

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 1**

Wednesday 22 May 2019 (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]**.

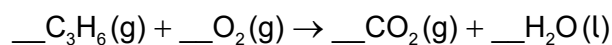
# The Periodic Table

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

1. How many moles of magnesium hydroxide are produced with 0.50 mol of ammonia?



- A. 0.25  
B. 0.33  
C. 0.75  
D. 1.5
2. What is the sum of the integer coefficients when propene undergoes complete combustion?



- A. 11  
B. 17  
C. 21  
D. 23
3. What is the volume of gas when the pressure on 100 cm<sup>3</sup> of gas is changed from 400 kPa to 200 kPa at constant temperature?
- A. 50.0 cm<sup>3</sup>  
B. 100 cm<sup>3</sup>  
C. 200 cm<sup>3</sup>  
D. 800 cm<sup>3</sup>
4. What is the concentration, in mol dm<sup>-3</sup>, of 20.0 g of NaOH ( $M_r = 40.0$ ) in 500.0 cm<sup>3</sup>?
- A. 0.250  
B. 0.500  
C. 1.00  
D. 4.00

Turn over

5. Which is correct for  ${}^{34}_{16}\text{S}^{2-}$ ?

	Protons	Neutrons	Electrons
A.	16	18	14
B.	18	16	18
C.	16	18	16
D.	16	18	18

6. Which transition in the hydrogen atom emits visible light?

- A.  $n = 1$  to  $n = 2$
- B.  $n = 2$  to  $n = 3$
- C.  $n = 2$  to  $n = 1$
- D.  $n = 3$  to  $n = 2$

7. Which of the following would have the same numerical value for all elements in the same period?

- A. Highest energy levels occupied
- B. Energy sub-levels occupied
- C. Orbitals occupied
- D. Valence electrons

8. How do the following properties change down Group 17 of the periodic table?

	Ionization energy	Ionic radius
A.	increases	decreases
B.	increases	increases
C.	decreases	increases
D.	decreases	decreases

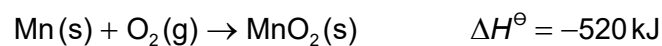
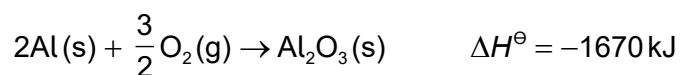
9. How does a lithium atom form the most stable ion?
- A. The atom gains a proton to form a positive ion.
  - B. The atom loses a proton to form a negative ion.
  - C. The atom loses an electron to form a positive ion.
  - D. The atom gains an electron to form a negative ion.
10. Which combination causes the strength of metallic bonding to increase?

	Charge on cations	Ionic radius
A.	smaller	smaller
B.	larger	larger
C.	smaller	larger
D.	larger	smaller

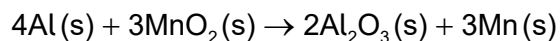
11. Which molecule contains an incomplete octet of electrons?
- A.  $\text{NF}_3$
  - B.  $\text{BF}_3$
  - C.  $\text{BrF}$
  - D.  $\text{SF}_2$
12. Which compound has hydrogen bonds between its molecules?
- A.  $\text{CH}_4$
  - B.  $\text{CH}_4\text{O}$
  - C.  $\text{CH}_3\text{Cl}$
  - D.  $\text{CH}_2\text{O}$

Turn over

13. Consider the following equations.

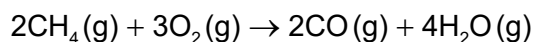


What is the standard enthalpy change, in kJ, of the reaction below?



- A.  $-1670 + 520$   
 B.  $\frac{3}{2}(-1670) + 3(520)$   
 C.  $2(-1670) + 3(-520)$   
 D.  $2(-1670) + 3(520)$

14. Methane undergoes incomplete combustion.

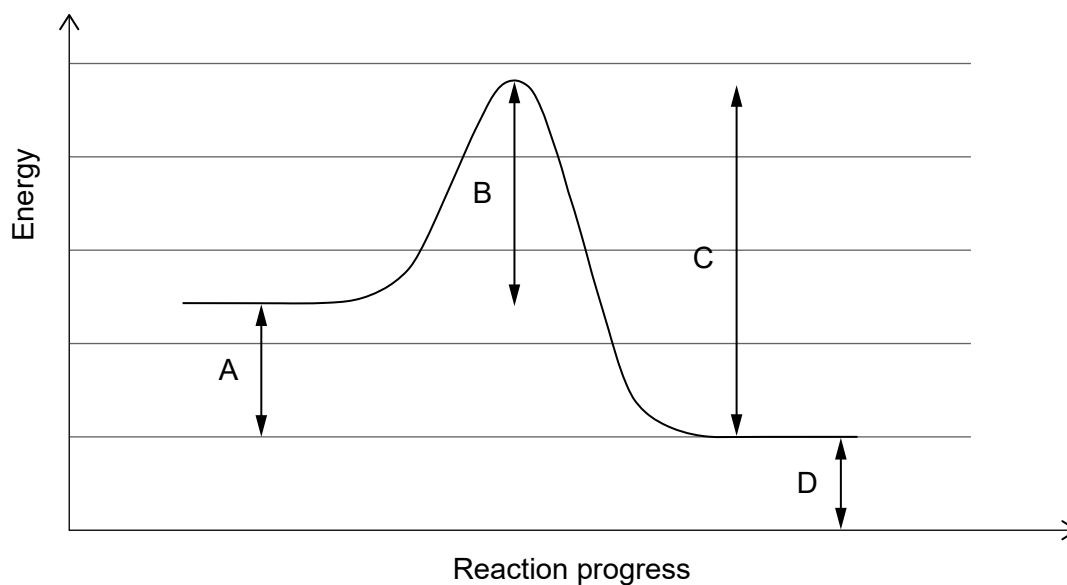


What is the enthalpy change, in kJ, using the bond enthalpy data given below?

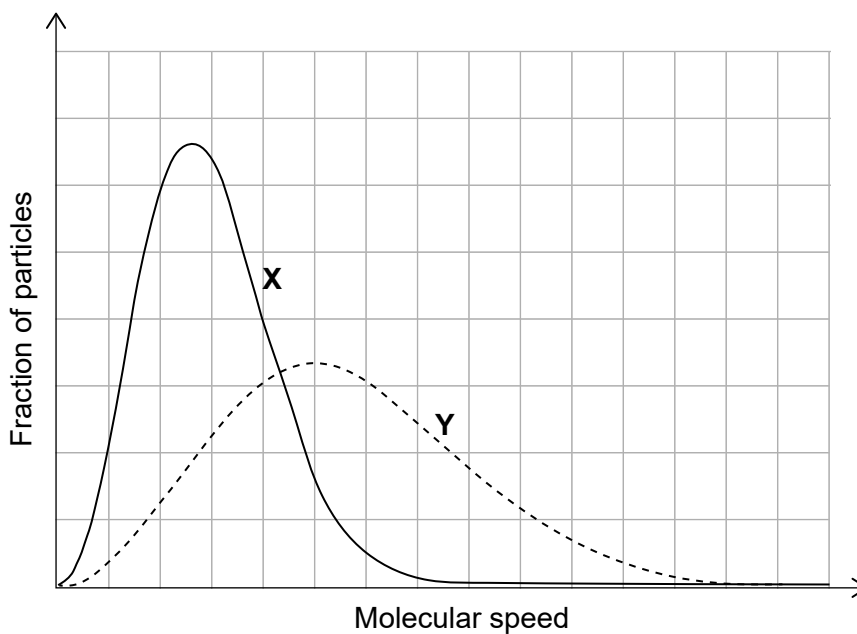
Bond	Average bond enthalpy / $\text{kJ mol}^{-1}$
C-H	414
O-H	463
O=O	498
C≡O	1077

- A.  $[2(1077) + 4(463)] - [2(414) + 3(498)]$   
 B.  $[2(414) + 3(498)] - [2(1077) + 4(463)]$   
 C.  $[8(414) + 3(498)] - [2(1077) + 8(463)]$   
 D.  $[2(1077) + 8(463)] - [8(414) + 3(498)]$

15. Which is the activation energy of the forward reaction?



16. The same amount of two gases, **X** and **Y**, are in two identical containers at the same temperature. What is the difference between the gases?



- A. **X** has the higher molar mass.
- B. **Y** has the higher molar mass.
- C. **X** has the higher average kinetic energy.
- D. **Y** has the higher average kinetic energy.

Turn over



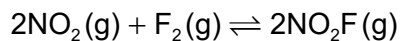
17. Several reactions of calcium carbonate with dilute hydrochloric acid are carried out at the same temperature.



Which reaction has the greatest rate?

	Concentration of HCl(aq)	Surface area of same mass of CaCO <sub>3</sub> (s)
A.	higher	larger
B.	lower	smaller
C.	lower	larger
D.	higher	smaller

18. What is the equilibrium constant expression for the following equation?



- A.  $\frac{2[\text{NO}_2\text{F}]}{2[\text{NO}_2] + [\text{F}_2]}$
- B.  $\frac{2[\text{NO}_2\text{F}]}{2[\text{NO}_2][\text{F}_2]}$
- C.  $\frac{[\text{NO}_2]^2[\text{F}_2]}{[\text{NO}_2\text{F}]^2}$
- D.  $\frac{[\text{NO}_2\text{F}]^2}{[\text{NO}_2]^2[\text{F}_2]}$

19. What is the pH of 0.001 mol dm<sup>-3</sup> NaOH(aq)?

- A. 1
- B. 3
- C. 11
- D. 13

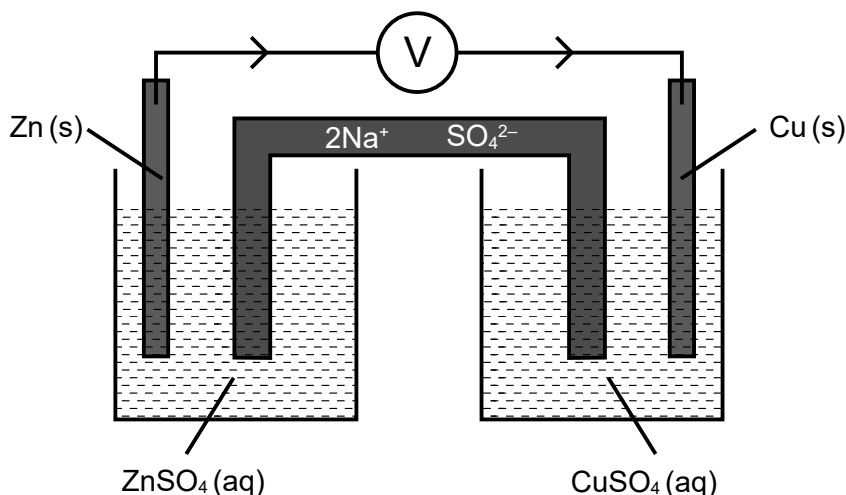
20. What is the major reason why the pH of unpolluted rain is less than 7?

- A. methane
- B. carbon dioxide
- C. nitrogen oxides
- D. sulfur dioxide

21. Which species contains nitrogen with the highest oxidation state?

- A.  $\text{NO}_3^-$
- B.  $\text{NO}_2^-$
- C.  $\text{NO}_2$
- D.  $\text{N}_2\text{O}$

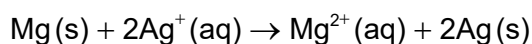
22. Consider the following electrochemical cell.



What happens to the ions in the salt bridge when a current flows?

- A.  $\text{Na}^+$  ions flow to the zinc half-cell and  $\text{SO}_4^{2-}$  ions flow to the copper half-cell.
- B.  $\text{Na}^+$  ions flow to the copper half-cell and  $\text{SO}_4^{2-}$  ions flow to the zinc half-cell.
- C.  $\text{Na}^+$  and  $\text{SO}_4^{2-}$  ions flow to the copper half-cell.
- D.  $\text{Na}^+$  and  $\text{SO}_4^{2-}$  ions flow to the zinc half-cell.

23. The following reaction occurs in a voltaic (galvanic) cell.



Which reaction takes place at each electrode?

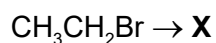
	<b>Anode (negative electrode)</b>	<b>Cathode (positive electrode)</b>
A.	$\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg(s)}$
B.	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$	$\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$
C.	$\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$
D.	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg(s)}$	$\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$

Turn over

24. Which compound has the lowest boiling point?

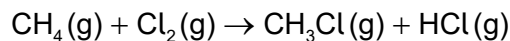
- A.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- B.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- C.  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- D.  $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CH}_3$

25. Which of the following can be both formed from bromoethane and converted directly into ethanal?



- A.  $\text{CH}_3\text{CH}_2\text{OH}$
- B.  $\text{CH}_3\text{OCH}_3$
- C.  $\text{CH}_3\text{COOH}$
- D.  $\text{H}_2\text{C}=\text{CHBr}$

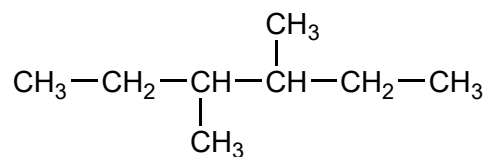
26. Methane reacts with chlorine in sunlight.



Which type of reaction occurs?

- A. free-radical substitution
- B. electrophilic substitution
- C. nucleophilic substitution
- D. electrophilic addition

27. What is the name of this compound using IUPAC rules?



- A. 2,3-diethylbutane  
 B. 2-ethyl-3-methylpentane  
 C. 3-methyl-4-ethylpentane  
 D. 3,4-dimethylhexane
28. The following data were recorded for determining the density of three samples of silicon, Si.

Mass / g $\pm 0.01$ g	Volume / cm <sup>3</sup> $\pm 0.1$ cm <sup>3</sup>
5.61	2.8
4.32	1.7
6.37	2.8

Which average density value, in g cm<sup>-3</sup>, has been calculated to the correct number of significant figures?

- A. 2  
 B. 2.3  
 C. 2.27  
 D. 2.273

Turn over

29. Data collected from a larger number of silicon samples could also be plotted to determine the density using the following axes.



Which statements are correct?

- I. The density is the slope of the graph.
  - II. The data will show that mass is proportional to volume.
  - III. The best-fit line should pass through the origin.
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III
30. What can be deduced from the infrared (IR) spectrum of a compound?
- A. Number of hydrogens
  - B. Number of hydrogen environments
  - C. Bonds present
  - D. Molar mass
-