2. Atoms, molecules and stoichiometry

2.4 Reacting masses and volumes

Paper 1

Question Paper

1 A 0.216 g sample of aluminium carbide reacts with an excess of water to produce methane gas. This is the only carbon-containing product formed in the reaction. This methane gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 produced at room temperature and pressure is 108 cm^3.

What is the formula of aluminium carbide?

A Al_2C_3 **B** Al_3C_2 **C** Al_3C_4 **D** Al_4C_3

2 A sample of propanoic acid of mass 3.70 g reacts with an excess of magnesium.

A second sample of propanoic acid of mass 3.70 g reacts with an excess of sodium.

Both reactions go to completion forming a gas.

Which row is correct?

	volume of gas formed with magnesium at s.t.p. / cm^3	volume of gas formed with sodium at s.t.p. / cm^3
A	560	560
B	560	1120
C	1120	560
D	1120	1120

3 Glauber's salt consists of crystals of hydrated sodium sulfate, $Na_2SO_4 \cdot xH_2O$, which can be used for the manufacture of detergents.

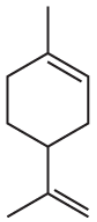
When a sample of Glauber's salt was heated, 1.91 g of water was removed leaving 1.51 g of anhydrous Na_2SO_4.

What is the value of x in $Na_2SO_4 \cdot xH_2O$?

A 1 **B** 8.85 **C** 10 **D** 11.25

4 The structure of limonene is shown.

limonene



What are the number of moles of carbon dioxide and water produced when a sample of limonene is completely combusted in oxygen?

	number of moles of carbon dioxide	number of moles of water
A	4	3
B	5	4
C	5	8
D	9	7

5 Sample X is added to water and made up to a total volume of 200 cm^3. This gives a solution of 0.100 mol dm^{-3} HCl.

What is X?

A 10 cm^3 of 1.00 mol dm^{-3} HCl

B 30 cm^3 of 0.90 mol dm^{-3} HCl

C 50 cm^3 of 0.40 mol dm^{-3} HCl

D 100 cm^3 of 0.30 mol dm^{-3} HCl

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

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

Which volume of gas was absorbed by the alkali?

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

7 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}

8 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

9 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

10 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

11 In this question you should assume that the gas formed behaves as an ideal gas.

A 1.7 g sample of Mg reacts with 50.0 cm^3 of 2.2 mol dm^{-3} HCl at 303 K and 110 400 Pa.

Which volume of gas is produced, measured under these conditions?

A 1.3 dm^3 **B** 1.6 dm^3 **C** 2.5 dm^3 **D** 5.0 dm^3

12 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

13 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

14 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

15 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** $CaCO_3$

16 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

17 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

18 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

19 17.6 g of pentan-1-ol is completely combusted.

Which volume of gaseous products is formed when measured at s.t.p.?

A 22.4 dm^3 **B** 24.0 dm^3 **C** 49.3 dm^3 **D** 52.8 dm^3

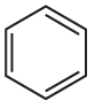
20 Which sample contains the most iodine?

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

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

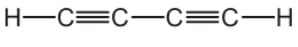
What could be the structure of hydrocarbon Q?

A

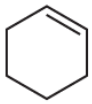


B

C



D



22 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

23 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

24 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

25 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

26 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 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

28 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

29 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

30 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)

31 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

32 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

33 The complete combustion of 2 moles of an alkane produces 400 dm^3 of carbon dioxide measured at 301 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the alkane?

A C_8H_{18} **B** $C_{16}H_{34}$ **C** $C_{20}H_{42}$ **D** $C_{40}H_{82}$

34 What is the smallest amount of oxygen molecules needed for the complete combustion of 40.0 g of methanol?

A 1.88 moles **B** 2.50 moles **C** 3.75 moles **D** 5.00 moles

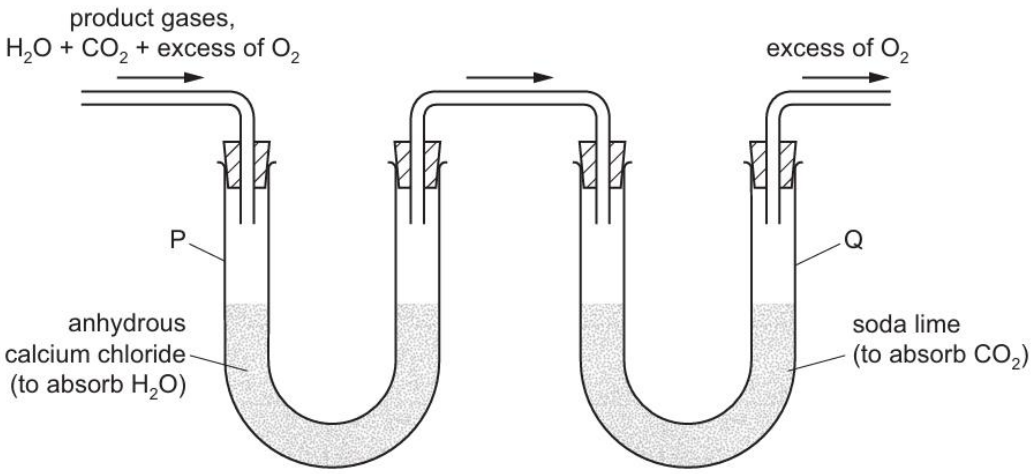
35 A washing powder contains sodium hydrogencarbonate, $NaHCO_3$, as one of the ingredients.

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%

36 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

37 5.0 g samples of the carbonates of barium, copper, lithium and magnesium are decomposed to the metal oxides and carbon dioxide.

For which compound is there the greatest loss in mass?

A barium carbonate

B copper(II) carbonate

C lithium carbonate

D magnesium carbonate

38 Exactly 1.00 g of a metallic element reacts completely with 300 cm^3 of oxygen at 298 K and 1 atm pressure to form an oxide which contains O^{2-} ions.

The volume of one mole of gas at this temperature and pressure is 24.0 dm^3.

What could be the identity of the metal?

A calcium

B magnesium

C potassium

D sodium

39 Which fuel would produce the largest mass of CO_2 when 10 kg of the fuel undergo complete combustion?

A biodiesel, $C_{17}H_{34}O_2$

B ethanol, C_2H_6O

C octane, C_8H_{18}

D propane, C_3H_8

40 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

41 To manufacture cement, 1000 million tonnes of limestone are decomposed each year. To manufacture lime for agriculture, 200 million tonnes of limestone are decomposed each year.

What is the total mass of carbon dioxide in million tonnes produced from these two processes in a year?

A 440 **B** 528 **C** 660 **D** 880