Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1

11 May 2023

Zone A afternoon | **Zone B** morning | **Zone C** 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]**.

2223–6116

13 pages

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																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01				Atomic number **Element** Relative atomic mass							5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	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
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. Which is the correct equation for the electrolysis of molten sodium chloride?

A. $2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

B. $2NaCl(s) \rightarrow 2Na(s) + Cl_2(g)$

C. $2NaCl(l) \rightarrow 2Na(s) + Cl_2(g)$

D. $2NaCl(aq) \rightarrow 2Na(s) + Cl_2(g)$

2. What is the mass of one molecule of C_{60}?

$$N_A = 6.0 \times 10^{23}$$

A. 1.0×10^{-22} g

B. 2.0×10^{-23} g

C. 8.3×10^{-24} g

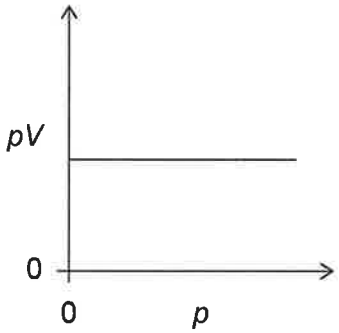
D. 1.2×10^{-21} g

3. $20\,cm^3$ of gas A reacts with $20\,cm^3$ of gas B to produce $10\,cm^3$ of gas A_xB_y and $10\,cm^3$ of excess gas A. What are the correct values for subscripts **x** and **y** in the empirical formula of the product $A_xB_y(g)$?

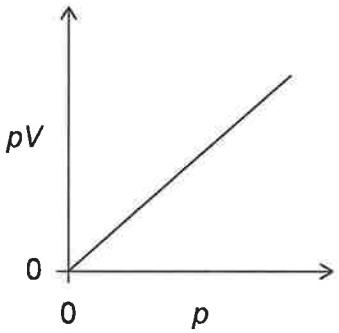
	x	**y**
A.	2	1
B.	2	2
C.	1	1
D.	1	2

4. The volume V for a fixed mass of an ideal gas was measured at constant temperature at different pressures p. Which graph shows the correct relationship between pV against p?

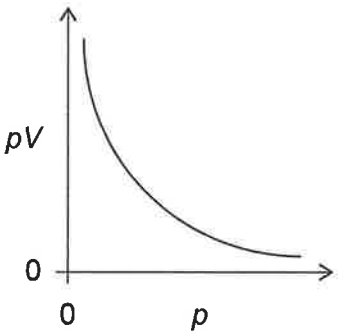
A.



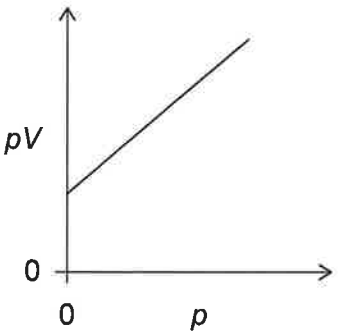
B.



C.



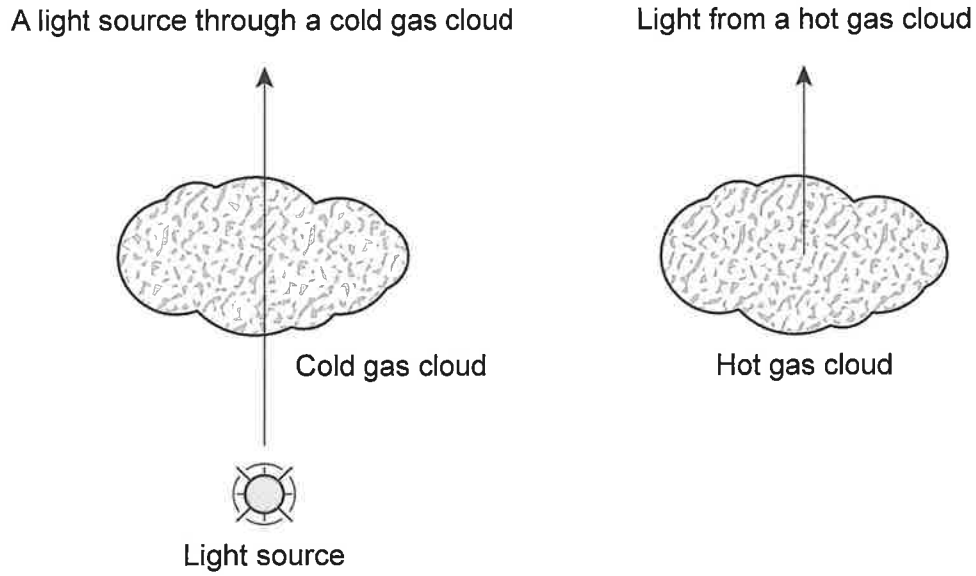
D.



5. What is the correct ground state electron orbital configuration for $2s^2 2p^2$?

	2s		2p	
A.	↑↓	↑	↑	
B.	↑↓	↑	↓	
C.	↑↑	↑	↑	
D.	↑↑	↑	↓	

6. The following diagram shows a light passing through a cold gas cloud, and light from a hot gas cloud.



Which types of spectra are associated with light passing through a cold gas cloud, **Spectrum A**, and light from a hot gas cloud, **Spectrum B**?

	Spectrum A	Spectrum B
A.	Absorption	Emission
B.	Emission	Absorption
C.	Absorption	Absorption
D.	Emission	Emission

7. What is the electron configuration for an element in group 4 period 5?

A. [Kr] $5s^2 4d^2$

B. [Ar] $4s^2 3d^3$

C. [Ar] $4s^2 3d^{10} 4p^3$

D. [Kr] $5s^2 4d^{10} 5p^2$

8. Which properties increase down the group 1 alkali metals?

I. atomic radii

II. melting point

III. reactivity with water

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

9. Which compound is both volatile and soluble in water?

A. NaCl

B. $CH_3CH_2CH_3$

C. CH_3OH

D. $C_{12}H_{22}O_{11}$

10. Which are the correct sequences of **increasing** bond strengths and bond lengths between two carbon atoms?

	Bond strength	**Bond length**
A.	C≡C < C=C < C–C	C≡C < C=C < C–C
B.	C≡C < C=C < C–C	C–C < C=C < C≡C
C.	C–C < C=C < C≡C	C≡C < C=C < C–C
D.	C–C < C=C < C≡C	C–C < C=C < C≡C

11. What is the electron domain geometry of sulfur dioxide, SO_2?

A. bent

B. linear

C. tetrahedral

D. trigonal planar

12. What is the correct comparison of H—N—H bond angles in NH_2^-, NH_3, and NH_4^+?

A. $NH_2^- < NH_3 < NH_4^+$

B. $NH_4^+ < NH_3 < NH_2^-$

C. $NH_3 < NH_2^- < NH_4^+$

D. $NH_3 < NH_4^+ < NH_2^-$

13. The enthalpy of formation of ammonia gas is $-46\,kJ\,mol^{-1}$.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

What is the energy released, in kJ, in the reaction?

A. 23

B. 46

C. 69

D. 92

14. What is ΔH, in kJ, for the reaction $N_2H_4(l) + H_2(g) \rightarrow 2NH_3(g)$?

Reaction	ΔH
$N_2H_4(l) + CH_3OH(l) \rightarrow CH_2O(g) + N_2(g) + 3H_2(g)$	–37 kJ
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	–46 kJ
$CH_3OH(l) \rightarrow CH_2O(g) + H_2(g)$	–65 kJ

A. –18

B. 18

C. –83

D. –148

15. Which statement concerning bond breaking is correct?

A. Requires energy and is endothermic.

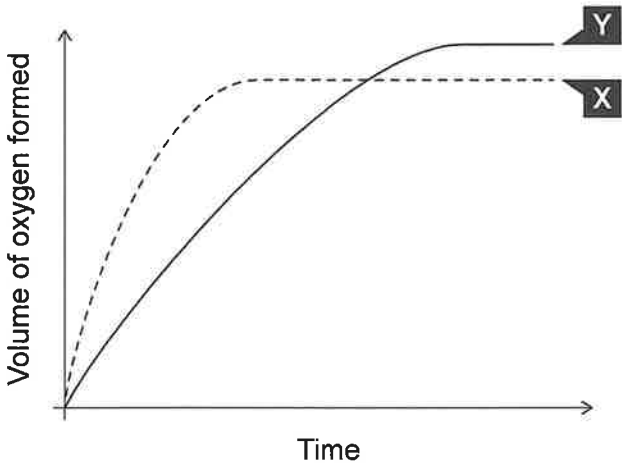
B. Requires energy and is exothermic.

C. Releases energy and is endothermic.

D. Releases energy and is exothermic.

16. Curve **X** on the following graph shows the volume of oxygen formed during the catalytic decomposition of a 1.0 mol dm^{-3} solution of hydrogen peroxide.

$$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$$



Which change would produce the curve **Y**?

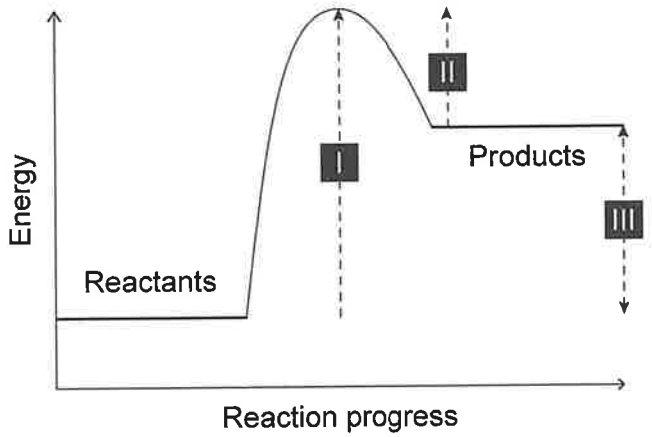
A. Adding water.

B. Adding some 0.1 mol dm^{-3} hydrogen peroxide solution.

C. Adding some 2.0 mol dm^{-3} hydrogen peroxide solution.

D. Repeating the experiment without a catalyst.

17. A potential energy profile is shown for a reaction.



Which energy changes would a catalyst affect?

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

18. Which condition will cause the given equilibrium to shift to the right?

$$Ag^{+}(aq) + Cl^{-}(aq) \rightleftharpoons AgCl(s)$$

A. One half of solid AgCl is removed.

B. Water is added.

C. Solid NaCl is added.

D. The system is subjected to increased pressure.

19. Which reaction represents the neutralization of a Brønsted–Lowry acid and base?

A. $2HCl(aq) + Zn(s) \rightarrow ZnCl_2(aq) + H_2(g)$

B. $2HCl(aq) + ZnO(s) \rightarrow ZnCl_2(aq) + H_2O(l)$

C. $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

D. $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

20. What is the hydroxide ion concentration in a solution of pH = 4 at 298 K?

A. 4

B. 10

C. 10^{-4}

D. 10^{-10}

21. Which element has variable oxidation states in its compounds?

A. Potassium

B. Calcium

C. Fluorine

D. Bromine

22. Which chemical process would produce a voltaic cell?

A. spontaneous redox reaction

B. spontaneous non-redox reaction

C. non-spontaneous redox reaction

D. non-spontaneous non-redox reaction

23. Which species could be reduced to form SO_2?

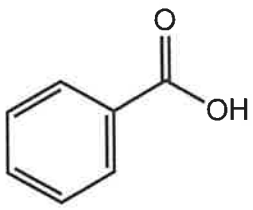
A. S

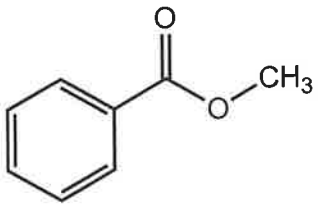
B. H_2SO_3

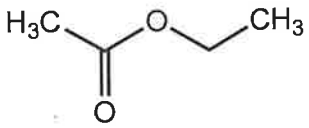
C. H_2SO_4

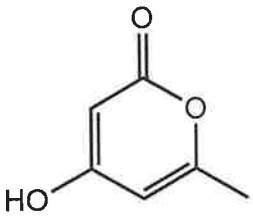
D. $(CH_3)_2S$

24. Which compound is an aromatic ester?

A. 

B. 

C. 

D. 

25. Which products could be obtained by heating isomers of C_3H_8O under reflux with acidified potassium dichromate (VI)?

I. propanal

II. propanone

III. propanoic acid

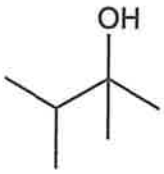
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

26. What is the preferred IUPAC name of the structure shown?



A. 2-ethyl-3-methylbutan-1-ol

B. 2,3-dimethylbutan-2-ol

C. 1-ethyl-2-methylpropan-1-ol

D. 1,1,2-trimethylpropan-1-ol

27. What are the most likely reactions ethene and benzene will undergo?

	Ethene	Benzene
A.	Addition	Substitution
B.	Addition	Addition
C.	Substitution	Addition
D.	Substitution	Substitution

28. Which observation would explain a systematic error for an experiment involving the combustion of magnesium to find the empirical formula of its oxide?

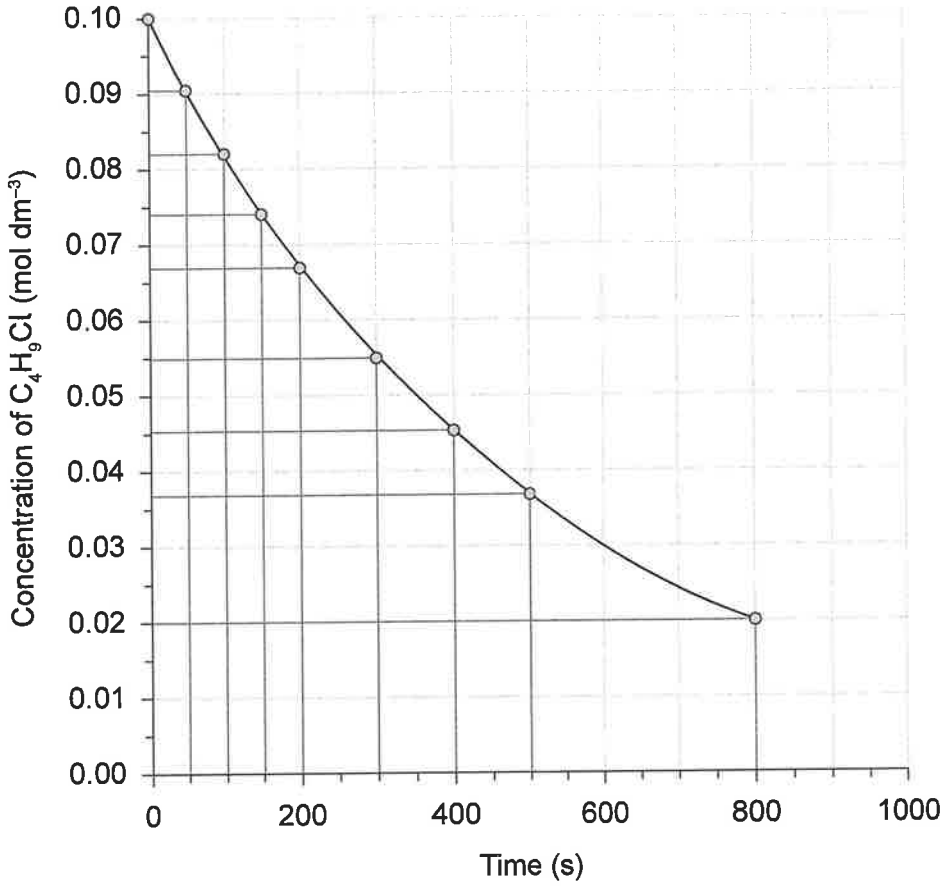
A. The crucible lid was slightly ajar during heating.

B. The product was a white powdery substance.

C. The crucible had black soot on the bottom after heating.

D. The flame colour during heating was yellow.

29. The following graph shows the concentration of C_4H_9Cl versus time.



What is the average rate of reaction over the first 800 seconds?

A. 1×10^{-3} mol dm^{-3} s^{-1}

B. 1×10^{-4} mol dm^{-3} s^{-1}

C. 2×10^{-3} mol dm^{-3} s^{-1}

D. 2×10^{-4} mol dm^{-3} s^{-1}

30. Which compound will have only one ^{1}H NMR signal and show a carbonyl group in the IR spectrum?

A. CH_3CHO

B. CH_3COOH

C. CH_3OCH_3

D. CH_3COCH_3

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:

6. Palma, C., 2020. *Kirchoff's Laws and Spectroscopy, ASTRO 801 Planets, Stars, Galaxies and the Universe*. [online], The Pennsylvania State University. Available at: <https://www.e-education.psu.edu/astro801/content/l3_p6.html> [Accessed 15 June 2021].

13. Argonne National Laboratory, 2021. *Active Thermochemical Tables*. [online] Available at: <https://atct.anl.gov/Thermochemical%20Data/version%201.118/species/?species_number=43> [Accessed 14 June 2021].

29. Blaber, M., 1996. *Chemical Kinetics*. [online] Available at: <https://mikeblaber.org/oldwine/chm1046/> [Accessed 14 July 2021].