OCR ADVANCED SUBSIDIARY GCE
IN CHEMISTRY (3882)

OCR ADVANCED GCE
IN CHEMISTRY (7882)

Specimen Question Papers and Mark Schemes

These specimen assessment materials are designed to accompany the OCR Advanced Subsidiary GCE and Advanced GCE specifications in Chemistry for teaching from September 2000.

Centres are permitted to copy material from this booklet for their own internal use.

The GCE awarding bodies have prepared new specifications to incorporate the range of features required by new GCE and subject criteria. The specimen assessment material accompanying the new specifications is provided to give centres a reasonable idea of the general shape and character of the planned question papers in advance of the first operational examination

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Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY
FOUNDATION CHEMISTRY **2811**

Specimen Paper

Additional materials:
Answer paper

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

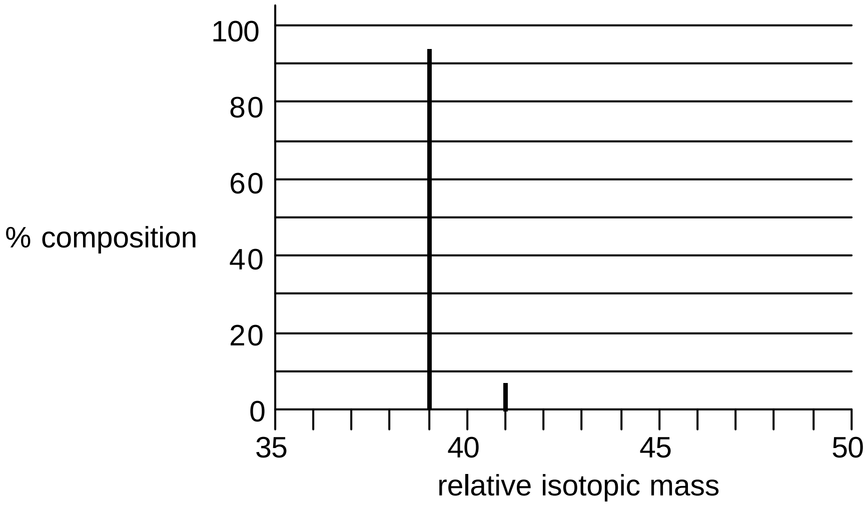
Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.
The total mark for this paper is 90.

Answer **all** questions.

1. Potassium was discovered and named in 1807 by the British chemist Sir Humphrey Davy. The mass spectrum of a sample of potassium is shown below:



(a) Use this mass spectrum to complete the table below to show the percentage composition and atomic structure of each potassium isotope in the sample.

isotope	percentage composition	protons	neutrons	electrons
^{39}K				
^{41}K				

[4]

(b) **(i)** The relative atomic mass of the potassium sample can be determined from its mass spectrum.
Explain what you understand by the term *relative atomic mass.*

....

....

....

(ii) Calculate the relative atomic mass of the potassium sample.

[3]

(c) Complete the electronic configuration of a potassium atom below.

$1s^2$ ....

[1]

(d) The first and second ionisation energies of potassium are shown in the table below:

ionisation	1st	2nd
ionisation energy/kJ mol^{-1}	419	3051

(i) Explain what you understand by the term *first ionisation energy* of potassium.

....

....

....

(ii) Why is there a **large** difference between the values for the first and the second ionisation energies of potassium?

....

....

....

....

[6]

[Total: 14]

2. Lead compounds are extensively used to provide the colour in paints and pigments.

(a) 'White lead', used for over 2000 years as a white pigment, is based upon lead carbonate. Analysis shows that lead carbonate has the following percentage composition by mass: Pb, 77.5%; C, 4.5%; O, 18.0%.

Calculate the empirical formula of lead carbonate. [A_r: C, 12.0; O, 16.0; Pb, 207.0]

[3]

(b) 'Red lead', is the pigment in paint used as a protective coating for structural iron and steel. It is based upon lead oxide Pb_3O_4, a scarlet powder formed by oxidising lead(II) oxide with oxygen.

(i) Balance the equation for the oxidation of PbO.

$$PbO\ (s) \quad + \quad O_2\ (g) \longrightarrow \quad Pb_3O_4\ (s)$$

(ii) What is the molar mass of Pb_3O_4? [A_r: O, 16.0; Pb, 207.0.]

(iii) Calculate the mass of Pb_3O_4 that could be formed from 0.300 mol of PbO.

[4]

[Total: 7]

3. **(a)** Showing outer electron shells only, draw 'dot-and-cross' diagrams to show the bonding in ammonia and water.

ammonia	water

[2]

(b) Draw diagrams to illustrate the shape of a molecule of each of these compounds. State the size of the bond angles on each diagram and name each shape.

NH_3	H_2O
shape:	shape:

[6]

(c) On mixing with water, ammonia forms an alkaline solution containing the ammonium ion, NH_4^+:

$$NH_3(g) + H_2O(l) \longrightarrow NH_4^+(aq) + OH^-(aq)$$

(i) The ammonium ion shows *dative covalent* (*co-ordinate*) bonding. Explain what is meant by this term.

....

....

....

(ii) Draw a 'dot-and-cross' diagram of the ammonium ion. Label on your diagram a dative covalent bond.

[5]

[Total: 13]

4. The atomic radii of some of the elements in groups 1-7 of the Periodic Table are shown in the table below. Some radii have been omitted.

		group						
		1	2	3	4	5	6	7
Period 2	element	Li	Be	B	C	N	O	F
	atomic radius/nm	0.134	0.125	0.090	0.077	0.075	0.073	0.071
Period 3	element	Na	Mg	Al	Si	P	S	Cl
	atomic radius/nm	0.154	0.145	0.130	0.118	0.110		0.099
Period 4	element	K	Ca	Ga	Ge	As	Se	Br
	atomic radius/nm	0.196	0.174		0.122	1.122	0.117	0.114

(a) **(i)** State the trend shown in atomic radius across a period.

....

(ii) Explain this trend.

....

....

....

....

[4]

(b) **(i)** State the trend shown in atomic radius down a group.

....

(iii) Explain this trend.

....

....

....

....

[4]

(c) Mendeleev studied periodic data to make predictions for the properties of elements which had yet to be discovered.

Using the data above, suggest values for the atomic radius of

(i) S…………. nm,

(ii) Ga……….. nm.

[2]

[Total: 10]

5. Wines often contain a small amount of sulphur dioxide that is added as a preservative. The amount of sulphur dioxide added needs to be carefully calculated; too little and the wine readily goes bad; too much and the wine tastes of sulphur dioxide.

The sulphur dioxide content of a wine can be found using its reaction with aqueous iodine.

$$SO_2(aq) + I_2(aq) + 2H_2O(l) \longrightarrow SO_4^{2-}(aq) + 2I^-(aq) + 4H^+(aq)$$

(a) **(i)** State the oxidation number of sulphur in SO_2 and in SO_4^{2-}.

.... SO_2

.... SO_4^{2-}

(ii) State, with a reason, whether sulphur is oxidised or reduced in the conversion of SO_2 into SO_4^{2-}.

....

....

[3]

(b) The sulphur dioxide content of a wine can be found by titration. An analyst found that the sulphur dioxide in 50.0 cm^3 of white wine reacted with exactly 16.4 cm^3 of 0.0100 mol dm^{-3} aqueous iodine.

(i) How many moles of iodine, I_2, did the analyst use in the titration?

(ii) How many moles of sulphur dioxide were in the 50.0 cm^3 of wine?

(iii) What was the concentration of sulphur dioxide in the wine

in mol dm^{-3};

in g dm^{-3}?

[5]

(c) The generally accepted maximum concentration of sulphur dioxide in wine is 0.25 g dm^{-3}. A concentration of less than 0.01 g dm^{-3} is insufficient to preserve the wine.

Comment on the effectiveness of the sulphur dioxide in the wine analysed in **(b)**.

....

....

.... **[1]**

[Total: 9]

6. A student carried out a series of two experiments with magnesium.

(a) In the first experiment, the student heated magnesium with oxygen forming magnesium oxide.

(i) State what the chemist would see in this reaction.

....

....

(ii) Write an equation, including state symbols, for the reaction.

....

(iii) The chemist added water to the magnesium oxide. Some of the magnesium oxide reacted forming a solution. Predict a value for the pH of this solution.

....

(iv) Magnesium oxide is a solid with a melting point of 2852 °C. Explain, in terms of structure and bonding, why its melting point is so high.

....

....

....

....

[8]

(b) In a second experiment, the student reacted 1.20 g of magnesium with 2.00 mol dm^{-3} hydrochloric acid. [A_r Mg, 24.0; C*l*, 35.5].

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

(i) How many moles of Mg were used in the experiment.

(ii) Calculate the minimum volume of 2.00 mol dm^{-3} hydrochloric acid needed to react completely with this amount of magnesium.

(iii) Calculate the volume of H_2 gas that would be produced at room temperature and pressure (r.t.p.). [1 mole of gas molecules occupies 24.0 dm^3 at r.t.p.]

(iv) State the reagent(s) that you could use to show the presence of chloride ions in the aqueous magnesium chloride. State what you would expect to observe.

reagent(s) ....

observation ....

....

....

[6]

(c) The student repeated both experiments with calcium.

(i) What difference would you expect in reactivity?.

....

(ii) Explain your answer to **(i)**

....

....

[3]

[Total: 17]

7. Using sodium chloride and copper as examples,

(a) explain, with suitable diagrams, what is meant by *ionic* and *metallic* bonding.

....

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....

[5]

(b) Compare and explain the electrical conductivities of sodium chloride and copper in terms of structure and bonding. (*In this question, 1 mark is available for the quality of written communication.)*

....

....

....

....

....

....

....

....

[4]

[Total: 9]

8. Explain the relative reactivity of chlorine, bromine and iodine and describe how you could show this trend by carrying out simple experiments in the laboratory. Include relevant equations in your answer. (*In this question, 1 mark is available for the quality of written communication.)*

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[Total: 11]

Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

Advanced Subsidiary GCE

CHEMISTRY

FOUNDATION CHEMISTRY **2811**

Mark Scheme

1. **(a)**

Isotope	percentage composition	protons	neutrons	electrons
^{39}K	92	19	20	19
^{41}K	8	19	22	19
mark	✓	✓	✓	✓

AO1: 3
AO2: 1
[4]

(b) **(i)** Mean/average ✓ mass of atoms compared to carbon-12 ✓ on scale where ^{12}C is 12/ one-twelfth of carbon-12 ✓

3 ⟶ 2 max AO1: 2

(ii) 92 x 39/100 + 8 x 41/100 = 39.16 ✓

AO2: 1
[3]

(c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ ✓

AO1: 1
[1]

(d) **(i)** Energy to remove an electron ✓ from each atom in 1 mole ✓ of gaseous atoms ✓

AO1: 3

(ii) 2nd electron is removed from a different shell ✓
closer to nucleus/more attraction ✓
less shielding ✓

AO2: 3
[6]

[Total: AO1: 9; AO2: 5 = 14]

2. **(a)** Pb 77.5/207.0 : C 4.5/12.0 : O 18.0/16.0 ✓

= 0.374 : 0.375 : 1.125 ✓

giving $PbCO_3$ ✓

AO2: 3
[3]

(b) **(i)** 6 PbO (s) + O_2 (g) ⟶ 2 Pb_3O_4 (s) ✓

AO1: 1

(ii) 207.0 x 3 + 16.0 x 4 = 665.0 g ✓

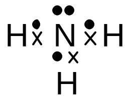
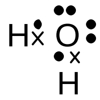
AO1: 1

(iii) moles Pb_3O_4 formed = 0.100 ✓

moles Pb_3O_4 formed = 66.5 g ✓

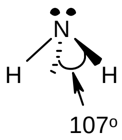
AO2: 2
[4]
[Total: AO1: 2; AO2: 5 = 7]

3. (a)

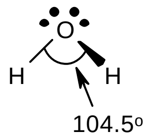
 ✓  ✓

AO1: 2
[2]

(b)



shape ✓; angle ✓; pyramidal ✓



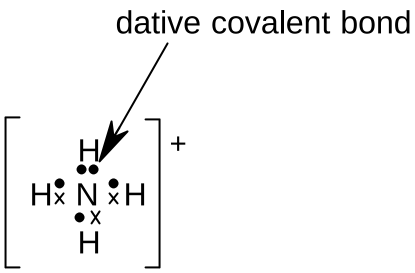
shape ✓; angle ✓; non-linear ✓

AO1: 6
[6]

(c) (i) a shared electrons ✓; shared pair ✓; both electrons from same atom ✓

AO1: 3

(ii)



dot-and-cross ✓; correct label ✓

AO2: 2

[5]

[Total: AO1: 11; AO2: 2 = 13]

4. **(a)** **(i)** decreases ✓

AO1: 1

(ii) protons added to nucleus/nuclear charge increases ✓

electrons added to same shell ✓

attraction is greater ✓

AO1: 3
[4]

(b) **(i)** increases ✓

AO1: 1

(ii) new shells added ✓

extra shielding ✓

attraction is less ✓

AO1: 3
[4]

(c) **(i)** S, 0.099 < radius < 0.110 nm ✓

AO2: 1

(ii) Ga, 0.130 < radius < 0.174 nm ✓

AO2: 1
[2]

[Total: AO1: 8; AO2: 2 =10]

5. **(a)** **(i)** SO_2: (+)4 ✓ '+' *not required*

SO_4^{2-}: (+)6 ✓ '+' *not required*

AO1: 2

(ii) oxidised because electrons are lost/oxidation number increases ✓
(this mark is consequential upon responses in (a)(i). need reason for mark)

AO2: 1
[3]

(b) **(i)** moles I_2 = 0.0100*16.4/1000 = 1.64×10^{-4} moles ✓

AO2: 1

(ii) moles SO_2 = 1.64×10^{-4} moles ✓ *consequentially, answer to (b)(i)*

AO2: 1

(iii) $20 \times 1.64 \times 10^{-4} = 3.28 \times 10^{-3}$ mol dm^{-3} ✓ *consequentially, answer to (b)(ii) x 20*

AO2: 1

(iv) M_r of SO_2 = 32.1+2x16 = 64.1 ✓

64.1 x 3.28 x 10^{-3} = 0.210 g dm^{-3} ✓ *consequentially, answer to (b)(iii) x M_r value*
(calculator value: 0.21048)

AO2: 2

i.e. 1 mark for 64.1: 1 mark for 0.210
use of '64' is OK and produces 0.210 also *(calculator value: 0.20992)*

[5]

(c) Comment will depend upon the answer from **(b)(iv)**

if ans **(b)(iv)** < 0.01 g dm^{-3} then wine goes off / below minimum

if 0.01 g dm^{-3} < ans **(b)(iv)** < 0.25 g dm^{-3} then wine is preserved

if ans **(b)(iv)** > 0.25 g dm^{-3} then wine tastes of SO_2 / above maximum ✓

AO2: 1

[1]

[Total: AO2: 2; AO2: 7 = 9]

6. (a) (i) white flame ✓

while solid/smoke ✓

AO1: 2

(ii) $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$ ✓✓
(1 mark for balanced equation, 1 mark for state symbols)

AO1: 2

(iii) 9-14 ✓

AO2: 1

(iv) strong bonds or forces to be broken / high temperature needed to break bonds ✓

between ions / ionic bonding ✓

giant structure ✓

AO2: 3

[8]

(b) (i) 1.20/24.0 = 0.0500 ✓

AO2: 1

(ii) 2 x 0.0500 mol required = 0.100 mol ✓

vol 2.00 mol dm^{-3} HCl = 50 cm^3 ✓

AO2: 2

(iii) 0.0500 x 24 = 0.12 dm^3 ✓

AO2: 1

(iv) add aqueous silver nitrate ✓
white precipitate ✓

AO1: 2
[6]

(c) **(i)** more reactive ✓

AO1: 1

(ii) electrons in Ca are lost more easily/ionisation energy is less ✓
greater atomic radius/outer electrons further away/greater shielding ✓

AO1: 2
[3]

[Total: AO1: 9; AO2: 8 = 17]

7. ***Quality of written communication assessed in this question***

(a) NaCl:
Na^+ and Cl^- ions shown ✓

'dot and cross' diagram showing clearly the origin of outer shell electrons ✓

attraction between oppositely charged ions ✓

Cu:
sea of electrons/ delocalised electrons ✓

attraction between electrons and positive ions ✓

Sub section: 5
AO1: 5

(b) NaCl:
solid lattice has fixed ions/ cannot conduct ✓

molten or aqueous solution can conduct from mobile ions ✓

Cu:
delocalised electrons conduct ✓

Sub section: 3
AO2: 3

Clear, well-organised, using specialist terms *1 mark*

[Total: AO1: 5; AO2: 3; qowc: 1 = 9]

8. ***Quality of written communication assessed in this question***

reactivity decreases down group ✓
as group descends, more shells are added/ increasing radius of atom ✓ and increased electron shielding ✓
down the group electron to be captured experiences less attraction ✓

AO1: 4

Add halogen to halides ✓ any reaction shows by change in colour ✓
chloride displaces bromide and iodide ✓
bromine displaces iodide ✓

4 ⟶ 3 max AO1: 3

Q – legible text with accurate spelling, punctuation and grammar *1 mark*

$Cl_2 + 2Br^- \longrightarrow Br_2 + 2Cl^-$ ✓
$Cl_2 + 2I^- \longrightarrow I_2 + 2Cl^-$ ✓
$Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$ ✓

AO2: 3

[11]
[Total: AO1: 7; AO2: 3; qowc: 1 = 11]

Assessment Grid: Unit 2811 Foundation Chemistry

Question	AO1	AO2	AO4	qowc	Total
1	9	5			14
2	2	5			7
3	11	2			13
4	8	2			10
5	2	7			9
6	9	8			17
7	5	3		1	9
8	7	3		1	11
Total	**53**	**35**		**2**	**90**

Assessment Grid: Unit 2811 Foundation Chemistry (Details)

Question				AO1	AO2	AO4	qowc	Total
1	(a)		5.1.1(c), 5.1.2(d)	3	1			
	(b)	(i)	5.1.1(a)	2				
		(ii)	5.1.1(e)		1			
	(c)		5.1.2(k)	1				
	(d)	(i)	5.1.2(f)	3				
		(ii)	5.1.2(f), (g), (h)		3			
Total				9	5			14
2	(a)		5.1.1(h)		3			
	(b)	(i)	5.1.1(i)	1				
		(ii)	5.1.1(j)	1				
		(iii)	5.1.1(j)		2			
Total				2	5			7
3	(a)		5.1.3(e)	2				
	(b)		5.1.3(f)	6				
	(c)	(i)	5.1.3(e)	3				
		(ii)	5.1.3(e)		2			
Total				11	2			13
4	(a)	(i)	5.1.4(b)	1				
		(ii)	5.1.4(c)	3				
	(b)	(i)	5.1.5(a)	1				
		(ii)	5.1.5(a)	3				
	(c)	(i)	5.1.4(b), 5.1.5(a)		1			
		(ii)	5.1.4(b), 5.1.5(a)		1			
Total				8	2			10
5	(a)	(i)	5.1.5(b)	2				
		(ii)	5.1.5(c)		1			
	(b)	(i)	5.1.1(k)		1			
		(ii)	5.1.1(k)		1			
		(ii)	5.1.1(k)		3			
	(c)		5.1.1(j)		1			
Total				2	7			9
6	(a)	(i)	5.1.5(d)	2				
		(ii)	5.1.5(d)	2				
		(iii)	5.1.5(e)		1			
		(iv)	5.1.3(p)		3			
	(b)	(i)	5.1.1(j)		1			
		(ii)	5.1.1(j)		2			
		(iii)	5.1.1(j)		1			
		(iv)	5.1.6(d)	2				
	(c)	(i)	5.1.5(d)	1				
		(ii)	5.1.5(d)	2				
Total				9	8			17
7	(a)		5.1.3(a), (b), (o)	5				
	(b)		5.1.3(p)		3		1	
Total				5	3		1	9
8			5.1.6(b), (c)	7	3		1	
Total				7	3		1	11
			TOTAL	**53**	**36**		**2**	**90**

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY
CHAINS AND RINGS **2812**

Specimen Paper

Additional materials:
Answer paper
Chemistry Data Sheet

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.
The total mark for this paper is 90.

Answer **all** questions

1 Carbon is able to form an enormous number of chemical compounds because of its ability to bond to itself to form chains and rings.

(a) Petrol is a mixture of alkanes containing between 6 and 10 carbon atoms. Some of these alkanes are structural isomers of one another.

(i) Explain the term structural isomers.

....

....

(ii) The alkanes are an example of a homologous series. Explain what is meant by this term.

....

....

....

(iii) State the molecular formula of an alkane that could be present in petrol.

....

[5]

(b) But-2-ene is an isomer of C_4H_8.

(i) Draw diagrams to show the *cis* and *trans* isomers of but-2-ene.

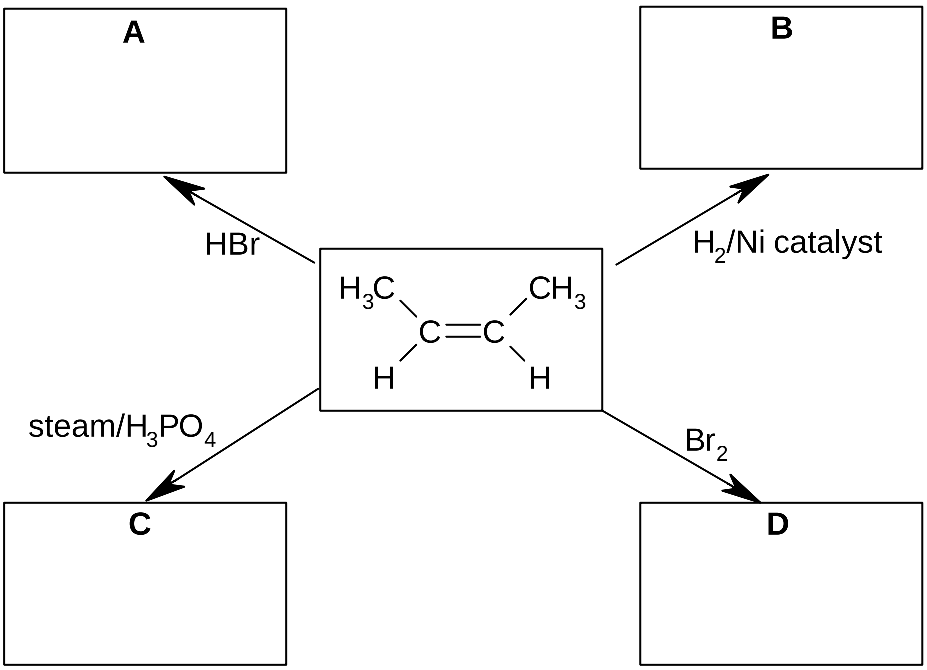
cis-isomer	trans-isomer

(ii) Draw diagrams of **two** isomers of C_4H_8 each of which are structural isomers of but-2-ene. Name each isomer.

name:	name:

[6]

(c) Alkenes such as but-2-ene, C_4H_8, are used by the petrochemical industry to produce many useful materials. Draw structures to represent possible compounds **A-D** in the reactions of but-2-ene shown below.



[4]

(d) But-2-ene is used to make a commercially important polymer.

(i) What type of polymerisation takes place?

....

(ii) Suggest a section of this polymer by drawing **two** repeat units.

[2]

(e) But-2-ene can be converted into buta-1,3-diene by a process called dehydrogenation. Buta-1,3-diene is used to make synthetic rubber.

(i) Suggest the structure of buta-1,3-diene.

(ii) Construct an equation for the dehydrogenation of but-1-ene to form buta-1,3-diene.

....

[2]

[Total: 19]

2 Crude oil is an important source of chemicals that can be obtained by fractional distillation and subsequent processing involving cracking, isomerisation and reforming.

(a) During fractional distillation, explain why hydrocarbons containing few carbon atoms distil at lower temperatures than hydrocarbons with many carbon atoms.

....

....

....

....

[2]

(b) **(i)** What is meant by *cracking*?

....

....

(ii) Suggest an equation which illustrates the cracking of decane, $C_{10}H_{22}$.

....

(iii) Although heat alone can be used to crack hydrocarbons, it is far more common for oil companies also to use catalysts. Suggest **two** reasons why oil companies use catalysts.

reason 1 ....

....

reason 2 ....

....

[5]

(c) Isomerisation produces branched hydrocarbon.

(i) Why should oil companies want to make branched hydrocarbons from straight-chain hydrocarbons?

....

....

(ii) Show the structure of a compound that could be obtained from the **isomerisation** of hexane. Name the compound.

Name:

(iii) One of the important hydrocarbons produced during reforming is benzene. Construct a balanced equation for its formation when hexane is reformed.

....

[4]

[Total: 11]

3 An alcohol has a relative molecular mass of 74 and has the following composition by mass: C, 64.9%; H, 13.5%; O, 21.6%.

(a) Calculate the empirical formula of the alcohol and show that its molecular formula is the same as the empirical formula.

[4]

(b) Draw the displayed formula of the **four** possible isomers of this alcohol.

[4]

(c) Compound **E**, one of these isomers, can be oxidised to form a ketone **F**.

(i) Show the structure of compound **F**.

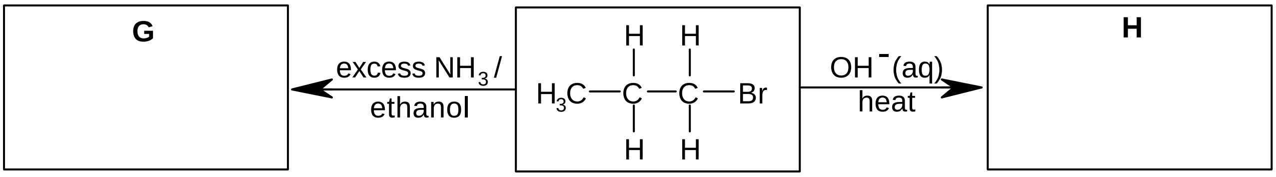
(ii) Deduce which of the four alcohols in **(a)(ii)** is compound **E**.

[2]

[Total : 10]

4 Bromoalkanes such as 1-bromopropane are used in the synthesis of many organic compounds

(a) Draw structures for compounds **G** and **H** in the boxes below.



[2]

(b) State the reagent(s) and essential conditions required to convert **H** back to 1-bromopropane.

reagent(s) ....

conditions ....

[2]

(c) Outline, with the aid of relevant dipoles and curly arrows, the mechanism for the reaction between 1-bromopropane and OH^-(aq) forming compound **H**.

[3]

(d) A student attempted to prepare compounds **G** and **H**, using the same reagents and conditions but using 1-fluoropropane in place of 1-bromopropane.
Suggest why the reactions would proceed at different rates.

....

....

....

[2]

(e) 1-bromopropane can also undergo an elimination reaction with hydroxide ions.

(i) Show the organic product of this reaction.

(ii) State the essential conditions required.

....

[2]

(f) Chlorofluroalkanes are used in air conditioners such as those used in cars and buildings. Air conditioners leak over time. Outline the consequences of this for the environment.

....

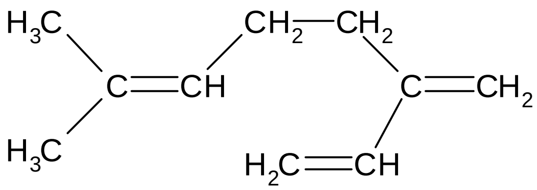
....

....

[1]

[Total: 12]

5 Myrcene is a naturally occurring oil present in bay leaves. The structure of myrcene is shown below.



(a) State the molecular formula of myrcene.

.... **[1]**

(b) Reaction of a 0.100 mol sample of myrcene with hydrogen produced a saturated alkane **A**.

(i) Explain what is meant by the term *saturated* alkane;

....

....

(ii) Determine the molecular formula of the saturated alkane **A**;

(iii) Construct a balanced equation for this reaction.

....

(iv) Calculate the volume of hydrogen, measured at room temperature and pressure (r.t.p.), that reacted with the sample of myrcene.
[1 mole of gas molecules occupy 24.0 dm^3 at r.t.p.] **[5]**

(c) Squalene is a naturally occurring oil present in shark liver oil. A 0.100 mol sample of squalene reacted with 14.4 dm^3 of hydrogen, measured at r.t.p., to form a saturated hydrocarbon $C_{30}H_{62}$.

(i) Calculate how many double bonds there are in each molecule of squalene.

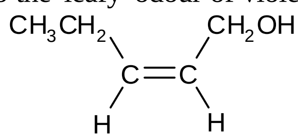
(ii) Suggest the molecular formula of squalene.

....

[3]

[Total: 9]

6 Compounds **J** and **K** contribute to the 'leafy' odour of violet oil.



J

(a) Name the functional groups present in compound **J**.

....

....

[2]

(b) What is the molecular formula of compound J?

....

[1]

(c) Draw the structure of the organic product formed by the reaction of compound **J** with

(i) Br_2;

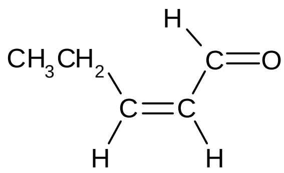
(ii) CH_3COOH in the presence of an acid catalyst.

[2]

(d) A chemist reacted compound **J** with HBr. He separated 2 structural isomers **K** and **L** with the molecular formula $C_5H_{10}Br_2$. Draw structures for **K** and **L**.

[2]

(e) Compound **M** below can be prepared from compound **J.**



M

(i) Suggest reagent(s) for the conversion of **J** into **M**.

....

(ii) Draw the structure of a possible organic impurity (other than **J**) which might contaminate the product. Explain your choice.

explanation ....

....

[3]

[Total: 10]

7 Describe the reaction of a named alkane with bromine. Your answer should include full details of the reaction mechanism.

....

....

....

....

....

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[Total: 8]

8 **(a)** Outline how ethanol is produced industrially from sugars and from ethene. Comment on the decisions that a company needs to consider when deciding which of these methods to use. (*In this question, 2 marks are available for the quality of written communication.)*

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[Total: 11]

Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

Advanced Subsidiary GCE

CHEMISTRY

CHAINS AND RINGS **2812**

Mark Scheme

1. **(a)** **(i)** same **molecular** formula ✓
with a different structural formula. ✓

AO1: 2

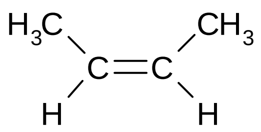
(ii) same functional group/similar chemical properties ✓
each successive member differs by CH_2 ✓

AO1: 2

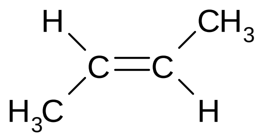
(iii) allow any alkane formula from C_6 to C_{10} e.g. C_8H_{18} ✓

AO2: 1
[5]

(b) **(i)**



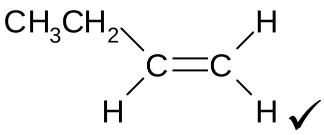
cis-isomer ✓



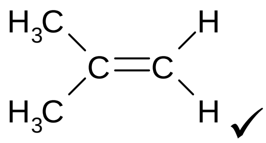
trans-isomer ✓

AO1: 2

(ii)



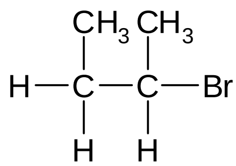
but-1-ene ✓

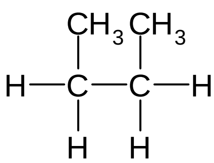


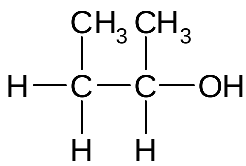
methylpropene ✓

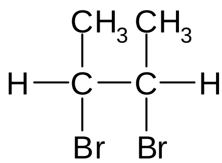
AO1: 4
[6]

(c)









A ✓ **B** ✓

C ✓ **D** ✓

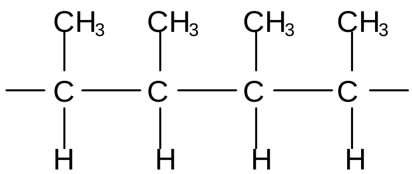
AO1: 4
[4]

(d) **(i)** addition ✓

AO1: 1

(ii)

AO2: 1
[2]



AO2: 1

(e) **(i)** unambiguous structure: bottom line is CH_2=CHCH=CH_2 ✓

AO2: 1

(ii) $CH_3CH{=}CHCH_3 \longrightarrow CH_2{=}CHCH{=}CH_2 + H_2$ ✓

(accept also: $C_4H_8 \longrightarrow C_4H_6 + H_2$)

AO2: 1

[2]

[Total: AO1: 15; AO2: 4 =19]

2 **(a)** van der Waals'/intermolecular forces are broken on boiling ✓

Long-chain hydrocarbons have greater van der Waals' forces ✓

More energy needed to break forces between long- than short-chain hydrocarbons ✓

3 ⟶ 2 max

AO2: 2

[2]

(b) **(i)** Breaking of a long chain hydrocarbon into smaller hydrocarbons ✓, one of which is an alkene ✓

AO1: 2

(ii) $C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$ ✓

AO2: 1

(iii) speeds up reaction ✓

AO1: 1

reaction takes place at a lower temperature/saves energy ✓

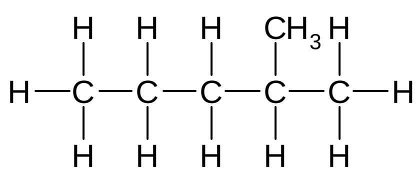
AO2: 1

[5]

(c) **(i)** Produce more useful hydrocarbons / better fuels ✓

AO1: 1

(ii) any branched hydrocarbons with 6 carbon atoms, i.e.:



✓

AO2: 1

2-methylpentane ✓

AO2: 2

(iii) $C_6H_{14} \longrightarrow C_6H_6 + 4H_2$ ✓

[4]

[Total: AO1: 4; AO2: 7 =11]

3 **(a)** C, 64.9/12.0 : H, 13.5/1.0 : O, 21.6/16.0 ✓

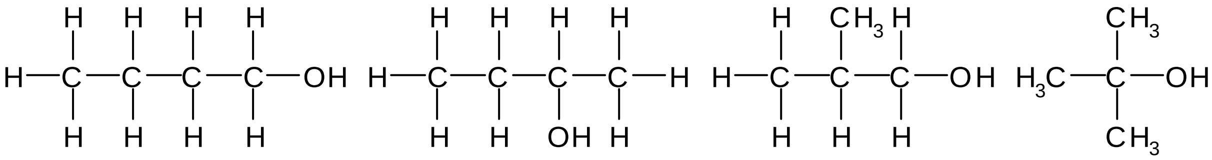
= 5.41 : 13.5 : 1.35 ✓

empirical formula = $C_4H_{10}O$ ✓

linking of formula mass (74) of $C_4H_{10}O$ with M_r (74) ✓

AO2: 4
[4]

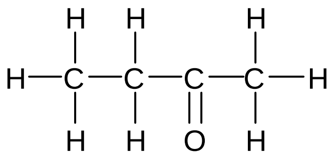
(b)



✓ ✓ ✓ ✓

AO1: 4
[4]

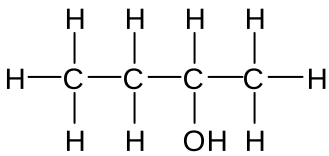
(c) (i)



✓

AO2: 1

(ii)

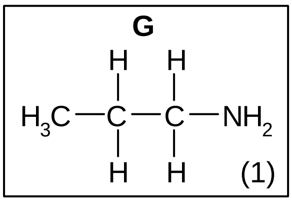


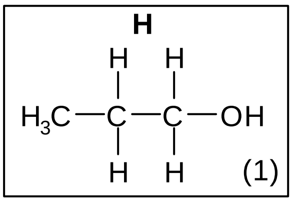
✓

AO2: 1
[2]

[Total: AO1: 4; AO2: 6 =10]

4 **(a)**





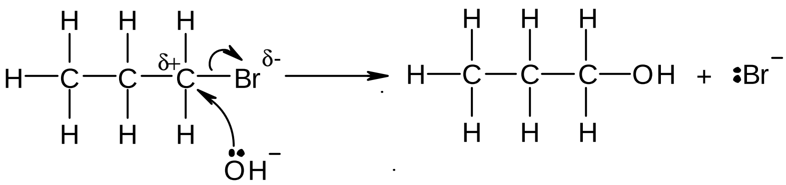
AO1: 2
[2]

(b) $NaBr/H_2SO_4$ ✓

heat/reflux ✓

AO1: 2
[2]

(c)



dipole ✓ arrows ✓ OH^- in, Br^- out ✓

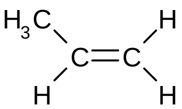
AO1: 3
[3]

(d) fluoropropane reacts slower ✓

C–F bond is stronger than C–Br ✓

AO2: 2
[2]

(e) **(i)**

 ✓

AO1: 1

(ii) ethanol/anhydrous ✓

AO1: 1
[2]

(f) CFCs deplete ozone layer ✓

AO1: 1
[1]

[Total: AO1: 10; AO2: 2 = 12]

5 **(a)** $C_{10}H_{16}$ ✓

AO1: 1
[1]

(b) **(i)** contains no double bond / max number of hydrogens / single bonds **only** ✓

AO1: 1

(ii) $C_{10}H_{22}$ ✓

AO2: 1

(iii) $C_{10}H_{16} + 3H_2 \longrightarrow C_{10}H_{22}$ ✓

AO2: 1

(iv) 1 mol of $C_{10}H_{16}$ reacts with 3 mol H_2 OR 0.3 mol H_2 ✓
(i.e. use of equation/reacting quantities)

Vol H_2 = 0.3 * 24.0 *(could be consequential)OR* 7.2 dm^3 ✓

AO2: 2
[5]

(c) **(i)** 14.4/24 *OR* 0.6 mol H_2 reacts ✓

squalene has 6 double bonds ✓

AO2: 2

(ii) $C_{30}H_{50}$ ✓

AO2: 1
[3]

[Total: AO1: 2; AO2: 7 =9]

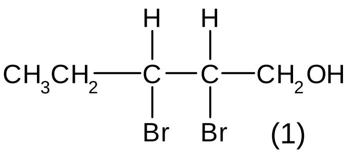
6 **(a)** alkene ✓; alcohol ✓

AO1: 2
[2]

(b) $C_5H_{10}O$ ✓

AO1: 1
[1]

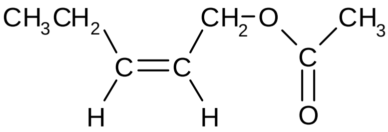
(c) **(i)**



(1)

AO2: 1

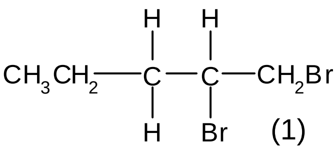
(ii)



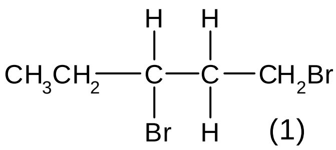
✓

AO2: 1
[2]

(d)



(1)

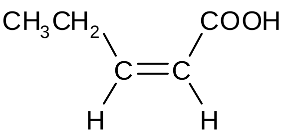


(1) ✓✓

AO2: 2
[2]

(e) **(i)** $K_2Cr_2O_7/H_2SO_4$ ✓

AO2: 1



✓

(ii) further oxidation occurs ✓

AO2: 2
[3]

[Total: AO1: 3; AO2: 7 =10]

7 Alkanes: reaction type: free radical ✓ substitution ✓
conditions: in u.v. light ✓

Equation e.g. $CH_4 + Br_2 \longrightarrow CH_3Br + HBr$ ✓

Mechanism: free radical formation: $Br_2 \longrightarrow 2Br\bullet$ ✓

2 propagation stages: $CH_4 + Br\bullet \longrightarrow CH_3\bullet + HBr$ ✓
$CH_3\bullet + Br_2 \longrightarrow CH_3Br + Br\bullet$ ✓

Any termination step: $CH_3\bullet + CH_3\bullet \longrightarrow C_2H_6$
$CH_3\bullet + Br\bullet \longrightarrow CH_3Br$
$2Br\bullet \longrightarrow Br_2$ ✓

AO1: 8
[Total: AO1: 8]

8 ***Quality of written communication assessed in this question***

sugars
use of yeast/fermentation ✓
equation: $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$
$C_6H_{12}O_6$ ✓ ; CO_2 ✓ ; balanced equation ✓
importance of absence of air/anaerobic conditions ✓
distil to obtain ethanol ✓

ethene
use of steam ✓ with phosphoric acid catalyst ✓
equation: $C_2H_4 + H_2O \longrightarrow C_2H_5OH$ ✓

AO1: 9 ⟶ 7 max

issues for consideration
availability of raw materials/oil countries use ethene/warm with no oil can grow sugar: use sugar ✓
cost of energy/ethene requires energy but sugars does not ✓
consideration of pollution/effect on the environment ✓

AO1: 3 ⟶ 2 max

QoWC – legible text with accurate spelling, punctuation and grammar *1 mark*
Clear, well-organised, using specialist terms *1 mark*

[Total: AO1: 9; AO2: 2; QoWC: 2 = 11]

Assessment Grid: Unit 2812 Chains and Rings

Question	AO1	AO2	AO4	QoWC	Total
1	15	4			19
2	4	7			11
3	4	6			10
4	10	2			12
5	2	7			9
6	3	7			10
7	8	0			8
8	7	2		2	11
Total	**53**	**35**		**2**	**90**

Assessment Grid: Unit 2812 Chains and Rings (Details)

Question			Assessment outcomes	AO1	AO2	AO4	QoWC	Total
1	(a)	(i)	5.2.1(b)	2				
		(ii)	5.2.1(a)	2				
		(iii)	5.2.3(a)		1			
	(b)	(i)	5.2.1(c)	2				
		(ii)	5.2.1(c)	4				
	(c)		5.2.4(d)	4				
	(d)	(i)	5.2.4(g)	1				
		(ii)	5.2.4(h)		1			
	(e)	(i)	5.2.4(d)		1			
		(ii)	5.1.1(i)		1			
			Total	**15**	**4**			**19**
2	(a)		5.2.2(b)		2			
	(b)	(i)	5.2.3(b)	2				
		(ii)	5.2.3(b)		1			
		(iii)	5.2.3(b)	1	1			
	(c)	(i)	5.2.3(d)	1				
		(ii)	5.2.3(b)		2			
		(iii)	5.2.3(b)		1			
			Total	**4**	**7**			**11**
3	(a)		5.1.1(h)		4			
	(b)		5.2.1(b)	4				
	(c)	(i)	5.2.5(e)		1			
		(ii)	5.2.5(c)		1			
			Total	**4**	**6**			**10**
4	(a)		5.2.6(a)	2				
	(b)		5.2.5(d)	2				
	(c)		5.2.6(c)	3				
	(d)		5.2.6(d)		2			
	(e)	(i)	5.2.6(e)	1				
		(ii)	5.2.6(e)	1				
	(f)		5.2.6(f)	1				
			Total	**10**	**2**			**12**
5	(a)		5.2.1(a)	1				
	(b)	(i)	5.2.2(a)	1				
		(ii)	5.2.1(a)		1			
		(iii)	5.1.1(i)		1			

		(iv)	5.1.1(j)		2			
	(c)	(i)	5.2.4(a); 5.1.1(j)		2			
		(ii)	5.2.1(a)		1			
			Total	**2**	**7**			**9**
6	(a)		5.2.1(a)	2				
	(b)		5.2.1(a)	1				
	(c)	(i)	5.2.4(d)		1			
		(ii)	5.2.5(d)		1			
	(d)		5.2.4(d); 5.2.5(e)		2			
	(e)	(i)	5.2.5(e)		1			
		(ii)	5.2.5(e)		2			
			Total	**3**	**7**			**10**
7			5.2.2(d), (e)	8				
			Total	**8**				**8**
8			5.2.5(b)	7				
			5.2.3(e); 5.2.5(g)		2			
							2	
			Total	**7**	**2**		**2**	**11**
			TOTAL	**53**	**35**		**2**	**90**

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY

HOW FAR, HOW FAST? **2813/01**

Specimen Paper

Additional materials:

Answer paper
Chemistry Data Sheet

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.

Write all your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

Answer **all** questions.

INFORMATION FOR CANDIDATES

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

You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.

In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark for this paper is 60.

Answer **all** questions.

1 The diagram below, Fig 1.1, shows the energy distribution of reactant molecules at a temperature $\mathbf{T_1}$.

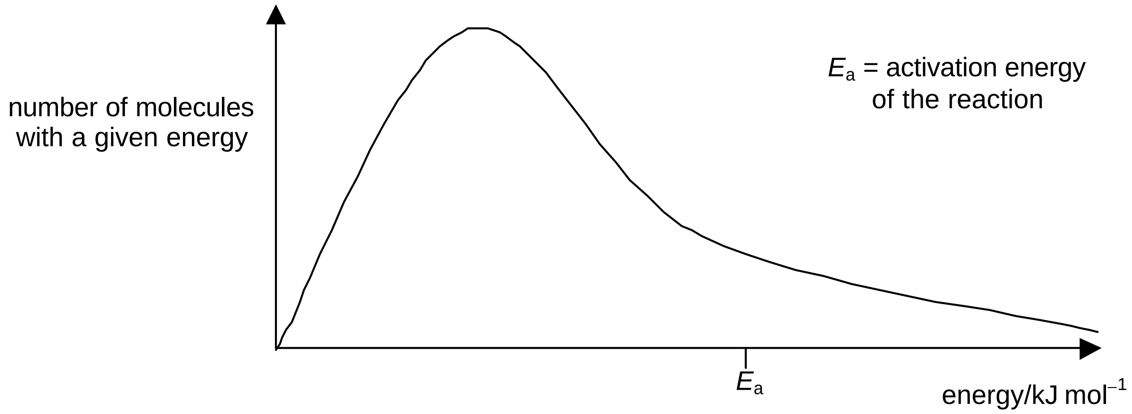


Fig 1.1

(a) Explain what you understand by the term *activation energy*.

....

....

[1]

(b) Mark on Fig 1.1 the activation energy, E_c in the presence of a catalyst.

[1]

(c) Explain, in terms of the distribution curve in Fig 1.1, how a catalyst speeds up the rate of a reaction.

....

....

[2]

(d) Raising the temperature can also increase the rate of this reaction.

(i) Sketch on Fig 1.1 a second curve to represent the energy distribution at a higher temperature. Label your curve $\mathbf{T_2}$.

(ii) Explain, in terms of Fig 1.1. how an increase in temperature can cause an increase in the rate of a reaction.

....

....

....

....

[4]

[Total: 8]

2 Bond enthalpies can provide information about the energy changes that accompany a chemical reaction.

(a) What do you understand by the term *bond enthalpy*?

....

....

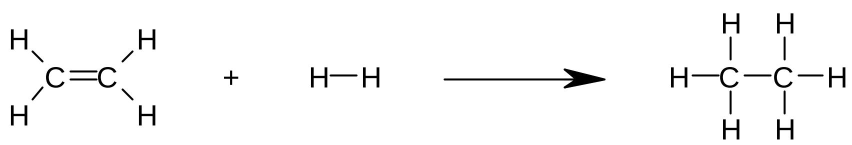
....

[2]

(b) The table below shows some average bond enthalpies.

bond	average bond enthalpy/kJ mol^{-1}
C–C	350
C=C	610
H–H	436
C–H	410

(i) Use this information to calculate the enthalpy change for the process:



(ii) The enthalpy change of this reaction can be found by experiment to be –136 kJ mol^{-1}. Explain why this value is different from that determined above from average bond enthalpies.

....

....

[4]

(c) Sketch a fully labelled enthalpy profile diagram for this reaction.

[2]

[Total: 8]

3 The hydrocarbon heptane, C_7H_{16}, is one of the hydrocarbons present in petrol. Its combustion reaction with oxygen provides some of the energy to propel a vehicle.

(a) **(i)** Define the term *standard enthalpy change of combustion*.

....

....

....

(ii) State the temperature and pressure that are conventionally chosen for quoting standard enthalpy changes.

....

[3]

(b) Use the data below to calculate the standard enthalpy change of combustion of heptane.

compound	$\Delta H^{\ominus}_f$ / kJ mol^{-1}
C_7H_{16} (l)	–224.4
CO_2 (g)	–393.5
H_2O (l)	–285.9

$$C_7H_{16}(l) + 11O_2(g) \longrightarrow 7CO_2(g) + 8H_2O(l)$$

[3]

(c) Suggest **two** reasons why the energy used to propel a vehicle from the combustion of heptane would be less than that calculated in **(b)**.

....

....

....

....

[2]

[Total: 8]

4 Sulphur trioxide, SO_3 is made industrially by the Contact process. This is an example of dynamic equilibrium:

$$2SO_2(g) + O_2(g) \ ? \ 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

(a) State **two** features of a reaction with a *dynamic equilibrium.*

....

....

....

....

[2]

(b) Use le Chatelier's principle to explain what happens to the **equilibrium** position of this reaction as

(i) the temperature is raised;

....

....

....

(ii) the pressure is increased.

....

....

....

[4]

(c) Use your answer to (b) to deduce the theoretical conditions for this equilibrium to provide a high yield.

....

....

[2]

(d) Explain what happens to the **rate** of this reaction as

(i) the temperature is raised;

....

....

....

(ii) the pressure is increased.

....

....

....

[4]

(e) The conditions often used in the Contact process are 400 °C and normal atmospheric pressure.

Using your answers to **(b)**, **(c)** and **(d)**, comment on this choice of

(i) temperature,

....

....

(ii) pressure.

....

....

[2]

[Total: 14]

5. Ammonia, NH_3 is made industrially by the Haber process.

(a) State the raw materials used to supply the nitrogen and hydrogen for the Haber Process

nitrogen...

hydrogen

[2]

(b) Write a balanced equation for the formation of ammonia in this process

....

[1]

(c) In the conditions often used in the Haber process, there is only a 15% yield of ammonia. Suggest what happens to any unreacted nitrogen and hydrogen.

....

....

[1]

(d) Much of the ammonia produced is used to make fertilisers such as ammonium nitrate, NH_4NO_3. This is prepared by an acid-base reaction between nitric acid, HNO_3, and ammonia.

(i) How does nitric acid behave as an acid?

....

....

(ii) Construct an equation for the acid-base reaction of ammonia with nitric acid.

....

(iii) Farmers use ammonium nitrate for its nitrogen content. Calculate the percentage by mass of nitrogen, N, in NH_4NO_3. [A_r: H, 1.0; N, 14.0; O, 16.0]

[4]
[Total: 8]

6. **(a)** Describe, using **one** example in each case, the different modes of action of homogeneous and heterogeneous catalysis. (*In this question, 1 mark is available for the quality of written communication.)*

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[10]

(b) Many catalysts are very expensive but their use does allow the chemical industry to operate more profitably. Outline why the use of catalysts provides economic benefits to this industry.

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[4]

[Total: 14]

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY

HOW FAR, HOW FAST? **2813/01**

Mark Scheme

1 **(a)** minimum energy for a reaction to occur/energy required to break bonds ✓

AO1: 1
[1]

(b) on energy axis to the left of E_a ✓ (i.e. idea of activation energy lowering)

AO1: 1
[1]

(c) reaction proceeds via different route ✓
more molecules exceed lower activation energy ✓

AO1: 2
[2]

(d) **(i)** curve that is displaced to the right ✓ with peak lower ✓

AO1: 2

(ii) average energy is now increased ✓
more molecules exceed activation energy ✓

AO1: 2
[4]

[Total: AO1: 8 =8]

2 **(a)** energy required to break bonds ✓ in 1 mole of bonds ✓

AO1: 2
[2]

(b) **(i)** bonds broken: C=C and H–H and bonds made: C–C ✓

$\Delta H = 610 + 436 - (350 + 2 \times 410)$ ✓

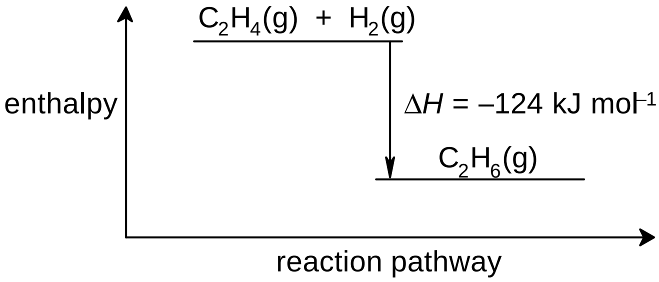
$\Delta H = -124 \text{ kJ mol}^{-1}$ ✓

AO2: 3

(ii) actual bonds are in different environments/have differing strength✓

AO1: 1
[4]

(c)



reactants above products ✓
ΔH clearly shown with arrow the correct way around ✓

AO1: 2

[2]

[Total: AO1: 5; AO2: 3 =8]

3 **(a)** **(i)** Enthalpy change associated when **1 mole** of a substance ✓ undergoes **complete combustion / reacts in excess air or O_2** ✓ (under standard conditions)

AO1: 2

(ii) 298 K/ 25°C **and** 1atm/101kPa/100kPa/1 bar ✓

AO1: 1

[3]

(b) $C_7H_{16}(l) + 11O_2(g) \longrightarrow 7CO_2(g) + 8H_2O(l)$

–224.4 , 7 * –393.5 and 8*–285.9 used ✓ *(use of 7* and 8* and 1*)*

{ 7 * –393.5 + 8 * –285.9 } –(–224.4) ✓ *(i.e. correct cycle used)*

= –4817.3 kJ mol^{-1} ✓ *(correct numerical answer: ignore units)*

AO2: 3

[3]

(c) incomplete combustion of hydrocarbons ✓
wasted energy given out as heat ✓

AO2: 2

[2]

[Total: AO1: 3; AO2: 5 = 8]

4 **(a)** 3 points from:
approached from both directions ✓
forward reaction at same rate as reverse reaction
occurs in closed system ✓
constancy of macroscopic properties

3 ⟶ 2 max AO1: 2
[2]

(b) **(i)** temperature raised;
moves to left ✓
equilibrium absorbs heat/ moves in endothermic direction ✓

AO2: 2

(ii) the pressure is increased.
moves to right ✓
equilibrium moves towards side with smaller number of gas moles ✓

AO2: 2
[4]

(c) low temperature ✓and high pressure ✓

AO2: 2
[2]

(d) **(i)** temperature raised;
rate increases ✓
more molecules possess activation energy ✓

AO1: 2

(ii) the pressure is increased.
rate increases ✓
concentration increases ✓

AO1: 2
[4]

(e) **(i)** temperature is raised because, although yield decreases, reaction proceeds too slowly at low temperatures ✓

AO2: 1

(ii) the pressure is not increase/ to cut costs/rate is fast enough ✓.

AO2: 1
[2]

[Total: AO1: 6; AO2: 8 =14]

5 **(a)** *nitrogen:* air ✓
hydrogen: methane/water ✓

AO1: 2
[2]

(b) $N_2(g) + 3H_2(g)$ ✓ $2NH_3(g)$

AO1: 2
[1]

(c) recycled ✓

AO2: 1
[1]

(d) **(i)** proton/H^+ donor ✓

AO1: 1

(ii) $NH_3 + HNO_3 \longrightarrow NH_4NO_3$ ✓

AO2: 1

(iii) NH_4NO_3 is 14 + 1x4 + 14 + 16x3 = 80 ✓
% nitrogen = 28/80 x 100 = 35% ✓

AO2: 2
[4]
[Total: AO1: 4; AO2: 4 = 8]

6 **(a)** ***Quality of written communication assessed in this question***

homogeneous: catalyst in same phase as reactants ✓;
heterogeneous: catalyst in different phase as reactants ✓

homogeneous: any example, e.g. Cl in ozone breakdown ✓
mode of action to match example: forms a intermediate/ClO ✓
propagation stages shown ✓
overall equation ✓

heterogeneous: any example, e.g. Fe in Haber process ✓
mode of action to match example: reactants adsorbed on surface of catalyst ✓
weakens bonds in reactants ✓
reaction takes place and products diffuse from surface of catalyst ✓

AO1: 9 max
Clear, well-organised, using specialist terms *1 mark*
[10]

(b) any three points from:
reaction proceeds quicker ✓
lower temperature ✓
energy costs saved ✓
more products can be made and therefore more sold ✓
enable reactions to take place that would be impossible otherwise ✓

AO2: 4 max
[4]

[Total: AO1: 9; AO2: 4; qowc: 1 = 14]

Assessment Grid: Unit 2813, Component 01 How Far, How Fast?

Question	AO1	AO2	AO4	QoWC	Total
1	8				8
2	5	3			8
3	3	5			8
4	6	8			14
5	4	4			8
6	9	4		1	14
Total	35	24		1	60

Assessment Grid: Unit 2813, Component 01 How Far, How Fast? (Details)

Question			Assessment outcomes	AO1	AO2	AO4	QoWC	Total
1	(a)		5.3.2(c)	1				
	(b)		5.3.2(h)	1				
	(c)		5.3.2(g), (h)	2				
	(d)	(i)	5.3.2(d)	2				
		(ii)	5.3.2(d)	2				
Total				**8**				**8**
2	(a)		5.3.1(f)	2				
	(b)	(i)	5.3.1(h)		3			
		(ii)	5.3.1(f)	1				
	(c)		5.3.1(d)	2				
Total				**5**	**3**			**8**
3	(a)	(i)	5.3.1(f)	2				
		(ii)	5.3.1(f)	1				
	(b)		5.3.1(h)		3			
	(c)		5.3.2(j)		2			
Total				**3**	**5**			**8**
4	(a)		5.3.3(a)	2				
	(b)	(i)	5.3.3(b)		2			
		(ii)	5.3.3(b)		2			
	(c)		5.3.3(c)		2			
	(d)	(i)	5.3.2(d)	2				
		(ii)	5.3.2(b)	2				
	(e)	(i)	5.3.3(c)		1			
		(ii)	5.3.3(c)		1			
Total				**6**	**8**			**14**
5	(a)		5.3.3(c)	2				
	(b)		5.3.3(c)	1				
	(c)		5.3.3(c)		1			
	(d)	(i)	5.3.3(e)	1				
		(ii)	5.3.3(e), (g); 5.1.1(i)		1			
		(iii)	5.1.1(j)		2			
Total				**4**	**4**			**8**
6	(a)		5.3.2(i), (k), (l)	9			1	
	(b)		5.3.2(f)		4			
Total				**9**	**4**		**1**	**14**
			TOTAL	**35**	**24**		**1**	**60**

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY

PRACTICAL EXAMINATION 1 **2813/03**

Specimen Planning Task for Skill P

OCR – Set Planning Task for Skill P for Unit 2813, Component 03.

This part of Practical Examination 1is a planning exercise.

Your plan, which should be between 500 and 1000 words, can be word processed if you wish.

Your plan must show that you have consulted an appropriate range of resources such as textbooks, CD-ROMs and databases. All resources used should be clearly referenced.

Your plan must be fastened to your answers to Practical Examination 1.

You are provided with the following task.

To determine the effectiveness of an indigestion tablet at neutralising acid.

Indigestion tablets can be used to neutralise acidity in the stomach.

You are to plan an experiment which will allow you to determine the effectiveness of an indigestion tablet at neutralising acid.

Your plan should survey the range of commercially available indigestion tablets. You should consider the active ingredient in each and the chemistry involved.

You may assume that you can use standard equipment and apparatus and chemicals available in a school or college science laboratory.

You plan should include the following:

- relevant chemical knowledge from the AS part of your chemistry course;
- a list of apparatus and chemicals;
- a detailed method which provides full instructions, including any necessary safety precautions.

Any quotations from the work of others should be acknowledged by quotation marks, with page references, and the sources should be included in a bibliography.

You need to produce a clear account using scientific language and accurate spelling, punctuation and grammar.

[8]

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY
PRACTICAL EXAMINATION 1 **2813/03**

Specimen Paper

Additional materials:
Answer paper
Chemistry *Data Sheet*

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided.
Write your answers in the spaces provided on the question paper.
If you need to use any more paper, fasten the sheets together securely.
Answer **all** questions.
Your plan for the OCR-set planning task must be fastened to your answers to Practical Examination 1.

INFORMATION FOR CANDIDATES

In this part of Practical Examination 1, you will be assessed on the Experimental and Investigative Skills below:

Skill I Implementing
Skill A Analysing evidence and drawing conclusions
Skill E Evaluating evidence and procedures

You may use a calculator.
You are advised to show all working in calculations.
Use of the *Data Sheet* is allowed.
The total mark for Unit 2813, Component 03 is 30 marks.

Introduction

FA 1 is a mixture containing sodium hydrogencarbonate, $NaHCO_3$.

Solution **A** is 0.0100 mol dm^3 hydrochloric acid HC*l*.

The percentage by mass of $NaHCO_3$ in **FA 1** can be determined using the following procedure which has 2 parts.

Part 1.
A 250 cm^3 solution of **FA 1** is prepared in a volumetric flask.

Part 2.
Part of the solution from **Part 1** is titrated with hydrochloric acid to find the amount of $NaHCO_3$ present.

Skill I Implementing

Part 1

FA 1 contains between 2.00 g and 2.20 g of sodium hydrogencarbonate, $NaHCO_3$.

- Weigh **FA 1** and the weighing bottle.
- Transfer **FA 1** to a 250 cm^3 volumetric flask.
- Re-weigh the weighing bottle.
- Record your results in a suitable format in the space below.

Results

- Add about 100 cm^3 of distilled water to the volumetric flask containing **FA 1**, shake until **FA 1** has dissolved. Make up the contents of the flask to 250 cm^3 with distilled water. Label this solution **B**. You will need this solution for **Part 2** of the practical task.

Part 2

- Pipette 25.00 cm^3 of solution **B** into a conical flask and add 4 or 5 drops of methyl orange indicator.
- Titrate this solution with 0.100 mol dm^{-3} hydrochloric acid, HC*l*(aq).
- Repeat the titration as many times as you think necessary to obtain accurate results.
- Record your results in a suitable format in the space below.

Results

Summary

25.00 cm^3 of solution **FA 1** required ________ cm^3 of 0.100 mol dm^{-3} HC*l*(aq)

Safety

Outline the safety precautions that you have taken during your experiment. Give your reason(s) for each precaution taken.

……

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……

……

[7]

Skill A Analysing evidence and drawing conclusions

The equation for the reaction between sodium hydrogencarbonate and hydrochloric acid in this titration is:

$$NaHCO_3(aq) + HCl\,(aq) \longrightarrow NaCl\,(aq) + CO_2(g) + H_2O(aq)$$

Complete the following. **In all stages, show your working clearly.**

(a) Use your results obtained from **Part 2** to calculate the number of moles of HC*l* (aq) used in the titration.

(b) Deduce the number of moles of $NaHCO_3$ in 25.00 cm^3 of solution **B**.

(c) Calculate the total number of moles of $NaHCO_3$ in **FA 1**.

(d) Calculate the mass of $NaHCO_3$ in **FA 1**.

(e) Calculate the % of $NaHCO_3$ in **FA 1**.

[8]

Skill E Evaluating evidence and procedures

A student carried out a series of experiments using a mixture similar to **FA 1**, containing sodium hydrogencarbonate, $NaHCO_3$, following the same procedure as in **Part 1** and **Part 2** and using 0.100 mol dm^{-3} hydrochloric acid.

- The student obtained one rough titre of 26.00 cm^3.
- The student obtained four accurate titrations of 25.10 cm^3, 25.90 cm^3, 25.00 cm^3 and 25.10 cm^3.

You are asked to evaluate the results above obtained by the student.

In your evaluation, you should:

- identify clearly any anomalous results.
- identify the main sources of error.
- compare, with reasons, the accuracy and reliability of any measurements that would have been made.
- compare, with reasons, the accuracy and reliability of the different techniques that would have been carried out.
- comment on the overall accuracy of **your** final result.
- suggest improvements that could be made to the experimental procedures whilst following essentially the same general method. You should consider how to improve the reliability of the results and minimise errors.

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[7]

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

CHEMISTRY
PRACTICAL EXAMINATION 1 **2813/03**

Mark Scheme

Skill P - Planning Total 8

The candidate:

Mark	**General strategy**	**Level**	**Choices within plan**	**Level**
0				
1	**P.1a** recognises that an acid/base titration is required and plans an outline procedure		**P.1b** suggests that one of carbonates, hydrogencarbonates, hydroxides or oxides could be used to control stomach acidity.	
2				
3	**P.3a** as 1a. uses information from one source recognises the need to prepare a solution of known concentration of the indigestion remedy.		**P.3b** as 1b suggests that more than one of carbonates, hydrogencarbonates, hydroxides or oxides could be used to control stomach acidity. selects an appropriate indicator.	
4				
5	**P.5a** as 3a uses information from two sources takes into account the need for safe working uses an appropriate calculation to determine a suitable concentration of the acid to allow a balanced titration result.		**P.5b** as 3b. chooses apparatus and reagents to support the chosen strategy	
6				
7	**P.7a** as 5a. retrieves and evaluates information from three or more sources uses information to develop a strategy which is well structured, logical and linked coherently to underlying scientific knowledge and understanding, including equations where appropriate. the strategy is clear and well-organised, using specialist terms where appropriate with accurate spelling, punctuation and grammar throughout.		**P.7b** as 5b. carefully explains the chosen strategy in terms of precision and reliability.	
8				

Skill I – Implementing **Total 7**

The candidate:

Mark		Manipulation	Level		Recording	Level
0						
1	**I.1a**	demonstrates competence in simple techniques (e.g. weighing, use of burette). shows some awareness of the need for safe working (e.g. eye protection).		**I.1b**	makes and records observations and/or measurements which are adequate for the activity, e.g. masses and burette readings.	
2						
3	**I.3a**	as 1a shows competence in a technique with 2 titres within 0.20 cm^3. makes some comment about the hazard of chemicals used, e.g. either HCl or $NaHCO_3$.		**I.3b**	makes systematic and accurate observations and/or measurements which are recorded clearly and accurately. obtains a titre value to within 0.6 cm^3 of the supervisor's value.	
4						
5	**I.5a**	as 3a. shows a high level of competence in a technique with 2 titres within 0.15 cm^3. makes some comment about the hazard of both HCl or $NaHCO_3$.		**I.5b**	records measurements with regard to the precision of the apparatus used. obtains a titre value to within 0.4 cm^3 of the supervisor's value. records measurements in an appropriate format.	
6						
7	**P.7a**	as 5a. obtaining at least two accurate titres within 0.10 cm^3. makes some comment about the hazard of both HCl or $NaHCO_3$, justifying any safety precautions taken.		**P.7b**	records all measurements to a correct level of precision and in an appropriate format. obtains a titre value to within 0.2 cm^3 of the supervisor's value.	
8						

Skill A - Analysing Evidence and Drawing Conclusions **Total 8**

The candidate:

Mark	Processing evidence		Level	Drawing conclusions		Level
0						
1	**A.1a**	is able to process titration results to obtain an average titre.		**A.1b**	is able to calculate the number of moles of HCl using titration results.	
2						
3	**A.3a**	as 1a makes use of the equation.		**A.3b**	is able to calculate the number of moles of $NaHCO_3$ in solution **C.**	
4						
5	**A.5a**	as 3a. takes into account the need for scaling when considering dilution of solutions used in a titration.		**A.5b**	as 3b. calculates the number of moles of $NaHCO_3$ in the mixture.	
6						
7	**A.7a**	as 5a. explains the calculation with full clarity, shows due regard to nomenclature, terminology and the use of significant figures.		**A.7b**	as 5b. calculates the % of $NaHCO_3$ in the mixture, with all steps of the calculation accurate. uses spelling, punctuation and grammar accurately.	
8						

Skill E - Evaluating Evidence and Procedures **Total 7**

The candidate:

Mark		Evaluating procedures	Level		Evaluating evidence	Level
0						
1	**E.1 a**	comments, in general terms, on the suitability of the experimental techniques used.		**E.1 b**	recognises where the measurements may be inaccurate (e.g. clearly anomalous titres are ignored)..	
2						
3	**E.3 a**	recognises main sources of error in the techniques used (e.g. solution **B** may not be fully mixed).		**E.3 b**	comments on the reliability and accuracy of measurements made (with respect to volumetric apparatus). suggests reasons for any unreliable measurements.	
4						
5	**E.5 a**	as 3a. recognises how errors in procedures and techniques will affect the experimental result, e.g. **FA 1** may have not been homogeneous / thoroughly mixed; other components in FA 1 may have been acidic/basic; CO_2 may dissolve leading to extra acidity in solution . suggests methods of improvement., where appropriate		**E.5 b**	as 3a. calculates a correct value for the titre. compares the accuracy of the measurements made (e.g. estimates the accuracy of burette readings, volumetric readings; accuracy of readings made is justified). methods for improvement provide for more accurate measurements.	
6						
7	**E.7 a**	as 5a justifies proposed improvements to the experimental procedures and/or strategy in terms of minimising significant sources of error, e.g. repeat sampling of **FA 1** to ensure that the mixture is homogeneous; analyse other components in mixture.		**E.7 b**	as 5b. uses the value to calculate the correct % of $NaHCO_3$ in the mixture. comments on the accuracy of this value.	
8						

Assessment Grid: Unit 2813, Component 03: Practical Examination 1.

Skill	AO1	AO2	AO3	AO4	Total
P			8		8
I			7		7
A			8		8
E			7		7

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

CHAINS, RINGS AND SPECTROSCOPY **2814**

Specimen Paper

Additional materials:
 Answer paper
 Chemistry Data Sheet

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.
The total mark for this paper is 90.

Answer **all** questions.

1. **(a)** From the information given, draw the structural formula of each organic compound. **All** of the compounds consist of molecules which have **three carbon atoms**.

(i) A hydrocarbon that rapidly decolourises bromine.

(ii) A compound that is oxidised to a ketone.

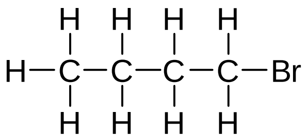
(iii) An ester.

(iv) A compound that forms a silver mirror when heated with Tollens' reagent.

(v) An amino acid.

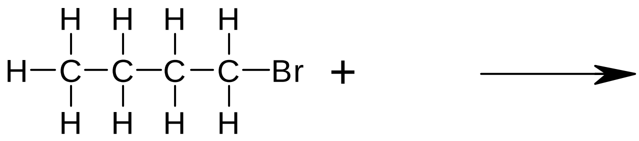
[5]

(b) 1-bromobutane (drawn below) can be used in the organic synthesis of a range of organic compounds by making use of different types of reaction.

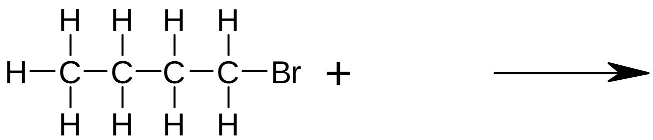


For each of the following reactions, complete a balanced equation for the reaction you have chosen. The equation should show clearly the structure of the organic product(s).

(i) a nucleophilic substitution reaction;



(ii) an elimination reaction.



[4]

[Total: 9]

2. Butanone can be reduced with $NaBH_4$ to form an alcohol **G**. Compound **G** has a chiral centre and can display optical isomerism.

(a) **(i)** Explain the meaning of the term *chiral centre*.

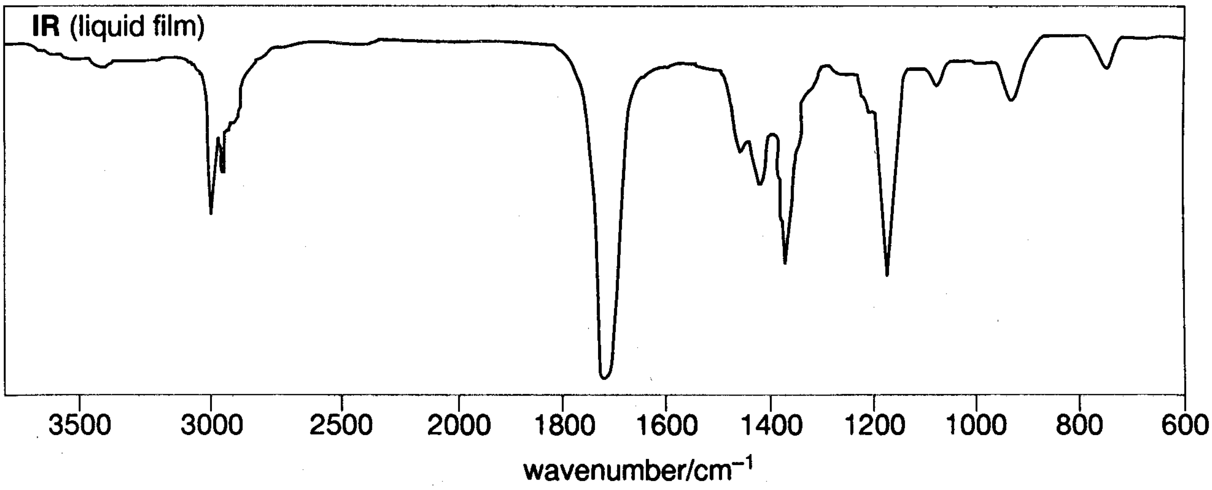
....

....

(ii) Deduce the identity of compound **G** and draw its optical isomers below.

[3]

(b) Butanone has the infra-red spectrum below.



(i) How does this infra-red spectrum confirm the presence of the functional group present in butanone?

....

....

(ii) How would you expect the infra-red spectrum of compound **G** to differ from that of butanone? Explain your answer clearly.

....

....

....

....

[4]

(c) Butanone reacts with hydrogen cyanide in the presence of potassium cyanide.

(i) Describe, with the aid of curly arrows, the mechanism for this reaction.

(ii) What type of reaction is this?

....

[4]

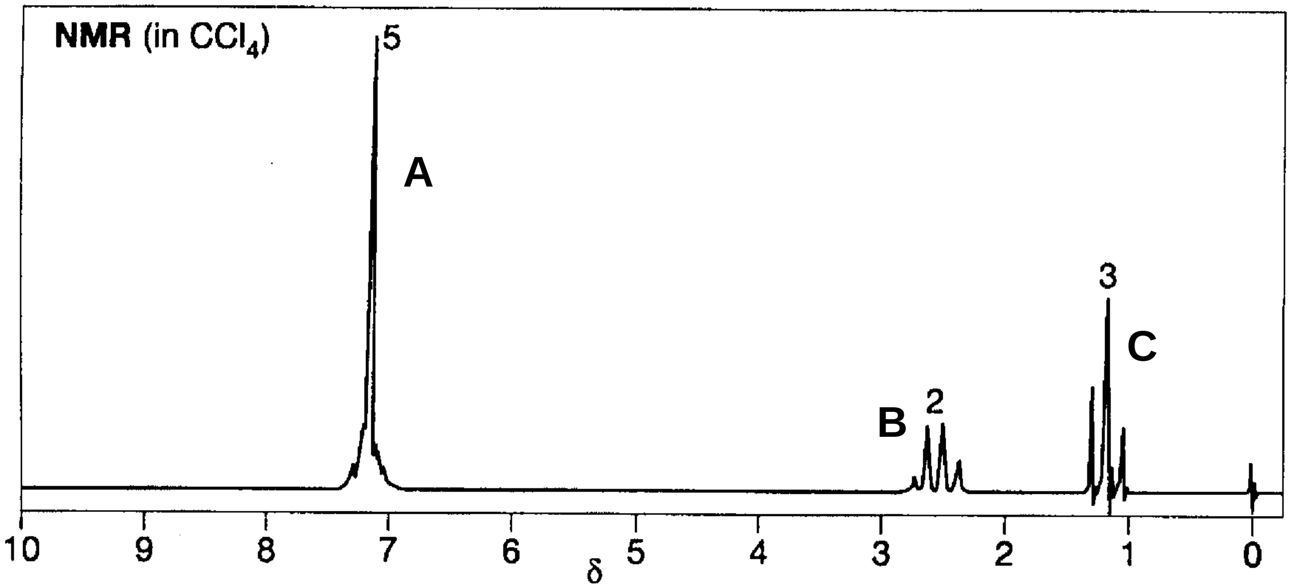
[Total : 11]

3. Compound **E** is an aromatic hydrocarbon with the molecular formula C_8H_{10}.

(a) Draw structures for the **four** possible isomers of **E** in the boxes below.

[4]

(b) The n.m.r. spectrum of **E** is shown below.



Suggest the identity of the protons responsible for the groups of peaks **A**, **B** and **C**. For each group of peaks, explain your reasoning carefully in terms of both the chemical shift value and the splitting pattern.

(i) **A**......................................

....

....

....

(ii) **B**

....

....

(iii) **C**

....

....

....

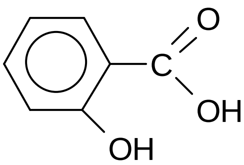
[9]

(c) Using the evidence from **(b),** identify and show the structure of hydrocarbon **E** below.

[1]

[Total: 14]

4. Salicylic acid, shown below, has been used as a painkiller.



(a) Name the functional groups present in salicylic acid.

....

....

[2]

(b) Deduce the molecular formula of salicylic acid.

....

[1]

(c) Show a displayed formula of a likely organic product formed when salicylic acid reacts with

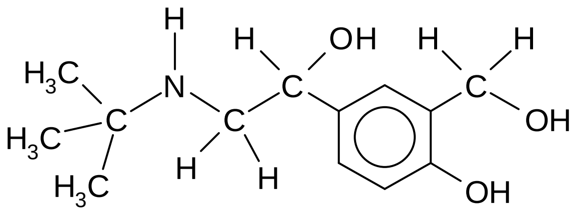
(i) ethanol and concentrated sulphuric acid under reflux;

(ii) bromine;

(iii) aqueous sodium hydroxide.

[4]

(d) Salbutamol, shown below, is used in inhalers to relieve asthma.



(i) Salbutamol is a chiral compound. Mark the chiral centre with an asterisk (*) on the structure above.

(ii) List **two** reasons why salbutamol may be used as a pharmaceutical as a single optical isomer.

....

....

(iii) Salbutamol is reacted with $K_2Cr_2O_7/H_2SO_4$ under reflux. Predict the likely organic product of this reaction and draw a dsiplayed formula of this product below.

[5]

[Total: 12]

5. A student prepared benzoic acid, C_6H_5COOH by hydrolysing methyl benzoate, $C_6H_5COOCH_3$ using the following method.

- *Dissolve 4.0 g of sodium hydroxide in water to make 50 cm^3 of an alkaline solution.*
- *Add the aqueous sodium hydroxide to 2.70 g of methyl benzoate in a 100 cm^3 flask and set up the apparatus for reflux.*
- *Reflux this mixture for 30 minutes.*
- *Distil the mixture and collect the first 2 cm^3 of distillate.*
- *Pour the residue from the flask into a beaker and add dilute sulphuric acid until the solution is acidic.*
- *Filter the crystals obtained and re-crystallise from hot water to obtain the benzoic acid.*

The overall equation for this hydrolysis is:

$$C_6H_5COOCH_3 + H_2O \longrightarrow C_6H_5COOH + CH_3OH$$

The student obtained 1.50 g of benzoic acid, C_6H_5COOH.

(a) Name the functional group that reacts during this hydrolysis.

....

[1]

(b) **(i)** Calculate how many moles of methyl benzoate were used.

(ii) What was the concentration, in mol dm^{-3}, of the aqueous sodium hydroxide used.

(iii) Calculate the percentage yield of the C_6H_5COOH obtained by the student.

(iv) Suggest why the percentage yield was substantially below 100%.

....

....

[9]

(c) **(i)** Why was the residue from the flask acidified before recrystallising?

....

....

....

(ii) Why were the crystals recrystallised?

....

....

[2]

(d) Infra-red spectroscopy can be used to monitor the progress of a chemical reaction.

(i) Predict the key identifying features of the infra-red spectra of methyl benzoate and its hydrolysis products, benzoic acid and methanol.

methyl benzoate ....

....

methanol ....

....

benzoic acid ....

(ii) How could you use infra-red spectroscopy to show that the ethanol did **not** contain any benzoic acid.

....

....

[6]

[Total: 18]

6. Describe, using an example in each case, the formation of the following polymers:

(a) **one** synthetic polymer by addition polymerisation;

....

....

....

[2]

(b) **one** *synthetic* polymer and **one** *natural* polymer by condensation polymerisation. (*In this question, 1 mark is available for the quality of written communication.)*

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[11]

[Total: 13]

7. **(a)** Describe the bonding in benzene and explain why benzene reacts less readily than alkenes with electrophiles. (*In this question, 1 mark is available for the quality of written communication.)*

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[7]

(b) Describe, including a mechanism, the nitration of benzene by electrophilic substitution.

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....

....

[6]

[Total: 13]

Oxford Cambridge and RSA Examinations

Advanced GCE

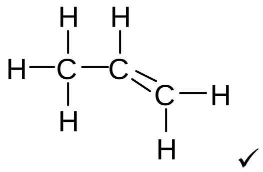
CHEMISTRY

CHAINS, RINGS AND SPECTROSCOPY **2814**

Mark Scheme

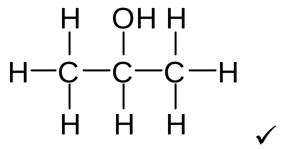
1. (a) (i) A hydrocarbon that rapidly decolourises bromine.

formula



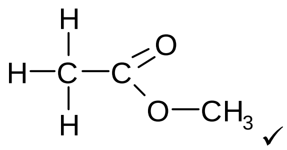
(ii) A hydrocarbon that is oxidised to a ketone.

formula



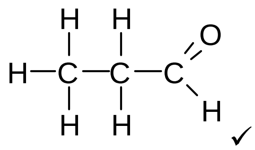
(iii) An ester.

formula



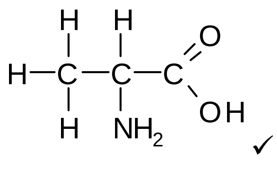
(iv) A compound that forms a silver mirror when heated with Tollens' reagent.

formula



(v) An amino acid.

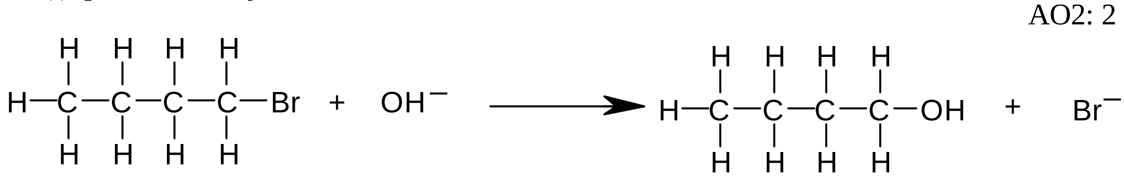
formula



AO1: 5
[10]

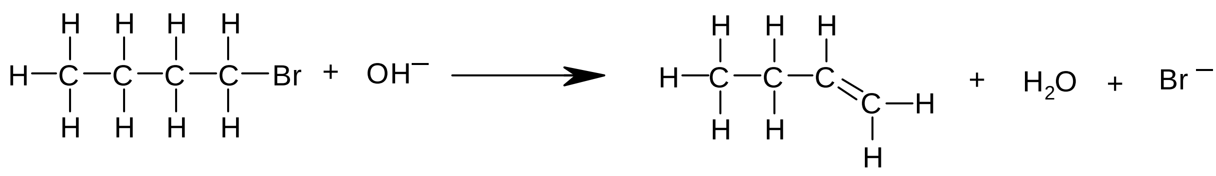
(b) **(i)** *product* ✓; *equation* ✓:

AO2: 2



(ii) *product* ✓; *equation* ✓:

AO2: 2



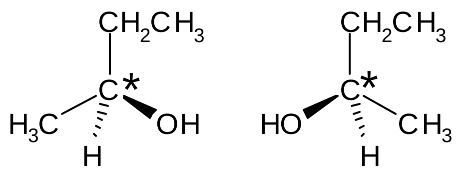
[4]

[Total AO1: 5; AO2: 4: 9]

2 **(a)** **(i)** A carbon atom bonded to four different groups ✓

AO1: 1

(ii)



✓

each optical isomer drawn to show 3D (wedges)
must be mirror images of each other ✓

AO2: 2

[3]

(b) **(i)** absorption at ≈ 1720 cm^{-1} characteristic of carbonyl group ✓

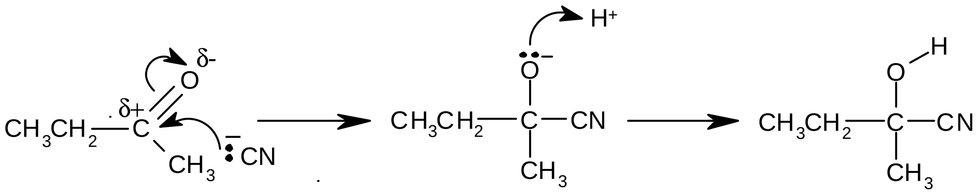
AO2: 1

(ii) absorption from C=O disappears ✓
new absorption between 3200 and 3700 cm^{-1} ✓
due to OH group ✓

AO2: 3

[4]

(c) **(i)**



dipoles shown on the carbonyl with curly arrow from the $:CN^-$ to the δ+ ✓
formation of an intermediate anion with negative charge on the O ✓
correct product: $CH_3CH_2CCN(OH)CH_3$ ✓

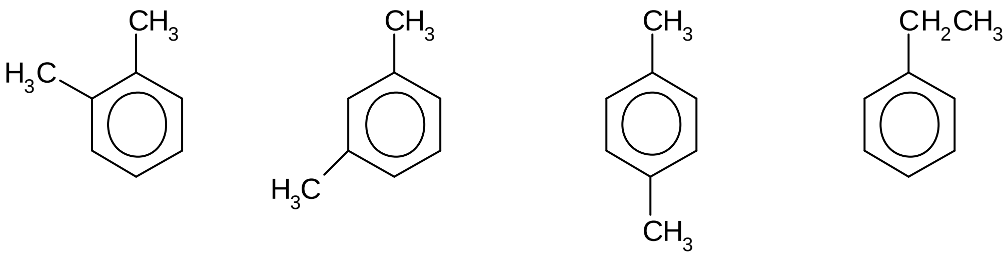
AO1: 3

(ii) nucleophilic addition ✓

AO1: 1
[4]

[Total AO1: 5; AO2: 6 =11]

3 (a)



structures: 1,2-dimethylbenzene; 1,3-dimethylbenzene; 1,4-dimethylbenzene; ethylbenzene.
4 x 1 mark ✓✓✓✓

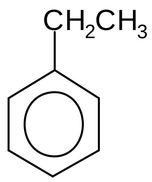
AO1: 4
[4]

(b) (i) C CH_3 ✓
split into a triplet because next to a CH_2 ✓
chemical shift consistent with data value, alkyl next to carbon chain ✓ AO2: 3

(ii) B CH_2 ✓
split into a quartet because next to a CH_3 ✓
chemical shift consistent with data value, alkyl next to benzene ring ✓ AO2:3

(iii) A C_6H_5 ✓
no splitting due to equivalent protons/no proton on adjacent carbon ✓
chemical shift consistent with data value ✓ AO2: 3
[9]

(c) Ethylbenzene



✓

AO2:1
[1]
[Total AO1: 4; AO2: 10 =14]

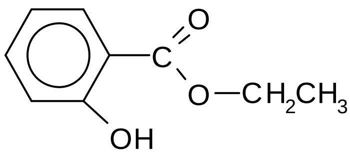
4 **(a)** phenol ✓
carboxylic acid ✓

AO1: 2
[2]

(b) $C_7H_6O_3$ ✓

AO2: 1
[1]

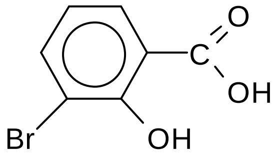
(c) **(i)**



✓

AO2: 1

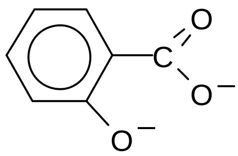
(ii) One Br or more at any position on the aryl ring, e.g:



✓

AO2: 1

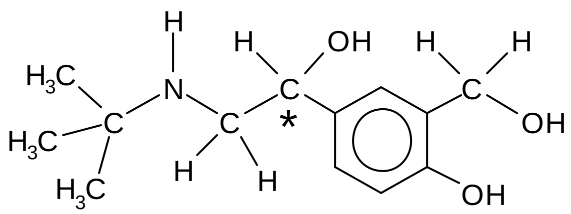
(iii)



negative charge at each O: ✓✓

AO2: 2
[4]

(d) **(i)**



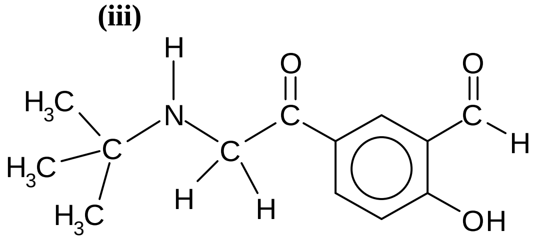
✓

AO2: 1

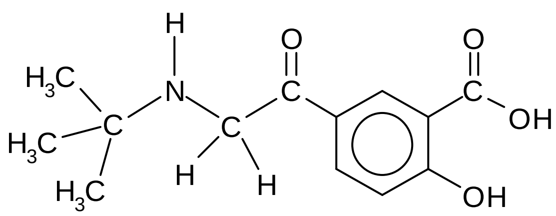
(ii) 2 points from:
side effects from other optical isomer ✓
lower dose/less waste ✓
improved pharmacological activity ✓

2 max: AO1: 2

(iii)



OR



i.e. the primary alcohol would be oxidised to either an aldehyde **OR** a carboxylic acid ✓

the secondary alcohol is oxidised to a ketone ✓

AO2: 2

[5]

[Total AO1: 4; AO2: 8 = 12]

5 (a) ester ✓

AO1: 1

[1]

(b) (i) M_r of ester = 136 ✓

moles methyl benzoate = 0.0200 (0.0198)

AO2: 2

(ii) moles NaOH = 4.0/40 ✓

concentration = 2.0 (mol dm^{-3}) ✓

AO2: 2

(iii) M_r of C_6H_5COOH = 120 ✓

max yield of C_6H_5COOH = 0.02 mol ✓

max yield of C_6H_5COOH = (0.02 * 120) = 2.4 g ✓

% yield = (1.50/ 2.4) * 100 = 62.5% ✓

AO2: 4

(iv) hydrolysis not complete/ C_6H_5COOH slightly soluble in water ✓

any 1 point ⟶ AO2: 1

[9]

(c) (i) $C_6H_5COO^-Na^+$ is water soluble/ to precipitate C_6H_5COOH ✓

AO2: 1

(ii) to remove any impurities ✓

AO1: 1

[2]

(d) (i)

methyl benzoate:	1680 – 1750 cm^{-1}	C=O ✓	
ethanol:	3230 – 3550 cm^{-1}	O–H ✓	
benzoic acid:	1680 – 1750 cm^{-1}	C=O ✓	
	2500 – 3300 cm^{-1}	O-H ✓	

AO1: 4

(ii) Absence of C=O peak ✓

O–H peak not broad ✓

AO2: 2

[6]

[Total AO1: 6; AO2: 12 =18]

6 ***Quality of written communication is assessed in this question.***

(a) *Addition polymerisation*
Examples:
monomer = ethene, phenylethene, etc ✓ AO1: 1
polymer = section of polymer showing repeat unit ✓
AO2: 1
[2]

(b) *Condensation polymerisation: synthetic polymer*
Examples:
ethane-1,2-diol ✓ and benzene-1,4-dioic acid ✓ **OR**
1,6-diaminohexane ✓ hexanedioic acid ✓
1 pair of monomers named/shown ⟶ AO1: 2

polymer: section of polymer showing repeat unit ✓ and either ester OR amide ✓
AO2: 2

HCl or H_2O condensed out ✓
AO1: 1

natural polymer
polypeptide/protein forms ✓
AO1: 1

Examples:
amino acid monomers shown ✓
AO1: 1

polymer: section of polypeptide shown ✓ with correct peptide linkage ✓
AO2: 2

H_2O condensed out ✓
AO1: 1

Clear, well-organised, using specialist terms *1 mark*
[11]

[Total AO1: 7; AO2: 5; QoWC: 1 =13]

7 ***Quality of written communication is assessed in this question.***

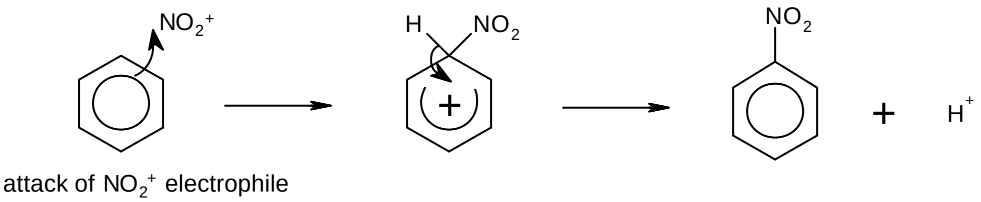
(a) overlap of p-orbitals ✓
leads to pi-bonds ✓
delocalised ✓
ring of electrons above and below ✓
planar benzene molecule ✓
AO1: 4 max

alkenes have a greater electron density/localised double bond ✓
attract electrophiles more readily ✓
in benzene stable delocalised system would need to be disturbed ✓
AO2: 2 max

Q – legible text with accurate spelling, punctuation and grammar *1 mark*
[7]

(b)

reagents: HNO_3 ✓ H_2SO_4 ✓
equation for nitronium ion: $H_2SO_4 + HNO_3 \longrightarrow H_2NO_3^+ + HSO_4^-$
$H_2NO_3 \longrightarrow H_2O + NO_2^+$ ✓
mechanism:



✓ ✓ ✓

sulphuric acid is a catalyst/$H^+ + HSO_4^- \longrightarrow H_2SO_4$ ✓

AO1: 6 max
[6]

[Total AO1: 10; AO2: 2; qowc: 1 = 13]

Assessment Grid: Unit 2814: Chains, Rings and Spectroscopy

Question	AO1	AO2	AO4	QoWC	Total
1	5	4			9
2	5	6			11
3	4	10			14
4	4	8			12
5	6	12			18
6	7	5		1	13
7	10	2		1	13
Total	41	47		2	90

Question			Assessment outcome	AO1	AO2	AO4	QoWC	Total
1	(a)	(i)	5.2.4(d)	1				
		(ii)	5.2.5(e)	1				
		(iii)	5.2.5(d); 5.4.3(b)	1				
		(iv)	5.4.2(d)	1				
		(v)	5.4.4(e)	1				
	(b)	(i)	5.2.6(a)		2			
		(ii)	5.2.6(e)		2			
			Total	**5**	**4**			**9**
2	(a)	(i)	5.4.5(b)	1				
		(ii)	5.4.5(a), (b)		2			
	(b)	(i)	5.4.7(a); 5.2.5(f)		1			
		(ii)	5.4.7(a); 5.2.5(f)		3			
	(c)	(i)	5.4.2(b)	3				
		(ii)	5.4.2(b)	1				
			Total	**5**	**6**			**11**
3	(a)		5.2.1(b)	4				
	(b)	(i)	5.4.7(c)		3			
		(ii)	5.4.7(c)		3			
		(iii)	5.4.7(c)		3			
	(c)		5.4.7(c)		1			
			Total	**4**	**10**			**14**
4	(a)		5.4.1(f); 5.4.3(b)	2				
	(b)		5.2.1(a)		1			
	(c)	(i)	5.4.3(b); 5.2.5(d)		1			
		(ii)	5.4.1(f)		1			
		(iii)	5.4.1(f), 5.4.3(b)		2			
	(d)	(i)	5.4.5(b)		1			
		(ii)	5.4.5(e)	2				
		(iii)	5.2.5(e)		2			
			Total	**4**	**8**			**12**
5	(a)		5.4.3(d)	1				
	(b)	(i)	5.1.1(j)		2			
		(ii)	5.1.1(j)		2			
		(iii)	5.1.1(j); 5.2.1(d)		4			
		(iv)	5.2.1(d)		1			
	(c)	(i)	5.4.3(b)		1			
		(ii)	5.2.1	1				
	(d)	(i)	5.4.7(a); 5.2.5(f)	4				
		(ii)	5.4.7(a); 5.2.5(f)		2			
			Total	**6**	**12**			**18**
6	(a)		5.2.4(g); 5.4.6(a)	1	1			
	(b)		5.4.6(c)	3	2			
	(c)		5.4.4(g), 5.4.6(c)	3	2			
							1	
			Total	**7**	**5**		**1**	**13**
7	(a)		5.4.1(a); 5.4.1(e)	4	2		1	
	(b)		5.4.1(b), (c)	6				
			Total	**10**	**2**		**1**	**13**
			TOTAL	**41**	**47**		**2**	**90**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY
TRENDS AND PATTERNS **2815/01**

Specimen Paper

Additional materials:
Answer paper
Chemistry Data Sheet

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.
The total mark for this paper is 45.

Answer **all** questions.

1 The table below relates to oxides of Period 3 in the Periodic Table.

oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3
melting point /°C	1275	2827	2017	1607	580	33
bonding						
structure						

(a) Complete the table using the following guidelines.

(i) Complete the *'bonding'* row using **only** the words: *ionic* or *covalent*.

(ii) Complete the *'structure'* row using **only** the words: *simple molecular* or *giant*.

(iii) Explain, in terms of forces, the difference between the melting points of MgO and SO_3.

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....

[5]

(b) The oxides Na_2O and SO_3 were each added separately to water.
For each oxide, construct a balanced equation for its reaction with water.

(i) SO_3 reaction with water

....

(ii) Na_2O reaction with water

....

[2]

[Total: 7]

2. The lattice enthalpy of rubidium chloride, RbCl, can be determined indirectly using a Born-Haber cycle.

(a) Use the data in the table below to construct the cycle and to determine a value for the lattice enthalpy of rubidium chloride.

enthalpy change	energy/kJ mol^{-1}
formation of rubidium chloride	–435
atomisation of rubidium	+81
atomisation of chlorine	+122
1st ionisation energy of rubidium	+403
1st electron affinity of chlorine	–349

[6]

(b) Explain why the lattice enthalpy of lithium chloride, LiCl, is more exothermic than that of rubidium chloride.

....

....

....

[2]

[Total: 8]

3. A student prepared two chlorides of iron by carrying out two experiments in the laboratory.

(a) In the first experiment, the student reacted iron with an excess of hydrogen chloride gas forming a chloride **A**, with the composition by mass, Fe: 44.0 %; C*l*: 56.0 %.

(i) Identify compounds **A**, including all of your working in your answer,

(ii) Construct an equation for this reaction.

....

[3]

(b) In the second experiment, the student formed 8.12 g of a chloride **B** by reacting 2.79 g of iron with an excess of chlorine. [A_r: Fe, 55.8; C*l*, 35.5.]

(i) Identify compounds **B**, including all of your working in your answer,

(ii) Construct an equation for this reaction.

....

[4]

(c) Write down are the sub-shell electronic configurations of iron in

(i) metallic iron; ……………………………………………………………………..

(ii) compound **A**; ……………………………………………………………………..

(iii) compound **B**. ……………………………………………………………………..

[3]

(d) Aqueous solutions of **A** and **B** both contain Cl^-(aq) ions. Describe a simple test for the presence of these ions.

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[2]

(e) The chloride **A** has a much higher melting point (672°C) than that of the chloride **B** (220°C). An aqueous solution of chloride **A** is neutral whereas that of **B** is acidic. Explain what this information suggests about the structure and bonding in **A** and in **B**.

……

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……

[4]

[Total: 16]

4. Redox reactions are an important type of reaction in chemistry.

Explain what is meant by a redox reaction. Illustrate your answer with **two** examples drawn from inorganic chemistry (one of which should involve a transition element) and **two** examples from organic chemistry. *(In this question, 1 mark is available for the quality of written communication.)*

[Total: 14]

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Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

Advanced GCE

CHEMISTRY

TRENDS AND PATTERNS **2815/01**

Mark Scheme

1

oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3
bonding	*ionic*	*ionic*	*ionic/ covalent*	*covalent*	*covalent*	*covalent*
structure	*giant*	*giant*	*giant*	*giant*	*simple molecular*	*simple molecular*

each row must be correct for mark

(a) **(i)** ✓

AO1: 1

(ii) ✓

AO1: 1

(iii) MgO strong forces are broken **and** SO_3 weak forces are broken ✓
MgO: forces between ions ✓
SO_3: forces between molecules /van der Waals' forces ✓

AO2: 3
[5]

(b) **(i)** $SO_3 + H_2O \longrightarrow H_2SO_4$ ✓

(ii) $Na_2O + H_2O \longrightarrow 2NaOH$ ✓

AO2: 2
[2]

[Total: AO1: 2; AO2: 5 =7]

2 **(a)** Suitable cycle drawn with steps clearly labelled: ✓✓✓✓
6 steps correct: (4); 5/4 correct: (3); 3 correct (2): 2 correct (1)

AO1: 4

$\Delta H = -435 - \{ 81 + 403 + 122 + (-349) \}$ ✓

$\therefore$ lattice enthalpy = -692 kJ mol^{-1} ✓

AO2: 2
[6]

(b) Li^+ ion is smaller than Rb^+ / charge density of Li^+ is greater than Rb^+ ✓

attractive forces in LiCl lattice are stronger than RbCl lattice ✓

AO2: 2
[2]

[Total: AO1: 4; AO2: 4 =8]

3. (a) (i) A Fe : Cl = 44.0/55.8 : 56.0/35.5 OR = 0.789 : 1.58 ✓
Formula is $FeCl_2$ /iron(II) chloride ✓
($FeCl_2$ would gain 2 marks – this & mark above)

(ii) $Fe + 2HCl \longrightarrow FeCl_2 + H_2$ ✓

[3]
[AO4: 3]

(b) (i) B no of moles of Fe = 2.79/55.8 = 0.0500 moles ✓
no of moles of Cl = 5.33/35.5 = 0.150 moles ✓
Formula = $FeCl_3$ /iron(III) chloride ✓
($FeCl_3$ would gain 3 marks – this & 2 marks above

(ii) $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$ ✓

[4]
[AO4: 4]

(c) Fe: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$ ✓

A: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$ ✓

B: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ ✓

[3]
[AO4: 3]

(d) add $AgNO_3$(aq) ✓
white precipitate forms ✓

[2]
[AO4: 2]

(e) **A** is giant; **B** is simple molecular ✓ from boiling points ✓
A is ionic; **B** is covalent ✓ from conductivity ✓

[4]
[AO4: 4]

[Total: AO4=16]

4. ***Quality of written communication assessed in this question***
idea of an gain and loss of electrons ✓
reduction: gain of electrons ✓ decrease in ox no ✓
oxidation: loss of electrons ✓ increase in ox no ✓
valid examples chosen from inorganic chemistry ✓✓
equations shown ✓✓
correct oxidation number changes ✓✓
valid examples of oxidation chosen from organic chemistry ✓
equation shown – using [O] ✓
valid example of reduction chosen from organic chemistry ✓
equation shown – using [H] or H_2 ✓

AO4:15 ⟶ 13 max
Clear, well-organised, using specialist terms *1 mark*

[Total: AO4: 13; qowc: 1 = 14]

Assessment Grid: Unit 2815: Component 01, Trends and Patterns

Question	AO1	AO2	AO4	QoWC	Total
1	2	5			7
2	4	4			8
3			16		16
4			13	1	14
Total	6	9	29	1	45

Assessment Grid: Unit 2815: Component 01Trends and Patterns (Details)

Question			Assessment outcomes	AO1	AO2	AO4	QoWC	Total
1	(a)	(i)	5.1.3(p), (q); 5.5.2(c)	1				
		(ii)	5.1.3(p); 5.5.2(c)	1				
		(iii)	5.1.3(p); 5.5.2(c)		3			
	(c)	(i)	5.5.2(b)		1			
		(ii)	5.5.2(b)		1			
			Total	**2**	**5**			**7**
2	(a)		5.5.1(b)	4	2			
	(b)		5.5.1(c)		2			
			Total	**4**	**4**			**8**
3	(a)	(i)	5.1.1(h)			2		
		(ii)	5.1.1(i)			1		
	(b)	(i)	5.1.1(j)			3		
		(ii)	5.1.1(i)			1		
	(c)		5.1.2(k); 5.5.3(b)			3		
	(d)		5.1.6(d)			2		
	(e)		5.1.3(p), (q)			4		
			Total			**16**		**16**
4			from: 5.1.5; 5.1.6; 5.5.2;					
			5.5.3			9		
			5.2; 5.4			4		
			(depends on answer)					
							1	
			Total			**13**	**1**	**14**
			TOTAL	**6**	**9**	**29**	**1**	**45**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY
BIOCHEMISTRY **2815/02**

Specimen Paper

Additional materials:
Answer paper
Chemistry Data Sheet

TIME 50 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark on this paper is 45.

Answer **all** questions.

1 The phosphorylation of glucose is the first step of glycolysis (the oxidation of glucose) and is universally catalysed by the enzyme hexokinase.

(a) **(i)** On Fig 1.1 below, draw a line to show how the rate of glycolysis changes as the glucose concentration increases. Label this line **S**.

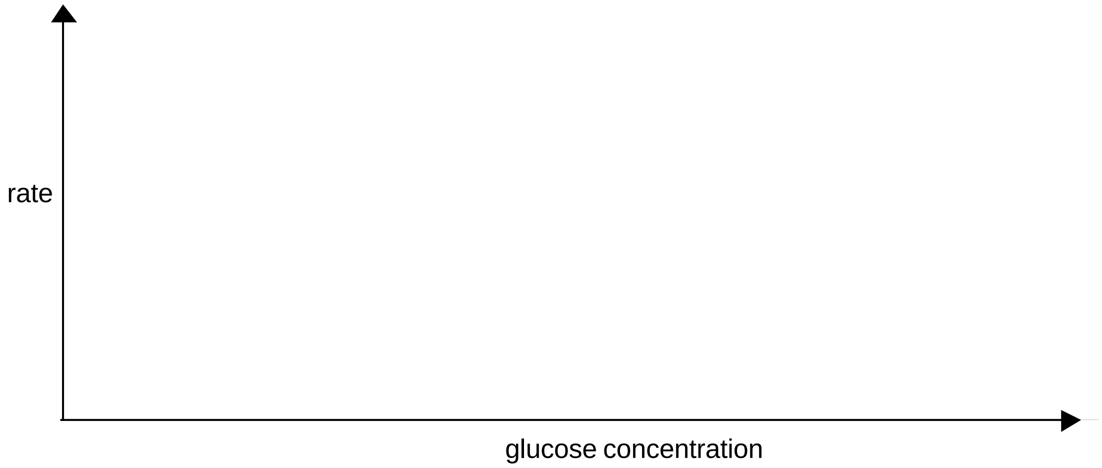


Fig 1.1

(ii) Explain the shape of your sketch.

....

....

....

....

[4]

(b) Some compounds can inhibit the rate of an enzyme-catalysed reaction.

(i) On Fig 1.1 draw a line to show the effect of a **competitive** inhibitor. Label this line **C**.

(ii) Explain how a competitive inhibitor functions.

....

....

....

....

[3]

(c) **(i)** On Fig 1.1 draw a line on Fig 1.1 to show the effect of a **non-competitive** inhibitor. Label this line **N**.

(ii) Explain how a non-competitive inhibitor functions.

....

....

....

....

[3]

[Total: 10]

2 Lipids and carbohydrates can be used as energy stores by cells in humans.

(a) Write the displayed formula for the triglyceryl ester formed from octadecanoic (stearic) acid, $CH_3(CH_2)_{16}COOH$.
[You are **not** asked to write out the hydrocarbon tails.]

[3]

(b) The diagram below shows a part of the structure of a carbohydrate storage polymer which can be broken down by enzyme action.

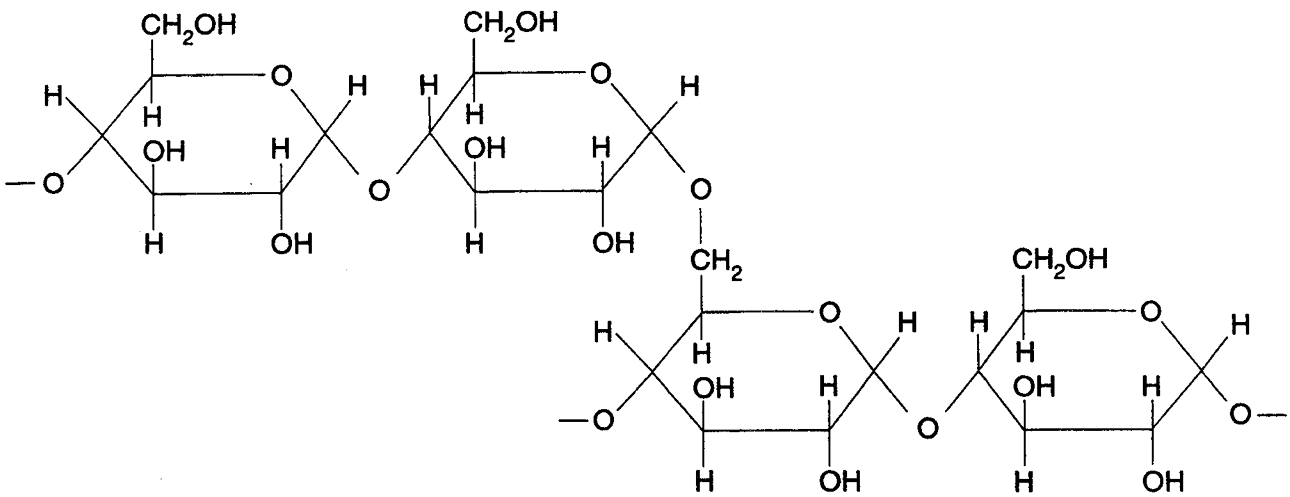


Fig 2.1

(i) Clearly label the carbohydrate linkages on Fig 2.1.and number the carbon atoms responsible for each linkage.

(ii) Name this type of breakdown reaction.

....

(iii) Draw the structure of the monomer unit produced.

(iv) Suggest why the polymer functions as an energy store but the monomer does not.

....

....

[6]

(c) Lipids, fatty acids and carbohydrates are all energy sources. The enthalpy change for the complete combustion (per gramme) of octadecanoic acid is –40 kJ g^{-1} and that of glucose is –16 kJ g^{-1}.

(i) Complete the following equation for the complete combustion of octadecanoic acid and calculate its enthalpy change of combustion per mole.

$C_{18}H_{36}O_2$ + ………….. ⟶ ………….. + ………….. ΔH = …………… kJ mol^{-1}

M_r of octadecanoic acid = 284

(ii) Suggest why lipids (or fatty acids) have a higher energy content (than glucose (or carbohydrates) in metabolism.

....

....

....

[3]

[Total: 12]

3 The following abbreviations are used in diagrams of nucleic acids:

P = phosphate	A adenine	C = cytosine
S = sugar	U = uracil	G = guanine

(a) Use these abbreviations to draw a simple block diagram of the structure of DNA, showing three different nucleotides.

[4]

(b) The base sequence of DNA for a specific tetrapeptide is:

CGACATGAACCG

(i) Write down the base sequence of the mRNA transcribed from the above DNA sequence.

....

(ii) Given the following mRNA triplet codes, deduce the amino acid sequence of the tetrapeptide.

alanine	GCU
aspartic acid	GAU
glycine	GGC and GGA
leucine	CUU
valine	GUA
isoleucine	AUU

Tetrapeptide is ....

(iii) If a mutation occurs in which all three G bases in the DNA are converted into T bases, deduce the amino acid sequence in the mutant tetrapeptide.

....

....

[4]

(c) **(i)** Explain why the changing of a base in a codon may still code for the same amino acid.

....

....

....

(ii) Explain how the synthesis of a polypeptide chain is terminated.

....

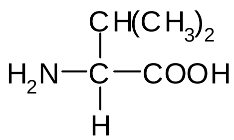
....

....

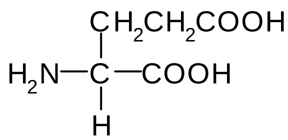
[2]

[Total: 10]

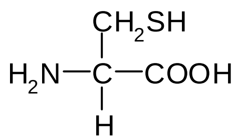
4 Three naturally-occurring amino acids are valine, glutamic acid and cystine.



valine



glutamic acid



cystine

(a) Draw a tripeptide composed from each of these three amino acids.

[2]

(b) Describe how a section of a protein containing these three amino acids can contribute to ordered secondary and tertiary structures of a protein with an α-helix.

Your answer should include diagrams and should discuss the relevant bonds and forces that stabilise each structure. (*In this question, 1 mark is available for the quality of written communication.)*

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[11]

[Total: 13]

Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

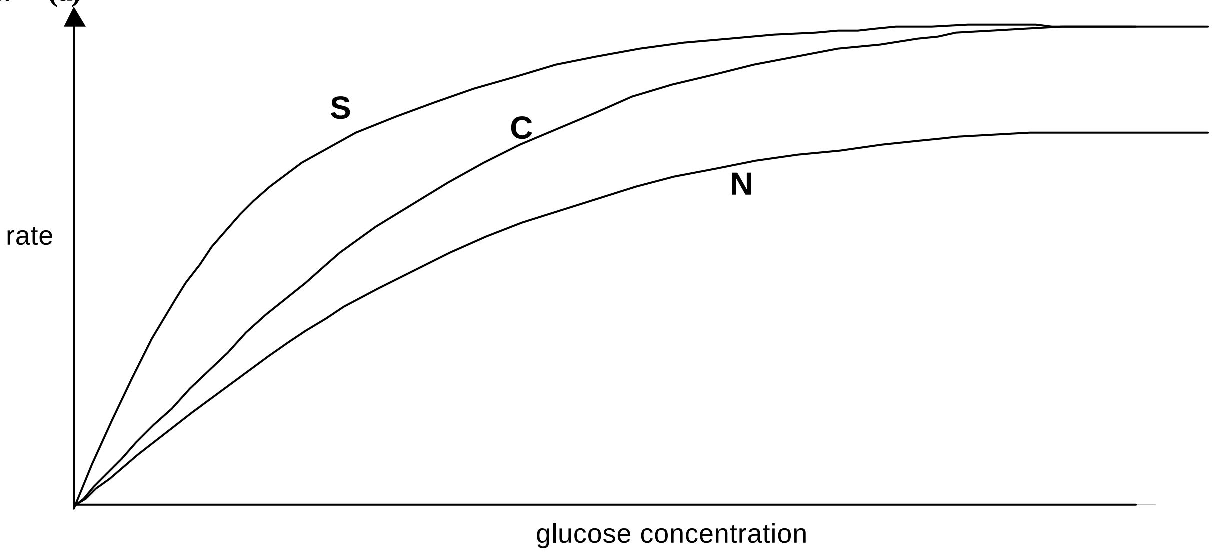
Advanced GCE

CHEMISTRY

BIOCHEMISTRY **2815/02**

Mark Scheme

1. (a)



(i) line on graph, **S**. ✓

AO1: 1

(ii) When [glucose] is low, rate is fastest/As [glucose] increases, rate slows down ✓

AO2: 1

Rate is determined by availability of free active sites on enzyme ✓
As [glucose] increases the enzyme become saturated/all free active sites used ✓

AO2: 2
[4]

(b) (i) line on graph, **C**. ✓

AO1: 1

(ii) chemically similar compound ✓
which fits into active site ✓

AO2: 2
[3]

(c) (i) line on graph, **N**. ✓

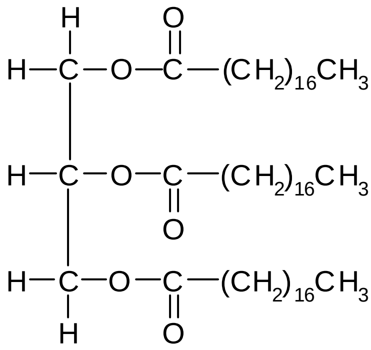
AO1: 1

(ii) inhibitor binds to enzyme ✓
distorting its shape ✓

AO2: 2
[3]

[Total: AO1: 3; AO2: 7 =10]

2. **(a)**



ester linkage correct ✓; glycerol residue correct ✓; rest of molecule correct ✓

AO1: 3
[3]

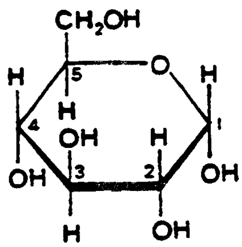
(b) **(i)** Labels: (1α-6) ✓ and (1α-4) ✓

AO1: 2

(ii) Hydrolysis ✓

AO1: 1

(iii)



✓

AO1: 1

(iv) polymer is insoluble/monomer is soluble ✓
polymer cannot be metabolised ✓

AO2: 2
[6]

(c) **(i)** $C_{18}H_{36}O_2 + 25O_2 \longrightarrow 18CO_2 + 18H_2O$ ✓ $\Delta H = -11{,}360$ (kJ mol^{-1}) ✓

AO2: 2

(ii) glucose contains more oxygen within each molecule ✓

AO2: 1
[3]

[Total: AO1: 7; AO2: 5 =12]

3. **(a)** nucleotide shown, i.e. P–S–Base ✓
structure shows three nucleotides ✓
correct pairing: A to T ✓; G to C ✓

AO1: 4
[4]

(b) **(i)** GCUGUACUUGGC ✓

AO2: 1

(ii) ala – val – leu – gly ✓

AO2: 1

(iii) asp – val – isoleu – gly: asp ✓; isoleu ✓

AO2: 2
[4]

(c) **(i)** a given amino acid my be coded for by more than one codon ✓
(ii) certain codons code for chain termination ✓

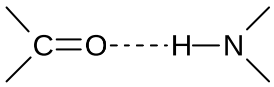
AO1: 2
[2]

[Total: AO1: 6; AO2: 4 =10]

4. **(a)** peptide link shown ✓
full tripeptide structure ✓

AO2: 2
[2]

(b) ***Quality of written communication assessed in this question***
Secondary:
There are 3 (plus) amino acids per turn of helix ✓
stabilised by hydrogen bonding ✓



✓

R groups stick out from helix ✓
(could be on a labelled diagram)

Tertiary:
the overall three-dimensional shape of a protein ✓
R group interactions cause folding ✓.

H-bonding/ dipole-dipole attractions ✓
glutamic acid COOH/ from $^{\delta-}$O–H$^{\delta+}$ ✓

van der Waals' attractions /from oscillating dipoles ✓
valine $CH(CH_3)_2$ ✓

disulphide linkages /covalent bonds: S–S ✓
cystine S ✓

AO1: 10 max
Q – legible text with accurate spelling, punctuation and grammar *1 mark*
[11]

[Total: AO1: 10; AO2: 2; QoWC: 1 = 13]

Assessment Grid: Unit 2815, Component 02: Biochemistry

Question	AO1	AO2	AO4	qowc	Total
1	3	7			10
2	7	5			12
3	6	4			10
4	10	2		1	13
Total	**26**	**18**		**1**	**45**

Assessment Grid: Unit 2815, Component 02: Biochemistry (Details)

Question			Assessment outcome	AO1	AO2	AO4	qowc	Total
1	**(a)**	**(i)**	5.6.2(b)	1				
		(ii)	5.6.2(b), (c); 5.3.2(a)		3			
	(b)	**(i)**	5.6.2(d)	1				
		(ii)	5.6.2(c), (d)		2			
	(c)	**(i)**	5.6.2(d)	1				
		(ii)	5.6.2(c), (d)		2			
			Total	**3**	**7**			**10**
2	**(a)**		5.6.4(a)	3				
	(b)	**(i)**	5.6.3(d)	2				
		(ii)	5.6.3(e)	1				
		(iii)	5.6.3(d), (b)	1				
		(iv)	5.6.3(f)		2			
	(c)	**(i)**	5.1.1(f), (i); 5.3.1(b), (f)		2			
		(ii)	5.6.3(g); 5.6.4(e)		1			
			Total	**7**	**5**			**12**
3	**(a)**		5.6.5(a)	4				
	(b)	**(i)**	5.6.5(c)		1			
		(ii)	5.6.5(d)		1			
		(iii)	5.6.5(d)		2			
	(c)		5.6.5(d)	2				
			Total	**6**	**4**			**10**
4	**(a)**		5.4.4(e); 5.6.1(a)		2			
	(b)		5.6.1(a), (b), (c); 5.1.3(k), (l)	10			1	
			Total	**10**	**2**		**1**	**13**
			TOTAL	**26**	**18**		**1**	**45**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY
ENVIRONMENTAL CHEMISTRY **2815/03**

Specimen Paper

Additional materials:

Answer paper
Chemistry Data Sheet

TIME 50 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark on this paper is 45.

Answer **all** questions.

1. The greenhouse effect is often largely associated with carbon dioxide although many other gases are able to make a more substantial contribution. The compound CCl_2F_2, known as CFC-12 has a relative greenhouse effect 25000 times greater than that of carbon dioxide. CFC-12 can also be involved in processes that damage the ozone layer.

(a) Explain the greenhouse effect.

....

....

....

....

[3]

(b) **(i)** Why is carbon dioxide considered to make a significant contribution to the greenhouse effect?

....

....

(ii) Approximately 79% of the atmosphere consist of nitrogen. Explain why this does **not** contribute to the greenhouse effect.

....

....

(iii) Suggest why CFC-12 has a large relative greenhouse effect.

....

....

....

[5]

(c) Write an equation to show how CFC-12 produces a free radical which will attacks the ozone layer.

....

[1]

[Total: 9]

2. Oxides of nitrogen and unburned hydrocarbons can be involved in a series of reactions that produce toxic chemicals in the troposphere. Some of these reactions are listed below.

$NO_2(g) \longrightarrow NO(g) + O^*(g)$	(1)
$O^*(g) + H_2O(g) \longrightarrow 2HO\bullet(g)$	(2)
$CH_4(g) + HO\bullet \longrightarrow H_2O(g) + CH_3\bullet\,(g)$	(3)
$CH_3\bullet\,(g) + O_2(g) \longrightarrow CH_3OO\bullet\,(g)$	(4)
$CH_3OO\bullet\,(g) + NO(g) \longrightarrow CH_3O\bullet\,(g) + NO_2(g)$	(5)
$CH_3O\bullet\,(g) + O_2\,(g) \longrightarrow HCHO(g) + HO_2\bullet\,(g)$	(6)

(a) **(i)** Apart from the reaction in equation (5), give a reaction in the troposphere that produces nitrogen dioxide.

....

(ii) Explain what is indicated by the '*' in the formula O*.

....

....

(iii) Give the formula of any aldehyde(s) in the above sequence of reactions.

....

(iv) Draw a 'dot-and-cross' diagram of HO• and explain why it is a free radical.

explanation ....

....

(v) Explain, using the above sequence of reactions, why NO_2 can be considered a catalyst in the formation of HCHO.

....

....

....

[8]

(b) Many of the pollutants in the troposphere are products of the burning of fuels in vehicles. A catalytic converter can limit this pollution.

(i) Describe the structure of a catalytic converter.

....

....

....

(ii) Explain how the design of a catalytic converter allows **both** carbon monoxide and nitrogen monoxide to be removed.

....

....

....

[6]

[Total: 14]

3. Hard water is a significant problem to industries that require the use of large quantities of hot water. The deposits in pipes carrying the water could substantially increase costs.

(a) Explain how temporary hardness occurs in water that has flowed over limestone beds.

....

....

....

[2]

(b) Write an equation, including state symbols, for the process you have described in **(a)**.

....

[2]

(c) Suggest **two** factors that might control the extent of the hardness in such water.

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....

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[2]

(d) How does a deposit form in hot water pipes?

……………………………………………………………………………………………………

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[2]

(e) What method would be used to soften water on a large scale?

……………………………………………………………………………………………………

[1]

[Total: 9]

4. Domestic waste is often disposed of by landfill methods. Apart from being potentially unsightly these sites have to be carefully managed. Under anaerobic conditions a potentially explosive gas may be formed and the toxic and foul-smelling gas, hydrogen sulphide may form.

(a) How has the composition of domestic waste changed in recent years?

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

[1]

(b) Name the potentially explosive gas.

……………………………………………………………………………………………………

[1]

(c) Hydrogen sulphide may be formed from sulphate ions.

$$SO_4^{2-} + 10H^+ + 8e^- \longrightarrow H_2S + 4H_2O$$

Deduce the changes in oxidation number that take place in this process.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

[2]

(d) Domestic waste is also disposed of by incineration. Outline **one** advantage of this method.

……

……

[1]

[Total: 5]

5. A permanent cation exchange is also a feature of silicate clays. Explain how the structures of clays allows this to occur and its importance for effective plant growth. (*In this question, 1 mark is available for the quality of written communication.)*

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[Total: 8]

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

ENVIRONMENTAL CHEMISTRY **2815/03**

Mark Scheme

1 **(a)** uv from the sun ✓
released form earth's surface as i.r. ✓
i.r. absorbed by molecules of greenhouse gases ✓

AO1: 3
[3]

(b) **(i)** considerable amounts of greenhouse gases are released by burning fossil fuels ✓
AO2: 1

(ii) no i.r. active vibrations ✓because no charge on dipole ✓
AO2: 2

(iii) many bonds ✓
highly polar bonds ✓
AO2: 2
[5]

(c) release of Cl• from C–Cl ✓
AO2: 1
[1]

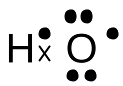
[Total: AO1: 3; AO2: 6 = 9]

2 **(a)** **(i)** the reaction between nitrogen and oxygen caused by lightning ✓
AO1: 1

(ii) activated oxygen atoms (high energy atoms) ✓
AO1: 1

(iii) HCHO ✓
AO2: 1

(iv)



✓✓ (1 mark for correct covalent bond; 1 mark for rest)

this is a free radical because of unpaired electron ✓
AO2: 3

(v) NO_2 decomposes as indicated in equation 1 ✓
however the NO produced reacts in equation 5 to produce NO_2 ✓
AO2: 2
[8]

(b) **(i)** transition metals ✓
Pt/ Pd/ Rh ✓
honeycomb structure for maximum surface area ✓
AO1: 2 max

(ii) oxidation of CO (and unburned hydrocarbons) to CO_2 ✓
reduction of NO to N_2 ✓
NO requires CO to be present ✓
$2NO(g) + 2CO(g) \longrightarrow N_2(g) + 2CO_2(g)$ ✓
Pd and Pt promote oxidation ✓
Rh promotes reduction ✓

AO1: 4 m **[6]**

[Total: AO1: 8; AO2: 6 =14]

3 **(a)** these combine to make calcium hydrogen carbonate ✓

AO1: 2
[2]

(b) $CaCO_3(s) + H_2O(l) + CO_2(g) \longrightarrow Ca(HCO_3)_2(aq)$ *equation* ✓ *state symbols* ✓

AO2: 2
[2]

(c) speed of flow of water ✓
concentration of CO_2 ✓

AO2: 2
[2]

(d) reaction in (b) reverses ✓
depositing $CaCO_3$ ✓

AO1: 2
[2]

(e) ion exchange ✓

AO1: 1
[1]

[Total: AO1: 5; AO2: 4 = 9]

4 **(a)** increase in polymers ✓

AO1: 1
[1]

(b) methane ✓

AO1: 1
[1]

(c) in SO_4^{2-}, S is +6 ✓
in H_2S, S is −2 ✓

AO2: 2
[2]

(d) reduction in bulk/ useful energy can be generated ✓

AO1: 1
[1]

[Total: AO1: 3; AO2: 2 = 5]

5 ***Quality of written communication assessed in this question***
silicate clays have SiO_4^{4-} structural units ✓
or AlO_6^{3-} units ✓
substitution can take place involving replacement of cation with another of lower charge ✓
Al^{3+} for Si^{4+} or Mg^{2+} for Al^{3+} ✓
clay then has a deficiency of positive charge ✓
which is compensated by the adherence of cations to the clay's surface ✓
plants need cations for growth ✓
K^+ and NH_4^+ particularly ✓
without cation exchange, cations would be washed away ✓

AO1: 9 ⟶ 7 max
[7]

Q – legible text with accurate spelling, punctuation and grammar *1 mark*

[Total: AO1: 7; qowc: 1 = 8]

Assessment Grid: Unit 2815, Component 03: Environmental Chemistry

Question	AO1	AO2	AO4	QoWC	Total
1	3	6			9
2	8	6			14
3	5	4			9
4	3	2			5
5	7			1	8
Total	**26**	**18**		**1**	**45**

Assessment Grid: Unit 2815. Component 03: Environmental Chemistry (Details)

Question			Assessment outcome	AO1	AO2	AO4	QoWC	Total
1	**(a)**		5.7.1(j)	3				
	(b)	**(i)**	5.7.1(j)		1			
		(ii)	5.7.1(j)		2			
		(iii)	5.7.1(j)		2			
	(c)		5.7.1(e)		1			
			Total	**3**	**6**			**9**
2	**(a)**	**(i)**	5.7.1(g)	1				
		(ii)	5.7.1(c)	1				
		(iii)	5.2.5(i); 5.4.2		1			
		(iv)	5.1.3(e)		3			
		(v)	5.7.1(g)		2			
	(b)	**(i)**	5.7.1(h); 5.3.2(i), (k)	2				
		(ii)	5.7.1(h); 5.3.2(i), (k)	4				
			Total	**8**	**6**			**14**
3	**(a)**		5.7.2(e)	2				
	(b)		5.7.2(e)		2			
	(c)		5.7.2(e)		2			
	(d)		5.7.2(f)	2				
	(e)		5.7.2(f)	1				
			Total	**5**	**4**			**9**
4	**(a)**		5.7.4(a)	1				
	(b)		5.7.4(c)	1				
	(c)		5.7.4(c) & 5.1.5(b), (c)		2			
	(d)		5.7.4(d)	1				
			Total	**3**	**2**			**5**
5			5.7.3(d), (e), (g), (h)	7			1	
			Total	**7**			**1**	**8**
			TOTAL	**26**	**18**		**1**	**45**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

METHODS OF ANALYSIS AND DETECTION **2815/04**

Specimen Paper

Additional materials:
- Answer paper
- Chemistry Data Sheet

TIME 50 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark on this paper is 45.

Answer **all** questions.

1 Organic molecules often absorb energy in the uv/visible region of the spectrum as a result of electronic transitions.

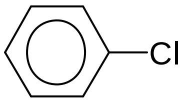
(a) The molecules drawn below each show at least one absorption in the uv/visible region. For each molecule, state the feature(s) responsible for the absorption(s).

(i) propene: $CH_3CH=CH_2$

feature(s) responsible for absorption(s)..

....

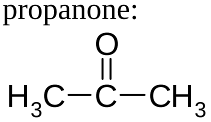
(ii) chlorobenzene:



feature(s) responsible for absorption(s)..

....

(iii) propanone:

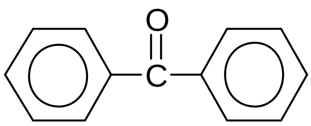


feature(s) responsible for absorption(s)..

....

[5]

(b) Diphenylketone, shown below, also absorbs in the uv/visible region of the spectrum.



(i) Predict where, relative to the absorptions shown by propanone, diphenylketone will absorb energy.

....

....

(ii) Explain your answer to **(i)**.

....

....

....

[3]

[Total: 8]

2 **(a)** The atomic masses of some elements are shown in the Fig 2.1 below:

element	*relative atomic mass*
hydrogen, ^{1}H	1.0078
carbon, ^{12}C	12.0000
nitrogen, ^{14}N	14.0031
oxygen, ^{16}O	15.9949

Fig 2.1

(i) Using the data in Fig 2.1, explain why nitrogen monoxide (NO) and ethene (C_2H_4) can be distinguished with high resolution mass spectrometry.

....

....

....

(ii) High-resolution mass spectrometers are included on planetary space probes. Such a probe recorded gases with masses of 27.0109 and 31.0421.

Identify these two gases, each containing elements from the group shown in Fig 2.1.

Gas **A**, mass 27.0109 ……………………………………

Gas **B**, mass 31.0421 ……………………………………

[4]

(b) It is possible to identify that a given compound contains either chlorine or bromine from the presence of M and (M+2) peaks in the mass spectrum of the compound.

State what species causes the (M+2) peaks in each of the following compounds.

(i) C_3H_7Cl …………………………………………………..

(ii) C_2H_5Br …………………………………………………..

[2]

(c) Describe the differences in relative heights of the M and (M+2) peaks in the mass spectra of chlorine- and bromine-containing compounds.

....

....

....

[2]

[Total 8]

3 **(a)** Explain the terms *partition* and *absorption* with reference to two types of chromatography of your choice. (*In this question, 1 mark is available for the quality of written communication.)*

....

....

....

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....

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....

....

[5]

(b) Using the amino acid glycine, H_2NCH_2COOH, as an example, explain how the pH of the solution used for electrophoresis can influence the results.

....

....

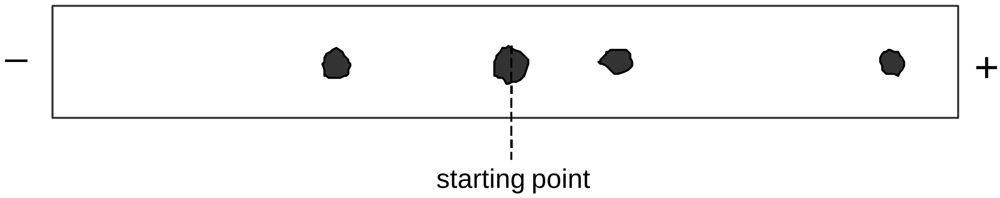
....

....

....

[3]

(c) The diagram below shows the result of carrying out electrophoresis on a sample of amino acids obtained from hydrolysing a protein.



On the diagram

(i) label with an **L** the amino acid with the lowest M_r;

(ii) label with a **+** an amino acid with a positive charge.

[2]

[Total: 10]

4 When an electrical discharge passes through gaseous hydrogen at low pressure, electromagnetic radiation is emitted.

(a) Explain what processes within a hydrogen atom cause radiation to be emitted.

....

....

....

....

[3]

(b) If the radiation in **(a)** is passed through a spectrometer, several series of converging lines are observed.

(i) Explain why there are several series of lines.

....

....

(ii) Why does each series of lines converge?

....

....

[2]

(c) The convergence limit of the Lyman series of lines occurs at a wavelength of 1.00×10^{-7} m.

(i) What does the limit represent?

....

(ii) Calculate the energy, in kJ mol^{-1}, of the convergence limit.

($c = 3.00 \times 10^{8}$ m s^{-1}; $L = 6.02 \times 10^{23}$ mol^{-1}; $h = 6.34 \times 10^{-34}$ J s)

[4]

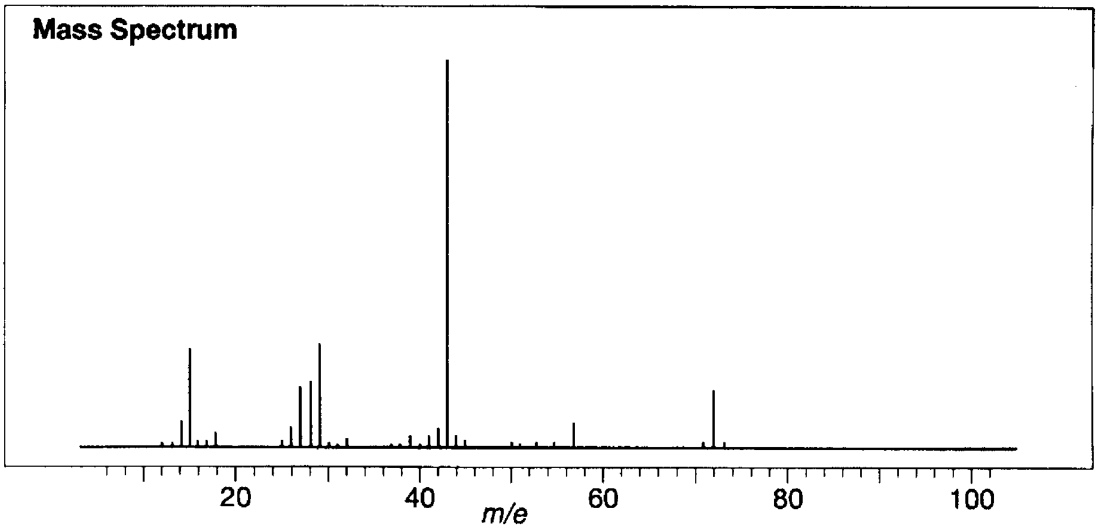
(d) State one use of *flame* emission spectroscopy.

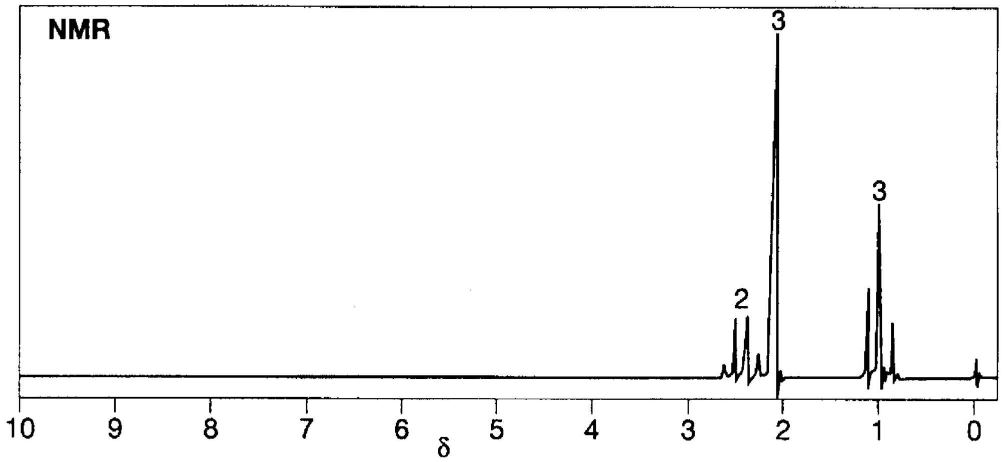
....

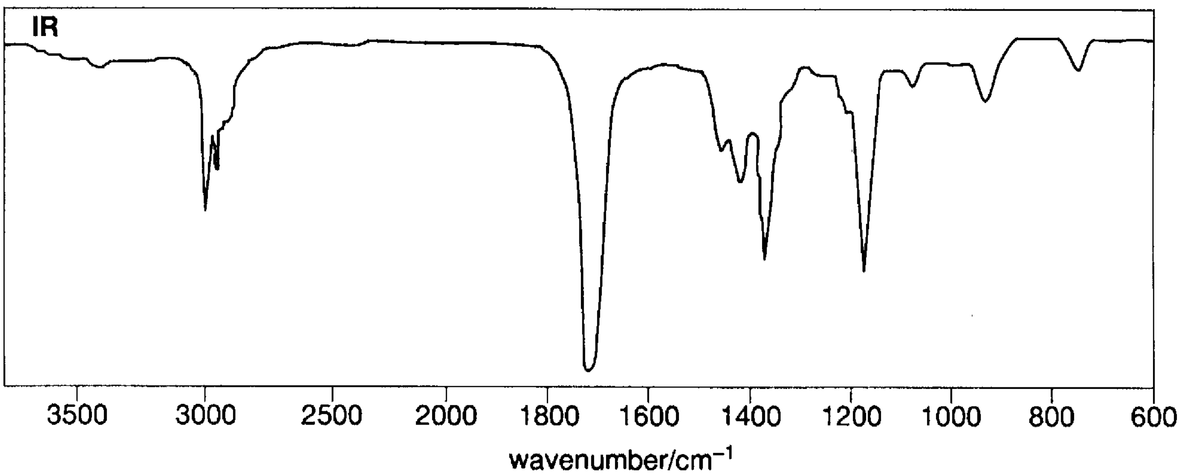
[1]

[Total 10]

5 The spectra shown below were obtained from an organic compounds **G**. Using data from the three spectra, suggest a structure for **G**, indicating what evidence you have used from the spectra.







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……………………………………………………………………………………………………

[Total: 9]

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Advanced GCE

CHEMISTRY

METHODS OF ANALYSIS AND DETECTION **2815/04**

Mark Scheme

1 **(a)** **(i)** C=C ✓

AO1: 1

(ii) benzene ring ✓ and lone pair on Cl ✓

AO1: 2

(iii) C=O ? and lone pair on O ✓

AO1: 2

[5]

(b) **(i)** At lower energy / longer wavelength ✓

AO2: 1

(ii) Extended chromophore / delocalisation of electrons ✓
brings energy levels closer together thus requiring less energy for transitions ✓

AO2: 2

[3]

[Total: AO1: 5; AO2: 3 = 8]

2 **(a)** **(i)** NO is (14.0031 + 15.9949) = 29.9980 ✓

C_2H_6 is ((2 x 12.0000) + (6 x 1.0078) = 30.0468 ✓

AO1: 2

(ii) **A** is HCN ✓

B is CNH_5 (or CH_3NH_2) ✓

AO2: 2

[4]

(b) **(i)** $C_3H_7{}^{37}Cl^+$ ✓

AO1: 1

(ii) $C_2H_5{}^{81}Br^+$ ✓

AO1: 1

[2]

(c) For chlorine containing compounds the M : (M+2) ratio is approx 3 : 1 ✓

For bromine-containing compounds the M : (M+2) ratio is approx 1 : 1 ✓

AO1: 2

[2]

[Total: AO1: 6; AO2: 2 = 8]

3 (a) ***Quality of written communication assessed in this question***

Partition

the distribution of a solute between two dissimilar liquid phase, one the eluant, the other held on the stationary phase ✓

example: paper/glc ✓

Adsorption

the interaction between a component and the polar stationary phase ✓

example: tlc/hplc ✓

AO1: 4

Q – legible text with accurate spelling, punctuation and grammar *1 mark*

[5]

(b) H_2NCH_2COOH can ionise as follows

any two from:

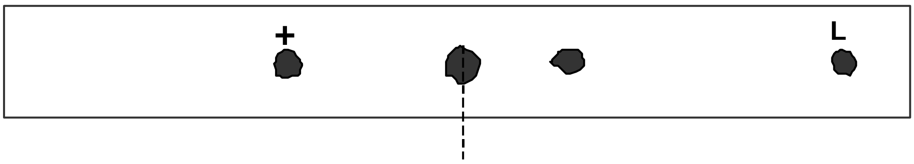
$H_3N^+CH_2COOH$ ✓ $H_3N^+CH_2COO^-$ ✓ $H_2NCH_2COO^-$ ✓

The form present depends upon the pH of the buffer used, and dictates whether the ion moves to the anode, cathode or remains unmoved ✓

AO1: 3

[3]

(c)



correct identification of **(i)** 'L'✓ and **(ii)** '+' ✓

AO2: 2

[2]

[Total: AO1: 7; AO2: 2; qowc: 1 = 10]

4 **(a)** An electron is promoted to a higher energy level ✓
On falling back to lower energy level energy is released ✓
in the form of radiation ✓

AO1: 3
[3]

(b) **(i)** The atom possess several energy levels which can accommodate electrons ✓

AO1: 1

(ii) The convergence represents the levels getting closer together ✓

AO1: 1
[2]

(c) **(i)** Ionisation of the hydrogen atom ✓

AO1: 1

(ii) $E = hf$ *or* hc/l ✓

AO1: 1

$E = Lhc/l$ per mole ✓

$E = 6.02 \times 10^{23} \times 6.63 \times 10^{-34} \times 3 \times 10^{8} / 1.0 \times 10^{7} = 1197$ (kJ mol^{-1}) ✓

AO2: 2
[4]

(d) example: sodium in blood serum ✓

AO1: 1
[1]

[Total: AO1: 8; AO2: 2 = 10]

5 *From i.r.*

Sharp peak 1720 cm^{-1} from C=O ✓

From n.m.r.

Peak at 1.0 δ

chemical shift suggests CH_3 is next to a carbon ✓
triplet suggest next to CH_2 ✓

Peak at 2.1 δ

chemical shift suggests CH_3 is next to a carbonyl ✓
triplet suggest next to C ✓

Peak at 2.3 δ

chemical shift suggests CH_2 is next to a carbonyl ✓
quadruplet suggest next to CH_3 ✓

From mass spec.

molecular ion peak suggests $M_r = 72$ ✓
large fragment ion at m/e = 43 suggests CH_3CO^+ ✓

Deduction

Linking together evidence from ir, nmr and mass spectrum ✓
Suggests **G** is a butanone, $CH_3CH_2COCH_3$ ✓

AO2: 11 ⟶ 9 max
[9]

[Total: AO2: 9]

Assessment Grid: Unit 2815, Component 04: Methods of Analysis and Detection

Question	AO1	AO2	AO4	QoWC	Total
1	5	3			8
2	6	2			8
3	7	2		1	10
4	8	2			10
5		9			9
					2
Total	**26**	**18**		**1**	**45**

Assessment Grid: Unit 2815, Component 04: Methods of Analysis and Detection (Details)

Question			Assessment outcome	AO1	AO2	AO4	QoWC	Total
1	**(a)**	**(i)**	5.8.4(a), (b)	1				
		(ii)	5.8.4(a), (b)	2				
		(iii)	5.8.4(a), (b)	2				
	(b)	**(i)**	5.8.4(c)		1			
		(ii)	5.8.4(c)		2			
			Total	**5**	**3**			**8**
2	**(a)**	**(i)**	5.8.2(a)	2				
		(ii)	5.8.2(a)		2			
	(b)	**(i)**	5.8.2(e)	1				
		(ii)	5.8.2(e)	1				
	(c)		5.8.2(e)	2				
			Total	**6**	**2**			**8**
3	**(a)**		5.8.1(a)	4			1	
	(b)		5.8.1(f); 5.4.4(f)	3				
	(c)	**(i)**	5.8.1(f); 5.4.4(f)		1			
		(ii)	5.8.1(f); 5.4.4(f)		1			
			Total	**7**	**2**		**1**	**10**
4	**(a)**		5.8.3(b)	3				
	(b)	**(i)**	5.8.3(c)	1				
		(ii)	5.8.3(e)	1				
	(c)	**(i)**	5.8.3(d)	1				
		(ii)	5.8.3(a), (d)	1	2			
	(d)		5.8.3(g)	1				
			Total	**8**	**2**			**10**
5			5.8.5(b); 5.4.6(b); 5.2.5(f); 5.4.7		9			
			Total		**9**			**9**
			TOTAL	**26**	**18**		**1**	**45**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY
GASES, LIQUIDS AND SOLIDS **2815/05**

Specimen Paper

Additional materials:
Answer paper
Chemistry Data Sheet

TIME 50 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark on this paper is 45.

Answer **all** questions.

1. **(a)** **(i)** Sketch and label the phase diagram of water. Include the boiling point and freezing point of water.

(ii) Explain the atypical feature of this diagram.

....

....

....

[7]

(b) **(i)** Describe and explain what phase or phases are present in clouds.

....

....

(ii) Suggest and explain how clouds can form out of clear blue skies. Indicate, on your phase diagram, the phase change that occurs when clouds form.

....

....

....

....

[4]

[Total: 11]

2. **(a)** Sketch the phase diagram for mixtures of lead (m.pt. 376 °C) and tin (m.pt. 232 °C). The eutectic point is 62 % tin by mass and the eutectic temperature is 183 °C.
Quantitative data are not expected, but all points and areas should be clearly labelled.

[4]

(b) **(i)** Plumber's solder, used for fixing and manipulating pipes and metal joints, contains 34 % of tin by mass.
Draw a dotted line on your diagram in **(a)** for the cooling of plumber's molten solder until it is completely solidified.

(ii) Suggest why this composition of the lead-tin mixture is useful for plumbing.

....

....

....

(iii) Electrician's solder, used for joining cables, needs to solidify rapidly and at as low a temperature as possible.
Suggest a composition for electrician's solder.

....

[4]

[Total: 8]

3. **(a)** **(i)** State Henry's Law.

....

....

....

(ii) Henry's Law is not obeyed by some gases dissolved in water. State one such gas.

....

(iii) Explain, with the aid of an equation, why your chosen gas does not obey Henry's Law.

....

....

....

[5]

(b) The Henry's Law constant, K_h, for carbon dioxide in water at 25 °C is 3.8×10^{-2} mol dm^{-3} atm^{-1}.

(i) Write an expression for K_h.

(ii) Soda water (aqueous carbon dioxide) can be produced by using a carbonating process which supplies carbon dioxide at a pressure of 10 atm.

What volume of carbon dioxide, measured at 25 °C and 1 atm, would be dissolved in a 750 cm^3 bottle of soda water, assuming that Henry's Law is obeyed?

[3]

[Total: 8]

4. **(a)** **(i)** State Raoult's Law.

....

....

....

(ii) Explain, with a suitable example, what combinations of liquids obey Raoult's Law.

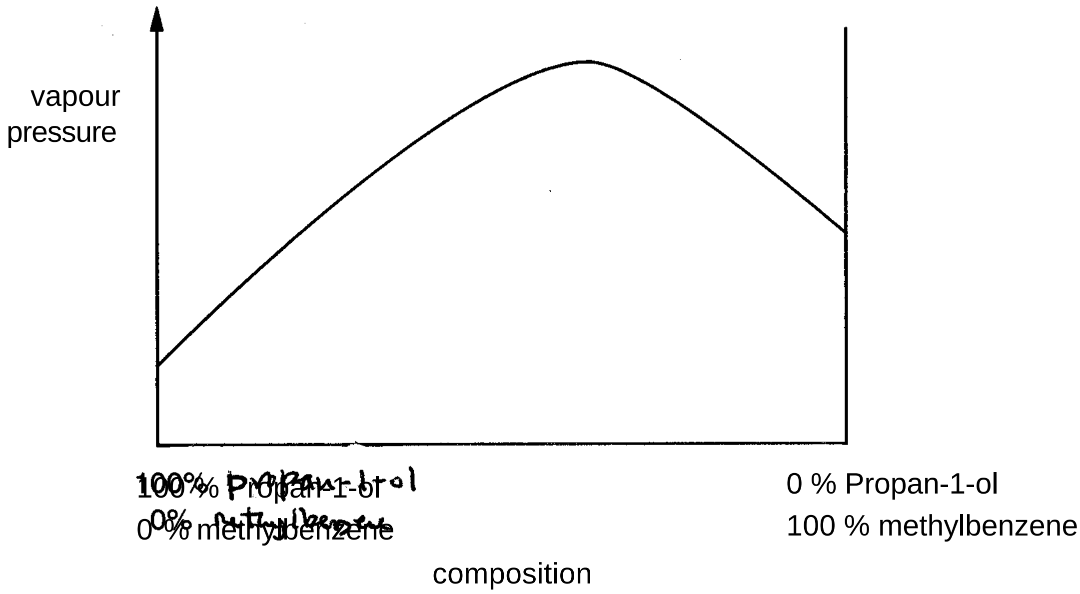
....

....

....

[4]

(b) The diagram below shows the vapour pressure of a mixture of propan-1-ol and methylbenzene.



Explain the shape of this vapour pressure curve.

....

....

....

....

....

[4]

[Total: 8]

5. **(a)** Describe, using a kinetic-molecular model, the processes that take place in each of the following changes:

(i) melting

....

....

....

(ii) a liquid evaporating;

....

....

....

[4]

(b) Outline the basic assumptions of the kinetic theory as applied to an ideal gas. Explain why a gas behaves most like an 'ideal gas' as low pressures and high temperatures. (*In this question, 1 mark is available for the quality of written communication.)*

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[6]

[Total: 10]

Oxford Cambridge and RSA Examinations

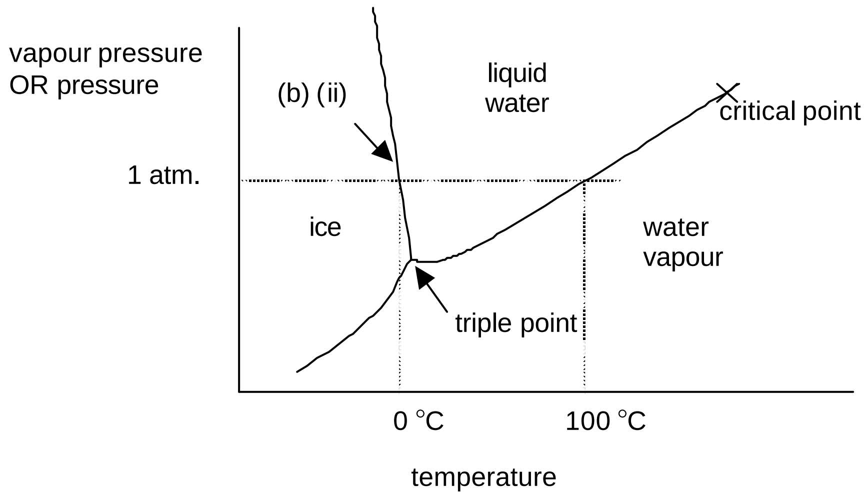
Advanced GCE

CHEMISTRY

GASES, LIQUIDS AND SOLIDS **2815/05**

Mark Scheme

1 (a) (i)



axes ✓
shape ✓
areas labelled ✓
101 kPa/1 atm & 100 C (or in K) ✓
one of triple or critical point ✓

AO1: 5

(ii) Ice is less dense than water (see negative slope on graph above ✓
high pressure favours smaller volume of (liquid) water ✓

AO1: 2

[7]

(b) (i) (water) vapour & liquid (or ice if temperature below 0 C) ✓

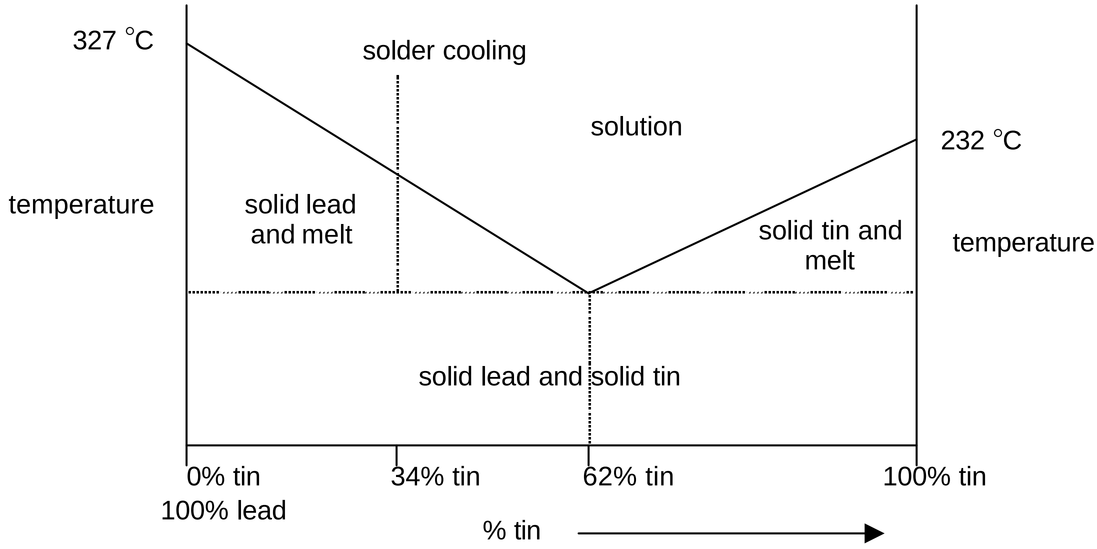
AO2: 1

(ii) cooling must occur ✓
across phase boundary ✓
line on graph with arrow ✓

AO2: 3
[4]

[Total: AO1: 7; AO2: 4 = 11]

2 (a)



axes ✓
3 points ✓

4 areas labelled ✓✓

AO1:4
[4]

(b) (i) line on graph ✓

AO2: 1

(ii) The solder melts over a range of temperature ✓
allows the join to be worked/manipulated ✓

AO2: 2

(iii) The eutectic; 62% tin (38% lead) ✓

AO2: 1
[4]

[Total: AO1: 4; AO2: 4 =8]

3 (a) (i) The solubility of a gas in a liquid is proportional to the (partial) pressure of the gas ✓
The system at equilibrium/holds for low pressures/gas must be in same molecular state in gas & in solution ✓

AO1: 2

(ii) hydrogen chloride/ammonia/sulphur dioxide ✓

AO2: 1

(iii) The gas reacts with water to form a different species/ions ✓
equation ✓

AO2: 2

[5]

(b) **(i)** $K_h = [CO_2(aq)]/pCO_2 = 3.8 \times 10^{-2}$ mol dm^{-3} atm^{-1} ✓

AO2: 1

(ii) $[CO_2(aq)] = 10 \times 3.8 \times 10^{-2} = 0.38$ mol dm^{-3} ✓

volume of CO_2 = 24,000 x 3/4 x 0.38

= 6840 cm^3 or 6.84 dm^3 ✓

AO2: 2
[3]

[Total: AO1: 2; AO2: 6 =8]

4 **(a)** **(i)** The vapour pressure exerted by a liquid in a mixture is the vapour pressure of that liquid ✓ multiplied by its mole fraction ✓ (in the mixture).

AO1: 2

(ii) Liquids which are chemically similar; have similar intermolecular forces ✓

e.g. O_2/N_2 or H_2O/CH_3OH or two alkanes ✓
(accept an two substances that interact similarly)

AO1: 2
[4]

(b) The energy required to vaporise the liquid is reduced ✓
The intermolecular forces are weaker ✓
than between the two components (on their own) ✓
propan-1-ol is hydrogen bonded ✓
methylbenzene has van der Waals' forces ✓

vapour pressure of propan-1-ol is less than that of methylbenzene as H-bonds are stronger ✓

max 4
AO2: 4
[4]

[Total: AO1: 4; AO2: 4 =8]

5 **(a)** **(i)** In a solid, the particles are fixed in positions but in a liquid, they have kinetic energy✓ vibrations in solid cause particles to break out of lattice (crystal) forces. ✓

AO1: 2

(ii) Particles in liquid are adjacent and are held by intermolecular force ✓ The extra energy (KE) allows particles to break these forces/break surface tension to reach vapour phase ✓

AO1: 2
[4]

(b) ***Quality of written communication assessed in this question.***

There are no intermolecular attractions ✓

The volume occupied by the molecules of the gas is insignificant compared with the volume of the vessel ✓

All collisions made by the molecules are perfectly elastic ✓

volume of gas molecules in negligible compared with total gas volume ✓

molecules are far apart so intermolecular forces are negligible ✓

AO1: 5

Q – legible text with accurate spelling, punctuation and grammar *1 mark*

[6]

[Total: AO1: 9; qowc: 1 = 10]

Assessment Grid: Unit 2815, Component 05: Gases, Liquids and Solids

Question	AO1	AO2	AO4	QoWC	Total
1	7	4			11
2	4	4			8
3	4	4			8
4	2	6			8
5	9			1	10
Total	26	18		1	45

Assessment Grid: Unit 2815, Component 05: Gases, Liquids and Solids (Details)

Question			Assessment outcome	AO1	AO2	AO4	QoWC	Total
1	**(a)**	**(i)**	5.9.2(d)	5				
		(ii)	5.9.2(d)	2				
	(b)	**(i)**	5.9.2(f)		1			
		(ii)	5.9.2(f)		3			
Total				**7**	**4**			**11**
2	**(a)**		5.9.2(g)	4				
	(b)	**(i)**	5.9.2(f)		1			
		(ii)	5.9.2(f)		2			
		(iii)	5.9.2(e)		1			
Total				**4**	**4**			**8**
3	**(a)**	**(i)**	5.9.3(b)	2				
		(ii)	5.9.3(a)		1			
		(iii)	5.9.3(a)		2			
	(b)	**(i)**	5.9.3(b)		1			
		(ii)	5.9.3(b)		2			
Total				**2**	**6**			**8**
4	**(a)**	**(i)**	5.9.4(a)	2				
		(ii)	5.9.4(d)	2				
	(b)		5.9.4(d)		4			
Total				**4**	**4**			**8**
5	**(a)**	**(i)**	5.9.1(a); 5.1.3(p)	2				
		(ii)	5.9.1(a) ; 5.1.3(p)	2				
	(b)		5.9.1(b); 5.9.1(c)	5			1	
Total				**9**			**1**	**10**
Total				**26**	**18**		**1**	**45**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

TRANSITION ELEMENTS **2815/06**

Specimen Paper

Additional materials:

Answer paper
Chemistry Data Sheet

TIME 50 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

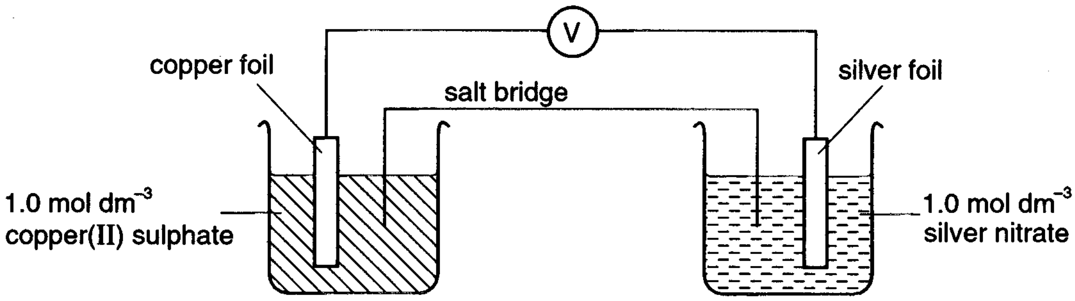
INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark on this paper is 45.

Answer **all** questions.

1 A student set up the following electrochemical cell.



You are provided with the following standard electrode potentials:

Cu^{2+}/Cu $E^{\ominus}$ = +0.34 V

Ag^{+}/Ag $E^{\ominus}$ = +0.80 V

(a) How could the student have made the salt bridge?

.... **[1]**

(b) Write half-equations showing the reactions that occurred in

(i) the Cu/Cu^{2+} half cell,

....

(ii) the Ag/Ag^{+} half cell.

.... **[2]**

(c) Write an equation for the overall cell reaction.

.... **[1]**

(d) **(i)** Calculate the standard cell potential for this cell.

(ii) Identify the electrode at which reduction occurs. Explain your answer.

electrode ....

reason ....

.... **[4]**

(e) The student found that the e.m.f. obtained for this cell was less than the calculated value. Suggest **two** reasons for this.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

[2]
[Total : 10]

2 The highest oxidation state of chromium exists in the yellow oxyanion: CrO_4^{2-}.

(a) Deduce the oxidation number of chromium in CrO_4^{2-}.

[1]

(b) When a dilute acid is added to a solution of CrO_4^{2-}, the solution changes colour.

(i) State the new colour formed.

(ii) Write a balanced equation for the reaction that has taken place.

....
[2]

(c) When treated with sulphur dioxide in acidic solution, the oxyanion CrO_4^{2-} can be reduced to a lower oxidation state forming an ion **A**.

(i) What is identity of ion **A** formed from CrO_4^{2-}? ....

(ii) State the new colour formed...
[2]

(d) Manganese forms an unstable green oxychloride, **B,** with the following composition by mass: Mn, 39.7%; O, 34.7%; Cl, 25.6%.

(i) Calculate the empirical formula of the oxychloride **B**.

(ii) Deduce the oxidation state of manganese in the oxyanion **B**.

[3]

[Total: 8]

3 1,2-Diaminoethane, $NH_2CH_2CH_2NH_2$, is a *bidentate ligand*..

(a) Explain the term *bidentate ligand*.

....

....

[2]

(b) There are three isomeric complexes with the formula $[Cr(NH_2CH_2CH_2NH_2)_2Cl_2]^+$, all having the same basic shape.

(i) State the shape of these complexes:

....

(ii) Draw structures of these three complexes to show the differences between them:

Complex I | Complex II | Complex III

(iii) Which of the complexes you have drawn above will have a dipole?

....

[5]

[Total: 7]

4 **(a)** Explain what is meant by ligand exchange.

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……………………………………………………………………………………………………

[1]

(b) Describe all the colour changes and observations that take place when an aqueous solution of ammonia is gradually added to a solution of Cu^{2+}(aq), until the ammonia is in excess. Write equations for these transformations.

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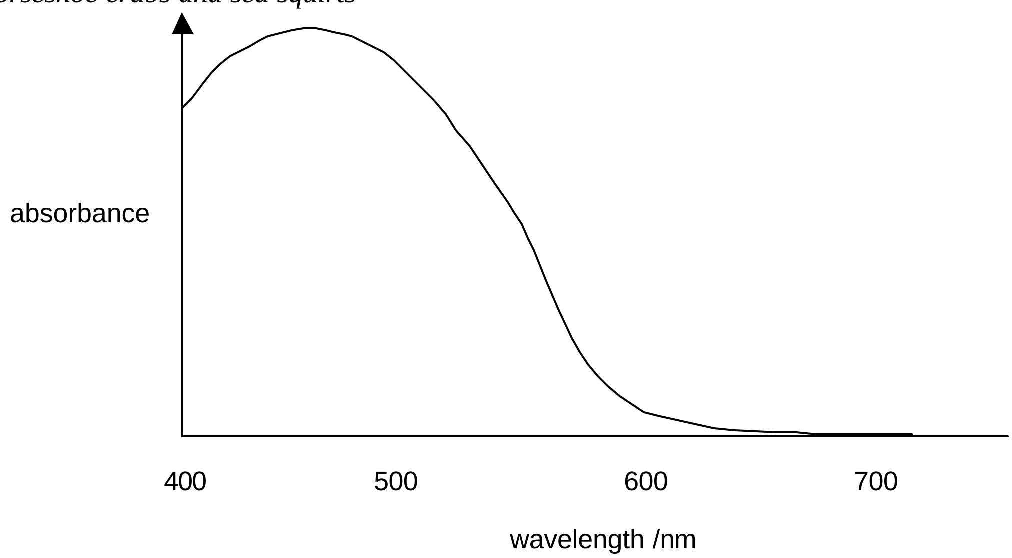
[4]

(c) Blood gets its colour from oxygen-carrying molecules with organic groups surrounding a transition metal ion. In humans this transition metal is iron, and the blood is red. In horseshoe crabs, the metal is copper and the blood is blue, and in sea squirts the metal is vanadium and the blood is green.

The sketch below shows the major absorption peak for human blood.

On this sketch show and label the corresponding absorption peaks for the blood of horseshoe crabs and sea squirts



[2]

(d) A 0.0100 mol sample of an oxochloride of vanadium, $VOCl_x$ required 20.0 cm^3 of 0.100 mol dm^3 acidified potassium manganate(VII) for oxidation of the vanadium to its +5 oxidation state.

(i) Calculate how many moles of potassium manganate(VII) were reacted.

(ii) How many moles of electrons were removed by the MnO_4^- ions?

....

(iii) Determine the change in oxidation state of the vanadium.

(iv) Deduce the value of x in the formula $VOCI_x$.

....

[4]

[Total: 11]

5 Cobalt(II) forms the following coloured complexes with water molecules and chloride ions: $[Co(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

Describe how the different ligands, H_2O and Cl^- affect the stereochemistry and colour of these complexes. (*In this question, 1 mark is available for the quality of written communication.)*

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[Total: 9]

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

TRANSITION ELEMENTS **2815/06**

Mark Scheme

1 **(a)** filter paper/material soaked in (aqueous saturated) KNO_3 / glass tube of agar/gel + aqueous saturated KNO_3 ✓ AO1: 1

[1]

(b) **(i)** $Cu(s) \longrightarrow Cu^{2+} + 2e^-$ ✓
AO1: 1

(ii) $Ag^+(aq) + e^- \longrightarrow Ag(s)$ ✓
AO1: 1
[2]

(c) $Cu(s) + 2Ag^+ \longrightarrow Cu^{2+} + 2Ag$ ✓
AO2: 1
[1]

(d) **(i)** $E^{\ominus}_{cell} = +0.80 - (+0.34)$ ✓

$= +0.46$ V ✓
AO2: 2

(ii) silver ✓
explanation in terms of electron gain/ change in oxidation state/
system A moves to right/has more positive standard electrode potential ✓
AO2: 2
[4]

(e) *any 2 points from:*

conditions not standard / cell operating at <100% efficiency / temperature not standard / concn. of either solution changes/ surface contamination of electrodes ✓✓
AO2: 1
[2]

[Total: AO1: 3; AO2: 7 = 10]

2 **(a)** +6 ✓
AO1: 1
[1]

(b) **(i)** orange ✓
AO1: 1

(ii) $2CrO_4^{2-}(aq) + 2H^+(aq) \longrightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$ ✓
AO1: 1
[2]

(c) **(i)** Cr^{3+} ✓
AO1: 1

(ii) green ✓
AO1: 1
[2]

(d) **(i)** Mn = 39.7/54.9 = 0.723 ⇒ 1
O = 34.7/16 = 2.169 ⇒ 3
Cl = 25.6/35.5 = 0.721 ⇒ 1 ✓
⇒ MnO_3Cl ✓
AO1: 2

(ii) +7 ✓

AO1: 1
[3]

[Total: AO1: 8]

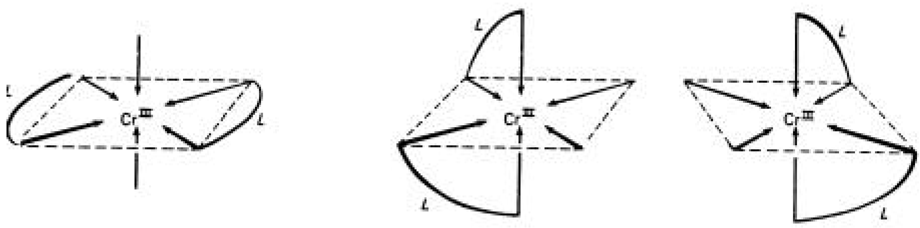
3 **(a)** A *bidentate ligand* is a molecule(or ion) having two **lone pairs of electrons**, capable of forming **two dative bonds** to a metal.

AO1: 2
[2]

(b) **(i)** octahedral ✓

AO2: 1

(ii)



Complex I ✓ (trans) | Complex II ✓ (cis, (+)) | Complex III ✓ (cis, (-))

AO2: 3

(iii) Complexes II and III (as drawn above) ✓

AO2: 1
[5]

[Total: AO1: 2; AO2: 5 = 7]

4 **(a)** substitution of one ligand for another ✓

AO1: 1
[1]

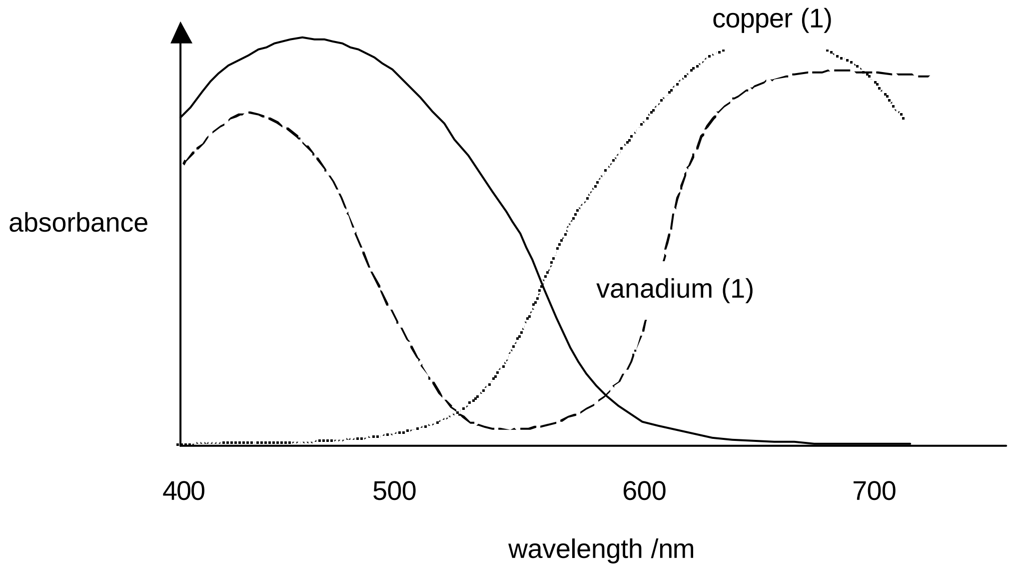
(b) pale blue ppt ✓
$Cu^{2+}(aq) + 2OH^{-}(aq) \longrightarrow Cu(OH)_2(s)$ ✓

AO1: 2

dissolves to give deep blue solution ✓
$Cu(OH)_2(s) + 4NH_3(aq) \longrightarrow [Cu(NH_3)_4]^{2+}(aq) + 2OH^{-}(aq)$ ✓

AO1: 2
[4]

(c)



✓ ✓ AO2: 2
[2]

(d) **(i)** 0.002 mol ✓

(ii) 5 ✓

(iii) increases by 1 ✓

(iv) 2 (i.e. $VOCl_2$) ✓

AO2: 4
[4]
[Total: AO1: 5; AO2: 6 = 11]

5 ***Quality of written communication assessed in this question***

$[Co(H_2O)_6]^{2+}$ is an octahedral complex ion ✓
$[CoCl_4^{2-}]$ is tetrahedral ✓
As ligands approach the Co^{2+} ion the d-orbitals split into two energy levels ✓
In the Co^{2+} ions the d-orbitals are not full ✓
In promoting electrons from lower to higher energy orbitals ✓,
visible radiation is absorbed ✓
The complex appears as the complementary colour to that absorbed ✓
O atoms are smaller than Cl^- ions ✓,
hence water can pack closer to the Co^{2+} ion / there is not enough room to pack six chloride ions to give octahedral structure. ✓

9 ⟶ AO1: 8 max
Clear, well-organised, using specialist terms *1 mark*
[8]

[Total: AO1: 8; qowc: 1 = 9]

Assessment Grid: Unit 2815, Component 06: Transition Elements

Question	AO1	AO2	AO4	QoWC	Total
1	3	7			10
2	8				8
3	2	5			7
4	5	6			11
5	8			1	9
Total	**26**	**18**		**1**	**45**

Assessment Grid: Unit 2815, Component 06: Transition Elements

Question			Assessment outcome	AO1	AO2	AO4	QoWC	Total
1	**(a)**	**(i)**	5.10.1(b)	1				
	(b)	**(i)**	5.10.1(d); 5.5.3(j)	1				
		(ii)	5.10.1(d); 5.5.3(j), (k)	1				
	(c)		5.5.3(j), (k)		1			
	(d)	**(i)**	5.10.1(c)		2			
		(ii)	5.10.1(d); 5.1.5(c)		2			
	(e)		5.10.1(e)		1			
			Total	**3**	**7**			**10**
2	**(a)**		5.1.5(b)	1				
	(b)	**(i)**	5.10.4(b)	1				
		(ii)	5.10.4(b)	1				
	(c)	**(i)**	5.10.4(b)	1				
		(ii)	5.10.4(b)	1				
	(d)	**(i)**	5.1.1(h)	2				
		(ii)	5.1.5(b)	1				
			Total	**8**				**8**
3	**(a)**		5.10.2(a), (c)	2				
	(b)	**(i)**	5.10.2(b), (c)		1			
		(ii)	5.10.2(c)		3			
		(iii)	5.1.3(i), (k)		1			
			Total	**2**	**5**			**7**
4	**(a)**		5.10.3(d); 5.5.3(f)	1				
	(b)		5.5.3(d), (f)	4				
	(c)		5.10.3(e)		2			
	(d)	**(i)**	5.1.1(j); 5.5.3(j)		1			
		(ii)	5.5.3(j); 5.1.3(k)		1			
		(iii)	5.10.4(a); 5.1.5(c)		1			
		(iv)	5.1.3(k)		1			
			Total	**5**	**6**			**11**
5			5.10.3(a), (b), (d); 5.10.4(c)	8				
			Total	**8**			**1**	**9**
			TOTAL	**26**	**28**		**1**	**45**

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY
UNIFYING CONCEPTS IN CHEMISTRY **2816/01**

Specimen Paper

Additional materials:
Answer paper
Chemistry Data Sheet

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
Write all your answers on the separate answer paper provided.
If you use more than one sheet of paper, fasten the sheets together.
Answer **all** questions.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
You will be awarded marks for the quality of written communication where an answer requires a piece of extended writing.
In this paper you are expected to show your knowledge and understanding of different aspects of Chemistry and the connections between them.

The total mark on this paper is 60.

Answer **all** questions.

1. Nitrogen oxides such as nitrogen monoxide, NO, and nitrogen dioxide, NO_2, are formed unintentionally by man and cause considerable harm to the environment.

(a) The oxidation of nitrogen monoxide in car exhausts may involve the following reaction:

$$NO(g) + CO(g) + O_2(g) \longrightarrow NO_2(g) + CO_2(g)$$

This reaction was investigated in a series of experiments. The results are shown below in the table below.

experiment	[NO(g)] /mol dm^{-3}	[CO(g)] /mol dm^{-3}	[O_2(g)] /mol dm^{-3}	initial rate /mol $dm^{-3}s^{-1}$
1	1.00×10^{-3}	1.00×10^{-3}	1.00×10^{-1}	0.44×10^{-3}
2	2.00×10^{-3}	1.00×10^{-3}	1.00×10^{-1}	1.76×10^{-3}
3	2.00×10^{-3}	2.00×10^{-3}	1.00×10^{-1}	1.76×10^{-3}
4	2.00×10^{-3}	2.00×10^{-3}	4.00×10^{-1}	7.04×10^{-3}

(i) For each reactant, deduce the order of reaction. Show your reasoning.

NO ....

....

CO...

....

....

O_2 ....

....

....

(ii) Deduce the rate equation and calculate the rate constant for this reaction.

(iii) Suggest, with a reason, what would happen to the value of the rate constant, k, as the car's exhaust gets hotter.

....

....

....

[11]

(b) State **two** environmental consequences of nitrogen oxides.

....

....

....

[2]

(c) Not all nitrogen compounds are harmful: some, such as nitrogen fertilisers, are beneficial to man.
A nitrogen fertiliser, **D**, was analysed in the laboratory and was shown to have the composition by mass Na, 27.1%; N, 16.5%; O, 56.4%. On heating, 3.40 g of **D** was broken down into sodium nitrite, $NaNO_2$, and oxygen gas

Showing your working, suggest an identity for the fertiliser, **D**, and calculate the volume of oxygen that was formed.
[Under the experimental conditions, 1 mole of gas molecules occupy 24 dm^3.]

[4]
[Total: 17]

2. Ethanol, C_2H_5OH, is an important industrial chemical with about 200,000 tonnes manufactured in the UK each year. The usual method of manufacture is by the hydration of ethene with steam in the presence of a phosphoric acid catalyst at 550 K and a pressure of about 7000 kPa.

$$C_2H_4(g) + H_2O(g) \ ? \ C_2H_5OH(g) \qquad \Delta H = -46 \text{ kJ mol}^{-1}$$

(a) **(i)** Predict, with justification, the optimum conditions for this reaction.

....

....

....

....

....

(ii) Explain why the actual conditions used may be different from the optimum conditions.

....

....

....

(iii) The boiling points of the three chemicals involved in this equilibrium are shown the table below.

compound	C_2H_4	H_2O	CH_3CH_2OH
boiling point/°C	–104	100	78

Suggest how the ethanol could be separated from the equilibrium mixture.

....

[8]

(b) **(i)** Write an expression for K_p of this reaction and

(ii) explain, with a reason in each case, whether you would expect the value of K_p to alter if any of the external variables below were changed as indicated.

increase in temperature..

....

increase in pressure..

....

presence of catalyst...

....

[5]

(c) Alcohols such as ethanol can be used as alternative fuels to petrol. The combustion of ethanol tends to be more complete than the combustion of the alkanes present in petrol, partly because less oxygen is required for combustion.

(i) Use equations to compare the amount of oxygen required per gramme of fuel combusted.

(ii) Suggest why there is this difference between the amount of oxygen required per gramme for these two fuels.

....

....

[5]
[Total: 18]

3. This question refers to different aspects of acid/base chemistry:

(a) Hydrochloric acid HCl is classed as a **strong** acid but it can have both **concentrated** and **dilute** solutions. Explain why this is so.

....

....

....

....

[3]

(b) Sodium phosphate, Na_3PO_4, a water-softening agent, can be prepared in the laboratory by neutralising phosphoric acid.

A student prepared this compound in the laboratory from 20.0 cm^3 of 0.100 mol dm^{-3} phosphoric acid and 0.250 mol dm^{-3} sodium hydroxide:

$$H_3PO_4(aq) + 3NaOH(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$$

(i) Deduce the oxidation state of phosphorus in sodium phosphate, Na_3PO_4.

(ii) Calculate the volume of NaOH(aq) that the student would need to use to just neutralise the phosphoric acid using the quantities above.

[4]

(c) Calculate the pH of the NaOH(aq) used in **(b)** (K_w = 1.00 x 10^{-14} mol^2 dm^{-6}.)

[4]
[Total: 11]

4. Using knowledge, principles and concepts from different areas of chemistry, explain and interpret, as fully as you can, the data given in the table below. In order to gain full credit, you will need to consider each type of information separately and also to link this information together. *(In this question, 1 mark is available for the quality of written communication.)*

compound	boiling point /K	properties of a 0.1 mol dm^{-3} solution	
		electrical conductivity	$[H^+]$/mol dm^{-3}
NaCl	1686	good	1.0 x 10^{-7}
CH_3COOH	391	slight	1.3 x 10^{-3}
CH_3CH_2OH	352	poor	1.0 x 10^{-7}
$AlCl_3$	451	good	3.0 x 10^{-1}

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[Total: 14]

Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

Advanced GCE

CHEMISTRY

UNIFYING CONCEPTS IN CHEMISTRY **2816/01**

Mark Scheme

Each ✓ is a marking point

1 **(a)** **(i)** 2nd order ✓
using experiments 1 and 2, $[NO_2]$ doubled, rate quadrupled ✓

CO(g), zero order ✓
using experiments 2 and 3, [CO] doubled, rate constant ✓

O_2(g), 1st order ✓
using experiments 1 and 2, $[O_2]$ doubled, rate quadrupled ✓

AO4: 6

(ii) rate = $k[NO]^2[O_2]$ ✓

$k = 4400$ ✓
units = $dm^6 mol^{-2} s^{-1}$ ✓

AO4: 3

(iii) temperature of reactants increases / rate increases ✓
rate constant *k* increases ✓

AO4: 2
[11]

(b) nitrogen oxides cause **acid** (rain) ✓, greenhouse effect ✓ photochemical smog/ozone build-up ✓

AO4: 2 max
[2]

(c) **F** Na: N: O = 27.1/23 : 16.5/14.0 : 56.4/16.0 ✓

= $NaNO_3$ ✓

EITHER: *equation*: $2NaNO_3 \longrightarrow 2NaNO_2 + O_2$
OR: 0.04 mol $\longrightarrow$ 0.02 mol ✓ *(idea of a 2:1 ratio)*

24*0.0200 dm^3 = 0.48 dm^3 ✓ *(Units required)*

AO4: 4
[4]

[Total: AO4: 17]

2. **(a)** **(i)** low temperature & high pressure ✓
temperature: as temperature decreased, system acts to restore temperature ✓

equilibrium position moves in exothermic direction ✓

pressure: increase pressure, system acts to reduce pressure ✓

equilibrium moves towards side with smaller number of gas moles ✓

AO4: 5

(ii) low temperatures may mean a very slow rate of reaction ✓
increased pressure may be expensive to generate/unsafe ✓

AO4: 2

(iii) Fractional distillation ✓

AO4: 1

[8]

(b) **(i)** $K_p = p\,(C_2H_5OH) / (p\,(C_2H_4) \times p\,(H_2O))$ ✓

AO4: 1

(ii)

increase temperature: K_p decreases ✓

exothermic reaction: change in equilibrium achieved by change in K_p value. ✓

increase pressure: K_p is unchanged because

K_p is temperature dependent only/change achieved by restoring K_p value ✓

presence of catalyst: K_p is unchanged because

K_p is temperature dependent only/catalyst speeds up reaction only ✓

AO4: 4

[5]

(c) **(i)** $C_2H_5OH + 3\,O_2 \longrightarrow 2CO_2 + 3H_2O$ ✓

$C_8H_{18} + 12.5\,O_2 \longrightarrow 8CO_2 + 9H_2O$ ✓

1 g ethanol requires 3/46 = 0.065 mol O_2 ✓

1 g octane requires 12.5/114 = 0.11 mol O_2 ✓

AO4: 4

(ii) ethanol contains oxygen in its molecule which contributes to the combustion ✓

AO4: 1

[5]

[Total: AO4 = 18]

3 **(a)** a **strong** acid completely dissociates ✓

concentration is a measure of moles per cubic decimetre ✓

concentrated (many) and dilute (few) refer to the relative number of mol dm^{-3} ✓

AO4: 3

[3]

(b) **(i)** (+)5 ✓

AO4: 1

(ii) moles H_3PO_4 = 0.100 x 20.0/1000 = 0.00200 mol ✓

moles NaOH = 3 x moles H_3PO_4 / moles NaOH = 3 x 0.00200 = 0.00600 mol ✓

(i.e. use of 3:1 molar ratio. For e.c.f., answer to (i) x 3))

volume NaOH = 0.00600 x 1000/0.250 = 24.0 cm^3 H_3PO_4 ✓

(i.e. scaling. Units required)

For e.c.f., answer above x 1000

[answer only gives full 2 marks]

AO4: 3

[4]

(c) $K_w = [H^+(aq)][OH^-]$ ✓

$\therefore$ $[H^+(aq)] = 1.00 \times 10^{-14} / 0.250$ ✓ $= 4 \times 10^{-14}$ mol dm^{-3}

pH = $-\log[H^+]$ ✓

pH = $-\log(4 \times 10^{-14}) = 13.4$ ✓ AO4: 4

[4]

[Total AO4 = 11]

4 ***Quality of written communication is assessed in this question***

Candidates will link information together in many ways. The scheme below highlights key marking points.

NaCl: giant lattice ✓: strong forces *(high b pt)* ✓ between ions *(conductivity)* ✓

CH_3COOH, CH_3CH_2OH and $AlCl_3$: simple molecular ✓: weak forces *(low b pt)* ✓ between molecules *(conductivity)* ✓

NaCl mobile ions *(conductivity)* ✓

CH_3CH_2OH no mobile charge carriers *(conductivity)*✓

CH_3COOH partial dissociation to ions *(conductivity)* ✓

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ ✓

$AlCl_3$ conducts by reacting forming ions *(conductivity and [H⁺])*✓

$AlCl_3$ forms HCl(aq) / $AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3H^+ + 3Cl^-$ ✓

Solutions of NaCl and CH_3CH_2OH are neutral/pH = 7 *($[H^+]$)* ✓

Solution of $AlCl_3$ has a pH = 0.5 *($[H^+]$)* ✓

Solution of CH_3COOH has a pH = 2.88 *($[H^+]$)*✓

$K_a = [CH_3COO^-][H^+]/[CH_3COOH]$ ✓

$= [H^+]^2/[CH_3COOH]$ ✓ $= [1.3 \times 10^{-3}]^2/0.1$ ✓ $= 1.7 \times 10^{-5}$ mol dm^{-3} ✓*($[H^+]$ and $[CH_3COOH]$)*

[AO4: 13 max]

Clear, well-organised, using specialist terms *1 mark*

[Total: AO4: 13; QoWC 1 = 14]

Assessment Grid: Unit 2816, Component 01: Unifying Concepts in Chemistry

Question	AO1	AO2	AO4	QoWC	Total
1			17		17
2			18		18
3			11		11
4			13	1	14
Total			59	1	60

Assessment Grid: Unit 2816, Component 01: Unifying Concepts in Chemistry (Details)

Question			Assessment outcomes	AO1	AO2	AO4	QoWC	Total
1	(a)	(i)	5.11.1(e)			6		
		(ii)	5.11.1(f), (g)			3		
		(iii)	5.11.1(h)			2		
	(b)		5.3.2(j)			2		
	(c)		5.1.1(h), (j), (k)			4		
			Total			**17**		**17**
2	(a)	(i)	5.3.3(b), (c)			5		
		(ii)	5.3.3(c)			2		
		(iii)	5.1.3(p)			1		
	(b)		5.11.2(c)			1		
			5.11.2(e)			4		
	(c)		5.2.5(d); 5.2.3(c); 5.1.1(i), (j), (k); 5.3.1(b), (f)			5		
			Total			**18**		**18**
3	(a)		5.3.3(h); 5.1.1(j)			3		
	(b)	(i)	5.1.5(b)			1		
		(ii)	5.1.1(j), (k)			3		
	(c)		5.11.3(b), (c)			4		
			Total			**11**		**11**
4			from: 5.1.3(p), (q) 5.3.3(g), (h); 5.4.3(a) 5.5.2(a) 5.11.3(c)			13	1	
			Total			**13**	**1**	**14**
			TOTAL			**59**	**1**	**60**

Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

Advanced GCE

CHEMISTRY
PRACTICAL EXAMINATION 2 **2816/03**

Specimen Planning Task for Skill P.

In this planning task, you will need to use and bring together chemical knowledge, understanding and practical techniques from different parts of your chemistry course.

In your response, you will be assessed for Quality of Written Communication.

OCR – set Planning Task for Skill P for Unit 2816, Component 03.

Skill P Planning

This part of Practical Examination 2 is a planning exercise.

Your plan, which should be between 500 and 1000 words, can be word processed if you wish.

Your plan must show that you have consulted an appropriate range of resources such as textbooks, CD-ROMs and databases. All resources used should be clearly referenced.

Your plan must be fastened to your answers to Practical Examination 2.

You are provided with the following task.

Analysis of the iron(II) and iron(III) in a sample of an iron-containing ore

Compounds of iron are found in a variety of ores, and may be present as both oxidation states (II) and (III).

You are to plan an experimental procedure which would allow you to determine the proportions by mass of Fe^{2+} and Fe^{3+} in a sample of an ore. You should take into account the fact that the ore will contain impurities, but you may assume that these will not react.

You may assume that you can use standard equipment and apparatus and chemicals available in a school or college science laboratory.

You plan should include the following:

- relevant chemical knowledge from both the AS and A2 parts of your chemistry course;
- a list of apparatus and chemicals;
- a detailed method which provides full instructions, including any necessary safety precautions.

Any quotations from the work of others should be acknowledged by quotation marks, with page references, and the sources should be included in a bibliography.

You need to produce a clear account using scientific language and accurate spelling, punctuation and grammar.

[8]

Oxford Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

PRACTICAL EXAMINATION 2 **2816/03**

PRACTICAL TEST

Additional materials:

Answer paper
Chemistry Data Sheet

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, Centre number and candidate number in the spaces provided.
Write all your answers in the spaces provided on the question paper.
If you need to use any more than one sheet of paper, fasten the sheets together securely.
Your plan for the OCR – set planning task must be fastened to your answers to Practical Examination 2.
Answer **all** questions.

INFORMATION FOR CANDIDATES

In this part of Practical Examination 2, you will be assessed on the Experimental and Investigative Skills below:

Skill I Implementing
Skill A Analysing evidence and drawing conclusions
Skill E Evaluating evidence and procedures

You may use a calculator.

You are advised to show all working in calculations.

Use of the *Data Sheet* is allowed.

Practical Task: Introduction

Solution **A** contains a mixture of Fe^{2+} and Fe^{3+}.

Solution **B** is 0.0100 mol dm^{3} potassium manganate(VII), $KMnO_4$.

The percentages of Fe^{2+} and Fe^{3+} in solution **A** can be determined using the following procedure which has 3 parts:

Part 1.

A sample of solution **A** is heated with a reducing agent such as zinc and dilute sulphuric acid. The reducing agent converts Fe^{3+} in the mixture to Fe^{2+} and all the iron in the mixture will now be present as Fe^{2+}.

Part 2.

A sample of original solution **A** is titrated with acidified potassium manganate(VII) to find the Fe^{2+} content of the mixture.

Part 3.

The reduced mixture from **Part 1** is titrated with acidified potassium manganate(VII) to find the total iron content of the mixture.

You will carry out **Part 1** and **Part 3** of the task. You will be provided with results for the **Part 2**.

In your answers, you should consider relevant chemistry from both the AS and A2 parts of your chemistry course.

Part 1

- Pipette 25.00 cm^3 of solution **A** into 250 cm^3 conical flask. To this add about 25 cm^3 of dilute sulphuric acid and approximately 3 g of granulated zinc. Put a filter funnel in the neck of the flask and place it on a tripod and warm for 10 minutes. The hot mixture will reduce all of the Fe^{3+} ions to Fe^{2+}.
- While your mixture is warming, prepare the titration apparatus required for **Part 3**.
- You will need the resulting solution for **Part 3**. Label this solution **C** and leave it to cool. While the solution is cooling, complete **Part 2**.

Part 2

A sample of the original solution **A** was titrated with acidified potassium manganate(VII) to find the Fe^{2+} content of the mixture.

By carrying out this procedure, it was shown that 25.0 cm^3 of solution **A** reacted exactly with ……...cm^3 of 0.0100 mol dm^3 potassium manganate(VII), $KMnO_4$.

The half equations for the reaction between iron(II) ions and acidified aqueous manganate(VII) ions in this titration are:

$$Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$$
$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$$

- Use the results obtained from **Part 2** to calculate the concentration, in mol dm^{-3}, of the Fe^{2+} content of **A**.

Part 3

Remove the excess zinc from solution **C** by passing the solution into a 250 cm^3 volumetric flask through a filter funnel containing mineral wool. (**Care is needed in the handling of mineral wool.**) Rinse the conical flask and residue in the filter funnel with distilled water and add all rinsings to the volumetric flask. Then make the solution up to 250 cm^3 and label this solution **D**.

- Pipette 25.00 cm^3 of solution **D** into a conical flask and add about 10 cm^3 of dilute sulphuric acid. Titrate this solution with the manganate(VII) solution, **B**, until the first permanent pink colour remains in the solution.
- Repeat the titration as many times as you think necessary to obtain accurate results.
- Record your results in a suitable format in the space below.

Results

Summary

25.00 cm^3 of solution **D** reacted with ________ cm^3 of solution **B**.

Safety

Outline the safety precautions that you have taken during your experiment. Give your reason(s) for each precaution taken.

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[7]

(a) Use your results obtained from **Part 3** to calculate the concentration, in mol dm^{-3}, of the total iron content (i.e. Fe^{2+} and reduced Fe^{2+}) in the original solution **A**.

(b) Use your result from **(b)** and the value obtained from **Part 2** to calculate the percentage by mass of Fe^{2+} and Fe^{3+} in the original solution **A**.

[8]

Skill E Evaluating evidence and procedures

This evaluation is in two parts.

(a) You are asked to evaluate the practical task that you have carried out.

In your evaluation, you should:

- identify clearly any anomalous results.
- identify the main sources of error.
- compare, with reasons, the accuracy and reliability of your measurements and indicate, the accuracy of the measurements that you made.
- compare, with reasons, the accuracy and reliability of the different techniques that you used during the practical task.
- comment on the overall accuracy of your final result.
- suggest improvements that could be made to the experimental procedures whilst following essentially the same general method. You should consider improvements that improve the reliability of the results and that minimise errors.

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(b) Another method that could be used to find the percentages of Fe^{2+} and Fe^{3+} in solution **A** is outlined below:

Part 1.

A sample of solution **A** is added to an excess of aqueous potassium thiocyanate KCNS(aq). The Fe^{3+} ions present in solution **A** react forming the deep-red complex ion $[Fe(H_2O)_5CNS]^{2+}$. This allows the concentration of Fe^{3+} in solution **A** to be determined by colorimetry.

Part 2.

A sample of original solution **A** is titrated with acidified potassium manganate(VII) to find the Fe^{2+} content of the mixture.

Carefully compare this method with the method that you used in the practical task. You should consider relevant chemistry from both the AS and A2 parts of your chemistry course.

In your comparison, you should

- consider advantages and disadvantages of each procedure in terms of the accuracy and reliability of any measurements made;
- justify which of the two procedures would be likely to give a more accurate result.

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[7]

Oxford, Cambridge and RSA Examinations

Advanced GCE

CHEMISTRY

PRACTICAL EXAMINATION 2 **2816/03**

Mark Scheme

Skill P - Planning **Total 8**

The candidate:

Mark	General strategy	Level	Choices within plan	Level
0				
1	**P.1a** suggests a method that could be used to estimate the amount of either Fe^{2+} or Fe^{3+}.		**P.1b** chooses appropriate apparatus for estimation of either Fe^{2+} or Fe^{3+}.**	
2				
3	**P.3a** uses information from one source suggests methods that could be used to estimate the amounts of both Fe^{2+} and Fe^{3+}. **uses knowledge and understanding from more than one area of the specification*.**		**P.3b** chooses appropriate apparatus for estimation of both Fe^{2+} or Fe^{3+}.	
4				
5	**P.5a** as 3a. uses information from two sources **uses and links together effectively knowledge and understanding from more than one module of the specification**. takes into account the need for safe working provides detailed procedures which allow both concentrations to be determined.		**P.5b** as 3b. gives detail of reagents required for both methods.	
6				
7	**P.7a** as 5a. retrieves and evaluates information from three or more sources **uses knowledge and understanding from different parts of the AS and A2 specification with due consideration to more than one approach**. chooses a method which allow a high level of accuracy. provides a plan which is well structured, logical and linked coherently to underlying scientific knowledge and understanding, with accurate spelling, punctuation and grammar throughout.		**P.7b** as 5b. provides accurate details of concentrations of solutions, indicators and apparatus to ensure the highest level of precision and reliability.	
8				

*** areas of the specifications could include AS: Foundation Chemistry, use of the mole concept and reacting quantities (5.1.1(j), (k)), and A2: Trends and Patterns, redox titrations (5.5.3(j), (k), (l)) and colorimetry (5.5.3(h)).**
**** suitable methods could include a titration, colorimetry (or other acceptable method)** Total: AO3: 1; AO4: 7 = 8

Skill I – Implementing **Total 7**

The candidate:

Mark	Manipulation	Level	Recording	Level
0				
1	**I.1a** demonstrates competence in simple techniques (e.g. use of burette, warming of solution, filtering). shows some awareness of the need for safe working (e.g. eye protection).		**I.1b** makes and records observations and/or measurements which are adequate for the activity, e.g. burette readings.	
2				
3	**I.3a** as 1a shows competence in a technique with 2 titres within 0.20 cm^3. makes some comment about at least three of the chemicals used: Fe^{2+}, Fe^{3+}, $KMnO_4$, Zn, H_2SO_4.		**I.3b** makes systematic and accurate observations and/or measurements which are recorded clearly and accurately. obtains results for one of the titrations which are accurate to within 0.40 cm^3 of the supervisor's result.	
4				
5	**I.5a** as 3a. makes some comment about the hazard of all reagents: Fe^{2+}, Fe^{3+}, $KMnO_4$, Zn, H_2SO_4. or all techniques shows a high level of competence in a technique with 2 titres within 0.15 cm^3.		**I.5b** records measurements with regard to the precision of the apparatus used. obtains results which are accurate to within 0.20 cm^3 of the supervisor's result. records measurements in an appropriate format.	
6				
7	**I.7a** as 5a efficiently **brings together all practical techniques** in the available time by obtaining at least two accurate titres within 0.10 cm^3. makes some comment about the hazards of all reagents and all techniques, justifying any safety precautions taken.		**I.7b** obtains titration results accurate to within 0.10 cm^3 of the supervisor's results; records observations in an appropriate format with volumes recorded to the nearest 0.05 cm^3.	
8				

Total: AO3: 6; AO4: 1 = 7

Skill A - Analysing Evidence and Drawing Conclusions — Total 8

The candidate:

Mark	Processing evidence	Level	Drawing conclusions	Level
0				
1	**A.1a** is able to process titration results to obtain an average titre.		**A.1b** is able to make progress with a calculation (e.g. number of moles of $KMnO_4$ used.).	
2				
3	**A.3a** as 1a makes use of the reacting moles by using half equations.		**A.3b** as 1b **draws together knowledge and understanding from more than one area of the specification, e.g. AS: Foundation Chemistry, use of the Mole Concept and reacting quantities in aqueous solutions, A2: Unifying concepts, Redox titrations to calculate the concentration of Fe^{2+} in solution A in Part 2.**	
4				
5	**A.5a** as 3a. takes into account the need for scaling when considering dilution of solutions used in a titration.		**A.5b** as 3b. **independently draws together knowledge and understanding from more than one module of the specification: e.g. as 3b, and is able to independently analyse data requiring scaling of reacting quantities to calculate the total iron concentration in solution A in Part 3.**	
6				
7	**A.7a** as 5a. explains the calculation fully and clearly, showing due regard to nomenclature, terminology and the use of significant figures.		**A.7b** as 5b. **independently links together knowledge and understanding from different parts of the AS and A2 specification: e.g. as 5b and is able to link together data from Part 2 and Part 3 of the practical task and independently convert moles to masses to calculate the percentages of Fe^{2+} and Fe^{3+} in solution A.**	
8				

Total: AO3: 2; AO4: 6 = 8

Skill E - Evaluating Evidence and Procedures Total 7

The candidate:

Mark	Evaluating procedures	Level	Evaluating evidence	Level
0				
1	**E.1a** comments, in general terms, on the suitability of the experimental techniques used.		**E.1b** recognises where the results may be inaccurate (e.g. clearly anomalous titres are ignored).	
2				
3	**E.3a** recognises main sources of error in the techniques used (e.g. the procedure assume that Fe^{3+} is completely reduced; problems with complete transfer of Fe^{2+} following reduction).		**E.3b** comments on the reliability and accuracy of measurements made (with respect to volumetric apparatus). suggests reasons for any unreliable results.	
4				
5	**E.5a** as 3a. recognises how errors in technique will affect the experimental result, e.g. incomplete reduction of Fe^{3+} to Fe^{2+} would produce a result with a low Fe^{2+} concentration. suggests methods of improvement., where appropriate.		**E.5b** as 3b. compares the accuracy of the measurements made (e.g. estimates the accuracy of burette readings, volumetric readings; accuracy of readings made is justified). methods for improvement provide for more accurate measurements.	
6				
7	**E.7a** as 5a justifies proposed improvements to the experimental procedures and/or strategy in terms of minimising significant sources of error, e.g. Fe^{2+} may reoxidise prior to titration so measures could be put in place to eliminate air.		**E.7b** compares, with justification, the two methods **using knowledge and understanding from more than one area of the specification**.	
8				

Total: AO3: 6; AO4: 1 = 7

Assessment Grid: Unit 2816, Component 03: Practical Examination 2

Skill	AO3	AO4	Total
P	1	7	8
I	6	1	7
A	2	6	8
E	6	1	7
Total	**15**	**15**	**30**

Statements in bold require candidates to link together their knowledge and understanding from different areas of the specification. Skill levels requiring this skill are assigned to AO4.

Skill	descriptor		AO3	AO4	Total
P	1a	1b	1		
P	3a	3b		2	
P	5a	5b		2	
P	7a	7b		2	
	8			1	
			1	**7**	**8**
I	1a	1b	1		
I	3a	3b	1		
I	5a	5b	2		
I	7a	7b	1	1	
			6	**1**	**7**
A	1a	1b	1		
A	3a	3b	1	1	
A	5a	5b		2	
A	7a	7b		2	
	8			1	
			2	**6**	**8**
E	1a	1b	1		
E	3a	3b	1		
E	5a	5b	2		
E	7a	7b	1	1	
			6	**1**	**7**
	Total		**15**	**15**	**30**