

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL A-LEVEL CHEMISTRY (9620)

Unit 3: Inorganic 2 and Physical 2

Wednesday 3 June 2026

08:00 UK Time

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
TOTAL	



J U N 2 6 C H 0 3 0 1

Answer **all** questions in the spaces provided.

0 1

This question is about Period 3 elements and their compounds.

0 1 . 1

Magnesium reacts slowly with cold water but rapidly with steam.

State **one** similarity and **one** difference between the products of these reactions.

[2 marks]

Similarity _____

Difference _____

0 1 . 2

A sample of phosphorus is heated in an excess of oxygen.

When the reaction is complete, some water is added to the product and a second reaction occurs.

Write an equation for the reaction between phosphorus and an excess of oxygen.

Write an equation for the reaction that occurs when water is added to the product.

[2 marks]

Equation for the reaction between phosphorus and an excess of oxygen:

Equation for the reaction that occurs when water is added to the product:

0 1 . 3

A Period 3 element forms a chloride **Q**.

Q is a liquid at room temperature and reacts with water to form a solution with low pH.

Identify the bonding **and** name the type of structure in **Q**.

[1 mark]

Bonding _____

Structure _____



0 2

This question is about enthalpies of lattice dissociation.

A Born–Haber cycle can be used to calculate the enthalpy of lattice dissociation of calcium oxide.

Table 1 shows some thermodynamic changes in the Born–Haber cycle.

Table 1

Enthalpy of atomisation of calcium
Enthalpy of atomisation of oxygen
First ionisation energy of calcium
First electron affinity of oxygen
Second electron affinity of oxygen

0 2 . 1

The data for **two** more enthalpy changes are needed to calculate the enthalpy of lattice dissociation for calcium oxide using a Born–Haber cycle.

Give the name for each of these enthalpy changes.

[2 marks]

1 _____

2 _____

0 2 . 2

Write an equation, including state symbols, for the process that occurs when the second electron affinity of oxygen is measured.

[1 mark]

Question 2 continues on the next page

Turn over ►



A theoretical value for the enthalpy of lattice dissociation can be calculated using the perfect ionic model.

Table 2 shows some theoretical enthalpies of lattice dissociation of some Group 2 metal chlorides.

Table 2

	Enthalpy of lattice dissociation / kJ mol^{-1}
MgCl_2	2326
CaCl_2	2223
SrCl_2	2127
BaCl_2	2033

0 2 . 3 State what is meant by the perfect ionic model.

[1 mark]

0 2 . 4 Explain why the value for the enthalpy of lattice dissociation of magnesium chloride is greater than the value for the enthalpy of lattice dissociation of calcium chloride.

[2 marks]



0 2 . 5

How does the value for the enthalpy of lattice dissociation calculated from a Born–Haber cycle for magnesium chloride differ from the value for the theoretical enthalpy of lattice dissociation (2326 kJ mol^{-1})?

Tick (✓) **one** box.

[1 mark]

Born–Haber cycle value is larger

☐

Born–Haber cycle value is the same

☐

Born–Haber cycle value is smaller

☐

7

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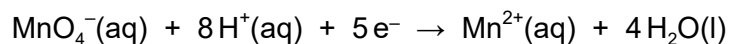
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0 3

Hydrogen sulfide gas can be used as a reducing agent.

When hydrogen sulfide is bubbled into acidified aqueous potassium manganate(VII), the manganate(VII) ions are reduced to Mn^{2+} ions.



In an experiment, 41.20 cm^3 of $0.0200 \text{ mol dm}^{-3}$ potassium manganate(VII) are reduced using hydrogen sulfide.

50.0 cm^3 of hydrogen sulfide, measured at $101\,000 \text{ Pa}$ and 22°C , are used for a complete reaction.

Calculate the simplest whole-number reacting ratio of $\text{MnO}_4^- : \text{H}_2\text{S}$

Determine the final oxidation state of the sulfur at the end of the reaction.

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[5 marks]

Reacting ratio of $\text{MnO}_4^- : \text{H}_2\text{S}$

_____ : _____

Final oxidation state of sulfur _____

5



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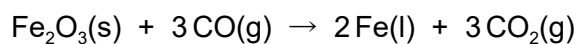
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0 4

This question is about entropy and thermodynamics.

Iron(III) oxide can be reduced by carbon monoxide.



The entropy change (ΔS) for this reaction is $+28 \text{ J K}^{-1} \text{ mol}^{-1}$

Table 3 shows some entropy data.

Table 3

Substance	$\text{Fe}_2\text{O}_3(\text{s})$	$\text{CO}(\text{g})$	$\text{CO}_2(\text{g})$
$S / \text{J K}^{-1} \text{ mol}^{-1}$	90	198	214

0 4 . 1

Use the data in **Table 3** and the entropy change for the reaction to calculate the entropy, in $\text{J K}^{-1} \text{ mol}^{-1}$, for $\text{Fe}(\text{l})$

[3 marks]

Entropy for $\text{Fe}(\text{l})$ _____ $\text{J K}^{-1} \text{ mol}^{-1}$



Table 4 shows some data about iron.

Table 4

Melting point / K	1810
Enthalpy change for melting / kJ mol^{-1}	15.4

0 4 . 2 The melting point of iron is the minimum temperature at which the melting of iron becomes feasible.

Use the data in **Table 4** to calculate the entropy change, in $\text{J K}^{-1} \text{mol}^{-1}$, for the melting of iron.

[2 marks]

Entropy change _____ $\text{J K}^{-1} \text{mol}^{-1}$

Question 4 continues on the next page

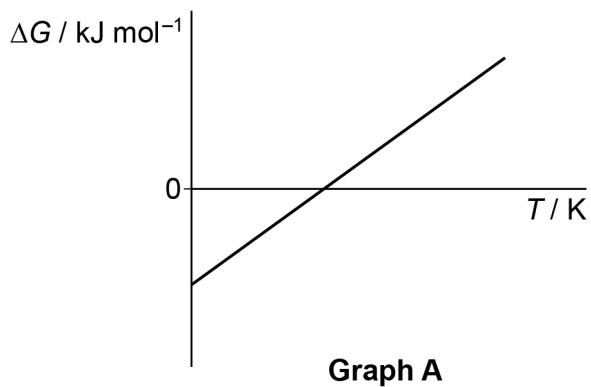
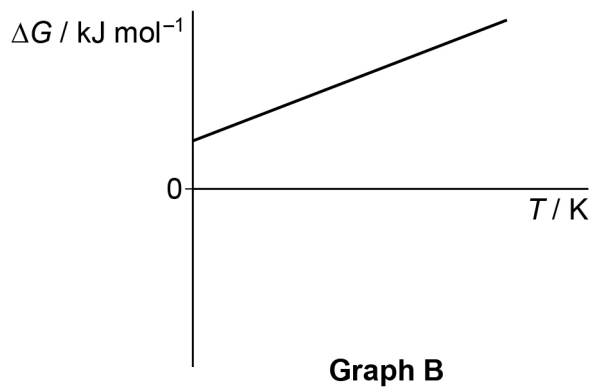
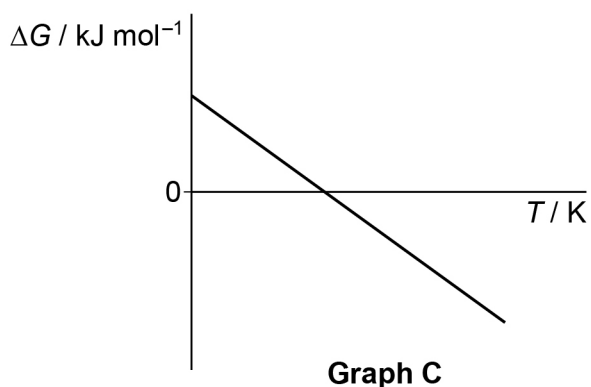
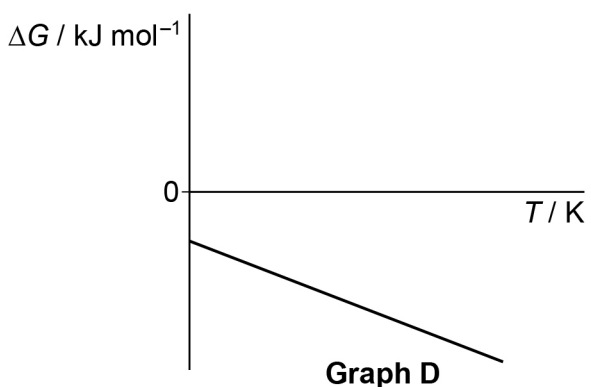
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Figure 1 shows four different graphs.

Each graph shows how the Gibbs free-energy change (ΔG) varies with temperature (T) for a different reaction.

Figure 1



0 4 . 3

Which graph represents how ΔG varies with T for a reaction that is **not** feasible at any temperature?

Tick (✓) **one** box.

[1 mark]

Graph A

☐

Graph B

☐

Graph C

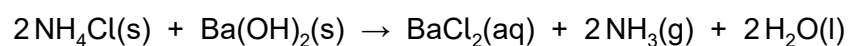
☐

Graph D

☐

0 4 . 4

Which graph represents how ΔG varies with T for the reaction between ammonium chloride and barium hydroxide?



$$\Delta H = +165 \text{ kJ mol}^{-1}$$

Tick (✓) **one** box.

[1 mark]

Graph A

☐

Graph B

☐

Graph C

☐

Graph D

☐

7

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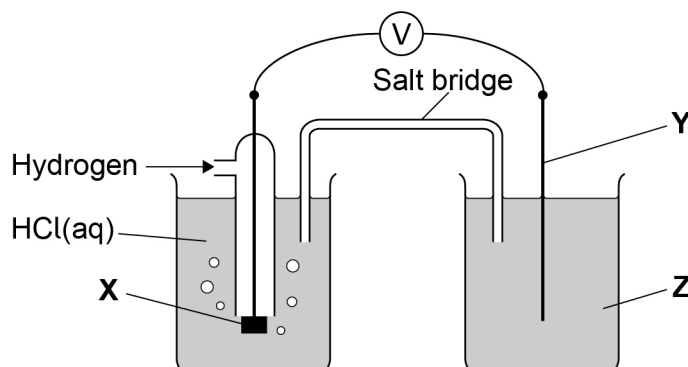


0 5

This question is about electrode potentials.

Figure 2 shows the electrochemical cell using the standard hydrogen electrode to measure the standard electrode potential for the $\text{Al}^{3+} / \text{Al}$ electrode.

Figure 2



0 5 . 1

Identify substances **X**, **Y** and **Z**.

[3 marks]

X _____

Y _____

Z _____

0 5 . 2

The standard hydrogen electrode is operated at 298 K

State **two** other conditions needed for the standard hydrogen electrode.

[1 mark]

1 _____

2 _____



A student suggests that the salt bridge should be prepared by using a piece of filter paper soaked in sodium hydroxide solution.

0	5	.	3
---	---	---	---

Write an equation to show why sodium hydroxide solution should **not** be used in contact with the standard hydrogen electrode.

[1 mark]

0	5	.	4
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Write an equation to show why sodium hydroxide solution should **not** be used in contact with the Al^{3+}/Al electrode.

[1 mark]

6

Turn over for the next question

Turn over ►



0 6

This question is about iron and its ions.

Table 5 shows some electrode potential data.

Table 5

	$E^\ominus / \text{V}$
$\text{V}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{V}(\text{s})$	-1.20
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Br}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	+1.07
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36

0 6 . 1

Use the data in **Table 5** to explain why Cu reduces Fe^{3+} in aqueous solution to Fe^{2+} but does **not** reduce the Fe^{2+} any further.

[2 marks]



0	6	.	2
---	---	---	---

Give the formula of a species in **Table 5** that can reduce Fe^{3+} to Fe

[1 mark]

0	6	.	3
---	---	---	---

A cell is made when a $\text{Fe}^{2+}(\text{aq})/\text{Fe}(\text{s})$ electrode is connected to a $\text{Cl}_2(\text{g})/\text{Cl}^{-}(\text{aq})$ electrode.

Give the conventional representation of this cell.

Calculate the EMF of this cell.

[3 marks]

Conventional representation

EMF _____ V

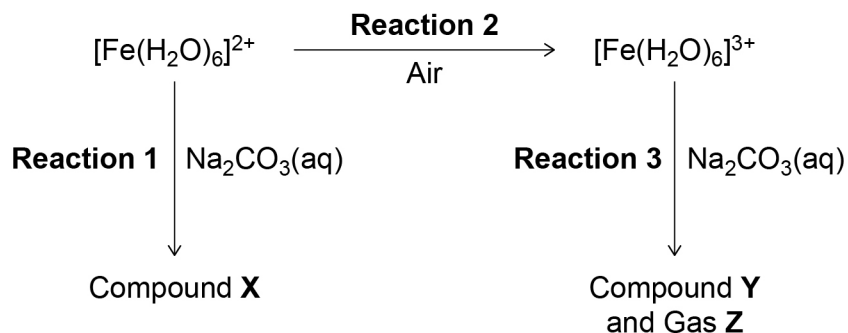
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Figure 3 shows some reactions of iron ions in aqueous solution. **X** and **Y** are compounds containing iron.

Figure 3



0 6 . 4 Describe what is observed in **Reaction 1**.

Write an equation for **Reaction 1**.

[2 marks]

Observation in **Reaction 1** _____

Equation

0 6 . 5 State the role of air in **Reaction 2**.

[1 mark]

0 6 . 6 Give the formula of **Y** and the formula of **Z**.

[1 mark]

Formula of **Y** _____

Formula of **Z** _____



0	6	.	7
---	---	---	---

Separate aqueous solutions containing $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ ions and $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions are made. The solutions are made so that the concentration of $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions is the same as the concentration of $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ ions.

Explain why the solution containing $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ ions has a lower pH than the solution containing $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ ions.

[2 marks]

12

Turn over for the next question

Turn over ►



0 7This question is about Cu^{2+} ions.**0 7 . 1**

Copper is a transition metal.

State, with reference to electrons, the meaning of the term transition metal.

[1 mark]

0 7 . 2Give the full electron configuration of the Cu^{2+} ion.**[1 mark]**

0 7 . 3 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions react with an excess of hydrochloric acid.

Write an equation for this reaction.

[1 mark]

0 7 . 4 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions react with an excess of sodium hydroxide to form a complex that shows stereoisomerism.Draw the structures of the **two** stereoisomers.**[2 marks]**

Isomer 1

Isomer 2



0	7	.	5
---	---	---	---

When a solution containing EDTA^{4-} ions is added to a solution containing $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions, a more stable complex is formed.

Write an equation for this reaction.

Explain why the complex is more stable.

[3 marks]

Equation

Explanation

8

Turn over for the next question

Turn over ►



0 8

This question is about potassium manganate(VII), KMnO_4

0 8 . 1

A solution of KMnO_4 has an unknown concentration.

A student uses colorimetry to determine the concentration of this solution.

Describe how a graph is produced and used to determine the concentration of the KMnO_4 solution.

[3 marks]

Manganate(VII) ions react with ethanedioate ions.
This reaction is autocatalysed.

0 8 . 2

Identify the autocatalyst in this reaction.

[1 mark]

0 8 . 3

Write an equation for each of the **two** steps that show how the autocatalyst is involved in this reaction.

[2 marks]

Step 1 _____

Step 2 _____

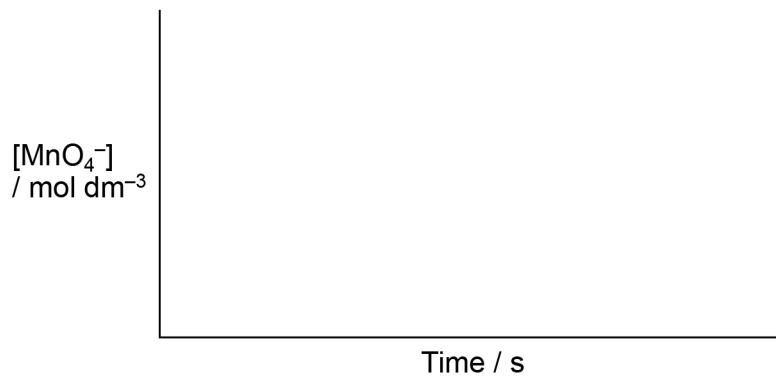


0	8	.	4
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The concentration of MnO_4^- is monitored throughout this autocatalysis reaction using a colorimeter.

Sketch a graph to show how the concentration of MnO_4^- changes with time.

[1 mark]



7

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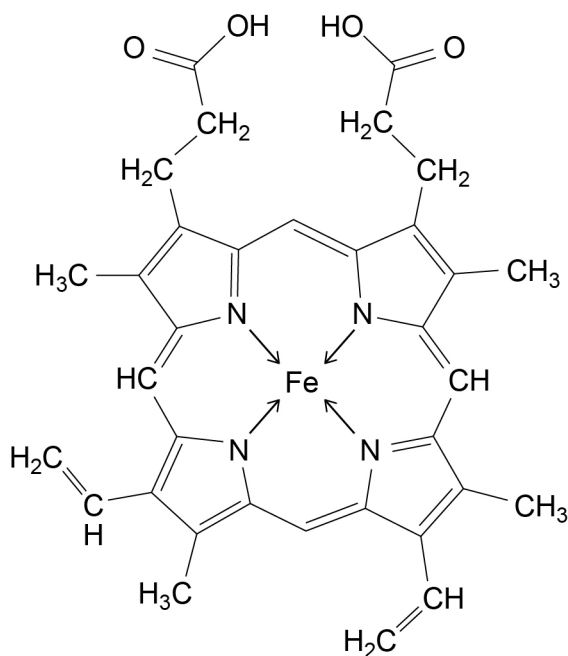


0 9

Haem is an iron(II) complex with a multidentate ligand.

Figure 4 shows the structure of haem.

Figure 4



0 9 . 1

Give the meaning of the term multidentate.

[1 mark]

0 9 . 2

Haem bonds with oxygen and one other monodentate ligand to form oxyhaemoglobin.

Which is the shape around the iron in oxyhaemoglobin?

Tick (✓) **one** box.

[1 mark]

Linear

☐

Tetrahedral

☐

Square planar

☐

Octahedral

☐


0 9 . 3

Explain, with reference to haemoglobin, why carbon monoxide is toxic.

[1 mark]

0 9 . 4

Haem causes blood to be red.
Explain why complexes formed from transition metal ions are coloured.

[3 marks]

0 9 . 5

In a sample of haem, each electron is excited by gaining
 3.67×10^{-19} J of energy.

Calculate the wavelength, in nm, of light absorbed by each electron.

Speed of light, $c = 3.00 \times 10^8 \text{ m s}^{-1}$

Planck constant, $h = 6.63 \times 10^{-34} \text{ J s}$

[2 marks]

Wavelength _____ nm

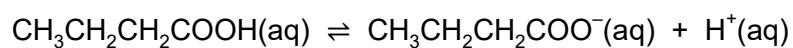
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1	0
---	---

Butanoic acid is a weak acid.



At 298 K, the $\text{p}K_{\text{a}}$ for butanoic acid = 4.82

1	0	.	1
---	---	---	---

Give the expression for the acid dissociation constant, K_{a} , for butanoic acid.

[1 mark]

K_{a}

1	0	.	2
---	---	---	---

Calculate the value of K_{a} , in mol dm^{-3} , for butanoic acid at 298 K

[1 mark]

K_{a} _____ mol dm^{-3}



1	0	.	3
---	---	---	---

A different acid, propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$ is reacted with NaOH
 14.0 cm^3 of $0.200 \text{ mol dm}^{-3}$ aqueous propanoic acid are reacted with
 25.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ aqueous NaOH

At 298 K, the K_a of propanoic acid = $1.35 \times 10^{-5} \text{ mol dm}^{-3}$

Calculate the pH of the final mixture.
Give your answer to 2 decimal places.

[6 marks]

pH _____

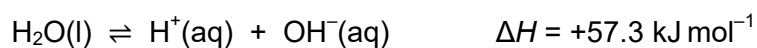
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1 1

This question is about the ionic product of water, K_w 

1 1 . 1

Give the expression for K_w

[1 mark]

 K_w

1 1 . 2

At 5 °C, the pH of pure water is **not** 7.00State why the water is neutral, even though the pH is **not** 7.00

[1 mark]

1 1 . 3

At 5 °C, $K_w = 1.86 \times 10^{-15} \text{ mol}^2 \text{ dm}^{-6}$

Calculate the pH of water at 5 °C

Give your answer to 2 decimal places.

[2 marks]

pH _____



1	1	.	4
---	---	---	---

Calculate the pH of a $0.100 \text{ mol dm}^{-3}$ solution of $\text{Ba}(\text{OH})_2$ at 5°C
Give your answer to 2 decimal places.

At 5°C , $K_w = 1.86 \times 10^{-15} \text{ mol}^2 \text{ dm}^{-6}$

[3 marks]

pH _____

7

END OF QUESTIONS



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