Metals – 2019 June

1. 0620/31/M/J/19/No.2

This question is about iron and iron compounds.

(a) Name the main ore of iron.

..... [1]

(b) In a blast furnace used for the extraction of iron, carbon reacts with oxygen from the air to form carbon monoxide.

Complete the chemical equation for this reaction.

$$....C + ... \rightarrow 2CO$$

[2]

(c) In the hotter parts of the furnace, carbon reacts with the iron(III) oxide present in the iron ore.

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

How does this equation show that carbon is oxidised?

.....

..... [1]

(d) Limestone is added to the blast furnace. The limestone is converted into calcium oxide and carbon dioxide. The reaction is endothermic.

$$CaCO_3 \xrightarrow{\text{heat}} CaO + CO_2$$

(i) What type of chemical reaction is this?

..... [1]

(ii) What type of oxide is calcium oxide?
Give a reason for your answer.

.....

..... [2]

(e) Iron is a metal.

Give **three** physical properties that are characteristic of metals.

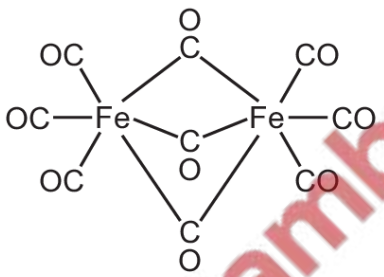
1 .....

2 .....

3 .....

[3]

(f) The structure of a compound of iron is shown.



Deduce the molecular formula of this compound to show the number of iron, carbon and oxygen atoms.

..... [1]

[Total: 11]

2. 0620/32/M/J/19/No.2

This question is about iron and compounds of iron.

(a) Iron can be converted into steel in a basic oxygen converter.
Oxygen is blown into the impure molten iron to remove some of the impurities.

(i) Oxygen reacts with the carbon in the impure iron to form carbon dioxide.

Write a chemical equation for this reaction.

..... [2]

(ii) Basic oxides in the lining of the converter react with impurities such as sulfur dioxide to form slag.

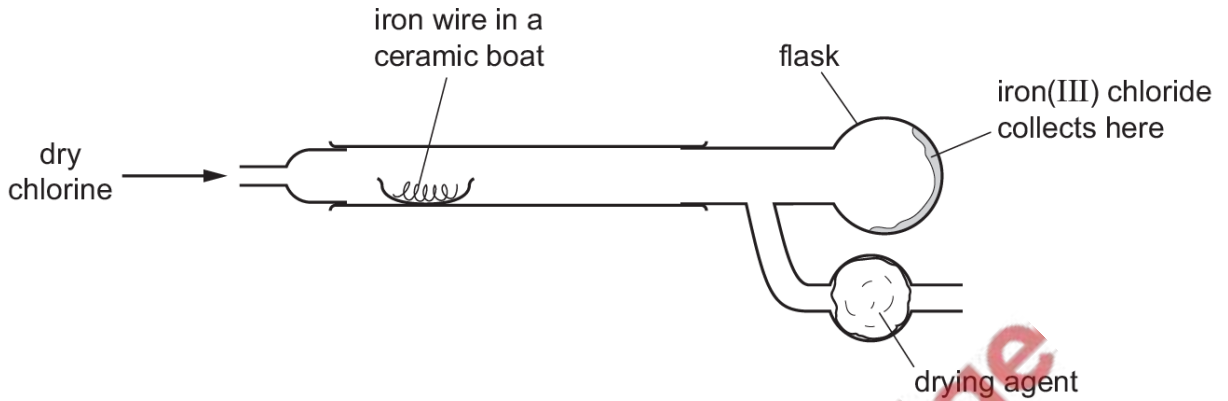
What type of oxide is sulfur dioxide?
Give a reason for your answer.

.....

..... [2]

(b) Iron(III) chloride, Fe_2Cl_6, is produced when iron is heated with chlorine.
The diagram shows the apparatus used.

(i) Draw an arrow on the diagram to show where the apparatus is heated.



[1]

(ii) Iron(III) chloride undergoes sublimation.

What is meant by the term *sublimation*?

.....

..... [1]

(iii) Suggest why the iron(III) chloride is collected in the flask and **not** in the ceramic boat.

.....

..... [2]

(iv) At higher temperatures, iron(III) chloride decomposes.

$$Fe_2Cl_6 \xrightarrow{\text{heat}} 2FeCl_2 + Cl_2$$

Explain why this is a decomposition reaction.

.....

..... [1]

(c) Iron reacts with chlorine and other halogens.

Name **two** other substances which react with iron.

1 .....

2 .....

[2]

(d) Describe a test for iron(II) ions.

test .....

observations .....

[2]

[Total: 13]

3. 0620/32/M/J/19/No.3

(a) The table shows the percentage by mass of the elements in the Earth's crust and in the oceans.

element	percentage by mass in the Earth's crust	percentage by mass in the oceans
aluminium	8.20	0.00
calcium	3.60	0.05
chlorine	0.05	1.80
hydrogen	0.22	11.00
iron	5.00	0.00
oxygen	46.60	85.80
silicon	29.50	0.00
sodium	2.80	1.15
other elements	4.03	
total	100.00	100.00

Answer these questions using only the information in the table.

(i) Deduce the percentage by mass of other elements present in the oceans.

..... % [1]

(ii) Which element is present in the Earth's crust in the greatest percentage by mass?

..... [1]

(iii) Give **two** major differences in the percentage by mass of the elements in the Earth's crust and in the oceans.

1 .....

.....

2 .....

.....

[2]

(b) Aluminium oxide is a compound present in aluminium ore.

(i) Name an ore which contains aluminium oxide.

..... [1]

(ii) Predict the products of the electrolysis of molten aluminium oxide at:

the positive electrode .....

the negative electrode. .....
[2]

(iii) Suggest why aluminium is extracted by electrolysis and **not** by reduction with carbon.

..... [1]

[Total: 8]

4. 0620/33/M/J/19/No.2

This question is about iron and iron compounds.

(a) Iron can be extracted from iron ore by reduction with carbon in a blast furnace.

(i) Which **one** of these substances is an ore of iron?
Draw a circle around the correct answer.

bauxite **graphite** **hematite** **limestone**

[1]

(ii) The equation shows one of the reactions occurring in the blast furnace.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

How does this equation show that Fe_2O_3 is reduced?

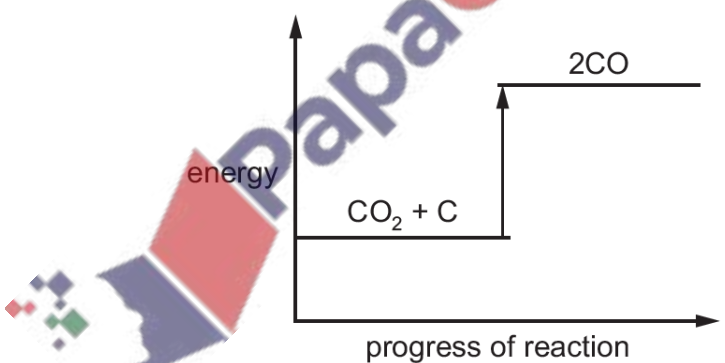
.....

..... [1]

(iii) The carbon dioxide formed can be reduced by carbon.

$$CO_2 + C \rightarrow 2CO$$

The energy level diagram for this reaction is shown.



Explain how this diagram shows that the reaction is endothermic.

.....

..... [1]

(iv) Explain why iron is extracted by reduction with carbon and **not** by electrolysis.
Refer to the position of iron in the reactivity series in your answer.

.....

..... [1]

(b) Describe **three** properties of iron that show that it is a transition element and **not** a Group I element.

1 .....

2 .....

3 .....

[3]

(c) Iron reacts with chlorine to form iron(III) chloride, Fe_2Cl_6.

(i) Balance the chemical equation for this reaction.

$$.....Fe + ...Cl_2 \rightarrow Fe_2Cl_6$$

[2]

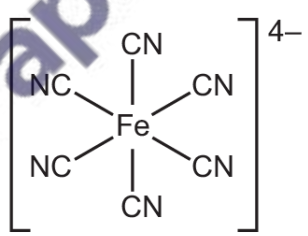
(ii) At 400 °C Fe_2Cl_6 molecules decompose.

$$Fe_2Cl_6 \rightleftharpoons 2FeCl_3$$

What is meant by the symbol $\rightleftharpoons$?

..... [1]

(d) The structure of an ion is shown.



Deduce the molecular formula of this ion to show the number of iron, carbon and nitrogen atoms.

..... [1]

[Total: 11]

5. 0620/33/M/J/19/No.3

The table shows the percentage by mass of the elements in the oceans and in the biosphere. The biosphere is all living organisms.

element	percentage by mass in the oceans	percentage by mass in the biosphere
calcium	0.05	0.40
carbon	0.01	39.00
chlorine	1.80	0.05
hydrogen	11.00	6.60
magnesium	0.12	0.10
oxygen	85.80	53.00
silicon	0.00	0.10
sodium	1.15	0.05
other elements	0.07	
total	100.00	100.00

(a) Answer these questions using only the information in the table.

(i) Deduce the percentage by mass of other elements present in the biosphere.

..... % [1]

(ii) Which metallic element is present in the oceans in the greatest percentage by mass?

..... [1]

(iii) Give **two** major differences in the percentage by mass of the elements in the oceans and in the biosphere.

1 .....

.....

2 .....

.....

[2]

(b) Living organisms respire. Water is produced during respiration.

(i) Name the other product of respiration.

..... [1]

(ii) Describe a chemical test for water.

test .....

observations .....
[2]

[Total: 7]

6. 0620/41/M/J/19/No.3

Zinc and copper are elements next to each other in the Periodic Table.

(a) Zinc is obtained from zinc blende in a two-step process.

- In **step 1**, zinc blende is converted into zinc oxide.
- In **step 2**, zinc oxide is converted into zinc in a blast furnace.

Outline how each of these steps are done.

In your answer:
- give **one** chemical equation for each step
- describe how zinc is removed from the blast furnace in **step 2**.

step 1 .....

.....

chemical equation .....

step 2 .....

.....

chemical equation .....

removal of zinc in **step 2** .....

.....
[5]

(b) Name the alloy formed when zinc is mixed with copper.

..... [1]

(c) Copper is a transition element. It can have variable oxidation states.

State **two** other chemical properties of transition elements which make them different from Group I elements.

1 .....

2 .....

[2]

(d) A compound of copper can be used to test for water.

(i) State the full name of this compound of copper.

..... [1]

(ii) State the colour change that occurs when water is added to this compound of copper.

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

[2]

(e) Aqueous potassium iodide reacts with aqueous copper(II) sulfate to produce iodine.

(i) Balance the chemical equation for this reaction.

$$KI + CuSO_4 \rightarrow CuI + I_2 + K_2SO_4$$

[2]

(ii) Deduce the charge on the copper ion in CuI.

..... [1]

(iii) In terms of electron transfer, explain why copper is reduced in this reaction.

..... [1]

(iv) Identify the reducing agent.

..... [1]

[Total: 16]

7. 0620/42/F/M/19/No.5

This question is about transition elements.

(a) Transition elements are harder and stronger than Group I elements.

Describe **two** other differences in **physical** properties between transition elements and Group I elements.

1 .....

2 .....

[2]

(b) State **one** physical property of transition elements that is similar to Group I elements.

..... [1]

(c) State **two** chemical properties of transition elements.

1 .....

2 .....

[2]

(d) Cobalt is a transition element. Anhydrous cobalt(II) chloride is used to test for water.

State the colour change that occurs when water is added to anhydrous cobalt(II) chloride.

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

[2]

(e) Iron is a transition element.

(i) Which **two** substances react with iron to form rust?

1 .....

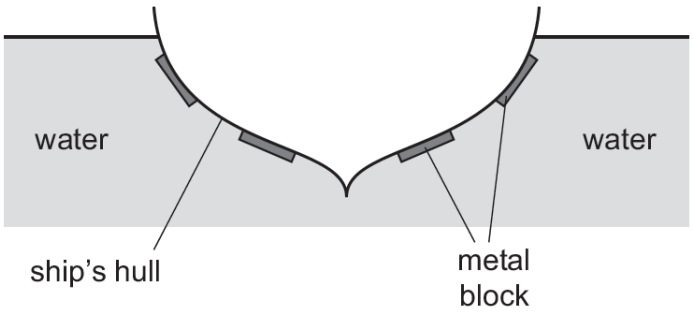
2 .....

[2]

(ii) Which metal is used to galvanise iron?

..... [1]

(f) The hull of a ship is made from steel (mainly iron). Metal blocks are placed on the ship's hull to prevent rusting.



Use your knowledge of the reactivity series to explain why:

- magnesium is suitable to use as the metal blocks
- copper is **not** suitable to use as the metal blocks.

.....

.....

..... [2]

(g) Rust contains iron(III) oxide.

Phosphoric acid, H_3PO_4, can be used to remove rust from an iron object and prevent further rusting.

(i) Write a chemical equation for the reaction between iron(III) oxide and phosphoric acid to form iron(III) phosphate and water.

..... [2]

(ii) Iron(III) phosphate is an insoluble salt.

Suggest how the formation of iron(III) phosphate prevents further rusting.

.....

..... [1]

[Total: 15]