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Chemistry

Higher level

Paper 1A

16 May 2025

Zone A afternoon | Zone B afternoon | Zone C afternoon

2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for paper 1A is **[40 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.

Section A

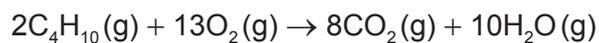
1. How many oxygen atoms are present in 0.0200 mol $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$?

- A. 1.20×10^{22}
- B. 1.08×10^{22}
- C. 6.02×10^{23}
- D. 1.08×10^{23}

2. What is a possible empirical formula for a substance with $M_r = 58$?

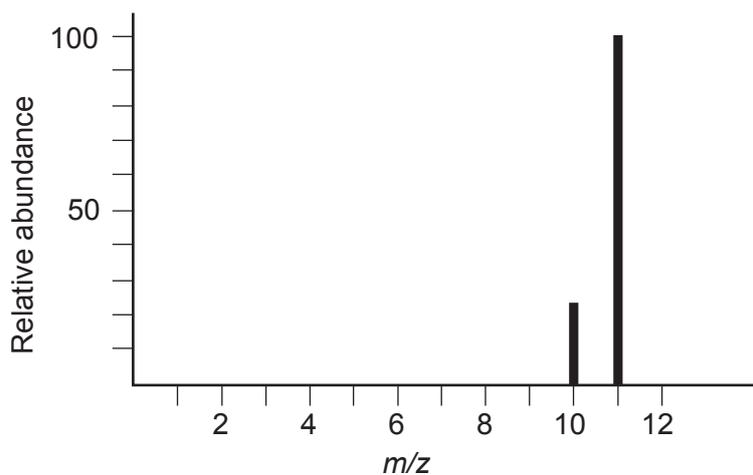
- I. C_2H_5
 - II. C_4H_{10}
 - III. $\text{C}_3\text{H}_6\text{O}$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

3. Which volume of butane gas, in cm^3 , will produce 40 cm^3 of carbon dioxide gas when it is completely combusted in oxygen?



- A. 5
- B. 10
- C. 20
- D. 40

4. What is the relative atomic mass of an element with the following mass spectrum?



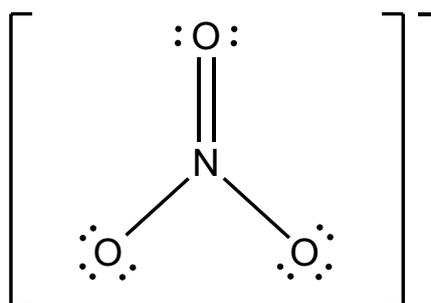
- A. 10.2
B. 10.5
C. 10.8
D. 11.0
5. What is the maximum number of electrons that can occupy the fourth main energy level of an atom?
- A. 8
B. 18
C. 32
D. 64
6. What is the formula of the compound formed by aluminium ions and sulfate(VI) ions?
- A. AlSO_3
B. $\text{Al}_2(\text{SO}_3)_3$
C. AlSO_4
D. $\text{Al}_2(\text{SO}_4)_3$

7. A substance has the following properties:

Melting point (°C)	Electrical conductivity	
	When solid	When molten
714	poor	good

What is the most probable structure of this substance?

- A. Simple molecular
 B. Ionic lattice
 C. Covalent network
 D. Metallic lattice
8. Which forces of attraction cause the boiling point of ammonia, NH_3 , to be significantly higher than that of phosphine, PH_3 ?
- A. Covalent bonds
 B. Dipole–dipole forces
 C. London (dispersion) forces
 D. Hydrogen bonds
9. What is the formal charge of the nitrogen atom in NO_3^- ?



- A. –3
 B. –1
 C. +1
 D. +3

10. What is the hybridization of carbon and oxygen in CO_3^{2-} ?

	C	O
A.	sp^2	sp^3
B.	sp^2	sp^2
C.	sp^3	sp^2
D.	sp^3	sp

11. Which answer shows the correct order of metallic bond strength from strongest to weakest?

- A. $\text{Al} > \text{Mg} > \text{Na} > \text{K}$
- B. $\text{Al} > \text{Mg} > \text{K} > \text{Na}$
- C. $\text{Na} > \text{K} > \text{Mg} > \text{Al}$
- D. $\text{K} > \text{Na} > \text{Mg} > \text{Al}$

12. Which of these elements is in the f-block of the periodic table?

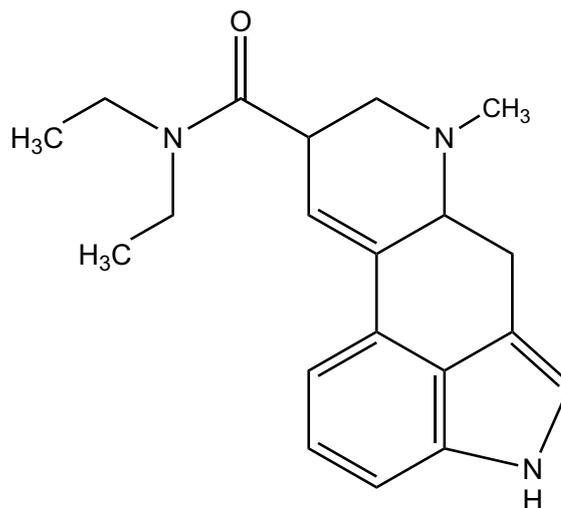
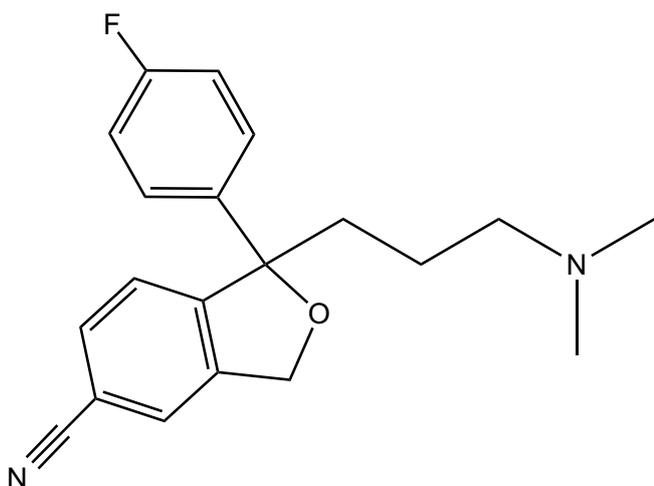
- A. Ra
- B. Lu
- C. Rf
- D. Nh

13. What is the electron configuration of an atom of Cu?

- A. $[\text{Ar}]3\text{d}^9$
- B. $[\text{Ar}]4\text{s}^23\text{d}^9$
- C. $[\text{Ar}]4\text{s}^24\text{d}^9$
- D. $[\text{Ar}]4\text{s}^13\text{d}^{10}$

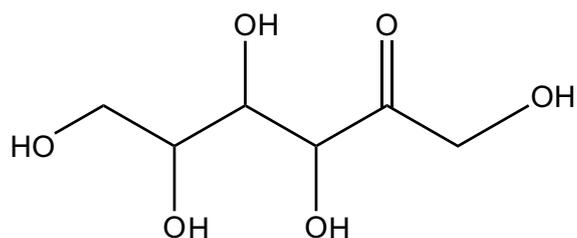
14. Which pair of elements would react with each other the least vigorously?
- A. Lithium and fluorine
 - B. Lithium and iodine
 - C. Caesium and fluorine
 - D. Caesium and iodine
15. Which compounds contain an atom in a +3 oxidation state?
- I. NO_2^-
 - II. FeCl_3
 - III. BrF_3
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III
16. Which statement correctly explains the violet colour of the complex ion $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$, formed when copper(II) sulfate reacts with an excess of ammonia?
- A. Violet light is released as electrons move from higher to lower energy levels.
 - B. Violet light is absorbed as electrons move from lower to higher energy levels.
 - C. Yellow light is released as electrons move from higher to lower energy levels.
 - D. Yellow light is absorbed as electrons move from lower to higher energy levels.

17. Which functional groups are present in both of these molecules?



- A. Amino and amido
- B. Amino and alkoxy
- C. Amino and carbonyl
- D. Amino and a benzene ring
18. What is the identity of the alcohol with the molecular formula C₄H₉OH, with four peaks in the ratio 6:2:1:1 in its ¹H NMR spectrum?
- A. Butan-1-ol
- B. Butan-2-ol
- C. 2-methylpropan-1-ol
- D. 2-methylpropan-2-ol

19. How many chiral centres are there in the following molecule?



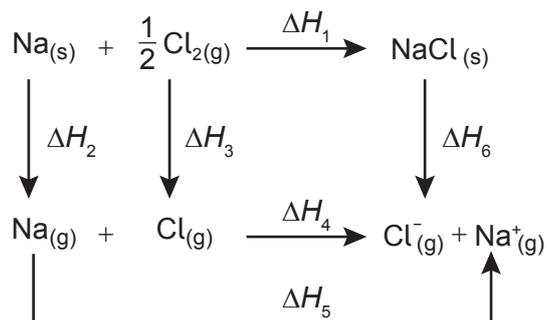
- A. 2
 B. 3
 C. 4
 D. 5
20. Which statement about an exothermic reaction is correct?
- A. Temperature decreases and the products have higher enthalpy than the reactants.
 B. Temperature decreases and the products have lower enthalpy than the reactants.
 C. Temperature increases and the products have higher enthalpy than the reactants.
 D. Temperature increases and the products have lower enthalpy than the reactants.
21. The energy from burning 0.321 g of methanol causes the temperature of 200 cm³ of water to rise by 5.00 K. What is the enthalpy of combustion of the methanol in kJ mol⁻¹?

Specific heat capacity of water: 4.18 J g⁻¹ K⁻¹, M_r methanol = 32.05 g mol⁻¹

$$Q = mc\Delta T$$

- A. -417
 B. -579
 C. -23200
 D. -417000

22. Which energy change on the diagram below represents the electron affinity of chlorine?



- A. ΔH_2
- B. ΔH_3
- C. ΔH_4
- D. ΔH_5

23. In which reaction does entropy decrease?

- A. $\text{KBr}(s) \rightarrow \text{KBr}(aq)$
- B. $\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s)$
- C. $\text{Mg}(s) + \text{H}_2\text{SO}_4(aq) \rightarrow \text{MgSO}_4(aq) + \text{H}_2(g)$
- D. $\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$

24. What are the signs of ΔH and ΔS for a reaction that is non-spontaneous at low temperatures but spontaneous at high temperatures?

	ΔH	ΔS
A.	+	-
B.	-	-
C.	+	+
D.	-	+

25. Which process to produce ethanol has an atom economy of 100?

- A. $C_2H_4 + H_2O \rightarrow C_2H_5OH$
- B. $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
- C. $CH_3COOC_2H_5 + NaOH \rightarrow C_2H_5OH + CH_3COONa$
- D. $CH_3COOC_2H_5 + H_2O \rightleftharpoons C_2H_5OH + CH_3COOH$

26. Which apparatus can be used to monitor the progress of this reaction?



- I. A pH meter
- II. A gas syringe
- III. A colorimeter

- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

27. Compounds **P** and **Q** were mixed together at various concentrations and the initial rate of each reaction was measured.

Experiment	[P] mol dm ⁻³	[Q] mol dm ⁻³	Initial rate of reaction (mol dm ⁻³ s ⁻¹)
1	0.20	0.15	0.50
2	0.10	0.15	0.25
3	0.20	0.30	1.00

What are the orders of reaction with respect to **P** and **Q**?

	Order with respect to P	Order with respect to Q
A.	1	1
B.	1	2
C.	2	1
D.	1	0

28. What are the units for the rate constant, k , in the following expression?

$$\text{Rate} = k[X]^2[Y]^0$$

- A. $\text{mol}^2 \text{dm}^{-6} \text{s}^{-1}$
- B. $\text{mol dm}^{-3} \text{s}^{-1}$
- C. $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$
- D. $\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$
29. Which statement about this equilibrium reaction is correct?
- $$\text{CH}_3\text{CH}_2\text{OH}(\text{aq}) + \text{HCOOH}(\text{aq}) \rightleftharpoons \text{CH}_3\text{CH}_2\text{OOCH}(\text{aq}) + \text{H}_2\text{O}(\text{l})$$
- A. Removing water from the reaction mixture has no effect on the position of equilibrium.
- B. Adding ethanol to the reaction mixture moves the position of equilibrium to the left.
- C. Removing ethanol from the reaction mixture moves the position of equilibrium to the left.
- D. Adding water to the reaction mixture moves the position of equilibrium to the right.
30. How many moles of oxygen are needed for the complete combustion of 11.5 g of $\text{C}_3\text{H}_8(\text{g})$?
- M_r propane = 44.1 g mol^{-1}
- A. 10.4
- B. 5.20
- C. 2.60
- D. 1.30
31. What is the pH of $0.0010 \text{ mol dm}^{-3} \text{HCl}(\text{aq})$?
- A. 2.0
- B. 2.5
- C. 3.0
- D. 3.5

32. Which solution is acidic at 25 °C?
- A. $[\text{H}^+] = 1.0 \times 10^{-9} \text{ mol dm}^{-3}$
- B. $[\text{OH}^-] = 1.0 \times 10^{-13} \text{ mol dm}^{-3}$
- C. $[\text{OH}^-] = 1.0 \times 10^{-6} \text{ mol dm}^{-3}$
- D. $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-13} \text{ mol dm}^{-3}$
33. Which equation correctly describes a chemical reaction?
- A. $2\text{HCl} + \text{Na}_2\text{CO}_3 \rightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$
- B. $\text{Cu} + 2\text{HCl} \rightarrow \text{CuCl}_2 + \text{H}_2$
- C. $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2$
- D. $2\text{HCl} + \text{Ca}(\text{HCO}_3)_2 \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}$
34. Which of these bases has the strongest conjugate acid?

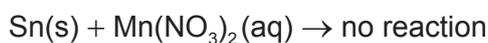
Bases	K_b	$\text{p}K_b$
NH_3	1.8×10^{-5}	
CH_3NH_2		3.35
$(\text{CH}_3)_2\text{NH}$	5.9×10^{-4}	
CH_3CONH_2		14.5

- A. NH_3
- B. CH_3NH_2
- C. $(\text{CH}_3)_2\text{NH}$
- D. CH_3CONH_2

35. What is the pH of a buffer solution which contains $0.500 \text{ mol dm}^{-3}$ of methanoic acid and $0.250 \text{ mol dm}^{-3}$ of sodium methanoate?

pK_a (methanoic acid) = 3.75

- A. 3.25
 B. 3.45
 C. 3.75
 D. 4.05
36. The following occurs when tin is added to separate solutions of lead(II) nitrate, $\text{Pb}(\text{NO}_3)_2$, and manganese(II) nitrate, $\text{Mn}(\text{NO}_3)_2$.



What is the order of decreasing reactivity of the metals?

- A. $\text{Sn} > \text{Pb} > \text{Mn}$
 B. $\text{Sn} > \text{Mn} > \text{Pb}$
 C. $\text{Mn} > \text{Sn} > \text{Pb}$
 D. $\text{Pb} > \text{Sn} > \text{Mn}$
37. What are the products of the electrolysis of molten aluminium oxide, $\text{Al}_2\text{O}_3(\text{l})$?

	Product at anode	Product at cathode
A.	O_2	Al
B.	O_3	Al
C.	Al	O_2
D.	Al	O_3

38. Which compound can be reduced to produce butanal?
- A. Butanoic acid
 B. Butan-1-ol
 C. Butanone
 D. Butan-2-ol

39. Consider the following standard electrode potentials:

	E^\ominus (V)
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	-0.76
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.45
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Ni}(\text{s})$	-0.26

Which species will react with each other spontaneously under standard conditions?

- A. Zn and Fe^{2+}
 - B. Fe and Zn^{2+}
 - C. Ni and Zn^{2+}
 - D. Ni and Fe^{2+}
40. Which of these ions would be a suitable species to react with benzene in a substitution reaction?
- A. NO_2^-
 - B. NH_4^+
 - C. NO_2^+
 - D. Br^-
-

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References:

4. With permission from Jim Clark. www.chemguide.co.uk/analysis/masspec/elements.html.

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