PEARSON EDEXCEL IAL CHEMISTRY · YCH11

CHEMISTRY



EXAM QUESTION PACK

UNIT 2: REDOX CHEMISTRY

SCORE	PERCENTAGE
/113	%

STEMUP

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Q1.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Iodate(V) ions, IO_3^-, oxidise dithionate ions, $S_2O_6^{2-}$, according to the equation

$$\mathbf{x}\ IO_3^- + \mathbf{y}\ S_2O_6^{2-} + 4H_2O \rightarrow \mathbf{z}\ SO_4^{2-} + 8H^+ + I_2$$

What are the balancing numbers **x**, **y** and **z**?

		x	y	z
☐	**A**	2	1	2
☐	**B**	2	2	4
☐	**C**	2	5	5
☐	**D**	2	5	10

(Total for question = 1 mark)

Q2.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about the reaction shown.

$$2KMnO_4 + xH_2C_2O_4 + yH_2SO_4 \rightarrow 2MnSO_4 + K_2SO_4 + 10CO_2 + zH_2O$$

(a) What values of x, y and z are needed to balance the equation?

(1)

	x	y	z
☒ **A**	5	6	8
☒ **B**	10	3	4
☒ **C**	5	3	8
☒ **D**	10	6	4

(b) What is the reducing agent in the reaction?

(1)

☒ **A** H^+

☒ **B** $C_2O_4^{2-}$

☒ **C** MnO_4^-

☒ **D** SO_4^{2-}

(Total for question = 2 marks)

Q3.

This question is about bicycles.

Bicycle frames have been made from steel and aluminium for many years but more recently titanium has been used.

Titanium is a metal that is extracted from its ore, impure titanium oxide (TiO_2), in a two-step process.

Step **1**

The titanium oxide reacts with chlorine in the presence of carbon to form titanium(IV) chloride ($TiCl_4$) and carbon monoxide.

Step **2**

The titanium(IV) chloride reacts with magnesium.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

(a) (i) Write the equation for Step **1**.

State symbols are not required.

(1)

(ii) Explain why Step **2** is a redox reaction.

Refer to relevant oxidation numbers in your answer.

(2)

.....

.....

.....

(b) Titanium(IV) chloride is a liquid that reacts violently with water, producing white smoke. This reaction has been used to produce naval smoke screens to hide ships.

Suggest the type of reaction taking place **and** the compound producing the white smoke.

(2)

Type of reaction

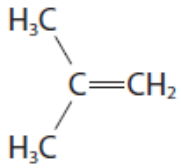
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Compound

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(c) Many bicycles use an inner tube inside the tyre.

A common material used for inner tubes is the addition polymer formed from 2-methylpropene.

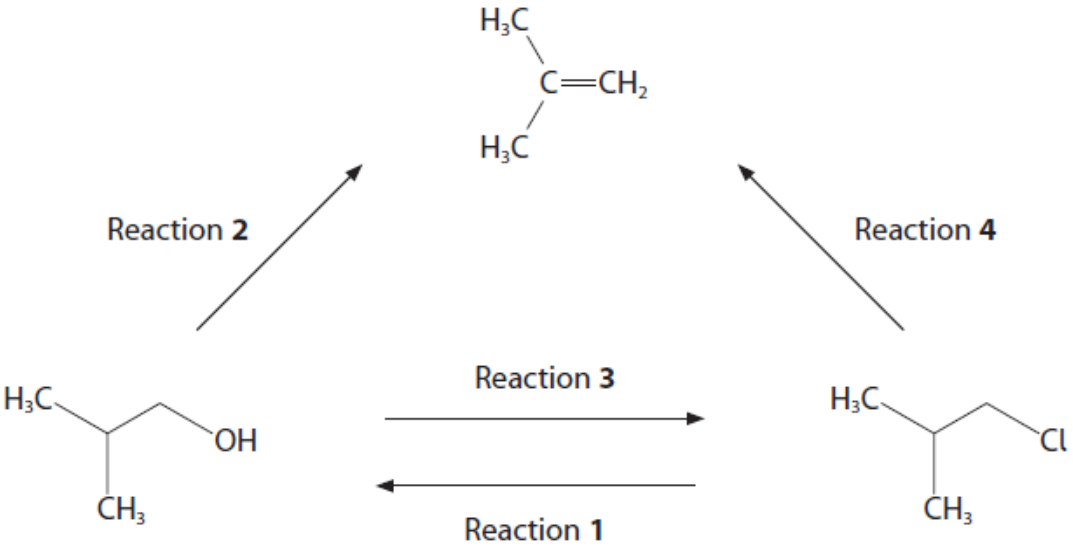


2-methylpropene

Draw a section of the polymer showing two repeat units.

(2)

(d) A reaction scheme involving 2-methylpropene is shown.



(i) For Reaction **1**, give the name or formula of a suitable reagent, stating the conditions for the reaction.

(2)

Reagent

.....

Conditions

.....

(ii) For Reaction **2**, give the name or formula of a suitable reagent, stating the type of reaction taking place.

(2)

Reagent

.....

Type of reaction

.....

(iii) For Reaction **3**, give the name or formula of a suitable reagent, writing an equation for the reaction taking place.

(2)

Reagent

.....

Equation

(iv) For Reaction **4**, the reagent used is potassium hydroxide (KOH).

Give the conditions required for this reaction, stating the role of the hydroxide ions in this reaction.

(2)

Conditions

.....

Role of hydroxide ions

.....

(e) Many cyclists carry a small cylinder of carbon dioxide to inflate their inner tube if it is punctured. The carbon dioxide is stored under pressure.



(Source: © Douglas Sacha/Getty Images)

A gas cylinder contains 16.0 g of carbon dioxide (CO_2).
The cylinder has a volume of 20 cm^3 .

Calculate the pressure in the cylinder at 25 °C. Include units in your answer.
Assume that all the CO_2 in the cylinder is a gas.

[$pV = nRT$ $R = 8.31$ J mol^{-1} K^{-1}]

(5)

(Total for question = 20 marks)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A student is provided with 25.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

What volume of distilled water should the student add to this solution to make a 0.0500 mol dm^{-3} solution?

☐ **A** 25.0 cm^3

☒ **B** 50.0 cm^3

☒ **C** 475 cm^3

☒ **D** 500 cm^3

(Total for question = 1 mark)

Q5.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

How does an oxidising agent change during a redox reaction?

		Electrons	Oxidation number
☒	**A**	gains electrons	decreases
☒	**B**	gains electrons	increases
☒	**C**	loses electrons	decreases
☒	**D**	loses electrons	increases

(Total for question = 1 mark)

Q6.

Iodine can be extracted from seaweed. The seaweed is heated strongly to burn off the organic matter. The resultant ash is boiled in water to dissolve the iodide ions, and the mixture is filtered.

(a) Acidified hydrogen peroxide (H_2O_2) is added to the filtrate.

A redox reaction takes place with iodine and water as the only products.

(i) Write half-equations for the oxidation and reduction reactions that take place.

State symbols are not required.

(2)

(ii) Use your answers to (a)(i) to write the overall equation for this redox reaction.

State symbols are not required.

(1)

(b) The iodine is separated from the aqueous solution using solvent extraction.

The aqueous solution is mixed with cyclohexane in a separating funnel, forming two layers.

The mixture is then shaken gently and left until the layers separate.

Most of the iodine dissolves in the cyclohexane layer.

(i) State the colour of each layer **after** separation.

(2)

Aqueous layer
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Cyclohexane layer
.....

(ii) Explain why iodine is very soluble in cyclohexane but only slightly soluble in water.

(2)

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(c) The cyclohexane layer is then removed from the separating funnel and dried.

Identify, by name or formula, a suitable drying agent.

(1)

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(Total for question = 8 marks)

Q7.

Equations for four reactions of copper or its compounds are shown.

Reaction 1 $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$

Reaction 2 $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

Reaction 3 $2Cu^+ \rightarrow Cu + Cu^{2+}$

Reaction 4 $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$

(a) Which is a disproportionation reaction?

(1)

☒ **A** Reaction 1

☒ **B** Reaction 2

☒ **C** Reaction 3

☒ **D** Reaction 4

(b) Which is an acid-base reaction?

(1)

☒ **A** Reaction 1

☒ **B** Reaction 2

☒ **C** Reaction 3

☒ **D** Reaction 4

(Total for question = 2 marks)

Q8.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Hydrogen peroxide decomposes in the presence of a catalyst.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

(a) What type of reaction occurs?

(1)

☒ **A** displacement

☒ **B** disproportionation

☒ **C** elimination

☒ **D** hydrolysis

(b) In an experiment, the volume of oxygen produced by the decomposition of hydrogen peroxide was measured at various times as the reaction progressed and a graph was plotted.

The initial gradient of the graph was 0.50 $cm^3\ s^{-1}$.

What is the initial rate of decomposition of hydrogen peroxide in mol s^{-1}?

[Molar volume of a gas at r.t.p. = 24 $dm^3\ mol^{-1}$]

(1)

☒ **A** 2.1×10^{-2} mol s^{-1}

☒ **B** 4.2×10^{-5} mol s^{-1}

☒ **C** 2.1×10^{-5} mol s^{-1}

☒ **D** 1.0×10^{-5} mol s^{-1}

(Total for question = 2 marks)

Q9.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which of these is a disproportionation reaction?

☒ **A** $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

☒ **B** $6NaOH + 3Br_2 \rightarrow 5NaBr + NaBrO_3 + 3H_2O$

☒ **C** $2NaOH + 2Al + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

☒ **D** $NaOH + CO_2 \rightarrow NaHCO_3$

(Total for question = 1 mark)

Q10.

This question is about Group 1 metals.

(a) When potassium is placed into a beaker of cold water, potassium hydroxide and hydrogen are formed.

(i) Write the equation for this reaction. Include state symbols.

(2)

(ii) This is a redox reaction.

State which element is oxidised and which is reduced.
Justify your answer by giving the initial and final oxidation numbers of any element that changes oxidation state.

(2)

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(iii) The reaction of potassium with water is very vigorous and a flame is seen.

State the colour of the flame.

(1)

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(b) The label has come off a bottle known to contain **M**, a Group 1 metal which is stored in oil.

A student carried out an experiment to determine the identity of **M**.

Procedure

Step **1**

A small piece of **M** was wiped with tissue paper to remove the oil.
The piece of **M** was weighed and placed in a beaker of distilled water.

Step **2**

After the reaction had finished, the contents of the beaker and washings were transferred to a 250.0 cm^3 volumetric flask. The solution was made up to the mark with distilled water and mixed thoroughly.

Step **3**

A pipette was used to transfer 25.0 cm^3 portions of this solution to conical flasks. Each portion was then titrated with hydrochloric acid of concentration 0.400 mol dm^{-3}.

Results

Mass of metal, **M**	0.37 g
Mean titre of hydrochloric acid	12.80 cm^3

The reaction taking place is shown.

$$\mathbf{M}OH(aq) + HCl(aq) \rightarrow \mathbf{M}Cl(aq) + H_2O(l)$$

(i) The indicator used was phenolphthalein.

State the colour **change** at the end-point.

(2)

from ..... to .....

(ii) Calculate the relative atomic mass of **M** and use it to identify the Group 1 metal, **M**.

(4)

(c) Another student repeated the experiment, using a different sample of metal **M**, but did not wipe off the oil before weighing it.

State how this would change the calculated value of the relative atomic mass of **M**. Justify your answer.

(2)

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(Total for question = 13 marks)

Q11.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Dichromate(VI) ions may be reduced in acidic solution.

$$Cr_2O_7^{2-}(aq) + x\,H^+(aq) + y\,e^- \rightarrow 2Cr^{3+}(aq) + z\,H_2O(l)$$

The coefficients in this half-equation are

	x	y	z
☒ **A**	14	6	7
☒ **B**	14	3	7
☒ **C**	7	6	3.5
☒ **D**	7	3	3.5

(Total for question = 1 mark)

Q12.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

In an oxide of potassium, the oxidation number of oxygen is $-\frac{1}{2}$.

What is the formula of this oxide?

☒ **A** K_2O

☒ **B** K_2O_2

☒ **C** K_2O_3

☒ **D** KO_2

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(Total for question = 1 mark)

Q13.

The oxidation number of sulfur in the sulfate ion, SO_4^{2-}, is

☒ **A** −2

☒ **B** +4

☒ **C** +6

☒ **D** +8

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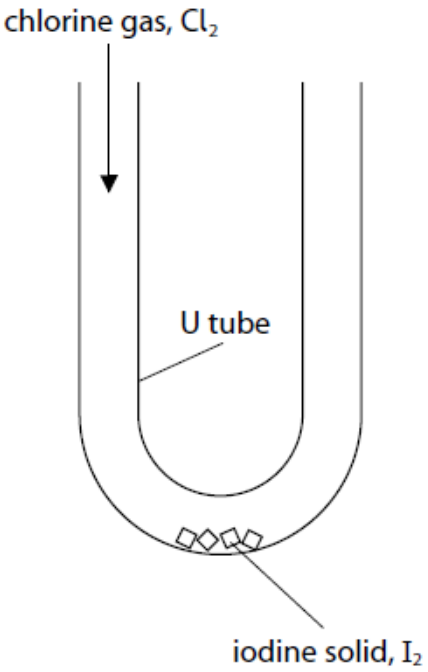
(Total for question = 1 mark)

Q14.

Iodine monochloride, ICl, is a covalent compound produced by the reaction of iodine with chlorine. Iodine monochloride is a dark brown liquid at room temperature.

The equipment shown can be used to pass chlorine over solid iodine to produce iodine

monochloride.



When excess chlorine is passed through the U tube, the iodine monochloride reacts to produce iodine trichloride in an equilibrium reaction.

(a) Write a chemical equation for the reaction of iodine with chlorine to produce iodine monochloride. Include state symbols.

(2)

(b) The iodine monochloride molecule has a permanent dipole. Complete the following table using the electronegativity data from your Data Booklet and hence show the dipole on the diagram of the iodine monochloride molecule.

(1)

Element	Electronegativity
Cl	
I	

I — Cl

(c) Iodine monochloride reacts with propene to form two isomeric products. This is an addition reaction that is similar to the reaction of propene with hydrogen halides.

(i) Draw the skeletal formulae of both isomers.

(2)

(ii) Explain which of these isomers is the major product.

(3)

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(d) The equation for the reaction between iodine monochloride and chlorine is:

$$\underset{\text{brown liquid}}{ICl(l)} + Cl_2(g) \rightleftharpoons \underset{\text{yellow solid}}{ICl_3(s)}$$

(i) State and justify **one** precaution that must be taken when preparing iodine trichloride.

(2)

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(ii) Give the oxidation number of iodine in both iodine-containing compounds in the equilibrium.

(1)

I in ICl

.....

I in ICl_3

.....

(iii) Iodine trichloride can also be made by reacting potassium chlorate(V) with iodine in hydrochloric acid. The equation for the reaction is

$$KClO_3 + I_2 + 6HCl \rightarrow KCl + 2ICl_3 + 3H_2O$$

By considering oxidation numbers for chlorine, explain whether or not this reaction is a disproportionation.

(2)

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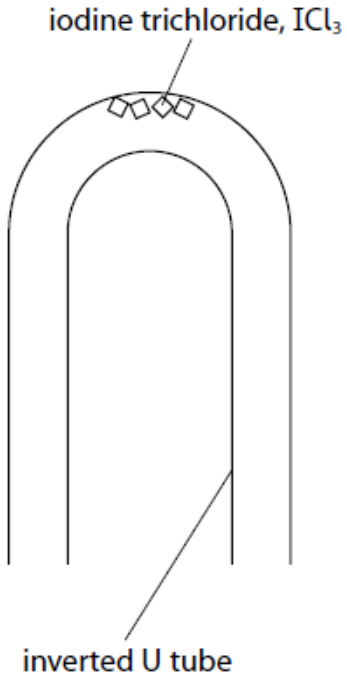
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(e) Chlorine gas has a molar volume of 24 000 cm^3 mol^{-1} under the conditions used in this reaction.

(i) Show that the density of chlorine gas is approximately 3 g dm^{-3}.

(2)

(ii) Air has an average density of 1.25 g dm^{-3}. If the U-tube used in part (d) is inverted, as shown in the diagram, the solid yellow iodine trichloride produced in the equilibrium reaction turns to a brown liquid.



Explain this observation.

(3)

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(f) A mass of 0.64 g of iodine reacted with fluorine to form 1.31 g of a fluoride of iodine.

Calculate the empirical formula of this compound of iodine and fluorine.

(2)

(Total for question = 20 marks)

Q15.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Two half-equations for a reaction are shown.

$$Cu \rightarrow Cu^{2+} + 2e^-$$

$$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$$

What is the overall ionic equation for this reaction?

☒ **A** $Cu + NO_3^- + 4H^+ \rightarrow Cu^{2+} + NO + 2H_2O$

☒ **B** $2Cu + NO_3^- + 4H^+ \rightarrow 2Cu^{2+} + NO + 2H_2O$

☒ **C** $3Cu + 2NO_3^- + 8H^+ \rightarrow 3Cu^{2+} + 2NO + 4H_2O$

☒ **D** $6Cu + 2NO_3^- + 8H^+ \rightarrow 6Cu^{2+} + 2NO + 4H_2O$

(Total for question = 1 mark)

Q16.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Barium hydroxide reacts with sulfuric acid as shown.

$$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$

Which is the ionic equation for this reaction?

☒ **A** $Ba^{2+}(aq) + 2OH^-(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$

☒ **B** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

☒ **C** $OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

☒ **D** $Ba^{2+}(aq) + 2OH^-(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow Ba^{2+}(s) + SO_4^{2-}(s) + 2H_2O(l)$

(Total for question = 1 mark)

Q17.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Magnesium reacts with hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Which statement about this reaction is correct?

☒ **A** magnesium atoms act as oxidising agents

☒ **B** hydrogen molecules act as reducing agents

☒ **C** hydrogen ions act as oxidising agents

☒ **D** chloride ions act as oxidising agents

(Total for question = 1 mark)

Q18.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

What is the name of the compound with the formula $KClO_2$?

☒ **A** potassium chlorate(II)

☒ **B** potassium chlorate(III)

☒ **C** potassium chlorate(IV)

☒ **D** potassium chlorate(V)

(Total for question = 1 mark)

Q19.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Hydrogen peroxide, H_2O_2 , breaks down into water and oxygen.

In terms of oxidation and reduction, how do hydrogen and oxygen change in this reaction?

		Hydrogen	Oxygen
☒	**A**	oxidised	reduced
☒	**B**	oxidised and reduced	unchanged
☒	**C**	reduced	oxidised
☒	**D**	unchanged	oxidised and reduced

(Total for question = 1 mark)

Q20.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

What is the oxidation number of bromine in BrO_3^-?

☒ **A** +1

☒ **B** +3

☒ **C** +5

☒ **D** +7

(Total for question = 1 mark)

Q21.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

What is the oxidation number of chromium in $Na_2Cr_2O_7$?

☒ **A** +1

☒ **B** +2

☒ **C** +3

☒ **D** +6

(Total for question = 1 mark)

Q22.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

What is the oxidation number of phosphorus in the phosphate ion, PO_4^{3-}

☒ **A** –3

☒ **B** +3

☒ **C** +5

☒ **D** +7

(Total for question = 1 mark)

Q23.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

In which compound is the oxidation number of nitrogen +5?

☒ **A** $Ca(NO_3)_2$

☒ **B** Mg_3N_2

☒ **C** N_2O_3

☒ **D** $NaNO_2$

(Total for question = 1 mark)

Q24.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

In an oxide of nitrogen, the oxidation number of nitrogen is +4.

Which is the formula of the oxide?

☒ **A** N_2O

☒ **B** N_2O_3

☒ **C** N_2O_4

☒ **D** N_2O_5

(Total for question = 1 mark)

Q25.

Potassium chlorate(V), $KClO_3$, is a crystalline solid used in fireworks.

It is produced by the Liebig Process in two stages.

Stage **1** Chlorine gas is passed through hot calcium hydroxide solution forming calcium chlorate(V), $Ca(ClO_3)_2$.

$$6Ca(OH)_2(aq) + 6Cl_2(g) \rightarrow Ca(ClO_3)_2(aq) + 5CaCl_2(aq) + 6H_2O(l)$$

Stage **2** Potassium chloride solution is then added to form potassium chlorate(V).

$$Ca(ClO_3)_2(aq) + 2KCl(aq) \rightarrow 2KClO_3(aq) + CaCl_2(aq)$$

The solution is heated to reduce its volume and then allowed to crystallise.
The crystals are filtered off.
The remaining filtrate is evaporated further to obtain more crystals.

(a) (i) Write the **overall** equation for the Liebig Process.
State symbols are not required.

(1)

(ii) Calculate the **overall** atom economy by mass for the production of potassium chlorate(V), $KClO_3$, using your equation in (a)(i).

(3)

(b) Explain the type of reaction that takes place in Stage 1 of the Liebig Process, using oxidation numbers.

$$6Ca(OH)_2(aq) + 6Cl_2(g) \rightarrow Ca(ClO_3)_2(aq) + 5CaCl_2(aq) + 6H_2O(l)$$

(3)

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(c) The crystals of potassium chlorate(V) formed also contain some halide ion impurities.

(i) Describe a chemical test on a solution of these crystals to **confirm** that the impurities present are chloride ions rather than bromide ions. Include the expected results.

(3)

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(ii) 1.52 g of impure potassium chlorate(V), formed in the Liebig Process, was heated until the mass of solid remaining was constant at 1.02 g.

The reaction that occurred was

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

The impurities present did not decompose on heating.

Calculate the percentage purity of the sample.
Give your answer to an appropriate number of significant figures.

(5)

(d) In fireworks, potassium chlorate(V) decomposes. This thermal decomposition takes place in two stages with a solid catalyst.

$$4KClO_3 \rightarrow KCl + 3KClO_4$$

$$KClO_4 \rightarrow KCl + 2O_2$$

(i) Give the systematic name of $KClO_4$.

(1)

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(ii) A student investigated the role of the catalyst in this reaction.

Procedure

Step **1** Heat a sample of $KClO_3$, in a test tube, with a known mass of insoluble catalyst until the mass remains constant.

Step **2** Mix the contents of the test tube with water.

Step **3** Filter the mixture and rinse with deionised water.

Step **4** Dry the remaining solid.

Step **5** Measure the mass of the dry solid.

Explain how each of the steps in this procedure is needed to show that the catalyst is **not** used up in this reaction.

(4)

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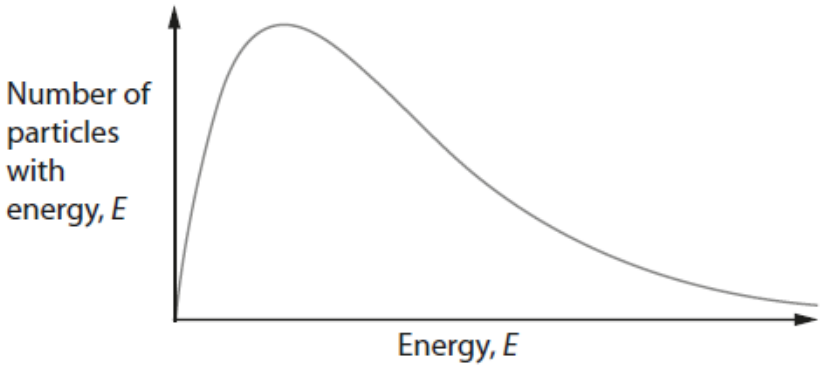
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(e) Explain, using the diagram, how a catalyst speeds up a chemical reaction.

(2)



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(Total for question = 22 marks)

Q26.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

This question is about the reaction of potassium iodide with concentrated sulfuric acid.

(a) Which of these would **not** be seen?

(1)

☒ **A** misty fumes

☒ **B** black solid

☒ **C** yellow solid

☒ **D** dense white smoke

(b) One of the reaction products is the gas H_2S.

What is the **change** in oxidation number of sulfur as H_2S forms?

(1)

☒ **A** −8

☒ **B** −6

☒ **C** −2

☒ **D** +6

(Total for question = 2 marks)

Q27.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A small piece of calcium is added to a beaker of distilled water.

(a) Which is the equation for this reaction?

(1)

☒ **A** $Ca + H_2O \rightarrow CaO + H_2$

☒ **B** $Ca + 2H_2O \rightarrow CaO_2 + 2H_2$

☒ **C** $Ca + H_2O \rightarrow CaOH + \frac{1}{2} H_2$

☒ **D** $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

(b) Which element is oxidised and which is reduced when calcium reacts with water?

(1)

		Element oxidised	Element reduced
☒	**A**	calcium	hydrogen
☒	**B**	calcium	oxygen
☒	**C**	hydrogen	calcium
☒	**D**	hydrogen	oxygen

(Total for question = 2 marks)

Q28.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer

with a cross ☒.

Which reaction is **not** a disproportionation?

☒ **A** $3Cl_2(g) + 6NaOH(aq) \rightarrow NaClO_3(aq) + 5NaCl(aq) + 3H_2O(l)$

☒ **B** $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

☒ **C** $Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HClO(aq)$

☒ **D** $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

(Total for question = 1 mark)

Q29.

For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

In which reaction is the copper species acting as an oxidising agent?

☒ **A** $Cu^{2+} + 2Ag \rightarrow 2Ag^{+} + Cu$

☒ **B** $2Cu^{+} + O^{2-} \rightarrow Cu_2O$

☒ **C** $3Cu + O_2 \rightarrow Cu_2O + CuO$

☒ **D** $Cu + Hg^{2+} \rightarrow Hg + Cu^{2+}$

(Total for question = 1 mark)

Q30.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Which reaction is **not** a redox reaction?

☒ **A** $4KClO_3(s) \rightarrow 3KClO_4(s) + KCl(s)$

☒ **B** $2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$

☒ **C** $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

☒ **D** $Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HClO(aq)$

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Correct Answer	Mark
	The only correct answer is D (2, 5, 10) ***A*** *is incorrect as charges and oxygen atoms do not balance* ***B*** *is incorrect as charges and oxygen atoms do not balance* ***C*** *is incorrect as charges, oxygen atoms and sulfur atoms do not balance*	**1**

Q2.

Question Number	Answer	Mark
(a)	**The only correct answer is C** (5:3:8) *A is not correct because y is wrong* *B is not correct because x and z are wrong* *D is not correct because x, y and z are wrong*	**(1)**

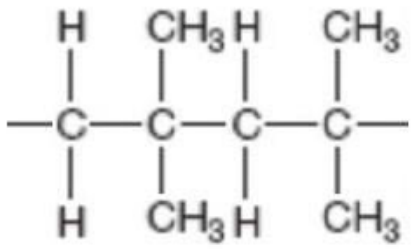
Question Number	Answer	Mark
(b)	**The only correct answer is B** ($C_2O_4^{2-}$) *A is not correct because the oxidation number of H has not changed* *C is not correct because it is the oxidising agent* *D is not correct because the oxidation numbers of S and O have not changed*	**(1)**

Q3.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	$TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$	Ignore state symbols even if incorrect Allow multiples	1

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	• Ti is reduced **and** from +4 to 0 (1) • Mg is oxidised **and** from 0 to +2 (1)	Four correct oxidation numbers with no or incorrect mention of reduced or oxidised scores (1) Ti is reduced as it gains electrons and Mg is oxidised as it loses electrons with no or incorrect oxidation numbers scores (1)	2

Question Number	Answer	Additional Guidance	Mark
(b)	• hydrolysis (1) • titanium((IV)) oxide/TiO_2 (1)	Do not award hydration Ignore hydrogen chloride/HCl Allow titanium((IV))hydroxide/$Ti(OH)_4$	2

Question Number	Answer	Additional Guidance	Mark
(c)			2
	• correct repeating unit (1)	Allow adjacent pairs of methyl groups	
	• two repeating units and extension (1)	Ignore square brackets and subscript n/2	
	Note M2 depends on M1 or near miss eg missing a H	Ignore connectivity of CH_3	

Question Number	Answer	Additional Guidance	Mark
(d)(i)	An answer that makes reference to the following points:		2
	• reagent: potassium hydroxide / KOH (1)	Allow sodium hydroxide / NaOH	
	• conditions: aqueous/water (1)	Ignore any reference to concentration or heat Allow dilute	
	M2 dependent on M1or near miss e.g. OH^- will not score M1 but will allow access to M2.		

Question Number	Answer	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points:		2
	• reagent: (concentrated) phosphoric((V)) acid / H_3PO_4 (1)	Allow (concentrated) sulfuric acid Ignore heat Do not award H_3PO_3 Allow passing vapour over porous pot / alumina or any surface catalyst **and** heat	
	• reaction type: elimination/dehydration (1)		
	Independent marks		

Question Number	Answer	Additional Guidance	Mark
(d)(iii)	An answer that makes reference to the following points: • reagent: phosphorus(V) chloride/ phosphorus pentachloride/PCl_5 (1) • equation: $C_4H_9OH + PCl_5 \rightarrow C_4H_9Cl + HCl + POCl_3$ (1)	Allow thionyl chloride / $SOCl_2$ Allow phosphorus (III) chloride / phosphorus trichloride / PCl_3 Allow $C_4H_9OH + SOCl_2 \rightarrow C_4H_9Cl + HCl + SO_2$ $3C_4H_9OH + PCl_3 \rightarrow 3C_4H_9Cl + H_3PO_3$ Allow skeletal, structural, displayed or molecular formulae	2

Question Number	Answer	Additional Guidance	Mark
(d)(iv)	An answer that makes reference to the following points: • conditions: alcoholic (1) • role of the hydroxide ions: base (1) Note answers may be given on either line	Allow ethanol/ethanolic Ignore heat and concentration Allow proton acceptor/reacts with H^+	2

Question Number	Answer	Additional Guidance	Mark
(e)	An answer that makes reference to the following points: • moles of carbon dioxide **(1)** • conversion of cm^3 to m^3 **(1)** • conversion of °C to K **(1)** • rearrangement of the ideal gas equation **(1)** • calculation of pressure and correct units given **(1)**	Examples of calculation 16 ÷ 44 = 0.36364 (mol)/ 4÷11(mol) 20 ÷ 1000000 = 2×10^{-5} / 0.00002 (m^3) 273 + 25 = 298 (K) $p = \frac{nRT}{V}$ $\frac{0.3636 \times 8.31 \times 298}{2 \times 10^{-5}}$ = 45025000 Pa / 45025 kPa 4.5 x 10^7 Pa / 45MPa Ignore SF except 1 Allow TE for answers to M1, M2 and M3 But no TE on wrong rearrangement of gas equation Correct answer, including units with or without working scores **(5)**	5

Q4.

Question Number	Answer	Mark
	The only correct answer is C (475 cm^3) ***A** is not correct because this would only halve the concentration to 0.5 mol dm^{-3}* ***B** is not correct as this would be the total volume to produce a concentration of 0.5 mol dm^{-3}* ***D** is not correct because this is the total volume*	**(1)**

Q5.

Question number	Answer	Mark
	The only correct answer is A (gains electrons and decreases in oxidation number) ***B*** *is incorrect because oxidising agents are reduced during a reaction so there is a decrease in oxidation number* ***C*** *is incorrect because oxidising agents are reduced during a reaction so they gain electrons* ***D*** *is incorrect because oxidising agents are reduced during a reaction so they gain electrons and there is a decrease in oxidation number*	(1)

Q6.

Question Number	Answer	Additional guidance	Mark
(a)(i)	• $2I^- \rightarrow I_2 + 2e^{(-)}$ **(1)** • $2H^+ + 2e^- + H_2O_2 \rightarrow 2H_2O$ **(1)**	Allow $2I^- - 2e^{(-)} \rightarrow I_2$ Ignore state symbols, even if incorrect Allow multiples Allow equations in either order	**(2)**

Question Number	Answer	Additional guidance	Mark
(a)(ii)	$2I^- + 2H^+ + H_2O_2 \rightarrow I_2 + 2H_2O$ OR $2HI + H_2O_2 \rightarrow I_2 + 2H_2O$	Ignore state symbols, even if incorrect Allow multiples No TE from (a)(i) Do not award uncancelled electrons	**(1)**

Question Number	Answer	Additional guidance	Mark
(b)(i)	An answer that makes reference to the following points: (pale) yellow aqueous layer **(1)** Pink cyclohexane layer **(1)**	 Do not award just 'brown' / colourless / orange allow light brown / pale brown / yellowbrown / straw Allow purple / violet Do not award red / grey	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	An explanation that makes reference to the following points: Cyclohexane and iodine form London forces (between molecules) **(1)** Hydrogen bonds between water molecules are stronger than London forces (between iodine and water molecules so less soluble in aqueous layer) **(1)**	 Allow 'van der Waals' / dispersion forces / instantaneous dipole – induced dipole forces Allow 'Hydrogen bonds in water are strong' Allow one mark for answers that compare type of attraction without any reference to magnitude or answers based solely on polarity e.g. Just 'iodine forms London forces with cyclohexane but cannot form hydrogen bonds with water' scores 1 mark 'iodine and cyclohexane are non-polar, but water is polar' scores 1 e.g. 'Intermolecular forces formed by iodine and water are weaker than intermolecular forces in water' scores 1	**(2)**

Question Number	Answer	Additional guidance	Mark
(c)	(Anhydrous) sodium sulfate / Na_2SO_4 / magnesium sulfate / $MgSO_4$ / calcium chloride / $CaCl_2$ / calcium sulfate / $CaSO_4$ / calcium oxide / CaO	Allow silica gel Do not award concentrated sulfuric acid / phosphoric acid Do not award $CuSO_4$ / $CaCO_3$	**(1)**

Q7.

Question Number	Answer	Mark
(a)	**The only correct answer is C** (Reaction 3) *A is incorrect because different species are oxidised and reduced* *B is incorrect because different species are oxidised and reduced* *D is incorrect because there is no change in oxidation state*	**(1)**

Question Number	Answer	Mark
(b)	**The only correct answer is D** (Reaction 4) *A is incorrect because neither reactant is acting as an acid or base* *B is incorrect because this is a redox reaction* *C is incorrect because neither reactant is acting as an acid or base and it is a redox reaction*	**(1)**

Q8.

Question Number	Answer	Mark
(a)	**The only correct answer is B** (disproportionation) ***A*** *is incorrect because no species has been replaced/displaced* ***C*** *is incorrect because no species has been eliminated* ***D*** *is incorrect because water is produced and no species is hydrolysed*	**(1)**

Question Number	Answer	Mark
(b)	**The only correct answer is B** (4.2×10^{-5} mol s^{-1}) ***A*** *is incorrect because incorrect units for the Molar Volume of a gas has been used* ***C*** *is incorrect because the stoichiometry has not been taken into account* ***D*** *is incorrect because the stoichiometry is incorrect*	**(1)**

Q9.

Question number	Answer	Mark
	The only correct answer is B ($6NaOH + 3Br_2 \rightarrow 5NaBr + NaBrO_3 + 3H_2O$) ***A*** *is not correct because it is a neutralisation reaction* ***C*** *is not correct because only Al is oxidised and only H is reduced* ***D*** *is not correct because no oxidation numbers change*	**(1)**

Q10.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	• correct equation (1) • correct state symbols (1)	Examples of equations $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$ OR $K(s) + H_2O(l) \rightarrow KOH(aq) + \frac{1}{2}H_2(g)$ Allow multiples M2 dependent on M1 or correct species and an unbalanced equation	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following points: • K / potassium from 0 to +1 **and** oxidation (1) • H / hydrogen from +1 to 0 **and** reduction (1)	If oxidation numbers are wrong or omitted one mark is scored for K oxidised **and** H reduced. or one mark is scored for K changes from 0 to +1 **and** H changes from +1 to 0.	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(iii)	• lilac	Allow purple or lilac-purple Do not award any other colour	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	• from (pale) pink (1) • to colourless (1)	Do not award red/purple Award (1) mark for correct colours in reverse order	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	• moles of HCl in titre (1) • moles of MOH in the flask (= mol M) (1) • molar mass of M (1) • identification of M (1)	<u>Example of calculation</u> $12.8 \times 0.400 \div 1000 = 5.12 \times 10^{-3}$ / 0.00512 (mol) 5.12×10^{-3} / $0.00512 \times 10 = 5.12 \times 10^{-2}$ / 0.0512 $0.37 \div 5.12 \times 10^{-2} = 7.23$ (g mol^{-1}) Ignore SF Li TE for each stage but for M4, **M** must be a Group 1 metal and is dependent on a calculation of a molar mass.	(4)

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Question Number	Answer	Additional Guidance	Mark
(c)	A description that makes reference to the following points: • (some) oil weighed with M/ the mass of M is lower than the mass of material weighed/ (1) • relative atomic mass of M will be greater (1)	Ignore mass increased/decreased/mass different Allow fewer moles of HCl (required in the titration)/lower titration value	(2)

Q11.

Question Number	Answer	Mark
	The only correct answer is A (14,6,7) ***B*** *is incorrect because the charges do not balance and the number of electrons is incorrect* ***C*** *is incorrect because the oxygen atoms do not balance and the charges do not balance* ***D*** *is incorrect because the charges do not balance and the oxygen atoms do not balance*	**(1)**

Q12.

Question Number	Answer	Mark
	The only correct answer is D (KO_2) ***A*** *is incorrect because in this oxide potassium would have an oxidation number of +1/4* ***B*** *is incorrect because in this oxide potassium would have an oxidation number of +1/2* ***C*** *is incorrect because in this oxide potassium would have an oxidation number of +3/4*	**(1)**

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Q13.

Question number	Answer	Mark
	The only correct answer is C (+6) *A is not correct because the oxidation number of S in a compound is not always –2* *B is not correct because this is the value for the SO_3^{2-} ion* *D is not correct because the sum of all the oxidation states should be equal to the charge on the ion, not 0*	**(1)**

Q14.

Question number	Answer	Additional guidance	Mark
(a)	• balanced equation (1) • all states correct (1)	$I_2(s) + Cl_2(g) \rightarrow 2ICl(l)$ Accept multiples	**2**

Question number	Answer	Additional guidance	Mark
(b)	• correct electronegativity values and correct dipole diagram	Cl = 3.0 **and** I = 2.5 δ+ I — Cl δ- Do not award full charges	**1**

Question number	Answer	Additional guidance	Mark
(c)(i)	• 1 mark each correct formula	 Allow 1 mark for 2 correct non-skeletal formulae	**2**

Question number	Answer	Additional guidance	Mark
(c)(ii)	An explantion that makes reference to the following points: • identification of correct isomer (1) • iodine is δ+ and is attacked by the π electrons (1) • more stable secondary carbocation formed. (1)	2-chloro-1-iodopropane	**3**

Question number	Answer	Additional guidance	Mark
(d)(i)	An answer that makes reference to the following points: • carry out in fume cupboard (1) • chlorine is toxic. (1)	 Allow fume hood or similar description Do not allow 'harmful'	2

Question number	Answer	Additional guidance	Mark
(d)(ii)	• I in ICl = +1 I in ICl_3 = +3	Both needed for the mark	1

Question number	Answer	Additional guidance	Mark
(d)(iii)	• +5 **and** -1 to -1 (and -1) (1) • not disproportionation because the chlorine has not undergone both oxidation and reduction (1)		2

Question number	Answer	Additional guidance	Mark
(e)(i)	• correct method (1) • answer with units (1)	$Cl_2 = 2 \times 35.5 = 71$ $71 \div 24000$ $= 0.0029583$ g cm^{-3} $= 3$ g dm^{-3}	2

Question number	Answer	Additional guidance	Mark
(e)(ii)	An explanation that makes reference to the following points: • chlorine (gas) is more dense than air (1) • chlorine (gas) removed (from the equilibrium) (1) • position of equilibrium moves to the LHS (more brown liquid/ICl). (1)		3

Question number	Answer	Additional guidance	Mark
(f)	• calculation of mols of iodine and fluorine (1) • calculation of whole number ratio and formula (1)	Mols of iodine = $0.64 \div 126.9 = 5.04 \times 10^{-3}$ Mols of fluorine = $(1.31-0.64) \div 19 = 3.53 \times 10^{-2}$ Ratio 1:7 therefore formula IF_7	2

Q15.

Question Number	Answer	Mark
	The only correct answer is C ($3Cu + 2NO_3^- + 8H^+ \rightarrow 3Cu^{2+} + 2NO + 4H_2O$) ***A*** *is incorrect because the charges have not been balanced* ***B*** *is incorrect because the charges have not been balanced* ***D*** *is incorrect because the charges have not been balanced*	**(1)**

Q16.

Question Number	Answer	Mark
	The only correct answer is A ($Ba^{2+}(aq) + 2OH^-(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$) ***B*** *is incorrect because it only shows the precipitation reaction* ***C*** *is incorrect because it only shows the neutralisation reaction* ***D*** *is incorrect because it shows the barium sulfate ions as separated*	**(1)**

Q17.

Question Number	Correct Answer	Mark
	The only correct answer is C (hydrogen ions act as oxidising agents) ***A*** *is incorrect as magnesium atoms lose electrons* ***C*** *is incorrect as hydrogen molecules are a product* ***D*** *is incorrect as chloride ions do not gain or lose electrons*	**1**

Q18.

Question number	Answer	Mark
	The only correct answer is B (potassium chlorate(III)) ***A*** *is incorrect because the oxidation number of chlorine in* $KClO_2$ *is +3* ***C*** *is incorrect because the oxidation number of chlorine in* $KClO_2$ *is +3* ***D*** *is incorrect because the oxidation number of chlorine in* $KClO_2$ *is +3*	**(1)**

Q19.

Q	Answer	Mark
	The only correct answer is D (Hydrogen unchanged, Oxygen oxidised and reduced) ***A*** *is incorrect because hydrogen is unchanged and oxygen is both oxidised and reduced* ***B*** *is incorrect because hydrogen is unchanged and oxygen is both oxidised and reduced* ***C*** *is incorrect because hydrogen is unchanged and oxygen is both oxidised and reduced*	**1**

Q20.

Question Number	Answer	Mark
	The only correct answer is C (+5) ***A*** *is not correct because the oxidation number is +5 in* BrO_3^- ***B*** *is not correct because the oxidation number is +5 in* BrO_3^- ***D*** *is not correct because the oxidation number is +5 in* BrO_3^-	**1**

Q21.

Q	Answer	Mark
	The only correct answer is D (+6) ***A*** *is incorrect because this does not consider the numbers of oxygen and sodium atoms in the compound* ***B*** *is incorrect because this is the number of chromium atoms in the compound* ***C*** *is incorrect because this does not consider the oxidation numbers of sodium and oxygen*	**1**

Q22.

Question Number	Answer	Mark
	The only correct answer is C (+5) ***A*** *is not correct because this is the charge on the ion* ***B*** *is not correct because, although this is a common oxidation number of phosphorus, it is incorrect here* ***D*** *is not correct because this hbecause been obtained using the oxidation number of oxygen because –1*	**(1)**

Q23.

Question Number	Answer	Mark
	The only correct answer is A ($Ca(NO_3)_2$) ***B*** *is incorrect because the oxidation number of nitrogen is -3* ***C*** *is incorrect because the oxidation number of nitrogen is +3* ***D*** *is incorrect because the oxidation number of nitrogen is +3*	**(1)**

Q24.

Q	Answer	Mark
	The only correct answer is C (N_2O_4) ***A** is incorrect because the oxidation number of nitrogen is +1* ***B** is incorrect because the oxidation number of nitrogen averages +3* ***D** is incorrect because the oxidation number of nitrogen is +5*	**1**

Q25.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	$3Ca(OH)_2 + 3Cl_2 + KCl \rightarrow KClO_3 + 3CaCl_2 + 3H_2O$ OR $6Ca(OH)_2 + 6Cl_2 + 2KCl \rightarrow 2KClO_3 + 6CaCl_2 + 6H_2O$	Allow multiples If multiple used allow '$CaCl_2$ +5$CaCl_2$' Ignore state symbols	**1**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	• calculation of M_r of $KClO_3$ **(1)** • calculation of M_r of all products / reactants **(1)** • calculation of overall atom economy **(1)**	<u>Example of calculation</u> 39.1 + 35.5 + 48 (= 122.6) 122.6 + (3 ×18) + ((71+40.1) × 3) = 509.9 Value for M2 should be consistent with numerator of atom economy expression (122.6 ÷509.9) ×100 = 24.044 = 24.0 % Ignore SF except 1 SF Use of 39 for K or 40 for Ca is acceptable Allow TE from (a)(i) using either M_r of all products or reactants Allow TE throughout calculation But TE for M3 must give a value of less than 100 %	**3**

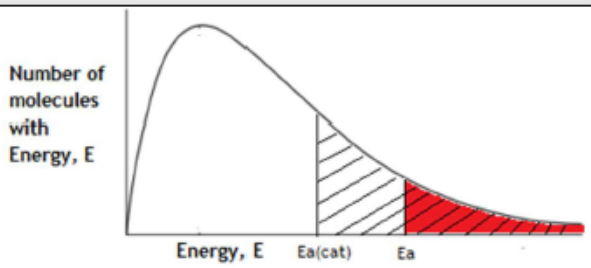
Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	An explanation that makes reference to the following points: • disproportionation reaction **(1)** • as chlorine (atoms) are oxidised from 0 (in chlorine) to (+) 5 (in calcium chlorate) **(1)** • and reduced (from 0) to −1 (in calcium chloride) **(1)**	Allow incorrect spellings of disproportionation if the word is recognisable and could not be confused with another chemical term Ignore redox Mark independently of M2 and M3 If initial oxidation state of 0 is not referenced at least once in either M2 or M3, then allow 1 for Cl is oxidised to +5 and reduced to -1 Changes in oxidation number can be shown above equation If no reference to oxidation and reduction then allow 1 mark for correct changes in oxidation number	**3**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(i)	An answer that makes reference to the following points: • add (dilute) nitric acid and silver nitrate (solution) **(1)** • white precipitate forms / precipitate forms whose colour is difficult to distinguish (between white and cream) **(1)** • which dissolves in dilute ammonia / dilute NH_3 / $NH_3(aq)$**(1)**	Throughout the question if formulae are given they must be correct Allow acidified silver nitrate / $AgNO_3$ and H^+ Allow $AgNO_3$ Allow HNO_3 Do not award hydrochloric acid / sulfuric acid Allow white solid / white crystals / white ppt Allow aqueous ammonia Allow 'disappears' for dissolves Do not award **just** 'dissolves in concentrated NH_3' M2 and M3 dependent on reference to silver nitrate / $AgNO_3$	**3**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	• calculation of mass of oxygen **(1)** • calculation of moles of oxygen **(1)** • deduction of moles of potassium chlorate /calculation of mass of KCl **(1)** • calculation of mass of potassium chlorate in impure sample **(1)** • calculation of % purity of sample to 2 or 3 SF **(1)**	<u>Example of calculation</u> 1.52 − 1.02 = 0.50 (g) 0.50 ÷ 32 = 0.015625 (mol) 0.015625 × (2÷3) = 0.010417 (mol) / 0.015625 x (2/3) x 74.6 = 0.777 (g) 0.010417 × (39.1 + 35.5 + 48) = 1.2771 (g) / 0.777 + 0.5 = 1.277 (g) = (1.2771 ÷ 1.52) × 100 = 84.019 = 84 / 84.0 (%) Penalise incorrect rounding once only in M1-M4 Allow TE at each step, but TE for M5 must give a value less than 100% and based on 1.52 Allow alternative methods based on finding x where x = mass of impurity	**5**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	potassium chlorate(VII) OR chlorate(VII) potassium	Allow pottassium chlorate(VII) Do not award just potassium chlorate	**1**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An explanation that makes reference to any four of the following points: • heat to constant mass so all of the potassium chlorate(V) decomposes **(1)** • the solid product or potassium chloride dissolves (when the water is added) **(1)** • the rinsing removes potassium chloride (solution, which would otherwise add to the mass of the solid when it dries **(1)** • drying ensures the final mass recorded is only that of that catalyst **(1)** • the mass (of solid) recorded (at the end of the procedure) should be the same of that of the catalyst at the start **(1)**	Allow so all $KClO_3$ reacts / so reaction goes to completion Allow the catalyst does not dissolve (when the water is added) Ignore KCl reacts with the water / catalyst does not react with the water Allow to remove soluble impurities (from catalyst) Allow 'to remove water from the catalyst' / 'ensure the catalyst is dry' Allow 'to compare to the mass of catalyst' Allow 'to check the mass (of catalyst) hasn't changed'	4

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	An explanation that makes reference to the following points: • activation energies shown and labelled for both catalysed and uncatalysed reaction **(1)** • number of molecules with $E > E_a$ shown on diagram **(1)**	 M2 can be awarded by written description	2

Q26.

Question Number	Correct Answer	Mark
(a)	**The only correct answer is D** (dense white smoke) ***A*** *is incorrect as the reaction produces misty fumes of HI* ***B*** *is incorrect as the reaction produces the black solid* I_2 ***C*** *is incorrect as the reaction produces the yellow solid S*	**1**

Question Number	Correct Answer	Mark
(b)	**The only correct answer is A** (−8) ***B*** *is incorrect as -6 is the change in oxidation number when S(s) forms* ***C*** *is incorrect as -2 is the oxidation number of S in* H_2S ***D*** *is incorrect as +6 is the oxidation number of S in* H_2SO_4	**1**

Q27.

Question number	Answer	Mark
(a)	**The only correct answer is D** ($Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$) ***A*** *is incorrect because CaO is not a product of the reaction* ***B*** *is incorrect because* CaO_2 *is an incorrect formula for calcium oxide* ***C*** *is incorrect because CaOH is an incorrect formula for calcium hydroxide*	**(1)**

Question number	Answer	Mark
(b)	**The only correct answer is A** (calcium oxidised, hydrogen reduced) ***B*** *is incorrect because oxygen is not reduced* ***C*** *is incorrect because hydrogen is not oxidised and calcium is not reduced* ***D*** *is incorrect because hydrogen is not oxidised and oxygen is not reduced*	**(1)**

Q28.

Question Number	Answer	Mark
	The only correct answer is D ($Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$) *A is not correct because Cl has undergone disproportionation* *B is not correct because O has undergone disproportionation* *C is not correct because Cl has undergone disproportionation*	1

Q29.

Question Number	Answer	Mark
	The only correct answer is A ($Cu^{2+} + 2Ag \rightarrow 2Ag^{+} + Cu$) *B is incorrect because the oxidation number of the copper is unchanged* *C is incorrect because this is a reaction where copper is oxidised* *D is incorrect because this is a reaction where copper is oxidised*	**(1)**

Q30.

Question Number	Answer	Mark
	The only correct answer is B ($2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$) *A is not correct because it is a redox reaction* *C is not correct because it is a redox reaction* *D is not correct because it is a redox reaction*	**(1)**