Q1. Which one of the following is the electron arrangement of the strongest reducing agent?

A $1s^2\ 2s^2\ 2p^5$

B $1s^2\ 2s^2\ 2p^6\ 3s^2$

C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

(Total 1 mark)

Q2. Which one of the following is **not** a redox reaction?

A $Br_2 + SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2Br^-$

B $SnCl_2 + HgCl_2 \rightarrow Hg + SnCl_4$

C $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$

D $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

(Total 1 mark)

Q3. Hydrogen gas is used in the chemical industry.

(a) Tungsten is extracted by passing hydrogen over heated tungsten oxide (WO_3).

(i) State the role of the hydrogen in this reaction.

.....

(1)

(ii) Write an equation for this reaction.

.....

(1)

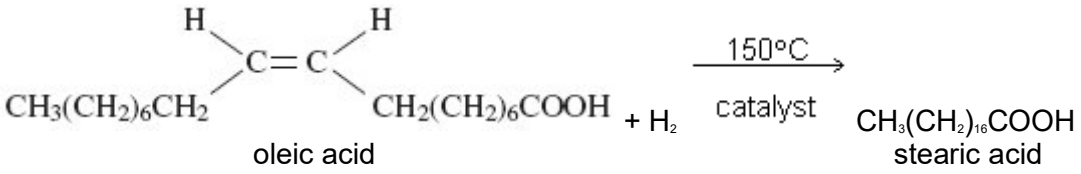
(iii) State **one** risk of using hydrogen gas in metal extractions.

.....

.....

(1)

(b) Hydrogen is used to convert oleic acid into stearic acid as shown by the following equation.



oleic acid stearic acid

(i) Use your knowledge of the chemistry of alkenes to deduce the type of reaction that has occurred in this conversion.

.....

(1)

(ii) State the type of stereoisomerism shown by oleic acid.

.....

(1)

(c) Hydrogen reacts with nitrogen in the Haber Process. The equation for the equilibrium that is established is shown below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State Le Chatelier's principle.

.....

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(1)

(ii) Use Le Chatelier's principle to explain why an increase in the total pressure of this equilibrium results in an increase in the equilibrium yield of ammonia.

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.....

(2)

(d) Hydrogen reacts with oxygen in an exothermic reaction as shown by the following equation.

$$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g) \qquad \Delta H = -242 \text{ kJ mol}^{-1}$$

Use the information in the equation and the data in the following table to calculate a value for the bond enthalpy of the H–H bond.

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

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(3)
(Total 11 marks)

Q4. Copper is extracted from the ore chalcopyrite ($CuFeS_2$) in a three-stage process.

(a) In the first stage of this extraction, the chalcopyrite is heated with silicon dioxide and oxygen.

(i) Balance the following equation for this first stage in which copper(I) sulfide is formed.

.....$CuFeS_2$ + ...SiO_2 + ...O_2 → Cu_2S + ...$FeSiO_3$ + ...SO_2

(1)

(ii) Give **one** environmental reason why the SO_2 gas formed in this reaction is not allowed to escape into the atmosphere.

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(1)

(iii) State **one** use for the sulfur dioxide formed in this reaction.

.....

.....

(1)

(b) In the second stage of this extraction, the copper(I) sulfide is converted into copper(II) oxide. This occurs by roasting the sulfide with oxygen at high temperature.
Write an equation for this reaction.

.....

(1)

(c) In the third stage of this extraction, copper(II) oxide is reduced to copper by its reaction with carbon. Write an equation for this reaction.

.....

(1)

(d) Scrap iron can be used to extract copper from dilute aqueous solutions containing copper(II) ions.

(i) Explain why this is a low-cost method of extracting copper.

.....

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(1)

(ii) Write the **simplest ionic** equation for the reaction of iron with copper(II) ions in aqueous solution.

.....

(1)
(Total 7 marks)

Q5. Oxidation and reduction can de defined in terms of electron transfer.

(a) Define the term *reduction* in terms of electrons.

.....

(1)

(b) The oxide of nitrogen formed when copper reacts with nitric acid depends upon the concentration and the temperature of the acid. The reaction of copper with cold, dilute acid produces NO as indicated by the following equation.

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

In warm, concentrated acid, NO_2 is formed.

Oxidation states can be used to understand electron transfer in these reactions.

(i) Give the oxidation states of nitrogen in NO_3^-, NO and NO

Oxidation state in NO_3^- .....

Oxidation state in NO_2 .....

Oxidation state in NO .....

(ii) Identify, as oxidation or reduction, the formation of NO_2 from NO_3^- ions in the presence of H^+ ions. Deduce the half-equation for the reaction.

NO from NO_3^- .....

Half-equation .;.....

(iii) Deduce the half-equation for the formation of NO_2 from NO_3^- ions in the presence of H+ ions.

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(iv) Deduce the overall equation for the reaction of copper with NO_3^- ions and H^+ ions to produce Cu^{2+} ions, NO_2 and water.

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(8)
(Total 9 marks)

Q6. This question is about the extraction of metals.

(a) Coke is mainly carbon and is a raw material used in the extraction of iron from iron(III) oxide.

(i) Write an equation for the formation of carbon monoxide from carbon.

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(1)

(ii) Write an equation for the reduction of iron(III) oxide to iron by carbon monoxide.

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(1)

(iii) The Earth's resources of iron(III) oxide are very large and commercial ores have a high iron content. Give **one** economic and **one** environmental reason for recycling scrap iron and steel.

Economic reason .....

.....

Environmental reason .....

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(2)

(b) Pure titanium is extracted by the reduction of titanium(IV) chloride, but not by the direct reduction of titanium(IV) oxide using carbon.

(i) Write an equation for the conversion of titanium(IV) oxide into titanium(IV) chloride.

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(2)

(ii) Write an equation for the extraction of titanium from titanium(IV) chloride.

.....

(2)

(iii) State why titanium is not extracted directly from titanium(IV) oxide using carbon.

.....

(1)

(c) Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide.

(i) State why the electrolysis needs to be of a *molten* mixture.

.....

(1)

(ii) Write an equation for the reaction of oxide ions at the positive electrode during the electrolysis.

.....

(1)

(iii) State why the positive electrodes need frequent replacement.

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(1)

(iv) Give the major reason why it is less expensive to recycle aluminium than to extract it from aluminium oxide by electrolysis.

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(1)

(Total 13 marks)

Q7. In the past 150 years, three different processes have been used to extract bromine from potassium bromide. These processes are illustrated below.

Extraction Process **1**

$2KBr + MnO_2 + 2H_2SO_4 \rightarrow MnSO_4 + K_2SO_4 + 2H_2O + Br_2$

Extraction Process **2**

The reaction of solid potassium bromide with concentrated sulfuric acid.

Extraction Process **3**

The reaction of aqueous potassium bromide with chlorine gas.

(a) Write a half-equation for the conversion of MnO_2 in acid solution into Mn^{2+} ions and water. In terms of electrons, state what is meant by the term *oxidising agent* and identify the oxidising agent in the overall reaction.

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(3)

(b) Write an equation for Extraction Process **2** and an equation for Extraction Process **3**.
Calculate the percentage atom economy for the extraction of bromine from potassium bromide by Extraction Process **3**. Suggest why Extraction Process **3** is the method in large-scale use today.

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(5)

(c) Bromine has been used for more than 70 years to treat the water in swimming pools.
The following equilibrium is established when bromine is added to water.

$$Br_2 + H_2O \rightleftharpoons HBrO + HBr$$

Give the oxidation state of bromine in HBr and in HBrO

Deduce what will happen to this equilibrium as the HBrO reacts with micro-organisms in the swimming pool water. Explain your answer.

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(4)
(Total 12 marks)