Ex

[6]

(b) Use your calculations in **(a)** to determine the value of x in $Na_2CO_3.xH_2O$.

[2]

[Total: 8]

Q18.

1 A sample of a fertiliser was known to contain ammonium sulfate, $(NH_4)_2SO_4$, and sand only.

A 2.96 g sample of the solid fertiliser was heated with 40.0 cm^3 of NaOH(aq), an excess, and all of the ammonia produced was boiled away.

After cooling, the remaining NaOH(aq) was exactly neutralised by 29.5 cm^3 of 2.00 mol dm^{-3} HC*l*.

In a separate experiment, 40.0 cm^3 of the original NaOH(aq) was exactly neutralised by 39.2 cm^3 of the 2.00 mol dm^{-3} HC*l*.

STEMUP.CO.UK

In a separate experiment, 40.0 cm^3 of the original NaOH(aq) was exactly neutralised by 39.2 cm^3 of the 2.00 mol dm^{-3} HC*l*.

(a) (i) Write balanced equations for the following reactions.

NaOH with HC*l*

.....

$(NH_4)_2SO_4$ with NaOH

.....

(ii) Calculate the amount, in moles, of NaOH present in the 40.0 cm^3 of the original NaOH(aq) that was neutralised by 39.2 cm^3 of 2.00 mol dm^{-3} HC*l*.

(iii) Calculate the amount, in moles, of NaOH present in the 40.0 cm^3 of NaOH(aq) that remained after boiling the $(NH_4)_2SO_4$.

(iv) Use your answers to **(ii)** and **(iii)** to calculate the amount, in moles, of NaOH that reacted with the $(NH_4)_2SO_4$.

STEMUP.CO.UK

(v) Use your answers to **(i)** and **(iv)** to calculate the amount, in moles, of $(NH_4)_2SO_4$ that reacted with the NaOH.

(vi) Hence calculate the mass of $(NH_4)_2SO_4$ that reacted.

(vii) Use your answer to **(vi)** to calculate the percentage, by mass, of $(NH_4)_2SO_4$ present in the fertiliser.
Write your answer to a suitable number of significant figures.

[9]

(b) The uncontrolled use of nitrogenous fertilisers can cause environmental damage to lakes and streams. This is known as *eutrophication*.

What are the processes that occur when excessive amounts of nitrogenous fertilisers get into lakes and streams?

.....

.....

..... [2]

(c) Large quantities of ammonia are manufactured by the Haber process.
Not all of this ammonia is used to make fertilisers.
State **one** large-scale use for ammonia, **other than** in the production of nitrogenous fertilisers.

..... [1]

[Total: 12]

Q19.

STEMUP.CO.UK

2 Chile saltpetre is a mineral found in Chile and Peru, and which mainly consists of sodium nitrate, $NaNO_3$. The mineral is purified to concentrate the $NaNO_3$ which is used as a fertiliser and in some fireworks.

In order to find the purity of a sample of sodium nitrate, the compound is heated in NaOH(aq) with Devarda's alloy which contains aluminium. This reduces the sodium nitrate to ammonia which is boiled off and then dissolved in acid.

$$3NaNO_3(aq) + 8Al(s) + 5NaOH(aq) + 18H_2O(l) \rightarrow 3NH_3(g) + 8NaAl(OH)_4(aq)$$

The ammonia gas produced is dissolved in an excess of H_2SO_4 of known concentration.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

The amount of unreacted H_2SO_4 is then determined by back-titration with NaOH of known concentration.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(a) A 1.64 g sample of impure $NaNO_3$ was reacted with an excess of Devarda's alloy.
The NH_3 produced was dissolved in 25.0 cm^3 of 1.00 mol dm^{-3} H_2SO_4.
When all of the NH_3 had dissolved, the resulting solution was titrated with NaOH(aq).
For neutralisation, 16.2 cm^3 of 2.00 mol dm^{-3} NaOH were required.

(i) Calculate the amount, in moles, of H_2SO_4 present in the 25.0 cm^3 of 1.00 mol dm^{-3} H_2SO_4.

(ii) Calculate the amount, in moles, of NaOH present in 16.2 cm^3 of 2.00 mol dm^{-3} NaOH.

(iii) Use your answer to **(ii)** to calculate the amount, in moles, of H_2SO_4 that reacted with 16.2 cm^3 of 2.00 mol dm^{-3} NaOH.

STEMUP.CO.UK

(iv) Use your answers to **(i)** and **(iii)** to calculate the amount, in moles, of H_2SO_4 that reacted with the NH_3.

(v) Use your answer to **(iv)** to calculate the amount, in moles, of NH_3 that reacted with the H_2SO_4.

(vi) Use your answer to **(v)** to calculate the amount, in moles, of $NaNO_3$ that reacted with the Devarda's alloy.

(vii) Hence calculate the mass of $NaNO_3$ that reacted.

(viii) Use your answer to **(vii)** to calculate the percentage by mass of $NaNO_3$ present in the impure sample.
Write your answer to a suitable number of significant figures.

[9]

(b) The above reaction is an example of a redox reaction.
What are the oxidation numbers of nitrogen in $NaNO_3$ and in NH_3?

$NaNO_3$ ..... NH_3 ..... [1]

[Total: 10]

Q20.

STEMUP.CO.UK

1 Most submarines travel under water using electrical power from batteries. The German engineer Helmut Walter designed a diesel engine that could be used to propel a submarine beneath the surface of the sea. Instead of taking air from above the surface of the sea, Walter's engine used hydrogen peroxide, H_2O_2, to provide oxygen for a conventional diesel engine.

Hydrogen peroxide may be catalytically decomposed to give water and oxygen.

(a) (i) What is meant by the term *catalyst*?

.....

.....

(ii) Construct a balanced equation for the decomposition of H_2O_2.

..... [3]

Diesel fuel may be considered to consist of the hydrocarbon $C_{15}H_{32}$ which reacts completely with oxygen according to the following equation.

$$C_{15}H_{32} + 23O_2 \rightarrow 15CO_2 + 16H_2O$$

(b) (i) To which homologous series does $C_{15}H_{32}$ belong?

.....

(ii) Use the equation above and your answer to **(a)(ii)** to calculate the amount, in moles, of H_2O_2, that will provide sufficient oxygen for the complete oxidation of one mole of $C_{15}H_{32}$.

amount of H_2O_2 = ... mol

[3]

STEMUP.CO.UK

A submarine equipped with a Walter engine used 212 tonnes of diesel fuel during an underwater voyage. The submarine also carried concentrated aqueous H_2O_2.
[1 tonne = 10^6 g]

For Examiner's Use

(c) **(i)** Calculate the amount, in moles, of diesel fuel used during the underwater voyage.

amount of diesel fuel = ... mol

(ii) Use your answers to **(b)(ii)** and **(c)(i)** to calculate the mass, in tonnes, of hydrogen peroxide used during the underwater voyage.

mass of H_2O_2 = ... tonnes
[4]

(d) The exhaust products of the Walter engine were passed into the sea.

What would happen to them?

..... [1]

[Total: 11]

Q21.

1 In 1814, Sir Humphrey Davy and Michael Faraday collected samples of a flammable gas, **A**, from the ground near Florence in Italy.
They analysed **A** which they found to be a hydrocarbon. Further experiments were then carried out to determine the molecular formula of **A**.

(a) What is meant by the term *molecular formula*?

.....

.....

.....[2]

STEMUP.CO.UK

Davy and Faraday deduced the formula of **A** by exploding it with an excess of oxygen and analysing the products of combustion.

(b) Complete and balance the following equation for the complete combustion of a hydrocarbon with the formula C_xH_y.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow \text{.....} + \text{.....}$$

[2]

(c) When $10\,cm^3$ of **A** was mixed at room temperature with $50\,cm^3$ of oxygen (an excess) and exploded, $40\,cm^3$ of gas remained after cooling the apparatus to room temperature and pressure.
When this $40\,cm^3$ of gas was shaken with an excess of aqueous potassium hydroxide, KOH, $30\,cm^3$ of gas still remained.

(i) What is the identity of the $30\,cm^3$ of gas that remained at the end of the experiment?

.....

(ii) The combustion of **A** produced a gas that reacted with the KOH(aq).

What is the identity of this gas?

.....

(iii) What volume of the gas you have identified in **(ii)** was produced by the combustion of **A**?

.....cm^3

(iv) What volume of oxygen was used up in the combustion of **A**?

.....cm^3 [4]

STEMUP.CO.UK

(d) Use your equation in **(b)** and your results from **(c)(iii)** and **(c)(iv)** to calculate the molecular formula of **A**.
Show all of your working.

[3]

[Total: 11]

Q22.

1 Compound **A** is an organic compound which contains carbon, hydrogen and oxygen.

When 0.240 g of the vapour of **A** is slowly passed over a large quantity of heated copper(II) oxide, CuO, the organic compound **A** is completely oxidised to carbon dioxide and water. Copper is the only other product of the reaction.

The products are collected and it is found that 0.352 g of CO_2 and 0.144 g of H_2O are formed.

(a) In this section, give your answers to <u>three</u> decimal places.

(i) Calculate the mass of carbon present in 0.352 g of CO_2.

Use this value to calculate the amount, in moles, of carbon atoms present in 0.240 g of **A**.

STEMUP.CO.UK

(ii) Calculate the mass of hydrogen present in 0.144 g of H_2O.

Use this value to calculate the amount, in moles, of hydrogen atoms present in 0.240 g of **A**.

(iii) Use your answers to calculate the mass of oxygen present in 0.240 g of **A**.

Use this value to calculate the amount, in moles, of oxygen atoms present in 0.240 g of **A**.

[6]

STEMUP.CO.UK

(b) Use your answers to **(a)** to calculate the empirical formula of **A**.

[1]

(c) When a 0.148 g sample of **A** was vapourised at 60°C, the vapour occupied a volume of 67.7 cm^3 at a pressure of 101 kPa.

(i) Use the general gas equation $pV = nRT$ to calculate M_r of **A**.

M_r =.....

(ii) Hence calculate the molecular formula of **A**.

[3]

Q23.

2 When 0.42 g of a gaseous hydrocarbon **A** is slowly passed over a large quantity of heated copper(II) oxide, CuO, **A** is completely oxidised.

The products are collected and it is found that 1.32 g of CO_2 and 0.54 g of H_2O are formed. Copper is the only other product of the reaction.

(a) **(i)** Calculate the mass of carbon present in 1.32 g of CO_2.

Use this value to calculate the amount, in moles, of carbon atoms present in 0.42 g of **A**.

STEMUP.CO.UK

(ii) Calculate the mass of hydrogen present in 0.54 g of H_2O.

Use this value to calculate the amount, in moles, of hydrogen atoms present in 0.42 g of **A**.

(iii) It is thought that **A** is an alkene rather than an alkane.

Use your answers to **(i)** and **(ii)** to deduce whether this is correct.

Explain your answer.

.....

..... [5]

(b) Analysis of another organic compound, **B**, gave the following composition by mass: C, 64.86%; H, 13.50%, O, 21.64%.

(i) Use these values to calculate the empirical formula of **B**.

Q24.

STEMUP.CO.UK

1 Zinc is an essential trace element which is necessary for the healthy growth of animals and plants. Zinc deficiency in humans can be easily treated by using zinc salts as dietary supplements.

(a) One salt which is used as a dietary supplement is a hydrated zinc sulfate, $ZnSO_4.xH_2O$, which is a colourless crystalline solid.

Crystals of zinc sulfate may be prepared in a school or college laboratory by reacting dilute sulfuric acid with a suitable compound of zinc.

Give the formulae of **two** simple compounds of zinc that could **each** react with dilute sulfuric acid to produce zinc sulfate.

..... and ..... [2]

(b) A simple experiment to determine the value of x in the formula $ZnSO_4.xH_2O$ is to heat it carefully to drive off the water.

$$ZnSO_4.xH_2O(s) \rightarrow ZnSO_4(s) + xH_2O(g)$$

A student placed a sample of the hydrated zinc sulfate in a weighed boiling tube and reweighed it. He then heated the tube for a short time, cooled it and reweighed it when cool. This process was repeated four times. The final results are shown below.

mass of empty tube / g	mass of tube + hydrated salt / g	mass of tube + salt after fourth heating / g
74.25	77.97	76.34

(i) Why was the boiling tube heated, cooled and reweighed four times?

.....

.....

(ii) Calculate the amount, **in moles**, of the anhydrous salt produced.

(iii) Calculate the amount, **in moles**, of water driven off by heating.

STEMUP.CO.UK

(iv) Use your results to **(ii)** and **(iii)** to calculate the value of x in $ZnSO_4.xH_2O$.

[7]

(c) For many people, an intake of approximately 15 mg per day of zinc will be sufficient to prevent deficiencies.

Zinc ethanoate crystals, $(CH_3CO_2)_2Zn.2H_2O$, may be used in this way.

(i) What mass of pure crystalline zinc ethanoate (M_r = 219.4) will need to be taken to obtain a dose of 15 mg of zinc?

(ii) If this dose is taken in solution as 5 cm^3 of aqueous zinc ethanoate, what would be the concentration of the solution used?
Give your answer in mol dm^{-3}.

[4]

[Total: 13]

STEMUP.CO.UK

Q25.

1 Carbon dioxide, CO_2, makes up about 0.040 % of the Earth's atmosphere. It is produced by animal respiration and by the combustion of fossil fuels.

In animal respiration, oxygen reacts with a carbohydrate such as glucose to give water, carbon dioxide and energy.

The typical daily food requirement of a human can be considered to be the equivalent of 1.20 kg of glucose, $C_6H_{12}O_6$.

You should express all of your numerical answers in this question to <u>three</u> significant figures.

(a) (i) Construct a balanced equation for the complete oxidation of glucose.

.....

(ii) Use your equation to calculate the amount, in moles, of CO_2 produced by one person in one day from 1.20 kg of glucose.

(iii) On the day on which this question was written, the World population was estimated to be 6.82×10^9.

Calculate the total mass of CO_2 produced by this number of people in one day. Give your answer in tonnes. [1 tonne = 1.00×10^6 g]

[5]

STEMUP.CO.UK

(b) When fossil fuels are burned in order to give energy, carbon dioxide and water are also produced.

The hydrocarbon octane, C_8H_{18}, can be used to represent the fuel burned in motor cars. A typical fuel-efficient motor car uses about 4.00 dm^3 of fuel to travel 100 km.

(i) Construct a balanced equation for the complete combustion of octane.

.....

(ii) The density of octane is 0.700 g cm^{-3}.

Calculate the amount, in moles, of octane present in 4.00 dm^3 of octane.

(iii) Calculate the mass of CO_2 produced when the fuel-efficient car is driven for a distance of 100 km.

[5]

(c) Calculate how many kilometres the same fuel-efficient car would have to travel in order to produce as much CO_2 as is produced by the respiration of 6.82×10^9 people during one day. Use your answer to **(a)(iii)**.

[2]

STEMUP.CO.UK

(d) Carbon dioxide is one of a number of gases that are responsible for global warming. When fossil fuels such as octane are burned in a car engine, other atmospheric pollutants are also produced.
Give the formula of **one** atmospheric pollutant that may be produced in a car engine, other than CO_2, and state how this pollutant damages the environment.

pollutant .....

damage caused ..... [2]

[Total: 14]

Q26.

For Examiner's Use

4 Compound **R** is a weak diprotic (dibasic) acid which is very soluble in water.

(a) A solution of **R** was prepared which contained 1.25 g of **R** in 250 cm^3 of solution.
When 25.0 cm^3 of this solution was titrated with 0.100 mol dm^{-3} NaOH, 21.6 cm^3 of the alkali were needed for complete reaction.

(i) Using the formula H_2X to represent **R**, construct a balanced equation for the reaction between H_2X and NaOH.

.....

(ii) Use the data above to calculate the amount, in moles, of OH^- ions used in the titration.

(iii) Use your answers to **(i)** and **(ii)** to calculate the amount, in moles, of **R** present in 25.0 cm^3 of solution.

(iv) Calculate the amount, in moles, of **R** present in 250 cm^3 of solution.

STEMUP.CO.UK

(v) Calculate M_r of **R**.

[5]

(b) Three possible structures for **R** are shown below.

S	T	U
$HO_2CCH=CHCO_2H$	$HO_2CCH(OH)CH_2CO_2H$	$HO_2CCH(OH)CH(OH)CO_2H$

(i) Calculate the M_r of each of these acids.

M_r of **S** = ... M_r of **T** = ... M_r of **U** = ...

(ii) Deduce which of the structures, **S**, **T** or **U**, correctly represents the structure of the acid, **R**.

R is represented by .....

[2]

STEMUP.CO.UK

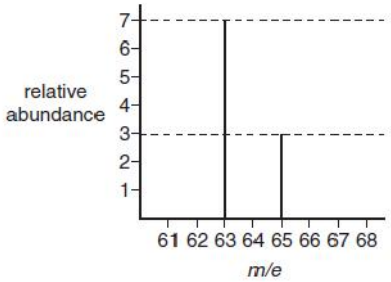
As a simplification, an adult human can be considered to have a daily diet of 1.80 kg of carbohydrate (empirical formula CH_2O).

Which mass of carbon dioxide does a person produce each day if all the carbohydrate eaten is digested and oxidised?

A 0.267 kg **B** 0.800 kg **C** 1.32 kg **D** 2.64 kg

[2002 M/J (2)]

The diagram shows the mass spectrum of a sample of naturally-occurring copper.



What is the relative atomic mass of this copper?

A 63.3 **B** 63.5 **C** 63.6 **D** 64.0

[2002 M/J (3)]

Which pairs of compounds have the same empirical formula?

1 ethane and ethene

2 ethene and cyclohexane

3 cyclohexane and oct-1-ene

[2002 M/J (31)]

A mixture of 10 cm^3 of methane and 10 cm^3 of ethane was sparked with an excess of oxygen. After cooling to room temperature, the residual gas was passed through aqueous potassium hydroxide.

What volume of gas was absorbed by the alkali?

A 15 cm^3

B 20 cm^3

C 30 cm^3

D 40 cm^3

[2002 O/N (1)]

Which compounds have the empirical formula CH_2O?

1 methanal

2 ethanoic acid

3 methyl methanoate

[2002 O/N (31)]

What is the number of molecules in 500 cm^3 of oxygen under room conditions?

A 1.25×10^{22}

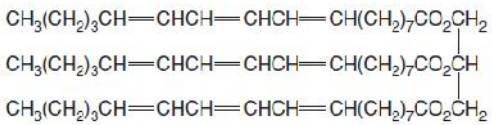
B 1.34×10^{22}

C 3.0×10^{22}

D 3.0×10^{26}

[2003 M/J (1)]

In the preparation of soft margarine, glyceryl trieleostearate



is suitably hydrogenated so that, on average, one of its side-chains is converted into the $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7CO_2$ residue and two side-chains are converted into the $CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2$ residue.

How many moles of hydrogen are required to convert one mole of glyceryl trieleostearate into the soft margarine?

A 4 **B** 5 **C** 6 **D** 9

[2003 M/J (2)]

Use of the Data Booklet is relevant to this question.

Analytical chemists can detect very small amounts of amino acids, down to 3×10^{-21} mol. How many molecules of an amino acid (M_r = 200) would this be?

A 9 **B** 200 **C** 1800 **D** 360 000

[2003 O/N (1)]

Use of the Data Booklet is relevant to this question.

A garden fertiliser is said to have a phosphorus content of 30.0% 'P_2O_5 soluble in water'.

What is the percentage by mass of phosphorus in the fertiliser?

A 6.55% **B** 13.1% **C** 26.2% **D** 30.0%

[2003 O/N (2)]

One mole of each of the following compounds is strongly heated and any gas produced is collected at room temperature and pressure.

From which compound is 24 dm^3 of gas likely to be collected?
[One mole of any gas occupies 24 dm^3 at room temperature and pressure.]

A $MgCl_2$ **B** $MgCO_3$ **C** $Mg(NO_3)_2$ **D** $Mg(OH)_2$

[2003 O/N (15)]

Which of these samples of gas contains the same number of atoms as 1g of hydrogen (M_r : H_2, 2)?

A 22g of carbon dioxide (M_r : CO_2, 44)

B 8g of methane (M_r : CH_4, 16)

C 20g of neon (M_r : Ne, 20)

D 8g of ozone (M_r : O_3, 48)

[2004 M/J (1)]

Use of the Data Booklet is relevant to this question.

Most modern cars are fitted with airbags. These work by decomposing sodium azide to liberate nitrogen gas, which inflates the bag.

$$2NaN_3 \rightarrow 3N_2 + 2Na$$

A typical driver's airbag contains 50g of sodium azide.

Calculate the volume of nitrogen this will produce at room temperature.

A 9.2 dm^3 **B** 13.9 dm^3 **C** 27.7 dm^3 **D** 72.0 dm^3

[2004 M/J (3)]

Which substance, in 1 mol dm^{-3} aqueous solution, would have the same hydrogen ion concentration as 1 mol dm^{-3} of hydrochloric acid?

A ethanoic acid

B nitric acid

C sodium hydroxide

D sulphuric acid

[2004 M/J (9)]

Granular urea, CON_2H_4, can be used to remove NO_2 from the flue gases of power stations, converting it into harmless nitrogen.

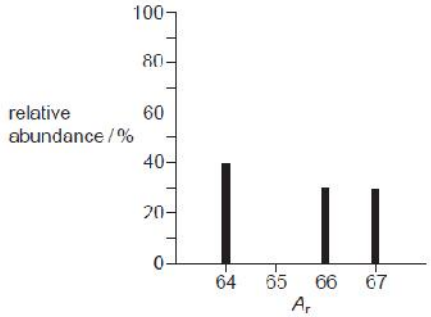
$$2CON_2H_4 + xNO_2 \rightarrow 2CO_2 + yH_2O + zN_2$$

What are the values of x, y and z in a balanced equation?

	x	y	z
A	1½	2	1¼
B	2	4	3
C	3	4	3½
D	3	4	3

[2004 O/N (1)]

The diagram shows the mass spectrum of a sample of zinc. Use the data to calculate the relative atomic mass of the sample.



A 65 **B** 65.25 **C** 65.5 **D** 65.66

[2004 O/N (2)]

On collision, airbags in cars inflate rapidly due to the production of nitrogen.

The nitrogen is formed according to the following equations.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

How many moles of nitrogen gas are produced from 1 mol of sodium azide, NaN_3?

A 1.5 **B** 1.6 **C** 3.2 **D** 4.0

[2005 M/J (2)]

The petrol additive tetraethyl-lead(IV), $Pb(C_2H_5)_4$, is now banned in many countries. When it is completely burned in air, lead(II) oxide, CO_2 and H_2O are formed.

How many moles of oxygen are required to burn one mole of $Pb(C_2H_5)_4$?

A 9.5 **B** 11 **C** 13.5 **D** 27

[2005 O/N (1)]

Chlorine dioxide is produced on a large scale as it is used for bleaching paper pulp. It is made by the following reaction.

$$2ClO_3(aq) + SO_2(g) \rightarrow 2ClO_2(g) + SO_4^{2-}(aq)$$

How do the oxidation numbers of chlorine and sulphur change in this reaction?

	chlorine	sulphur
A	decreases by 1	increases by 1
B	decreases by 1	increases by 2
C	decreases by 3	increases by 1
D	decreases by 3	increases by 2

[2005 O/N (9)]

Use of the Data Booklet is relevant to this question.

What volume of oxygen, measured under room conditions, can be obtained from the thermal decomposition of 8.2g of calcium nitrate (M_r = 164)?

A 150 cm^3 **B** 300 cm^3 **C** 600 cm^3 **D** 1200 cm^3

[2005 O/N (15)]

The relative molecular mass of a molecule of chlorine is 72.

Which properties of the atoms in this molecule are the same?

1 radius

2 nucleon number

3 relative isotopic mass

[2005 O/N (31)]

N_2O_4 is a poisonous gas. It can be disposed of safely by reaction with sodium hydroxide.

$$N_2O_4(g) + 2NaOH(aq) \rightarrow NaNO_3(aq) + NaNO_2(aq) + H_2O(l)$$

What is the minimum volume of 0.5 mol dm^{-3} NaOH(aq) needed to dispose of 0.02 mol of N_2O_4?

A 8 cm^3 **B** 12.5 cm^3 **C** 40 cm^3 **D** 80 cm^3

[2006 M/J (1)]

A sample of chlorine containing isotopes of mass numbers 35 and 37 was analysed in a mass-spectrometer.

How many peaks corresponding to Cl_2^+ were recorded?

A 2 **B** 3 **C** 4 **D** 5

[2006 M/J (2)]

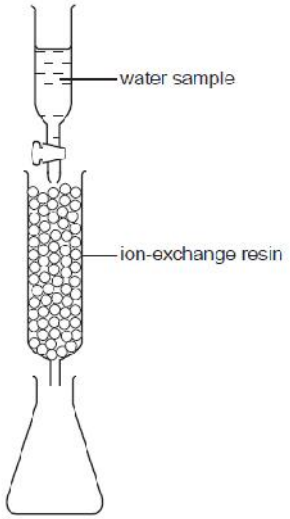
Use of the Data Booklet is relevant to this question.

What mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70g **B** 1.00g **C** 1.40g **D** 2.25g

[2006 M/J (16)]

The amount of calcium ions in a sample of natural water can be determined by using an ion-exchange column as shown in the diagram.



A 50 cm^3 sample of water containing dissolved calcium sulphate was passed through the ion-exchange resin. Each calcium ion in the sample was exchanged for two hydrogen ions. The resulting acidic solution collected in the flask required 25 cm^3 of 1.0×10^{-2} mol dm^{-3} potassium hydroxide for complete neutralisation.

What was the concentration of the calcium sulphate in the original sample?

A 2.5×10^{-3} mol dm^{-3}

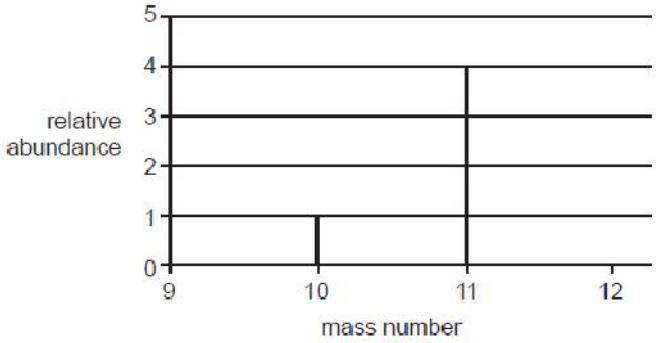
B 1.0×10^{-2} mol dm^{-3}

C 2.0×10^{-2} mol dm^{-3}

D 4.0×10^{-2} mol dm^{-3}

[2006 O/N (1)]

The isotopic composition of an element is indicated below.



What is the relative atomic mass of the element?

A 10.2 **B** 10.5 **C** 10.8 **D** 11.0

[2007 M/J (1)]

Use of the Data Booklet is relevant to this question.

Oxides of nitrogen are pollutant gases which are emitted from car exhausts.

In urban traffic, when a car travels one kilometre, it releases 0.23 g of an oxide of nitrogen N_xO_y, which occupies 120 cm^3.

What are the values of *x* and *y*?
(Assume 1 mol of gas molecules occupies 24.0 dm^3.)

A $x = 1, y = 1$

B $x = 1, y = 2$

C $x = 2, y = 1$

D $x = 2, y = 4$

[2007 M/J (2)]

In the treatment of domestic water supplies, chlorine is added to the water to form chloric(I) acid, HC*l*O.

$$Cl_2(aq) + H_2O(l) \rightarrow H^+(aq) + Cl^-(aq) + HClO(aq)$$

This reacts further to give the chlorate(I) ion.

$$HClO(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO^-(aq)$$

Both HC*l*O and C*l*O$^-$ kill bacteria by oxidation.

What is the change in oxidation number of chlorine in forming the chlorate(I) ion from the aqueous chlorine?

A −1 **B** 0 **C** +1 **D** +2

[2007 M/J (15)]

Use of the Data Booklet is relevant to this question.

When a sports medal with a total surface area of 150 cm^2 was evenly coated with silver, using electrolysis, its mass increased by 0.216 g.

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 1.2×10^{21}

D 4.1×10^{22}

[2007 O/N (1)]

The first stage in the manufacture of nitric acid is the oxidation of ammonia by oxygen.

$$wNH_3(g) + xO_2(g) \rightarrow yNO(g) + zH_2O(g)$$

Which values for **w**, **x**, **y** and **z** are needed to balance the equation?

	w	x	y	z
A	4	5	4	6
B	4	6	4	5
C	5	6	5	4
D	6	5	6	4

[2007 O/N (3)]

In an experiment, 50.0 cm^3 of a 0.10 mol dm^{-3} solution of a metallic salt reacted exactly with 25.0 cm^3 of 0.10 mol dm^{-3} aqueous sodium sulphite.

The half-equation for oxidation of sulphite ion is shown below.

$$SO_3^{2-}(aq) + H_2O(l) \rightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e$$

If the original oxidation number of the metal in the salt was +3, what would be the new oxidation number of the metal?

A +1 **B** +2 **C** +4 **D** +5

[2007 O/N (9)]

In the Basic Oxygen steel-making process the P_4O_{10} impurity is removed by reacting it with calcium oxide. The only product of this reaction is the salt calcium phosphate, $Ca_3(PO_4)_2$.

In this reaction, how many moles of calcium oxide react with one mole of P_4O_{10}?

A 1 **B** 1.5 **C** 3 **D** 6

[2008 M/J (1)]

Use of the Data Booklet is relevant to this question.

A typical solid fertiliser for use with household plants and shrubs contains the elements N, P, and K in the ratio of 15 g : 30 g : 15 g per 100 g of fertiliser. The recommended usage of fertiliser is 14 g of fertiliser per 5 dm^3 of water.

What is the concentration of nitrogen atoms in this solution?

A 0.03 mol dm^{-3}

B 0.05 mol dm^{-3}

C 0.42 mol dm^{-3}

D 0.75 mol dm^{-3}

[2008 M/J (2)]

Use of the Data Booklet is relevant to this question.

Titanium(IV) oxide, TiO_2, is brilliantly white and much of the oxide produced is used in the manufacture of paint.

What is the maximum amount of TiO_2 obtainable from 19.0 tonnes of the ore ilmenite, $FeTiO_3$?

A 10.0 tonnes **B** 12.7 tonnes **C** 14.0 tonnes **D** 17.7 tonnes

[2008 O/N (1)]

Carbon disulphide vapour burns in oxygen according to the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

A sample of 10 cm^3 of carbon disulphide was burned in 50 cm^3 of oxygen. After measuring the volume of gas remaining, the product was treated with an excess of aqueous sodium hydroxide and the volume of gas measured again. All measurements were made at the same temperature and pressure, under such conditions that carbon disulphide was gaseous.

What were the measured volumes?

	volume of gas after burning / cm^3	volume of gas after adding NaOH(aq) / cm^3
A	30	0
B	30	20
C	50	20
D	50	40

[2008 O/N (2)]

Use of the Data Booklet is relevant to this question.

In leaded petrol there is an additive composed of lead, carbon and hydrogen only. This compound contains 29.7% carbon and 6.19% hydrogen by mass.

What is the value of **x** in the empirical formula PbC_8H_x?

A 5 **B** 6 **C** 16 **D** 20

[2009 M/J (1)]

A household bleach contains sodium chlorate(I), NaC*l*O, as its active ingredient. The concentration of NaC*l*O in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide, H_2O_2.

$$NaClO(aq) + H_2O_2(aq) \rightarrow NaCl(aq) + O_2(g) + H_2O(l)$$

When 25.0 cm^3 of bleach is treated with an excess of aqueous H_2O_2, 0.0350 mol of oxygen gas is given off.

What is the concentration of NaC*l*O in the bleach?

A 8.75×10^{-4} mol dm^{-3}

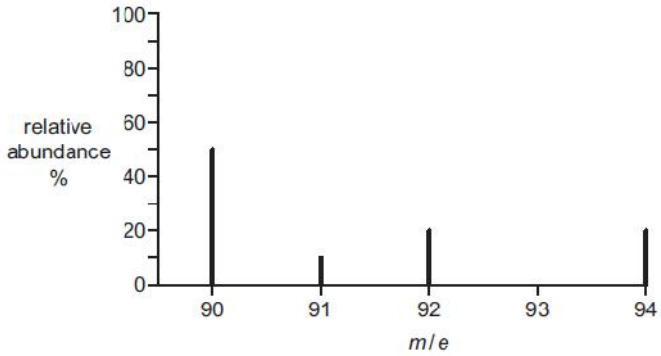
B 0.700 mol dm^{-3}

C 0.875 mol dm^{-3}

D 1.40 mol dm^{-3}

[2009 M/J (2)]

An element **X** consists of four isotopes. The mass spectrum of **X** is shown in the diagram.



What is the relative atomic mass of **X**?

A 91.00 **B** 91.30 **C** 91.75 **D** 92.00

[2009 O/N – 11 (1)]

0.200 mol of a hydrocarbon undergo complete combustion to give 35.2 g of carbon dioxide and 14.4 g of water as the only products.

What is the molecular formula of the hydrocarbon?

A C_2H_4 **B** C_2H_6 **C** C_4H_4 **D** C_4H_8

[2009 O/N – 11 (2)]

Ammonium nitrate, NH_4NO_3, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3 when this reaction proceeds?

A –2, –4 **B** +2, +6 **C** +4, –6 **D** +4, –4

[2010 M/J – 11 (6)]

Use of the Data Booklet is relevant to this question.

2.920 g of a Group II metal, **X**, reacts with an excess of chlorine to form 5.287 g of a compound with formula XCl_2.

What is metal **X**?

A barium

B calcium

C magnesium

D strontium

[2010 M/J – 11 (8)]

Which reactions are redox reactions?

1 $CaBr_2 + 2H_2SO_4 \rightarrow CaSO_4 + Br_2 + SO_2 + 2H_2O$

2 $CaBr_2 + 2H_3PO_4 \rightarrow Ca(H_2PO_4)_2 + 2HBr$

3 $CaBr_2 + 2AgNO_3 \rightarrow Ca(NO_3)_2 + 2AgBr$

[2010 M/J – 11 (32)]

Sulfur dioxide, SO_2, is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2, a sample of wine is titrated with iodine, I_2. In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2.

What is the change in oxidation number of sulfur in this reaction?

A +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

[2010 O/N -13 (4)]

Sulfur dioxide, SO_2, is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2, a sample of wine is titrated with iodine, I_2. In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2.

What is the change in oxidation number of sulfur in this reaction?

A +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

[2010 O/N -13 (5)]

Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.

How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?

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

[2010 O/N -13 (15)]

Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

1 $Cl_2(g) + 2OH^-(aq) \rightarrow H_2O(l) + Cl^-(aq) + ...$

2 $3Cl_2(g) + 6OH^-(aq) \rightarrow 3H_2O(l) + ClO_3^-(aq) + ...$

3 $2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + ...$

[2010 O/N -13 (34)]

In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?

$$NO_3^-(aq) \xrightarrow{A} NO_2^-(aq) \xrightarrow{B} NO(g) \xrightarrow{C} N_2O(g) \xrightarrow{D} N_2(g)$$

[2011 M/J – 11 (2)]

0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 60 cm^3

[2011 M/J – 11 (13)]

Use of the Data Booklet is relevant to this question.

Zinc reacts with hydrochloric acid according to the following equation.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Which statements are correct?

[All volumes are measured at room conditions.]

1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.

2 A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen.

[2011 M/J – 11 (33)]

Use of the Data Booklet is relevant to this question.

Lead(IV) chloride will oxidise bromide ions to bromine. The Pb^{4+} ions are reduced to Pb^{2+} ions in this reaction.

If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?

A 0.799 g **B** 1.598 g **C** 3.196 g **D** 6.392 g

[2011 O/N – 11 (2)]

When chlorine and aqueous sodium hydroxide are heated together the following overall reaction occurs.

$$3Cl_2(aq) + 6NaOH(aq) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$

What are the oxidation numbers for chlorine in each of the following species?

	Cl_2	$NaCl$	$NaClO_3$
A	0	+1	–5
B	+2	–1	+3
C	0	–1	+5
D	–2	+1	–3

[2011 O/N – 11 (7)]

The oxide of titanium, TiO_2, is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.

What is the change, if any, in the oxidation number (oxidation state) of titanium in the reaction $FeTiO_3 \rightarrow TiO_2$?

A It is oxidised from +3 to +4.

B It is reduced from +3 to +2.

C It is reduced from +6 to +4.

D There is no change in the oxidation number.

[2012 M/J – 11 (10)]

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 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

A 46.8 cm^3 **B** 72.0 cm^3 **C** 93.6 cm^3 **D** 144 cm^3

[2012 M/J – 11 (14)]

In the treatment of domestic water supplies, chlorine is added to the water to form HClO.

$$Cl_2(aq) + H_2O(l) \rightarrow H^+(aq) + Cl^-(aq) + HClO(aq)$$

The HClO reacts further to give ClO^- ions.

$$HClO(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO^-(aq)$$

Both HClO and ClO^- kill bacteria by oxidation.

What is the overall change in oxidation number of chlorine when forming the ClO^- ion from the aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

[2012 M/J – 11 (16)]

Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Ammonia behaves as a reducing agent.

2 Ammonia behaves as a base.

3 The oxidation number of the hydrogen changes

[2012 M/J – 11 (34)]

In which reaction does an element undergo the largest change in oxidation state?

A $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$

B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$

C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

[2012 O/N – 11 (1)]

Use of the Data Booklet is relevant to this question.

The nitrates of beryllium, calcium, magnesium, and strontium all decompose in the same way when heated. When 2.00 g of one of these anhydrous nitrates is decomposed, 1.32 g of gas is produced.

What is the nitrate?

A beryllium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

[2012 O/N – 11 (15)]

Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.

$$3ClO^- \rightarrow ClO_3^- + 2Cl^-$$

Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	–1
B	–1	+3	+1
C	+1	+5	–1
D	–1	+5	+1

[2013 M/J – 11 (1)]

A mixture of 10 cm^3 of methane and 10 cm^3 of ethane was sparked with an excess of oxygen. After cooling to room temperature, the residual gas was passed through aqueous potassium hydroxide.

All gas volumes were measured at the same temperature and pressure.

What volume of gas was absorbed by the alkali?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 40 cm^3

[2013 M/J – 11 (2)]

A solution of Sn^{2+} ions will reduce an acidified solution of MnO_4^- ions to Mn^{2+} ions. The Sn^{2+} ions are oxidised to Sn^{4+} ions in this reaction.

How many moles of Mn^{2+} ions are formed when a solution containing 9.5 g of $SnCl_2$ (*M*r: 190) is added to an excess of acidified $KMnO_4$ solution?

A 0.010 **B** 0.020 **C** 0.050 **D** 0.125

[2013 M/J – 11 (11)]

Use of the Data Booklet is relevant to this question.

Magnesium nitrate, $Mg(NO_3)_2$, will decompose 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

[2013 M/J – 11 (16)]

In which reaction does a single nitrogen atom have the greatest change in oxidation number?

A $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

B $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

C $2NO + O_2 \rightarrow 2NO_2$

D $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

[2013 O/N – 11 (2)]

The following half reactions occur when potassium iodate(V), KIO_3, in hydrochloric acid solution oxidises iodine to ICl_2^-.

$$IO_3^- + 2Cl^- + 6H^+ + 4e^- \rightarrow ICl_2^- + 3H_2O$$

$$I_2 + 4Cl^- \rightarrow 2ICl_2^- + 2e^-$$

What is the ratio of IO_3^- to I_2 in the balanced chemical equation for the overall reaction?

A 1:1 **B** 1:2 **C** 1:4 **D** 2:1

[2013 O/N – 11 (3)]

Use of the Data Booklet is relevant to this question.

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

What mass of ammonia was formed?

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

[2014 M/J – 11 (18)]

In which reaction is the species in **bold** acting as an oxidising agent?

A $\mathbf{2Ca} + O_2 \rightarrow 2CaO$

B $Cr_2O_7^{2-} + 8H^+ + \mathbf{3SO_3^{2-}} \rightarrow 2Cr^{3+} + 4H_2O + 3SO_4^{2-}$

C $Mg + \mathbf{Fe^{2+}} \rightarrow Mg^{2+} + Fe$

D $\mathbf{SO_2} + 2H_2O + 2Cu^{2+} + 2Cl^- \rightarrow H_2SO_4 + 2H^+ + 2CuCl$

[2014 M/J – 12 (6)]

Ammonium sulfate in the soil is slowly oxidised by air, producing sulfuric acid, nitric acid and water as the only products.

How many moles of oxygen gas are needed for the complete oxidation of one mole of ammonium sulfate?

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

[2014 M/J – 12 (14)]

When solid sodium iodide reacts with concentrated sulfuric acid, the products include $NaHSO_4$, H_2S, SO_2 and S.

In the formation of which product has the oxidation state of sulfur changed by a value of 8?

A H_2S **B** $NaHSO_4$ **C** S **D** SO_2

[2014 M/J – 12 (17)]

Use of the Data Booklet is relevent to this question.

In an experiment, 0.125 mol of chlorine gas, Cl_2, is reacted with an excess of cold aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen, and chlorine.

Which mass of this product is formed?

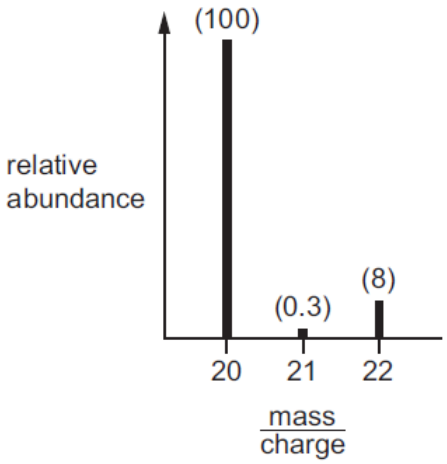
A 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

[2014 M/J – 12 (19)]

Atoms, molecules and stoichiometry – 2021 AS

1. Nov/2021/Paper_11/No.1

The mass spectrum of a sample of neon is shown. The relative abundance of each peak is written in brackets above it.



What is the relative atomic mass, A_r, of this sample of neon?

A 20.15 **B** 20.20 **C** 21.00 **D** 21.82

2. Nov/2021/Paper_11/No.2

2.0 g of ammonium nitrate, NH_4NO_3, decomposes to give 0.90 g of water and a single gas.

What is the identity of the gas?

A NO **B** NO_2 **C** N_2O **D** N_2

3. Nov/2021/Paper_11/No.3

Which of these elements has the highest fifth ionisation energy?

A C **B** N **C** P **D** Si

4. Nov/2021/Paper_11/No.4

The ion X^{2+} has the same electronic configuration as the atom Kr.

What is the electronic configuration of an atom of X?

A $[Ar]4s^23d^{10}4p^6$

B $[Ar]4s^23d^{10}4p^65s^2$

C $[Ar]4s^24d^{10}4p^6$

D $[Ar]4s^24d^{10}4p^65s^2$

STEMUP.CO.UK

5. Nov/2021/Paper_11/No.12

Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

A aluminium

B magnesium

C phosphorus

D sodium

6. Nov/2021/Paper_12/No.1

Compound X consists of 40.0% carbon, 6.7% hydrogen and 53.3% oxygen by mass.

What is the empirical formula of compound X?

A CH_2O **B** C_2H_2O **C** C_2H_4O **D** CHO

7. Nov/2021/Paper_12/No.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.

8. Nov/2021/Paper_12/No.3

Technetium (Tc) is a second row transition element that does not occur naturally on Earth. One of its isotopes has 56 neutrons.

What is the nucleon number of this isotope?

A 43 **B** 56 **C** 99 **D** 112

9. Nov/2021/Paper_12/No.4

Which atom has more unpaired electrons than paired electrons in orbitals of principal quantum number 2?

A carbon

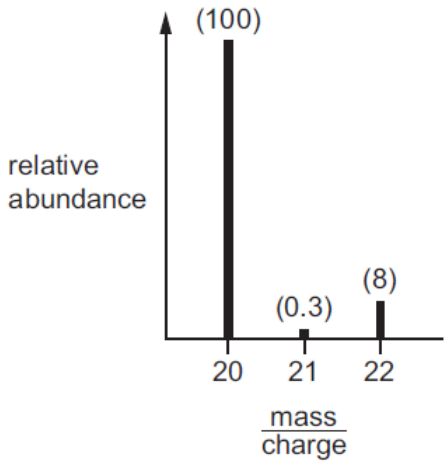
B nitrogen

C oxygen

D fluorine

10. Nov/2021/Paper_13/No.1

The mass spectrum of a sample of neon is shown. The relative abundance of each peak is written in brackets above it.



What is the relative atomic mass, A_r, of this sample of neon?

A 20.15 **B** 20.20 **C** 21.00 **D** 21.82

11. Nov/2021/Paper_13/No.2

2.0 g of ammonium nitrate, NH_4NO_3, decomposes to give 0.90 g of water and a single gas.

What is the identity of the gas?

A NO **B** NO_2 **C** N_2O **D** N_2

12. Nov/2021/Paper_13/No.3

Which of these elements has the highest fifth ionisation energy?

A C **B** N **C** P **D** Si

13. Nov/2021/Paper_13/No.4

The ion X^{2+} has the same electronic configuration as the atom Kr.

What is the electronic configuration of an atom of X?

A $[Ar]4s^23d^{10}4p^6$

B $[Ar]4s^23d^{10}4p^65s^2$

C $[Ar]4s^24d^{10}4p^6$

D $[Ar]4s^24d^{10}4p^65s^2$

STEMUP.CO.UK

14. Nov/2021/Paper_13/No.7

In order to determine the enthalpy of neutralisation of a strong acid and a strong alkali, 25.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid. The increase in temperature is 12 °C.

In a second experiment, the same method is used, but 50.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide is added to 50.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid.

What is the increase in temperature in the second experiment?

A 6 °C **B** 12 °C **C** 24 °C **D** 48 °C

15. Nov/2021/Paper_13/No.12

Which element requires the least number of moles of oxygen for the complete combustion of 1 mol of its atoms?

A aluminium

B magnesium

C phosphorus

D sodium

16. Nov/2021/Paper_21/No.1(d)

(d) The compound As_2S_3 is a common mineral.

When As_2S_3 is heated strongly in air, it forms a mixture of products, as shown.

$$2As_2S_3(s) + 9O_2(g) \rightarrow As_4O_6(s) + 6SO_2(g)$$

(i) A sample containing 0.198 g As_2S_3 is placed in 0.100 dm^3 of pure oxygen, an excess, in a reaction chamber connected to a gas syringe at room temperature.

The reactants are heated until no further change is observed. The products are then allowed to cool to room temperature.

Calculate the volume, in dm^3, of gas present at the end of the experiment.

The molar volume of gas is 24.0 $dm^3 mol^{-1}$ under these conditions. Assume that the pressure is constant throughout the experiment.

Show your working.

volume of gas remaining = ... dm^3
[4]

(ii) State the environmental consequences of releasing $SO_2(g)$ into the atmosphere.

..... [1]

(iii) $SO_2(g)$ can be removed from the air by reacting it with NaOH(aq).

Construct an equation for the reaction of $SO_2(g)$ with NaOH(aq). Include state symbols.

..... [2]

STEMUP.CO.UK

17. March/2021/Paper_12/No/.1

The table shows the numbers of protons, neutrons and electrons in four different particles, W, X, Y, and Z.

	number of protons	number of neutrons	number of electrons
W	32	40	32
X	32	40	34
Y	32	42	32
Z	34	40	34

Which pair represents the atoms of two isotopes of the same element?

A W and Y **B** W and Z **C** X and Y **D** X and Z

18. March/2021/Paper_12/No/.2

Where in the Periodic Table is the element that has an outer electron shell arrangement of $4s^2 4p^3$?

	Group	Period
A	13	3
B	13	4
C	15	3
D	15	4

19. March/2021/Paper_12/No/.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

20. March/2021/Paper_12/No/.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

STEMUP.CO.UK

21. March/2021/Paper_12/No/.6

A solution contains 0.25 g of sulfur dioxide in 1.00 dm^3 of water.

Which volume of sulfur dioxide, measured at 50 °C and a pressure of 1×10^5 Pa, must be added to 1.00 dm^3 of water to produce this solution?

A 0.0162 cm^3 **B** 0.105 cm^3 **C** 16.2 cm^3 **D** 105 cm^3

22. March/2021/Paper_12/No/.13

Which row is correct?

	statement	reason
A	The first ionisation energy of phosphorus is greater than that of magnesium.	electron is lost from a 3p orbital in both cases
B	The melting point of phosphorus is greater than that of magnesium.	phosphorus has more valence electrons than magnesium
C	The atomic radius of phosphorus is smaller than that of magnesium.	phosphorus has greater nuclear charge than magnesium
D	The electrical conductivity of phosphorus is smaller than that of magnesium.	bonding changes from ionic in magnesium to covalent in phosphorus

23. March/2021/Paper_12/No/.35

A sample containing *x* mol of Al_2Cl_6 is dissolved in water to give solution W.

In order to precipitate all of the aluminium as its hydroxide, *y* mol of sodium hydroxide are required.

More of the alkali is added to re-dissolve the precipitate, giving solution Z.

Which statements are correct?

1 the initial pH of solution W is below 7

2 $y = 3x$

3 Z contains *x* mol of aluminium

STEMUP.CO.UK

24. June/2021/Paper_11/No.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

25. June/2021/Paper_11/No.2

In which pair of species do both species have only one unpaired p electron?

A Ar^+ and C^- **B** B and Ti^+ **C** F and Ga **D** Se^- and Si^-

26. June/2021/Paper_11/No.6

What is the minimum mass of oxygen required to ensure the complete combustion of 12 dm^3 of propane measured under room conditions?

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

27. June/2021/Paper_11/No.7

Why is the first ionisation energy of oxygen less than that of nitrogen?

A The nitrogen atom has its outer electron in a different subshell.

B The nuclear charge on the oxygen atom is greater than that on the nitrogen atom.

C The oxygen atom has a pair of electrons in one p orbital that repel one another.

D There is more shielding in an oxygen atom.

28. June/2021/Paper_12/No.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.

29. June/2021/Paper_12/No.2

Which equation represents the first ionisation energy of iodine?

A $\frac{1}{2}I_2(g) + e^- \rightarrow I^-(g)$

B $I(g) + e^- \rightarrow I^-(g)$

C $\frac{1}{2}I_2(g) \rightarrow I^+(g) + e^-$

D $I(g) \rightarrow I^+(g) + e^-$

STEMUP.CO.UK

30. June/2021/Paper_12/No.31

In which ions are the number of electrons equal to the number of neutrons?

1 $^{19}_{9}F^{-}$

2 $^{31}_{15}P^{-}$

3 $^{23}_{11}Na^{+}$

31. June/2021/Paper_13/No.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** $C_4H_3O_2Cl_2$

32. June/2021/Paper_13/No.2

A sample of propane, C_3H_8, 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 dm^3 **B** 5.24 dm^3 **C** 14.7 dm^3 **D** 15.7 dm^3

33. June/2021/Paper_13/No.3

Which atom has the same number of electrons as an ammonium ion?

A Mg **B** Na **C** Ne **D** O

34. June/2021/Paper_13/No.9

Copper dissolves in dilute nitric acid producing a blue solution of $Cu(NO_3)_2$, water and nitrogen(II) oxide as the only products.

How many moles of acid react with three moles of copper in the balanced equation?

A 2 **B** 4 **C** 6 **D** 8

35. June/2021/Paper_13/No.31

Which statements about first ionisation energies are correct?

1 They are always endothermic.

2 They decrease down Group 2.

3 They decrease across Period 3.

STEMUP.CO.UK

36. June/2021/Paper_13/No.34

Element X is a solid under room conditions. It occurs as a contaminant of fossil fuels.

Its oxide, Y, is formed when fossil fuels are burned.

In the atmosphere, Y can be further oxidised to Z.

Which statements about X, Y and Z are correct?

1 Atoms of X have paired p electrons.

2 The atmospheric oxidation of Y to Z is a catalysed reaction.

3 With water, Z forms a strong acid.

STEMUP.CO.UK

37. June/2021/Paper_21/No.1

Ethanedioic acid, HO_2CCO_2H, has a relative molecular mass of 90.0.

(a) (i) Explain what is meant by the term *relative molecular mass*.

.....

.....

..... [2]

(ii) State the empirical formula of ethanedioic acid.

..... [1]

(iii) Calculate how many atoms of carbon are present in 0.18 g of ethanedioic acid, HO_2CCO_2H.

Show your working.

atoms of carbon present = ... [3]

(b) Solid ethanedioic acid reacts with aqueous calcium ions to make a precipitate of calcium ethanedioate, CaC_2O_4.

CaC_2O_4 breaks down when heated to form calcium oxide, carbon dioxide and carbon monoxide.

(i) Construct an equation to represent the reaction of CaC_2O_4 when heated. Include state symbols.

..... [2]

(ii) Identify the type of reaction which occurs when CaC_2O_4 is heated.

..... [1]

(iii) Identify another compound containing calcium ions which will also produce carbon dioxide and calcium oxide when it is heated.

..... [1]

[Total: 10]

STEMUP.CO.UK

38. June/2021/Paper_23/No.1(e)

(e) The concentration of NaC*l*O in bleach **S** is $x\,g\,dm^{-3}$.

NaC*l*O reacts with $H_2O_2(aq)$ as shown.

$$H_2O_2(aq) + NaClO(aq) \rightarrow H_2O(l) + NaCl(aq) + O_2(g)$$

A $5.00\,cm^3$ sample of **S** completely reacts with $H_2O_2(aq)$. The volume of $O_2(g)$ produced is $24.0\,cm^3$ under room conditions.

Assume that only the NaC*l*O in **S** reacts with $H_2O_2(aq)$.

Calculate *x*. Show your working.

x = ... $g\,dm^{-3}$

[3]

STEMUP.CO.UK

Atoms, molecules and stoichiometry – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.3

In separate experiments, 5.0 g samples of each of four s-block metals are added to an excess of water. The gas evolved is collected and its volume measured under the same conditions of temperature and pressure for each sample.

Which metal produces the largest volume of gas?

A calcium

B potassium

C rubidium

D strontium

2. June/2022/Paper_11/No.4

A student reacts 1 mol of copper with concentrated nitric acid to produce 1 mol of copper(II) nitrate, 2 mol of water and substance X. No other product is formed.

Substance X does not contain copper or hydrogen.

What could be substance X?

A N_2 **B** N_2O **C** NO **D** NO_2

3. June/2022/Paper_11/No.7

'Black powder' is a mixture of potassium nitrate, carbon and sulfur. The mixture reacts as shown.

$$4KNO_3(s) + 7C(s) + S(s) \rightarrow 3CO_2(g) + 3CO(g) + 2N_2(g) + K_2S(s) + K_2CO_3(s)$$

A sealed tube containing black powder has a volume of 10.0 cm^3. When all of the black powder reacts, the reaction causes a pressure of 2×10^6 Pa and a temperature of 2500 K.

The volume of the K_2CO_3 and K_2S produced can be ignored.

How many moles of KNO_3 are contained in the sealed tube?

A 4.81×10^{-4} **B** 9.63×10^{-4} **C** 1.93×10^{-3} **D** 9.63×10^{-1}

4. June/2022/Paper_11/No.11

A student reacts 4 mol of ammonia with oxygen to produce an oxide of nitrogen and water only. Each nitrogen atom increases its oxidation state by 5 in the reaction.

How many moles of oxygen gas react with 4 mol of ammonia in this reaction?

A 4 mol **B** 5 mol **C** 7 mol **D** 10 mol

STEMUP.CO.UK

5. June/2022/Paper_11/No.16

A 3.0 g sample of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HC*l*. The volume of CO_2 produced is 600 cm^3.

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

[M_r: Na_2CO_3, 106.0]

Which volume of CO_2 is produced if 1.0 g of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HC*l* under the same conditions?

A 600 cm^3 **B** 452 cm^3 **C** 226 cm^3 **D** 200 cm^3

6. June/2022/Paper_12/No.3

Which sample contains the most iodine?

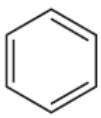
A 1 g of CaI_2 **B** 1 g of KI **C** 1 g of NaI **D** 1 g of NH_4I

7. June/2022/Paper_12/No.4

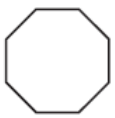
When a small sample of hydrocarbon Q is completely combusted, it produces 3.52 g of carbon dioxide and 1.44 g of water.

What could be the structure of hydrocarbon Q?

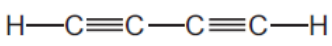
A



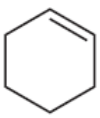
B



C



D



8. June/2022/Paper_13/No.3

Analysis of the hormone thyroxine gives the results shown.

Heating 0.500 g of thyroxine with aqueous silver nitrate produces 0.604 g of silver iodide. All of the iodine in the thyroxine sample is converted to silver iodide.

Complete combustion of 0.500 g of thyroxine produces 232 cm^3 of carbon dioxide and 7.72 cm^3 of nitrogen, measured under room conditions.

Which molecular formula of thyroxine agrees with these values?

A $C_{15}H_{11}NO_4I_4$ M_r = 776.6

B $C_{15}H_7NO_4I_8$ M_r = 1280.2

C $C_{30}H_{25}NO_6I_4$ M_r = 1002.6

D $C_{30}H_{21}NO_6I_8$ M_r = 1506.2

STEMUP.CO.UK

9. June/2022/Paper_13/No.4

How many moles of oxygen, O_2, are needed to burn 1 mol of ethane if the products of the reaction are water and carbon only?

A 1.5 **B** 3 **C** 3.5 **D** 5

10. June/2022/Paper_13/No.8

A student reacts 1 mol of magnesium powder in a sealed 0.030 m^3 container of oxygen at a pressure of 2.0×10^5 Pa and a temperature of 600 K. The magnesium reacts completely to form MgO.

Which percentage of the oxygen will be used up?

A 5.0% **B** 10% **C** 42% **D** 83%

11. June/2022/Paper_21/No.4(a)

Compound **V** is a liquid.

V contains 77.2% carbon, 11.4% hydrogen and 11.4% oxygen by mass.

V has a relative molecular mass of 280.

(a) Calculate the molecular formula of **V**. Show your working.

molecular formula of **V** = ... [3]

STEMUP.CO.UK

12. June/2022/Paper_23/No.1(e, f)

(e) An isotope of copper has a relative isotopic mass of 65.

Complete Table 1.2 for an atom of copper-65.

Table 1.2

	atomic number	nucleon number	number of neutrons	electronic arrangement
copper-65				

[3]

(f) **(i)** The element copper has a relative atomic mass of 63.5.

Calculate how many atoms are present in 1.05 g of copper.

atoms of copper present = ... [1]

(ii) Copper has a melting point of 1085 °C and a high electrical conductivity.

Explain these properties of copper by referring to its structure and bonding.

.....

.....

..... [2]

STEMUP.CO.UK

Atoms, molecules and stoichiometry – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.1

Which sample contains the same number of the named species as the number of molecules in 35.5 g of chlorine?

A atoms in 16 g of sulfur

B atoms in 23 g of sodium

C ions in 74.5 g of potassium chloride

D molecules in 88 g of carbon dioxide

2. Nov/2022/Paper_11/No.2

Mixture R consists of one mole of C_3H_6 and one mole of C_4H_6.

What is the minimum number of moles of oxygen molecules needed for complete combustion of mixture R?

A 6.5 **B** 7 **C** 10 **D** 20

3. Nov/2022/Paper_11/No.8

The carbonate of an s-block element is reacted with an excess of hydrochloric acid.

0.833 g of the carbonate releases 200 cm^3 of gas, measured under room conditions.

What is the identity of the metal carbonate?

A Na_2CO_3 **B** K_2CO_3 **C** $MgCO_3$ **D** $CaCO_3$

4. Nov/2022/Paper_12/No.2

Sodium peroxide, Na_2O_2, is used to absorb carbon dioxide from the atmosphere and release oxygen in closed environments such as space capsules and submarines.

$$2Na_2O_2 + 2CO_2 \rightarrow 2Na_2CO_3 + O_2$$

Which mass of sodium peroxide would be required to remove 2.4 dm^3 of carbon dioxide from the atmosphere at room temperature and pressure?

A 2.4 g **B** 3.9 g **C** 7.8 g **D** 15.6 g

STEMUP.CO.UK

5. Nov/2022/Paper_12/No.3

In which species are the numbers of protons, neutrons and electrons all different?

A $^{27}_{13}Al$ **B** $^{35}_{17}Cl^-$ **C** $^{32}_{16}S^{2-}$ **D** $^{39}_{19}K^+$

6. Nov/2022/Paper_12/No.4

Calcium oxide and magnesium sulfide each react with acid.

$$CaO(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l)$$

$$MgS(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2S(g)$$

A mixture of these two compounds, X, reacts with exactly 0.125 mol of dilute hydrochloric acid.

The amount of hydrogen sulfide formed is 0.0250 mol.

What was the mass of calcium oxide in mixture X?

A 1.4 g **B** 2.1 g **C** 2.8 g **D** 4.2 g

7. Nov/2022/Paper_22/No.1(d)

(d) There are many naturally occurring hydrated compounds that contain the anion PO_4^{3-}.

(i) Name the anion PO_4^{3-}.

..... [1]

(ii) Struvite is a soft hydrated mineral with M_r = 245.3. The anhydrous form of the mineral has the formula NH_4MgPO_4.

Calculate the number of molecules of water of crystallisation in struvite.

Give your answer to the nearest integer. Show your working.

number of molecules of water of crystallisation = ... [2]

STEMUP.CO.UK

Atoms, molecules and stoichiometry – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.1

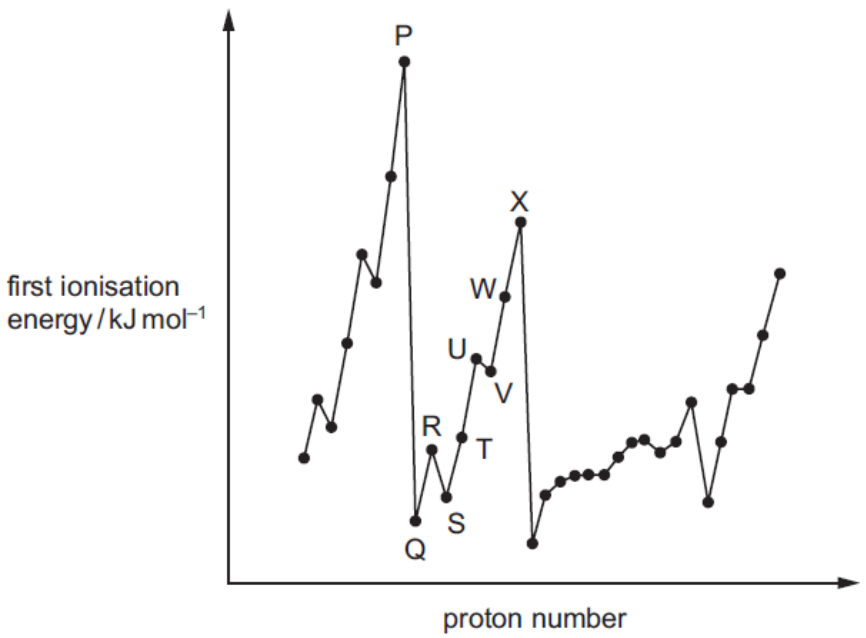
Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

What are the numbers of electrons in the sodium ion and the azide ion?

	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

2. Nov/2023/Paper_ 9701/11/No.2

The graph shows the variation of the first ionisation energy with proton number for some elements. The letters used are **not** the actual symbols for the elements.



Which statement about the elements is correct?

A P and X are in the same period in the Periodic Table.

B The general increase from Q to X is due to increasing atomic radius.

C The small decrease from R to S is due to decreased shielding.

D The small decrease from U to V is due to repulsion between paired electrons.

3. Nov/2023/Paper_ 9701/11/No.3

Aluminium carbide, Al_4C_3, reacts readily with aqueous sodium hydroxide. The two products of the reaction are $NaAlO_2$ and a hydrocarbon. Water molecules are also involved as reactants.

What is the formula of the hydrocarbon?

A CH_4 **B** C_2H_6 **C** C_3H_8 **D** C_6H_{12}

4. Nov/2023/Paper_ 9701/11/No.4

A sample of 35.6 g of hydrated sodium carbonate contains 25.84% sodium ions by mass.

When this sample is heated, anhydrous sodium carbonate and water are formed.

Which mass of water is given off?

A 7.2 g **B** 10.6 g **C** 14.4 g **D** 21.2 g

5. Nov/2023/Paper_ 9701/12/No.1

Which particle contains 8 protons, 9 neutrons and 10 electrons?

A $^{16}_{8}O^-$ **B** $^{16}_{8}O^{2-}$ **C** $^{17}_{8}O^-$ **D** $^{17}_{8}O^{2-}$

6. Nov/2023/Paper_ 9701/12/No.2

The second ionisation energy of oxygen is greater than the second ionisation energy of fluorine.

Which factor explains this difference?

A The atomic radius of an oxygen atom is smaller than that of fluorine.

B The covalent bond in a fluorine molecule is weaker than the bond in an oxygen molecule.

C A spin-paired electron is removed from fluorine but **not** from oxygen.

D Fluorine has more electrons in total than oxygen. This causes a greater shielding of the nuclear attraction in fluorine.

7. Nov/2023/Paper_ 9701/12/No.3

Zinc reacts with concentrated nitric acid giving three products only: zinc nitrate, an oxide of nitrogen and water.

3.0 moles of zinc react with 8.0 moles of nitric acid. Zinc nitrate contains Zn^{2+} ions.

What could be the formula of the oxide of nitrogen?

A N_2O **B** NO **C** N_2O_3 **D** NO_2

STEMUP.CO.UK

8. Nov/2023/Paper_ 9701/12/No.4

A 3.7 g sample of copper(II) carbonate is added to 25 cm^3 of 2.0 mol dm^{-3} hydrochloric acid.

Which volume of gas is produced at room conditions?

A 0.60 dm^3 **B** 0.72 dm^3 **C** 1.20 dm^3 **D** 2.40 dm^3

9. Nov/2023/Paper_ 9701/12/No.8

In an experiment, 0.100 mol of propan-1-ol is burnt completely in 12.0 dm^3 of oxygen, measured at room conditions.

What is the final volume of gas, measured at room conditions?

A 7.20 dm^3 **B** 8.40 dm^3 **C** 16.80 dm^3 **D** 18.00 dm^3

10. Nov/2023/Paper_ 9701/21/No.1(a, b)

The elements phosphorus, sulfur and chlorine are in Period 3 of the Periodic Table.

Table 1.1 shows some properties of the elements P to C*l*.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	C*l*
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy /kJ mol^{-1}	1060		1260
formula of most common anion	P^{3-}	S^{2-}	Cl^{-}

(a) (i) Complete Table 1.1 to show the number of electrons in the 3p subshell and the total number of unpaired electrons in an atom of P, S and C*l*. [2]

(ii) Construct an equation to represent the first ionisation energy of P.

..... [1]

(iii) Three possible values for the first ionisation energy of S are given.

1000 kJ mol^{-1} **1160 kJ mol^{-1}** **1320 kJ mol^{-1}**

Circle the correct value.

Explain your choice by comparing your chosen value to those of P and C*l*.

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(b) P^{3-}, S^{2-} and Cl^- have the same number of electrons.

(i) Give the full electronic configuration of P^{3-}.

..... [1]

(ii) State the trend in ionic radius shown by P^{3-}, S^{2-} and Cl^-.

Explain your answer.

.....

.....

.....

..... [2]

11. June/2023/Paper_9701/11/No.1

Element X has six more protons than element Y.

Which statement **must** be correct?

A Atoms of element Y are smaller than atoms of element X.

B Element X has a full shell of electrons.

C Element X and element Y are in the same group.

D Element X and element Y are in the same period.

12. June/2023/Paper_9701/11/No.2

Which statement explains why calcium has a higher melting point than barium?

A Calcium cations are smaller than barium cations and have a stronger attraction to the delocalised electrons.

B The structure of calcium is partly giant molecular.

C There are more delocalised electrons in calcium than in barium as it has a lower ionisation energy.

D There is greater repulsion between barium atoms as they have more complete electron shells than calcium atoms.

STEMUP.CO.UK

13. June/2023/Paper_9701/11/No.3

Three statements about potassium and chlorine and their ions are listed.

1 The atomic radius of a potassium atom is greater than the atomic radius of a chlorine atom.

2 The first ionisation energy of potassium is greater than the first ionisation energy of chlorine.

3 The ionic radius of a potassium ion is greater than the ionic radius of a chloride ion.

Which statements are correct?

A 1 only **B** 2 only **C** 1 and 3 **D** 2 and 3

14. June/2023/Paper_9701/11/No.10

Which statement is correct?

A The relative atomic mass of a ^{35}Cl atom is 35.5.

B The relative formula mass of $CaCO_3$ is 100.1.

C The relative isotopic mass of a ^{24}Mg atom is 24.3.

D The relative molecular mass of O_2 is 16.0.

15. June/2023/Paper_9701/12/No.1

When chlorine gas is analysed in a mass spectrometer $^{35}Cl^+$ ions are detected.

Which row is correct?

	number of neutrons in $^{35}Cl^+$	electronic configuration of $^{35}Cl^+$
A	17	$1s^2 2s^2 2p^6 3s^2 3p^4$
B	17	$1s^2 2s^2 2p^6 3s^2 3p^6$
C	18	$1s^2 2s^2 2p^6 3s^2 3p^4$
D	18	$1s^2 2s^2 2p^6 3s^2 3p^6$

16. June/2023/Paper_9701/12/No.2

Which species is a free radical?

A He **B** Be^- **C** O^{2-} **D** Zn

STEMUP.CO.UK

17. June/2023/Paper_9701/12/No.3

Which statement is correct?

A The first ionisation energy of chlorine is more than the first ionisation energy of argon.

B The second ionisation energy of calcium is more than the second ionisation energy of magnesium.

C The second ionisation energy of sulfur is equal to the first ionisation energy of phosphorus.

D The eighth ionisation energy of chlorine is more than the first ionisation energy of neon.

18. June/2023/Paper_9701/12/No.4

If 1 mole of hexane combusts in an excess of oxygen, how many moles of products are formed?

A 11 **B** 12 **C** 13 **D** 14

19. June/2023/Paper_9701/12/No.5

Separate samples, each of mass 1.0 g, of the compounds listed are treated with an excess of dilute acid.

Which compound releases the largest amount of CO_2?

A 1.0 g $CaCO_3$ **B** 1.0 g Li_2CO_3 **C** 1.0 g $MgCO_3$ **D** 1.0 g Na_2CO_3

20. June/2023/Paper_9701/13/No.3

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 mol dm^{-3} hydrochloric acid.

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

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

21. June/2023/Paper_9701/13/No.11

Which mixture will react to form exactly one mole of water?

	volume 2.00 mol dm^{-3} H_2SO_4 / cm^3	volume 1.00 mol dm^{-3} NaOH / cm^3
A	250	500
B	250	1000
C	500	500
D	500	1000

22. June/2023/Paper_9701/21/No.1

Tellurium is an element in Group 16. The most common isotope of tellurium is ^{130}Te. Its electronic configuration is [Kr] $4d^{10}\ 5s^2\ 5p^4$.

(a) Complete Table 1.1.

Table 1.1

	nucleon number	number of neutrons	number of electrons
^{130}Te			

[3]

(b) Identify the sub-shell in an atom of Te that contains electrons with the lowest energy.

..... [1]

(c) Construct an equation to represent the first ionisation energy of Te.

..... [1]

(d) **(i)** The radius of Te ions decreases after each successive ionisation.

State **two** factors that are responsible for the increase in the first six ionisation energies of Te.

.....

.....

..... [2]

STEMUP.CO.UK

(ii) Sketch a graph in Fig. 1.1 to show the trend in the first **seven** ionisation energies of Te.

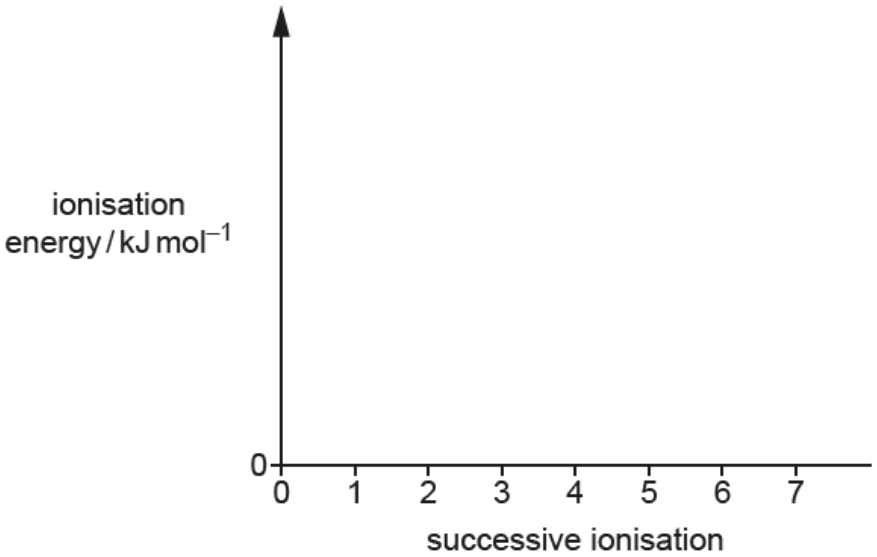


Fig. 1.1

[2]

(e) Te reacts with F_2 at 150 °C to form TeF_x. Molecules of TeF_x are octahedral with bond angles of 90°.

Explain why TeF_x is octahedral with bond angles of 90°.

.....

.....

..... [2]

(f) TeF_x reacts with water to form tellurium hydroxide and HF. The oxidation number of tellurium does **not** change during this reaction.

(i) Construct an equation for the reaction of TeF_x with water.

..... [1]

(ii) Name the type of reaction that occurs when TeF_x reacts with water.

..... [1]

[Total: 13]

STEMUP.CO.UK

23. June/2023/Paper_9701/23/No.1

Copper is used in electrical equipment. It has a melting point of 1085 °C.

(a) (i) Identify the lattice structure of copper.

..... [1]

(ii) Draw a labelled diagram to show the bonding present in copper.

[1]

(b) The relative isotopic masses and natural abundances of the two isotopes in a sample of copper are shown in Table 1.1.

Table 1.1

isotope	relative isotopic mass	% abundance
^{63}Cu	62.930	69.15
^{65}Cu	64.928	30.85

(i) Define the unified atomic mass unit.

.....

..... [1]

(ii) Define relative atomic mass, A_r, in terms of the unified atomic mass unit.

.....

..... [1]

(iii) Calculate the relative atomic mass, A_r, of copper in this sample using the data in Table 1.1.

Show your working.

A_r = ... [1]

STEMUP.CO.UK

(c) The mass spectrum of a sample of pure copper is shown in Fig. 1.1.

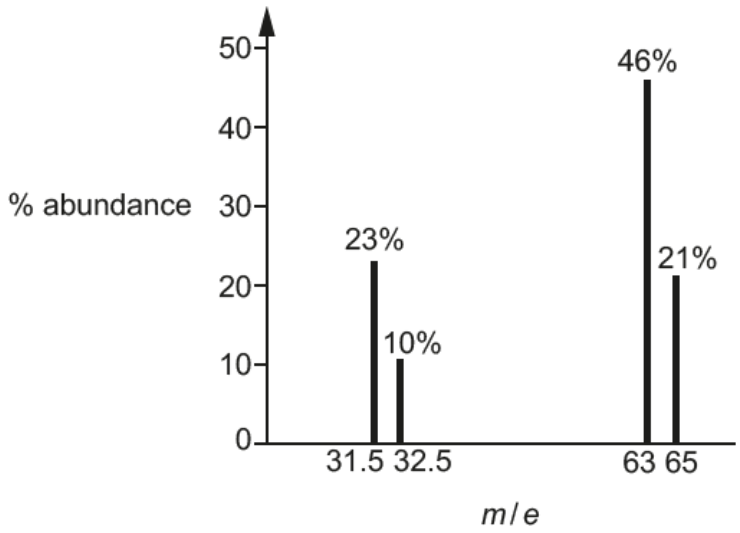


Fig. 1.1

Identify the ion with an abundance of 23% in the sample.

..... [1]

(d) When KI(aq) is added to $CuSO_4$(aq) the blue-coloured solution turns brown and a white precipitate of CuI(s) is seen.

The reaction between copper ions and iodide forms only two products.

(i) Complete the equation for this reaction.

.....Cu^{2+} + ...I^- → .....CuI + ...

[1]

(ii) Identify the oxidising agent in this reaction. Explain your answer in terms of electron transfer.

.....

..... [1]

(iii) State the full electronic configuration of Cu^{2+}.

..... [1]

[Total: 9]

STEMUP.CO.UK

24. March/2023/Paper_9701/12/No.12

Which atom contains four times as many neutrons as the $^{7}_{3}Li$ atom?

A $^{40}_{20}Ca$ **B** $^{24}_{12}Mg$ **C** $^{31}_{15}P$ **D** $^{26}_{14}Si$

25. March/2023/Paper_9701/12/No.13

Which statement about the first ionisation energies of magnesium and neon is correct?

A Magnesium has the greater numerical value and both are endothermic.

B Magnesium has the greater numerical value and both are exothermic.

C Neon has the greater numerical value and both are endothermic.

D Neon has the greater numerical value and both are exothermic.

26. March/2023/Paper_9701/12/No.15

Hydrated cobalt(II) sulfate loses water when heated to give anhydrous cobalt(II) sulfate. All the water of crystallisation is lost to the atmosphere as steam.

When 3.10 g of hydrated cobalt(II) sulfate, $CoSO_4 \cdot xH_2O$, is heated to constant mass the **loss** in mass is 1.39 g.

What is the value of x, to the nearest whole number?

A 4 **B** 6 **C** 7 **D** 11

STEMUP.CO.UK

27. March/2023/Paper_9701/22/No.1

The Pauling electronegativity values of elements can be used to predict the chemical properties of compounds.

Use the information in Table 1.1 to answer the following questions.

Table 1.1

element	H	Li	C	O	S
Pauling electronegativity value	2.1	1.0	2.5	3.5	2.6
first ionisation energy / kJ mol^{-1}	1310	519	1090	1310	1000
second ionisation energy / kJ mol^{-1}	—	7300	2350	3390	2260

(a) (i) Define electronegativity.

.....

..... [1]

(ii) O and S are in Group 16.

Explain the difference in the Pauling electronegativity values of O and S.

.....

.....

..... [2]

(b) (i) LiH is an ionic compound.

Draw a dot-and-cross diagram of LiH.

Include **all** electrons.

[2]

(ii) Suggest the shape of a molecule of H_2S.

..... [1]

STEMUP.CO.UK

(c) **(i)** Write an equation that represents the first ionisation energy of H.

..... [1]

(ii) Explain why there is no information given in Table 1.1 for the second ionisation energy of H.

..... [1]

(iii) Give the full electronic configuration of $S^{2+}(g)$.

..... [1]

(d) CO_2 and SO_2 are acidic gases.

(i) Write an equation for the reaction of SO_2 with H_2O.

..... [1]

(ii) Write an equation for the reaction of SO_2 with NaOH.

..... [1]

(iii) Construct an equation for the reaction of CO_2 with $Mg(OH)_2$.

..... [1]

STEMUP.CO.UK

(e) **(i)** Complete Table 1.2 by placing a tick (✓) to show which of the compounds have molecules with an overall dipole moment.

Table 1.2

compound	O=C=O	O=S=O	S=C=S	S=C=O
overall dipole moment				

[2]

(ii) At 150 °C and 103 kPa, all of the compounds listed in Table 1.2 are gases.

Under these conditions, 0.284 g of one of the compounds occupies a volume of 127 cm^3.

Use this information to calculate the M_r of the compound. Hence, identify the compound from those given in Table 1.2.

Show your working.

M_r = ... identity of compound = ...

[3]

[Total: 17]

STEMUP.CO.UK