Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 1A

16 May 2025

Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

1 hour 30 minutes [Paper 1A and Paper 1B]

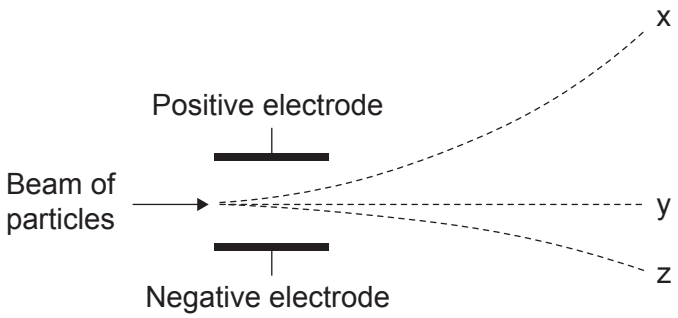
Instructions to candidates

- 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 **[30 marks]**.
- The maximum mark for paper 1A and paper 1B is **[55 marks]**.

2225 – 6210

14 pages

1. The diagram below shows the behaviour of protons, neutrons and electrons in an electric field.



What is the correct identity of each particle?

	Protons	Electrons	Neutrons
A.	y	z	x
B.	x	y	z
C.	z	x	y
D.	x	z	y

2. Which of the following species have the same number of outer electrons? The letters **do not** represent symbols of elements.

$^{24}_{12}W^{2+}$ $^{31}_{16}X^{-}$ $^{45}_{21}Y^{2+}$ $^{19}_{9}Z^{-}$

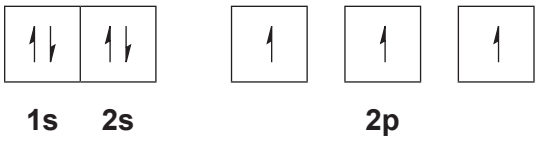
A. X and Y

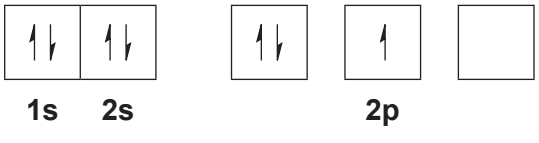
B. X and W

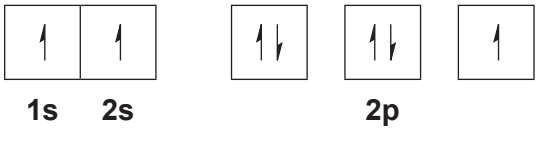
C. Z and Y

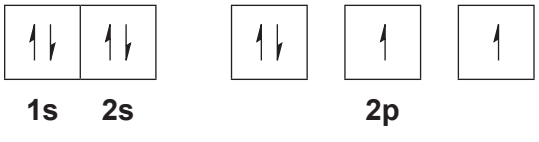
D. Z and W

3. Which diagram shows the correct electron configuration of a nitrogen atom in the ground state?

A. 

B. 

C. 

D. 

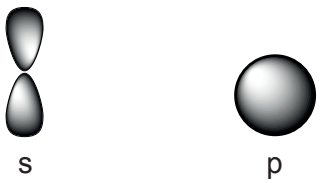
4. Which row shows a gas that would deviate the least from ideal gas behaviour?

	Gas	Pressure	Temperature
A.	Phosphine, PH_3	Low	High
B.	Ammonia, NH_3	Low	High
C.	Phosphine, PH_3	High	Low
D.	Ammonia, NH_3	High	Low

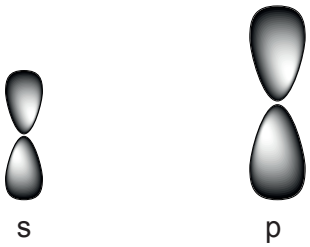
5. Which row correctly shows the shape of s and p atomic orbitals?

A.

B.



C.



D.

6. The volume of a container filled with a fixed amount of gas is increased by 100 % at constant temperature. How does this affect the pressure in a container? $pV = nRT$

A. Pressure increases by 100 %.

B. Pressure decreases by 100 %.

C. Pressure increases by 50 %.

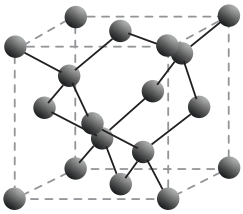
D. Pressure decreases by 50 %.

7. Which row shows the correct formula and electron configuration of the species in calcium nitride?

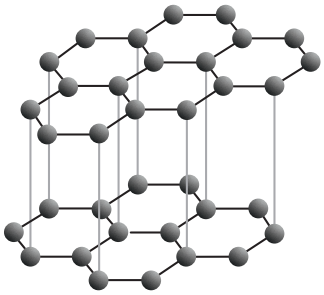
	Formula	**Electron configuration of the Ca species**	**Electron configuration of the N species**
A.	Ca_2N_3	[Ar]	[Ne]
B.	Ca_2N_3	[Ar] $4s^2$	[He] $2s^2\ 2p^3$
C.	Ca_3N_2	[Ar] $4s^2$	[He] $2s^2\ 2p^3$
D.	Ca_3N_2	[Ar]	[Ne]

8. Diagrams of four stable allotropes of carbon are shown.
Which row correctly identifies each structure?

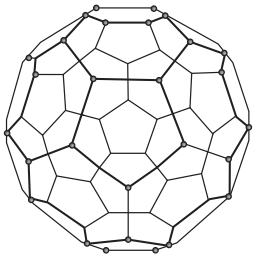
W



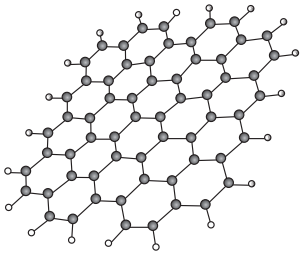
X



Y



Z



	Graphene	Fullerene	Graphite	Diamond
A.	Z	Y	X	W
B.	W	Z	Y	X
C.	X	W	Z	Y
D.	Y	X	W	Z

9. In which of the following molecules do all atoms obey the octet rule?

I. NF_3

II. BF_3

III. PCl_3

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

10. Which compound has the weakest ionic bond?

A. MgO

B. MgS

C. CaO

D. CaS

11. Which row puts these molecules in order of decreasing bond angle?

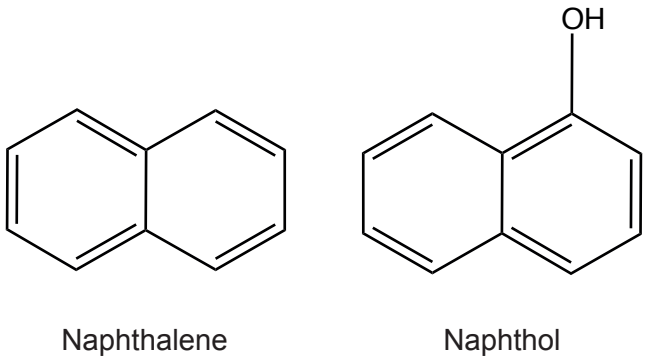
A. NH_3, H_2O, C_2H_4, CH_4

B. H_2O, C_2H_4, CH_4, NH_3

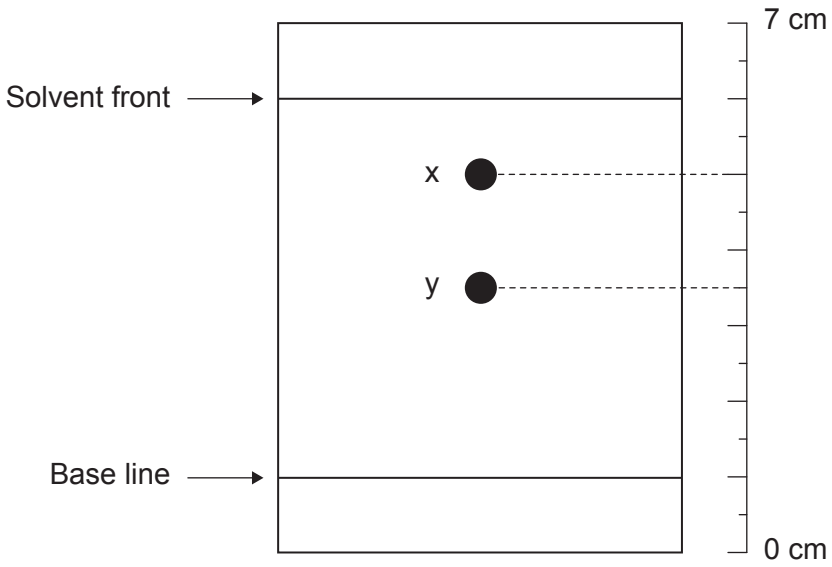
C. C_2H_4, CH_4, NH_3, H_2O

D. CH_4, NH_3, H_2O, C_2H_4

12. The following thin-layer chromatogram was obtained from a mixture of naphthalene, $C_{10}H_8$, and naphthol, $C_{10}H_8O$. A polar silica was used as the stationary phase, and a non-polar hexane as the mobile phase.



Naphthalene Naphthol



What are the position and retardation factor (R_F) of naphthalene?

A. y and 0.50

B. y and 0.58

C. x and 0.80

D. x and 0.83

13. Aluminium trichloride, $AlCl_3(g)$, and beryllium chloride, $BeCl_2(g)$, have been known for many years. Which adaptation of the bonding model was made to explain the bonding in $AlCl_3(g)$ and $BeCl_2(g)$?

A. The existence of coordination bonding was proposed.

B. Ideas about oxidation states were formed.

C. Exceptions to the octet rule were introduced.

D. Lewis formulas of molecules were developed.

14. Germanium has several stable oxidation states. Which row shows these species in order of increasing radius?

A. Ge^{4+}, Ge^{2+}, Ge, Ge^{4-}.

B. Ge^{4-}, Ge^{4+}, Ge^{2+}, Ge.

C. Ge, Ge^{4-}, Ge^{4+}, Ge^{2+}.

D. Ge^{2+}, Ge, Ge^{4-}, Ge^{4+}.

15. Which statement explains the trend in first ionisation energy from sodium, Na, to chlorine,Cl?

A. Nuclear charge increases.

B. Electronegativity decreases.

C. Atomic radius increases.

D. Shielding decreases.

16. Which elements would react with each other most vigorously?

A. K(s) and $Br_2(g)$

B. K(s) and $Cl_2(g)$

C. Na(s) and $Br_2(g)$

D. Na(s) and $Cl_2(g)$

17. Ammonia, NH_3 and nitrous acid, HNO_2, are compounds of nitrogen. What are the oxidation states of nitrogen in these compounds?

	NH_3	HNO_2
A.	+3	+3
B.	–3	–3
C.	+3	–3
D.	–3	+3

18. Consider a reaction mixture that is in thermal equilibrium with the surroundings. When a reaction takes place, the temperature of the mixture decreases.

Which row correctly shows the changes in energy when the new thermal equilibrium is established?

	Energy of system	Energy of surroundings
A.	decreases	decreases
B.	increases	increases
C.	decreases	increases
D.	increases	decreases

19. 0.050 mol of sodium hydrogencarbonate was added to 50 cm^3 of 2.0 mol dm^{-3} solution of citric acid.

$$C_6H_8O_7(aq) + 3NaHCO_3(s) \rightarrow C_6H_5O_7Na_3(aq) + 3CO_2(g) + 3H_2O(l)$$

The initial temperature of the solution was 298 K and the final temperature was 297 K.
What is the enthalpy of this reaction in kJ mol^{-1}? ($c_w = 4.18$ J g^{-1} K^{-1}, $Q = mc\Delta T$)

A. +4.18

B. –4.18

C. +12.5

D. –12.5

20. Chloroethane is produced by the reaction of ethane with chlorine.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

$(C_2H_6 = 30.08\,g\,mol^{-1}, Cl_2 = 70.90\,g\,mol^{-1}, C_2H_5Cl = 64.52\,g\,mol^{-1}, HCl = 36.46\,g\,mol^{-1})$

$$\% \text{ atom economy} = \frac{\text{molar mass of desired product}}{\text{molar mass of all reactants}} \times 100$$

What is the atom economy for this reaction?

A. 15.7 %

B. 46.6 %

C. 63.9 %

D. 99.9 %

21. 75 cm^3 of propane was completely combusted in 400 cm^3 of oxygen according to the following equation.

$$CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

What is the volume of unreacted oxygen remaining at the original conditions?

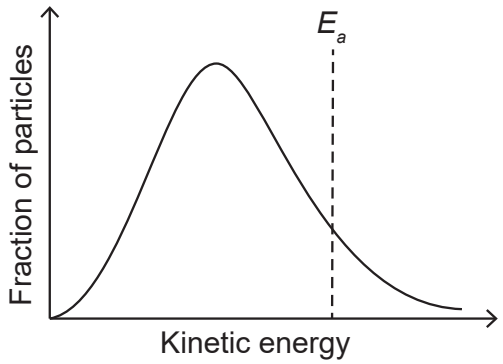
A. 25 cm^3

B. 50 cm^3

C. 75 cm^3

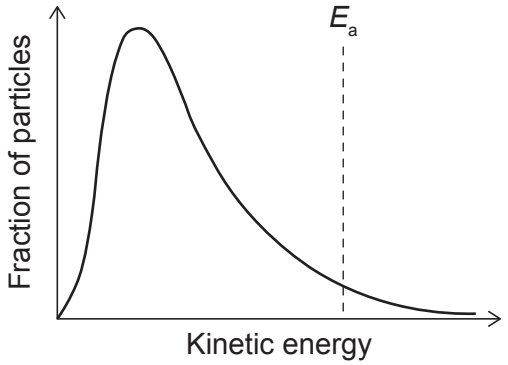
D. 150 cm^3

22. Consider the following Maxwell–Boltzmann energy distribution at a certain temperature.



Which represents the distribution and value of activation energy at a lower temperature?

A.



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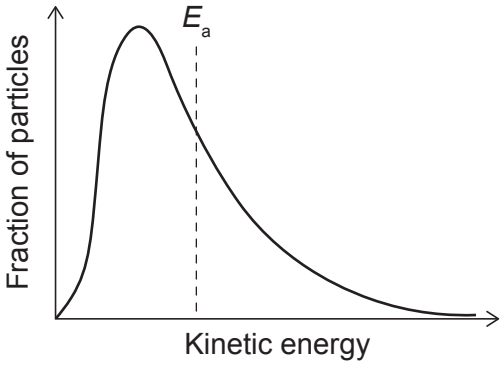
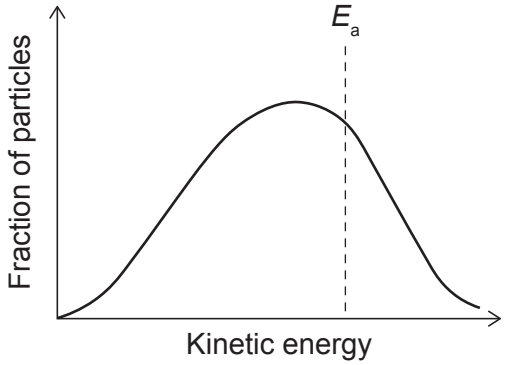
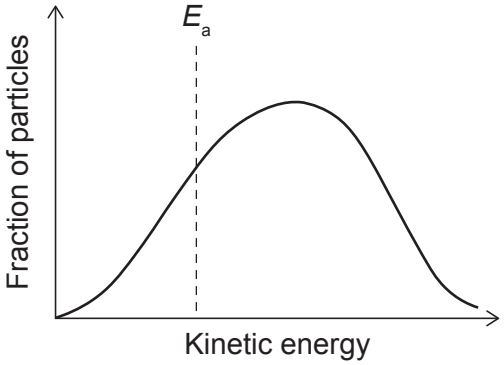


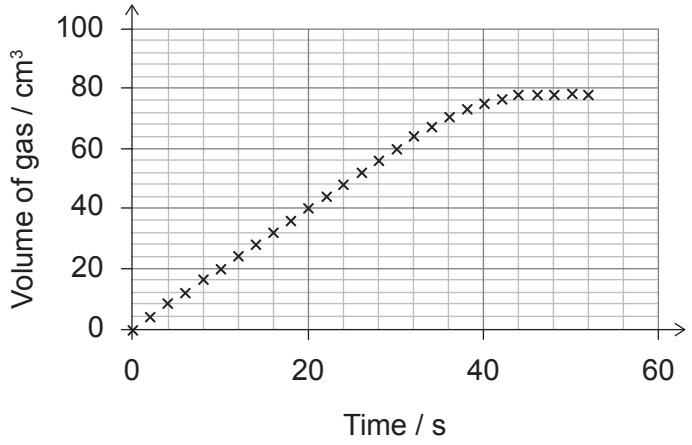
C.



D.



23. The volume of gas produced in a kinetics experiment is plotted against time.



What is the average rate of gas production for the first 20 seconds?

A. $2.0\,cm^3\,s^{-1}$

B. $1.5\,cm^3\,s^{-1}$

C. $1.0\,cm^3\,s^{-1}$

D. $0.5\,cm^3\,s^{-1}$

24. The following equilibrium was established.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)\ \Delta H^{\ominus} = +9\,kJ\ mol^{-1}$$

Which changes would shift the position of equilibrium furthest to the left?

	Pressure	**Temperature**
A.	decreases	no change
B.	increases	decreases
C.	decreases	increases
D.	increases	no change

25. Which two species can be both Brønsted–Lowry acids and Brønsted–Lowry bases?

A. H_3PO_4 and PO_4^{3-}

B. HPO_4^{2-} and $H_2PO_4^{-}$

C. HPO_4^{2-} and PO_4^{3-}

D. PO_4^{3-} and $H_2PO_4^{-}$

26. A solution has a pH of 3.0. What is the hydrogen ion concentration in the solution in mol dm^{-3}?

A. 3.0×10^{-3}

B. 1.0×10^{-3}

C. 1.0×10^{3}

D. 3.0×10^{3}

27. A reactivity series of selected elements, arranged from highest activity to lowest, is shown.

Zn
Fe
Cd
Co
Ni
Sn
Pb
Cu

Which reaction is spontaneous?

A. $Cd^{2+}(aq) + Pb(s) \rightarrow Pb^{2+}(aq) + Cd(s)$

B. $Fe^{2+}(aq) + Sn(s) \rightarrow Sn^{2+}(aq) + Fe(s)$

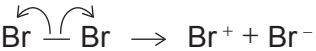
C. $Zn^{2+}(aq) + Cu(s) \rightarrow Cu^{2+}(aq) + Zn(s)$

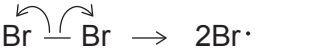
D. $Ni^{2+}(aq) + Co(s) \rightarrow Co^{2+}(aq) + Ni(s)$

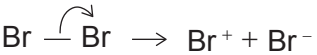
28. Which alcohol and conditions would produce the highest yield of methylpropanoic acid?

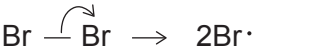
	Alcohol	Conditions
A.	2-methylpropan-2-ol	Reflux
B.	2-methylpropan-1-ol	Reflux
C.	2-methylpropan-2-ol	Distillation
D.	2-methylpropan-1-ol	Distillation

29. Which row correctly shows heterolytic fission?

A. 

B. 

C. 

D. 

30. The methanol fuel cell relies on the oxidation of methanol by oxygen. The two half-equations are as follows:

$$\text{Anode: } CH_3OH(l) + H_2O(l) \rightarrow CO_2(g) + 6H^+(aq) + 6e^-$$

$$\text{Cathode: } 4H^+(aq) + O_2(g) + 4e^- \rightarrow 2H_2O(l)$$

What is the balanced equation for the overall reaction?

A. $2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(l)$

B. $CH_3OH(l) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

C. $2CO_2(g) + 4H_2O(l) \rightarrow 2CH_3OH(l) + 3O_2(g)$

D. $CO_2(g) + 2H_2O(l) \rightarrow CH_3OH(l) + 2O_2(g)$