OCR
Oxford Cambridge and RSA

GCE

Chemistry A

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

Advanced Subsidiary GCE

Mark Scheme for June 2018

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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.

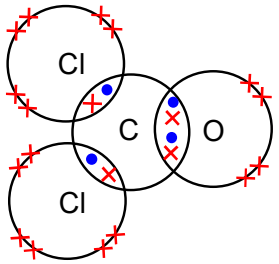
You should ensure that you have copies of these materials.

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

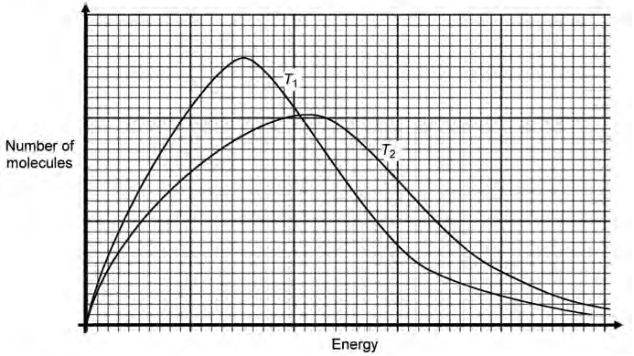
Question			Answer	Marks	Guidance
21	(a)	(i)	<table><tr><th></th><th>Protons</th><th>Neutrons</th><th>Electrons</th><th></th></tr><tr><td>^{29}Si</td><td>14</td><td>16</td><td>14</td><td>✓</td></tr></table>	1	
	(a)	(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **IF answer = 28.11 (to 2 DP) award 2 marks** $\frac{(28 \times 92.23) + (29 \times 4.68) + (30 \times 3.09)}{100}$ **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 (×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**	

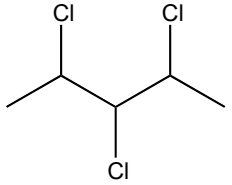
Question			Answer	Marks	Guidance
22	(a)	(i)	Oxidised **AND** (Mg) transfers/loses/donates **2** electrons ✓ ***2** essential*	1	**ALLOW** Mg loses 6 electrons: *3 Mg in equation* **ALLOW** $Mg \rightarrow Mg^{2+} + 2e^-$ **IGNORE** oxidation numbers (even if wrong)
	(a)	(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **IF answer = 2.26 (3 SF) award 3 marks** --- $n(H_3PO_4) = \frac{1.24 \times 50.0}{1000} = 0.062(0)$ (mol) ✓ $n(Mg) = \frac{3}{2} \times 0.062(0) = 0.093(0)$ (mol) ✓ **mass of Mg** = $0.0930 \times 24.3 = 2.26$ (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** $3MgO + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3H_2O$ **OR** $3Mg(OH)_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6H_2O$ **OR** $3MgCO_3 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 3CO_2 + 3H_2O$ ✓	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. $3MgCl_2 + 2H_3PO_4 \rightarrow Mg_3(PO_4)_2 + 6HCl$

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** $n(PH_3) = \frac{3.20 \times 10^{-2}}{4}$ **OR** $8(.00) \times 10^{-3}$ (mol) ✓ **Unit conversions** *p* conversion → Pa = 100×10^3 (Pa) **AND** *T* conversion → K = 473 (K) ✓ **Evidence of use of rearranged gas equation** **OR** $V = \frac{nRT}{p}$ **OR** $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100 \times 10^3}$ **OR** $V = 3.15 \times 10^{-4}$ ✓ *Calculator:* $= 3.1460176 \times 10^{-4}$ ***V* conversion of $m^3 \rightarrow cm^3$** $V = 3.15 \times 10^{-4} \times 10^6 = 315\ cm^3$ ✓ *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)* $V = \frac{3.2(0) \times 10^{-2} \times 8.314 \times 473}{100 \times 10^3} \times 10^6$ $= 1258.40704\ cm^3$ (1260 to 3 SF) ***No temperature conversion from ºC to K*** $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 200}{100 \times 10^3} \times 10^6$ $= 133\ cm^3$ ***No p conversion from kPa to Pa*** $V = \frac{8(.00) \times 10^{-3} \times 8.314 \times 473}{100} \times 10^6$ $= 315000\ cm^3$ ***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 $\Delta_r H$ = –457 OR –458 (kJ mol^{-1}) award 4 marks** **IF $\Delta_r H$ = ±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($AgNO_3$)*** = $0.512 \times \frac{25.0}{1000} = 1.28 \times 10^{-2}$ (mol) ✓ **ΔH per mole $AgNO_3$ in kJ AND 3 SF** *Answer **MUST** divide energy by n($AgNO_3$)* $\pm \frac{2.926}{1.28 \times 10^{-2}} = \pm 228.59375$ = ±229 (kJ) ✓ **3 SF** needed Sign **NOT** needed **ΔH for 2 mol $AgNO_3$ AND – sign AND** 3 SF $\Delta H_r = 2 \times -228.59375 = -457$ (kJ mol^{-1}) **OR** $2 \times -229 = -458$ (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) ✓ $n(AgNO_3) = 1.28 \times 10^{-2}$ (mol) ✓ $n(Mg) = \frac{1.28 \times 10^{-2}}{2} = 6.4 \times 10^{-3}$ (mol) ✓ $\Delta H_r = \frac{2.926}{6.4 \times 10^{-3}} = -457$ (kJ mol^{-1}) ✓ **– sign AND** 3 SF needed
	(a)	**(ii)**	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ ✓ **State symbols required** **White** precipitate **AND** $AgNO_3/Ag^+$ **NOT ALL** reacted **OR** **NO white** precipitate **AND** $AgNO_3/Ag^+$ **ALL** reacted ✓	**2**	**ALLOW** $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ 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 ✓ **Common molecular formula:** *1 mark* C_5H_{12} for all 3 hydrocarbons ✓	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') **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*

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Radical substitution ✓</td><td>1</td><td>ALLOW Free radical substitution</td></tr>
<tr><td></td><td>(b)</td><td>(ii)</td><td><table><tr><th>A</th><th>B</th></tr><tr><td>3 ✓</td><td>4 ✓</td></tr></table></td><td>2</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(iii)</td><td>Structure of D
Structure of a trichloro isomer of A, e.g.
 

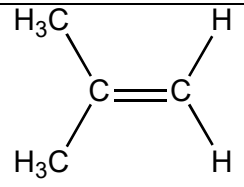
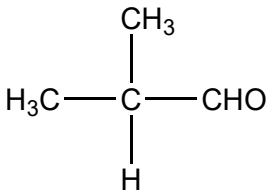
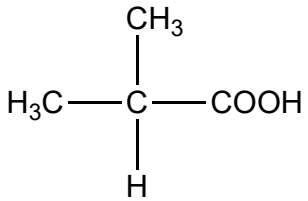
✓
ALLOW any trichloro isomer of A
CHECK carefully

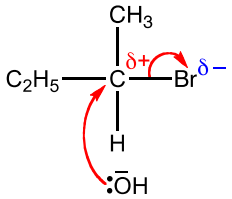
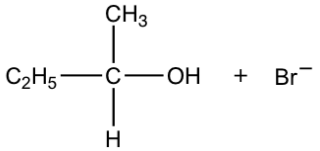
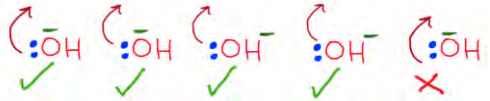
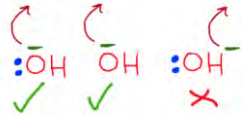
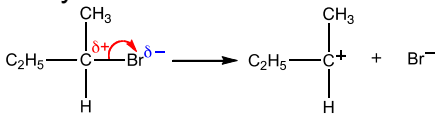
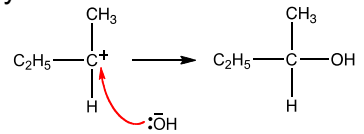
Equation
$C_5H_{12} + 3Cl_2 \rightarrow C_5H_9Cl_3 + 3HCl$ ✓
Molecular formulae required

NO ECF from incorrect structure of D</td><td>2</td><td>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)

IGNORE molecular formula

ALLOW multiples,
e.g. $2C_5H_{12} + 6Cl_2 \rightarrow 2C_5H_9Cl_3 + 6HCl$</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>10</td><td></td></tr>
</table>

Question			Answer	Marks	Guidance
25	(a)	(i)	 **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 ✓  **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^- ✓  **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^-  • **OR** start from – charge **on O** of ^-OH ion  *(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  --- **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 ✓  **Second mark** Curly arrow from OH^- **AND** to correct carbocation  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**	

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