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## Chemistry

### Assessment Unit A2 1

*assessing*

Periodic Trends and Further Organic,  
Physical and Inorganic Chemistry

[AC212]



FRIDAY 23 MAY, MORNING

#### TIME

2 hours.

#### INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all sixteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all six** questions in **Section B**. Write your answers in the spaces provided in this question paper.

#### INFORMATION FOR CANDIDATES

The total mark for this paper is 120.

Quality of written communication will be assessed in Question **14(d)(i)**. In Section A all questions carry equal marks, i.e. **two** marks for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of the Elements, containing some data, is included in this question paper.

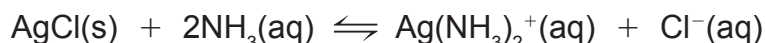
For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
<b>Total Marks</b>	

## Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

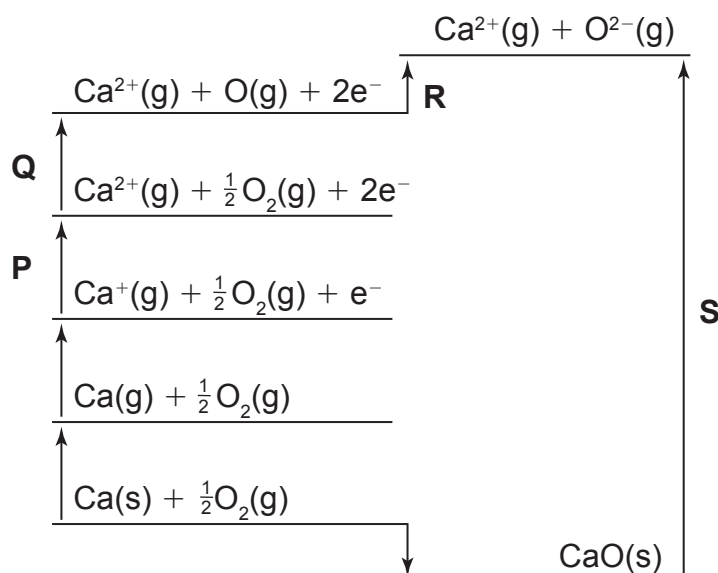
- 1 Which one of the following is the pH of the solution obtained by mixing 50.0 cm<sup>3</sup> of 1 mol dm<sup>-3</sup> sodium hydroxide solution with 49.0 cm<sup>3</sup> of 1 mol dm<sup>-3</sup> hydrochloric acid?
- A 2  
B 8  
C 10  
D 12
- 2 Which one of the following compounds can be reduced to form a product which can exist as optical isomers?
- A Butan-2-one  
B Hex-2-ene  
C Propanal  
D *Trans*-butenedioic acid
- 3 The following equilibrium is established when excess silver chloride is added to aqueous ammonia:



Which one of the following occurs when aqueous sodium chloride is added?

- A AgCl(s) dissolves  
B More Ag(NH<sub>3</sub>)<sub>2</sub><sup>+</sup>(aq) is formed  
C More AgCl(s) is precipitated  
D NH<sub>4</sub>Cl(s) is formed

4 The Born–Haber cycle for calcium oxide is shown below:



Which one of the following is a correct statement about the cycle?

- A The electron affinity of oxygen is **Q**
- B The second ionisation enthalpy of calcium is **P**
- C The enthalpy of formation of calcium oxide is **S**
- D The bond dissociation enthalpy of oxygen is **R**

5 The value of the equilibrium constant for the reaction



can be increased by

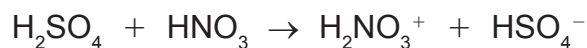
- A decreasing the pressure.
- B decreasing the temperature.
- C increasing the pressure.
- D increasing the temperature.

6 Which one of the following oxides is amphoteric?

- A Aluminium oxide
- B Carbon dioxide
- C Dichlorine heptoxide
- D Magnesium oxide

- 7 Which one of the following has a positive enthalpy value?
- A  $\text{Na(g)} \rightarrow \text{Na(s)}$
  - B  $\text{Na(g)}^+ + \text{e}^- \rightarrow \text{Na(g)}$
  - C  $\text{O(g)} + \text{e}^- \rightarrow \text{O}^-(\text{g})$
  - D  $\text{O}^-(\text{g}) + \text{e}^- \rightarrow \text{O}^{2-}(\text{g})$
- 8 0.01 g of a monobasic acid requires  $5.0 \text{ cm}^3$  of  $0.01 \text{ mol dm}^{-3}$  sodium hydroxide for neutralisation. Which one of the following is the approximate relative molecular mass of the acid?
- A 20
  - B 50
  - C 200
  - D 250
- 9 The saponification value of a monoglyceride is
- A the number of grams of KOH required to react with 1 g of the monoglyceride.
  - B the number of milligrams of KOH required to react with 1 g of the monoglyceride.
  - C the number of grams of NaOH required to react with 1 g of the monoglyceride.
  - D the number of milligrams of NaOH required to react with 1 g of the monoglyceride.

- 10 Sulfuric acid reacts with nitric acid as follows:



Which one of the following is the role of  $\text{HNO}_3$  in the reaction?

- A Conjugate acid of  $\text{H}_2\text{NO}_3^+$
- B Conjugate acid of  $\text{HSO}_4^-$
- C Conjugate base of  $\text{H}_2\text{NO}_3^+$
- D Conjugate base of  $\text{HSO}_4^-$

## Section B

Answer all **six** questions in this section.

11 A table of the oxides of Period 3 is shown below. Fill in the gaps.

name	formula	reaction with water	pH value of saturated solution in water	bonding
sodium oxide	Na <sub>2</sub> O	vigorous	14	ionic
magnesium oxide				
aluminium oxide				
silicon dioxide				
phosphorus pentoxide				
sulfur trioxide				
dichlorine heptoxide				

[8]

12 Ammonium cyanide,  $\text{NH}_4\text{CN}$ , is a white crystalline solid. It is very soluble in water and the solution smells of almonds. The smell is associated with hydrogen cyanide gas.

(a) One method of preparation is to mix solutions of calcium cyanide and ammonium carbonate.

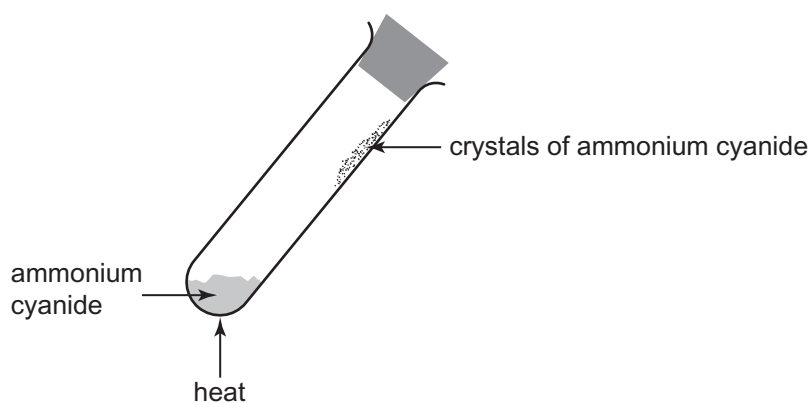
(i) Write the equation, using state symbols, for the reaction of calcium cyanide with ammonium carbonate.

\_\_\_\_\_ [2]

(ii) Explain, giving experimental details, how you would obtain a solution of ammonium cyanide from the mixture.

\_\_\_\_\_  
\_\_\_\_\_ [2]

(b) When heated, ammonium cyanide decomposes to form ammonia and hydrogen cyanide. An equilibrium is formed in a sealed test tube.

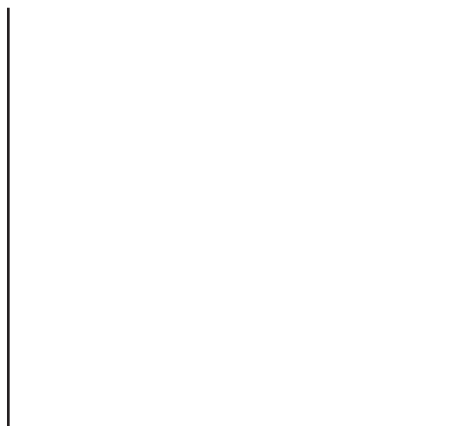


Explain if the reverse reaction is exothermic or endothermic.

\_\_\_\_\_  
\_\_\_\_\_ [2]

(c) Theoretically ammonium cyanide could be prepared by the titration of aqueous ammonia with aqueous hydrocyanic acid (HCN). However, in practice this is not normally carried out because HCN is a weak acid.

(i) Draw the expected titration curve for the titration and label the axes.



[3]

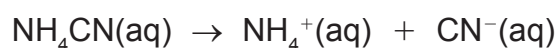
(ii) Use the titration curve to explain why the titration is not normally carried out.

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[2]

(d) Explain, using equations, how a solution of ammonium cyanide can be used as a buffer solution.



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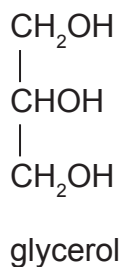
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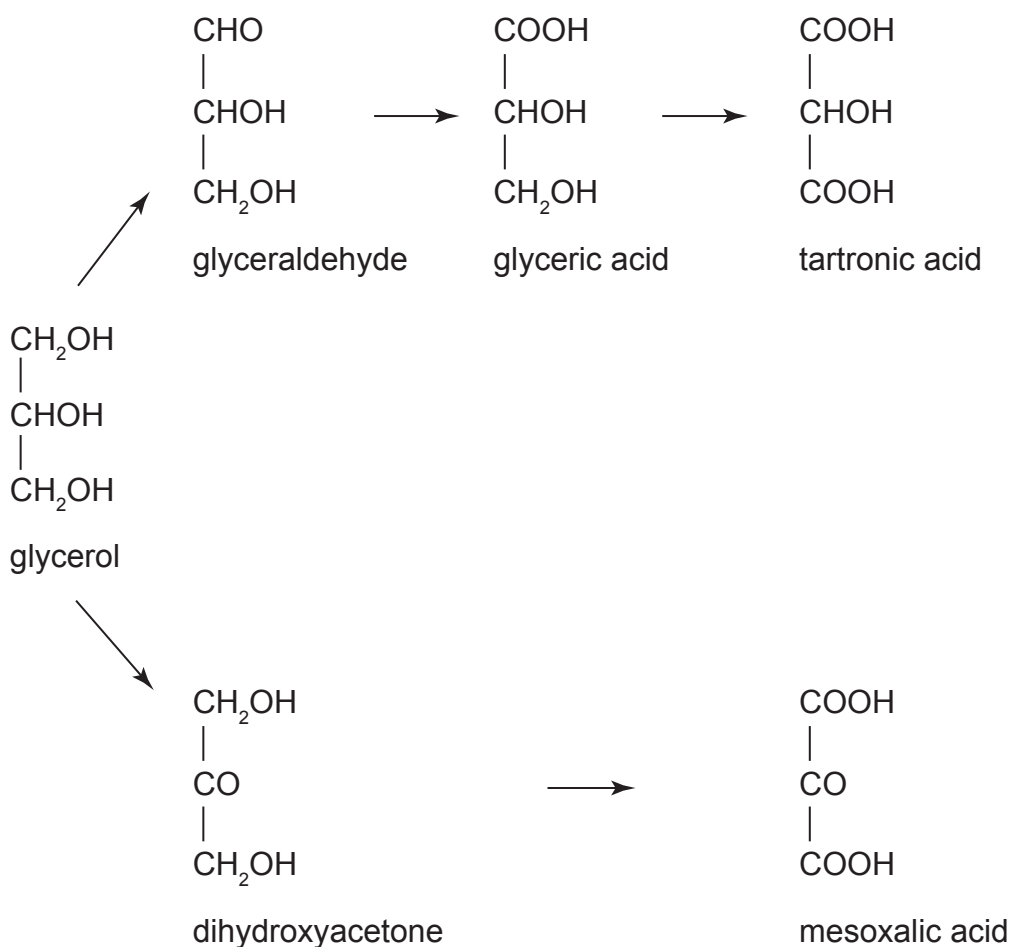
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[3]

13 Glycerol (glycerine) is the most common trihydric alcohol found in nature.



(a) Glycerol is easily oxidised, the oxidation product depending on the oxidising agent. The following series of reactions are carried out using a variety of oxidising agents.



Use the complete flow scheme above to answer the following questions.

(i) Which compound(s) are dicarboxylic acids?

\_\_\_\_\_ [2]

(ii) Which compound(s) are optically active?

\_\_\_\_\_ [2]



(iii) Which compound(s) will form 2,4-dinitrophenylhydrazone derivatives?

\_\_\_\_\_ [2]

(iv) Which compound(s) contain primary alcohol groups?

\_\_\_\_\_  
\_\_\_\_\_ [2]

(b) Glycerol reacts with an oxidising agent represented as [O] to form glyceric acid. Write the equation for the reaction.

\_\_\_\_\_ [2]

(c) Suggest the systematic name for glyceric acid.

\_\_\_\_\_ [2]

(d) Glycerol reacts with acids to form esters. The reaction with oleic acid,  $C_{17}H_{33}COOH$ , forms glyceryl trioleate. The reaction with nitric acid forms trinitrolycerine.

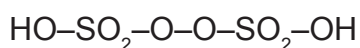
(i) Write the structure of glyceryl trioleate.

[2]

(ii) Suggest the structure of trinitrolycerine.

[2]

- 14 Potassium persulfate,  $K_2S_2O_8$ , is made by the oxidation of potassium sulfate using electricity. It is a salt of peroxy-sulfuric acid.



peroxy-sulfuric acid

- (a) Suggest the structure of peroxy-sulfuric acid showing all the bonds present.

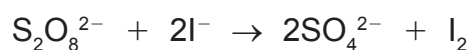
[2]

- (b) Although peroxy-sulfuric acid is a powerful oxidising agent it is a weak acid. Explain whether a solution of potassium persulfate is acidic, alkaline or neutral.

\_\_\_\_\_

\_\_\_\_\_ [2]

- (c) Persulfate ions oxidise iodide ions according to the following equation:



Calculate the oxidation numbers of sulfur and iodine and show that this is a redox reaction.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ [3]

- (d) The following results were obtained in an experiment to determine the rate of reaction between persulfate ions and iodide ions in aqueous solution.

concentration of $S_2O_8^{2-}/\text{mol dm}^{-3}$	concentration of $I^-/\text{mol dm}^{-3}$	initial rate/ $\text{mol dm}^{-3} \text{ s}^{-1}$
0.050	0.050	0.18
0.100	0.050	0.36
0.100	0.100	0.72

- (i) Describe how you would study the rate of the reaction. The concentration of one of the reactants or products will need to be measured with respect to time and can then be used to determine the rate of the reaction.

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\_\_\_\_\_ [5]

Quality of written communication [2]

- (ii) Deduce the order of reaction with respect to each of the reactants.

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\_\_\_\_\_ [2]

- (iii) Write the rate equation for the reaction.

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\_\_\_\_\_ [2]

- (iv) Using this reaction explain what is meant by the overall order of a reaction.

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\_\_\_\_\_ [1]

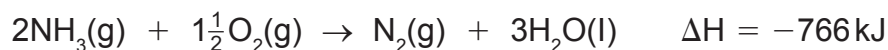
- (v) Calculate the rate constant and state its units.

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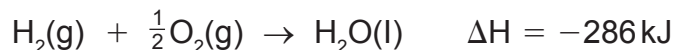
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\_\_\_\_\_ [2]

15 Ammonia burns in oxygen to form nitrogen and water.



Hydrogen burns in oxygen to form water.



(a) Hess's law can be used to calculate the enthalpy change for the decomposition of ammonia.



(i) State Hess's law.

\_\_\_\_\_ [2]

(ii) Use the values of the enthalpies of combustion of ammonia and hydrogen to calculate the molar enthalpy of decomposition of ammonia.

\_\_\_\_\_ [2]

(b) The molar enthalpy of decomposition of ammonia can also be calculated using bond energies. Use the following table to calculate the molar enthalpy of decomposition of ammonia.

bond	bond enthalpy/kJ mol <sup>-1</sup>
H — H	436
N — H	388
N ≡ N	944

\_\_\_\_\_ [2]

- (c) The entropy change for the molar decomposition of ammonia can be calculated using the following values of entropy.

substance	entropy value/ $\text{J K}^{-1} \text{mol}^{-1}$
$\text{N}_2(\text{g})$	191.6
$\text{H}_2(\text{g})$	130.7
$\text{NH}_3(\text{g})$	192.8

Calculate the value of the entropy change for the molar decomposition of ammonia.

\_\_\_\_\_ [2]

- (d) Assuming that both the values of  $\Delta H$  and  $\Delta S$  are independent of temperature the minimum temperature at which the thermal decomposition of ammonia becomes spontaneous can be calculated.

- (i) State the equation which links  $\Delta H$  and  $\Delta S$  to  $\Delta G$ .

\_\_\_\_\_ [1]

- (ii) Explain what is meant by the term spontaneous or feasible.

\_\_\_\_\_ [1]

- (iii) Calculate the temperature at which the reaction becomes feasible using the value of  $\Delta H$  from part (a)(ii) or (b).

\_\_\_\_\_ [2]

(e) Ammonia may be used as a fertiliser itself but more often it is used as the salt ammonium nitrate.

(i) State how water pollution from ammonium nitrate leads to eutrophication.

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[3]

(ii) State whether ammonium nitrate is described as an artificial or a natural fertiliser.

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[1]

(iii) Describe **one** advantage of using artificial fertilisers.

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[1]

(iv) Describe **one** advantage of using natural fertilisers.

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[1]

(v) State how you would control, reduce and manage water pollution caused by nitrate fertilisers.

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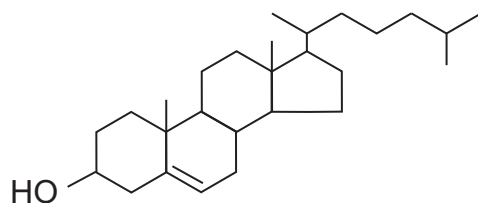
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[2]

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**(Questions continue overleaf)**

- 16 Cholesterol is present in animal tissue, but is concentrated in the brain and in the spinal cord. The total amount present in an 82 kg person is 240 g. It is present both as the free alcohol and as esters of organic acids.



cholesterol

- (a) Cholesterol has a melting point of 148–149 °C.
- (i) In an experiment to determine the melting point of a powder suspected to be cholesterol what would it mean if the melting point was found to be 146–149 °C?

\_\_\_\_\_ [1]

- (ii) What would it mean if the melting point was found to be 155–157 °C?

\_\_\_\_\_ [1]

- (b) (i) Cholesterol is a monohydric alcohol whereas glycerol is trihydric. Suggest the meaning of the term **monohydric**.

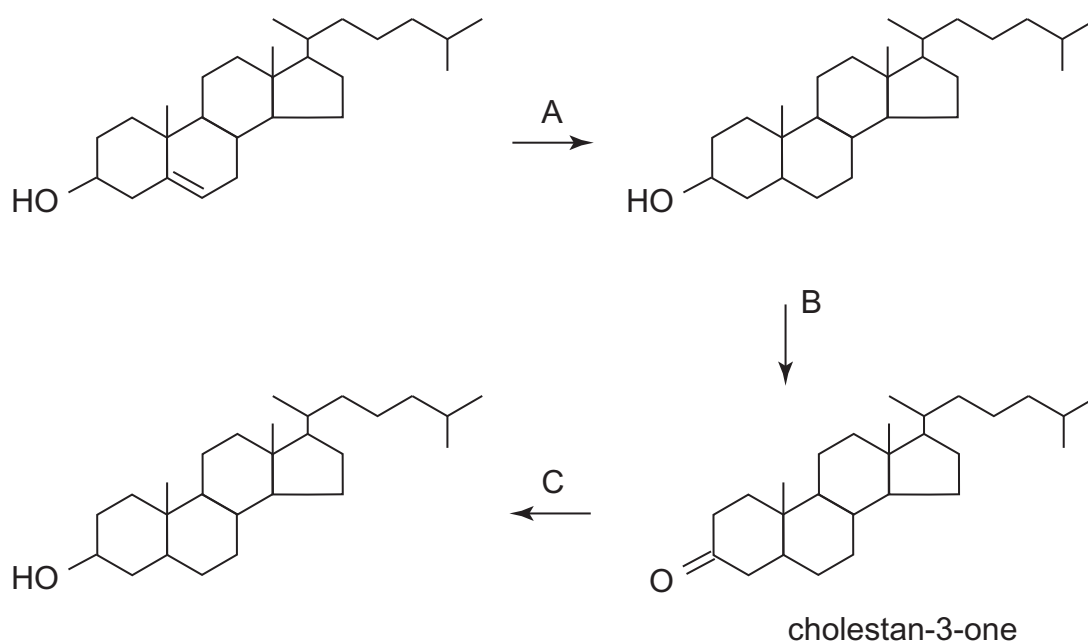
\_\_\_\_\_  
\_\_\_\_\_ [2]

- (ii) Explain whether cholesterol is a primary, secondary or tertiary alcohol.

\_\_\_\_\_  
\_\_\_\_\_ [1]



(c) Cholesterol can be converted to cholestan-3-one and then reduced as shown by the following flow scheme.



(i) Name the reagents A, B and C.

A \_\_\_\_\_ [1]

B \_\_\_\_\_ [1]

C \_\_\_\_\_ [1]

(ii) Cholesterol is not very soluble in water and cholestan-3-one is even less soluble than cholesterol. Explain these solubilities.

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ [3]

(iii) Cholestan-3-one forms a 2,4-dinitrophenylhydrazone. Using the formula  $\text{>C=O}$  for the ketone write the equation for the reaction.

\_\_\_\_\_ [3]

(d) Cholesterol forms an ester with ethanoic acid.

(i) Suggest the name of the ester formed.

\_\_\_\_\_ [1]

(ii) Using the formula ROH for cholesterol write the equation for the formation of the ester.

\_\_\_\_\_ [2]

(iii) Name a substance that can be used to catalyse the formation of the ester in this reaction.

\_\_\_\_\_ [1]

(iv) Name another substance that reacts with cholesterol to form the same ester and using the formula ROH for cholesterol write the equation for the reaction.

\_\_\_\_\_  
\_\_\_\_\_ [3]

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**THIS IS THE END OF THE QUESTION PAPER**

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