

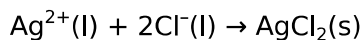
## Formulae, Equations and Amounts of Substance - Questions by Topic

Q1.

This question is about compounds containing chlorine.

(a) A precipitate of silver chloride is formed when silver nitrate solution reacts with sodium chloride solution.

A student wrote an ionic equation for the reaction.



Explain why this equation is incorrect, even though it is balanced.

(2)

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(b) A sample of a compound is analysed and found to contain **only** 3.09 g carbon, 0.26 g hydrogen and 9.15 g chlorine.

The molar mass of the compound is  $97.0 \text{ g mol}^{-1}$ .

Calculate the molecular formula of this compound.

You **must** show your working.

(3)

(c) Nitrogen trichloride has the formula  $\text{NCl}_3$ .

(i) A sample of nitrogen trichloride contained only nitrogen atoms with mass number 14, and chlorine atoms with mass numbers 35 and 37.

Give the formula and mass/charge ratio for each of the **four** ions responsible for the molecular ion peaks in the mass spectrum of nitrogen trichloride.

(2)

**(Total for question = 7 marks)**

Q2.

This question is about nitrogen.

(a) Nitrogen gas consists of nitrogen molecules.

(i) Draw a dot-and-cross diagram to show the bonding in a molecule of nitrogen.

(1)

(ii) Calculate the number of nitrogen **atoms** in 5.60 g of nitrogen gas.

[Avogadro constant =  $6.02 \times 10^{23} \text{ mol}^{-1}$ ]

(2)

(iii) A sample of nitrogen gas occupied  $108 \text{ cm}^3$  at a temperature of  $25 \text{ }^\circ\text{C}$  and a pressure of  $1.36 \times 10^5 \text{ Pa}$ .

Using the ideal gas equation, calculate the number of moles of nitrogen gas in this sample.

[ $pV = nRT$   $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ ]

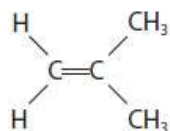
(4)

**(Total for question = 7 marks)**

Q3.

This question is about the alkene 2-methylpropene.

The formulae show two different ways of representing a molecule of 2-methylpropene.



formula 1



formula 2

(a) Give the **empirical** formula of 2-methylpropene.

(1)

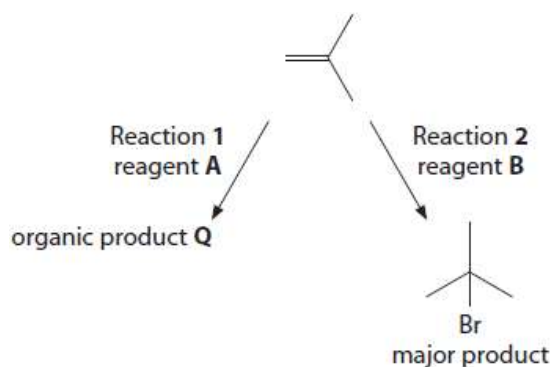
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(b) Draw the mechanism for the reaction between 2-methylpropene and bromine, Br<sub>2</sub>. Include curly arrows, and relevant lone pairs and dipoles.

Use formula 1 to represent 2-methylpropene.

(4)

(c) Two reactions of 2-methylpropene are shown.



(i) In Reaction **1** the reagent **A** is acidified potassium manganate(VII).

Give the **skeletal** formula of organic product **Q**.

(1)

(ii) Give the colour change seen during Reaction **1**.

(1)

From ..... to .....

(iii) Identify, by name or formula, reagent **B** in Reaction 2.

(1)

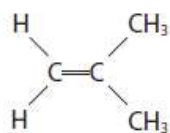
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(iv) Explain why 2-bromo-2-methylpropane is the major organic product in Reaction 2.

(2)

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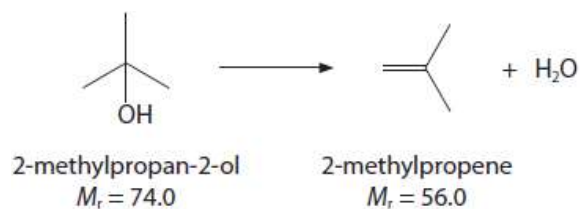
(d) Draw **two** repeat units of poly(2-methylpropene).



2-methylpropene

(2)

(e) A sample of 2-methylpropene was prepared from 2-methylpropan-2-ol



The yield of this reaction was 58.2%.

Calculate the mass of 2-methylpropene formed from 6.85 g of 2-methylpropan-2-ol.  
Give your answer to an appropriate number of significant figures.

(4)

**(Total for question = 16 marks)**

Q4.

This question is about bromine.

(a) Complete the electronic configuration for a bromine atom, using the s, p, d notation.

(1)

[Ar] .....

(b) Bromine exists as two isotopes with mass numbers 79 and 81.

(i) Complete the table to show the numbers of subatomic particles in a  $^{79}\text{Br}$  atom and a  $^{81}\text{Br}^-$  ion.

(2)

Species	Protons	Neutrons	Electrons
$^{79}\text{Br}$			
$^{81}\text{Br}^-$			

A sample of bromine contained equal amounts of the two isotopes.

(ii) Calculate the number of bromine molecules in 2.00 g of  $\text{Br}_2$ .

[Avogadro constant =  $6.02 \times 10^{23} \text{ mol}^{-1}$ ]

(2)

Number of molecules = .....

(c) A sample of bromine gas occupied  $200 \text{ cm}^3$  at a temperature of  $77 \text{ }^\circ\text{C}$  and a pressure of  $1.51 \times 10^5 \text{ Pa}$ .

Calculate, using the ideal gas equation, the amount in moles of bromine molecules in this sample.

[ $pV = nRT$        $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ ]

(4)

Amount of bromine molecules = ..... mol

**(Total for question = 9 marks)**

Q5.

There is 0.045 g of solute in 1500 g of a solution.

What is the concentration of the solution in parts per million (ppm)?

(1)

- A 3.00
- B 6.75
- C 30.0
- D 67.5

**(Total for question = 1 mark)**

Q6.

What is the concentration, in  $\text{mol dm}^{-3}$ , of a solution containing 7.84 g of phosphoric(V) acid,  $\text{H}_3\text{PO}_4$ , in  $400 \text{ cm}^3$  of solution?

(1)

- A 0.02
- B 0.08
- C 0.20
- D 19.6

**(Total for question = 1 mark)**

Q7.

A sample of a hydrocarbon with mass 7.2 g contained 6.0 g of carbon.  
What is the empirical formula of the hydrocarbon?

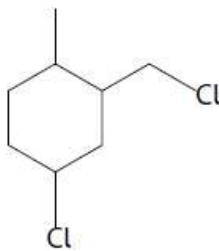
(1)

- A  $\text{CH}_2$
- B  $\text{C}_5\text{H}_{12}$
- C  $\text{C}_6\text{H}_6$
- D  $\text{C}_7\text{H}_6$

**(Total for question = 1 mark)**

Q8.

What is the empirical formula of the following molecule?



(1)

- A** C<sub>4</sub>H<sub>4</sub>Cl
- B** C<sub>4</sub>H<sub>7</sub>Cl
- C** C<sub>8</sub>H<sub>11</sub>Cl<sub>2</sub>
- D** C<sub>8</sub>H<sub>14</sub>Cl<sub>2</sub>

**(Total for question = 1 mark)**

Q9.

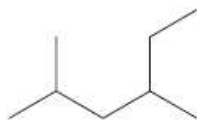
The alkanes are a homologous series of saturated hydrocarbons.

(a) Draw the displayed formulae of the three alkanes with molecular formula  $C_5H_{12}$ .

(3)

(b) Give the systematic name of compound **P**.

(1)



Compound **P**

Systematic name

.....

(c) The table shows the boiling temperatures of the first four straight-chain alkanes.

Molecular formula of alkane	Boiling temperature / °C
$CH_4$	-164
$C_2H_6$	-89
$C_3H_8$	-42
$C_4H_{10}$	-0.5

Predict the molecular formula and boiling temperature of the straight-chain alkane that has five carbon atoms in its molecules.

(2)

Molecular formula .....

Boiling temperature .....

(d) Alkanes undergo incomplete combustion when they burn in a limited supply of air.

(i) Write the equation for the incomplete combustion of propane,  $C_3H_8$ , to form carbon, carbon monoxide, carbon dioxide and water.

State symbols are not required.

(1)

(ii) Explain the toxicity of carbon monoxide.

(2)

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(e) Propane reacts with chlorine in the presence of ultraviolet radiation. The reaction starts when some chlorine molecules are split into free radicals. A mixture of products is formed.

(i) Write the two propagating steps to show how C<sub>3</sub>H<sub>7</sub>Cl is formed.

Curly arrows are not required.

(2)

(ii) Identify the different C<sub>3</sub>H<sub>7</sub>Cl molecules that are produced in this reaction.

(1)

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(iii) Give a reason why a mixture of C<sub>3</sub>H<sub>7</sub>Cl molecules is formed.

(1)

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(iv) Give a reason why some hexane is formed in this reaction.

(1)

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(v) A small amount of a product with molar mass 113 g mol<sup>-1</sup> is formed.

Deduce the structure and name of a possible product with this molar mass.

(2)

Structure

.....

Name

.....

**(Total for question = 16 marks)**

Q10.

Calcium reacts with dilute nitric acid to form calcium nitrate and hydrogen.

Which is the balanced equation for this reaction?

- A**  $\text{Ca} + 2\text{HNO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + \text{H}_2$
- B**  $\text{Ca} + \text{H}_2\text{NO}_3 \rightarrow \text{CaNO}_3 + \text{H}_2$
- C**  $\text{Ca} + 2\text{H}_2\text{NO}_3 \rightarrow \text{Ca}(\text{NO}_3)_2 + 2\text{H}_2$
- D**  $2\text{Ca} + 2\text{HNO}_3 \rightarrow 2\text{CaNO}_3 + \text{H}_2$

**(Total for question = 1 mark)**

Q11.

What mass of anhydrous sodium carbonate is needed to make  $50.0 \text{ cm}^3$  of a  $0.0800 \text{ mol dm}^{-3}$  solution of sodium carbonate,  $\text{Na}_2\text{CO}_3$ ?

[ $A_r$  values: C = 12.0, O = 16.0, Na = 23.0]

- A** 0.332 g
- B** 0.424 g
- C** 5.30 g
- D** 8.48 g

**(Total for question = 1 mark)**

Q12.

A sample of air, with a mass of 5.0 kg, contained carbon monoxide with a concentration of 12 parts per million by mass.

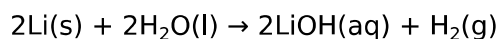
What is the mass of carbon monoxide in this sample of air?

- A**  $6.0 \times 10^{-2} \text{ g}$
- B**  $6.0 \times 10^{-5} \text{ g}$
- C**  $2.4 \times 10^{-6} \text{ g}$
- D**  $2.4 \times 10^{-9} \text{ g}$

**(Total for question = 1 mark)**

Q13.

What is the maximum volume of hydrogen formed, at room temperature and pressure (r.t.p.), when 0.207 g of lithium is added to excess water?



[ $A_r$  Li = 6.9 Molar volume of gas at r.t.p. =  $24.0 \text{ dm}^3 \text{ mol}^{-1}$ ]

- A 0.36  $\text{dm}^3$
- B 0.72  $\text{dm}^3$
- C 1.44  $\text{dm}^3$
- D 2.48  $\text{dm}^3$

**(Total for question = 1 mark)**

Q14.

Which pair of substances contains the same number of moles at room temperature and pressure (r.t.p.)?

[ $A_r$  values Ca = 40, Li = 7, Al = 27, Mg = 24. Molar volume of gas at r.t.p. =  $24 \text{ dm}^3 \text{ mol}^{-1}$ ] (1)

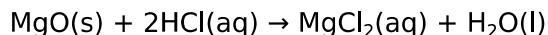
- A 24  $\text{dm}^3$  of chlorine,  $\text{Cl}_2$ , and 20 g of calcium, Ca
- B 24  $\text{dm}^3$  of oxygen,  $\text{O}_2$ , and 14 g of lithium, Li
- C 1.2  $\text{dm}^3$  of hydrogen,  $\text{H}_2$ , and 2.7 g of aluminium, Al
- D 1.2  $\text{dm}^3$  of nitrogen,  $\text{N}_2$ , and 1.2 g of magnesium, Mg

**(Total for question = 1 mark)**

Q15.

Magnesium is a metal in Group 2 of the Periodic Table. It reacts with chlorine to form the salt magnesium chloride,  $\text{MgCl}_2$ .

(a) Magnesium chloride can also be made by reacting magnesium oxide with dilute hydrochloric acid.



(i) Write the **ionic** equation, including state symbols, for this reaction.

(1)

(ii) Calculate the minimum volume of  $2.00 \text{ mol dm}^{-3}$  hydrochloric acid needed to completely react with 2.45 g of magnesium oxide.

(3)

Minimum volume of hydrochloric acid = .....  $\text{cm}^3$

(b) A further method for making magnesium chloride is by reacting magnesium carbonate with dilute hydrochloric acid.



Calculate the maximum mass of magnesium chloride that could be formed when 2.25 g of magnesium carbonate is added to excess dilute hydrochloric acid.

(2)

Maximum mass magnesium chloride = ..... g

(c) Explain why the reaction to make magnesium chloride from magnesium oxide has a higher atom economy than the reaction using magnesium carbonate.

No calculation is required.

(2)

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**(Total for question = 8 marks)**