Please check the examination details below before entering your candidate information

Candidate surname: StemUp Model Solution | Other names:

Pearson Edexcel GCE

Centre Number | Candidate Number

Monday 20 May 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **8CH0/01**

Chemistry

Advanced Subsidiary

Paper 1: Core Inorganic and Physical Chemistry

Candidates must have: Scientific calculator
Data Booklet

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ▶

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 How many **ions** are present in 306 g of aluminium oxide, Al_2O_3?

[Avogadro constant = 6.02×10^{23} mol^{-1} Molar mass of Al_2O_3 = 102 g mol^{-1}]

☒ **A** 6.02×10^{23}

☒ **B** 1.81×10^{24}

☒ **C** 3.01×10^{24}

☒ **D** 9.03×10^{24}

(Total for Question 1 = 1 mark)

2 What is the electronic configuration of the sulfide ion, S^{2-}?

☒ **A** $1s^2 2s^2 2p^6 3s^2 3p^2$

☒ **B** $1s^2 2s^2 2p^6 3p^4$

☒ **C** $1s^2 2s^2 2p^6 3s^2 3p^4$

☒ **D** $1s^2 2s^2 2p^6 3s^2 3p^6$

(Total for Question 2 = 1 mark)

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3 This question is about isotopes.

(a) State, in terms of subatomic particles, what is meant by the term **isotopes**.

(2)

Isotopes are atoms of the same element with the same number of protons but different numbers of neutrons.

(b) The element gallium has a relative atomic mass of 69.735 and only contains two isotopes.
A sample of gallium contained the isotope ^{69}Ga, with a relative abundance of 63.25 %.

Calculate the mass number of the other isotope.
You **must** show all your working.

(2)

abundance of the other isotope = 100 − 63.25 = 36.75 %

((69 × 63.25) + (M × 36.75)) ÷ 100 = 69.735

4364.25 + 36.75M = 6973.5

36.75M = 2609.25

M = 2609.25 ÷ 36.75 = 71

Mass number of the other isotope = 71

(Total for Question 3 = 4 marks)

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4 This question is about trends within Group 2 of the Periodic Table.

(a) Which of the following describes the trends in thermal stability of the Group 2 carbonates and nitrates going down the group?

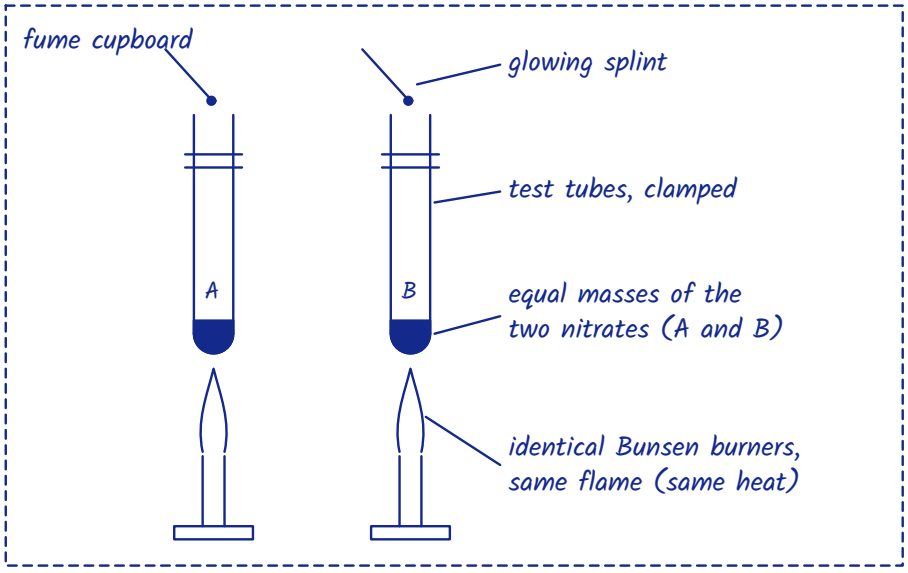
(1)

		Thermal stability	
		Carbonates	Nitrates
☒	**A**	increases	increases
☐	**B**	increases	decreases
☐	**C**	decreases	increases
☐	**D**	decreases	decreases

(b) Describe, with the aid of a labelled diagram, how you would compare the thermal stability of two different Group 2 nitrates using simple laboratory equipment.

Your answer **must** include **one** safety precaution (excluding the use of gloves, laboratory coat and eye protection).

(4)



Put equal masses of each nitrate into two separate test tubes.

Heat each test tube with the same Bunsen flame (same heat), and time how long it takes for brown fumes of NO_2 to appear, or for oxygen to relight a glowing splint.

The nitrate that takes longer is more thermally stable.

Safety: do this in a fume cupboard, because NO_2 is toxic.

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(c) Which of the following describes the trends in the solubility in water of the Group 2 hydroxides and sulfates going down the group?

(1)

	Solubility in water	
	Hydroxides	Sulfates
☒ **A**	increases	increases
☒ **B**	increases	decreases
☒ **C**	decreases	increases
☒ **D**	decreases	decreases

(Total for Question 4 = 6 marks)

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5 This question is about iron(II) salts.

(a) What is the percentage by mass of iron in anhydrous iron(II) sulfate, $FeSO_4$, to 3 significant figures?

(1)

☒ **A** 21.3%

☒ **B** 35.1%

☒ **C** 36.7%

☒ **D** 53.8%

(b) Describe a chemical test, and the expected result, to show that sulfate ions are present in a solution of iron(II) sulfate in water.

(2)

Add dilute hydrochloric acid, then add barium chloride solution.

A white precipitate (of barium sulfate) forms.

(c) Mohr's salt is another compound containing iron(II) ions.

It has the formula $(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$.

What is the molar mass, in g mol^{-1}, of Mohr's salt?

(1)

☒ **A** 392.0

☒ **B** 312.0

☒ **C** 302.0

☒ **D** 284.0

(Total for Question 5 = 4 marks)

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6 A solid, white, water-soluble compound was thought to be magnesium bromide.
A student carried out tests to confirm the identity of both ions present.

(a) A flame test was carried out to test for the cation.

(i) Describe how a flame test is carried out.

(3)

Dip a nichrome (or platinum) wire loop into concentrated hydrochloric acid to clean it.

Dip the wet wire into the solid sample.

Place the wire in a hot, non-luminous (blue) Bunsen flame and observe the colour of the flame.

(ii) Explain the origin of flame test colours.

(4)

Heat energy from the flame is absorbed by the electrons in the ions.

The electrons are promoted (excited) to higher energy levels.

The excited electrons then drop back down to lower energy levels (towards the ground state).

As they drop down, energy is given out as light. The light emitted is in the visible region, so a characteristic flame colour is seen.

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(iii) Give a reason why the magnesium ion does not produce a flame colour.

(1)

The energy released when the electrons drop back down is not in the visible region (it is in the ultraviolet), so no visible light is emitted.

(iv) Give a reason why the lack of a flame colour is not a positive test for the magnesium ion.

(1)

Other ions, such as Be^{2+}, also do not produce a flame colour.

(b) (i) Give the **formula** of a reagent that would produce a cream-coloured precipitate when added to an aqueous solution of magnesium bromide.

(1)

$AgNO_3$

(ii) The identity of the anion may be confirmed by testing the solubility of the cream-coloured precipitate in ammonia solution. Which pair of responses helps to confirm the identity of the anion?

(1)

	Solubility in dilute ammonia solution	Solubility in concentrated ammonia solution
☒ **A**	insoluble	insoluble
☒ **B**	insoluble	soluble
☒ **C**	soluble	insoluble
☒ **D**	soluble	soluble

(Total for Question 6 = 11 marks)

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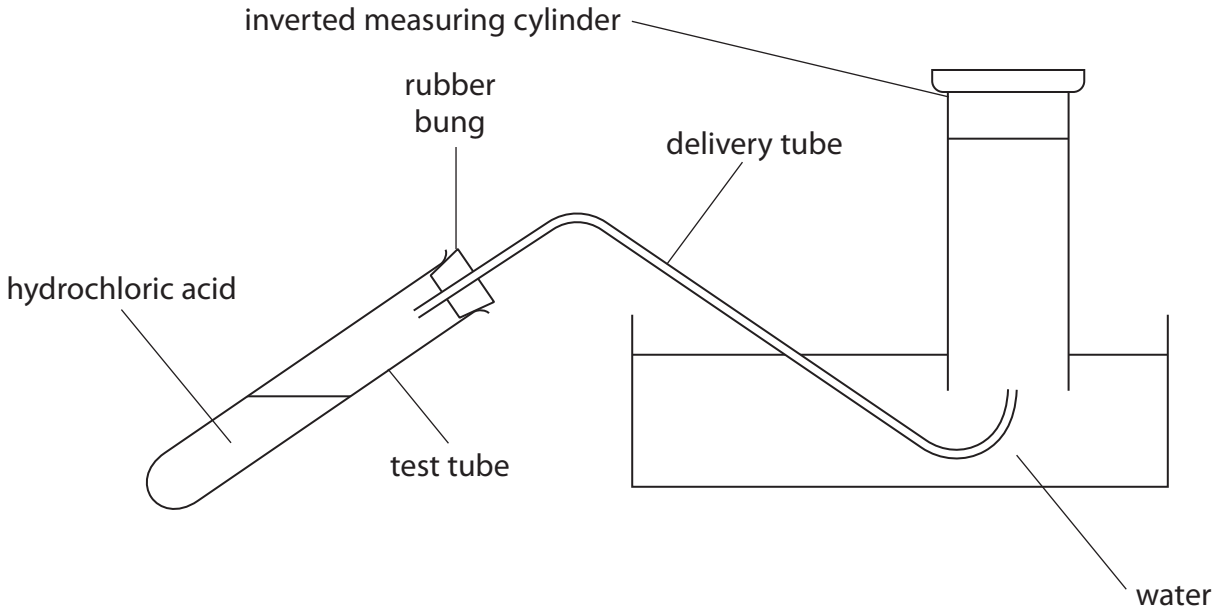
7 This question is about the reaction of magnesium with dilute hydrochloric acid.

(a) Write an equation for the reaction of magnesium with hydrochloric acid.
Include state symbols.

(2)

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

(b) The apparatus shown in the diagram can be used to collect the gas produced during the reaction of magnesium with dilute hydrochloric acid.



The following procedure was used.

Step **1** The apparatus was set up as shown in the diagram. The test tube contained 10.0 cm^3 of 0.20 mol dm^{-3} hydrochloric acid.

Step **2** A piece of magnesium ribbon was weighed. It had a mass of 0.12 g.

Step **3** The delivery tube and bung were removed from the test tube, the magnesium ribbon was added and the delivery tube and bung quickly replaced.

Step **4** When the reaction was complete, the final volume of gas was recorded.

(i) A measuring cylinder was used to measure the 10.0 cm^3 of dilute hydrochloric acid in Step **1**. The uncertainty for a volume measurement is ± 0.5 cm^3.
Calculate the percentage uncertainty in the volume of hydrochloric acid.

(1)

$(0.5 \div 10.0) \times 100 = 5.0\ \%$

percentage uncertainty = 5.0 %

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(ii) Determine which reactant is in excess by calculating the number of moles of magnesium and of hydrochloric acid used in the experiment.

(3)

moles of Mg = 0.12 ÷ 24.3 = 4.94 × 10^{-3} mol

moles of HCl = (10.0 × 0.20) ÷ 1000 = 2.0 × 10^{-3} mol

Mg + 2HCl: 2.0 × 10^{-3} mol HCl reacts with only

2.0 × 10^{-3} ÷ 2 = 1.0 × 10^{-3} mol Mg

1.0 × 10^{-3} mol < 4.94 × 10^{-3} mol, so

magnesium is in excess (HCl is used up)

(iii) Calculate the maximum number of moles of gas that could be produced, using your answers to (a) and (b)(ii).

(1)

moles of H_2 = 2.0 × 10^{-3} ÷ 2

= 1.0 × 10^{-3} mol

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(iv) Under the conditions of the experiment, the temperature was 23°C and the pressure 98 000 Pa.

Calculate the maximum volume of gas, **in cm^3**, that could be produced using your answer in (b)(iii).
Give your answer to an appropriate number of significant figures.

[The ideal gas equation is $pV = nRT$. Gas constant (R) = 8.31 J mol^{-1} K^{-1}]

(4)

$pV = nRT$, so $V = nRT \div p$

$T = 23 + 273 = 296$ K

$V = (1.0 \times 10^{-3} \times 8.31 \times 296) \div 98\,000$

$V = 2.51 \times 10^{-5}$ m^3

$V = 2.51 \times 10^{-5} \times 10^{6} = 25.1$ cm^3

Maximum volume of gas = 25 cm^3 (2 s.f.)

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(c) (i) Deduce **two** possible reasons why the volume of gas collected in the experiment was smaller than that calculated in (b)(iv).

(2)

Some hydrogen gas was lost (escaped) before the bung and delivery tube were replaced.

The magnesium ribbon was coated with magnesium oxide, which reacts with the acid to form water instead of hydrogen.

(ii) Describe **two** changes to the procedure that would enable the volume of gas collected to be closer to that calculated in (b)(iv).

(2)

Arrange the apparatus so that the magnesium ribbon drops into the acid after the bung and delivery tube are in place, e.g. hold the ribbon on a thread above the acid, then release it.

Clean the magnesium ribbon with emery paper (sandpaper) before weighing it, to remove the oxide coating.

(Total for Question 7 = 15 marks)

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8 The table shows some information about a selection of elements and compounds.

	Graphene	Graphite	Diamond	Magnesium oxide	Potassium bromide	Iron
Melting temperature / K	> 4000	3950	3820	3125	1007	1808
Density / g cm^{-3}	not measured	2.2 to 2.8	3.51	3.58	2.75	7.86
Compressive strength / GPa	not measured	2.3 and 15.3	443	152	15	170

(a) Explain the difference in the melting temperatures of magnesium oxide and potassium bromide.

(3)

Magnesium oxide contains Mg^{2+} and O^{2-} ions, which have a greater charge than the K^+ and Br^- ions in potassium bromide.

The Mg^{2+} ion is smaller than the K^+ ion, and the O^{2-} ion is smaller than the Br^- ion.

So the electrostatic attraction between the oppositely charged ions is stronger in MgO, and more energy is needed to overcome it.

(b) Explain why the electrical conductivity of solid potassium bromide is poor but an aqueous solution of potassium bromide is a good electrical conductor.

(2)

In solid potassium bromide the ions are held in fixed positions in the lattice and are not free to move, so it is a poor conductor.

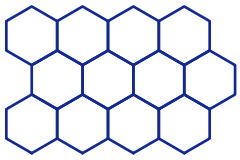
In aqueous solution the K^+ and Br^- ions are free to move and carry the charge, so the solution is a good conductor.

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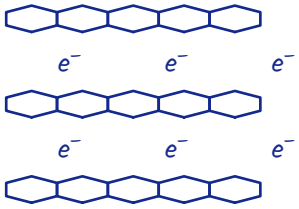
*(c) Graphene, graphite and diamond are all forms of solid carbon.
Explain, in terms of structure and bonding, why graphene and graphite are good electrical conductors but diamond is a poor electrical conductor.

You may include labelled diagrams in your answer.

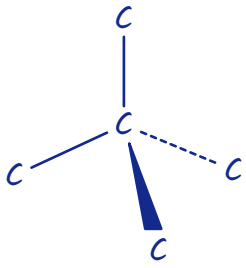
(6)



graphene: one layer, each C bonded to 3 C, delocalised electrons



graphite: layers, each C bonded to 3 C, delocalised electrons between the layers



diamond: each C bonded to 4 C (tetrahedral), no delocalised electrons

Graphene is a single layer (sheet) of carbon atoms arranged in hexagons. Graphite is made of many of these layers stacked on top of each other.

In both graphene and graphite, each carbon atom is covalently bonded to only three other carbon atoms.

This means each carbon atom has one outer (fourth) electron that is not used in bonding, and these electrons are delocalised over the whole layer.

In graphene the delocalised electrons are mobile and can move across the sheet, so graphene conducts electricity when a potential difference is applied.

In graphite the delocalised electrons are mobile and can move along the layers (between the layers), so graphite is also a good electrical conductor.

In diamond, each carbon atom is covalently bonded to four other carbon atoms in a tetrahedral arrangement, forming a giant covalent lattice.

So in diamond all four outer (valence) electrons of every carbon atom are used in bonding. There are no delocalised electrons, as all the electrons are localised in the C–C bonds.

Therefore diamond has no mobile electrons (no charged particles free to move) to carry

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the current, so it is a poor electrical conductor.

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(d) Deduce **two** possible reasons why the density of iron (7.86 g cm^{-3}) is much greater than the density of graphite (2.2 to 2.8 g cm^{-3}).

(2)

Iron atoms have a much greater mass (higher A_r, 55.8) than carbon atoms (12.0).

Iron atoms are closely packed in the metallic lattice, whereas in graphite there is much more space between the layers of carbon atoms.

(e) The compressive strength is a measure of the energy required to break some of the bonds within a substance.

Deduce possible reasons why there are two widely different values for the compressive strength of graphite.
Both the values (2.3 and 15.3 GPa) are valid experimental results.

(2)

The lower value (2.3 GPa) is for overcoming the weak London forces between the layers.

The higher value (15.3 GPa) is for breaking the strong covalent C–C bonds within each layer.

(Total for Question 8 = 15 marks)

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9 This question is about chlorine and its compounds.

(a) Potassium chlorate(V) can be produced by passing chlorine gas into hot, concentrated potassium hydroxide solution.

$$3Cl_2 + 6KOH \rightarrow 5KCl + KClO_3 + 3H_2O$$

(i) This reaction is an example of

(1)

☐ **A** oxidation only

☐ **B** reduction only

☒ **C** disproportionation

☐ **D** decomposition

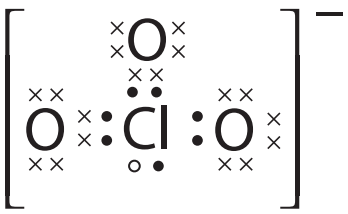
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(ii) A dot-and-cross diagram for the chlorate(V) ion (ClO_3^-) is shown.

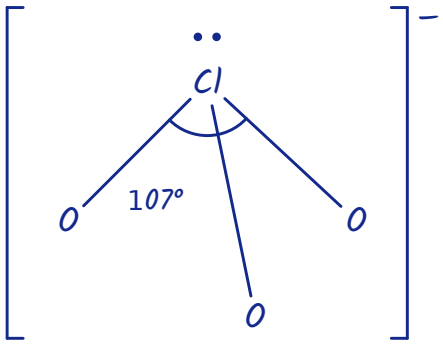


Key
- • = chlorine electrons
- ○ = an added electron
- × = oxygen electrons

Predict the shape and bond angle (O—Cl—O) of the chlorate(V) ion.

Justify your answer.

(4)



(trigonal) pyramidal
3 bond pairs + 1 lone pair

Shape: (trigonal) pyramidal. Bond angle (O–Cl–O): 107°.

Around the chlorine atom there are three groups (pairs) of bonding electrons, one for each Cl–O bond, and one lone pair of electrons.

The electron pairs repel each other to positions of minimum repulsion (maximum separation), so the four groups are arranged tetrahedrally.

Lone pair to bond pair repulsion is greater than bond pair to bond pair repulsion, so the O–Cl–O bond angle is reduced from 109.5° to 107°, and the shape is pyramidal.

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(b) (i) The following reaction occurs when potassium chlorate(V) is heated at a suitable temperature.
Complete the equation by balancing it.
State symbols are not required.

4 $KClO_3$ → 1 KCl + 3 $KClO_4$

(1)

(ii) The table shows some properties of potassium chloride and potassium chlorate(VII).

	Potassium chloride KCl	Potassium chlorate(VII) $KClO_4$
Solubility in water (mol/100 g)	4.81×10^{-1}	1.29×10^{-2}
Solubility in ethanol (mol/100 g)	2.9×10^{-4}	8.7×10^{-6}

Devise a brief method to show how the compounds produced in the decomposition of potassium chlorate(V) could most effectively be separated.
Use information from the table.

(3)

Add the mixture of solids to water only, as water is the best solvent: KCl is about 37 times more soluble in water than $KClO_4$.

Use just enough cold water to dissolve all the potassium chloride, so that most of the potassium chlorate(VII) stays undissolved.

Filter the mixture: the undissolved potassium chlorate(VII), $KClO_4$, is left as the residue.

Wash it with a little cold water and dry it.

Evaporate the water from the filtrate to obtain the potassium chloride, KCl.

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(c) Chlorine gas, Cl_2, can be dissolved in swimming pool water to disinfect it.

An Olympic-sized swimming pool contains about 2500 m^3 of water.
The chlorine content is 2 ppm (parts per million) by mass.
Calculate the number of moles of chlorine, Cl_2, in the swimming pool.

[One ppm is equivalent to 1 g of chlorine dissolved in 1×10^6 g of water.
Density of water = 1 g cm^{-3}]

(3)

mass of water = 2500×10^6 cm^3 × 1 g cm^{-3} = 2.5×10^9 g

mass of Cl_2 = $(2 \times 2.5 \times 10^9) \div (1 \times 10^6) = 5.0 \times 10^3$ g

moles of Cl_2 = $5.0 \times 10^3 \div 71.0$ = 70.4 mol

Number of moles of Cl_2 = 70.4 mol

(d) When chlorine gas is dissolved in water, it reacts according to the equation

$$Cl_2 + H_2O \rightarrow HCl + HClO$$

The chloric(I) acid (HClO) produced is much more effective as a disinfectant than dissolved chlorine.
Chloric(I) acid is a weak acid and has little effect on the pH of the water.

Swimming pools usually have a chlorine content of 1 – 3 ppm.
Use the equation to explain one **disadvantage** of a chlorine content that is much lower than 1 ppm and one **disadvantage** of a chlorine content that is much higher than 3 ppm.

(4)

Much lower than 1 ppm: less Cl_2 reacts with water, so the concentration of HClO is too low. The water would be disinfected ineffectively and bacteria would survive.

Much higher than 3 ppm: more HCl is also formed, so the concentration of HCl is high. HCl is a strong acid, so the pH of the water is lowered (it becomes more acidic), which irritates swimmers' eyes and skin and is corrosive to the pool.

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(e) In many swimming pools, sodium chlorate(I) has replaced chlorine gas as a disinfectant.

Sodium chlorate(I) is an ionic compound. It is very soluble in water.

$$NaClO(aq) \rightarrow Na^+(aq) + ClO^-(aq)$$

(i) Describe, using diagrams to illustrate your answer, the interactions between each of the ions and the solvent when sodium chlorate(I) dissolves in water.

(2)



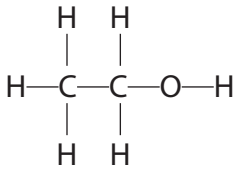
The Na^+ ion is attracted to the δ− oxygen atoms (lone pairs) of the surrounding water molecules.

The ClO^- ion is attracted to the δ+ hydrogen atoms of the surrounding water molecules.

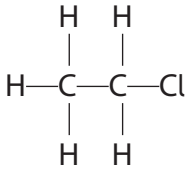
Each ion becomes surrounded by water molecules (hydrated) by these ion to dipole attractions.

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(ii) The displayed formulae of ethanol and chloroethane are shown.



ethanol



chloroethane

Ethanol is very soluble in water whereas chloroethane is almost insoluble in water.

Explain this observation by comparing the types of intermolecular forces formed by each of these molecules with water.

(2)

Ethanol has an O–H group, so it forms hydrogen bonds with water molecules, which is why ethanol is very soluble.

Chloroethane forms only (permanent) dipole-dipole attractions and London forces with water. These are weaker than the hydrogen bonds between water molecules, so chloroethane is almost insoluble.

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(f) Calcium chlorate(I), $Ca(ClO)_2$, can be used to disinfect drinking water.

The concentration of chlorate(I) ions required to disinfect water is about 5.6×10^{-6} mol dm^{-3}.

Calculate the mass of calcium chlorate(I), in g, that should be added to 1000 dm^3 of water to produce a chlorate(I) ion concentration of 5.6×10^{-6} mol dm^{-3}.

(3)

moles of ClO^- = $5.6 \times 10^{-6} \times 1000 = 5.6 \times 10^{-3}$ mol

moles of $Ca(ClO)_2$ = $5.6 \times 10^{-3} \div 2 = 2.8 \times 10^{-3}$ mol

M_r of $Ca(ClO)_2$ = $40.1 + 2(35.5 + 16.0) = 143.1$

mass = $2.8 \times 10^{-3} \times 143.1 = 0.40$ g

Mass of calcium chlorate(I) = 0.40 g

(Total for Question 9 = 23 marks)

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 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

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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