OCR
Oxford Cambridge and RSA

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Monday 15 June 2015 – Morning

GCSE GATEWAY SCIENCE
CHEMISTRY B

B742/02 Chemistry modules C4, C5, C6 (Higher Tier)

Candidates answer on the Question Paper.
A calculator may be used for this paper.

OCR supplied materials:
None

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: 1 hour 30 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- Your quality of written communication is assessed in questions marked with a pencil (✐).
- The Periodic Table can be found on the back page.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **85**.
- This document consists of **32** pages. Any blank pages are indicated.

Answer **all** the questions.

SECTION A – Module C4

1 Look at the electronic structures of some atoms.

Atom	**Electronic structure**
W	2.8.1
X	2.8.4
Y	2.8.7
Z	2.8.8

(a) (i) One of the atoms is a metal which makes a positive ion.

Which one? Choose from the table.

answer .... **[1]**

(ii) One of the atoms has a stable electronic structure and is unreactive.

Which one? Choose from the table.

answer .... **[1]**

(iii) Two of the atoms can combine together by **transferring** electrons to form an **ionic** bond.

Which two? Choose from the table.

.... and .... **[1]**

(b) Ammonia has the formula, NH_3.

The electronic structure of nitrogen is 2.5.

The electronic structure of hydrogen is 1.

Draw a 'dot and cross' diagram to show the **covalent** bonding in ammonia.

Show all the electrons.

[2]

(c) Sodium chloride is an **ionic** compound.

Sodium chloride

- will not conduct electricity when it is a solid
- will conduct electricity when it is dissolved in water.

Explain these two observations in terms of structure and bonding.

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.... **[2]**

2 Look at the information about a chlorine atom and an oxide ion.

$$^{37}_{17}\mathrm{Cl} \qquad\qquad ^{16}_{8}\mathrm{O}^{2-}$$

(a) Complete the table to show the number of protons, neutrons and electrons in each particle.

Two have been done for you.

	Chlorine atom, Cl	**Oxide ion, O^{2-}**
Number of protons	....	8
Number of neutrons	....	....
Number of electrons	17	....

[3]

(b) Many scientists have helped in the development of the theory of atomic structure.

Two of these scientists were J. J. Thomson and Niels Bohr.

Describe what J. J. Thomson and Niels Bohr contributed to the theory of atomic structure.

J. J. Thomson ....

....

Niels Bohr ....

.... **[2]**

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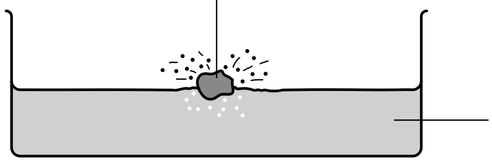
3 This question is about the reaction of Group 1 elements with water.

Lithium, sodium and potassium are Group 1 elements.

They all react with water.



Look at the table.

Group 1 element	Time for 0.5 g of metal to react in seconds	Observations
sodium	15	melts moves across surface of water makes a gas which burns with a 'pop' makes an alkaline solution
potassium	7	melts and catches fire moves quickly across surface of water makes a gas which burns with a 'pop' makes an alkaline solution
lithium	25	moves slowly across surface of water makes a gas which burns with a 'pop' makes an alkaline solution

Rubidium is another Group 1 element.

It is **below** potassium in Group 1 of the periodic table.

Predict the reaction time, and name the products, of the reaction between rubidium and water.

Include a **balanced symbol** equation for the reaction.

The quality of written communication will be assessed in your answer to this question.

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4 This question is about substances that are found in different types of water.

(a) River water contains dissolved substances.

River water has to be purified before it can be drunk.

The water purification process has three stages.

These are

- filtration
- sedimentation
- chlorination.

Pollutants such as fertilisers are still in the water after this purification.

Explain why.

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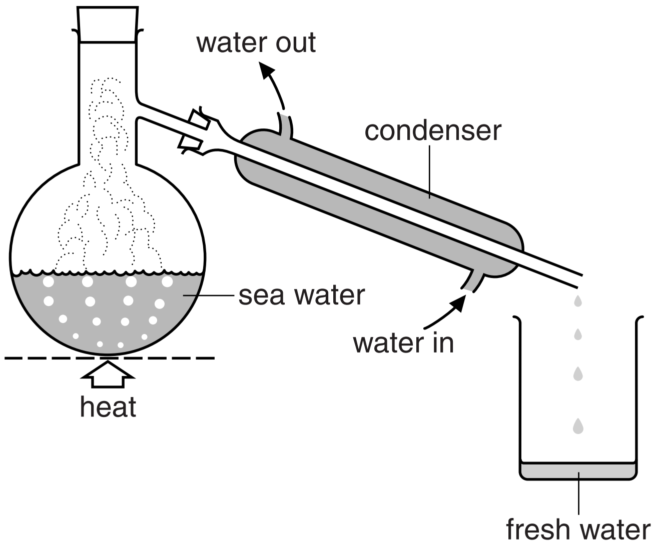
.... **[1]**

(b) Sea water can be made into drinking water.

One way this can be done is by **distillation**.

Look at the diagram. It shows the apparatus used to distil water in the laboratory.



Explain the **disadvantages** of using distillation to make **large amounts** of drinking water.

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.... **[2]**

(c) Pete analyses two samples.

Look at Pete's results.

Sample	Addition of sodium hydroxide solution	Addition of barium chloride solution
A	blue solid made	white solid made
B	brown solid made	no reaction

Pete thinks that sample **A** is copper sulfate.

He thinks that sample **B** is iron(III) sulfate.

Is Pete right about **each** sample?

Explain your answer.

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.... **[4]**

SECTION B – Module C5

5 Space probes have been sent to Mars to analyse the soil.

One compound analysed has the formula $Ca(ClO_4)_2$.

(a) Calculate the molar mass of $Ca(ClO_4)_2$.

The relative atomic mass, A_r, of O = 16, of Cl = 35.5 and of Ca = 40.

molar mass .... g/mol **[1]**

(b) A compound with the formula K_2FeO_4 has also been discovered on Mars.

A sample of K_2FeO_4 is analysed.

The 1.00 g sample contains 0.39 g of potassium and 0.28 g of iron.

Calculate the percentage by mass of oxygen in this sample of K_2FeO_4.

percentage by mass = ... % **[2]**

(c) Another compound found on Mars has the molecular formula C_4H_{10}.

What is the **empirical** formula for this compound?

.... **[1]**

(d) Another compound found on Mars contains iron and oxygen.

The compound contains 70% by mass of iron and 30% by mass of oxygen.

Calculate the empirical formula of this compound.

The relative atomic mass, A_r, of O = 16 and of Fe = 56.

empirical formula is .... **[3]**

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6 This question is about acids.

Nitric acid, HNO_3, is a strong acid and propanoic acid, C_2H_5COOH, is a weak acid.

David investigates the reaction of both of these acids with calcium carbonate.

David does two experiments

- the first with nitric acid
- the second with propanoic acid.

Each time he puts 50 cm^3 of 2.0 mol/dm^3 acid into a conical flask.

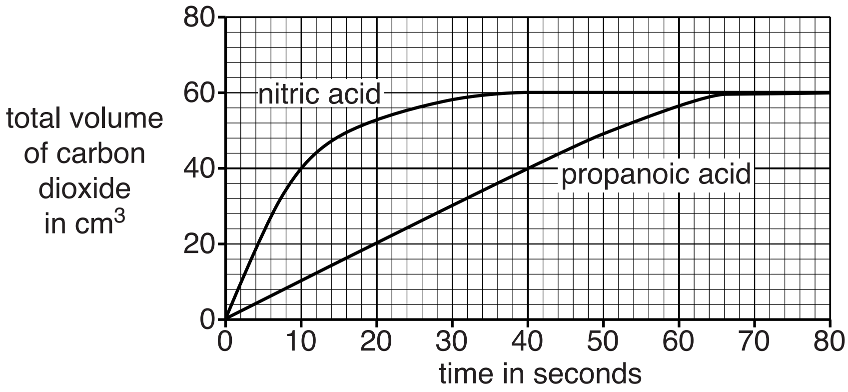
He then adds the same mass of calcium carbonate to each acid.

David measures the total volume of carbon dioxide made every 10 seconds.

(a) Draw a labelled diagram of the apparatus David can use in these experiments.

[2]

(b) Look at the graph of David's results.



The two lines are different shapes because the strength of each acid is different.

Write about the difference between a strong and a weak acid and explain why the two lines are different.

The quality of written communication will be assessed in your answer to this question.

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(c) Look at the balanced symbol equation for the reaction of calcium carbonate with nitric acid.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$$

(i) David's experiment with nitric acid makes 60 cm^3 of carbon dioxide at room temperature and pressure.

How many moles of carbon dioxide are made at the end of the reaction?

One mole of carbon dioxide has a volume of 24 000 cm^3 at room temperature and pressure.

moles of carbon dioxide = ... **[1]**

(ii) Calculate the mass of calcium carbonate needed to make this amount of carbon dioxide.

The relative formula mass, M_r, of calcium carbonate, $CaCO_3$, is 100.

mass of calcium carbonate = …………….. g **[1]**

7 In a closed system a reversible reaction will form an equilibrium mixture.

(a) Which of the following statements are true for a reversible reaction at **equilibrium**?

Tick (✓) the **two** correct answers.

The rate of the forward reaction is faster than the rate of the backward reaction.	☐
The position of equilibrium will not change if more product is added.	☐
The concentration of the reactants does not change.	☐
The rate of the forward reaction is the same as the rate of the backward reaction.	☐
The concentration of the reactants is the same as the concentration of the products.	☐
The position of equilibrium moves to the left when product is removed from the equilibrium.	☐

[2]

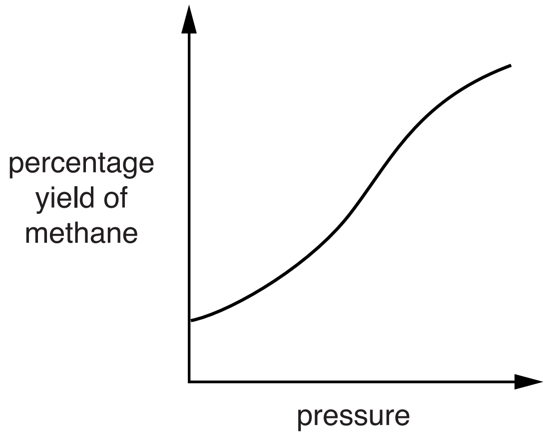
(b) Methane is a fuel that can be made by the reaction between carbon dioxide and hydrogen.

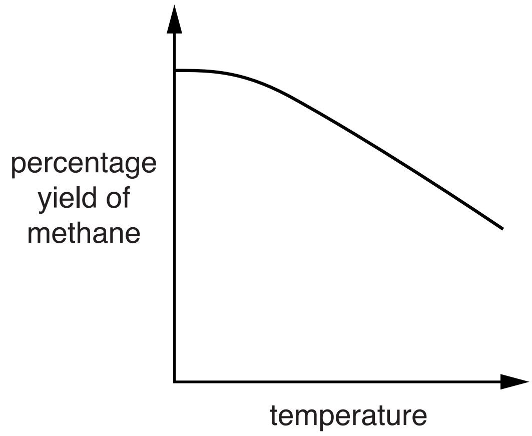
$$CO_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2O(g)$$

Paul predicts that

- the reaction is exothermic
- there are more moles of gas on the right-hand side of the equation.

Look at the two graphs.





Do the graphs support Paul's predictions?

Explain your answer.

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.... **[2]**

8 Sam researches different ways of making insoluble salts such as lead iodide.

In one reaction she adds potassium iodide solution to lead nitrate solution.

Potassium iodide solution contains $K^+(aq)$ and $I^-(aq)$.

Lead nitrate solution contains $Pb^{2+}(aq)$ and $NO_3^-(aq)$.

Look at the balanced ionic equation for the precipitation reaction.

$$Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$$

(a) Explain why this precipitation reaction is extremely fast.

....

.... **[1]**

(b) In this reaction the $K^+(aq)$ and the $NO_3^-(aq)$ are called **spectator ions**.

What is meant by a spectator ion?

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.... **[1]**

(c) Sam publishes her results in a scientific journal.

Explain how this can help her research.

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.... **[2]**

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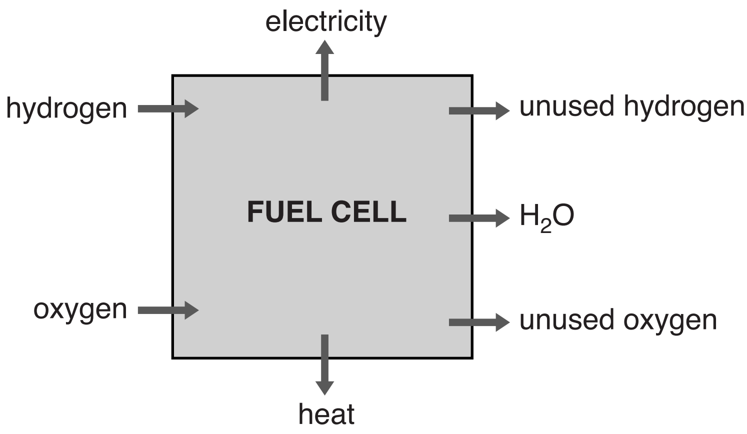
Question 9 starts on the next page

SECTION C – Module C6

9 Fuel cells are used to make electricity.

Look at the diagram. It shows what happens in a fuel cell.



(a) In this fuel cell, hydrogen, H_2, reacts with oxygen, O_2.

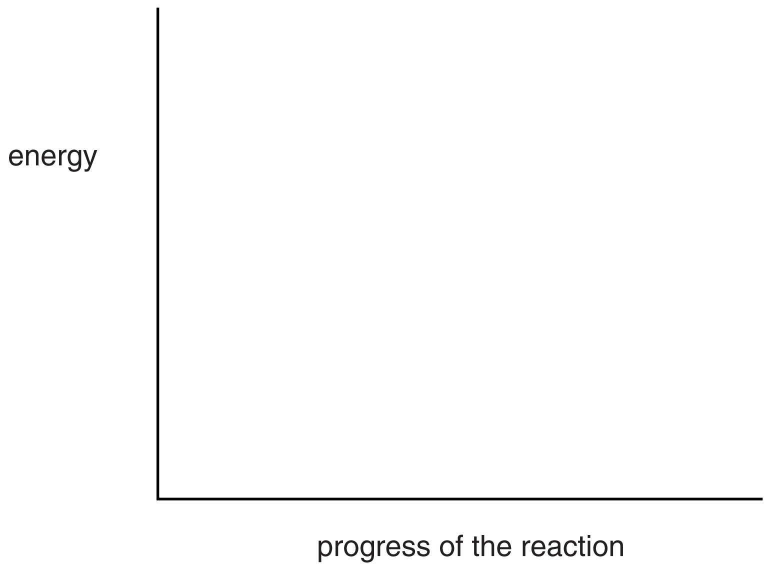
Water, H_2O, is made.

Write a **balanced symbol** equation for this reaction.

.... **[2]**

(b) The reaction between hydrogen and oxygen is **exothermic**.

Draw and label an energy level diagram for the reaction between hydrogen and oxygen



[2]

(c) Fuel cells are used to provide electrical energy in spacecraft.

Write down one **other advantage** of using fuel cells in spacecraft.

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.... **[1]**

(d) Hydrogen-oxygen fuel cells produce water.

Water is not a pollutant.

Fuel cells still cause pollution.

Write down two ways that fuel cells can cause pollution.

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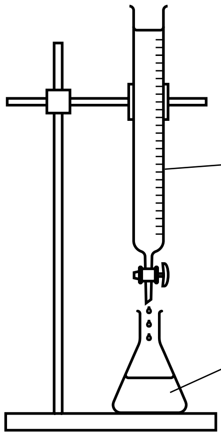
10 Kate is testing some samples of water with soap solution.

Look at the diagram. It shows the apparatus she uses.



Kate adds soap solution to each sample of water and shakes it.

She keeps adding soap solution until a lather remains.

Look at the table. It shows her results.

Sample		**Volume of soap solution added in cm^3**
distilled water		5.0
X	before boiling	15.0
	after boiling	5.0
Y	before boiling	20.0
	after boiling	20.0
Z	before boiling	14.0
	after boiling	10.0

(a) There are two types of water hardness.

These are permanent hardness and temporary hardness.

What types of hardness are present in each water sample?

X ....

Y ....

Z ....

Explain your answers.

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.... **[4]**

(b) Washing soda (sodium carbonate) can be used to soften hard water.

Explain how washing soda softens hard water.

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.... **[2]**

11 Nick is investigating ways of preventing iron from rusting.

He wants to protect the bottom of a ship.

The bottom of the ship is made from iron.

He treats samples of iron in different ways.

He leaves them in a damp place and sees how long it takes for the first signs of rust to appear.

Look at Nick's results.

Type of treatment	Time for rust to appear in days	Cost of treatment in £ per tonne of iron
untreated iron (no treatment)	1	
painted iron	10	100
iron mixed with chromium (alloying)	120	1000
iron with blocks of magnesium attached	50	500

Evaluate the **advantages** and **disadvantages** of each type of treatment for protecting the bottom of the ship from rusting.

Explain how attaching blocks of magnesium helps to prevent rusting.

The quality of written communication will be assessed in your answer to this question.

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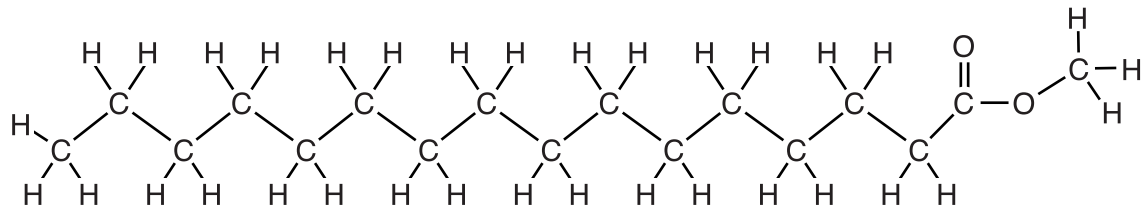
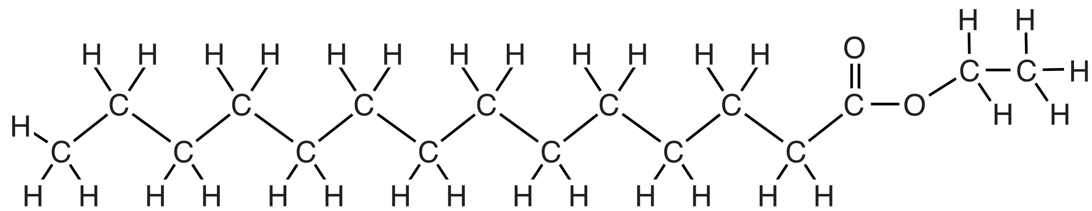
12 Look at the diagrams. They show the displayed formulas of some fats and oils.

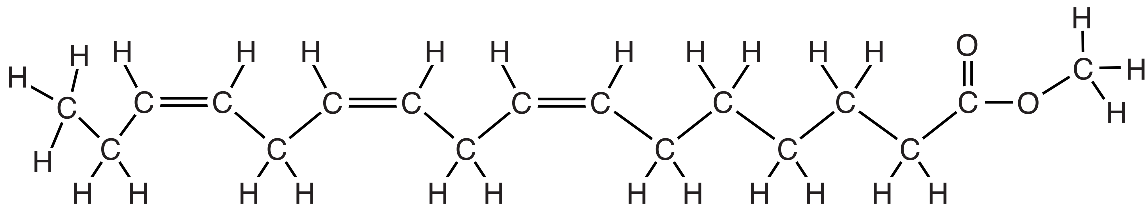
Formula **A**



Formula **B**



Formula **C**



(a) Which formula is **unsaturated**?

Explain your answer.

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.... **[2]**

(b) Fats and oils can be split up by **saponification**.

Explain what happens during saponification.

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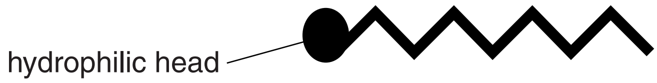
.... **[2]**

(c) Look at the diagram of a detergent molecule.



Explain, using its structure, how a detergent molecule removes fat and oil stains from clothes.

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.... **[2]**

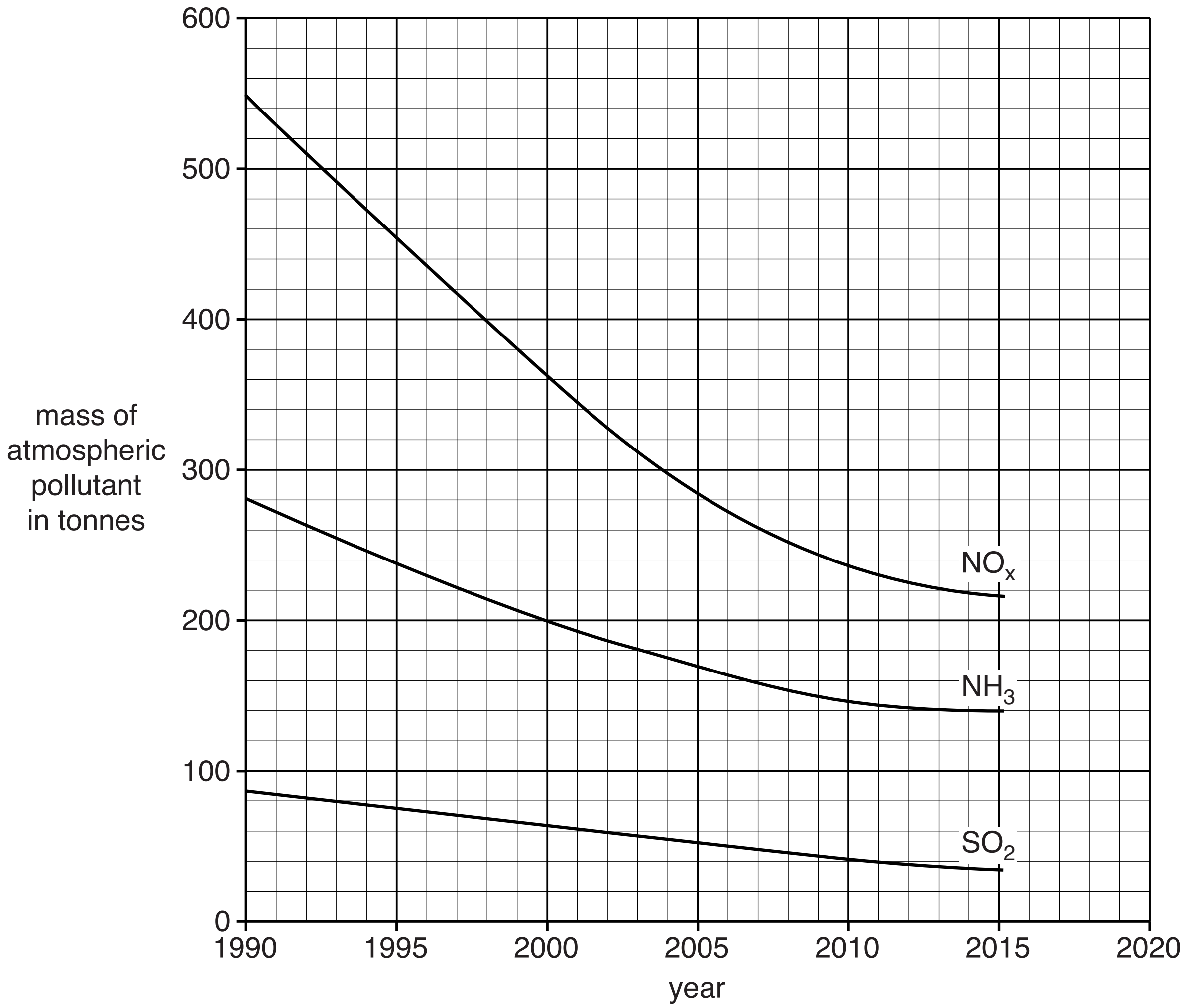
SECTION D

13 This question is about air pollution.

Three atmospheric pollutants are ammonia, NH_3, oxides of nitrogen, NO_x, and sulfur dioxide, SO_2.

(a) Look at the graph.

It shows how the masses of atmospheric pollutants have changed in a city since 1990.



Which atmospheric pollutant showed the **greatest** change in mass between 1990 and 2000?

Explain your answer.

....

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.... **[2]**

(b) The table shows information about atmospheric pollutants in some countries of the European Union.

Country	Population in millions	Mass of pollutant made in kilotonnes		
		NO_x	SO_2	NH_3
Estonia	1.3	38	83	10
Germany	80	1323	449	548
Poland	39	867	974	271
Slovakia	5.4	89	69	24
Sweden	9.6	161	34	52
United Kingdom	64	1106	406	284
Whole of European Union	508	9200	4600	3600

(i) What percentage of the total mass of NH_3 made by the European Union comes from Sweden?

percentage = ... % **[2]**

(ii) The population of Sweden is 1.9% of the population of the European Union.

Compare this percentage with your answer in part **(i)**.

What conclusion can you make from these results?

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.... **[1]**

(iii) Across the whole of the European Union an average of 9.1 kilotonnes of SO_2 is made for every million people.

In Poland how many kilotonnes of SO_2 are made for every million people?

Give your answer to **two significant figures**.

answer = ... kilotonnes **[2]**

(iv) What conclusion can you make from your answer?

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.... **[1]**

(v) Ann concludes that the amount of atmospheric pollutant made by a country is linked only to its population.

Nick thinks there are **other** factors involved as well.

Evaluate the evidence in the table in terms of both of these conclusions.

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.... **[2]**

END OF QUESTION PAPER

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The Periodic Table of the Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[98] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

**** The lanthanoids (atomic numbers 58-71) and the actinoids (atomic numbers 90-103) have been omitted.***

The relative atomic masses of copper and chlorine have not been rounded to the nearest whole number.