

© International Baccalaureate Organization 2022

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 2022

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, 2022

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 1

Wednesday 18 May 2022 (afternoon)

45 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[30 marks]**.

The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	1 H 1.01	Atòmic number																	
2	3 Li 6.94	4 Be 9.01	Element																
3	11 Na 22.99	12 Mg 24.31	Relative atomic mass																
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.90	
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29	
6	55 Cs 132.91	56 Ba 137.33	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)	
7	87 Fr (223)	88 Ra (226)	89 ‡ Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (269)	109 Mt (278)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Unt (286)	114 Uug (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 Uuo (294)	
	†																		
	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97					
	‡																		
	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)					

1. 0.2 mol of sodium hydrogencarbonate is decomposed by heating until constant mass.



How many moles of gas are produced?

- A. 0.1
B. 0.2
C. 0.3
D. 0.4
2. Which sample contains the fewest moles of HCl?
- $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$.
- Molar volume of an ideal gas at STP = $22.7 \text{ dm}^3 \text{ mol}^{-1}$.
- A. 10.0 cm^3 of 0.1 mol dm^{-3} HCl(aq)
B. 6.02×10^{24} molecules of HCl(g)
C. 0.365 g of HCl(g)
D. 2.27 dm^3 of HCl(g) at STP
3. What is the molecular formula of a compound with an empirical formula of CHO_2 and a relative molecular mass of 90?
- A. CHO_2
B. $\text{C}_2\text{H}_2\text{O}_4$
C. $\text{C}_3\text{H}_6\text{O}_3$
D. $\text{C}_4\text{H}_{10}\text{O}_2$
4. 8.8 g of an oxide of nitrogen contains 3.2 g of oxygen. What is the empirical formula of the compound?
- A. N_2O_5
B. N_2O
C. NO_2
D. NO

Turn over

5. Naturally occurring gallium consists of the isotopes ^{71}Ga and ^{69}Ga . What is the approximate percentage abundance of ^{69}Ga ?

$$M_r(\text{Ga}) = 69.72.$$

- A. 40 %
- B. 50 %
- C. 60 %
- D. 75 %
6. What is the maximum number of electrons that can occupy a p-orbital?
- A. 2
- B. 3
- C. 6
- D. 8
7. Which gases are acidic?
- I. nitrogen dioxide
- II. carbon dioxide
- III. sulfur dioxide
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III
8. Which of the following is the electron configuration of a metallic element?
- A. $[\text{Ne}] 3s^2 3p^2$
- B. $[\text{Ne}] 3s^2 3p^4$
- C. $[\text{Ne}] 3s^2 3p^6 3d^3 4s^2$
- D. $[\text{Ne}] 3s^2 3p^6 3d^{10} 4s^2 4p^5$

9. A compound consists of the ions Ca^{2+} and PO_4^{3-} . What are the name and formula of the compound?

	Name	Formula
A.	calcium phosphorus oxide	CaPO_4
B.	calcium phosphorus oxide	$\text{Ca}_3(\text{PO}_4)_2$
C.	calcium phosphate	CaPO_4
D.	calcium phosphate	$\text{Ca}_3(\text{PO}_4)_2$

10. What is the explanation for the high melting point of sodium chloride?
- A. The covalent bond between sodium and chlorine atoms is strong.
 - B. Electrostatic attraction between sodium and chloride ions is strong.
 - C. Intermolecular forces in sodium chloride are strong.
 - D. Delocalized electrons cause strong bonding in sodium chloride.
11. Which molecule is most polar?
- A. CF_4
 - B. CCl_4
 - C. CHF_3
 - D. CClF_3
12. For which species can resonance structures be drawn?
- A. HCOOH
 - B. HCOO^-
 - C. CH_3OH
 - D. H_2CO_3

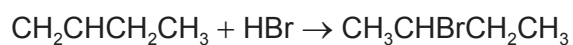
Turn over

13. The energy from burning 0.250 g of ethanol causes the temperature of 150 cm³ of water to rise by 10.5 °C. What is the enthalpy of combustion of ethanol, in kJ mol⁻¹?

Specific heat capacity of water: 4.18 Jg⁻¹ K⁻¹.

- A. $\frac{150 \times 4.18 \times 10.5}{\frac{0.250}{46.08}}$
- B. $\frac{150 \times 4.18 \times 10.5}{\frac{0.250}{46.08} \times 1000}$
- C. $\frac{150 \times 4.18 \times (273 + 10.5)}{\frac{0.250}{46.08}}$
- D. $\frac{150 \times 4.18 \times (273 + 10.5)}{\frac{0.250}{46.08} \times 1000}$

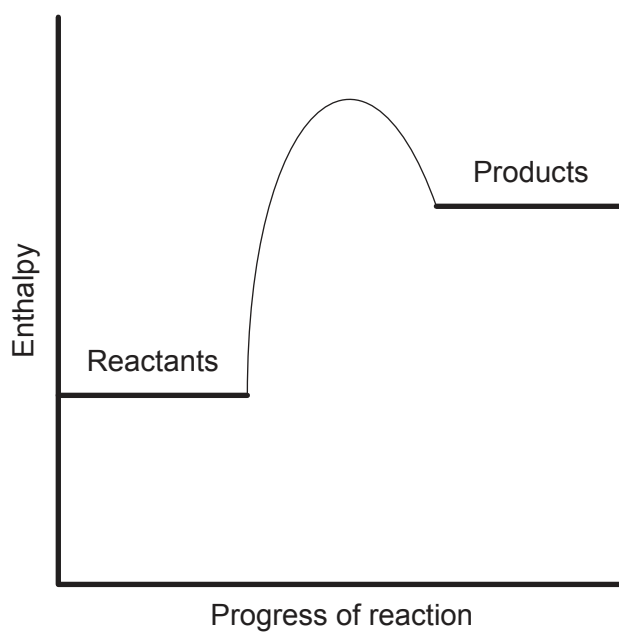
14. What is the enthalpy change of the following reaction?



Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
CH ₂ CHCH ₂ CH ₃	0.1
HBr	-36.3
CH ₃ CHBrCH ₂ CH ₃	-156.0

- A. -119.6 kJ
- B. +119.6 kJ
- C. -119.8 kJ
- D. +119.8 kJ

15. What is the correct interpretation of the following potential energy profile?

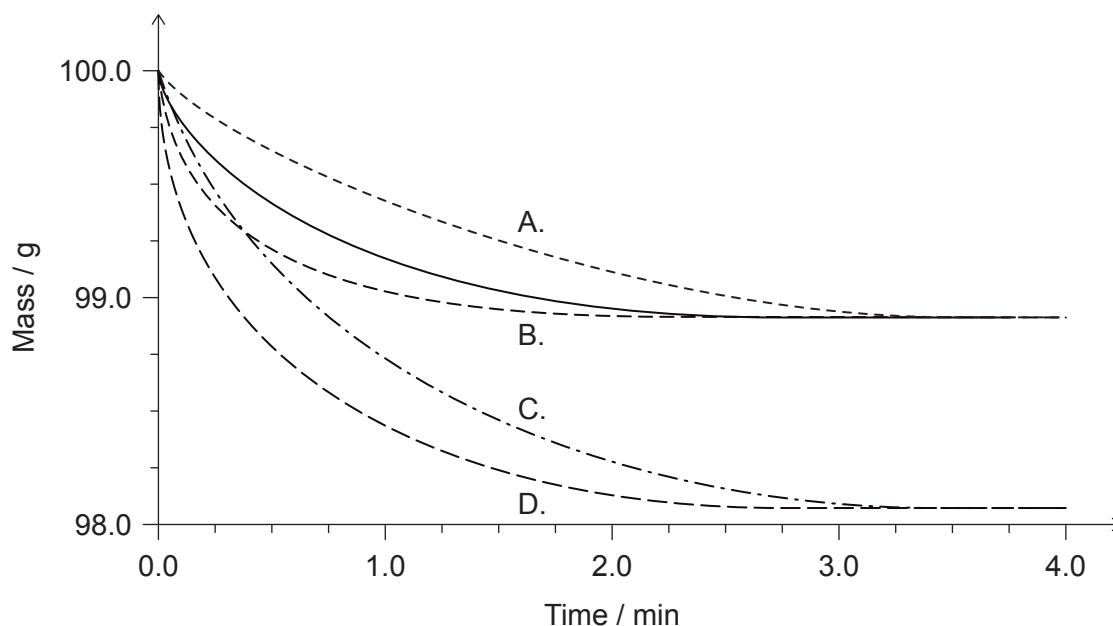


- A. Endothermic reaction; products more stable than reactants.
- B. Exothermic reaction; products more stable than reactants.
- C. Endothermic reaction; products less stable than reactants.
- D. Exothermic reaction; products less stable than reactants.

Turn over

16. A sample of calcium carbonate reacts with excess hydrochloric acid in a beaker. The solid line shows how the mass of the beaker changes with time.

Which dashed line represents the results obtained when the acid concentration is doubled?

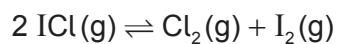


17. A student was investigating rates of reaction. In which of the following cases would a colorimeter show a change in absorbance?

- A. $\text{KBr(aq)} + \text{Cl}_2(\text{aq})$
- B. $\text{Cu(s)} + \text{Na}_2\text{SO}_4(\text{aq})$
- C. $\text{HCl(aq)} + \text{NaOH(aq)}$
- D. $(\text{CH}_3)_3\text{COH(aq)} + \text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$

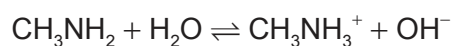
18. $\frac{1}{2} \text{Cl}_2(\text{g}) + \frac{1}{2} \text{I}_2(\text{g}) \rightleftharpoons \text{ICl}(\text{g}) \quad K_c = 454$

What is the K_c value for the reaction below?



- A. 2×454
- B. $\frac{1}{2 \times 454}$
- C. 454^2
- D. $\frac{1}{454^2}$

19. Which species are acids in the equilibrium below?



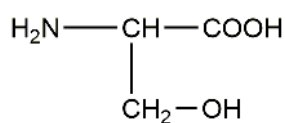
- A. CH_3NH_2 and H_2O
- B. H_2O and CH_3NH_3^+
- C. H_2O and OH^-
- D. CH_3NH_2 and CH_3NH_3^+
20. Which 0.01 mol dm^{-3} aqueous solution has the highest pH?
- A. HCl
- B. H_2SO_4
- C. NaOH
- D. NH_3
21. In which of the following species would sulfur be reduced if converted to SCl_2 ?
- A. $\text{S}_2\text{O}_3^{2-}$
- B. H_2S
- C. S
- D. SO_2
22. Which statement is correct for both voltaic and electrolytic cells?
- A. The oxidation reaction releases electrons.
- B. The oxidation reaction occurs at the positive electrode.
- C. The cathode is negative.
- D. Electrons flow through the electrolyte.

Turn over

23. How many electrons are needed when the following half-equation is balanced using the lowest possible whole numbers?



- A. 1
 B. 2
 C. 3
 D. 5
24. Which functional groups are present in serine?

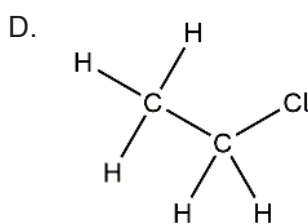
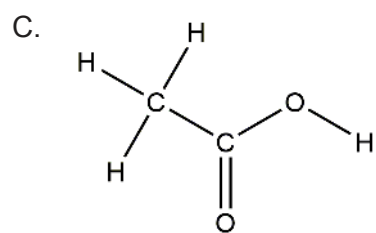
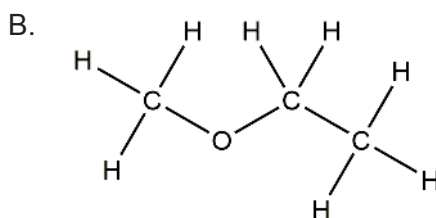
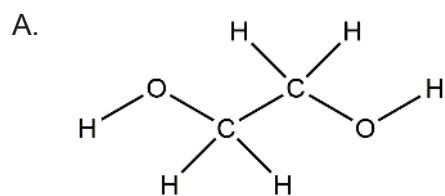
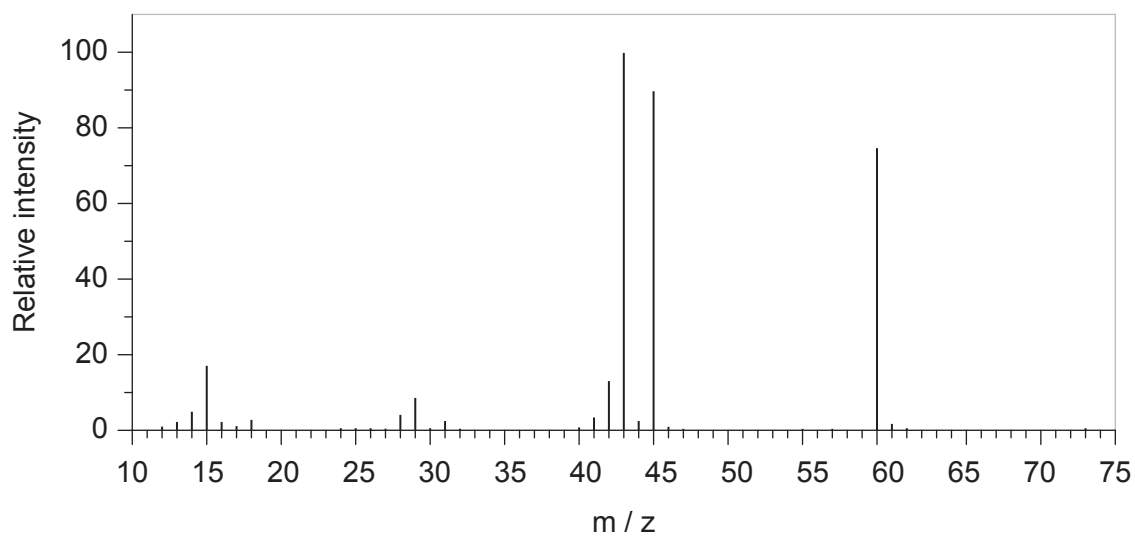


- A. nitro, carbonyl and carboxyl
 B. amino, hydroxyl and carbonyl
 C. nitro, carboxyl and hydroxyl
 D. amino, carboxyl and hydroxyl
25. Which compounds are members of the same homologous series?
- A. propanal, propanone, propanoic acid
 B. propane, propene, propyne
 C. hexan-1-ol, hexan-2-ol, hexan-3-ol
 D. ethanol, propan-1-ol, butan-1-ol
26. Which reagents and conditions are best for converting propan-1-ol into propanoic acid?
- A. Reflux with acidified potassium dichromate (VI)
 B. Reflux with aqueous sodium hydroxide
 C. Distil with acidified potassium dichromate (VI)
 D. Distil with aqueous sodium hydroxide

27. What is produced when chlorobutane is treated with aqueous sodium hydroxide solution?
- A. butane
 - B. butanoic acid
 - C. butanal
 - D. butan-1-ol
28. A student performed an experiment to find the melting point of sulfur, obtaining 118.0°C. The literature value is 115.2°C. What was the percentage error?
- A. $\frac{118.0 - 115.2}{115.2} \times 100\%$
 - B. $\frac{115.2}{118.0} \times 100\%$
 - C. $\frac{118.0 - 115.2}{118.0} \times 100\%$
 - D. $\frac{118.0}{115.2} \times 100\%$

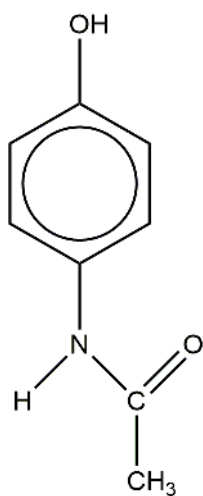
Turn over

29. Which compound produces this mass spectrum?



30. What is the index of hydrogen deficiency (IHD) of this molecule?

Paracetamol (acetaminophen)



- A. 3
 - B. 4
 - C. 5
 - D. 6
-

References:

29. Spectral Database for Organic Compounds, SDBS. SDBS Compounds and Spectral Search. [graph] Available at: <https://sdfs.db.aist.go.jp> [Accessed 3 January 2019].

All other texts, graphics and illustrations © International Baccalaureate Organization 2022