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Chemistry Higher level Paper 2

18 May 2026

Zone A morning | Zone B morning | Zone C morning

Session number

2 hours 30 minutes

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Instructions to students

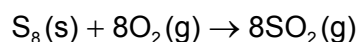
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[90 marks]**.



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 .



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]

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- (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 15.0dm^3 , although this is not the correct answer.

[1]

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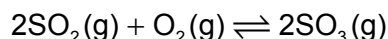
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(Question 1 continued)

- (b) Sulfur dioxide is converted to sulfur trioxide.



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

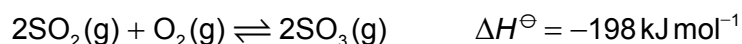
Compound	Oxidation state of sulfur
SO ₂	
SO ₃	

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

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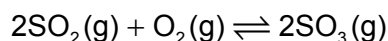
- (iii) State, with a reason, the effect of increasing the temperature on the value of the equilibrium constant, K . [1]



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



Position of equilibrium:

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Value of K :

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(This question continues on page 5)



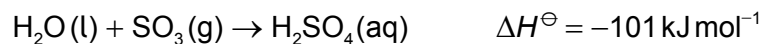
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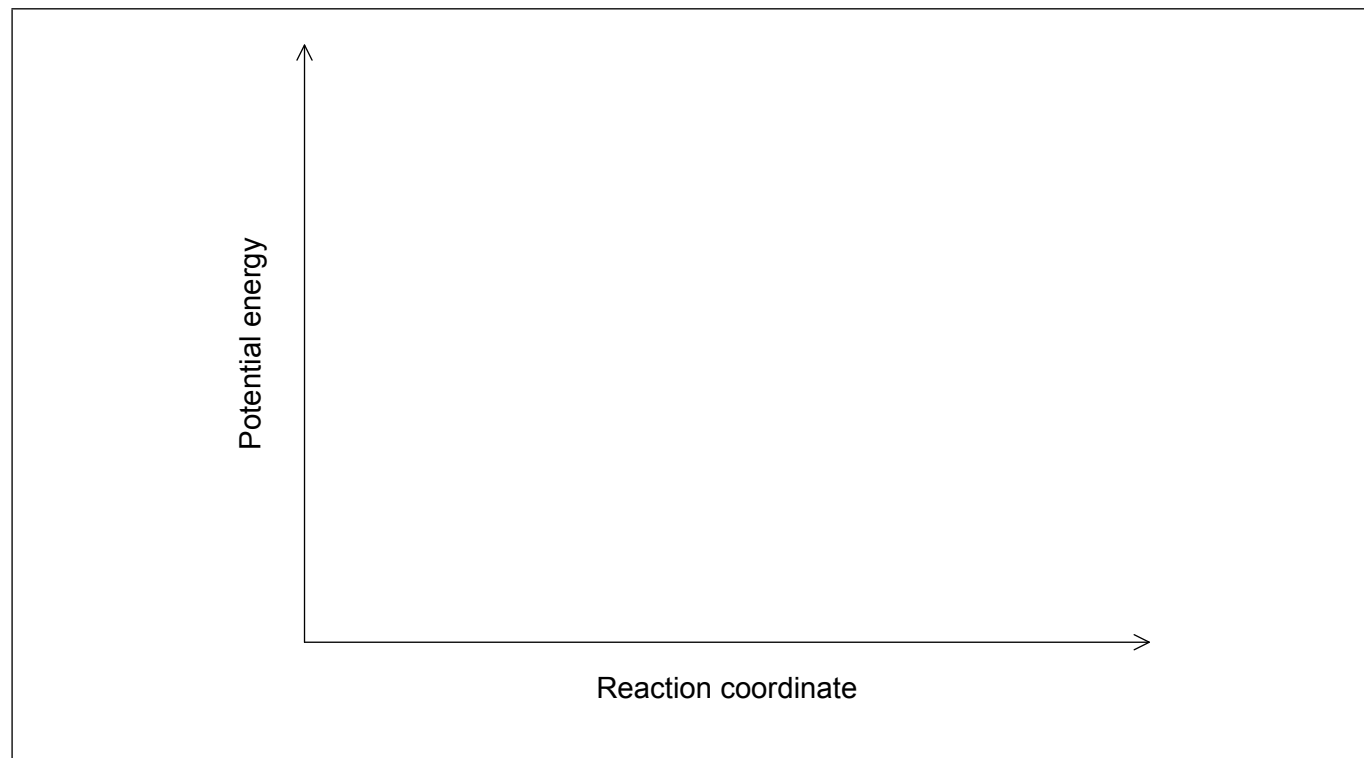


(Question 1 continued)

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



- (i) Sketch an energy profile for the overall reaction indicating the $\Delta H^\ominus$ and the activation energy. [2]



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

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(This question continues on the following page)



(Question 1 continued)

(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]

.....

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

[2]

Lewis formula:

Molecular geometry:

(This question continues on the following page)



(Question 1 continued)

- (iii) State the hybridization of the sulfur atom in the sulfite ion. [1]

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- (iv) Explain the stability of the sulfite ion based on its Lewis formula. [2]

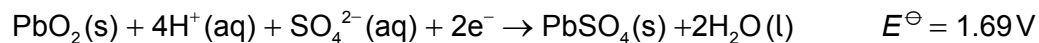
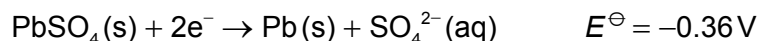
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(Question 1 continued)

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



- (i) Deduce the overall reaction for the cell. [1]

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- (ii) Calculate the cell potential, $E^\ominus_{\text{cell}}$. [1]

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- (iii) Calculate the standard change in Gibbs energy, $\Delta G^\ominus$, in kJ mol^{-1} , of the cell reaction.

Use sections 1 and 2 of the data booklet.

If you did not obtain an answer for (e)(ii) use 1.25 V, although this is not the correct answer. [2]

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(This question continues on the following page)



(Question 1 continued)

- (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:

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Cathode half-equation:

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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]

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- (iii) Determine the energy of a photon, in J, emitted from hydrogen with a wavelength of 434.0 nm.

Use sections 1, 2 and 3 of the data booklet. [2]

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2. Potassium, K, is a reactive metal.

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

Protons:	
Electrons:	
Neutrons:	

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

.....

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

Isotope	Mass	Percent abundance
^{39}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. [2]

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(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]

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

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- (iii) Explain why sulfur, S, has a lower first ionization energy than phosphorous, P. [2]

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(This question continues on the following page)



(Question 2 continued)

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

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

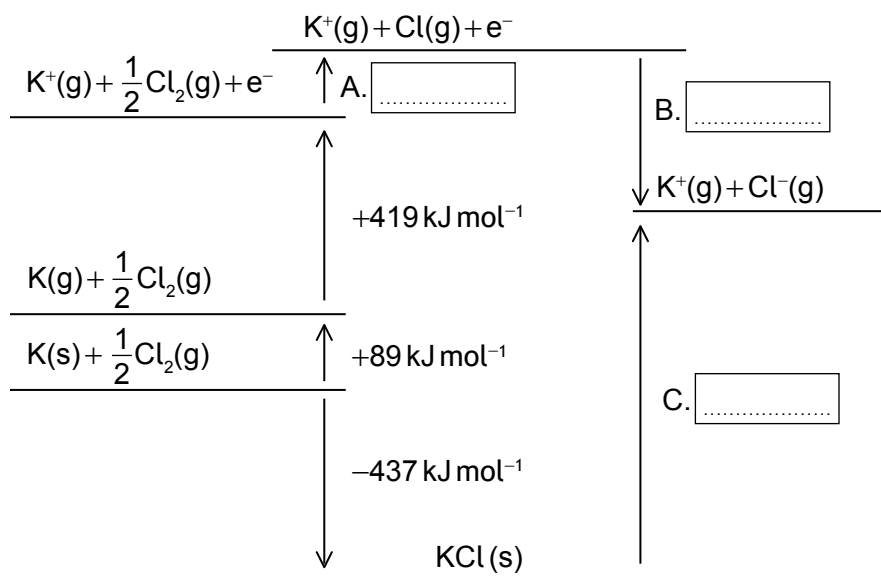
	Type of bonding	How valence electrons produce bonds
K		
H_2O		

- (d) Potassium also forms compounds with halogens such as chlorine, Cl.

Annotate the Born–Haber cycle for potassium chloride, KCl, with the correct values.

Use sections 9 and 12 of the data booklet.

[3]



(This question continues on the following page)



(Question 2 continued)

(e) Transition elements have unique properties.

(i) State **two** properties of transition elements other than the formation of coloured compounds.

[2]

Property 1:

Property 2:

(ii) Explain why transition element compounds are coloured.

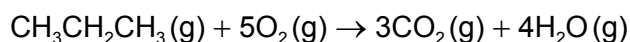
[3]

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3. Propane, $\text{CH}_3\text{CH}_2\text{CH}_3$, 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]



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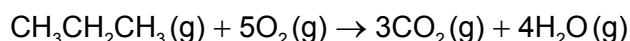
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- (ii) Calculate the mass, in g, of carbon dioxide, CO_2 , produced when 25.0 g of propane react with 95.0 g of oxygen, showing your work. [3]



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- (iii) The enthalpy of combustion for propane in table 14 of the data booklet is $-2219 \text{ kJ mol}^{-1}$.

Outline why there is a difference between the value in this table and the one obtained in (a)(i). [1]

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(This question continues on the following page)



(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:

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Propagation:

.....

.....

.....

(ii) 2-Bromopropane reacts with aqueous sodium hydroxide, NaOH(aq) , to form propan-2-ol, $\text{CH}_3\text{CH(OH)CH}_3$.

Suggest the mechanism for this reaction, giving your reason, based on the structure of 2-bromopropane. [2]

Mechanism:

Reason:

(iii) The product was analysed by ^1H NMR.

Predict the number and relative areas of signals for propan-2-ol. [2]

Number of signals:

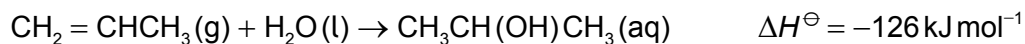
Relative areas:

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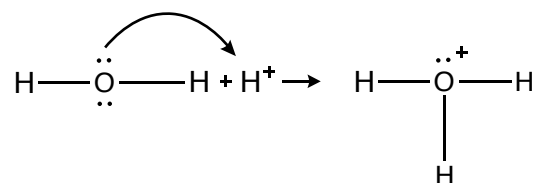


(Question 3 continued)

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



- (i) The first step of the mechanism for the formation of propan-2-ol is the protonation of water.



Sketch the mechanism for the formation of this product using curly arrows.

[4]

- (ii) Explain why increasing the temperature would increase the rate of this reaction.

[2]

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(Question 3 continued)

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

[2]

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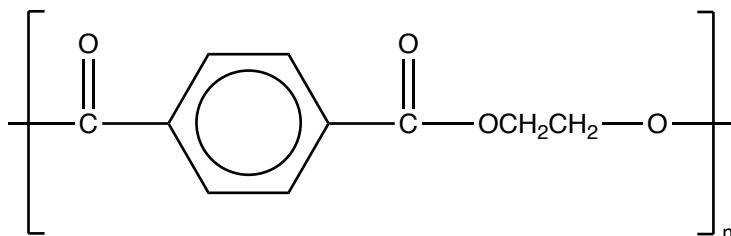
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(iv) Propene can also form a polymer.

Draw a section of the polymer with three repeating units.

[1]

(v) Dacron is a polymer formed by a condensation reaction.



Draw the structural formulas of the two monomers that form Dacron.

[2]

(This question continues on page 19)



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(Question 3 continued)

- (d) Propan-2-ol will react with acidified potassium dichromate, $\text{K}_2\text{Cr}_2\text{O}_7$, which is an oxidizing agent.

- (i) State the name of the product of this reaction. [1]

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- (ii) Explain how infrared spectroscopy could be used to distinguish between propan-2-ol and the product in (d)(i), referring to both structures.

- Use section 20 of the data booklet. [2]

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

(a) Calculate the pH of a $0.0685 \text{ mol dm}^{-3}$ solution of potassium hydroxide.

[2]

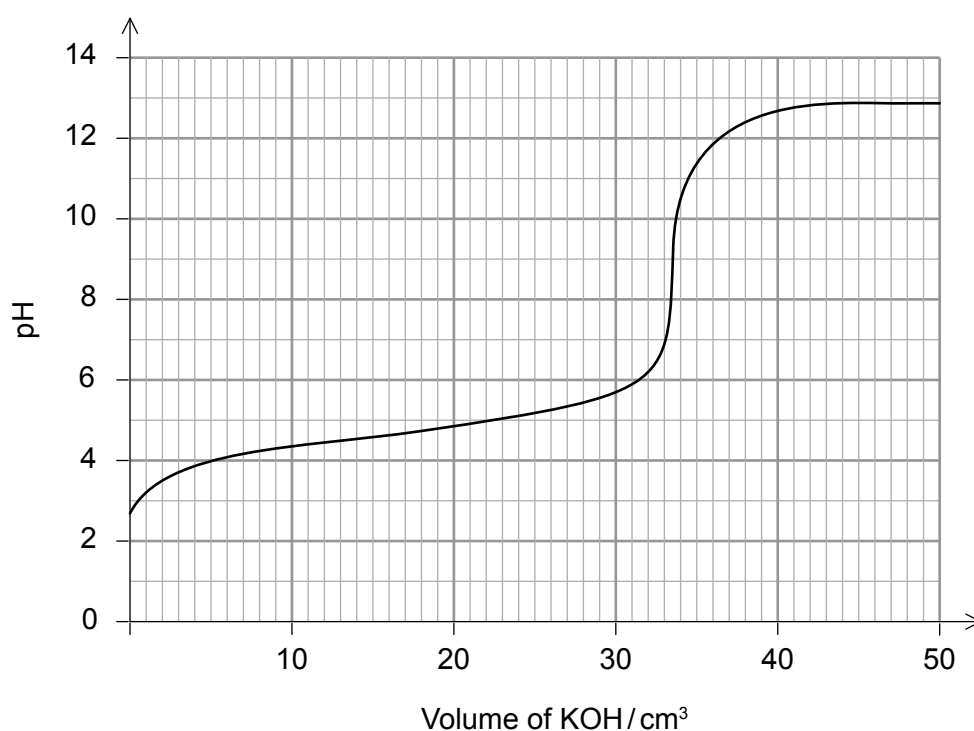
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(b) A sample of the potassium hydroxide solution is gradually added to 50.0 cm^3 of an aqueous solution of an unknown organic acid, producing the following pH curve.



Calculate the concentration of the unknown organic acid.

[2]

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(This question continues on the following page)



(Question 4 continued)

- (c) State, with a reason, which indicator would be appropriate for this titration, using section 18 of the data booklet.

[1]

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- (d) Suggest two different mixtures which would produce a buffer solution from the organic acid.

[2]

Mixture 1:

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Mixture 2:

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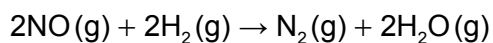


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5. Nitrogen(II) oxide reacts with hydrogen.



The data shows how the rate of reaction varies as the reactant concentrations change.

Experiment	Initial [NO] (g) / mol dm ⁻³	Initial [H ₂] (g) / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	0.100	0.100	2.53×10^{-6}
2	0.100	0.200	5.05×10^{-6}
3	0.200	0.100	10.10×10^{-6}
4	0.300	0.100	22.80×10^{-6}

- (a) Determine the order of reaction with respect to NO and with respect to H₂. [2]

Reactant	Order of reaction
NO	
H ₂	

- (b) Deduce the rate equation for the reaction. [1]

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- (c) Calculate the rate constant using the data from experiment 1 and include its units in the your answer. [2]

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