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Chemistry
Standard level
Paper 2

Wednesday 18 May 2022 (afternoon)

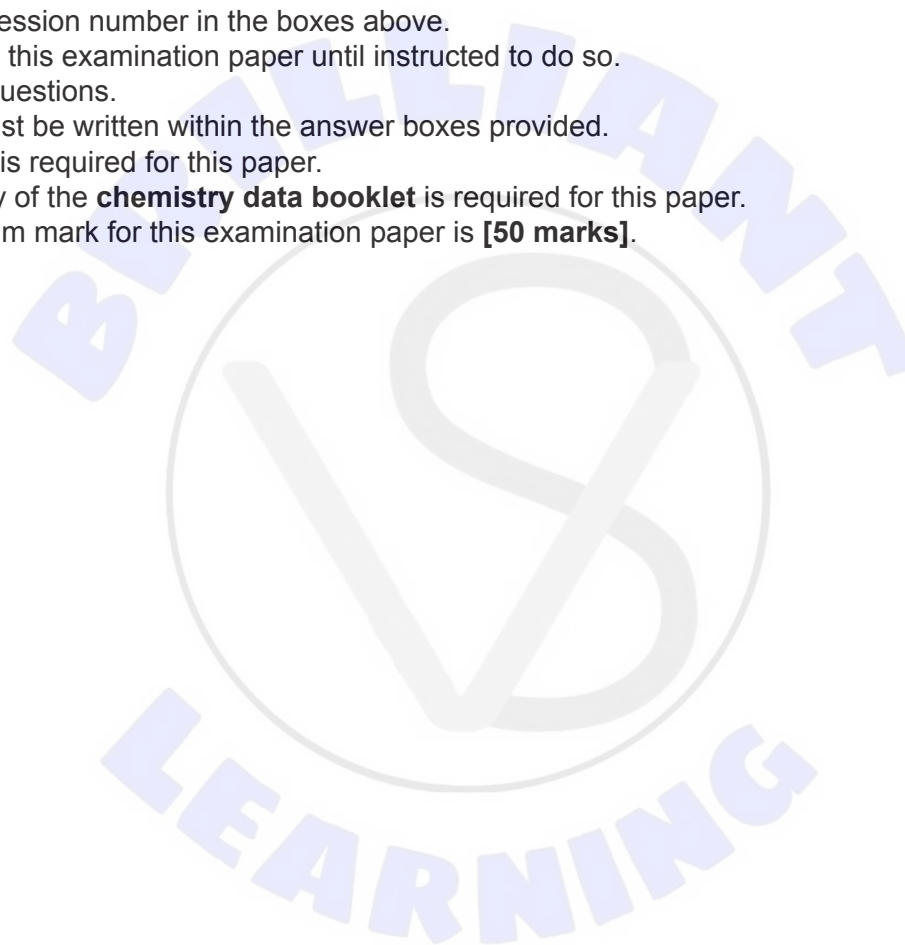
Candidate session number

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1 hour 15 minutes

Instructions to candidates

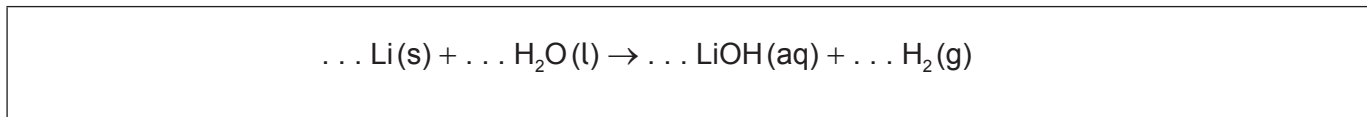
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



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

1. Lithium reacts with water to form an alkaline solution.

(a) Determine the coefficients that balance the equation for the reaction of lithium with water. [1]



(b) A 0.200g piece of lithium was placed in 500.0 cm³ of water.

(i) Calculate the molar concentration of the resulting solution of lithium hydroxide. [2]

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(ii) Calculate the volume of hydrogen gas produced, in cm³, if the temperature was 22.5 °C and the pressure was 103 kPa. Use sections 1 and 2 of the data booklet. [2]

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(iii) Suggest a reason why the volume of hydrogen gas collected was smaller than predicted. [1]

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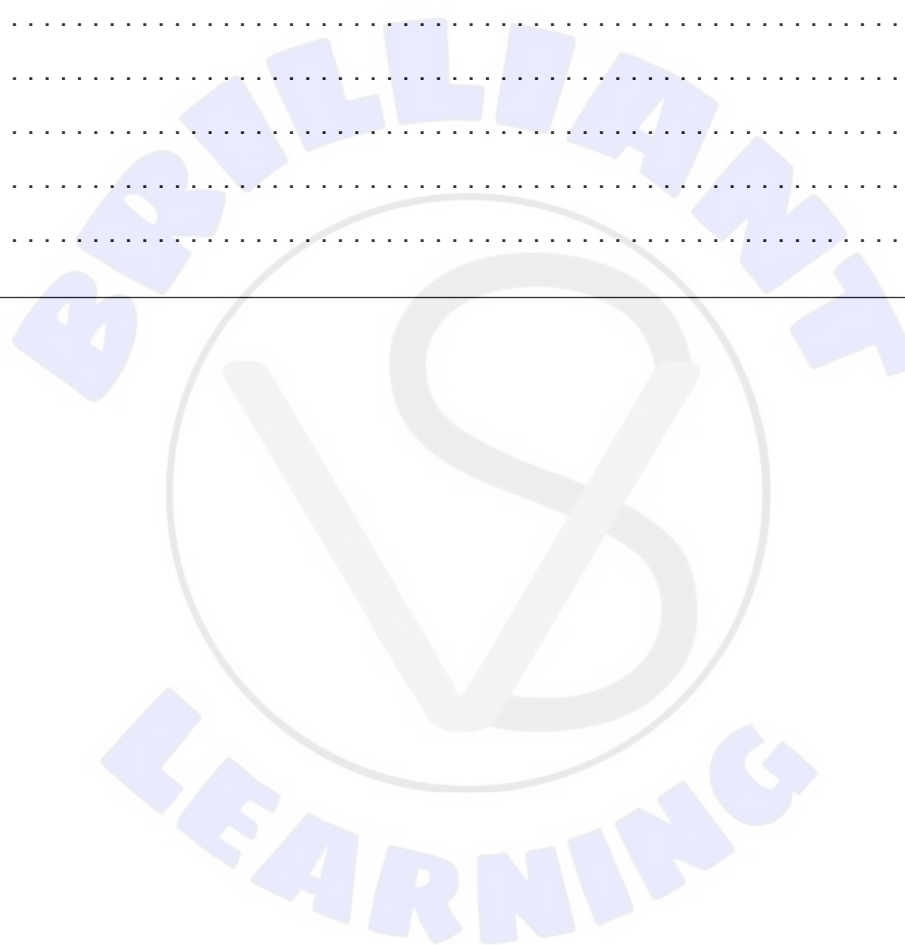
(Question 1 continued)

- (c) The reaction of lithium with water is a redox reaction. Identify the oxidizing agent in the reaction giving a reason. [1]

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- (d) Describe two observations that indicate the reaction of lithium with water is exothermic. [2]

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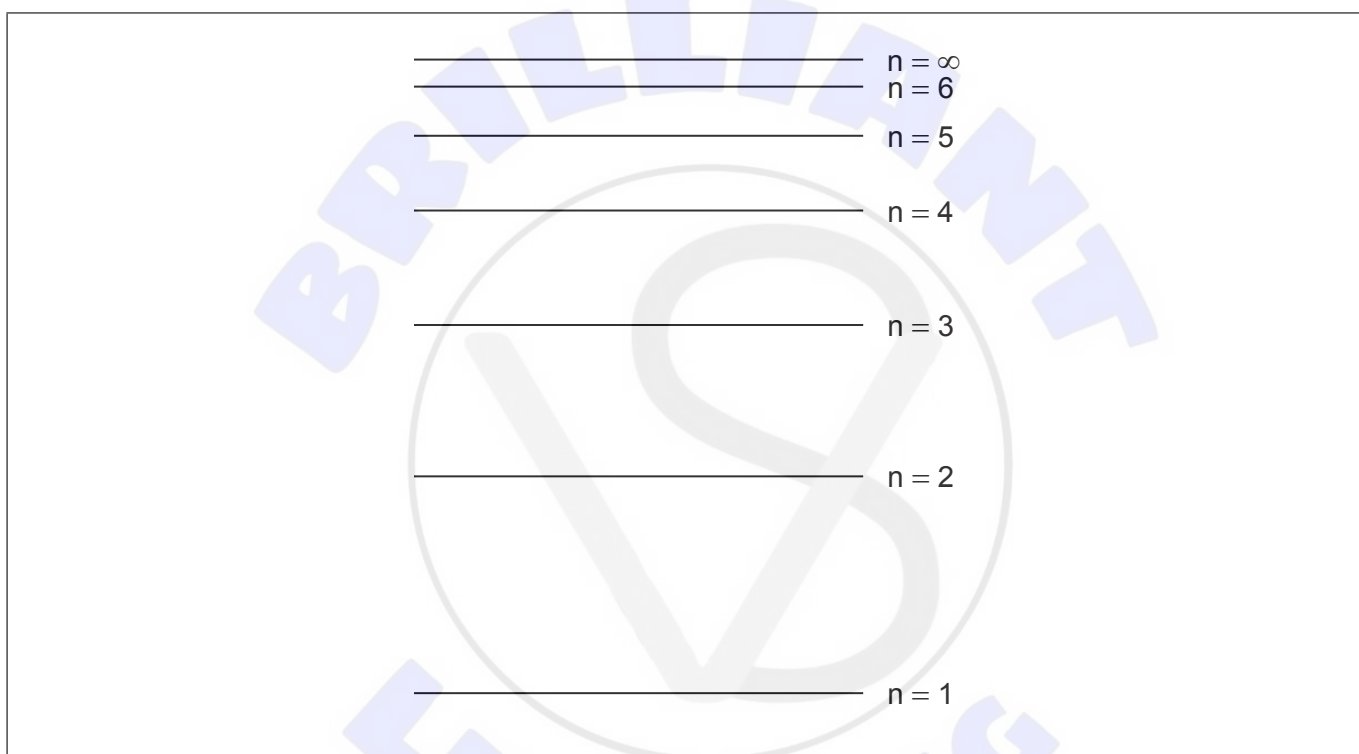


2. Electrons are arranged in energy levels around the nucleus of an atom.

(a) Explain why the first ionization energy of calcium is greater than that of potassium. [2]

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(b) The diagram represents possible electron energy levels in a hydrogen atom.



(i) All models have limitations. Suggest **two** limitations to this model of the electron energy levels. [2]

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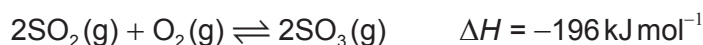
(Question 2 continued)

- (ii) Draw an arrow, labelled **X**, to represent the electron transition for the ionization of a hydrogen atom in the ground state. [1]

- (iii) Draw an arrow, labelled **Z**, to represent the lowest energy electron transition in the visible spectrum. [1]



3. Sulfur trioxide is produced from sulfur dioxide.



(a) Outline, giving a reason, the effect of a catalyst on a reaction. [2]

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(b) The reaction between sulfur dioxide and oxygen can be carried out at different temperatures.

(i) On the axes, sketch Maxwell-Boltzmann energy distribution curves for the reacting species at two temperatures T_1 and T_2 , where $T_2 > T_1$. [3]



(ii) Explain the effect of increasing temperature on the yield of SO_3 . [2]

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(Question 3 continued)

(c) (i) State the product formed from the reaction of SO_3 with water. [1]

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(ii) State the meaning of a strong Brønsted–Lowry acid. [2]

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(d) Nitric acid, HNO_3 , is another strong Brønsted–Lowry acid. Its conjugate base is the nitrate ion, NO_3^-

(i) Draw the Lewis structure of NO_3^- . [1]

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(ii) Explain the electron domain geometry of NO_3^- . [2]

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4. Carbon forms many compounds.

(a) C_{60} and diamond are allotropes of carbon.

(i) Outline **one** difference between the bonding of carbon atoms in C_{60} and diamond. [1]

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(ii) Explain why C_{60} and diamond sublime at different temperatures and pressures. [2]

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(b) (i) State two features showing that propane and butane are members of the same homologous series. [2]

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(Question 4 continued)

- (ii) Suggest the fragment causing peak **R** in the mass spectrum of butane. [1]

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- (c) Describe a test and the expected result to indicate the presence of carbon-carbon double bonds. [2]

Test:
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Result:
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(Question 4 continued)

(d) But-2-ene reacts with hydrogen bromide.

(i) Draw the full structural formula of but-2-ene.

[1]

(ii) Write the equation for the reaction between but-2-ene and hydrogen bromide.

[1]

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(iii) State the type of reaction.

[1]

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(iv) Suggest **two** differences in the ^1H NMR of but-2-ene and the organic product from (d)(ii).

[2]

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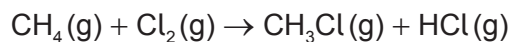
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(Question 4 continued)

(e) Chlorine reacts with methane.



(i) Calculate the enthalpy change of the reaction, ΔH , using section 11 of the data booklet.

[3]

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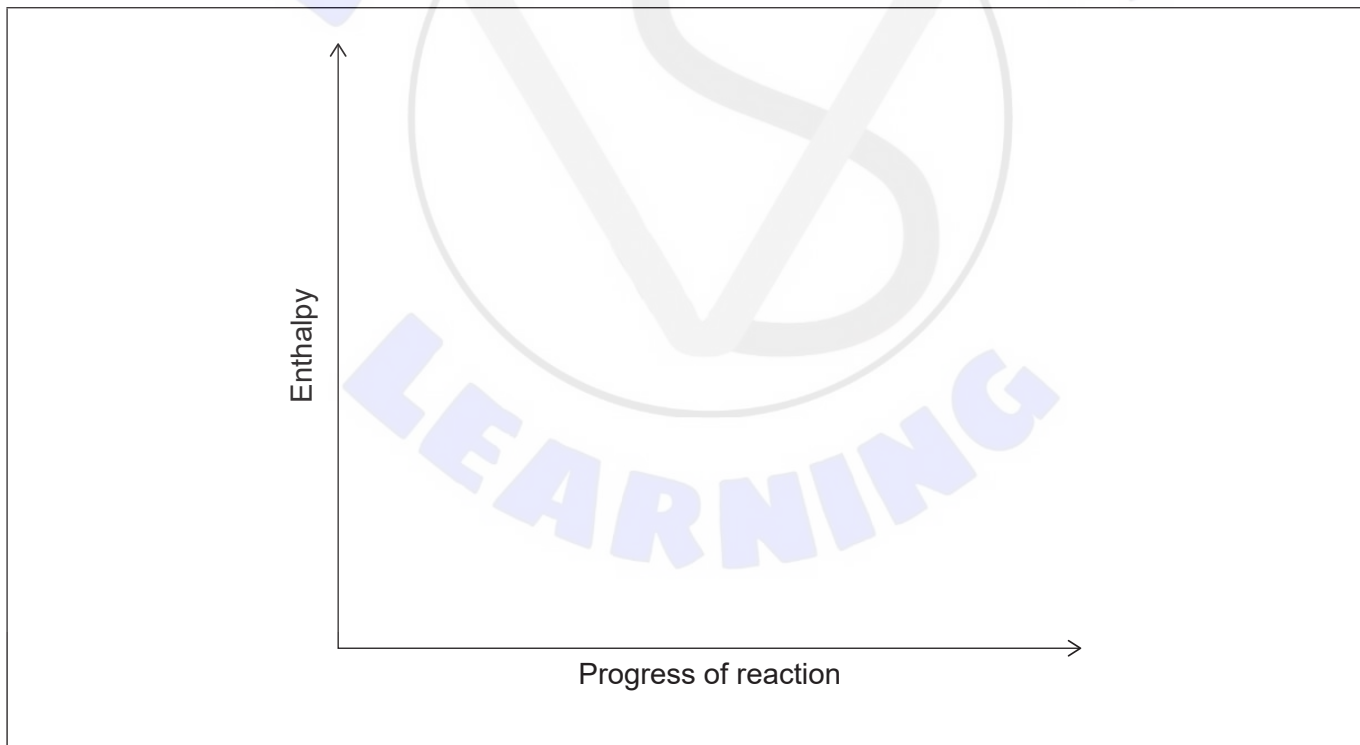
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(ii) Draw and label an enthalpy level diagram for this reaction.

[2]



5. Molten zinc chloride undergoes electrolysis in an electrolytic cell at 450°C.

(a) Deduce the half-equations for the reaction at each electrode. [2]

Cathode (negative electrode):

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Anode (positive electrode):

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(b) Deduce the overall cell reaction including state symbols. Use section 7 of the data booklet. [2]

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References:

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