For Examiner's Use

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Iron is extracted from iron ore in the Blast Furnace.
The equations **A**, **B**, **C**, **D** and **E** show some reactions that happen in the Blast Furnace.

A $C + O_2 \rightarrow CO_2$

B $CO_2 + C \rightarrow 2CO$

C $Fe_2O_3 + 3CO \rightarrow 3CO_2 + 2Fe$

D $CaCO_3 \rightarrow CaO + CO_2$

E $SiO_2 + CaO \rightarrow CaSiO_3$

Use the letters **A**, **B**, **C**, **D** and **E** to answer the following questions.

(a) Which equation shows combustion?

…… [1]

(b) Which equation shows thermal decomposition?

…… [1]

(c) Which equation shows a reaction between an acidic compound and a base?

…… [1]

(d) Which equation shows the formation of a toxic gas?

…… [1]

[Total: 4]

A2 Blast furnace can also be used to extract copper from its ores, which are chemically copper(I) sulfide. In the blast furnace, blasts of hot air are blown through the ore to convert copper(I) sulfide to solid copper(I) oxide and sulfur dioxide. The copper(I) oxide is then further converted by coke to molten copper, which is collected at the bottom of the furnace.

(a) Write a chemical equation, including state symbols, for the conversion of copper(I) sulfide to copper(I) oxide.

…… [2]

A2 **(b)** Describe a chemical test to identify the presence of sulfur dioxide in the waste gases produced during the extraction process. Include your observations.

Test ……...

…..…….. [1]

Observation …….

…..…….. [1]

(c) Sulfur dioxide is a pollutant and poses a danger to both health and environment if it is allowed to escape into the surroundings.
State one harmful effect to humans and one harmful effect to the environment that arise from sulfur dioxide.

Harmful effect to humans ……..

…… [1]

Harmful effect to the environment ……..

…… [1]

(d) The emission of sulfur dioxide can be reduced by passing the waste gases through a chamber containing finely powdered calcium oxide. The equation for the reaction is

$$CaO + SO_2 \rightarrow CaSO_3$$

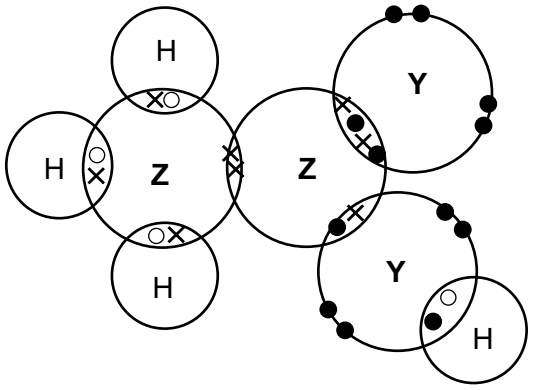
It was estimated that the daily sulfur dioxide emission from a copper extraction plant was 22 tonnes. Calculate the mass of calcium oxide needed daily to remove the mass of sulfur dioxide produced. (1 tonne = 1000 kg)

mass of CaO = ……. kg [3]

[Total: 9]

For Examiner's Use

A3 The diagram below shows the arrangement of electrons in a compound of hydrogen, H, element **Y** and element **Z**.
Only outer shell electrons are shown.



(a) What type of bonding is present in this compound?

……. [1]

(b) Elements **Y** and **Z** have proton numbers between 2 and 11.
Name elements **Y** and **Z**.

element **Y** …….

element **Z** ……. [2]

(c) Using the correct symbols for elements **Y** and **Z**, give the empirical formula of this compound.

……. [1]

(d) Using your understanding of bonding and structure, which of these statements would you predict to be TRUE and which would you predict to be FALSE for this compound?
Put a tick (✓) in one box in each row.

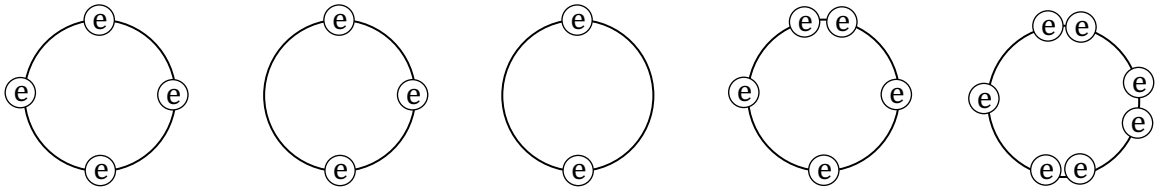
This compound …	TRUE	FALSE
has a low boiling point.		
has good electrical conductivity when molten.		
is very soluble in water.		
is a crystalline solid at room temperature.		

[2]

[Total: 6]

For Examiner's Use

A4 These diagrams show the electron arrangement in the outer shells of five elements, **A** to **E**. All elements are from Period 2 of the Periodic Table.



Use the letters **A** to **E** to answer the following questions.
Each letter may be used once, more than once, or not at all.

(a) Which element is likely to be a metal?

…… [1]

(b) Which element has an proton number of 4?

…… [1]

(c) Which element exists as diatomic molecules with triple covalent bonds?

…… [1]

(d) Which two elements will form a compound with the formula of the type YZ_2?

…… [2]

[Total: 5]

For Examiner's Use

A5 **(a)** **Table 5.1** shows data about the melting points and boiling points of three halogens – chlorine, bromine and iodine.
Complete **Table 5.1** by filling in the name of each halogen.

name of halogen	melting point / °C	boiling point / °C
	− 7.2	58.8
	− 100.9	− 34.7
	113.8	184.5

[1]

Table 5.1

(b) Sea water contains potassium bromide.

(i) Bromine can be produced from sea water by displacement.
Name an element that can displace bromine.
Give a reason for your choice.

name ……..

reason ……

……. [2]

(ii) Write an ionic equation for the displacement of bromine from sea water, using your answer from **(b)(i)**.

……..... [1]

(c) The Thermite reaction is used to weld railway rails together.
Aluminium powder reacts with iron(III) oxide to make small amounts of molten iron which runs into the gaps between the rails. Solid aluminium oxide is made at the same time.
The equation for the reaction is as follows:

$$2\ Al\ (s)\ +\ Fe_2O_3\ (s)\ \rightarrow\ 2\ Fe\ (l)\ +\ Al_2O_3\ (s)$$

(i) The reaction is an example of a metal displacement reaction and is highly exothermic.
The amount of heat energy given out is displacement reactions depends on the difference in reactivity of the two metals.
Suggest another metal that can replace aluminium to give a more exothermic reaction with iron(III) oxide.

……. [1]

For Examiner's Use

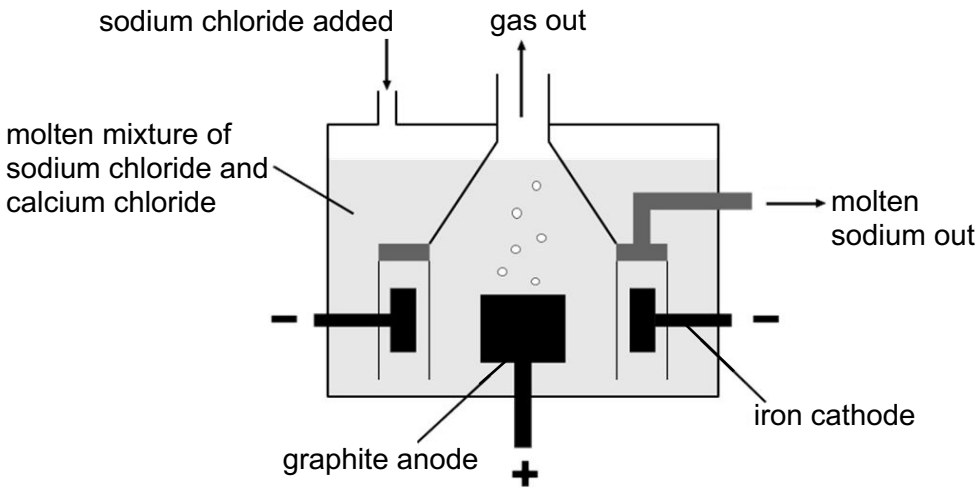
A5 (c) (ii) 100 kg of aluminium powder and 100 kg of iron(III) oxide are used to produce 50 kg of aluminium oxide during welding.
Calculate the percentage yield of aluminium oxide.

[5]

[Total: 10]

For Examiner's Use

A6 Sodium metal can be extracted from molten sodium chloride by electrolysis. The diagram below shows how the process works.



(a) **(i)** Write an ionic half equation, including state symbols, to show the reaction that happens at the anode.

……..... [2]

(ii) Describe a simple test and its result that would identify the gas given off at the anode.

test ……..

…….

result ……..

…….

……. [2]

(b) Calcium chloride is added to the sodium chloride to lower the melting point of the mixture.

(i) Explain why lowering the melting point makes the process cheaper to run.

…….

……. [1]

For Examiner's Use

A6 (b) (ii) The molten sodium contains metallic impurities,
Name the main metal impurity you would expect to find and explain how it forms.

……

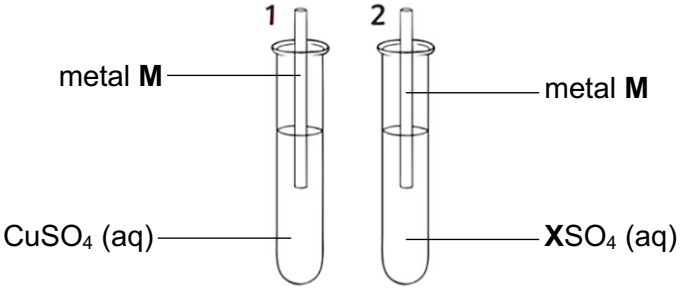
……

……

……

…… [2]

(c) A student set up the apparatus as shown below:



In test tube **1**, he placed a rod of metal **M** into copper(II) sulfate solution.
In test tube **2**, he placed a rod of metal **M** into the sulfate solution of metal **X**.

After some time, he made the following observations:

	test tube **1**	test tube **2**
Observation	Pink deposit on metal **M**. Blue colour turns colourless.	Grey deposit on metal **M**. Green solution turns colourless.

(i) Based on the observations, state one conclusion you can make about the reactivity of metal **M** compared to copper and metal **X**.

……

…… [1]

For Examiner's Use

A6 **(c)** **(ii)** Describe how you can perform a similar experiment to compare the reactivity between copper and metal **X**. Include observations and explain your answer.

……

……

……

……

……

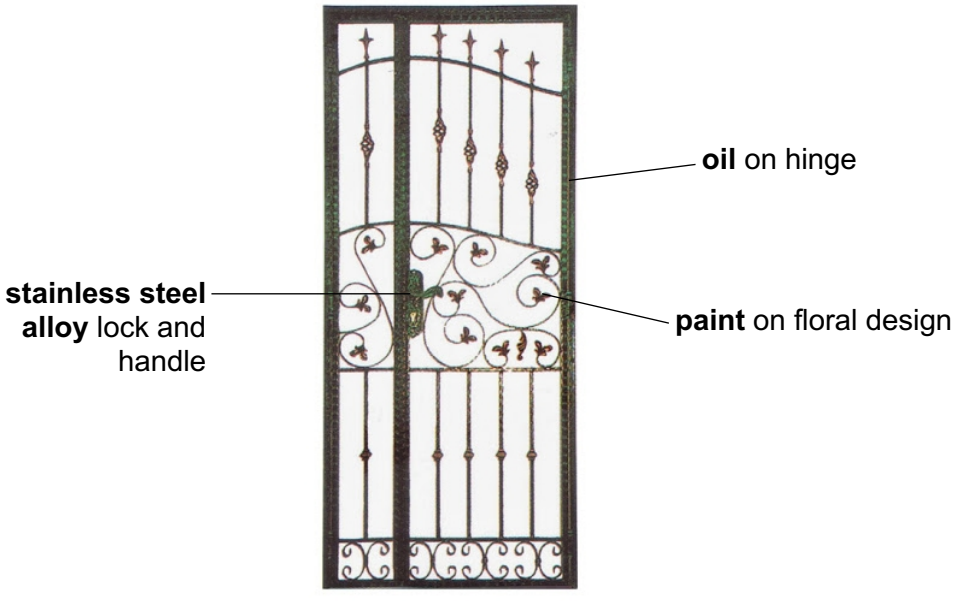
……

……

…… [3]

[Total: 11]

A7 The diagram shows the rust prevention methods used on different parts of a wrought iron gate.



(a) Stainless steel alloy is used to make the lock and handle of the gate.
What is meant by the term *alloy*?

……

…… [1]

For Examiner's Use

A7 **(b)** Explain how the paint and the oil slow down rusting.

……

……

……

…… [2]

(c) The gate is treated with a spray-on layer that prevents rusting. This spray-on layer contains particles of zinc.
Explain how this layer of zinc prevents rust from forming.

……

……

……

……

……

…… [2]

[Total: 5]

For Examiner's Use

Section B

Answer all **three** questions from this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

B8 The Chemistry of Fireworks

The sights and sounds of each explosion are the result of several chemical reactions taking place within the firework as it ascends into the sky. Fireworks consist of a mixture of black powder and other chemicals that create the spectacular colours.

What is black powder? Typically, black powder is made up of potassium nitrate, charcoal (carbon) and sulfur in the percentages by mass of 75 : 15 : 10. Each of these components plays an important role in the combustion of the black powder in the form of self-sustaining exothermic reactions that do not rely on oxygen from external sources.

Potassium nitrate acts as an oxidiser, decomposing to potassium oxide, nitrogen gas, and oxygen gas.

$$2KNO_3\ (s) \rightarrow K_2O\ (s) + N_2\ (g) + 2.5O_2\ (g)$$

Oxidisers supplies oxygen to the reducing agents, carbon and sulfur, which serve as a fuel. Carbon and sulfur react with the oxygen to produce carbon dioxide and sulfur dioxide respectively.

$$O_2\ (g) + C\ (s) \rightarrow CO_2\ (g) \quad \Delta H = -393\ kJ\ /\ mol\ of\ C$$
$$O_2\ (g) + S\ (s) \rightarrow SO_2\ (g) \quad \Delta H = -2368\ kJ\ /\ mol\ of\ S$$

The reactions that produce these gases release a great deal of heat energy, so not only are the gases produced rapidly, they are hot and rapidly expanding gases. This adds to the explosive force of the reaction. More than 10,000 kJ of energy is released for every kilogram of black powder used, and the resulting temperatures can reach 2000°C and beyond!

In recent years, a group of more explosive oxidisers called perchlorates are more commonly used. Perchlorates contain the perchlorate ion (ClO_4^-), in which each chlorine atom is bonded to four oxygen atoms. Perchlorate is able to release all four of its oxygen atoms, making it a better oxidiser than potassium nitrate.

$$KClO_4\ (s) \rightarrow KCl\ (s) + 2O_2\ (g)$$

B8 continued

For Examiner's Use

What makes the different colours in fireworks? Fireworks get their colours from metal salts. The colour of the flame depends on the cation; the anion of the salt has no direct influence. The anions however influence the flame brightness, both by increasing it (e.g. nitrates and chlorates) and decreasing it (e.g. carbonates and oxalates). Some examples of metal salts used in fireworks are given in the table.

colour	**chemical name**	**chemical formula**
blue	copper(II) carbonate	$CuCO_3$
green	barium carbonate	$BaCO_3$
green	barium chlorate	$Ba(ClO_3)_2$
orange	calcium carbonate	$CaCO_3$
red	strontium oxalate	SrC_2O_4
yellow	sodium nitrate	$NaNO_3$
yellow	sodium oxalate	$Na_2C_2O_4$

The chemistry of fireworks includes the formation of gases that pollute the air. Burning of fireworks releases atmospheric pollutants such as carbon monoxide, sulfur dioxide and nitrogen oxides.

(a) **(i)** Use oxidation states to show that reduction occurs when potassium nitrate acts as an oxidiser.

……

……

……

…… [1]

(ii) Use equations from the passage to **explain** why potassium perchlorate is a better oxidiser than potassium nitrate.

……

……

……

…… [1]

B8 continued

For Examiner's Use

(b) Black powder contains carbon and sulfur which serve as fuels in fireworks.

(i) Draw an energy profile diagram for the complete combustion of 1 mole of carbon or sulfur.

Your diagram should include:
- the formulae of the reactant(s) and product(s), and
- the value of the enthalpy change for the chosen reaction.

[3]

(ii) Calculate the energy produced by the complete combustion of 1 g of **each** fuel and use your calculations to show that the total energy released from the complete combustion of the carbon and sulfur content in 1 kg of black powder exceeds 10,000 kJ.

[3]

B8 continued

For Examiner's Use

(c) Describe how the colour and the flame brightness of the fireworks produced by mixtures 1 and 2 differ.

Firework mixture 1: CaC_2O_4 and $SrCO_3$
Firework mixture 2: $Ba(NO_3)_2$ and $Cu(ClO_3)_2$

……

……

……

……

……

…… [2]

(d) State how and why the burning of fireworks leads to the formation of nitrogen oxides.

……

……

……

……

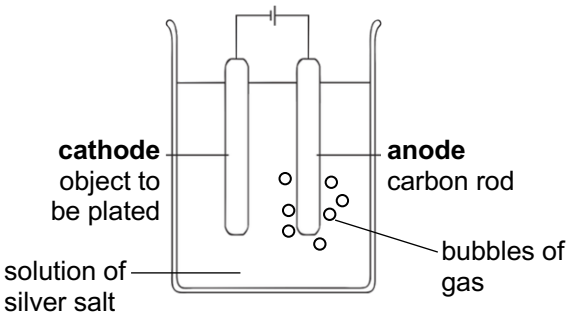
……

…… [2]

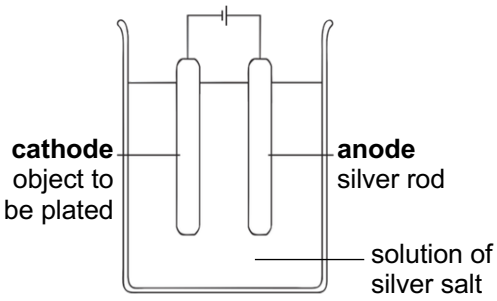
[Total 12 marks]

For Examiner's Use

B9 A student sets up two different experiments for electroplating an object with silver.



Experiment 1



Experiment 2

(a) Suggest a silver salt that can be used as electrolyte for both experiments.

……... [1]

(b) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

Experiment 1

Anode ……

Cathode ……

Experiment 2

Anode ……

Cathode …… [4]

B9

For Examiner's Use

(c) In **Experiment 1**, 100 cm^3 of the colourless gas was collected at the anode. What is the gain in mass of the cathode?

[3]

[Total: 8]

B10 EITHER

For Examiner's Use

A metallic element, **M**, has the following properties.

less dense than water
soft
melts below 100 °C
occurs naturally as its chloride, formula **M**C*l*
the oxide of **M** reacts with water to form a soluble hydroxide

(a) (i) Suggest to which Group of the Periodic Table metal **M** belongs.

……..

(ii) Suggest how metal **M** can be extracted from its compounds. Explain your reasoning.

……..

……..

……..

…….. [3]

(b) Outline a method to prepare crystals of **M**C*l*, starting with the carbonate $\mathbf{M}_2CO_3$.

……

……

……

……

……

……

……

……

……

…… [4]

B10 EITHER continued

For Examiner's Use

(c) 6.72 g of **M**C*l* contains 1.42 g of chlorine.
Calculate the number of moles of chlorine atoms in the sample, and hence suggest a value for the relative atomic mass of **M**.

[3]

[Total: 10]

B10 OR

For Examiner's Use

Ammonia is used to manufacture nitric acid, by a two stage process.

Stage 1: the ammonia is converted to nitrogen(II) oxide.

$$4NH_3\,(g) + 5O_2\,(g) \rightarrow 4NO\,(g) + 6H_2O\,(g) \qquad \Delta H = -950\ \text{kJ/mol}$$

(a) State and explain how the **rate** changes when the pressure is increased.
Use ideas about colliding particles.

……...

……

……

……

……

…… [2]

(b) During the reaction, the ammonia and hydrogen are passed through a powdered catalyst.

(i) Explain why the catalyst becomes hot during the reaction.

……

…… [1]

(ii) Explain why the catalyst is used in the form of a powder.

……

…… [1]

B10 OR continued

For Examiner's Use

(c) It is possible to find out whether this reaction has finished by following the pH changes during the reaction. Samples of gas are taken from the reaction vessel at intervals and bubbled through water to form a solution. The pH of each solution is measured.

Explain why the measured pH changes during the reaction.

……

……

……

……

……

…… [2]

Stage 2: the nitrogen dioxide is converted to nitric acid.

$$4NO\ (g)\ +\ 2H_2O\ (g)\ +\ 3O_2\ (g)\ \rightarrow\ 4HNO_3\ (aq)$$

(d) Calculate the maximum mass of nitric acid which can be made from 720 dm^3 of nitrogen(II) oxide, NO, at room temperature and pressure.

[3]

(e) Use the two equations in Stage 1 and 2 to construct an **overall** equation for the conversion of ammonia to nitric acid.

…… [1]

[Total: 10]

**********End of Paper**********