

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>.

Chemistry
Standard level
Paper 2

Wednesday 13 November 2019 (afternoon)

Candidate session number

1 hour 15 minutes

--	--	--	--	--	--	--	--	--	--

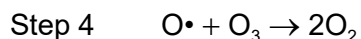
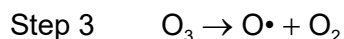
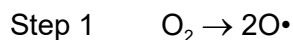
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



Answer **all** questions. Answers must be written within the answer boxes provided.

1. The equations show steps in the formation and decomposition of ozone in the stratosphere, some of which absorb ultraviolet light.



- (a) Draw the Lewis structures of oxygen, O_2 , and ozone, O_3 . [2]

- (b) Outline why both bonds in the ozone molecule are the same length and predict the bond length in the ozone molecule. Refer to section 10 of the data booklet. [2]

Reason:

.....

.....

.....

Length:

.....

- (c) Distinguish ultraviolet light from visible light in terms of wavelength and energy. [1]

.....

.....

.....

(This question continues on the following page)



(Question 1 continued)

- (d) Discuss how the different bond strengths between the oxygen atoms in O₂ and O₃ in the ozone layer affect radiation reaching the Earth's surface.

[2]

.....

.....

.....

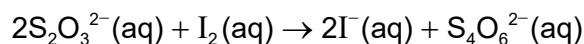
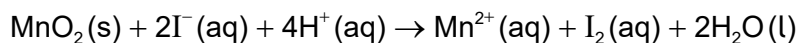
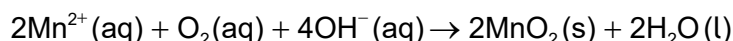
.....



16EP03

Turn over

2. The biochemical oxygen demand of a water sample can be determined by the following series of reactions. The final step is titration of the sample with sodium thiosulfate solution, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$.



A student analysed two 300.0 cm^3 samples of water taken from the school pond: one immediately (day 0), and the other after leaving it sealed in a dark cupboard for five days (day 5). The following results were obtained for the titration of the samples with $0.0100\text{ mol dm}^{-3}\text{ Na}_2\text{S}_2\text{O}_3(\text{aq})$.

Sample	Titre / $\text{cm}^3 \pm 0.1\text{ cm}^3$
Day 0	25.8
Day 5	20.1

- (a) (i) Determine the mole ratio of $\text{S}_2\text{O}_3^{2-}$ to O_2 , using the balanced equations. [1]

.....

(This question continues on the following page)



(Question 2 continued)

(ii) Calculate the number of moles of oxygen in the day 0 sample. [2]

.....
.....
.....
.....
.....

(iii) The day 5 sample contained 5.03×10^{-5} moles of oxygen.

Determine the 5-day biochemical oxygen demand of the pond, in mg dm^{-3} ("parts per million", ppm). [2]

.....
.....
.....
.....
.....

(b) (i) Calculate the percentage uncertainty of the day 5 titre. [1]

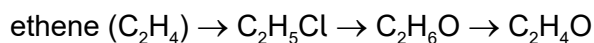
.....
.....
.....

(ii) Suggest a modification to the procedure that would make the results more reliable. [1]

.....
.....



3. The following shows some compounds which can be made from ethene, C₂H₄.



(a) State the type of reaction which converts ethene into C₂H₅Cl. [1]

.....

(b) Write an equation for the reaction of C₂H₅Cl with aqueous sodium hydroxide to produce a C₂H₆O compound, showing structural formulas. [1]

.....

(c) (i) Write an equation for the complete combustion of the organic product in (b). [1]

.....
.....

(ii) Determine the enthalpy of combustion of the organic product in (b), in kJ mol⁻¹, using data from section 11 of the data booklet. [3]

.....
.....
.....
.....
.....
.....

(This question continues on the following page)



(Question 3 continued)

- (d) (i) State the reagents and conditions for the conversion of the compound C_2H_6O , produced in (b), into C_2H_4O . [2]

.....

.....

.....

.....

- (ii) Explain why the compound C_2H_6O , produced in (b), has a higher boiling point than compound C_2H_4O , produced in d(i). [2]

.....

.....

.....

.....

- (e) Ethene is often polymerized. Draw a section of the resulting polymer, showing two repeating units. [1]

.....



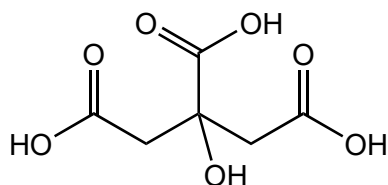
Please **do not** write on this page.

Answers written on this page
will not be marked.

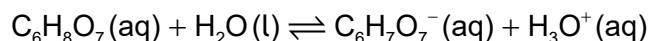


16EP08

4. A molecule of citric acid, $C_6H_8O_7$, is shown.



The equation for the first dissociation of citric acid in water is



(a) (i) Identify a conjugate acid–base pair in the equation. [1]

.....

.....

(ii) The value of the equilibrium constant for the first dissociation at 298K is 5.01×10^{-4} .

State, giving a reason, the strength of citric acid. [1]

.....

.....

(iii) The dissociation of citric acid is an endothermic process. State the effect on the hydrogen ion concentration, $[H^+]$, and on the equilibrium constant, of increasing the temperature. [2]

Effect on $[H^+]$	Effect on equilibrium constant
.....

(b) Outline **one** laboratory method of distinguishing between solutions of citric acid and hydrochloric acid of equal concentration, stating the expected observations. [1]

.....

.....

.....



5. Copper forms two chlorides, copper(I) chloride and copper(II) chloride.

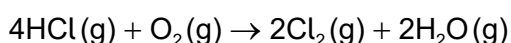
(a) (i) State the electron configuration of the Cu^+ ion.

[1]

.....

.....

(ii) Copper(II) chloride is used as a catalyst in the production of chlorine from hydrogen chloride.



Calculate the standard enthalpy change, ΔH^\ominus , in kJ, for this reaction, using section 12 of the data booklet.

[2]

.....

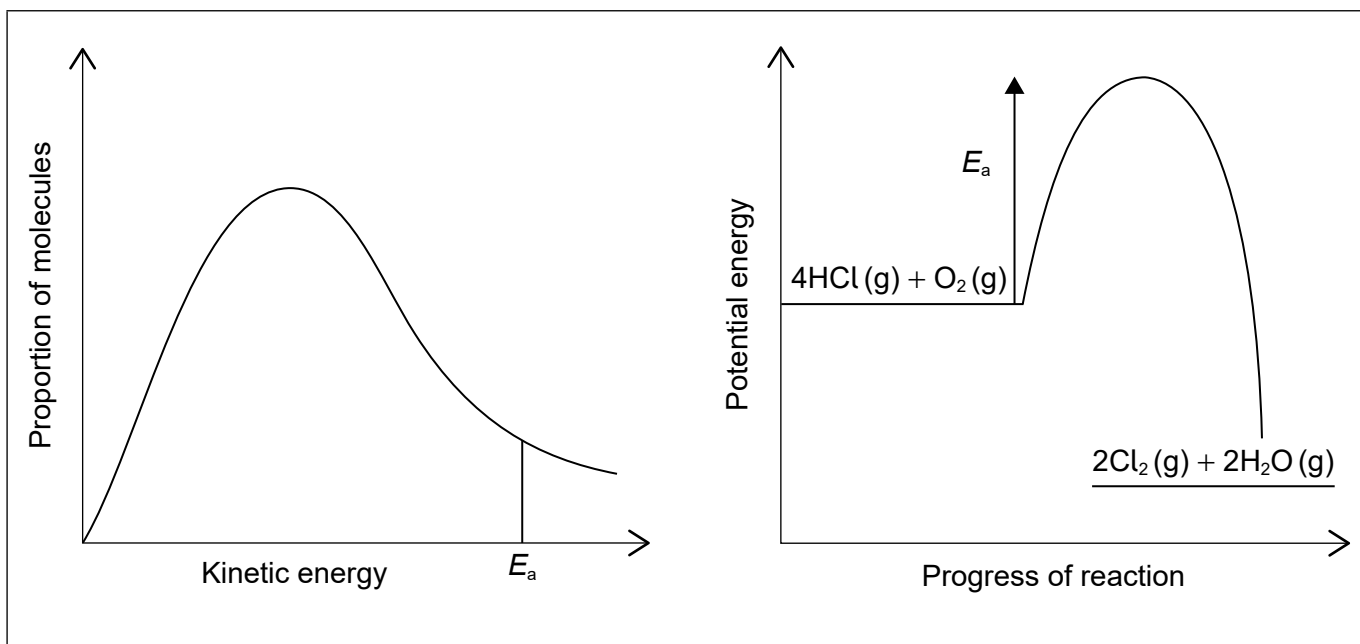
.....

.....

(iii) The diagram shows the Maxwell–Boltzmann distribution and potential energy profile for the reaction without a catalyst.

Annotate both charts to show the activation energy for the catalysed reaction, using the label $E_{a(\text{cat})}$.

[2]



(This question continues on the following page)



16EP10

(Question 5 continued)

(iv) Explain how the catalyst increases the rate of the reaction.

[2]

.....

.....

.....

.....

(b) Solid copper(II) chloride absorbs moisture from the atmosphere to form a hydrate of formula $\text{CuCl}_2 \cdot x\text{H}_2\text{O}$.

A student heated a sample of hydrated copper(II) chloride, in order to determine the value of x . The following results were obtained:

Mass of crucible = 16.221 g

Initial mass of crucible and hydrated copper(II) chloride = 18.360 g

Final mass of crucible and anhydrous copper(II) chloride = 17.917 g

Determine the value of x .

[3]

.....

.....

.....

.....

.....

.....

(This question continues on the following page)

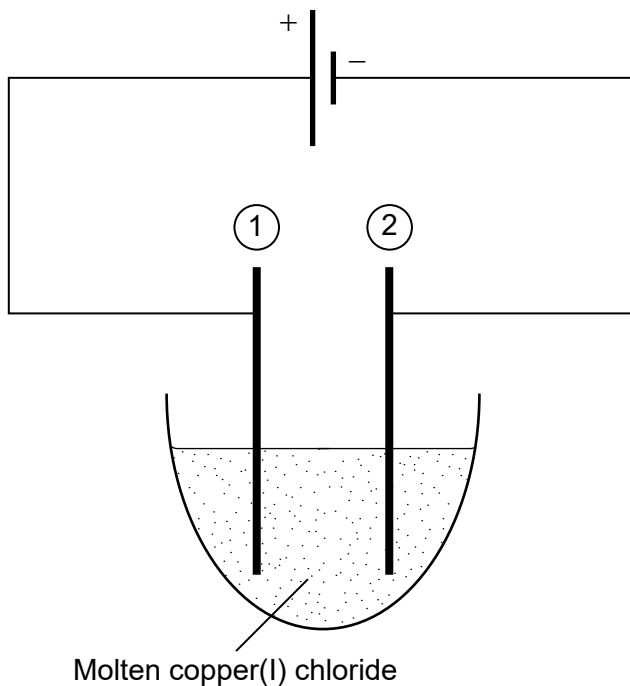


16EP11

Turn over

(Question 5 continued)

(c) An electrolysis cell was assembled using graphite electrodes and connected as shown.



(i) State how current is conducted through the wires and through the electrolyte. [2]

Wires:
.....

Electrolyte:
.....

(ii) Write the half-equation for the formation of gas bubbles at electrode 1. [1]

.....
.....



6. Automobile air bags inflate by a rapid decomposition reaction. One typical compound used is guanidinium nitrate, $C(NH_2)_3NO_3$, which decomposes very rapidly to form nitrogen, water vapour and carbon.

(a) (i) Deduce the equation for the decomposition of guanidinium nitrate. [1]

.....
.....

(ii) Calculate the total number of moles of gas produced from the decomposition of 10.0g of guanidinium nitrate. [1]

.....
.....
.....

(iii) Calculate the pressure, in kPa, of this gas in a 10.0dm^3 air bag at 127°C , assuming no gas escapes. [1]

.....
.....
.....

(iv) Suggest why water vapour deviates significantly from ideal behaviour when the gases are cooled, while nitrogen does not. [2]

.....
.....
.....
.....

(This question continues on the following page)



(Question 6 continued)

- (b) Another airbag reactant produces nitrogen gas and sodium.

Suggest, including an equation, why the products of this reactant present a safety hazard. [2]

.....

.....

.....

.....

.....



16EP14

Please **do not** write on this page.

Answers written on this page
will not be marked.



16EP15

Please **do not** write on this page.

Answers written on this page
will not be marked.



16EP16