Diploma Programme
Programme du diplôme
Programa del Diploma

Chemistry
Standard level
Paper 2

18 May 2026

Zone A morning | **Zone B** morning | **Zone C** morning

Session number

1 hour 30 minutes

Instructions to students

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes 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 this examination paper is **[50 marks]**.

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A004

2026 May Paper 2 SL

13 pages

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Sulfuric acid, H_2SO_4, is one of the highest-volume chemicals produced in the world.

(a) (i) The first step in the synthesis of sulfuric acid is to burn solid sulfur, S_8, to produce sulfur dioxide, SO_2.

$$S_8(s) + 8O_2(g) \rightarrow 8SO_2(g)$$

Determine the volume, in dm^3, of sulfur dioxide produced from 15.0 g of sulfur, at STP, using section 2 of the data booklet. [2]

$n(S_8) = \frac{15.0}{32.07 \times 8} = 0.0585\ mol$

$V(SO_2) = 8 \times 0.0585 \times 22.7\ dm^3\ mol^{-1} = 10.62\ dm^3$

(ii) Calculate the new volume, in dm^3, of sulfur dioxide if the temperature changes to 25.0 °C, using the final volume from (a) (i).

Use sections 1, 2 and 4 of the data booklet.

If you did not obtain an answer for (a) (i) use 15.0 dm^3, although this is not the correct answer. [1]

273.15 K.

$PV = nRT$ $V \propto T$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{10.62}{273.15} = \frac{V_2}{273.15 + 25}$

$V_2 = 11.59\ dm^3$

(This question continues on the following page)

(Question 1 continued)

(b) Sulfur dioxide is converted to sulfur trioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Identify the oxidation state of sulfur in both compounds. [1]

Compound	Oxidation state of sulfur
SO_2	+4
SO_3	+6

(ii) State the equilibrium constant expression, K, for this reaction. [1]

$K = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$

(iii) State, with a reason, the effect of increasing the temperature on the value of the equilibrium constant, K. [1]

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H^{\ominus} = -198\,kJ\,mol^{-1}$

exothermic reaction. T↑ move to reactant. K decrease

(iv) Discuss the effect of decreasing the volume of the system on the position of equilibrium and the value of K. [2]

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Position of equilibrium: move to right. product has less gaseous molecule than reactant. decrease V. as will move to right.

Value of K: no change. K will be only effected by T.

(Question 1 continued)

(c) The final synthetic step can be summarized as:

$$H_2O(l) + SO_3(g) \rightarrow H_2SO_4(aq) \qquad \Delta H^{\ominus} = -101\,kJ\,mol^{-1}$$

Describe the types of bonding found in the concentrated aqueous sulfuric acid product. [2]

covalent bonding in $SO_4^{2-}(aq)$ electrostatic attraction between nuclei ~~hydrogen bonding~~ and shared paired electron
hydrogen bondy H attached to very electronegative atom (NOF)
will have attraction towards lp (one pair of NOF

(d) Sulfuric acid, H_2SO_4, is strong, while sulfurous acid, H_2SO_3, is weak.

(i) Outline the difference between a strong and a weak acid. [1]

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strong acid : fully dissociate weak acid : partially dissociate

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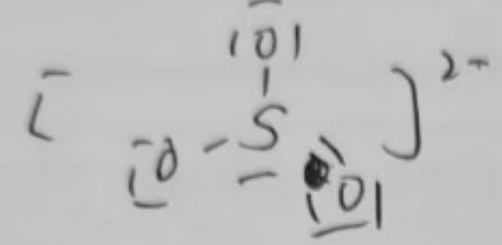
(Question 1 continued)

(ii) Deduce the Lewis formula and the molecular geometry for the sulfite ion, SO_3^{2-}. [2]

Lewis formula:



Molecular geometry: ....trigonal...pyramidal.....

.....

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(Question 1 continued)

(e) Sulfuric acid is used as the electrolyte in a lead-acid cell. Lead, Pb, is the anode in the cell.

$$PbSO_4(s) + 2e^- \rightarrow Pb(s) + SO_4^{2-}(aq)$$

$$PbO_2(s) + 4H^+(aq) + SO_4^{2-}(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$

Deduce the overall reaction for the cell. $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$ [1]

$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2H_2O(l) + 2PbSO_4(s)$

(f) Energy can be produced by a fuel cell with hydrogen gas at the anode and oxygen gas at the cathode with a base as the electrolyte.

(i) Deduce the half-equations for the electrode reactions in this fuel cell. [2]

Anode half-equation: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

Cathode half-equation: $O_2(g) + 4e^- + 2H_2O \rightarrow 4OH^-(aq)$

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(ii) Hydrogen produces a line emission spectrum with **four** lines in the visible region.

Discuss **two** properties of the current atomic model supported by the line emission spectrum of hydrogen. [2]

discrete existence of energy level

energy level converge at higher frequency

2. Potassium, K, is a reactive metal.

(a) (i) State the number of protons, electrons and neutrons in $^{39}K^{+}$. [2]

Protons:	19
Electrons:	18
Neutrons:	20

(ii) State the full electron configuration for $^{39}K^{+}$. [1]

$1s^2 2s^2 2p^6 3s^2 3p^6$

(iii) The relative atomic mass, A_r, of K is 39.10. [2]

Isotope	Mass	Percent abundance
^{x}K		93.26%
^{41}K	40.96	6.730%

Determine the relative mass of the first isotope of K to four significant figures, showing your work.

$x \times 93.26\% + 40.96 \times 6.730\% = 39.10$

$x = 38.97$

(This question continues on the following page)

(Question 2 continued)

(b) (i) Explain why K has a lower first ionization energy than calcium, Ca. [2]

Ca has a higher nuclear charge than K
Ca^{2+} has a smaller radius than K^+
Ca and K has same shielding same number of electron shell

(ii) Outline why K has a lower electronegativity than sodium, Na. [1]

K has more electron shell than Na higher radius

(c) (i) Write the equation for the reaction of K with water, H_2O, including state symbols. [2]

$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

(ii) Describe the type of bonding in K and H_2O and how the valence electrons in each produce these types of bonds. [2]

	Type of bonding	How valence electrons produce bonds
K	metallic bonding	~~the~~ delocalized to produce electron sea attraction toward positive ion
H_2O	Covalent bonding	share electron attract nuclei

3. Propane, $CH_3CH_2CH_3$, is a common fuel.

(a) (i) Determine the enthalpy of combustion of propane, in $kJ\,mol^{-1}$, using table 12 in the data booklet. [3]

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

~~Mr ($CH_3CH_2CH_3$) = 12.01 × 3 + 1.01 × 8 = 44.11 g mol⁻¹~~

Bond breaking = 2 C–C + 8 C–H + 5 O=O

= 2 × 346 + 8 × 414 + 5 × 498 = 6496

Bond making = 6 C=O + 8 H–O

= 6 × 804 + 8 × 463 = 8528

ΔH = 6496 − 8528 = −2032 kJ mol⁻¹

(ii) Calculate the mass, in g, of carbon dioxide, CO_2, produced when 25.0 g of propane react with 95.0 g of oxygen, showing your work. [3]

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

Mr ($CH_3CH_2CH_3$) = 44.11 g mol⁻¹

n ($CH_3CH_2CH_3$) = $\frac{25.0}{44.11}$ = 0.567 mol

n(O_2) = $\frac{95}{16 \times 2}$ = 2.97 mol $\frac{2.97}{5} > 0.567$ $CH_3CH_2CH_3$ is limiting reactant.

m(CO_2) = 0.567 × 3 × (16.0 × 2 + 12.01) = ~~74.86 g~~ 74.9 g

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(Question 3 continued)

(b) Propane reacts with bromine, Br_2, to form 2-bromopropane.

(i) Explain, using equations, the initiation step and **two** propagation steps for this reaction. [3]

Initiation: $Br_2(g) \xrightarrow{UV} 2Br^{\cdot}(g)$

Propagation: $Br^{\cdot} + CH_3CH_2CH_3 \rightarrow CH_3CH_2CH_2^{\cdot} + HBr$

$CH_3CH_2CH_2^{\cdot} + Br_2 \rightarrow CH_3CH_2CH_2Br + Br^{\cdot}$

(ii) State **one** termination step for this reaction. [1]

$CH_3CH_2CH_2^{\cdot} + Br^{\cdot} \rightarrow CH_3CH_2CH_2Br$ ✓

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(Question 3 continued)

(c) Propan-2-ol can form by reacting propene with water in the presence of an acid catalyst.

$$CH_2=CHCH_3(g) + H_2O(l) \rightarrow CH_3CH(OH)CH_3(aq) \qquad \Delta H^{\ominus} = -126\,kJ\,mol^{-1}$$

(i) Explain why increasing the temperature would increase the rate of this reaction. [2]

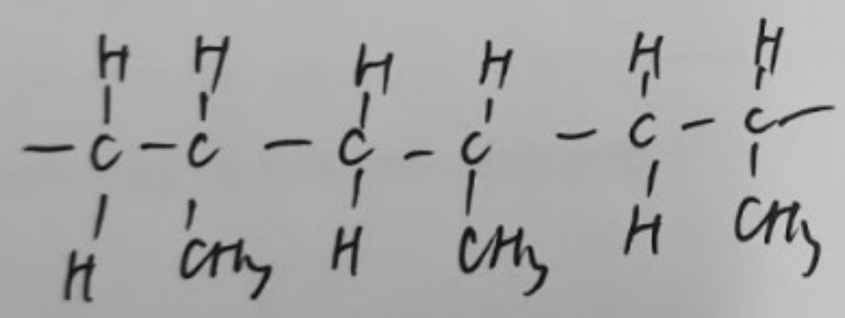
increase temperature will increase ke of particle more particle have higher energy than activation energy collision frequency also increase

(ii) Explain the relative solubility of propan-2-ol and propene in water. [2]

propan-2-ol will have higher solubility it ~~can~~ can form hydrogen bonding with water ~~pro~~ propene can't form hydrogen bonding with water propan-2-ol is more polar than propene

(iii) Propene can also form a polymer.

Draw a section of the polymer with three repeating units. [1]



(d) Propan-2-ol will react with acidified potassium dichromate, $K_2Cr_2O_7$, which is an oxidizing agent. [1]

$CH_3\overset{O}{\overset{\|}{C}}CH_3$

State the name of the product of this reaction.

propanone

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4. Potassium hydroxide, KOH, can neutralize organic acids.

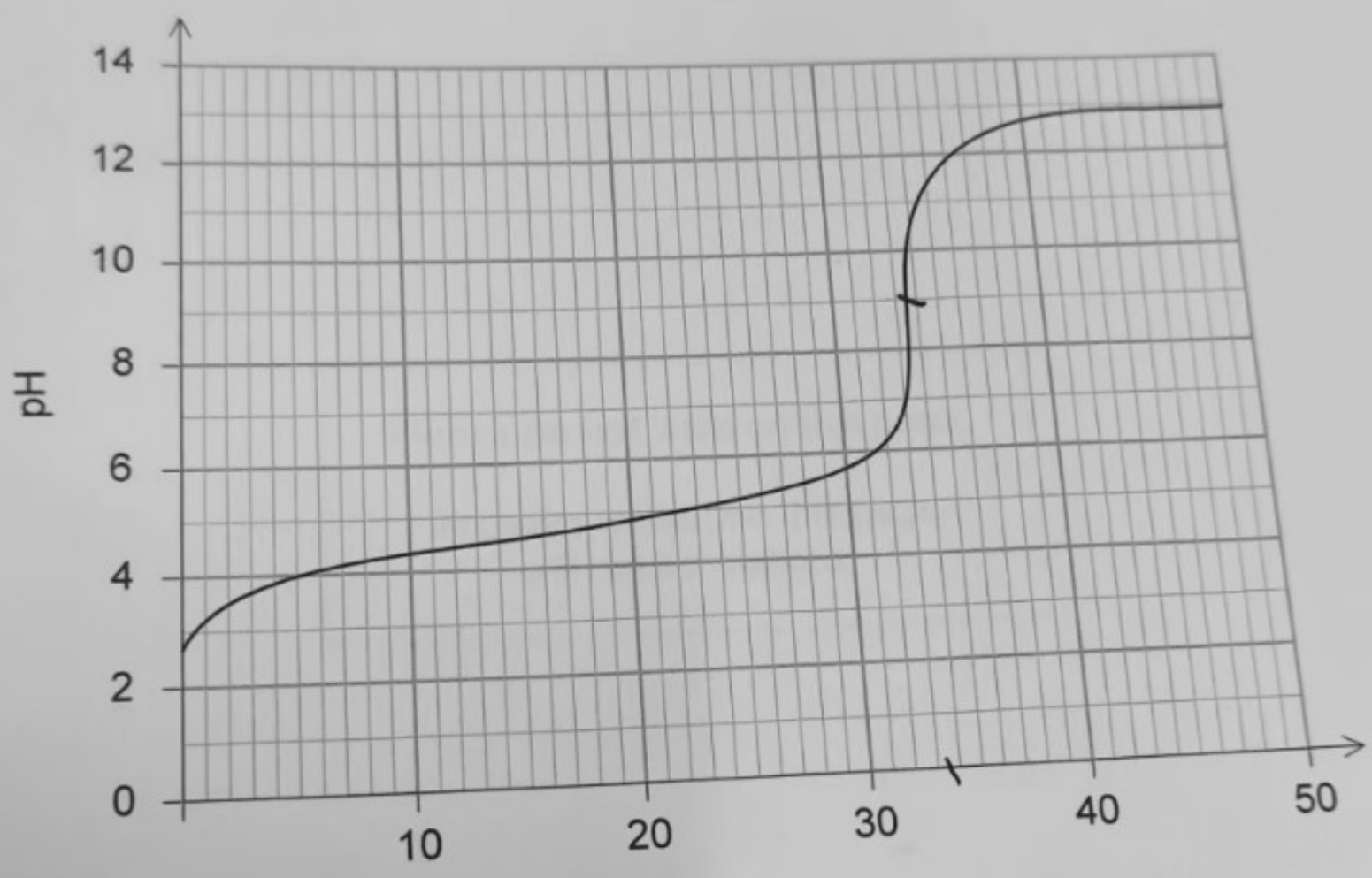
(a) Calculate the pH of a 0.0685 mol dm^{-3} solution of potassium hydroxide. [2]

$[OH^-] = 0.0685 \text{ mol dm}^{-3}$

$[H^+] = \frac{10^{-14}}{0.0685} = 1.46 \times 10^{-13}$

$pH = -\log_{10}[H^+] = 12.8$

(b) A sample of the potassium hydroxide solution is gradually added to 50.0 cm^3 of an aqueous solution of an unknown organic acid, producing the following pH curve.



Calculate the concentration of the unknown organic acid. [2]

$V(\text{equivalence point}) = 33.5 \text{ cm}^3$

$\frac{0.0685 \times 33.5}{50.0} = 0.0459 \text{ g dm}^{-3}$