



Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

StemUp Model Solution

Forename(s)

Candidate signature

I declare this is my own work.

A-level CHEMISTRY

Paper 1 Inorganic and Physical Chemistry

Tuesday 10 June 2025

Morning

Time allowed: 2 hours

Materials

For this paper you must have:

- the Periodic Table/Data Booklet, provided as an insert (enclosed)
- 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 105.

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



J U N 2 5 7 4 0 5 1 0 1

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

0 1

This question is about some Group 2 elements and their compounds.

0 1 . 1

Magnesium is reacted with titanium(IV) chloride to extract titanium metal.

Give the equation for this reaction.

State the role of magnesium in this reaction.

[2 marks]

Equation



Role of magnesium Reducing agent (electron donor)

0 1 . 2

Complete **Table 1** by giving the formula of a suitable calcium compound for each use.

[2 marks]

Table 1

Use	Formula of calcium compound
Decrease acidity of soil	Ca(OH)_2
Remove SO_2 from flue gases in power stations	CaCO_3

0 1 . 3

Magnesium hydroxide is used to relieve the symptoms of indigestion by neutralising stomach acid.

Suggest why magnesium hydroxide is safer than sodium hydroxide as a treatment for indigestion.

[1 mark]

Magnesium hydroxide is only sparingly soluble (sodium hydroxide is very soluble), so it is much less corrosive.



An ionic compound of a Group 2 element dissolves in water to form solution **X**.

Separate samples of solution **X** are tested to identify the ions.

Table 2 shows the observations.

Table 2

	Reagent added	Observation
Test 1	NaOH(aq)	White precipitate
Test 2	HNO ₃ (aq) and AgNO ₃ (aq)	Cream precipitate

0 1 . 4 Identify the Group 2 cation in solution **X**.

Give an ionic equation for the reaction that occurs in **Test 1**.

[2 marks]

Group 2 cation Mg²⁺

Ionic equation



Question 1 continues on the next page

Turn over ►



0 1 . 5

Identify the anion in solution **X**.Give an ionic equation, including state symbols, for the reaction that occurs in **Test 2**.Explain why $\text{AgNO}_3(\text{aq})$ is acidified.**[3 marks]**Anion Br^- (bromide ion)

Ionic equation

Explanation HNO_3 reacts with and removes carbonate ions (and other ions) which would also form a precipitate with the silver nitrate.

0 1 . 6

Give one **property** of barium sulfate that makes it useful in hospitals.**[1 mark]**It is insoluble (so it is not toxic) and it absorbs X-rays, so it shows up on an X-ray.

11



0	2
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This question is about ionisation energies.

0	2	.	1
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Explain why beryllium is the element with the highest first ionisation energy in Group 2.

[2 marks]

Beryllium has the smallest atoms in Group 2, with the fewest shells, so its outer electrons are closest to the nucleus with the least shielding. So there is the strongest attraction between the nucleus and the outer electrons.

0	2	.	2
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Give an equation, including state symbols, to show the process that occurs when the **second** ionisation energy of beryllium is measured.

[1 mark]



0	2	.	3
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Predict which element in Period 3 has the lowest **second** ionisation energy.

[1 mark]

Magnesium (Mg)

Question 2 continues on the next page

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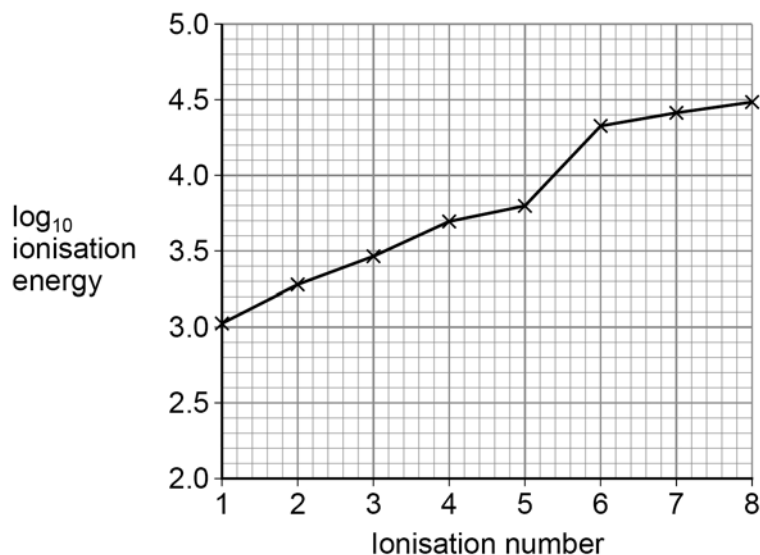


0 2 . 4

Figure 1 shows a plot of $\log_{10}(\text{ionisation energy})$ for a Period 3 element.

The ionisation energies are measured in kJ mol^{-1}

Figure 1



Deduce the identity of this element.

Explain your answer.

[3 marks]

Element Phosphorus (P)

Explanation Large jump from the 5th to the 6th ionisation energy, as the 6th electron is removed from the lower 2p energy level, closer to the nucleus.

0 2 . 5

Use **Figure 1** to determine the **third** ionisation energy, in kJ mol^{-1} , of this element.

[1 mark]

From Figure 1: $\log_{10}(IE_3) = 3.47$

$IE_3 = 10^{3.47} = 2950 \text{ kJ mol}^{-1}$

2950

kJ mol^{-1}

8



0 3

This question is about the chemistry of copper.

0 3 . 1

Deduce the number of unpaired electrons in a Cu^{2+} ion.

[1 mark]

1 (one), Cu^{2+} is $3d^9$

0 3 . 2

Describe how water acts as a ligand in the formation of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$

[1 mark]

The O atom in water has a lone pair of electrons which it donates to Cu^{2+} , forming a co-ordinate (dative covalent) bond.

0 3 . 3

A solution of sodium carbonate is added to a blue solution containing $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions.

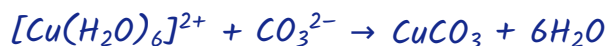
State what is observed.

Give an equation for the reaction.

[2 marks]

Observation *A blue-green precipitate forms*

Equation



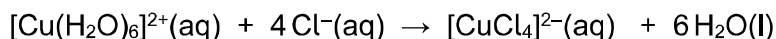
Question 3 continues on the next page

Turn over ►



0 3 4

When a solution containing $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions reacts with an excess of concentrated hydrochloric acid, a ligand exchange reaction occurs.



Blue

Yellow

The shape and the colour of the $[\text{CuCl}_4]^{2-}$ ion are different from the shape and the colour of the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ion.

Explain

- the shape of each complex ion and why these shapes are different
- how colour arises in complex ions
- why the $[\text{CuCl}_4]^{2-}$ ion has a yellow colour, different from the blue colour of the $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ion.

[6 marks]

$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ is octahedral, with six water ligands around Cu^{2+} (bond angle 90°). $[\text{CuCl}_4]^{2-}$ is tetrahedral, with four chloride ligands (bond angle 109.5°).

The shapes are different because Cl^{-} ligands are bigger than H_2O ligands, so only four Cl^{-} ions can fit around the Cu^{2+} ion instead of six water molecules.

Colour: when ligands bond to the Cu^{2+} ion, the d orbitals split into two different energy levels (a ground state and an excited state).

When white light passes through the solution, some wavelengths (frequencies) of visible light are absorbed by the complex. The energy absorbed promotes d electrons from the ground state to the excited state (d-d transitions).

The wavelengths that are not absorbed are transmitted (not emitted), so we see the complementary colour to the light absorbed.

A different ligand and a different co-ordination number (shape) change the size of the energy gap ΔE between the split d orbitals, so the octahedral and tetrahedral complexes have different energy gaps.



Since $\Delta E = h\nu = hc/\lambda$, a different energy gap means a different frequency (wavelength) of light is absorbed. So $[\text{CuCl}_4]^{2-}$ absorbs different wavelengths from $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, and the light transmitted is yellow instead of blue.

0 3 . 5

An excess of water, followed by an excess of concentrated aqueous ammonia, is added to a solution containing $[\text{CuCl}_4]^{2-}$ ions.

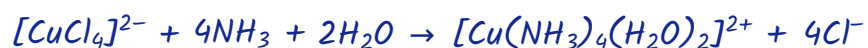
State what is observed.

Give an equation for the overall change that occurs.

[2 marks]

Observation Yellow solution turns to a deep blue solution

Equation



Question 3 continues on the next page

Turn over ►



A solution contains $M_2[Cu(C_2O_4)_2(H_2O)_2]$ where **M** is a metal.

A student does a titration to determine the identity of **M**.

- 2.52 g of solid $M_2[Cu(C_2O_4)_2(H_2O)_2]$ are dissolved in dilute sulfuric acid.
- This solution is transferred to a volumetric flask and made up to 250 cm³ with dilute sulfuric acid.
- A 25.0 cm³ portion is pipetted into a conical flask.
- The mixture in the conical flask is heated to 60 °C and then titrated with 0.0200 mol dm⁻³ KMnO₄ solution.
- Several titrations are done and the student's results are shown in **Table 3**.

In this titration, only the C₂O₄²⁻ ions react with the MnO₄⁻ ions.
2 mol of MnO₄⁻ ions react with 5 mol of C₂O₄²⁻ ions.

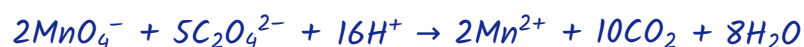
Table 3

	Rough	1	2	3
Final reading / cm³	29.5	28.60	30.35	34.05
Initial reading / cm³	0.0	0.00	1.55	5.55
Titre / cm³	29.5	28.60	28.80	28.50

0 3 . 6

Give an equation for the reaction between C₂O₄²⁻ ions and MnO₄⁻ ions in acidic solution.

[1 mark]



0 3 . 7

Calculate the mean titre from the student's results.

[1 mark]

$$(28.60 + 28.50) \div 2 \quad \underline{28.55} \quad \text{cm}^3$$

0 3 . 8

Calculate the M_r of $M_2[Cu(C_2O_4)_2(H_2O)_2]$

Identify M.

[7 marks]

$$n(MnO_4^-) = 28.55 \times 10^{-3} \times 0.0200 = 5.71 \times 10^{-4} \text{ mol}$$

$$n(C_2O_4^{2-}) = 5.71 \times 10^{-4} \times 5/2 = 1.4275 \times 10^{-3} \text{ mol (in } 25.0 \text{ cm}^3)$$

$$n(C_2O_4^{2-}) \text{ in } 250 \text{ cm}^3 = 1.4275 \times 10^{-3} \times 10 = 1.4275 \times 10^{-2} \text{ mol}$$

$$n(\text{complex}) = 1.4275 \times 10^{-2} \div 2 = 7.1375 \times 10^{-3} \text{ mol}$$

$$(2 \text{ C}_2\text{O}_4^{2-} \text{ per complex})$$

$$M_r = 2.52 \div 7.1375 \times 10^{-3} = 353$$

$$M_r \text{ of } [Cu(C_2O_4)_2(H_2O)_2] = 63.5 + 2(88.0) + 2(18.0) = 275.5$$

$$M_r \text{ of } 2M = 353 - 275.5 = 77.5$$

$$A_r \text{ of } M = 77.5 \div 2 = 38.8$$

M has a +1 oxidation state (complex ion is 2-), so M is potassium

$$M_r \text{ of } M_2[Cu(C_2O_4)_2(H_2O)_2] \quad \underline{353}$$

Identity of M Potassium (K)

Question 3 continues on the next page

Turn over ►



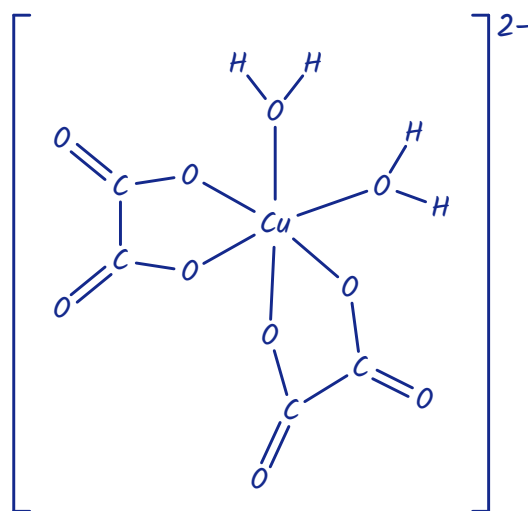
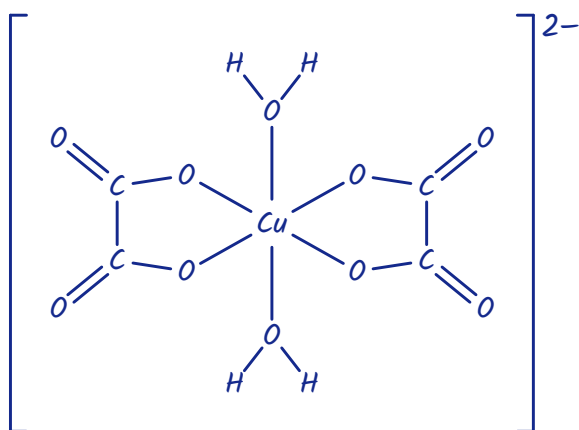
0 3 . 9

Draw the structure of **two** stereoisomers of the complex ion in $\text{M}_2[\text{Cu}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2]$ and include the charge on each structure.

[2 marks]

Structure 1

Structure 2



Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**

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0 4

Nitrogen dioxide gas is formed when magnesium nitrate is heated.



Table 4 shows some thermodynamic data.

Table 4

Substance	$\text{Mg}(\text{NO}_3)_2(\text{s})$	$\text{MgO}(\text{s})$	$\text{NO}_2(\text{g})$	$\text{O}_2(\text{g})$
$\Delta_f H^\circ / \text{kJ mol}^{-1}$	-790	-602	+34	0
$S^\circ / \text{J K}^{-1} \text{mol}^{-1}$	+164	+27	+240	+205

0 4 . 1

Give the standard conditions indicated by the symbol $^\circ$ in $\Delta_f H^\circ$ and S°

[1 mark]

Standard pressure of 100 kPa and a stated temperature, usually 298 K.

0 4 . 2

Use the equation and the data in Table 4 to calculate the temperature at which this reaction becomes feasible.

[5 marks]

$$\Delta H = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$$

$$\Delta H = (2 \times -602) + (4 \times 34) - (2 \times -790) = +512 \text{ kJ mol}^{-1}$$

$$\Delta S = (2 \times 27) + (4 \times 240) + 205 - (2 \times 164) = +891 \text{ J K}^{-1} \text{mol}^{-1}$$

$$\Delta S = +0.891 \text{ kJ K}^{-1} \text{mol}^{-1}$$

$$\text{Feasible when } \Delta G = \Delta H - T\Delta S \leq 0, \text{ so } T = \Delta H \div \Delta S$$

$$T = 512 \div 0.891 = 575 \text{ K}$$

Temperature 575 K



Nitrogen dioxide can also be produced in a reaction between ammonia and oxygen.

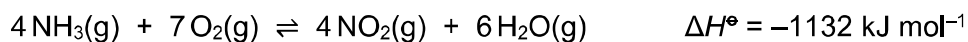


Table 5 shows some bond enthalpy values.

Table 5

	N-H	O=O	O-H
Mean bond enthalpy / kJ mol^{-1}	388	496	463

0 4 . 3

Assume that the bonds between N and O in NO_2 are the same.

Calculate the mean bond enthalpy, in kJ mol^{-1} , for a bond between N and O in NO_2

[3 marks]

$$\Delta H = \Sigma(\text{bonds broken}) - \Sigma(\text{bonds made})$$

$$-1132 = (12 \times 388) + (7 \times 496) - (8 \times \text{N-O}) - (12 \times 463)$$

$$8 \times \text{N-O} = 4656 + 3472 - 5556 + 1132 = 3704 \text{ kJ mol}^{-1}$$

$$\text{N-O} = 3704 \div 8 = 463 \text{ kJ mol}^{-1}$$

Bond enthalpy 463 kJ mol^{-1}

0 4 . 4

An alloy of platinum and rhodium is used as a catalyst in the reaction.

What type of catalyst is this?

[1 mark]

Tick (✓) **one** box.

Autocatalyst

☐

Heterogeneous catalyst

☒

Homogeneous catalyst

☐

Question 4 continues on the next page

Turn over ►



0 4 . 5

Some ammonia and oxygen are reacted and the mixture is left to reach equilibrium at a fixed temperature.

Explain why increasing the temperature of this equilibrium mixture decreases the mole fraction of NO_2 in the equilibrium mixture.

[2 marks]

The forward reaction is exothermic (ΔH is negative).

The equilibrium shifts in the endothermic direction (to the left) to

oppose the increase in temperature, so less NO_2 forms.

12



Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**

Turn over ►



0 5

This question is about the halogens and some of their compounds.

0 5 . 1

Explain why chlorine has a lower boiling point than bromine.

[2 marks]

Chlorine molecules are smaller, with fewer electrons (smaller M_r) than bromine molecules.

So the van der Waals forces between chlorine molecules are weaker, and less energy is needed to separate the molecules.

0 5 . 2

Bromine reacts with fluorine to form BrF_3

Determine the oxidation state of bromine and of fluorine in BrF_3

[1 mark]

Oxidation state of Br +3 Oxidation state of F -1

0 5 . 3

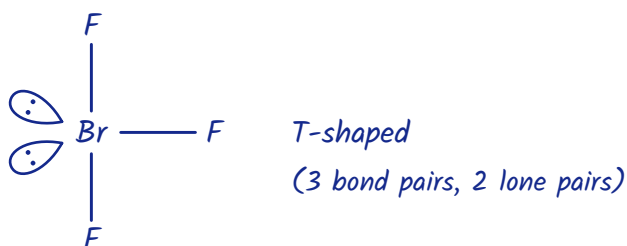
Draw the shape of a BrF_3 molecule.

Include any lone pairs of electrons that influence the shape.

Explain why the BrF_3 molecule has the shape you have drawn.

[2 marks]

Shape



Explanation of shape 3 bond pairs and 2 lone pairs on Br; electron pairs repel each other to be as far apart as possible.



0 5 . 4

Solid sodium bromide reacts with concentrated sulfuric acid.

Two reactions occur

- an acid-base reaction
- a redox reaction.

Give an equation and an observation for each reaction.

[4 marks]

Equation for acid-base reaction

Observation for acid-base reaction White misty (steamy) fumes of HBr

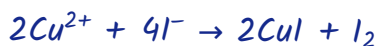
Equation for redox reaction

Observation for redox reaction Orange/brown fumes (of bromine)

0 5 . 5

Iodide ions reduce copper(II) ions in aqueous solution to form a precipitate of copper(I) iodide.

Give an equation for this redox reaction.

[1 mark]

10

Turn over ►



0 6

An alkaline hydrogen-oxygen fuel cell uses hydrogen and oxygen to produce electricity.

The overall equation for the reaction is

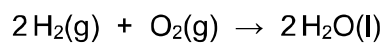
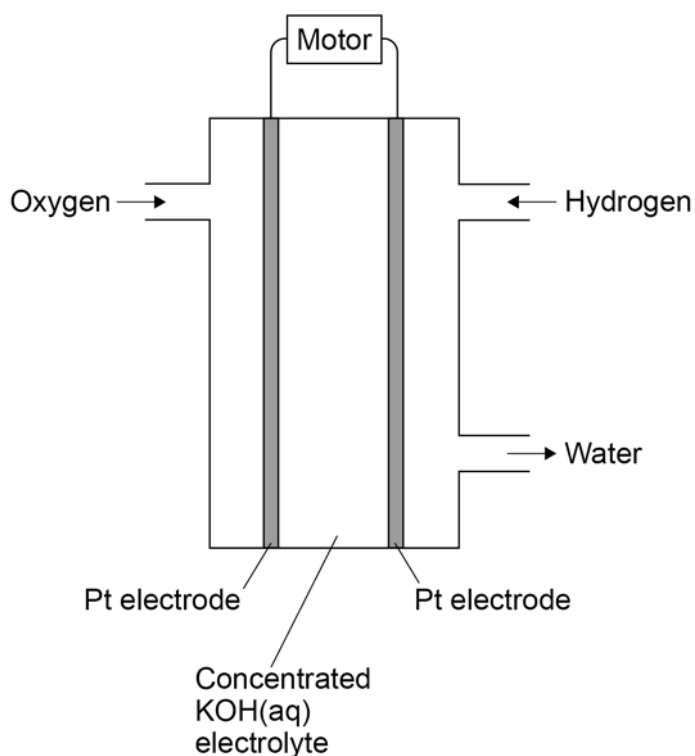


Figure 2 represents an alkaline hydrogen-oxygen fuel cell in use to power a motor.

Figure 2



0 6 . 1

Give a half-equation for the reaction occurring, in alkaline conditions, at each electrode.

[2 marks]

At negative electrode



At positive electrode



0 6 . 2

Suggest why it is **not** necessary to replace the KOH electrolyte during the operation of this fuel cell.

[1 mark]

OH⁻ ions are used up at the negative electrode but are produced again at the positive electrode, so they are not used up overall.

0 6 . 3

Describe how the reactions at the electrodes generate an electric current that can power the motor in the external circuit.

[2 marks]

At the negative electrode hydrogen is oxidised and releases electrons. These electrons flow through the external circuit (the motor) to the positive electrode, where oxygen gains them and is reduced.

0 6 . 4

This fuel cell uses pure oxygen, rather than air, as an oxidising agent.

Suggest the identity of the gas in air that would react with the KOH and affect the efficient operation of the cell.

[1 mark]

Carbon dioxide (CO₂)

0 6 . 5

When an alkaline hydrogen-oxygen fuel cell is used to power the motor in a car, the hydrogen can be stored as a liquid.

Suggest an advantage of storing hydrogen as a liquid.

[1 mark]

Liquid hydrogen occupies a much smaller volume than the gas, so more can be stored.

Question 6 continues on the next page

Turn over ►



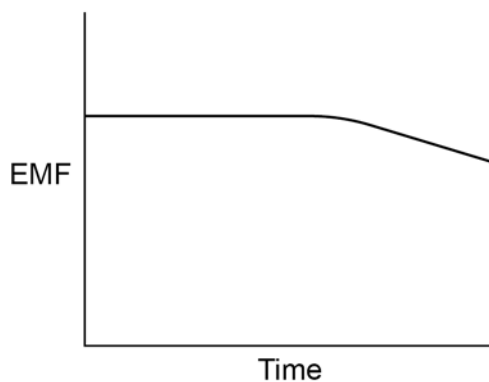
0 6 . 6

Which graph shows the change in EMF, with time, for an alkaline hydrogen-oxygen fuel cell?

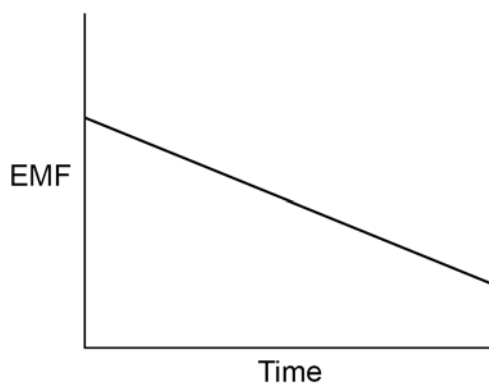
[1 mark]

Tick (✓) **one** box.

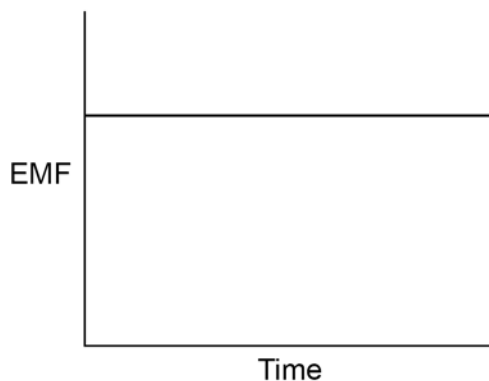
A


☐

B


☐

C


☒

0 6 . 7

An acidic hydrogen-oxygen fuel cell has different reactions at the electrodes.

Suggest why the EMF of the acidic hydrogen-oxygen fuel cell is the same as that of the alkaline hydrogen-oxygen fuel cell.

[1 mark]

Both cells have the same overall reaction: $2H_2 + O_2 \rightarrow 2H_2O$



0 7

This question is about vanadium and some of its compounds.

0 7 . 1

State the block in the Periodic Table that contains vanadium.

[1 mark]

d block

0 7 . 2

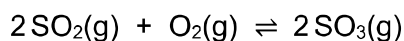
Suggest why vanadium can be pulled into thin wires.

[1 mark]

Vanadium is a metal: the layers of atoms (positive ions) can slide over one another (the metallic bonding is not broken).

0 7 . 3

Vanadium(V) oxide is a catalyst in the Contact process.

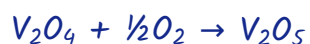
Give **two** equations to show how vanadium(V) oxide acts as a catalyst in this process.

[2 marks]

Equation 1



Equation 2



Question 7 continues on the next page

Turn over ►



0 7 . 4 Table 6 shows some electrode half-equations and their standard electrode potentials.

Table 6

Electrode half-equation	E° / V
$\text{VO}_2^+(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+1.00
$\text{VO}^{2+}(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+0.34
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{V}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{V}^{2+}(\text{aq})$	-0.26

Sn reduces VO_2^+ in acidic solution.

Use the data in **Table 6** to deduce an overall equation for the reaction that occurs.

[2 marks]

Sn (-0.14 V) reduces $\text{VO}_2^+ \rightarrow \text{VO}^{2+} \rightarrow \text{V}^{3+}$ but cannot reduce V^{3+}

to V^{2+} (-0.26 V is more negative), so V^{3+} is the only vanadium product.



Vanadium(III) sulfate is a pale yellow solid at room temperature.

0 7 . 5 Explain why vanadium(III) sulfate has a high melting point.

[2 marks]

Vanadium(III) sulfate is ionic: a giant lattice of oppositely charged V^{3+} and SO_4^{2-} ions.

There are strong electrostatic attractions between the oppositely charged ions, so a lot of energy is needed to overcome them.



0 7 . 6

When vanadium(III) sulfate dissolves in water, the vanadium-containing species formed is acidic.

Give an equation to show how vanadium(III) sulfate dissolves in water to form the acidic vanadium-containing species.

Explain why the vanadium-containing species is acidic.

[3 marks]

Equation



Explanation *V^{3+} has a high charge and a small size (high charge density).*

It attracts electrons from the O-H bonds in the water ligands,

weakening (polarising) the O-H bonds, so H^+ is released and forms

H_3O^+ ions.

0 7 . 7

Compound **Q** is found in crude oil and has the molecular formula $C_{33}H_{34}N_4VO_4$

A sample of **Q** is ionised by electrospray ionisation in a time of flight (TOF) mass spectrometer. The spectrum produced shows that the vanadium in **Q** is ^{51}V

Give an equation to show how **Q** is ionised using electrospray ionisation.

Determine the m/z value of the molecular ion formed in this ionisation process.

[2 marks]

Equation



m/z 602

Question 7 continues on the next page

Turn over ►



0 7 . 8

A sample of vanadium contains only ^{49}V and ^{51}V

The relative atomic mass of vanadium in this sample is 50.97

Calculate the percentage abundance of ^{51}V in this sample.**[2 marks]**

$$\text{Let } \% \text{ of } ^{51}\text{V} = x, \text{ so } \% \text{ of } ^{49}\text{V} = 100 - x$$

$$[51x + 49(100 - x)] \div 100 = 50.97$$

$$2x + 4900 = 5097, \text{ so } x = 98.5$$

Percentage abundance of ^{51}V 98.5%

15



0 8

This question is about acids and bases.

0 8 . 1

Nitric acid is a strong acid.

Calculate the pH of $0.150 \text{ mol dm}^{-3}$ nitric acid.

Give your answer to 2 decimal places.

[2 marks]

 HNO_3 is fully dissociated, so $[\text{H}^+] = 0.150 \text{ mol dm}^{-3}$

$$\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10}(0.150) = 0.82$$

pH 0.82

0 8 . 2

Propanoic acid is a weak acid.

Calculate the concentration of a solution of propanoic acid with $\text{pH} = 2.89$ at 25°C The acid dissociation constant (K_a) for propanoic acid at 25°C is $1.35 \times 10^{-5} \text{ mol dm}^{-3}$

[4 marks]

$$[\text{H}^+] = 10^{-\text{pH}} = 10^{-2.89} = 1.29 \times 10^{-3} \text{ mol dm}^{-3}$$

$$K_a = [\text{H}^+]^2 \div [\text{CH}_3\text{CH}_2\text{COOH}] \quad (\text{as } [\text{H}^+] = [\text{A}^-])$$

$$[\text{CH}_3\text{CH}_2\text{COOH}] = [\text{H}^+]^2 \div K_a$$

$$= (1.29 \times 10^{-3})^2 \div 1.35 \times 10^{-5}$$

$$= 0.123 \text{ mol dm}^{-3}$$

Concentration 0.123 mol dm^{-3}

Question 8 continues on the next page

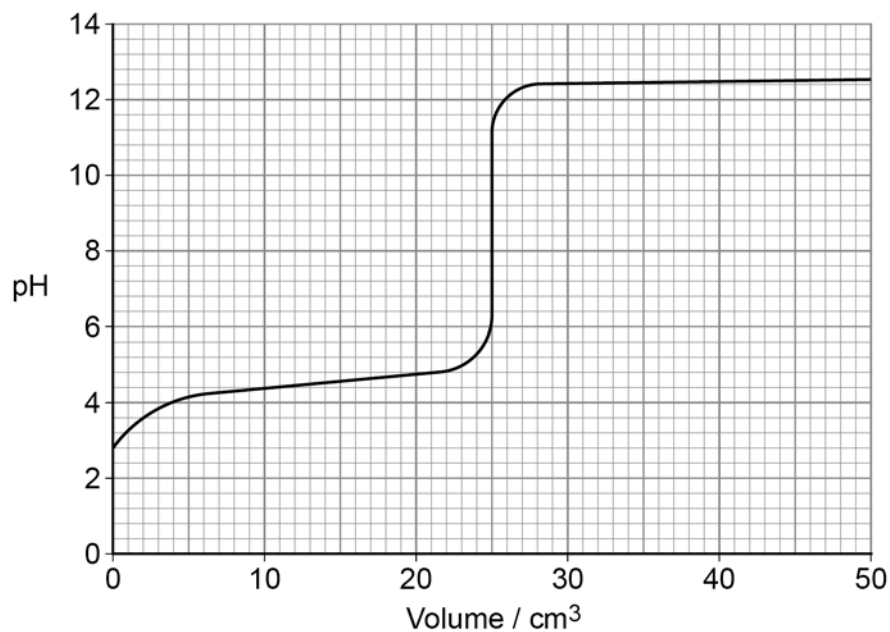
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A student records the pH as an alkali is added to an acid.

Figure 3 shows the pH curve for this reaction.

Figure 3



0 8 . 3 Which of these combinations gives the pH curve shown in **Figure 3**?

[1 mark]

Tick (✓) **one** box.

Strong alkali added to strong acid

☐

Strong alkali added to weak acid

☒

Weak alkali added to strong acid

☐

Weak alkali added to weak acid

☐

0 8 . 4

Different indicators change colour across different pH ranges.

Tick (✓) the box of **each** indicator that would change colour at the equivalence point in **Figure 3**.

[1 mark]

Name of indicator	pH range	
Methyl orange	3.2–4.4	☐
Bromocresol green	3.8–5.4	☐
Cresol red	7.2–8.8	☒
Naphtholphthalein	7.3–8.7	☒
Cresolphthalein	8.2–9.8	☒
Indigo carmine	11.5–14.0	☐

Question 8 continues on the next page

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Buffer solution **B** is made by dissolving 0.656 g of sodium ethanoate ($M_r = 82.0$) in 50 cm^3 of $0.120 \text{ mol dm}^{-3}$ ethanoic acid.

This buffer solution has $\text{pH} = 4.87$

0 8 . 5

Explain, qualitatively, how this buffer solution resists pH change when a small amount of sodium hydroxide solution is added.

[2 marks]

The added OH^- ions react with H^+ ions to form water.

The equilibrium $\text{CH}_3\text{COOH} \rightleftharpoons \text{H}^+ + \text{CH}_3\text{COO}^-$ shifts to the right to replace the H^+ ions, so $[\text{H}^+]$ and the pH stay almost constant.



0 8 . 6

Calculate the pH **change** that occurs when 1.50 cm³ of 0.200 mol dm⁻³ HCl(aq) are added to buffer solution **B**.

Give your answer to 2 decimal places.

The acid dissociation constant (K_a) for ethanoic acid at 25 °C is 1.78×10^{-5} mol dm⁻³

[7 marks]

$$n(\text{CH}_3\text{COOH}) \text{ at start} = 0.120 \times 50 \div 1000 = 0.00600 \text{ mol}$$

$$n(\text{CH}_3\text{COO}^-) \text{ at start} = 0.656 \div 82.0 = 0.00800 \text{ mol}$$

$$n(\text{H}^+) \text{ added} = 0.200 \times 1.50 \div 1000 = 0.000300 \text{ mol}$$



$$n(\text{CH}_3\text{COOH}) \text{ after} = 0.00600 + 0.000300 = 0.00630 \text{ mol}$$

$$n(\text{CH}_3\text{COO}^-) \text{ after} = 0.00800 - 0.000300 = 0.00770 \text{ mol}$$

$$[\text{H}^+] = K_a \times [\text{HA}] \div [\text{A}^-] = 1.78 \times 10^{-5} \times 0.00630 \div 0.00770$$

$$[\text{H}^+] = 1.46 \times 10^{-5} \text{ mol dm}^{-3}$$

$$\text{new pH} = -\log_{10}(1.46 \times 10^{-5}) = 4.84$$

$$\text{pH change} = 4.87 - 4.84 = 0.03 \text{ (pH decreases)}$$

pH change 0.03

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END OF QUESTIONS

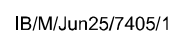


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