

© 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/>.

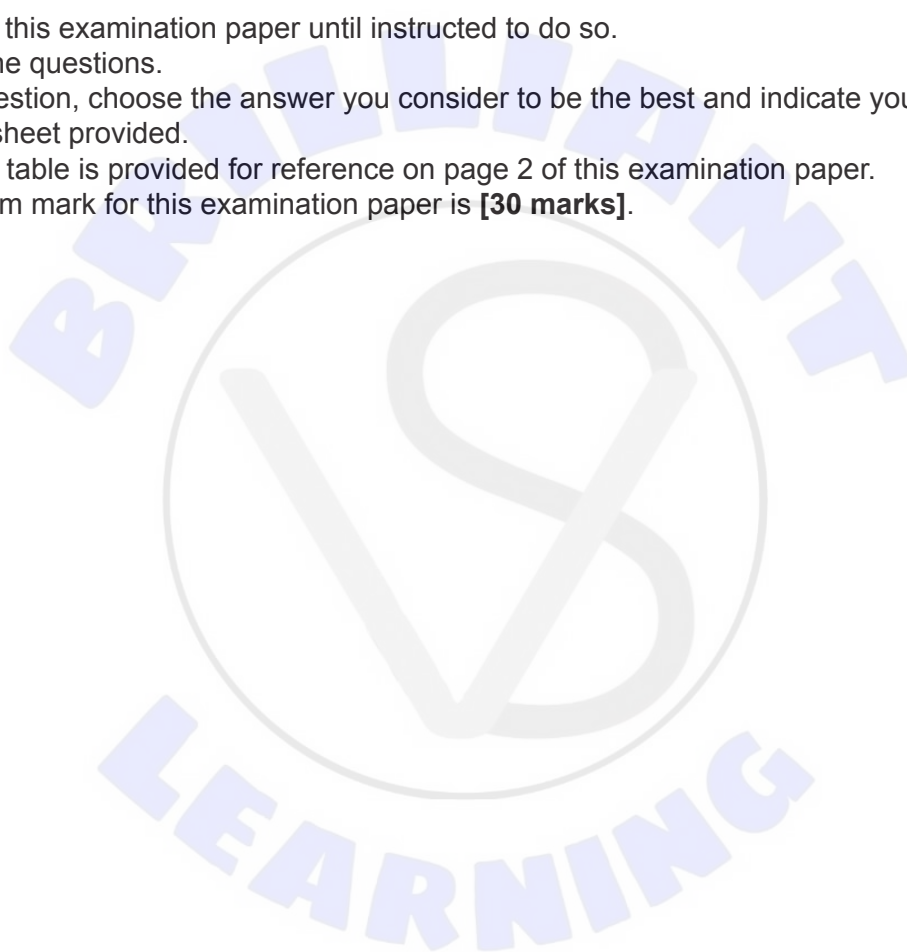
Chemistry
Standard level
Paper 1

Wednesday 9 November 2022 (morning)

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	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01	2 He 4.00	3 Li 6.94	4 Be 9.01	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
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
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
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)
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 Uut (286)	114 Uug (289)	115 Uup (288)	116 Uuh (293)	117 Uus (294)	118 Uuo (294)
			<div style="border: 1px solid black; padding: 5px;"> Atomic number Element Relative atomic mass </div>														
			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. How many oxygen atoms are present in 0.0500 mol $\text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}$?

$$N_A = 6.02 \times 10^{23}$$

- A. 3.01×10^{23}
- B. 6.02×10^{23}
- C. 3.01×10^{24}
- D. 6.02×10^{24}
2. What is the change of state for a gas to a solid?
- A. Condensation
- B. Deposition
- C. Freezing
- D. Sublimation
3. How many moles of carbon dioxide are produced by the complete combustion of 7.0 g of ethene, $\text{C}_2\text{H}_4(\text{g})$?
- $$M_r = 28$$
- A. 0.25
- B. 0.5
- C. 0.75
- D. 1.0
4. Which is a possible empirical formula for a substance with $M_r = 42$?
- A. CH
- B. CH_2
- C. C_3H_6
- D. C_3H_8

Turn over

5. Which quantities are different between two species represented by the notation ${}_{52}^{128}\text{Te}$ and ${}_{53}^{128}\text{I}^-$?
- A. The number of protons only
 - B. The number of protons and electrons only
 - C. The number of protons and neutrons only
 - D. The number of protons, neutrons and electrons
6. What is the relative atomic mass of a sample of chlorine containing 70 % of the ${}^{35}\text{Cl}$ isotope and 30 % of the ${}^{37}\text{Cl}$ isotope?
- A. 35.4
 - B. 35.5
 - C. 35.6
 - D. 35.7
7. Which elements are considered to be metalloids?
- I. Gallium
 - II. Germanium
 - III. Arsenic
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
8. Which property of elements increases down a group but decreases across a period?
- A. Atomic radius
 - B. Electronegativity
 - C. Ionic radius
 - D. Ionization energy

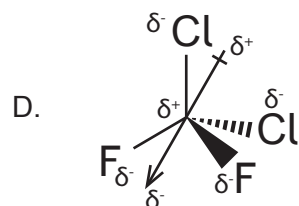
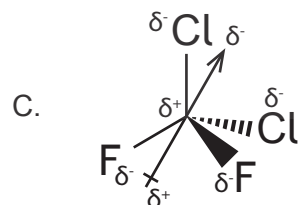
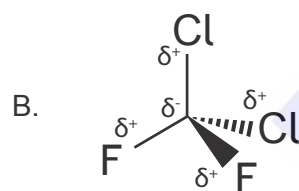
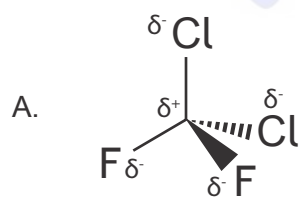
9. Which molecule can be represented by resonance structures?

- A. H_2S
- B. HNO_3
- C. H_2O_2
- D. HClO

10. Which molecule is polar?

- A. BeH_2
- B. AlH_3
- C. PH_3
- D. SiH_4

11. Which structure of CF_2Cl_2 is shown with correct bond and molecular dipoles?



Turn over

12. Alloying a metal with a metal of smaller atomic radius can disrupt the lattice and make it more difficult for atoms to slide over each other. Which property will increase as a result?
- A. Electrical conductivity
 - B. Ductility
 - C. Malleability
 - D. Strength

13. Chlorofluorocarbons (CFCs) contain bonds of the following lengths:

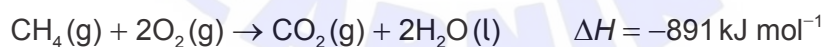
$$\text{C-C} = 1.54 \times 10^{-10} \text{ m}$$

$$\text{C-F} = 1.38 \times 10^{-10} \text{ m}$$

$$\text{C-Cl} = 1.77 \times 10^{-10} \text{ m}$$

What is the order of **increasing** bond strength in the CFC molecule?

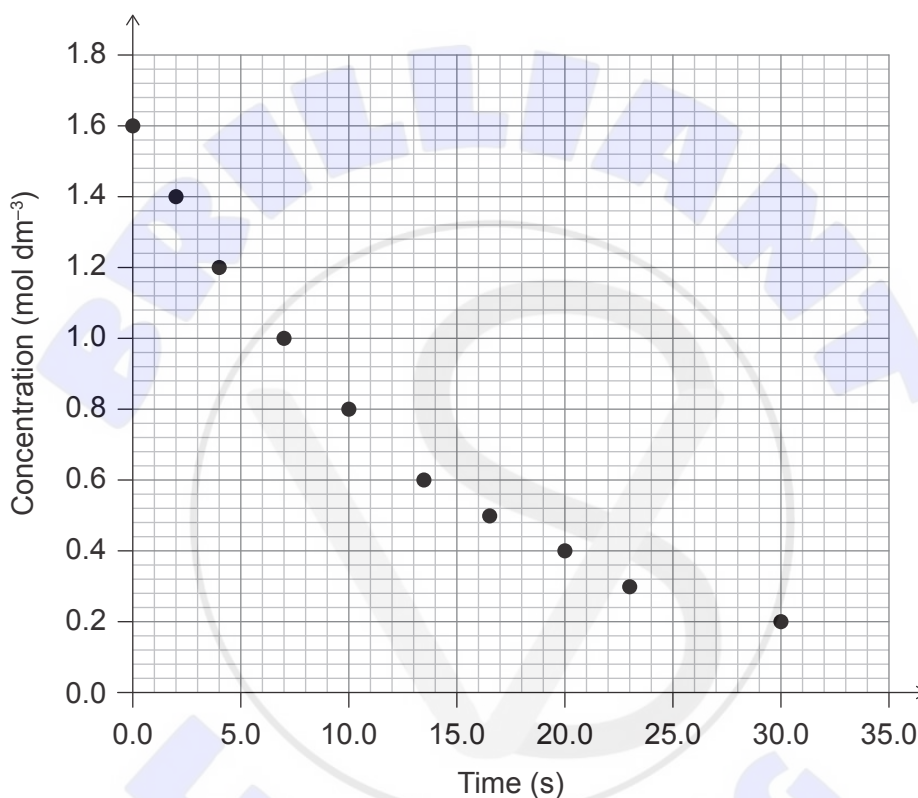
- A. $\text{C-C} < \text{C-F} < \text{C-Cl}$
 - B. $\text{C-C} < \text{C-Cl} < \text{C-F}$
 - C. $\text{C-Cl} < \text{C-C} < \text{C-F}$
 - D. $\text{C-F} < \text{C-C} < \text{C-Cl}$
14. What is the value for enthalpy of formation of methane from the given enthalpies of combustion?



- A. $(-394 - 286 - 891) \text{ kJ mol}^{-1}$
- B. $(-394 - (2 \times 286) - 891) \text{ kJ mol}^{-1}$
- C. $(-394 - 286 + 891) \text{ kJ mol}^{-1}$
- D. $(-394 - (2 \times 286) + 891) \text{ kJ mol}^{-1}$

15. Which statement best describes heat?
- A. A quantity of potential energy of particles
 - B. A quantity of average kinetic energy of particles
 - C. A quantity of energy transferred between particles
 - D. A quantity of the total energy held by particles

16. What initial rate of reaction can be determined from the graph?



- A. $0.1 \text{ mol dm}^{-3} \text{ s}^{-1}$
- B. $0.2 \text{ mol dm}^{-3} \text{ s}^{-1}$
- C. $1.0 \text{ mol dm}^{-3} \text{ s}^{-1}$
- D. $1.6 \text{ mol dm}^{-3} \text{ s}^{-1}$

17. Which changes would increase the rate of an exothermic reaction?

	Temperature	Particle size
A.	Increase	Decrease
B.	Increase	Increase
C.	Decrease	Increase
D.	Decrease	Decrease

18. The exothermic reaction $I_2(g) + 3Cl_2(g) \rightleftharpoons 2ICl_3(g)$ is at equilibrium in a fixed volume. What is correct about the reaction quotient, Q , and shift in position of equilibrium the instant temperature is raised?

- A. $Q > K$, equilibrium shifts right towards products.
- B. $Q > K$, equilibrium shifts left towards reactants.
- C. $Q < K$, equilibrium shifts right towards products.
- D. $Q < K$, equilibrium shifts left towards reactants.

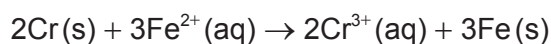
19. Equal volumes of 0.10 mol dm^{-3} weak acid and strong acid are titrated with 0.10 mol dm^{-3} NaOH solution. Which of these is the same for the two acids?

- A. Initial pH
- B. Heat evolved in the neutralization
- C. Volume of NaOH for complete neutralization
- D. Initial electrical conductivity

20. Which species has the weakest conjugate base?

- A. HCl
- B. NH_4^+
- C. HCO_3^-
- D. H_2O

21. What occurs during the operation of a voltaic cell based on the given reaction?



	External circuit	Ion movement in solution
A.	Electrons move from Cr to Fe	$\text{Fe}^{2+}(\text{aq})$ move away from Fe(s)
B.	Electrons move from Cr to Fe	$\text{Fe}^{2+}(\text{aq})$ move toward Fe(s)
C.	Electrons move from Fe to Cr	$\text{Cr}^{3+}(\text{aq})$ move away from Cr(s)
D.	Electrons move from Fe to Cr	$\text{Cr}^{3+}(\text{aq})$ move toward Cr(s)

22. Which substance is the reducing agent in the given reaction?



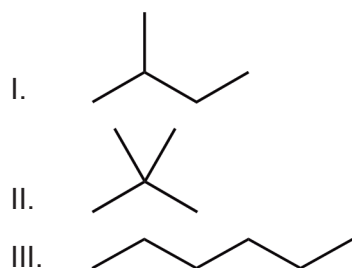
- A. H^+
 B. H_2O
 C. MnO_4^-
 D. SO_2

23. Which combination is correct regarding the anode and electron flow in an electrolytic cell?

	Polarity of anode	Movement of electrons in external circuit
A.	Positive electrode	Anode to cathode
B.	Positive electrode	Cathode to anode
C.	Negative electrode	Anode to cathode
D.	Negative electrode	Cathode to anode

Turn over

24. Which are isomers of C_5H_{12} ?



- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III
25. Which homologous series has the general formula $C_nH_{2n}O$ ($n > 2$)?
- A. Alcohols
- B. Carboxylic acids
- C. Ethers
- D. Ketones
26. Which conditions best favour oxidation of primary alcohols directly to carboxylic acids?
- A. Excess acidified potassium dichromate (VI) and distillation
- B. Excess acidified potassium dichromate (VI) and reflux
- C. Few drops of acidified potassium dichromate (VI) and distillation
- D. Few drops of acidified potassium dichromate (VI) and reflux
27. What are nucleophiles most likely to react with?
- A. Alkenes
- B. Benzene
- C. Alkanes
- D. Halogenoalkanes

28. What combination is the most effective for reducing random and systematic errors?

	Reduce random error	Reduce systematic error
A.	Repeat trials	Repeat trials
B.	Recalibrate equipment	Recalibrate equipment
C.	Repeat trials	Recalibrate equipment
D.	Recalibrate equipment	Repeat trials

29. A well tested scientific idea which has been used to make predictions cannot explain a particular event. Which statement describes the scientific approach to this dilemma?

- A. Hypothesis should be discarded.
- B. Hypothesis should be revised.
- C. Theory should be discarded.
- D. Theory should be revised.

30. What information about 2-hydroxybutanoic acid can be inferred through mass spectrometry, MS, infrared spectroscopy, IR, and proton nuclear magnetic resonance spectroscopy, ^1H NMR?

	MS	IR	^1H NMR
A.	$M = 104 \text{ g mol}^{-1}$.	Compound contains carboxyl and hydroxyl groups.	The hydroxyl group is on the 2nd, rather than 4th carbon.
B.	$M = 104 \text{ g mol}^{-1}$.	The hydroxyl group is on the 2nd, rather than 4th carbon.	Compound contains carboxyl and hydroxyl groups.
C.	Compound contains carboxyl and hydroxyl groups.	$M = 104 \text{ g mol}^{-1}$.	The hydroxyl group is on the 2nd, rather than 4th carbon.
D.	Compound contains carboxyl and hydroxyl groups.	The hydroxyl group is on the 2nd, rather than 4th carbon.	$M = 104 \text{ g mol}^{-1}$.

Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

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