

# Markscheme

May 2019

Chemistry

Standard level

Paper 2

12 pages

No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without written permission from the IB.

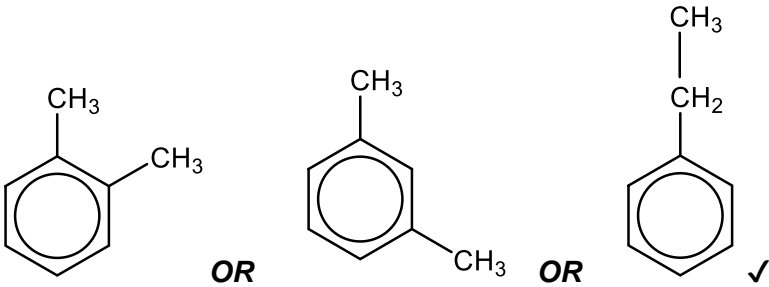
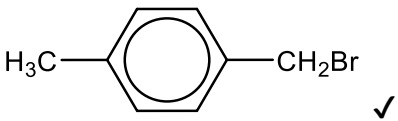
Additionally, the license tied with this product prohibits commercial use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, is not permitted and is subject to the IB's prior written consent via a license. More information on how to request a license can be obtained from <http://www.ibo.org/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

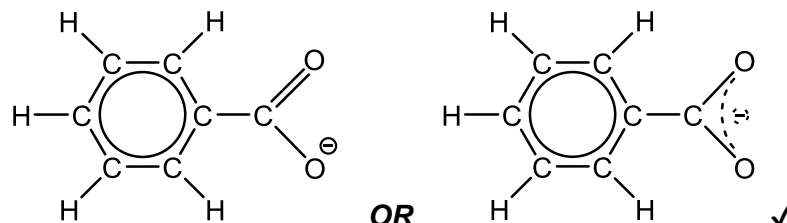
Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite de l'IB.

De plus, la licence associée à ce produit interdit toute utilisation commerciale de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, n'est pas autorisée et est soumise au consentement écrit préalable de l'IB par l'intermédiaire d'une licence. Pour plus d'informations sur la procédure à suivre pour demander une licence, rendez-vous à l'adresse <http://www.ibo.org/fr/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin que medie la autorización escrita del IB.

Además, la licencia vinculada a este producto prohíbe el uso con fines comerciales de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales— no está permitido y estará sujeto al otorgamiento previo de una licencia escrita por parte del IB. En este enlace encontrará más información sobre cómo solicitar una licencia: <http://www.ibo.org/es/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

Question			Answers	Notes	Total
1.	a		Number of signals: 2 ✓  Ratio: 3:2 <b>OR</b> 6:4 ✓	Accept any correct integer or fractional ratio. Accept ratios in reverse order.	2
1.	b		 OR		1
1.	c	i	$\text{Br}_2 \rightarrow 2\text{Br}\cdot$ ✓  «sun»light/UV/hv <b>OR</b> high temperature ✓	Do <b>not</b> penalize missing radical symbol on Br. Accept "homolytic fission of bromine" for M1.	2
1.	c	ii	 HBr ✓	Accept condensed formulae, such as $\text{CH}_3\text{C}_6\text{H}_4\text{CH}_2\text{Br}$ . Accept skeletal structures.	2

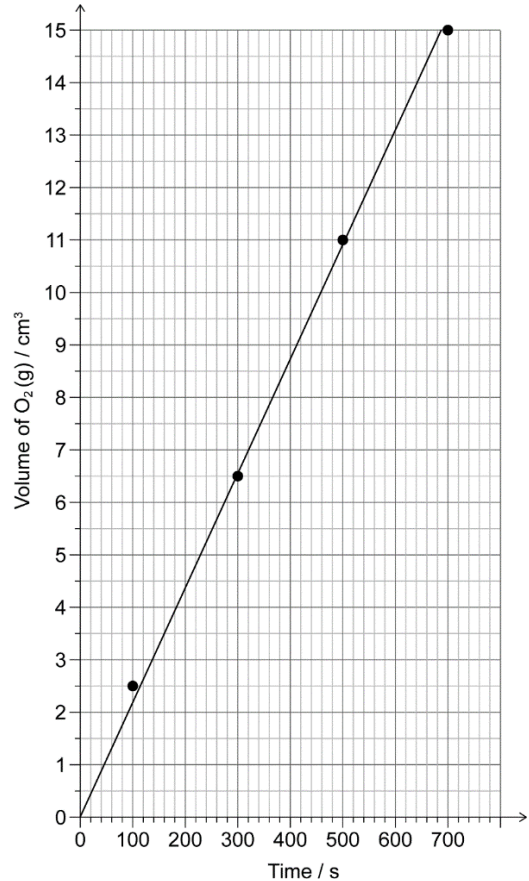
Question			Answers	Notes	Total
2.	a		 <p style="text-align: center;"><b>OR</b></p>	<p>Accept Kekulé structures.</p> <p>Negative sign must be shown in correct position- on the O or delocalised over the carboxylate.</p>	1
2.	b	i	<p><b>ALTERNATIVE 1:</b>  <math>[H^+] \llcorner 10^{-2.95} \llcorner = 1.122 \times 10^{-3} \llcorner \text{mol dm}^{-3} \llcorner \checkmark</math>  <math>\llcorner [OH^-] = \frac{1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}}{1.22 \times 10^{-3} \text{ mol dm}^{-3}} \Rightarrow 8.91 \times 10^{-12} \llcorner \text{mol dm}^{-3} \llcorner \checkmark</math></p> <p><b>ALTERNATIVE 2:</b>  <math>\text{pOH} = \llcorner 14 - 2.95 \Rightarrow \llcorner 11.05 \checkmark</math>  <math>\llcorner [OH^-] = 10^{-11.05} \Rightarrow 8.91 \times 10^{-12} \llcorner \text{mol dm}^{-3} \llcorner \checkmark</math></p>	<p>Award <b>[2]</b> for correct final answer.</p> <p>Accept other methods.</p>	2
2.	b	ii	$2C_6H_5COOH(s) + 15O_2(g) \rightarrow 14CO_2(g) + 6H_2O(l)$ correct products $\checkmark$ correct balancing $\checkmark$		2
2.	c		$\llcorner \text{intermolecular} \llcorner$ hydrogen bonding $\checkmark$	<p>Accept diagram showing hydrogen bonding.</p>	1

Question			Answers	Notes	Total
3.	a	i	<p>«3-D/giant» regularly repeating arrangement «of ions»  <b>OR</b>                      lattice «of ions» ✓</p> <p>electrostatic attraction between oppositely charged ions  <b>OR</b>                      electrostatic attraction between Na<sup>+</sup> and O<sup>2-</sup> ions ✓</p>	<p><i>Do not accept "ionic" without description.</i></p>	2
3.	a	ii	<p><i>Sodium oxide:</i>  <math>\text{Na}_2\text{O (s)} + \text{H}_2\text{O (l)} \rightarrow 2\text{NaOH (aq)}</math> ✓</p> <p><i>Phosphorus(V) oxide:</i>  <math>\text{P}_4\text{O}_{10} \text{(s)} + 6\text{H}_2\text{O (l)} \rightarrow 4\text{H}_3\text{PO}_4 \text{(aq)}</math> ✓</p> <p><i>Differentiation:</i>                      NaOH / product of Na<sub>2</sub>O is alkaline/basic/pH &gt; 7 <b>AND</b> H<sub>3</sub>PO<sub>4</sub> / product of P<sub>4</sub>O<sub>10</sub> is acidic/pH &lt; 7 ✓</p>		3

(continued...)

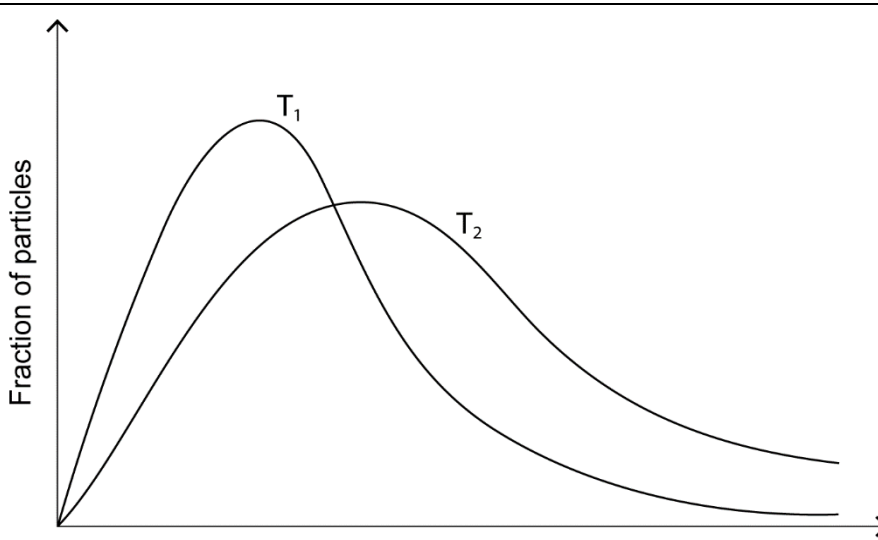
(Question 3 continued)

Question			Answers	Notes	Total
3.	b		$n(\text{Na}_2\text{O}_2)$ theoretical yield $\llcorner = \frac{5.00 \text{ g}}{61.98 \text{ g mol}^{-1}} \llcorner = 0.0807/8.07 \times 10^{-2} \llcorner \llcorner \text{ «mol»}$ <b>OR</b> mass $\text{Na}_2\text{O}_2$ theoretical yield $\llcorner = \frac{5.00 \text{ g}}{61.98 \text{ g mol}^{-1}} \times 77.98 \text{ g mol}^{-1} \llcorner = 6.291 \llcorner \llcorner \text{ «g»} \checkmark$  % yield $\llcorner = \frac{5.50 \text{ g}}{6.291 \text{ g}} \times 100 \llcorner \llcorner \text{ «%»} \checkmark$ <b>OR</b> $\llcorner = \frac{0.0705}{0.0807} \times 100 \llcorner \llcorner = 87.4 \llcorner \llcorner \text{ «%»} \checkmark$	Award <b>[2]</b> for correct final answer.	2
3.	c	i	$\Sigma \Delta H_f$ products = $2 \times (-1130.7) / -2261.4 \llcorner \llcorner \text{ «kJ»} \checkmark$ $\Sigma \Delta H_f$ reactants = $2 \times (-510.9) + 2 \times (-393.5) / -1808.8 \llcorner \llcorner \text{ «kJ»} \checkmark$ $\Delta H = \llcorner \Sigma \Delta H_f$ products $- \Sigma \Delta H_f$ reactants $= -2261.4 - (-1808.8) = -452.6 \llcorner \llcorner \text{ «kJ»} \checkmark$	Award <b>[3]</b> for correct final answer. Award <b>[2 max]</b> for “+452.6 «kJ»”.	3
3.	c	ii	only valid for covalent bonds <b>OR</b> only valid in gaseous state $\checkmark$		1
3.	d		NaOH $\checkmark$	Accept correct equation showing NaOH as a product.	1
3.	e		IV $\checkmark$		1

Question			Answers	Notes	Total
4.	a		decomposes in light ✓	Accept "sensitive to light".	1
4.	b	i	 <p>points correctly plotted ✓                      best fit line <b>AND</b> extended through (to) the origin ✓</p> <p>Average rate of reaction:                      «slope (gradient) of line =&gt; 0.022 «cm<sup>3</sup> O<sub>2</sub> (g) s<sup>-1</sup>» ✓</p>	Accept range 0.020–0.024 cm <sup>3</sup> O <sub>2</sub> (g) s <sup>-1</sup> .	3

(continued...)

(Question 4 continued)

Question			Answers	Notes	Total
4.	b	ii	 <p>peak of <math>T_2</math> to right of <b>AND</b> lower than <math>T_1</math> ✓ lines begin at origin <b>AND</b> <math>T_2</math> must finish above <math>T_1</math> ✓</p>		2
4.	b	iii	<p><math>E_a</math> marked on graph ✓ explanation in terms of more “particles” with <math>E \geq E_a</math> <b>OR</b> greater area under curve to the right of <math>E_a</math> in <math>T_2</math> ✓</p>		2
4.	b	iv	<p>manganese(IV) oxide <b>OR</b> manganese dioxide ✓</p>	Accept “manganese(IV) dioxide”.	1

(continued...)



(Question 4 continued)

Question		Answers	Notes	Total
4.	c	move «position of» equilibrium to right/products ✓	Accept "reactants are always present as the reaction is in equilibrium".	1
4.	d	$M(\text{H}_2\text{O}_2) = 2 \times 1.01 + 2 \times 16.00 = 34.02 \text{ «g» } \checkmark$ $\text{«% H}_2\text{O}_2 = 3 \times \frac{34.02}{314.04} \times 100 = \text{» } 32.50 \text{ «%» } \checkmark$	Award [2] for correct final answer.	2

Question			Answers	Notes	Total
5.	a		partial dissociation «in aqueous solution» ✓		1
5.	b		ethanoic acid/vinegar reacts with NaOH ✓  moves equilibrium to left/reactant side ✓  releases Cl <sub>2</sub> (g)/chlorine <u>gas</u> <b>OR</b> Cl <sub>2</sub> (g)/chlorine <u>gas</u> is toxic ✓	Accept “ethanoic acid produces H <sup>+</sup> ions”. Accept “ethanoic acid/vinegar reacts with NaOCl”.  Do <b>not</b> accept “2CH <sub>3</sub> COOH + NaOCl + NaCl → 2CH <sub>3</sub> COONa + Cl <sub>2</sub> + H <sub>2</sub> O” as it does not refer to equilibrium. Accept suitable molecular or ionic equations for M1 and M3.	3
5.	c	i	$\begin{array}{c} \cdot\cdot \\ \text{H} : \text{N} : \text{Cl} : \\ \cdot\cdot \\ \text{H} \end{array} \quad \checkmark$	Accept any combination of dots/crosses or lines to represent electron pairs.	1
5.	c	ii	Molecular geometry: «trigonal» pyramidal ✓  H–N–H bond angle: 107° ✓	Accept angles in the range of 100–109.	2

Question			Answers	Notes	Total
6.	a		${}^{54}_{26}\text{Fe}$ ✓		1
6.	b		<p>«<math>A_r</math> =» <math>54 \times 0.0584 + 56 \times 0.9168 + 57 \times 0.0217 + 58 \times 0.0031</math></p> <p><b>OR</b></p> <p>«<math>A_r</math> =» 55.9111 ✓</p> <p>«<math>A_r</math> =» 55.91 ✓</p>	<p>Award <b>[2]</b> for correct final answer.</p> <p>Do <b>not</b> accept data booklet value (55.85).</p>	2

(continued...)

(Question 6 continued)

Question	Answers	Notes	Total
<p>6. c</p>	<p>lemon juice is the electrolyte  <b>OR</b>                      lemon juice allows flow of ions  <b>OR</b>                      each nail/metal forms a half-cell with the lemon juice ✓  <i>Any one of:</i>                      iron is higher than copper in the activity series  <b>OR</b>                      each half-cell/metal has a different redox/electrode potential ✓                      iron is oxidized  <b>OR</b>  <math>Fe \rightarrow Fe^{2+} + 2e^{-}</math>  <b>OR</b>  <math>Fe \rightarrow Fe^{3+} + 3e^{-}</math>  <b>OR</b>                      iron is anode/negative electrode of cell ✓                      copper is cathode/positive electrode of cell  <b>OR</b>                      reduction occurs at the cathode  <b>OR</b>  <math>2H^{+} + 2e^{-} \rightarrow H_2</math> ✓                      electrons flow from iron to copper ✓</p>	<p><i>Accept “lemon juice acts as a salt bridge”.</i></p> <p><i>Accept “iron is more reactive than copper”.</i></p>	<p>2</p>