Oxford Cambridge and RSA

H

GCSE (9–1)

Chemistry A (Gateway Science)

J248/04: Paper 4 (Higher Tier)

General Certificate of Secondary Education

Mark Scheme for Autumn 2021

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

1. Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

2. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

3. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

The breakdown of Assessment Objectives for GCSE (9-1) in Chemistry:

	Assessment Objective
AO1	**Demonstrate knowledge and understanding of scientific ideas and scientific techniques and procedures.**
AO1.1	Demonstrate knowledge and understanding of scientific ideas.
AO1.2	Demonstrate knowledge and understanding of scientific techniques and procedures.
AO2	**Apply knowledge and understanding of scientific ideas and scientific enquiry, techniques and procedures.**
AO2.1	Apply knowledge and understanding of scientific ideas.
AO2.2	Apply knowledge and understanding of scientific enquiry, techniques and procedures.
AO3	**Analyse information and ideas to interpret and evaluate, make judgements and draw conclusions and develop and improve experimental procedures.**
AO3.1	Analyse information and ideas to interpret and evaluate.
AO3.1a	Analyse information and ideas to interpret.
AO3.1b	Analyse information and ideas to evaluate.
AO3.2	Analyse information and ideas to make judgements and draw conclusions.
AO3.2a	Analyse information and ideas to make judgements.
AO3.2b	Analyse information and ideas to draw conclusions.
AO3.3	Analyse information and ideas to develop and improve experimental procedures.
AO3.3a	Analyse information and ideas to develop experimental procedures.
AO3.3b	Analyse information and ideas to improve experimental procedures.

Question			Answer	Marks	AO element	Guidance
1			D ✓	1	2.1	
2			A ✓	1	1.2	
3			D ✓	1	1.1	
4			C ✓	1	1.1	
5			C ✓	1	2.2	
6			C ✓	1	2.1	
7			B ✓	1	2.2	
8			B ✓	1	1.1	
9			C ✓	1	1.1	
10			D ✓	1	1.1	
11			B ✓	1	2.2	
12			C ✓	1	1.1	
13			D ✓	1	2.1	
14			C ✓	1	1.1	
15			D ✓	1	1.1	

For answers to Section A if an answer box is blank ALLOW correct indication of answer e.g. circled or underlined.

Question			Answer	Marks	AO element	Guidance
16	(a)		**Any three from:** **Mass spectrum** Highest m/z value or molecular ion peak is at 46 which is the M_r of ethanol ✓ Peak at m/z = 31 indicates -CH_2OH group ✓ Peak at m/z = 15 indicates -CH_3 group ✓ **Infrared spectrum** Idea that IR spectrum shows peak in range 3230-3550 which indicates an O-H bond ✓ Idea that IR spectrum shows peak at approx. 1050 which indicates a C-C bond ✓ Idea that IR spectrum shows peak at just below 3000 which indicates a C-H bond ✓ Idea that IR spectrum shows peak at approx. 1100 which indicates a C-O bond ✓	3	3.1b	**ALLOW** m/z value linked to any other molecular fragment **ALLOW** correct link between wavenumber and bond <u>from spectrum</u>
	(b)		**Any two from:** More sensitive / can analyse very small amounts of substances ✓ More accurate ✓ Faster / can carry out analysis all the time ✓	2	1.1	**IGNORE** more precise
	(c)	(i)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ Formulae ✓ Balancing ✓	2	1.1 2.1	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae e.g. C2H5Oh + 3O2 → 2CO2 + 3H2O

Question			Answer	Marks	AO element	Guidance
	(c)	(ii)	Produces soot / produces carbon monoxide / produces less energy ✓	1	1.1	 **ALLOW** produces a toxic or poisonous gas **IGNORE** produces a harmful gas
	(d)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 61 / 60.9 / 60.87 (%) award 2 marks** Atom economy = $\frac{28.0}{(28.0 + 18.0)} \times 100 \; / \; \frac{28.0}{46.0} \times 100$ ✓ = 61(%) / 60.9 (%) / 60.87(%) ✓	2	2.1	**ALLOW** atom economy formula in words for one mark i.e. atom economy = $\frac{\text{total Mr of desired products}}{\text{total Mr of all products}} \times 100$ **ALLOW** ECF **ALLOW** any correct rounding from calculator value, 60.86956522

Question			Answer	Marks	AO element	Guidance
17	(a)	(i)	Idea of looking at each stage of the life of a product to work out the potential environmental impact at each stage ✓	1	1.1	
		(ii)	**Any two from:** Raw materials needed ✓ Energy used in processing or manufacturing ✓ Water used in processing or manufacturing ✓ Energy needed to <u>use</u> the product ✓ Energy needed to <u>maintain</u> the product ✓ Water or other substances needed to maintain the product ✓ Energy needed to <u>dispose</u> of the product ✓ Space needed to dispose of the product ✓	2	1.1	**ALLOW** sustainability **ALLOW** idea of environmental impact of transporting raw materials **ALLOW** do the materials used decompose or break down **ALLOW** can the product be recycled **IGNORE** references to cost **IGNORE** references to waste products or pollution (stem of question)

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	Vehicle operation ✓	1	3.1a	
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 9.5 (tonnes) award 4 marks** Mass of CO_2 produced by petrol car = 80% of 29.8 tonnes = 23.84 (tonnes) ✓ Mass of CO_2 produced by diesel car = 70% of 20.5 tonnes = 14.35 (tonnes) ✓ Difference = 23.84 – 14.35 = 9.49 (tonnes) ✓ To **2 sig figs** = 9.5 (tonnes) ✓	4	3.2b	**ALLOW** ECF **ALLOW** ECF **ALLOW** 1 mark for correct identification of percentages of CO_2 from vehicle operation for each car (petrol – 80%, diesel – 70%), if no other mark awarded **ALLOW** answers given to 2 sig figs throughout the question, i.e. Mass of CO_2 produced by petrol car = 24 (tonnes) Mass of CO_2 produced by diesel car = 14 (tonnes) Difference = 10 (tonnes)

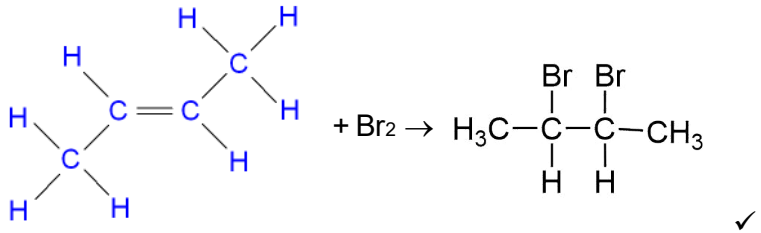
Question			Answer	Marks	AO element	Guidance
18	(a)		Use a gas syringe ✓	1	3.3b	**ALLOW** use a burette
	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.31 (cm^3/s) award 2 marks** Gradient = $\frac{\Delta y}{\Delta x}$ / $\frac{44 - 7}{120}$ / $\frac{37}{120}$ ✓ = 0.31 (cm^3/s) ✓	2	2.2 3.1a	**ALLOW** 0.3 / 0.308 / 0.3083 **ALLOW** ECF from incorrect calculation of volume ÷ time
		(ii)	Line starting at origin but steeper than original line ✓ Levels off at exactly 40 cm^3 ✓	2	2.2	
	(c)		The equation shows two HC*l* reacting with one $CaCO_3$ / ORA / Mole ratio is 2 HC*l* : 1 $CaCO_3$ / ORA / 1 mol of HC*l* reacts with 0.5 mol of $CaCO_3$ / ORA / ✓	1	2.2	**ALLOW** 0.5 mol of HC*l* reacts with 0.25 mol of $CaCO_3$ / ORA **ALLOW** idea that only 0.25 mol of $CaCO_3$ reacts **ALLOW** idea that more moles of HC*l* are needed so the $CaCO_3$ is in excess

Question			Answer	Marks	AO element	Guidance
18	(d) *		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Analyses the results to correctly identify the effects of changing the temperature AND changing the concentration, with a correct explanation of the results. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Analyses the results to correctly identify the effects of changing the temperature OR changing the concentration, with a correct explanation of the results. **OR** Correctly identifies the effects of changing the temperature AND changing the concentration **OR** Correctly explains the effect of changing the temperature AND changing the concentration. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Analyses the results to correctly identify the effects of changing the temperature OR changing the concentration. **OR** Correctly explains the effect of changing the temperature OR changing the concentration. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6	3 x 1.2 3 x 3.2b	**AO3.2b** • results of experiments 1 & 2 show that as the temperature increases the reaction time decreases, so the rate of reaction increases • results of experiments 2 & 3 show that as the concentration increases the reaction time decreases, so the rate of reaction increases • reaction rate is fastest in experiment 3 due to the combined effects of increased temperature & increased concentration **AO1.2** **Increasing concentration:** • idea of more crowded particles / particles are closer together / more particles per unit volume / more acid particles per cm^3 / more acid particles in the same space • idea of more collisions per second / collisions more often / increased collision frequency / more chance of a collision **IGNORE** references to just 'more particles' **Increasing the temperature:** • idea that acid particles move faster / particles have more energy • idea of more collisions per second / collisions more often / increased collision frequency / more chance of a collision • idea of more successful collisions / collisions between marble chips and acid are more energetic **IGNORE** references to 'faster' collisions

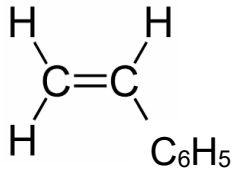
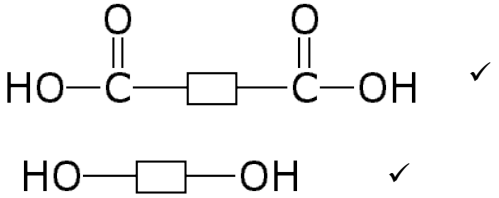
Question			Answer	Marks	AO element	Guidance
19	(a)		**Boiling point of fluorine** Answer in range -50 to -200 (°C) ✓ **Melting point of astatine** Answer in range 150 to 320 (°C) ✓	2	3.1a	
	(b)		$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$ Balancing ✓ Formulae ✓	2	1.1 2.1	**ALLOW** any correct multiple, including fractions **DO NOT ALLOW** and / & instead of '+' balancing mark is dependent on the correct formulae but **ALLOW** 1 mark for a balanced equation with a minor error in subscripts / formulae eg $CL_2 + 2NABr \rightarrow 2NaCl + Br2$
	(c)		(Group 7) atoms gain electrons ✓ Fluorine atoms are smaller (than astatine) / ORA / idea that outer electron shell is closer to the nucleus in fluorine / ORA / fluorine has less electron shells (than astatine) / ORA less shielding in fluorine (than astatine) / ORA ✓ Electrons are more strongly attracted to fluorine atoms / ORA / fluorine atoms gain electrons more easily / ORA / less energy needed to gain outer electron in fluorine / ORA ✓	3	1.1	**Assume unqualified answer refers to fluorine** **IGNORE** fluorine atoms gain electrons more quickly / ORA

Question	Answer	Marks	AO element	Guidance
(d)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 8.14(g) award 4 marks** M_r of $FeCl_3$ = 162.3 ✓ Mass of iron chloride = $\frac{162.3}{55.8}$ x 2.80 / $\frac{324.6}{111.6}$ x 2.80 / 2.90 x 2.80 ✓ = 8.144(g) ✓ To **3 sig figs** = 8.14 (g) ✓	**4**	**2.1**	**ALLOW** $2FeCl_3$ = 324.6 **ALLOW** ECF from incorrect M_r of $FeCl_3$ **ALLOW** ECF **ALLOW** alternative method, e.g. M_r of $FeCl_3$ = 162.3 ✓ Moles of iron = $\frac{2.80}{55.8}$ = 0.05 / Moles of iron chloride = 0.05 ✓ Mass of iron chloride = 0.05 x 162.3 = 8.115 ✓ To **3 sig figs** = 8.12 (g) ✓

Question			Answer	Marks	AO element	Guidance
20	(a)		LPG Petrol Diesel Bitumen **All 4 correct = 2 marks** **Any 2 correct = 1 mark**	**2**	**2.1**	
	(b)	**(i)**	**Any three from:** Idea of high demand for smaller molecules ✓ Smaller molecules used for fuels / alkenes used for polymers ✓ Idea of not enough supply of smaller molecules ✓ Idea of surplus of larger molecules ✓ Idea that cracking changes larger molecules to smaller molecules or alkenes ✓	**3**	**1.1**	**ALLOW** named larger and smaller molecules, e.g. bitumen and LPG / petrol **ALLOW** molecules with double bonds or unsaturated molecules are used for polymers **IGNORE** idea that the molecules are too long
		(ii)	Idea that any carbon to carbon bond in the molecule can break ✓	**1**	**2.1**	
		(iii)	$C_{30}H_{62} \rightarrow C_{20}H_{42} + 2\ \mathbf{C_5H_{10}}$ ✓	**1**	**2.1**	

Question			Answer	Marks	AO element	Guidance
	(c)	(i)	**Any one from:** Compound **B** is an alkene / compound **A** is an alkane ✓ Compound **B** is unsaturated / compound **A** is saturated ✓ Compound **B** contains a double bond / compound **A** only has single bonds ✓	1	1.2	**Assume unqualified answer refers to compound B**
		(ii)	 ✓ **OR** $C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$ ✓	1	2.2	**ALLOW** structure of -CH_3 group shown in product **ALLOW** butene drawn as a straight chain or product drawn at an angle as butene **ALLOW** $Br_2C_4H_8$

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>21</td><td>(a)</td><td></td><td>
<table>
<tr><th>Polymer</th><th>Type of monomer</th></tr>
<tr><td>DNA</td><td>Nucleotides ✓</td></tr>
<tr><td>Protein</td><td>Amino acids ✓</td></tr>
<tr><td>Starch</td><td>Sugars ✓</td></tr>
</table>
</td><td>3</td><td>1.1</td><td>ALLOW named nucleotides,
i.e. adenine/thymine/cytosine/guanine

ALLOW glucose / monosaccharide</td></tr>
<tr><td></td><td>(b)</td><td></td><td> 
Double bond between carbon atoms ✓
Rest of structure correct ✓</td><td>2</td><td>2.1</td><td></td></tr>
<tr><td></td><td>(c)</td><td></td><td>  </td><td>2</td><td>1.1</td><td>ALLOW 1 mark if a di-carboxylic acid and di-alcohol are seen</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
	(d)		**Any two from:** Avoid naked flames or sources of ignition because solvent is highly flammable ✓ Wear gloves because reagents are corrosive ✓ Wear eye protection because reagents are corrosive ✓	**2**	**1.2** **2.2**	**ALLOW** (Carry out experiment) in a well-ventilated lab / fume cupboard ✓ **ALLOW** a description of 2 precautions for 1 mark if no other mark awarded

Question			Answer	Marks	AO element	Guidance
22	(a)	(i)	150 (dm^3) ✓	1	2.1	
		(ii)	300 (dm^3) ✓	1	2.1	**ALLOW** ECF from (a)(i), ie 2 x (a)(i)
		(iii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.6 (g) award 4 marks** Moles of I_2 = $\frac{150}{24}$ / 6.25 ✓ Mass of I_2 = $\frac{150}{24}$ x 253.8 / 6.25 x 253.8 / 1586.25 g ✓ Mass of I_2 in kg = 1.586 / 1.58625 / 1.5863 (kg) ✓ To **1 decimal place** = 1.6 (kg) ✓	4	2.2	**ALLOW** ECF from moles of I_2 **ALLOW** ECF from mass of I_2 in grams **ALLOW** ECF for 1 decimal place mark

Question			Answer	Marks	AO element	Guidance
	(b)		**Any four from:** Lower temperature in **A** increases (equilibrium) yield or moves position of equilibrium to right (as forward reaction is exothermic) / higher temperature in **B** decreases (equilibrium) yield or moves position of equilibrium to left (as forward reaction is exothermic) ✓ Idea that reaction rate is faster or equilibrium reached faster in **B** because of higher temperature / Idea that reaction rate is slower or equilibrium reached slower in **A** because of lower temperature ✓ Idea **A** uses a compromise temperature ✓ Idea that higher pressure (in **B**) does not affect the position of equilibrium ✓ (Because) idea that there are the same number of molecules or moles on both sides of the equation ✓ Idea that the use of a catalyst does not affect the position of equilibrium ✓ (But) catalyst increases the rate (of reaching equilibrium) ✓	**4**	**2 x 2.1** **2 x 3.2b**	**Assume unqualified answer refers to A** **IGNORE** higher pressure (in **B**) increases the rate of reaction

Question			Answer	Marks	AO element	Guidance
23	(a)		Correct identification of sodium / Na^+ (from Test 1) ✓ Correct identification of sulfate / SO_4^{2-} (from Test 2) ✓ Correct formula of compound **Y** - Na_2SO_4 ✓	3	2 x 2.2 1 x 1.2	**Award all 3 marks for Na_2SO_4**
	(b)	(i)	Idea that more than one cation gives a white precipitate ✓	1	1.2	**ALLOW** answers which refer to specific cations that give a white precipitate (Al^{3+}, Ca^{2+}, Mg^{2+}, Zn^{2+}, Pb^{2+}) **IGNORE** incorrect cation charges **DO NOT ALLOW** incorrect cations
		(ii)	Idea that the chloride ions could have come from the hydrochloric acid ✓	1	3.2b	
		(iii)	Use nitric acid (instead of hydrochloric acid) ✓	1	1.2	**ALLOW** use a different acid / do not use hydrochloric acid **BUT DO NOT ALLOW** sulfuric acid

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