

**GCE**

**Chemistry B**

**H433/01: Fundamentals of chemistry**

Advanced GCE

**Mark Scheme for November 2020**

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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.

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## Annotations

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

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

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

## Section A

Question	Key	Mark	AO element
1	C	1	1.1
2	B	1	1.1
3	B	1	1.1
4	A	1	1.2
5	D	1	1.2
6	C	1	1.2
7	C	1	1.1
8	C	1	2.1
9	C	1	1.2
10	D	1	1.1
11	D	1	2.1
12	B	1	2.5
13	B	1	2.7
14	B	1	2.7
15	A	1	1.2
16	C	1	2.8
17	C	1	2.6
18	A	1	1.2
19	C	1	1.2
20	C	1	2.2
21	B	1	2.8
22	A	1	1.1
23	D	1	1.2
24	C	1	1.2
25	D	1	2.5
26	B	1	2.3
27	A	1	2.8
28	C	1	1.2
29	B	1	1.1
30	D	1	1.2

Question			Answer	Mark	AO Element	Guidance
31	(a)		$C_{16}H_{34} + 24\frac{1}{2} O_2 \rightarrow 16CO_2 + 17H_2O$ ✓	1	2.5	<b>ALLOW</b> multiples. <b>IGNORE</b> state symbols
31	(b)	(i)	Heterogeneous ✓ catalyst and reagents are in different states. ✓	2	1.1 x2	Mark independently States, if given, must be correct, (g) and (S) for catalyst
31	(b)	(ii)	Provides a route of lower $E_A$ ✓	1	1.1	Must mention activation, not just energy/enthalpy and alternate route.
31	(c)	(i)	Colourless gas ✓ turns brown ✓	2	1.1 x 2	
31	(c)	(ii)	$N_2 + O_2 \rightarrow 2NO$ ✓	1	1.1	If state symbols are shown they must be correct (all (g))
31	(d)	(i)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b> <b>If answer = 319 (K) award 3 marks</b>  $\Delta S_{sys} = \text{products} - \text{reactants}$ ✓  $= 213.6 + (2 \times 192.3) - 69.9 - 173.9$ $= (+) 354.4$ ✓  $\text{temp} = 113000/354.4$ $318.8 \text{ K}$ ✓	3	2.6 x 3	ALLOW 2 or more sf  <b>ALLOW</b> ecf on incorrect $\Delta S_{sys}$ Second mark subsumes first 354.4 gains 2 marks
31	(d)	(ii)	$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$ OR $2NH_3 + NO + O_2 \rightarrow 1\frac{1}{2} N_2 + 3H_2O$ ✓	1	2.1	<b>ALLOW</b> halves/ multiples <b>IGNORE</b> state symbols

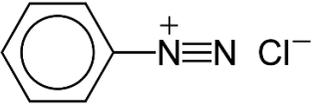
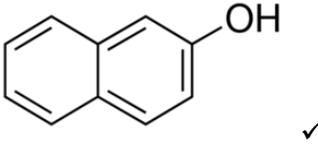
Question		Answer	Mark	AO Element	Guidance
31	(e)	<p>On short journeys the engine has not yet reached high temperature ✓</p> <p>(Equation 31.1 is) <u>endothermic</u> so (position of) eqm will be on the left ✓</p> <p>Less ammonia available to remove oxides of nitrogen ✓</p> <p>At lower temp the <u>rate</u> of formation of <u>ammonia</u> will be slower ✓</p>	4	3.1 2.5 3.1 2.5	ORA
31	(f)	<p><b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b>  <b>If answer = <math>0.67 \text{ dm}^6 \text{ mol}^{-2}</math> award 4 marks</b></p> <p>Expression for <math>K_c</math> ✓</p> <p>Eqm conc of hydrogen = <math>3 \text{ (mol dm}^{-3}\text{)}</math> <b>AND</b>            Eqm conc of nitrogen = <math>2 \text{ (mol dm}^{-3}\text{)}</math> ✓</p> <p><math>(K_c = 6^2/2 \times 3^3) = 0.67</math> ✓</p> <p>units <math>\text{dm}^6 \text{ mol}^{-2}</math> ✓</p>	4	2.6 x 4	<p><b>ALLOW</b> one or more sf.</p> <p><b>ALLOW</b> ecf on incorrect <math>[\text{N}_2]</math> and <math>[\text{H}_2]</math>            MP1 expression, MP2 concs of both, MP3 evaluation, MP4 units            If an expression for <math>K_c</math> contains only numbers, it must be clear which substance they relate to for MP1</p> <p><b>ALLOW</b> units in either order</p>

Question		Answer	Mark	AO Element	Guidance	
32	(a)	(Chlorine and bromine are) toxic ✓	1	1.1	Flammable is <b>CON</b> , <b>IGNORE</b> other correct statements e.g volatile	
32	(b)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b> <b>If answer = <math>4 \times 10^{19}</math> award 3 marks</b>  Unit conversion $5/1000 = 5 \times 10^{-3} \text{ g/cm}^3$ <b>AND</b> Mole conversion $5 \times 10^{-3}/79.9 = 6.258 \times 10^{-5}$ moles ✓  Multiplication by $N_A$ ✓  $= 4 \times 10^{19}$ ✓	3	2.2 x 3	3.7625...to 2 or more sf scores 2 marks.  <b>ALLOW</b> evaluation of any expression to 1 sf for MP3	
32	(c)	(i)	Orange/brown solution forms ✓	1	1.1	<b>IGNORE</b> starting colour if green/colourless/yellow <b>NOT</b> Red
32	(c)	(ii)	$\text{Cl}_2 + 2\text{Br}^- \rightarrow 2\text{Cl}^- + \text{Br}_2$ ✓	1	1.1	<b>IGNORE</b> state symbols
	(c)	(iii)	Chlorine better able to attract electrons than bromine/ Cl better oxidising agent so removes electrons from Br ✓	1	1.1	Must be comparative
32	(c)	(iv)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b> <b>If answer = <math>5.70 \times 10^4</math> (dm<sup>3</sup>) award 4 marks</b>  Volume of water electrolysed = $1000/1.24 = 806.45\text{dm}^3$ ✓  Moles of $\text{Cl}^-$ ions = $806.45 \times 208/35.5 = 4725.12$ ✓  Volume of chlorine = $4725.12 \times 24/2 = 56701 \text{ dm}^3$ ✓  $= 5.70 \times 10^4$ (dm <sup>3</sup> ) ✓	4	2.6 x 4	<b>ALLOW</b> 2 or more sf 57000, $1.13 \times 10^5$ , $8.72 \times 10^4$ score 3 marks.
32	(d)	(i)	Simple molecules with weak pd-pd forces/intermolecular bonds between ✓	1	2.5	If the type of imb is specified, it must be pd-pd. Must mention molecules or intermolecular

Question			Answer	Mark	AO Element	Guidance
32	(d)	(ii)	$\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- \checkmark$	1	1.2	<b>ALLOW</b> $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$ <b>NOT</b> eqm sign
32	(e)	(i)	Oxidation states of bromine -1 <b>AND</b> 0 $\checkmark$ Oxidation states of S +6 <b>AND</b> +4 $\checkmark$	2	1.2 x 2	<b>IGNORE</b> numbers in other boxes consider as working. Ox states must have signs before the number.
32	(e)	(ii)	$2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Br}_2 + \text{SO}_2 + 2\text{H}_2\text{O} \checkmark$	1	1.2	<b>IGNORE</b> state symbols



Question		Answer	Mark	AO Element	Guidance
33	(d)	<p><i>Please refer to the marking instructions on pages 4/5 of this mark scheme for guidance on how to mark this question.</i></p> <p><b>Level 3 (5–6 marks)</b> Identifies A as phenol and B as propanone using the evidence from some tests, the mass spectrum for product A and the composition of product B.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p><b>Level 2 (3–4 marks)</b> Identifies A as a phenol and B as a ketone or C<sub>3</sub>H<sub>6</sub>O using the evidence from some tests <b>OR</b> the mass spectrum for product A <b>OR</b> the composition of product B.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p><b>Level 1 (1–2 marks)</b> Identifies A as a phenol <b>OR</b> B as a ketone using the evidence from some tests <b>OR</b> the mass spectrum for product A <b>OR</b> the composition of product B.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p><b>0 marks</b> No response or no response worthy of credit</p>	6	3.1 x 3 3.2 x 3	<p><b>Indicative scientific points may include:</b></p> <p><b>Product A:</b></p> <ul style="list-style-type: none"> <li>• Is a phenol</li> <li>• It is weakly acidic, but not strong enough to react with sodium carbonate</li> <li>• Gives the purple colour with FeCl<sub>3</sub></li> <li>• Mass spectrum shows that the M<sub>r</sub> is 94</li> <li>• Consistent with phenol, C<sub>6</sub>H<sub>5</sub>OH</li> </ul> <p><b>Product B:</b></p> <ul style="list-style-type: none"> <li>• Moles: C 5.175; H 10.3; O 1.735</li> <li>• Empirical formula is C<sub>3</sub>H<sub>6</sub>O</li> <li>• Not an acid</li> <li>• Can be reduced to an alcohol so is aldehyde or ketone.</li> <li>• Does not get oxidised by Tollen's reagent so is a ketone.</li> <li>• propanone/ CH<sub>3</sub>COCH<sub>3</sub>.</li> </ul>

Question		Answer	Mark	AO Element	Guidance	
34	(a)	Below 5°C ✓  	1	1.2 x3	Mention of alkaline conditions is <b>CON</b>  <b>ALLOW</b> without chloride ion  Bonding in naphthol must be as shown.	
34	(b)	(i)	Concentrated sulfuric acid <b>and</b> reflux <b>OR</b> fuming sulfuric acid <b>and</b> 40°C ✓	1	1.2	<b>ALLOW</b> 'c'/conc' for concentrated and formula
34	(b)	(ii)	Dye <b>C</b> : Not very soluble as only the phenol group (and N atoms) can form H bonds <u>with water</u> . ✓  The rest of the molecule has weak id-id imbs . ✓  Dye <b>D</b> : More soluble because SO <sub>3</sub> <sup>-</sup> /O <sup>-</sup> can form ion dipole bonds <u>with water</u> . ✓  Forms more H bonds with water. ✓	4	2.7 x 4	Must mention groups that can H bond to score
34	(c)	(i)	Electrons in the extended delocalised system ✓ electrons move to higher energy levels ✓ $\Delta E = h\nu$ ✓	3	1.1 x 3	Splitting d-orbitals is <b>CON</b> for MP1, <b>IGNORE</b> chromophore alone
		(ii)	Complementary colour is seen/ frequencies not absorbed are seen (AW)	1	1.1	Light emitted is <b>CON</b>

Question		Answer	Mark	AO Element	Guidance
34	(d)	The $\text{NH}_2$ groups on wool become <u>protonated</u> /turn to $\text{NH}_3^+$ in weak acid ✓ Ionic interactions between $\text{SO}_3^-/\text{O}^-$ groups and $\text{NH}_3^+$ ✓	2	2.7 x 2	
34	(e)	<p><i>Please refer to the marking instructions on pages 4/5 of this mark scheme for guidance on how to mark this question.</i></p> <p><b>Level 3 (5–6 marks)</b> Detailed description of calibration of the colorimeter. <b>AND</b> Detailed description of testing of fabric samples. <b>AND</b> Includes several controlled variables. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p><b>Level 2 (3–4 marks)</b> Detailed description of calibration of the colorimeter. <b>OR</b> Detailed description of testing of fabric samples. <b>AND</b> Includes several controlled variables.</p> <p><b>OR</b> Outline description of calibration of the colorimeter. <b>AND</b> Outline description of testing of fabric samples. <b>AND</b> Includes a few controlled variables.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p><b>Level 1 (1–2 marks)</b></p>	6	3.1 x 2 3.3 x 2 3.4 x 2	<p><b>Indicative scientific points may include:</b></p> <p><b>Calibration of the colorimeter:</b></p> <ul style="list-style-type: none"> <li>• Make up several solutions of dye of known concentration.</li> <li>• Select a colour filter complementary to the dye colour.</li> <li>• Zero colorimeter with a cuvette of water.</li> <li>• Measure the absorbance of the standard dye solutions.</li> <li>• Plot a calibration curve.</li> </ul> <p><b>Testing the fabric samples:</b></p> <ul style="list-style-type: none"> <li>• Immerse fabric in water at the desired temperature for a fixed time and stir.</li> <li>• Remove fabric and test remaining water to find absorbance.</li> <li>• Use calibration curve to find concentration of dye washed out of the fabric.</li> <li>• Repeat using water of different temperatures.</li> </ul> <p><b>Controlled variables.</b></p> <ul style="list-style-type: none"> <li>• Immerse the fabric in water for a fixed time.</li> <li>• Use the same volume of water each time.</li> <li>• Keep the stirring constant</li> <li>• Cut the fabric into equal sized pieces for testing.</li> <li>• Same type of fabric</li> </ul>

Question			Answer	Mark	AO Element	Guidance
			Outline description of calibration of the colorimeter. <b>OR</b> Outline description of testing of fabric samples. <b>OR</b> Identifies a few controlled variables.  <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i>  <b>0 marks</b> No response or no response worthy of credit			

Question			Answer	Mark	AO Element	Guidance
35	(a)	(i)	White precipitate ✓	1	1.2	
		(ii)	$\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ ✓	1	1.2	
35	(b)		<p><b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b>  <b>If answer = 0.53 award 3 marks</b></p> <p>Moles of <math>\text{Cl}^-</math> ions in 25 cm<sup>3</sup> of the diluted sea water = 0.1 x 0.0265 (=2.65 x 10<sup>-3</sup>) ✓</p> <p>Moles of chloride ions in 20 cm<sup>3</sup> original sea water = 0.1 x 0.0265 x 100/25 (=0.0106) ✓</p> <p>Concentration of <math>\text{Cl}^-</math> ions in original sea water = 0.1 x 0.0265 x 100/25 x 1000/20 = 0.53 (mol dm<sup>-3</sup>) ✓</p>	3	2.8 x 3	<p><b>ALLOW</b> 2 or more significant figures 0.106 scores 2</p> <p><b>OR</b>            conc <math>\text{Cl}^-</math> (in diluted) = 26.5 x 0.1/25 = 0.106 ✓✓            conc <math>\text{Cl}^-</math> (in undiluted) = 26.5 x 0.1/25 x 5 = 0.53 ✓</p>
35	(c)	(i)	<p>At end point <math>[\text{Ag}^+] = [\text{Cl}^-]</math>, stated or implied ✓</p> <p><math>[\text{Ag}^+] = \sqrt{K_{\text{sp}}}</math> ✓</p>	2	2.7 2.8	Second mark depends on first
35	(c)	(ii)	<p><math>[\text{CrO}_4^{2-}] = 2.5 \times 10^{-4} \times 1000/52.50</math>  <math>= 4.76 \times 10^{-3}</math> ✓</p> <p><math>[\text{Ag}^+]^2 [\text{CrO}_4^{2-}] = 2 \times 10^{-10} \times 4.76 \times 10^{-3}</math>  <math>= 9.52 \times 10^{-13}</math> ✓</p> <p>This is less than the solubility product of silver chromate so no precipitate (of silver chromate) forms (before all the <math>\text{Cl}^-</math> ions have reacted). ✓</p>	3	3.1 x 3	<p>Alternative method:  <math>[\text{CrO}_4^{2-}]</math> when ppt forms = <math>3 \times 10^{-12}/[\text{Ag}^+]^2</math>  <math>= 0.015</math> ✓</p> <p><math>[\text{CrO}_4^{2-}]</math> in the solution is <math>2.5 \times 10^{-4} \times 1000/52.50</math>  <math>= 4.67 \times 10^{-3}</math> ✓</p> <p>This less than the 0.015 needed for a precipitate so no ppt forms ✓</p> <p><b>ALLOW</b> MP3 if a correct conclusion from incorrect calculated numbers</p>

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