Location Entry Codes

As part of CIE's continual commitment to maintaining best practice in assessment, CIE uses different variants of some question papers for our most popular assessments with large and widespread candidature. The question papers are closely related and the relationships between them have been thoroughly established using our assessment expertise. All versions of the paper give assessment of equal standard.

The content assessed by the examination papers and the type of questions is unchanged.

This change means that for this component there are now two variant Question Papers, Mark Schemes and Principal Examiner's Reports where previously there was only one. For any individual country, it is intended that only one variant is used. This document contains both variants which will give all Centres access to even more past examination material than is usually the case.

The diagram shows the relationship between the Question Papers, Mark Schemes and Principal Examiners' Reports that are available.

Question Paper	Mark Scheme	Principal Examiner's Report
Introduction	Introduction	Introduction
First variant Question Paper	First variant Mark Scheme	First variant Principal Examiner's Report
Second variant Question Paper	Second variant Mark Scheme	Second variant Principal Examiner's Report

Who can I contact for further information on these changes?
Please direct any questions about this to CIE's Customer Services team at:
international@cie.org.uk

The titles for the variant items should correspond with the table above, so that at the top of the first page of the relevant part of the document and on the header, it has the words:

- First variant Question Paper / Mark Scheme / Principal Examiner's Report

or

- Second variant Question Paper / Mark Scheme / Principal Examiner's Report

as appropriate.

First Variant Question Paper

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

2942397288

CHEMISTRY **0620/31**

Paper 3 (Extended) **October/November 2008**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES

Answer **all** questions.
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part questions.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
Total	

This document consists of **12** printed pages.

1 Complete the following table.

For Examiner's Use

gas	test for gas
ammonia	
	bleaches damp litmus paper
hydrogen	
	relights a glowing splint
	turns limewater milky

[Total: 5]

For Examiner's Use

2 There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium nitride is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a sodium atom.
Use o to represent an electron from a nitrogen atom.

[3]

(b) (i) Describe metallic bonding.

.....

..... [3]

(ii) Use the above ideas to explain why

metals are good conductors of electricity,

..... [1]

metals are malleable.

..... [2]

(c) Silicon(IV) oxide has a macromolecular structure.

(i) **Describe** the structure of silicon(IV) oxide (a diagram is not acceptable).

.....

.....

..... [3]

(ii) Diamond has a similar structure and consequently similar properties.
Give **two** physical properties common to both diamond and silicon(IV) oxide.

.....

..... [2]

[Total: 14]

For Examiner's Use

3 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is $Fe_2O_3.2H_2O$.
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

..... [2]

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

.....

..... [2]

(b) **(i)** Name a reagent that can reduce iron(III) oxide to iron.

..... [1]

(ii) Write a symbol equation for the reduction of iron(III) oxide, Fe_2O_3, to iron.

..... [2]

(c) **(i)** Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

..... [1]

(ii) Use your answer to **(i)** to calculate the percentage of iron in rust.

.....

..... [2]

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

.....

..... [1]

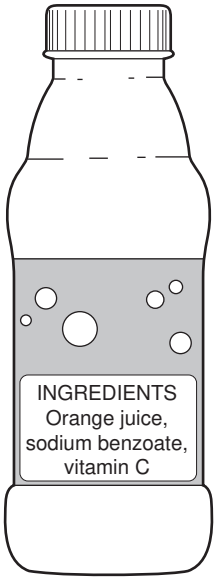
(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

.....

..... [2]

[Total: 13]

4 Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.



(a) Sodium benzoate is a salt, it has the formula C_6H_5COONa. It can be made by the neutralisation of benzoic acid by sodium hydroxide.

(i) Deduce the formula of benzoic acid.

..... [1]

(ii) Write a word equation for the reaction between benzoic acid and sodium hydroxide.

..... [1]

(iii) Name **two** other compounds that would react with benzoic acid to form sodium benzoate.

..... [2]

(b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

.....

..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

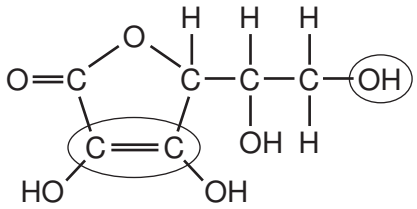
The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

[Turn over

For Examiner's Use

(c) The structural formula of Vitamin C is drawn below.



(i) What is its molecular formula?

..... [1]

(ii) Name the two functional groups which are circled.

..... [2]

[Total: 12]

For Examiner's Use

5 The electrolysis of concentrated aqueous sodium chloride produces three commercially important chemicals hydrogen, chlorine and sodium hydroxide.

(a) The ions present are $Na^+(aq)$, $H^+(aq)$,$Cl^-(aq)$ and $OH^-(aq)$.

(i) Complete the ionic equation for the reaction at the negative electrode (cathode).

..... + ... → H_2 [1]

(ii) Complete the ionic equation for the reaction at the positive electrode (anode).

..... – ..... → Cl_2 [1]

(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

..... [1]

(b) (i) Why does the water supply industry use chlorine?

..... [1]

(ii) Name an important chemical that is made from hydrogen.

..... [1]

(iii) How is sodium hydroxide used to make soap?

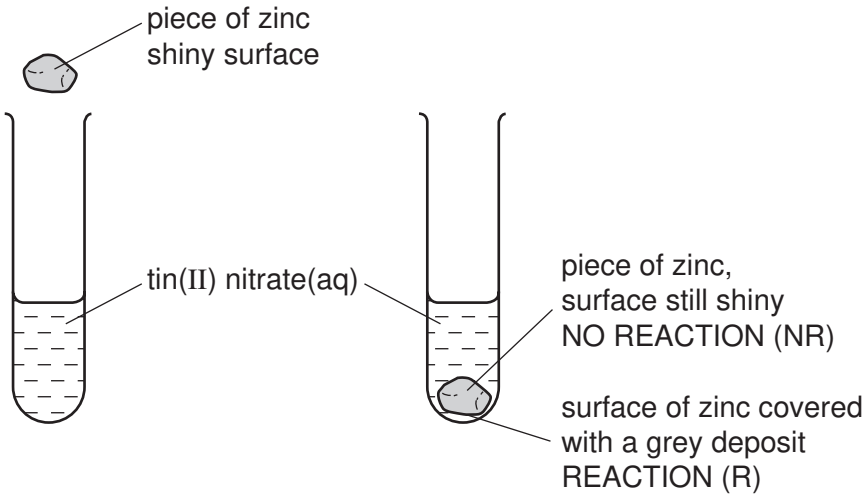
..... [2]

[Total: 7]

For Examiner's Use

6 The reactivity series lists metals in order of reactivity.

(a) To find out which is the more reactive metal, zinc or tin, the following experiment could be carried out.



This experiment could be carried out with other metals and the results recorded in a table. Then the order of reactivity can be deduced.

(i) The order was found to be:

manganese	most reactive
zinc	
tin	
silver	least reactive

Complete the table of results from which this order was determined.

aqueous solution	**tin Sn**	**manganese Mn**	**silver Ag**	**zinc Zn**
tin(II) nitrate		R	NR	R
manganese(II) nitrate				
silver(I) nitrate				
zinc nitrate				

[3]

(ii) Write the ionic equation for the reaction between tin atoms and silver(I) ions.

.....

[2]

(iii) The following is a redox reaction.

$$Mn + Sn^{2+} \longrightarrow Mn^{2+} + Sn$$

Indicate on the equation the change which is oxidation.
Give a reason for your choice.

.....

.....

[2]

(iv) Explain why experiments of this type cannot be used to find the position of aluminium in the reactivity series.

.....

.....

.....

[2]

(b) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges, K^+ and Ca^{2+}, their compounds behave differently when heated.

(i) Explain why the ions have different charges.

.....

.....

.....

[2]

(ii) Their hydroxides are heated.
If the compound decomposes, complete the word equation.
If it does not decompose, write "no reaction".

Potassium hydroxide ⟶ .....

Calcium hydroxide ⟶ ..... [2]

(iii) Complete the equations for the decomposition of their nitrates.

$2KNO_3 \longrightarrow$ ..... + ...

$2Ca(NO_3)_2 \longrightarrow$ ..... + ... + ... [4]

[Total: 17]

For Examiner's Use

7 The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) 10 cm^3 of butane is mixed with 100 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

(ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....

..... [2]

(b) The equation for a substitution reaction of butane is given below.

$$CH_3{-}CH_2{-}CH_2{-}CH_3 + Cl_2 \longrightarrow CH_3{-}CH_2{-}CH_2{-}CH_2{-}Cl + HCl$$

(i) Name the organic product.

..... [1]

(ii) This reaction does not need increased temperature or pressure.
What is the essential reaction condition?

..... [1]

(iii) Write a different equation for a substitution reaction between butane and chlorine.

..... [1]

For Examiner's Use

(c) Alkenes are more reactive and industrially more useful than alkanes. They are made by cracking alkanes.

$$\underset{\text{heptane}}{C_7H_{16}} \longrightarrow \underset{\text{propene}}{CH_3{-}CH{=}CH_2} + \underset{\text{but-1-ene}}{CH_3{-}CH_2{-}CH{=}CH_2} + H_2$$

(i) Draw the structural formula of the polymer poly(propene).

[2]

(ii) Give the structural formula and name of the alcohol formed when but-1-ene reacts with steam.

name ..... [1]

structural formula

[1]

(iii) Deduce the structural formula of the product formed when propene reacts with hydrogen chloride.

[1]

[Total: 12]

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	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 Sulphur 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	64 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	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	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

*58-71 Lanthanoid series
†90-103 Actinoid series

Key: a = relative atomic mass; **X** = atomic symbol; b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Second Variant Question Paper

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
International General Certificate of Secondary Education

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

7507316830

CHEMISTRY **0620/32**

Paper 3 (Extended) **October/November 2008**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES

Answer **all** questions.
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part questions.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
Total	

This document consists of **12** printed pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

For Examiner's Use

1 Complete the following table.

gas	test for gas
	turns damp red litmus paper blue
	bleaches damp litmus paper
hydrogen	
oxygen	
carbon dioxide	

[Total: 5]

For Examiner's Use

2 There are three types of giant structure – ionic, metallic and macromolecular.

(a) Sodium sulphide is an ionic compound. Draw a diagram that shows the formula of the compound, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x to represent an electron from a sodium atom.
Use o to represent an electron from a sulphur atom.

[3]

(b) (i) Describe metallic bonding.

.....

..... [3]

(ii) Use the above ideas to explain why

metals are good conductors of electricity,

..... [1]

metals are malleable.

..... [2]

(c) Silicon(IV) oxide has a macromolecular structure.

(i) **Describe** the structure of silicon(IV) oxide (a diagram is not acceptable).

.....

.....

..... [3]

(ii) Diamond has a similar structure and consequently similar properties.
Give **two** physical properties common to both diamond and silicon(IV) oxide.

.....

..... [2]

[Total: 14]

For Examiner's Use

3 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is $Fe_2O_3.2H_2O$.
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

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

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

.....

..... [2]

(b) (i) Name a reagent that can reduce iron(III) oxide to iron.

..... [1]

(ii) Write a symbol equation for the reduction of iron(III) oxide, Fe_2O_3, to iron.

..... [2]

(c) (i) Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

..... [1]

(ii) Use your answer to **(i)** to calculate the percentage of water in rust.

.....

..... [2]

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

.....

..... [1]

(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

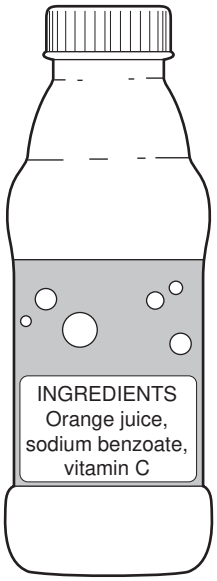
.....

..... [2]

[Total: 13]

For Examiner's Use

4 Across the world, food safety agencies are investigating the presence of minute traces of the toxic hydrocarbon, benzene, in soft drinks. It is formed by the reduction of sodium benzoate by vitamin C.



(a) Sodium benzoate is a salt, it has the formula C_6H_5COONa. It can be made by the neutralisation of benzoic acid by sodium hydroxide.

(i) Deduce the formula of benzoic acid.

..... [1]

(ii) Write a word equation for the reaction between benzoic acid and sodium hydroxide.

..... [1]

(iii) Name **two** other compounds that would react with benzoic acid to form sodium benzoate.

..... [2]

For Examiner's Use

(b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

.....

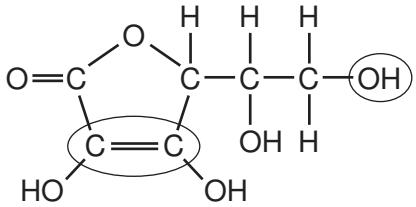
..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

(c) The structural formula of Vitamin C is drawn below.



(i) What is its molecular formula?

..... [1]

(ii) Name the two functional groups which are circled.

..... [2]

[Total: 12]

For Examiner's Use

5 The electrolysis of concentrated aqueous sodium chloride produces three commercially important chemicals; hydrogen, chlorine and sodium hydroxide.

(a) The ions present are $Na^+(aq)$, $H^+(aq)$,$Cl^-(aq)$ and $OH^-(aq)$.

(i) Complete the ionic equation for the reaction at the negative electrode (cathode).

..... + ... → H_2 [1]

(ii) Complete the ionic equation for the reaction at the positive electrode (anode).

$2Cl^-$ − ..... → ..... [1]

(iii) Explain why the solution changes from sodium chloride to sodium hydroxide.

..... [1]

(b) **(i)** Why does the water supply industry use chlorine?

..... [1]

(ii) Name an important chemical that is made from hydrogen.

..... [1]

(iii) Sodium hydroxide reacts with fats to make soap and glycerine
What type of compound are fats?

..... [1]

What type of the reaction is this?

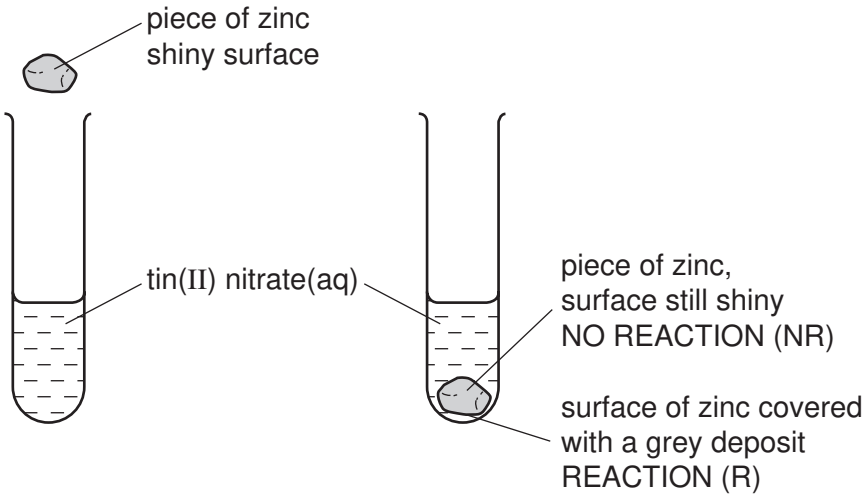
..... [1]

[Total : 7]

For Examiner's Use

6 The reactivity series lists metals in order of reactivity.

(a) To find out which is the more reactive metal, zinc or tin, the following experiment could be carried out.



This experiment could be carried out with other metals and the results recorded in a table. Then the order of reactivity can be deduced.

(i) The order was found to be:

manganese	most reactive
zinc	
tin	
silver	least reactive

Complete the table of results from which this order was determined.

aqueous solution	**tin Sn**	**manganese Mn**	**silver Ag**	**zinc Zn**
tin(II) nitrate		R	NR	R
manganese(II) nitrate				
silver(I) nitrate				
zinc nitrate				

[3]

(ii) Write the equation for the reaction between zinc and silver(I) nitrate.

..... [2]

For Examiner's Use

(iii) The following is a redox reaction.

$$Mn + Sn^{2+} \longrightarrow Mn^{2+} + Sn$$

Indicate on the equation which reagent is the oxidant or oxidizing agent.
Give a reason for your choice.

..... [2]

(iv) Explain why experiments of this type cannot be used to find the position of aluminium in the reactivity series.

.....

..... [2]

(b) Potassium and calcium are very reactive metals at the top of the series. Because their ions have different charges, K^+ and Ca^{2+}, their compounds behave differently when heated.

(i) Explain why the ions have different charges.

.....

..... [2]

(ii) Their hydroxides are heated.
If the compound decomposes, complete the word equation.
If it does not decompose, write "no reaction".

Potassium hydroxide ⟶ .....

Calcium hydroxide ⟶ ..... [2]

(iii) Complete the equations for the decomposition of their nitrates.

$2KNO_3 \longrightarrow$ ..... + ...

$2Ca(NO_3)_2 \longrightarrow$ ..... + ... + ... [4]

[Total: 17]

For Examiner's Use

7 The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) 20 cm^3 of butane is mixed with 150 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

(ii) Why is the incomplete combustion of any alkane dangerous, particularly in an enclosed space?

.....

..... [2]

(b) The equation for a substitution reaction of butane is given below.

$$CH_3{-}CH_2{-}CH_2{-}CH_3 + Cl_2 \longrightarrow CH_3{-}CH_2{-}CH_2{-}CH_2{-}Cl + HCl$$

(i) Name the organic product.

..... [1]

(ii) This reaction does not need increased temperature or pressure.
What is the essential reaction condition?

..... [1]

(iii) Write a different equation for a substitution reaction between butane and chlorine.

..... [1]

For Examiner's Use

(c) Alkenes are more reactive and industrially more useful than alkanes. They are made by cracking alkanes.

$$\underset{\text{heptane}}{C_7H_{16}} \longrightarrow \underset{\text{propene}}{CH_3{-}CH{=}CH_2} + \underset{\text{but-1-ene}}{CH_3{-}CH_2{-}CH{=}CH_2} + H_2$$

(i) Draw the structural formula of the polymer poly(propene).

[2]

(ii) Give the structural formula and name of the alcohol formed when propene reacts with steam.

name ..... [1]

structural formula

[1]

(iii) Deduce the structural formula of the product formed when but−1−ene reacts with hydrogen chloride.

[1]

[Total: 12]

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	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 Sulphur 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	64 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	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	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

*58-71 Lanthanoid series
†90-103 Actinoid series

Key: a = relative atomic mass; **X** = atomic symbol; b = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).