OCR
Oxford Cambridge and RSA

GCE

Chemistry A

Unit **H032/01:** Breadth in chemistry

Advanced Subsidiary GCE

Mark Scheme for June 2018

Oxford Cambridge and RSA Examinations

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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.

Annotations available in RM Assessor

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

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

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

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.
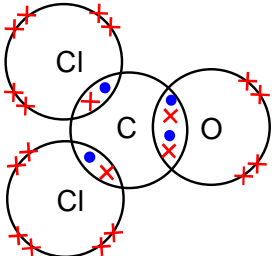
You should ensure that you have copies of these materials.

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**.

SECTION A

Question	Answer	Marks	Guidance
1	C	1	
2	C	1	
3	B	1	
4	C	1	
5	A	1	
6	C	1	**ALLOW** +6
7	D	1	
8	C	1	
9	A	1	
10	D	1	
11	B	1	
12	B	1	
13	C	1	
14	B	1	
15	D	1	
16	C	1	**ALLOW** 3
17	A	1	
18	D	1	
19	C	1	
20	D	1	
	Total	**20**	

SECTION B
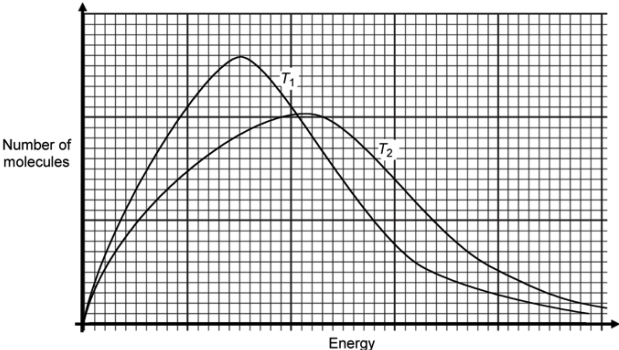
Question			Answer	Marks	Guidance
21	(a)	(i)	<table><tr><td></td><td>**Protons**</td><td>**Neutrons**</td><td>**Electrons**</td><td></td></tr><tr><td>^{29}Si</td><td>14</td><td>16</td><td>14</td><td>✓</td></tr></table>	1	
	(a)	(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **IF answer = 28.11 (to 2 DP) award 2 marks** $\dfrac{(28 \times 92.23) + (29 \times 4.68) + (30 \times 3.09)}{100}$ **OR** 28.1086 **OR** 28.109 ✓ = 28.11 (to 2 DP) ✓	2	**For 1 mark: ALLOW ECF** → to 2 DP if: • %s used with wrong isotopes **ONCE** **OR** • transposed decimal places for **ONE** %
	(b)	(i)	 ***CARE***: Check that lone pairs on Cl and O are included • Cl ($\times$2) has 6 non-bonded electrons (3 LPs) • O has 4 non-bonded electrons (2 LPs)	1	**NOTE**: O and Cl electrons **MUST** be shown differently from C electrons *(e.g. expected answer)* **IGNORE** inner shells **ALLOW** diagram with missing C, O or Cl symbols. For C=O bond, **ALLOW** sequence × × • • **ALLOW** non-bonding electrons unpaired

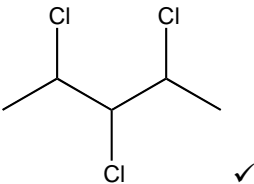| Question			Answer	Marks	Guidance
(b)	**(ii)**		**Shape** 　　Trigonal planar ✓ **Number of bonded regions** (C has)　3 electron (dense) regions 　　**OR** 3 bonding regions ✓ **Electron pair repulsion (***Seen anywhere***)** 　electron pairs/bonded pairs/bonded regions repel 　**OR** 　electron pairs move as far apart as possible 　**OR** 　bonds repel ✓	3	**ALLOW** bp for bonded pair **ALLOW** 3 bonded pairs (**BOD**) 　**OR** 3 sigma bonds 　**OR** 2 bonded pairs and 1 double bond 　**OR** 4 bonded pairs **including** a double bond **IGNORE** bonded atoms **IGNORE** just 3 bonds **ALLOW** alternative phrases/words for repel e.g. 'push apart' **IGNORE** electrons repel *(pairs needed)* **DO NOT ALLOW** atoms repel
	(c)		Highest energy electron(s) in a p orbital/p sub-shell ✓	1	**ALLOW outer** electron(s) in a p orbital/sub-shell 　　**BUT IGNORE** p **shell** **ALLOW** electron configuration ends in p 　**OR** the last electron is in a p orbital **ALLOW** valence electron(s) in p orbital/sub-shell
			Total	8	

	Question		Answer	Marks	Guidance
22	(a)	(i)	Oxidised **AND** (Mg) transfers/loses/donates **2** electrons ✓ **2** essential	1	**ALLOW** Mg loses 6 electrons: *3 Mg in equation* **ALLOW** $Mg \rightarrow Mg^{2+} + 2e^-$ **IGNORE** oxidation numbers (even if wrong)
	(a)	(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **IF answer = 2.26 (3 SF) award 3 marks** --- $n(H_3PO_4) = \dfrac{1.24 \times 50.0}{1000} = 0.062(0)$ (mol) ✓ $n(Mg) = \dfrac{3}{2} \times 0.062(0) = 0.093(0)$ (mol) ✓ **mass of Mg** = 0.0930 × 24.3 = 2.26 (g) ✓ **3 SF** required	3	At least **3SF** needed throughout **BUT** **ALLOW** no trailing zeroes (e.g. 0.062 for 0.0620) **ALLOW ECF** from $n(H_3PO_4)$ **ALLOW ECF** from $n(Mg)$ -- **COMMON ERRORS for 2 marks** 3:2 ratio omitted → $n(Mg)$ = 0.062(0) → 1.51 (g) Inverted 2:3 ratio → $n(Mg)$ = 0.0413 → 1.00 (g)

	(a)	(iii)	**Separation of solid**
			    Filter to obtain solid/precipitate ✓
			    Requires realisation that solid is filtered off.
			    Solid may be stated within in 'removal of water'
			Removal of water
			    Dry (solid)
			    OR Evaporate (water/solution/liquid) ✓
				2	**ALLOW**
					Removal of water
					    Evaporate/ distil water/solution/liquid ✓
					        IGNORE 'distil' if product **OR** H_2 is distilled
					Collection of remaining solid ✓
					    Requires realisation that solid remains
					IGNORE 'Leave to crystallise' *(already solid)*

	(a)	(iv)	**Formula**
			    MgO **OR** Mg(OH)$_2$ **OR** MgCO$_3$ **OR** soluble Mg salt ✓
			Equation
			    3MgO + 2H$_3$PO$_4$ → Mg$_3$(PO$_4$)$_2$ + 3H$_2$O
			    OR
			    3Mg(OH)$_2$ + 2H$_3$PO$_4$ → Mg$_3$(PO$_4$)$_2$ + 6H$_2$O
			    OR
			    3MgCO$_3$ + 2H$_3$PO$_4$ → Mg$_3$(PO$_4$)$_2$ + 3CO$_2$ + 3H$_2$O ✓
				2	**In equation:**
					NO ECF from incorrect formula
					ALLOW multiples
					IGNORE state symbols (even if incorrect)
					
					Soluble Mg salts include
					MgCl$_2$, MgSO$_4$, Mg(NO$_3$)$_2$, MgBr$_2$, MgI$_2$
					If unsure, check with TL
					e.g. 3MgCl$_2$ + 2H$_3$PO$_4$ → Mg$_3$(PO$_4$)$_2$ + 6HCl

Question			Answer	Marks	Guidance
(b)	(i)		**FIRST CHECK ANSWER ON THE ANSWER LINE** **IF answer = 315 (cm^3) award 4 marks** -- **Amount of PH_3** $n(PH_3) = \dfrac{3.20 \times 10^{-2}}{4}$ **OR** $8(.00) \times 10^{-3}$ (mol) ✓ **Unit conversions** p conversion → Pa $= 100 \times 10^3$ (Pa) **AND** T conversion → K $= 473$ (K) ✓ **Evidence of use of rearranged gas equation** **OR** $V = \dfrac{nRT}{p}$ **OR** $V = \dfrac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100 \times 10^3}$ **OR** $V = 3.15 \times 10^{-4}$ ✓ *Calculator: = 3.1460176 × 10^{-4}* **V conversion of m^3 → cm^3** $V = 3.15 \times 10^{-4} \times 10^6 = 315$ cm^3 ✓ *Calculator from unrounded cm^3: 314.60176 cm^3* **Requires 3 OR MORE SF, correctly rounded** **ALLOW use of R = 8.31 → 314.4504 → 314 to 3SF**	4	**If there is an alternative answer, check to see if there is any ECF credit possible** **ALLOW ECF** throughout -- **Common Errors** **(3 marks)** *Use of $n(H_3PO_4) = 3.20 \times 10^{-2}$ (Very common)* $V = \dfrac{3.2(0) \times 10^{-2} \times 8.314 \times 473}{100 \times 10^3} \times 10^6$ $= 1258.40704$ cm^3 (1260 to 3 SF) *No temperature conversion from ºC to K* $V = \dfrac{8(.00) \times 10^{-3} \times 8.314 \times 200}{100 \times 10^3} \times 10^6$ $= 133$ cm^3 *No p conversion from kPa to Pa* $V = \dfrac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100} \times 10^6$ $= 315000$ cm^3 *No volume conversion from m^3 to cm^3* $V = 3.15 \times 10^{-4}$ **IGNORE** use of 24/24000 for molar volume e.g. $3.2(0) \times 10^{-3} \times 24000 = 768$ scores zero $8(.00) \times 10^{-3} \times 24000 = 292$ scores 1st mark only
(b)	(ii)		$4PH_3 + 8O_2 \rightarrow P_4O_{10} + 6H_2O$ ✓	1	**ALLOW** multiples
			Total	13	
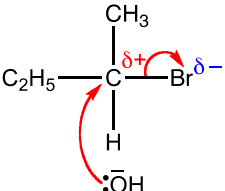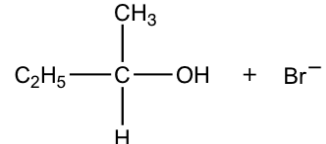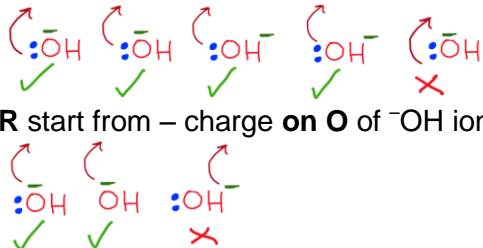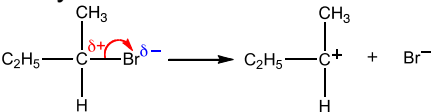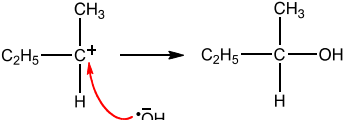
Question			Answer	Marks	Guidance
23	(a)	(i)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF $\triangle_rH$ = –457 OR –458 (kJ mol⁻¹) award 4 marks** **IF $\triangle_rH$ = ±229 OR 457 (kJ mol⁻¹) award 3 marks** - ***Energy released in J OR kJ*** = 25.0 × 4.18 × 28.0 = 2926 (J) **OR** 2.926 (kJ) ✓ ***Correctly calculates n(AgNO₃)*** = $0.512 \times \dfrac{25.0}{1000}$ = 1.28×10^{-2} (mol) ✓ $\triangle H$ **per mole AgNO₃ in kJ AND 3 SF** *Answer **MUST** divide energy by n(AgNO₃)* ±$\dfrac{2.926}{1.28 \times 10^{-2}}$ = ±228.59375 = ±229 (kJ) ✓ **3 SF** needed Sign **NOT** needed $\triangle H$ **for 2 mol AgNO₃ AND – sign AND** 3 SF $\triangle H_r = 2 \times -228.59375$ = –457 (kJ mol⁻¹) **OR** 2×-229 = –458 (kJ mol⁻¹) ✓	4	*FULL ANNOTATIONS MUST BE USED* - **ALLOW ECF** throughout -- **ALLOW** 2930 J **OR** 2.93 kJ **DO NOT ALLOW** < 3 SF **IGNORE** any sign **and** units i.e. **ALLOW** correctly calculated number in J **OR** kJ --- **Alternative approach** using 1 mol Mg Energy released = 2926 (J) **OR** 2.926 (kJ) ✓ $n(AgNO_3)$ = 1.28×10^{-2} (mol) ✓ $n(Mg) = \dfrac{1.28 \times 10^{-2}}{2}$ = 6.4×10^{-3} (mol) ✓ $\triangle H_r = \dfrac{2.926}{6.4 \times 10^{-3}}$ = –457 (kJ mol⁻¹) ✓ – **sign AND** 3 SF needed
	(a)	(ii)	Ag⁺(aq) + Cl⁻(aq) → AgCl(s) ✓ **State symbols required** **White** precipitate **AND** AgNO₃/Ag⁺ **NOT ALL** reacted **OR** **NO white** precipitate **AND** AgNO₃/Ag⁺ **ALL** reacted ✓	2	**ALLOW** AgNO₃(aq) + NaCl(aq) → AgCl(s) + NaNO₃(aq) Observation needs to be linked to conclusion

Question			Answer	Marks	Guidance

(b)			***Boltzmann distribution*** ***3 marks***
			
			 Curve
			     Curve starts within one small square of origin
			     AND curve does not touch x axis at high energy
			     AND curve does not increase by more than one
			     small square at higher energy ✓
			 Labels
			     Axes labels correct:
			     • Number of molecules **AND** Energy ✓
			
			 Curves for two temperatures
			     Drawing of **two** curves with higher and lower
			     temperature clearly identified in diagram or text
			     AND higher T maximum to right **AND** at least one small
			     square lower than lower T max ✓
			
			 Explanation ***1 mark***
			     More molecules have energy greater than E_a
			     OR
			     Greater area under curve above E_a ✓
			     Could be in diagram
				4	*FULL ANNOTATIONS MUST BE USED*
					 THROUGHOUT
					 -- 	
					
					 NOTE: Look for marking criteria within annotations on Boltzmann distribution diagram
					
					 IGNORE slight inflexion on the curve
					
					 For labels,
					     ALLOW number of particles
					     ALLOW amount of molecules/particles
					     IGNORE number of atoms
					     ALLOW kinetic energy
					     IGNORE enthalpy for energy
					
					 IGNORE curves meeting at higher energy **BUT**
					 DO NOT ALLOW crossing over by **more than** one small square
					
					 ALLOW more molecules have the energy to react
					 IGNORE more successful collisions
					             OR collide more frequently
					
					 DO NOT ALLOW explanation is in terms of two activation energies (i.e. 'catalyst explanation)

			Total	10	

Question			Answer		Marks	Guidance

24	(a)		**Structural isomers:** *1 mark*
			Different structural formulae
			AND same molecular formula ✓
					5	For 'structural':
						    ALLOW different structure
						    OR different displayed/ skeletal formula
						
						DO NOT ALLOW any reference to spatial/space/3D
						
						Same formula is **not** sufficient (no 'molecular')
						
						Different arrangement of atoms is **not** sufficient
						(no 'structure'/'structural')

			Common molecular formula: *1 mark*
			    C_5H_{12} for all 3 hydrocarbons ✓
						ALLOW 5 carbons and 12 hydrogens
						
						ALLOW for 2 marks:
						    Different structural formulae
						    AND same molecular formula ✓ of C_5H_{12} ✓

			Boiling point and branching:
			    1 mark
			Boiling point decreases with
			    more branching
			    OR more methyl/alkyl groups/side chains
			    OR shorter carbon chain ✓
			
			Branching and London forces: *1 mark*
			Could be seen anywhere within response
			More branching gives less (surface) contact
			    AND
			    fewer/weaker London forces ✓
			
			Energy and intermolecular forces: *1 mark*
			    Less energy to break London forces/
			    intermolecular forces/intermolecular bonds/ ✓
						Comparisons needed throughout
						ORA throughout
						
						ALLOW comparison between any alcohols, e.g.
						    A is least branched and has highest b pt
						    C is most branched and has lowest b pt
						
						ALLOW induced dipole(–dipole) interactions
						IGNORE van der Waals'/vdw forces
						ALLOW SA for surface area
						
						ALLOW 'harder to overcome intermolecular forces
						ALLOW more energy to separate the molecules
						
						IGNORE just 'bonds'
						intermolecular/London forces required

Question			Answer	Marks	Guidance
(b)	**(i)**		Radical substitution ✓	1	**ALLOW** Free radical substitution
(b)	**(ii)**		<table><tr><td>**A**</td><td>**B**</td></tr><tr><td>3 ✓</td><td>4 ✓</td></tr></table>	2	
(b)	**(iii)**		**Structure of D** Structure of a trichloro isomer of **A**, e.g. **ALLOW any** trichloro isomer of **A** **CHECK carefully** **Equation** $C_5H_{12} + 3Cl_2 \rightarrow C_5H_9Cl_3 + 3HCl$ ✓ **Molecular formulae required** **NO ECF** from incorrect structure of **D**	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **IGNORE** molecular formula **ALLOW** multiples, e.g. $2C_5H_{12} + 6Cl_2 \rightarrow 2C_5H_9Cl_3 + 6HCl$
			Total	10	

Question			Answer	Marks	Guidance
25	(a)	(i)	Structures **F**, **G**, **H** ✓ ✓ ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** mixture of the above (as long as unambiguous) **IGNORE** molecular formula **ALLOW** CH_3– **ALLOW** 1 mark for **G AND H** combined is structures are correct but in wrong boxes

	(a)	(ii)	2-methylpropan-1-ol ✓
			
			Both numbers required
				1	**IGNORE** absence of hyphen or use of dots or commas as separators
					
					DO NOT ALLOW 2-methylprop-1-ol
					                OR 2-methpropan-1-ol
					                OR 2-methypropan-1-ol

Question			Answer	Marks	Guidance

(b)	(i)		**ANNOTATE ANSWER WITH TICKS AND CROSSES**
			--- 	
			Curly arrows 2 marks
			  curly arrow from OH^- to C atom of C–Br bond ✓
			
			  dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,
			  AND curly arrow from C–Br bond to Br atom ✓
			
			(structure: CH_3, $C_2H_5-C^{\delta+}-Br^{\delta-}$, H, $:\bar{O}H$)
			
			  IGNORE incorrect R groups for curly arrow marks
			
			  IGNORE presence of Na^+/Na but OH^- needed
			  i.e. Na^+OH^-; $NaOH^-$ can be allowed with correct use of curly arrow
			--- 	
			Products 1 mark
			  correct organic product **AND** Br^- ✓
			
			(structure: CH_3, C_2H_5-C-OH + Br^-, H)
			
			  IGNORE presence of Na^+ but Br^- needed
			  i.e. Na^+Br^-/$NaBr^-$ can be allowed
			  BUT NaBr does **NOT** show Br^-
			
			NOTE: curly arrows can be straight, snake-like, etc.
			but **NOT** double headed or half headed arrows
				3	**1st curly arrow** must
					  • go to the C of C–Br
					  AND
					  • start from, **OR** be traced back to **any point across width** of lone pair on O of OH^-
					
					(diagrams: $:\bar{O}H$ ✓, $:\bar{O}H$ ✓, $:OH^-$ ✓, $:OH^-$ ✓, $:\bar{O}H$ ✗)
					
					  • **OR** start from – charge **on O** of ^-OH ion
					
					(diagrams: $:\bar{O}H$ ✓, $\bar{O}H$ ✓, $:OH$ ✗)
					
					*(Lone pair **NOT** needed if curly arrow shown from O^-)*
					
					2nd curly arrow must start from, **OR** be traced back to, **any part of** C–Br bond and go to Br
					
					(diagrams: $C-Br$ ✓, $C-Br$ ✓, $C-Br$ ✗)
					--- 	
					ALLOW S_N1 mechanism for 2 curly arrow marks
					
					First mark
					  Dipole shown on C–Br bond, $C^{\delta+}$ and $Br^{\delta-}$,
					  AND curly arrow from C–Br bond to Br atom ✓
					
					(mechanism: $C_2H_5-C^{\delta+}-Br^{\delta-}$ → $C_2H_5-C^+$ + Br^-)
					
					Second mark
					  Curly arrow from OH^- **AND** to correct carbocation
					
					(mechanism: $C_2H_5-C^+$ + $:\bar{O}H$ → C_2H_5-C-OH)
					
					Use curly arrow criteria in guidance above

Question			Answer	Marks	Guidance

	(b)	(ii)	**Disappearance** of
			    peak at 500–800 cm^{-1} **OR** C–Br peak ✓
			
			Appearance of
			    peak at 3200–3600 cm^{-1} **OR alcohol** O–H peak ✓
				2	**ALLOW** value within range 500–800 cm^{-1}
					
					ALLOW value within range 3200–3600 cm^{-1}
					
					DO NOT ALLOW responses that only describe the spectrum shown

			Total	9	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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