OCR
Oxford Cambridge and RSA

GCE

Chemistry A

Unit **H033/02:** Chemistry in depth

Advanced Subsidiary GCE

Mark Scheme for June 2017

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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**.

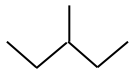
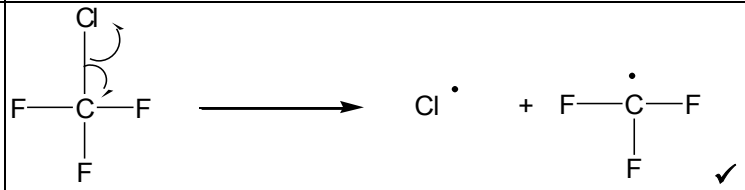
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Annotations

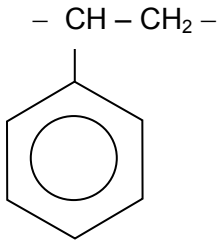
Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

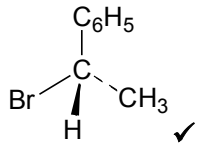
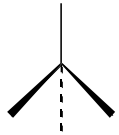
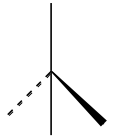
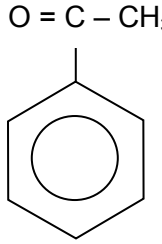
Annotation	Meaning
	Correct response
	Incorrect response
^	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

Question			Answer	Marks	Guidance
1	(a)		*heterogeneous* (the catalyst is in) a different state/phase (of matter to the reactants and products) ✓ *catalyst* (a substance that) increases the rate of/speeds up a (chemical) reaction/provides a route of lower activation enthalpy **AND** does not get used up (in the process) ✓	2	for *catalyst* **AND**, **IGNORE** 'does not take part in the reaction' unless it is included along with 'does not get used up' in which case it is a **CON** **ALLOW** 'not chemically changed' **IF** qualified by 'at end of reaction' **NOT** simply provides an alternative route or lower the activation enthalpy (must have both)
1	(b)	(i)	the student is incorrect the student should use equal amounts/number of moles /number of particles ✓	1	there is no mark for 'incorrect' – the mark is awarded for the explanation **IGNORE** references to particle size as question states powdered compounds
1	(b)	(ii)	*Any two from:* ✓ (for both) • concentration of hydrogen peroxide/solution • volume of solution • temperature (of solution)	1	**NOT** 'amount' instead of 'volume'
1	(c)	(i)	line of best fit drawn to exclude anomaly at (25, 55.0) ✓	1	look for a best fit line that goes above the anomalous point and levels off at 63
1	(c)	(ii)	manganese(IV) oxide (is the most effective catalyst) it produces most oxygen/gas in the shortest time/a given/stated time/at the fastest rate/it has the steepest curve ✓	1	explanation must include reference to rate or time
1	(c)	(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** If answer is 5.6×10^{-5} **or** 5.5×10^{-5} (2 or more sf) (mol s^{-1}) award 2 marks (volume of O_2 at 15 s = 20.0 cm^3) amount of O_2 at RTP = (20.0/24000) = 8.333×10^{-4} mol ✓ (average rate =) ($8.333 \times 10^{-4}/15.0$) = 5.6×10^{-5} (mol s^{-1}) ✓	2	**Alternative method** rate = 20/15 = 1.333 cm^3 s^{-1} ✓ = 1.333/24000 = 5.6×10^{-5} mol s^1 ✓ **ALLOW** 5.5×10^{-5} (mol s^{-1}) if amount is rounded to 2 sf **ALLOW** ECF on final answer if MP1 is correctly calculated, but for manganese(IV) oxide. Answer is 1.3×10^{-4} (again, allow 2 or more sf) **DO NOT ALLOW** calculation based on pV=nRT

Question			Answer	Marks	Guidance
1	(d)		  ✓(for branched alkane, eg as shown) ✓ (for methylpropene)	2	**ALLOW** any branched alkane containing 6-carbon atoms
1	(e)	(i)	Stage 1 reactant(s) adsorbed/bond to surface of catalyst Stage 2 (reactant) bonds (weaken) and break Stage 3 (product) new bonds form Stage 4 product(s) desorbed from surface of catalyst ✓ (for Stages 1 and 4) ✓ (for Stages 2 and 3)	2	In Stage 1, 'absorbed' is a **CON** **ALLOW** '(reactant) forms weak bonds with catalyst' **ALLOW** reference to 'chemisorption' In Stage 4, **ALLOW** 'leaves/diffuses' for 'desorbed from' but **DO NOT ALLOW** 'dissociates from'
1	(e)	(ii)	(the poison) blocks the active sites/surface ✓	1	
1	(f)	(i)	 ✓	1	**ALLOW** both products without 'dot' but not one with, one without. **ALLOW** 'CF_3' instead of full structural.
1	(f)	(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** If answer is 346 (nm) award 3 marks energy required to break a single C-Cl bond = (346 / 6.02 x 10^{23}) = 5.75 x 10^{-22} (kJ) ✓ E = hυ ∴ υ = E/h (minimum) frequency of radiation required = (5.75 x 10^{-22} x 1000/6.63 x 10^{-34}) = 8.67 x 10^{14} (Hz) ✓ c = υλ ∴ λ = c/υ (maximum) wavelength of radiation required = (3.00 x 10^{8}/8.67 x 10^{14}) = 3.46 x 10^{-7} (m) = 346 (nm) (3 sf) ✓	3	The working for an incorrect answer **MUST** be checked in detail. Do be aware that candidates may well multiply/divide the numbers in a different order to that shown in the answer column so the numbers in this method of working may not necessarily be seen. However, candidates should be using E = hυ, c = υλ (or correct combination) and a conversion into nm.

1	(g)		*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)** Gives a detailed description (to include equations in parts 1 and 2) AND a comparison of relative effects. *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)** Less detailed description and comparison (equations may be included) **OR** Detailed description and no comparison ORA *There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.* **Level 1 (1-2 marks)** Limited description and comparison *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**	**1.1 (x4)** **3.1 (x2)**	*Indicative Scientific points include:* **AO1.1 Description of and comparison of oxygen and chlorine atoms in the breakdown of ozone** Role of oxygen: ○ atoms/radicals react with ozone (in the stratosphere) ○ $O + O_3 \rightarrow 2O_2$ Role of Cl in removing O_3 ○ chlorine radicals react with ozone ○ $Cl + O_3 \rightarrow ClO + O_2$ ○ ClO react with oxygen atoms regenerating the chlorine radical ○ $ClO + O \rightarrow Cl + O_2$ ○ overall reaction is the removal of ozone $O + O_3 \rightarrow 2O_2$ **AO3.1 Make judgements: Comparison of relative effects** • the chlorine radical is in a catalytic cycle AW • one Cl atom can remove many ozone molecules • one O atom can only remove one ozone molecule
			Total	**23**		

Question			Answer	Marks	Guidance
2	(a)		 ✓ (for C – C single bond **AND** single bonds extending either side of each C-atom)	1	**ALLOW** C_6H_5 for phenyl group **IGNORE** brackets around repeating unit and use of 'n' to indicate a large number
2	(b)	(i)	Bond **A** – pi/π(-bond) Bond **B** – sigma/σ(-bond) ✓	1	
2	(b)	(ii)	Bond angle **C** = 120(°) ✓ Explanation there are 3 groups of electrons around the C-atom ✓ (which) repel so that they are as far apart as possible ✓	3	**ALLOW** 'areas of electron density' for 'groups of electrons' **ALLOW** arrange to minimise the repulsion between them **DO NOT ALLOW** 'repel as much as possible' unless qualified by the idea of 'minimising repulsion' **DO NOT ALLOW** 'three sets of bonding pairs' **DO NOT ALLOW** 'bonds repel' unless qualified by reference to 'electrons'
2	(c)	(i)	yellow/orange/brown to colourless ✓	1	**ALLOW** any colour or combination of colours but no other colour **DO NOT ALLOW** 'decolorised' or 'loses its colour' **IGNORE** clear Any reference to 'red' is a **CON**
2	(c)	(ii)	carbocation ✓	1	**ALLOW** carbonium ion **DO NOT ALLOW** 'carbon cation'
2	(c)	(iii)	chloride ions/Cl^- can attack/react with/bond with/combine with the carbocation/intermediate (in the second step of the mechanism) as well as bromide ions/Br^- ✓	1	Answer must refer to the carbocation/intermediate or if not, to the second step of the mechanism to get the mark

2	**(d)**		(there are) two different atoms/groups of atoms bonded/attached to the two carbon atoms of the double bond/C=C ✓ (and) there is no/limited (free) rotation about this bond/the C=C ✓	**2**	**DO NOT ALLOW** 'movement' unless qualified by 'rotational'
2	**(e)**	**(i)**	HBr/hydrogen bromide ✓	**1**	**ALLOW** BrH
2	**(e)**	**(ii)**	 ✓ **ALLOW** just 'C' for C_6H_5 and/or CH_3 (it is the shape that is being examined)	**1**	**ALLOW** other correct representations, eg  but not two 'lines' opposite each other, i.e  **ALLOW** 'dashed wedge' for 'dotted line'
2	**(e)**	**(iii)**	the hydroxyl group/OH/functional group is bonded to a carbon atom: with (only) one hydrogen atom **OR** attached to two carbon atoms ✓	**1**	**IGNORE** any reference to hydroxide (ion)/OH^- **IGNORE** 'it' for the OH group
2	**(e)**	**(iv)**	 ✓	**1**	**ALLOW** any unambiguous structure
			Total	**14**	

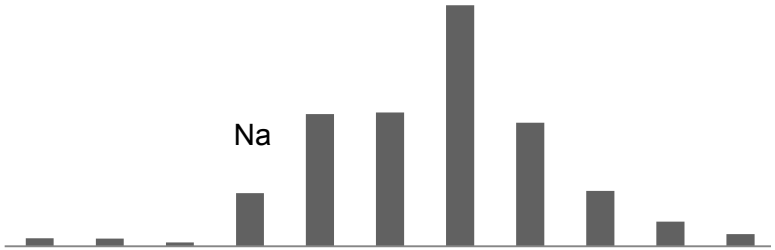
Question			Answer	Marks	Guidance
3	(a)	(i)	[M_r of NaOH = 40 g mol^{-1} 0.5 tonne = 5 x 10^5 g] amount of NaOH = (5 x 10^5 / 40) = 12500 (mol) ✓	1	Answer only (to 2 or more sf) (not the working) scores the mark
3	(a)	(ii)	[amount of Cl_2 formed in same time as 0.5 mol NaOH = (½ x 12500) = 6250 (mol) M of Cl_2 = 71] mass of Cl_2 = [(6250 x 71) = 443750 g =] 0.44 (tonnes) ✓ **ALLOW** ECF from (a)(i)	1	Answer only (to 2 or more sf) (not the working) scores the mark
3	(a)	(iii)	volume [= (6250 x 24) = 150 000 dm^3] = 150 m^3 ✓ **ALLOW** ECF from (a)(i) and/or (ii)	1	Answer only (to 2 or more sf) (not the working) scores the mark
3	(b)		similarity: chlorine is still produced (at the anode/positive electrode) difference: sodium is produced/hydrogen/hydroxide ion is not produced (at the cathode/negative electrode) ✓	1	
3	(c)		(i) anode (+): yellow/orange/brown (colour in solution) (ii) cathode (-): gas (evolved)/bubbles/effervescence /fizzing ✓ (for both i and ii)	1	**ALLOW** any of these colour or combination of them but no other colour at (i) **IGNORE** iodine at (i) and hydrogen at (ii)
3	(d)		(i) anode (+): $2Br^- \rightarrow Br_2 + 2e^-$ ✓ (ii) cathode (-): $2H_2O + 2e^- \rightarrow 2OH^- + H_2$✓	2	**ALLOW** multiples or halves of equations **ALLOW** $2Br^- - 2e^- \rightarrow Br_2$ **ALLOW** $2H^+ + 2e^- \rightarrow H_2$ **ALLOW** 'e' for 'e^-' **IGNORE** state symbols
3	(e)	(i)	Brown/orange/yellow ✓	1	**ALLOW** any of these colours (or combination of them) but no other colour **IGNORE** colourless
3	(e)	(ii)	$Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ ✓	1	**IGNORE** state symbols
3	(f)	(i)	$2I^- \rightarrow I_2 + 2e^-$ ✓	1	**ALLOW** $I^- \rightarrow ½I_2 + e^-$ **ALLOW** 'e' for 'e^-' **ALLOW** $2I^- - 2e^- \rightarrow I_2$

3	**(f)**	**(ii)**	chlorine/Cl_2 ✓	**1**	**IGNORE** Cl
3	**(g)**		halogens/they increase in atomic radius/size/get bigger/the outer shell is further from the nucleus/core/ shielding (by completed inner shells) from top to bottom of/going down the Group ✓ the (electrostatic) attraction between the nucleus/core and the outer electrons decreases from top to bottom of/going down the Group ✓ halogens/they gain an extra electron less readily/easily from top to bottom of/going down the Group ✓	**3**	**ALLOW** any reference to halogen as either atom or molecule
			Total	**14**	

Question			Answer	Marks	Guidance
4	(a)	(i)	(statement 1): equations should have (g) for both state symbols ✓ (statement 2): is correct ✓ (statement 3): the outer (shell) electrons in barium are further from/more well shielded from the nucleus (than in calcium) ✓ (the electrostatic) attraction between the nucleus/core and the outer electrons in barium is less (than in calcium) ✓	4	MP1, 3 and 4 are awarded for correcting the incorrect chemistry and not for simply stating 'incorrect' **DO NOT ALLOW** 'force' for 'attraction'
4	(a)	(ii)	**FIRST CHECK ANSWER ON ANSWER LINE** if answer = 754 (cm^3) award 2 marks (must be 3sf) amount of Ca = (1.26/40.1) = 3.14 x 10^{-2} (mol) amount of H_2 = 3.14 x 10^{-2} (mol) volume of hydrogen = (3.14 x 10^{-2} x 24000) = 754 (cm^3) ✓ answer to 3sf ✓	2	**ALLOW** ECF on sf from a correct seen calculation **Note** that if A_r of Ca is used as 40, answer is 756 **DO NOT ALLOW** an answer from calculation based on pV=nRT **BUT** the sf mark can still be awarded

Question			Answer	Marks	Guidance
4	(b)		*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)** Detailed description of an experiment that would work with reason(s) AND detailed suggested expected 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)** Outline description of an experiment **either** with reason(s) **or** suggested expected results **OR** Detailed description of the experiment without reason(s) or suggested expected results *There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.* **Level 1 (1-2 marks)** Outline description of an experiment **OR** Outline of suggestions for expected results *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks**	**6**	*Indicative scientific points include* **AO3.3 Develop practical techniques and procedures - Description of experiment** Description: • heating carbonate and bubbling gas into limewater / measuring volume of gas / measuring mass loss • equal amounts/number of moles of each carbonate heated • using the same Bunsen flame AW • the first to go cloudy has the lower thermal stability (or alternative methods based on amounts of cloudiness in certain time etc) Reasons: **not** just 'fair test' • comparing same number of particles • delivering the same energy / heat **A03.4 Interpretation - Suggested expected results** • $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ (**or** equation for strontium) or described in words • CO_2 given off shown by limewater going cloudy / gas collected / loss of mass • calcium carbonate decomposes quicker than strontium carbonate AW

Question			Answer	Marks	Guidance
			No response or no response worthy of credit		
4	(c)	(i)	it is the mean of 20.80 (cm^3) and 20.90 (cm^3) which are concordant/within 0.1(0) cm^3 **OR** 21.55 (cm^3) is a trial/rough titre/overshot the end-point/is an anomaly/outlier/not concordant/within 0.1(0) cm^3 ✓	1	
4	(c)	(ii)	(% error) = ([2 x 0.05]/20.80) = 0.5 (%) ✓	1	**ALLOW** 0.48 (%) **ALLOW ±**0.5/0.48 (%)
4	(c)	(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** If answer is 1.54 (g dm^{-3}) (to 2 or more sf) award 3 marks *(calculation of amount $Ca(OH)_2$ in titre):* amount of HCl = (20.85/1000 x 0.050) = 1.0425 x 10^{-3} (mol) amount of $Ca(OH)_2$ in 25 cm^3 = (½ x 1.0425 x 10^{-3}) = 5.2125 x 10^{-4} (mol) ✓ *(calculation of amount $Ca(OH)_2$ per dm^3):* $[Ca(OH)_2]$ = (5.2125 x 10^{-4} x 1000/25.0) = 2.085 x 10^{-2} (mol dm^{-3}) ✓ *(calculation of mass $Ca(OH)_2$ per dm^3):* M of $Ca(OH)_2$ = 40.1 + 2(16.0 + 1.0) = 74.1 (g mol^{-1}) concentration of $Ca(OH)_2$ = (2.085 x 10^{-2} x 74.1) = 1.54 (g dm^{-3}) ✓	3	**ALLOW** ecf **ALLOW** 2 or more sf.
4	(d)		the number of protons in the nucleus/atom ✓	1	**NOT** just 'element'

Question			Answer	Marks	Guidance
4	(e)		 correct position of Na ✓	1	
			Total	**19**	

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