

© International Baccalaureate Organization 2021

All rights reserved. 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 the prior written permission from the IB. Additionally, the license tied with this product prohibits 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, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organisation du Baccalauréat International 2021

Tous droits réservés. 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 préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation 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, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organización del Bachillerato Internacional, 2021

Todos los derechos reservados. 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 la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso 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—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

Chemistry
Standard level
Paper 2

Wednesday 18 May 2022 (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. When heated in air, magnesium ribbon reacts with oxygen to form magnesium oxide.

(a) (i) Write a balanced equation for the reaction that occurs. [1]

.....
.....

(ii) State the block of the periodic table in which magnesium is located. [1]

.....

(iii) Identify a metal, in the same period as magnesium, that does **not** form a basic oxide. [1]

.....

(b) The reaction in (a)(i) was carried out in a crucible with a lid and the following data was recorded:

Mass of crucible and lid = 47.372 ± 0.001 g

Mass of crucible, lid and magnesium ribbon before heating = 53.726 ± 0.001 g

Mass of crucible, lid and product after heating = 56.941 ± 0.001 g

(i) Calculate the amount of magnesium, in mol, that was used. [1]

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

(This question continues on the following page)



(Question 1 continued)

- (ii) Determine the percentage uncertainty of the mass of product after heating. [2]

.....

.....

.....

.....

- (iii) Assume the reaction in (a)(i) is the only one occurring and it goes to completion, but some product has been lost from the crucible. Deduce the percentage yield of magnesium oxide in the crucible. [2]

.....

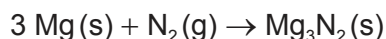
.....

.....

.....

.....

- (c) When magnesium is burnt in air, some of it reacts with nitrogen to form magnesium nitride according to the equation:



- (i) Evaluate whether this, rather than the loss of product, could explain the yield found in (b)(iii). [1]

.....

.....

.....

- (ii) Suggest an explanation, other than product being lost from the crucible or reacting with nitrogen, that could explain the yield found in (b)(iii). [1]

.....

.....

.....

(This question continues on the following page)



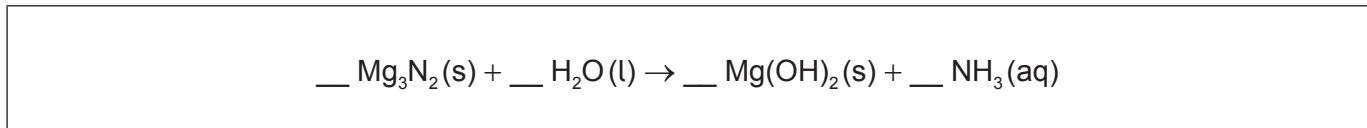
16EP03

Turn over

(Question 1 continued)

(d) The presence of magnesium nitride can be demonstrated by adding water to the product. It is hydrolysed to form magnesium hydroxide and ammonia.

(i) Calculate coefficients that balance the equation for the following reaction. [1]



(ii) Determine the oxidation state of nitrogen in Mg_3N_2 and in NH_3 . [1]

Mg_3N_2 :

NH_3 :

(iii) Deduce, giving reasons, whether the reaction of magnesium nitride with water is an acid–base reaction, a redox reaction, neither or both. [2]

Acid–base: Yes No

Reason:

.....

.....

Redox: Yes No

Reason:

.....

.....

(This question continues on the following page)



(Question 1 continued)

(e) Most nitride ions are $^{14}\text{N}^{3-}$.

(i) State the number of subatomic particles in this ion. [1]

| |
|------------------|
| Protons: |
| Neutrons: |
| Electrons: |

(ii) Some nitride ions are $^{15}\text{N}^{3-}$. State the term that describes the relationship between $^{14}\text{N}^{3-}$ and $^{15}\text{N}^{3-}$. [1]

| |
|-------|
| |
|-------|

(iii) The nitride ion and the magnesium ion are isoelectronic (they have the same electron configuration). Determine, giving a reason, which has the greater ionic radius. [1]

| |
|-------|
| |
| |

(f) Suggest **two** reasons why atoms are no longer regarded as the indivisible units of matter. [2]

| |
|-------|
| |
| |
| |
| |
| |

(This question continues on the following page)



(Question 1 continued)

(g) State the types of bonding in magnesium, oxygen and magnesium oxide, and how the valence electrons produce these types of bonding.

[4]

| Substance | Bond type | How the valence electrons produce these bonds |
|-----------------|-----------|---|
| Magnesium | | |
| Oxygen | | |
| Magnesium oxide | | |



16EP06

2. Ammonia, NH_3 , is industrially important for the manufacture of fertilizers, explosives and plastics.

(a) Draw arrows in the boxes to represent the electron configuration of a nitrogen atom. [1]

| | | | |
|----|--------------------------|--------------------------|--------------------------|
| 2p | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2s | <input type="checkbox"/> | | |
| 1s | <input type="checkbox"/> | | |

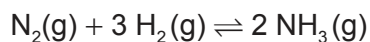
(b) Draw the Lewis (electron dot) structure of the ammonia molecule. [1]

(This question continues on the following page)



(Question 2 continued)

(c) Ammonia is produced by the Haber–Bosch process which involves the equilibrium:



(i) Deduce the expression for the equilibrium constant, K_c , for this equation. [1]

.....

.....

.....

(ii) Explain why an increase in pressure shifts the position of equilibrium towards the products and how this affects the value of the equilibrium constant, K_c . [2]

.....

.....

.....

.....

.....

(iii) State how the use of a catalyst affects the position of the equilibrium. [1]

.....

.....

(This question continues on the following page)



(Question 2 continued)

(d) The effect of temperature on the position of equilibrium depends on the enthalpy change of the reaction.

(i) Determine the enthalpy change, ΔH , for the Haber–Bosch process, in kJ. Use Section 11 of the data booklet. [3]

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

(ii) Calculate the enthalpy change, ΔH^\ominus , for the Haber–Bosch process, in kJ, using the following data.

$\Delta H_f^\ominus(\text{NH}_3) = -46.2 \text{ kJ mol}^{-1}$. [1]

.....
.....

(iii) Suggest why the values obtained in (d)(i) and (d)(ii) differ. [1]

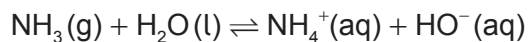
.....
.....
.....

(This question continues on the following page)



(Question 2 continued)

(e) Ammonia is soluble in water and forms an alkaline solution:



(i) State the relationship between NH_4^+ and NH_3 in terms of the Brønsted–Lowry theory. [1]

.....
.....

(ii) Determine the concentration, in mol dm^{-3} , of the solution formed when 900.0 dm^3 of $\text{NH}_3(\text{g})$ at 300.0 K and 100.0 kPa , is dissolved in water to form 2.00 dm^3 of solution. Use sections 1 and 2 of the data booklet. [2]

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

(iii) Calculate the concentration of hydroxide ions in an ammonia solution with $\text{pH} = 9.3$. Use sections 1 and 2 of the data booklet. [1]

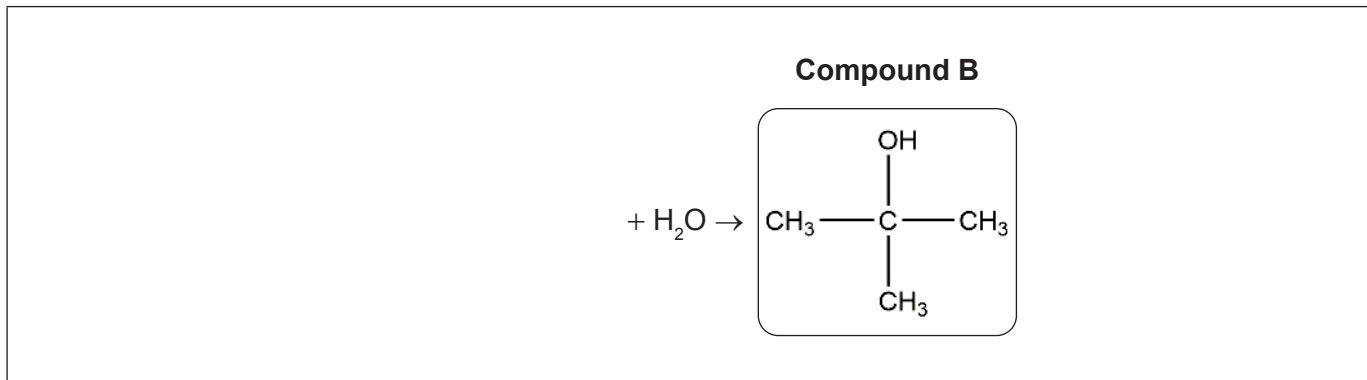
.....
.....
.....



(Question 3 continued)

(d) Compound B can also be prepared by reacting an alkene with water.

(i) Draw the structural formula of the alkene required. [1]



(ii) Deduce the structural formula of the repeating unit of the polymer formed from this alkene. [1]

Blank area for drawing the structural formula of the repeating unit of the polymer.

(e) Deduce what would be observed when Compound B is warmed with acidified aqueous potassium dichromate (VI). [1]

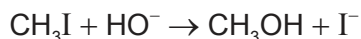
.....
.....
.....

(This question continues on the following page)



(Question 3 continued)

(f) Iodomethane is used to prepare CH_3MgI . It can also be converted into methanol:



(i) Identify the type of reaction. [1]

.....
.....

(ii) Outline the requirements for a collision between reactants to yield products. [2]

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

(iii) The polarity of the carbon-halogen bond, C-X, facilitates attack by HO^- . Outline, giving a reason, how the bond polarity changes going down group 17. [1]

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

References:

© International Baccalaureate Organization 2022



16EP13

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

Answers written on this page
will not be marked.



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