Metals and Reactivity [S]

For these questions you may need to refer to a Reactivity Series, you should use this one:

Au < Ag < Cu < (H) < Pb < Fe < Zn < (C) < Al < Mg < Ca < Li < Na < K

1. A reactivity series can be constructed by observing the reactions of some metals with dilute hydrochloric acid.
   a. The reaction of zinc with hydrochloric acid is typical of metals.
      i. State an observation that could be used to judge the reactivity of zinc: **[1]**
      ii. Write a balanced equation, with state symbols, for this reaction: **[3]**
   b. Explain why copper does not react with hydrochloric acid: **[2]**
   c. Give two reasons why reaction with hydrochloric acid cannot be used to distinguish between the reactivities of sodium and potassium: **[2]**
   d. Explain why the reactivity of aluminium would appear to be much less than its position in the reactivity series above would suggest: **[2]**

2. Iron can be extracted from its oxide in several ways.

   a. Industrially, extraction takes place in a blast furnace.

      i. Write the names and formulae of the three raw materials needed: **[6]**

      ii. Write two balanced equations to represent the formation of the carbon monoxide reducing agent: **[4]**

      iii. Write a balanced equation to represent the reduction of iron(III) oxide: **[2]**

      iv. Write two balanced equation to represent the removal of silicon dioxide impurities: **[4]**

      v. Explain how the blast furnace separates the molten iron and slag produced: **[2]**

b. In the laboratory, extraction can be achieved by heating iron(III) oxide and carbon in a crucible.

   i. Write a balanced equation for this reaction: **[2]**

   ii. Which species is being oxidised? **[1]**

   iii. Explain why magnesium could not be extracted from magnesium oxide using this method: **[2]**

3. Aluminium is extracted from its ore, bauxite, by electrolysis in molten cryolite.

   a. Write the name and formula of the main compound in bauxite: **[2]**

   b. Explain why molten cryolite is necessary for this process: **[2]**

   c. Write half-equations for the reactions at:

      i. The anode: **[3]**

      ii. The cathode: **[3]**

   d. The regular replacement of the anodes is a major factor in the cost of this process.

      i. What are the anodes composed of? **[1]**

      ii. Explain why the anodes require regular replacement: **[2]**

4. Rusting of iron is a major problem in many industries.

   a. State the two substances, other than iron, that are required for rusting: **[2]**

   b. Write a balanced equation for the rusting process: **[2]**

   c. State the species that is:

      i. Being oxidised: **[1]**

      ii. The oxidising agent : **[1]**

   d. Describe how sacrificial protection with magnesium prevents rusting: **[2]**

   e. State two other substances that can be applied to iron to prevent rusting: **[2]**

5. Write balanced equations, including state symbols, for the following if any reaction would occur:

   a. Zinc metal + lead nitrate solution: **[?]**

   b. Calcium metal + iron(III) sulphate: **[?]**

   c. Silver metal + zinc chloride solution: **[?]**

Metals and Reactivity [S]

For these questions you may need to refer to a Reactivity Series, you should use this one:

Au < Ag < Cu < (H) < Pb < Fe < Zn < (C) < Al < Mg < Ca < Li < Na < K

1. A reactivity series can be constructed by observing the reactions of some metals with dilute hydrochloric acid.

    a. The reaction of zinc with hydrochloric acid is typical of metals.

        i. State an observation that could be used to judge the reactivity of zinc: **[1]**

        amount/rate of fizzing [1]

        ii. Write a balanced equation, with state symbols, for this reaction: **[3]**

        Zn(s) + 2HCl(aq) → $ZnCl_2$(aq) + H_2(g) [formulae, balance, state symbols]

    b. Explain why copper does not react with hydrochloric acid: **[2]**

    Copper is less reactive than hydrogen [1]

    So it can't displace hydrogen from the acid [1]

    c. Give two reasons why reaction with hydrochloric acid cannot be used to distinguish between the reactivities of sodium and potassium: **[2]**

    The reactions between these metals and dilute acid would be too dangerous [1]

    Since both would probably explode, you couldn't assess the amount/rate of fizzing [1]

    d. Explain why the reactivity of aluminium would appear to be much less than its position in the reactivity series above would suggest: **[2]**

    Aluminium forms a thin oxide layer on its surface [1]

    This layer prevents the actual aluminium metal from being accessed by acid [1]

2. Iron can be extracted from its oxide in several ways.

   a. Industrially, extraction takes place in a blast furnace.

      i. Write the names and formulae of the three raw materials needed: **[6]**

         Coke – C [1]

         Limestone – $CaCO_3$ [1]

         Iron ore/haematite – Fe_2O_3 [1]

      ii. Write two balanced equations to represent the formation of the carbon monoxide reducing agent: **[4]**

         $C + O_2 \rightarrow CO_2$ [formulae, balance]

         $CO_2 + C \rightarrow 2CO$ [formulae, balance]

      iii. Write a balanced equation to represent the reduction of iron(III) oxide: **[2]**

         $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ [formulae, balance]

      iv. Write two balanced equation to represent the removal of silicon dioxide impurities: **[4]**

         $CaCO_3 \rightarrow CaO + CO_2$ [formulae, balance]

         $CaO + SiO_2 \rightarrow CaSiO_3$ [formulae, balance]

      v. Explain how the blast furnace separates the molten iron and slag produced: **[2]**

         Slag and molten iron are immiscible/don't mix [1]

         They are tapped off at different heights [1]

b. In the laboratory, extraction can be achieved by heating iron(III) oxide and carbon in a crucible.

i. Write a balanced equation for this reaction: **[2]**

$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$ [formulae, balance]

ii. Which species is being oxidised? **[1]**

carbon (C) [1]

iii. Explain why magnesium could not be extracted from magnesium oxide using this method: **[2]**

Magnesium is more reactive than carbon [1]

So carbon cannot reduce the magnesium/take the oxygen away [1]

3. Aluminium is extracted from its ore, bauxite, by electrolysis in molten cryolite.

a. Write the name and formula of the main compound in bauxite: **[2]**

aluminium oxide [1], Al_2O_3 [1]

b. Explain why molten cryolite is necessary for this process: **[2]**

The melting point of aluminium oxide is far too high [1]

Dissolving it in molten cryolite allows ions to move at lower temperatures [1]

c. Write half-equations for the reactions at:

i. The anode: **[3]**

$2O^{2-} \rightarrow O_2 + 4e^-$ [formulae, balance, charges]

ii. The cathode: **[3]**

$Al^{3+} + 3e^- \rightarrow Al$ [formulae, balance, charges]

d. The regular replacement of the anodes is a major factor in the cost of this process.

i. What are the anodes composed of? **[1]**

carbon (C) [1]

ii. Explain why the anodes require regular replacement: **[2]**

Carbon is used up [1]… because it reacts with the oxygen produced [1]

4. Rusting of iron is a major problem in many industries.

    a. State the two substances, other than iron, that are required for rusting: **[2]**

       oxygen [1] and water [1]

    b. Write a balanced equation for the rusting process: **[2]**

       $4Fe + 3O_2 + 2H_2O \rightarrow 2Fe_2O_3.H_2O$ [formulae, balance]

    c. State the species that is:

        i. Being oxidised: **[1]**

           iron (Fe) [1]

        ii. The oxidising agent : **[1]**

           oxygen (O or O_2) [1]

    d. Describe how sacrificial protection with magnesium prevents rusting: **[2]**

       magnesium is more reactive than iron [1]

       so it corrodes/oxidised instead [1]

    e. State two other substances that can be applied to iron to prevent rusting: **[2]**

       oil, grease, paint, plastic, zinc

       [1] each, maximum 2

5. Write balanced equations, including state symbols, for the following if any reaction would occur:

    a. Zinc metal + lead nitrate solution: **[3]**

       $Zn(s) + Pb(NO_3)_2(aq) \rightarrow Zn(NO_3)_2(aq) + Pb(s)$ [formulae, balance, state symbols]

    b. Calcium metal + iron(III) sulphate: **[3]**

       $3Ca(s) + Fe_2(SO_4)_3(aq) \rightarrow 3CaSO_4(aq) + 2Fe(s)$ [formulae, balance, state symbols]

    c. Silver metal + zinc chloride solution: **[1]**

       No reaction (silver is less reactive than zinc) [1]