

**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]**.



1. Which is the correct equation for the electrolysis of molten sodium chloride?

- A.  $2\text{NaCl}(\text{l}) \rightarrow 2\text{Na}(\text{l}) + \text{Cl}_2(\text{g})$
- B.  $2\text{NaCl}(\text{s}) \rightarrow 2\text{Na}(\text{s}) + \text{Cl}_2(\text{g})$
- C.  $2\text{NaCl}(\text{l}) \rightarrow 2\text{Na}(\text{s}) + \text{Cl}_2(\text{g})$
- D.  $2\text{NaCl}(\text{aq}) \rightarrow 2\text{Na}(\text{s}) + \text{Cl}_2(\text{g})$

2. What is the mass of one molecule of  $\text{C}_{60}$ ?

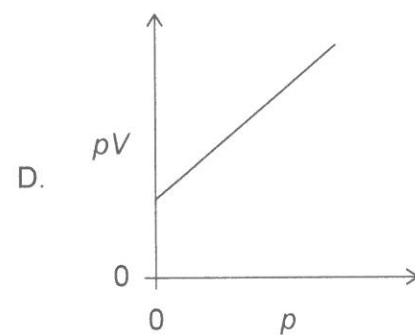
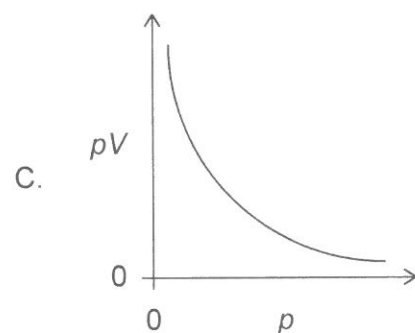
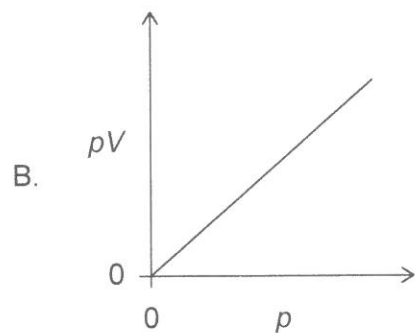
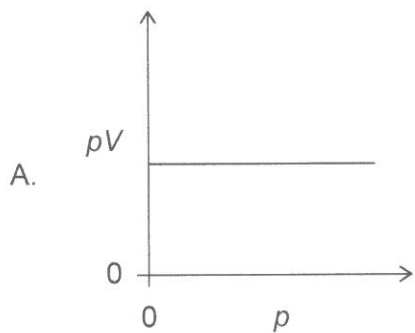
$$N_{\text{A}} = 6.0 \times 10^{23}$$

- A.  $1.0 \times 10^{-22} \text{ g}$
- B.  $2.0 \times 10^{-23} \text{ g}$
- C.  $8.3 \times 10^{-24} \text{ g}$
- D.  $1.2 \times 10^{-21} \text{ g}$

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

	<b>x</b>	<b>y</b>
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  $p$ ?



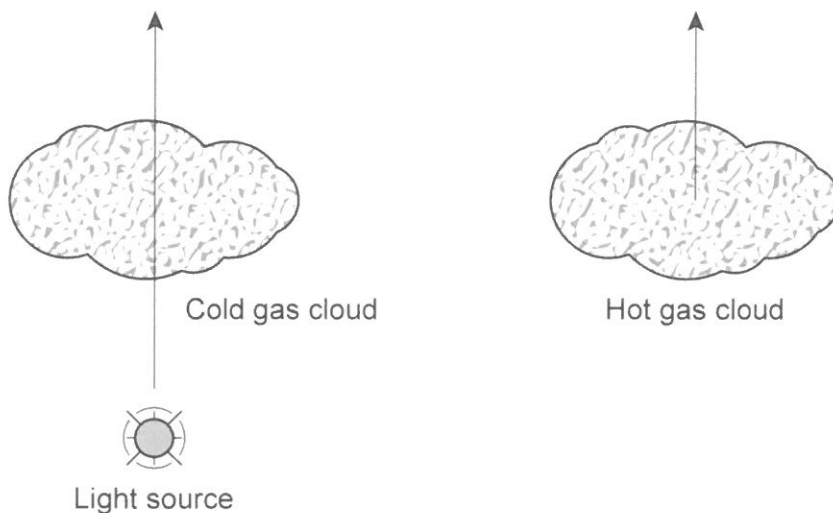
5. What is the correct ground state electron orbital configuration for  $2s^2 2p^2$ ?

	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.

A light source through a cold gas cloud

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.  $[\text{Kr}] 5s^2 4d^2$   
 B.  $[\text{Ar}] 4s^2 3d^3$   
 C.  $[\text{Ar}] 4s^2 3d^{10} 4p^3$   
 D.  $[\text{Kr}] 5s^2 4d^{10} 5p^2$
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.  $\text{NaCl}$   
 B.  $\text{CH}_3\text{CH}_2\text{CH}_3$   
 C.  $\text{CH}_3\text{OH}$   
 D.  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
10. Which are the correct sequences of **increasing** bond strengths and bond lengths between two carbon atoms?

	Bond strength	Bond length
A.	$\text{C}\equiv\text{C} < \text{C}=\text{C} < \text{C}-\text{C}$	$\text{C}\equiv\text{C} < \text{C}=\text{C} < \text{C}-\text{C}$
B.	$\text{C}\equiv\text{C} < \text{C}=\text{C} < \text{C}-\text{C}$	$\text{C}-\text{C} < \text{C}=\text{C} < \text{C}\equiv\text{C}$
C.	$\text{C}-\text{C} < \text{C}=\text{C} < \text{C}\equiv\text{C}$	$\text{C}\equiv\text{C} < \text{C}=\text{C} < \text{C}-\text{C}$
D.	$\text{C}-\text{C} < \text{C}=\text{C} < \text{C}\equiv\text{C}$	$\text{C}-\text{C} < \text{C}=\text{C} < \text{C}\equiv\text{C}$

11. What is the electron domain geometry of sulfur dioxide,  $\text{SO}_2$ ?
- A. bent  
 B. linear  
 C. tetrahedral  
 D. trigonal planar
12. What is the correct comparison of H–N–H bond angles in  $\text{NH}_2^-$ ,  $\text{NH}_3$ , and  $\text{NH}_4^+$ ?
- A.  $\text{NH}_2^- < \text{NH}_3 < \text{NH}_4^+$   
 B.  $\text{NH}_4^+ < \text{NH}_3 < \text{NH}_2^-$   
 C.  $\text{NH}_3 < \text{NH}_2^- < \text{NH}_4^+$   
 D.  $\text{NH}_3 < \text{NH}_4^+ < \text{NH}_2^-$

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



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

- A. 23  
 B. 46  
 C. 69  
 D. 92
14. What is  $\Delta H$ , in kJ, for the reaction  $\text{N}_2\text{H}_4(\text{l}) + \text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ ?

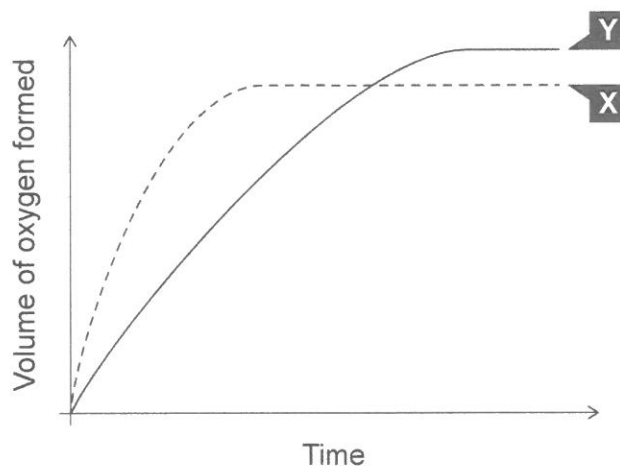
Reaction	$\Delta H$
$\text{N}_2\text{H}_4(\text{l}) + \text{CH}_3\text{OH}(\text{l}) \rightarrow \text{CH}_2\text{O}(\text{g}) + \text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$	$-37 \text{ kJ}$
$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$	$-46 \text{ kJ}$
$\text{CH}_3\text{OH}(\text{l}) \rightarrow \text{CH}_2\text{O}(\text{g}) + \text{H}_2(\text{g})$	$-65 \text{ kJ}$

- 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  $1.0 \text{ mol dm}^{-3}$  solution of hydrogen peroxide.

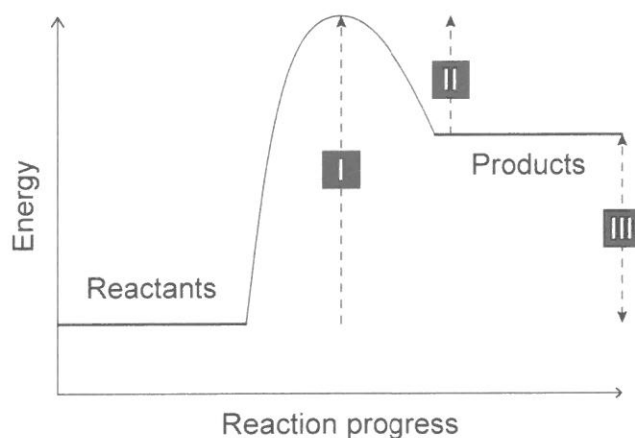


Which change would produce the curve Y?

- A. Adding water.
- B. Adding some  $0.1 \text{ mol dm}^{-3}$  hydrogen peroxide solution.
- C. Adding some  $2.0 \text{ mol dm}^{-3}$  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?



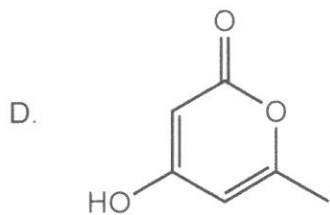
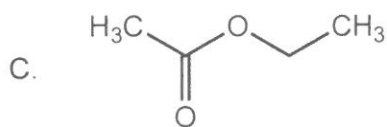
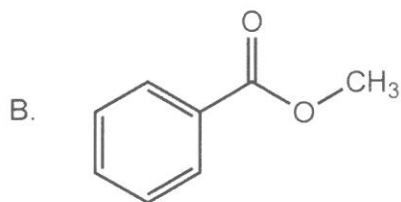
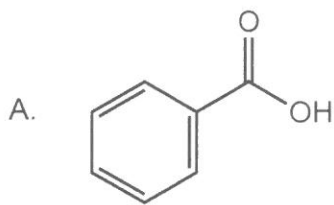
- A. One half of solid AgCl is removed.
- B. Water is added.
- C. Solid NaCl is added.
- D. The system is subjected to increased pressure.

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

- A.  $2\text{HCl}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g})$
- B.  $2\text{HCl}(\text{aq}) + \text{ZnO}(\text{s}) \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- C.  $4\text{NH}_3(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{NO}(\text{g}) + 6\text{H}_2\text{O}(\text{l})$
- D.  $\text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$

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  $\text{SO}_2$ ?
- A. S
  - B.  $\text{H}_2\text{SO}_3$
  - C.  $\text{H}_2\text{SO}_4$
  - D.  $(\text{CH}_3)_2\text{S}$

24. Which compound is an aromatic ester?

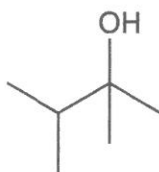


25. Which products could be obtained by heating isomers of  $C_3H_8O$  under reflux with acidified potassium dichromate (VI)?

- 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

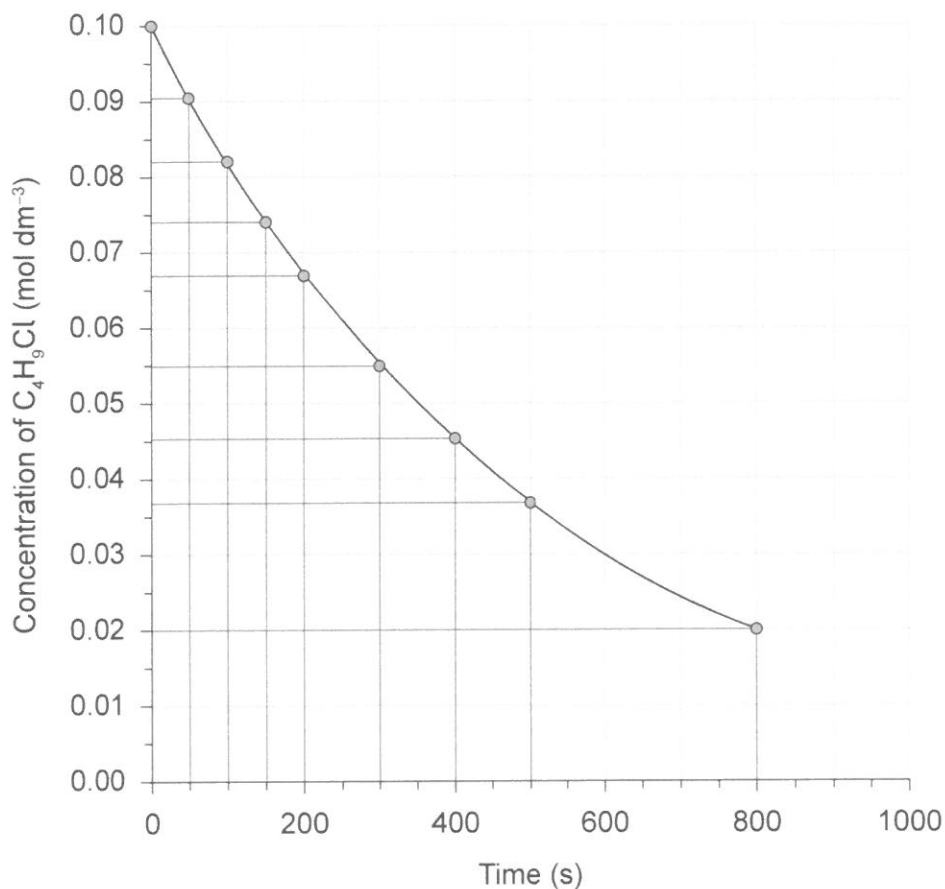
27. What are the most likely reactions ethene and benzene will undergo?

	<b>Ethene</b>	<b>Benzene</b>
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.  $1 \times 10^{-3} mol\ dm^{-3}\ s^{-1}$   
 B.  $1 \times 10^{-4} mol\ dm^{-3}\ s^{-1}$   
 C.  $2 \times 10^{-3} mol\ dm^{-3}\ s^{-1}$   
 D.  $2 \times 10^{-4} mol\ dm^{-3}\ s^{-1}$

30. Which compound will have only one  $^1H$  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](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](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].