Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Extraction and corrosion of metals

Time allowed: 1 hour 30 minutes

Subject code **0620**

Chemistry

Questions from Paper 3, Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 90

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 90 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 This question is about metals.

(a) Carbon is used to extract iron from iron ore in a blast furnace.

(i) Name the main ore of iron.

..... [1]

(ii) Iron(III) oxide in the iron ore is reduced by carbon monoxide.

Name the **two** substances which react in the blast furnace to produce carbon monoxide.

..... and ..... [2]

(b) Iron rusts in the presence of oxygen and water.

State **one** method of preventing rusting.

..... [1]

(c) Table 5.1 shows some information about the reaction of four metals with steam.

Table 5.1

metal	reaction with steam when metal is cold
beryllium	reacts slowly
chromium	reacts slowly only when the metal is very hot
magnesium	reacts rapidly
silver	no reaction

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive → most reactive

[2]

[Total: 6]

Extraction of iron and aluminium Click for more variations

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1(a)(i)	hematite	**1**
1(a)(ii)	carbon (1) carbon dioxide (1)	**2**
1(b)	coating with plastic / painting / greasing / galvanising	**1**
1(c)	silver<chromium<beryllium <magnesium (1) if 2 marks not scored: 1 mark for 1 pair reversed (consecutive) OR magnesium<beryllium<chromium<silver	**2**

2 **(a)** The table describes the ease of reduction of some metal oxides with carbon.

metal oxide	ease of reduction on heating
lead oxide	moderate heating at 200 °C needed
nickel oxide	high temperature at 750 °C needed
titanium oxide	very high temperatures above 1700 °C needed
zinc oxide	very high temperature at 900 °C needed

Put the metals in order of their reactivity. Put the least reactive metal first.

least reactive → most reactive

[2]

(b) Aluminium is extracted by the electrolysis of molten aluminium oxide.

Predict the products of this electrolysis at the

positive electrode (anode),.....

negative electrode (cathode)..... [2]

(c) When iron reacts with dilute hydrochloric acid, an aqueous solution containing iron(II) ions is formed.

Describe a test for iron(II) ions.

test.....

result..... [2]

(d) Iron rusts very easily.

(i) Complete the following sentence.

Iron rusts in the presence of ..... and ..... . [2]

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(ii) Describe **one** method of rust prevention and explain how it works.

.....

.....

..... [2]

[Total: 10]

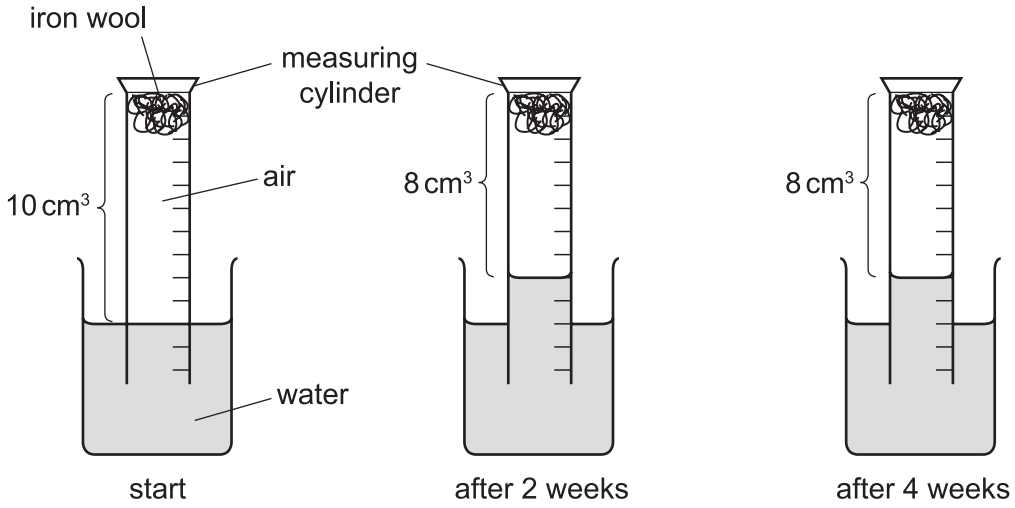
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Reactivity of metals Click for more variations

2(a)	lead < nickel < zinc < titanium; (1 mark if one pair reversed)	**2**
2(b)	 positive electrode: oxygen / O_2; negative electrode: aluminium / A*l*;	**2** 1 1
2(c)	 test: (aqueous) sodium hydroxide / (aqueous) ammonia; result: (grey-) green precipitate / solid;	**2** 1 1
2(d)(i)	 oxygen / air; water;	**2** 1 1
2(d)(ii)	 idea of covering surface with tin / zinc / other suitable metal / plastic / grease / oil / paint / galvanising; prevents oxygen / air or water / moisture / steam from getting to the surface;	**2** 1 1

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3 A student set up an experiment to demonstrate rusting as shown below.
He made observations at the start of the experiment, after 2 weeks and after 4 weeks.



(a) What conditions are needed for the iron wool to rust?

..... [2]

(b) Two weeks after the start of the experiment, the volume of air in the measuring cylinder had decreased. After a further two weeks there was no change in the volume of air.
Explain the results of this experiment.

.....

.....

.....

..... [3]

(c) What change would you observe in the iron wool as it rusted?

appearance at start .....

appearance after 2 weeks ..... [2]

(d) Rust contains iron(III) ions.
Describe a test for iron(III) ions.

test .....

result ..... [2]

(e) Clean iron reacts with dilute hydrochloric acid.

$$Fe + 2HCl \rightarrow FeCl_2 + H_2$$

Write a word equation for this reaction.

..... [2]

[Total: 11]

Rusting and its prevention Click for more variations

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3 **(a)** air / oxygen [1]
water [1]
allow: damp / humid

(b) idea of reaction of the oxygen (in first two weeks) [1]
ignore: air reacting
(oxygen reacting) with the iron / rusting / iron reacts [1]
ignore: reaction with rust / reaction with iron oxide
(after 2 weeks) all the oxygen had reacted / there was no further reaction / reaction had stopped / no more oxygen [1]
ignore: no more air / experiment was finished

(c) (at start →) shiny / silvery [1]
allow: grey
(after 2 weeks →) brown / reddish brown / orange [1]
allow: red
ignore: dull

(d) add (aqueous) sodium hydroxide / (aqueous) ammonia [1]
reddish-brown / brown precipitate (both colour and ppt needed) [1]
reject: red precipitate
note: 2nd mark dependent on correct reagent

(e) iron + hydrochloric acid → iron chloride + hydrogen [2]
1 mark for iron chloride; 1 mark for hydrogen
ignore: wrong oxidation numbers / numbers in equation

[Total: 11]

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4 Cassiterite is a naturally occurring form of tin oxide.

Describe how you would
- obtain a sample of tin from a large lump of cassiterite in the laboratory,
- determine the percentage by mass of tin present in cassiterite.

Tin is similar in reactivity to iron.

Your answer should include any apparatus and chemicals used and the conditions required.

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

[Total: 6]

Extraction of iron and aluminium Click for more variations

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4	any 6 from: • crush lumps • pestle and mortar • weigh cassiterite • heat / reduce • with carbon / CO / more reactive metal, e.g. Zn • weigh tin • (mass of tin / initial mass) × 100 (%)	**6**

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5 A list of oxides, **A** to **H**, is shown.

A calcium oxide

B aluminium oxide

C silicon(IV) oxide

D sulfur dioxide

E carbon dioxide

F iron(III) oxide

G silver oxide

H carbon monoxide

Answer the following questions about the oxides, **A** to **H**.
Each letter may be used once, more than once or not at all.

State which of the oxides, **A** to **H**:

(a) is responsible for acid rain

..... [1]

(b) has a giant covalent structure

..... [1]

(c) is a reducing agent in the blast furnace

..... [1]

(d) is the main constituent of bauxite

..... [1]

(e) is the main impurity in iron ore

..... [1]

(f) can be reduced by heating with copper.

..... [1]

[Total: 6]

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Extraction of iron and aluminium Click for more variations

5(a)	D	**1**
5(b)	C	**1**
5(c)	H	**1**
5(d)	B	**1**
5(e)	C	**1**
5(f)	G	**1**

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6 Aluminium was first isolated in 1827 using sodium.

$$AlCl_3 + 3Na \rightarrow Al + 3NaCl$$

Aluminium, obtained by this method, was more expensive than gold.

(a) Suggest an explanation why aluminium was so expensive.

.....

..... [1]

(b) The modern method for extracting aluminium is the electrolysis of a molten electrolyte, aluminium oxide dissolved in cryolite. The aluminium oxide decomposes.

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Both electrodes are made of carbon.

(i) Give **two** reasons why the oxide is dissolved in cryolite.

.....

.....

..... [2]

(ii) Complete the ionic equation for the reaction at the anode.

..... $O^{2-} \rightarrow O_2$ + ... e^-

[2]

(iii) Why do the carbon anodes need to be replaced frequently?

.....

..... [1]

(c) The electrolysis of a molten electrolyte is one method of extracting a metal from its ore. Other methods are the electrolysis of an aqueous solution and the reduction of the oxide by carbon. Explain why these last two methods cannot be used to extract aluminium.

electrolysis of an aqueous solution .....

.....

using carbon .....

..... [2]

[Total: 8]

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Extraction of iron and aluminium Click for more variations

6 **(a)** sodium is expensive / difficult to obtain sodium (from sodium chloride) / problems getting electricity / hard to extract sodium / high energy costs in extraction of sodium [1]

(b) **(i)** reduce temperature / reduce melting point (to 900/1000°C) temperature need not be stated, but if it is stated it must be within the range
better conductivity / solid aluminium oxide does not conduct
aluminium oxide is insoluble in water any **two** [2]

(ii) $2O^{2-} \rightarrow O_2 + 4e^-$ [2] or [0]

(iii) they burn (away) / react with oxygen / form carbon dioxide [1]

(c) hydrogen formed / aluminium above hydrogen in reactivity series / H^+ discharged in preference to Al^{3+} / aluminium is more reactive than hydrogen [1]
aluminium more reactive than carbon / carbon cannot reduce aluminium oxide / aluminium is higher than carbon in the reactivity series / carbon doesn't reduce aluminium oxide / carbon doesn't displace aluminium [1]
comparison is essential for mark

7 Iron from the blast furnace is impure. It contains 5% of impurities, mainly carbon, sulfur, silicon and phosphorus. Almost all of this impure iron is converted into the alloy, mild steel.

(a) **(i)** State a use of mild steel.

..... [1]

(ii) Name and give a use of another iron-containing alloy.

name .....

use ..... [2]

(b) The oxides of carbon and sulfur are gases. The oxides of silicon and phosphorus are not. Explain how these impurities are removed from the impure iron when it is converted into mild steel.

.....

.....

.....

.....

..... [5]

[Total: 8]

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Extraction of iron and aluminium Click for more variations

7 **(a)** **(i)** cars, ships, bridges, construction, white goods, screws, nails, roofing, fencing, etc. [1]

(ii) e.g. stainless steel [1]
cooking utensils, surgical equipment, sinks or main use [1]

(b) blow in oxygen **NOT** air [1]
carbon dioxide and sulfur dioxide (escape as gases) [1]
COND on reaction with air / oxygen
add calcium oxide / quicklime [1]
ALLOW calcium carbonate, limestone
phosphorus oxide **or** silicon oxide (are acidic)
reacts (with calcium oxide / $CaCO_3$) [1]
to form slag / calcium silicate [1]

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8 Aluminium is a very important metal.

Aluminium is extracted from its ore, bauxite, by electrolysis. Bauxite is an impure form of aluminium oxide, Al_2O_3.

(a) Describe how aluminium is extracted from **bauxite**. Include an ionic half-equation for the reaction at each electrode.

description .....

.....

.....

.....

.....

.....

.....

.....

ionic half-equation for the anode reaction .....

ionic half-equation for the cathode reaction.....

[5]

(b) Explain why the anodes have to be replaced regularly.

.....

..... [2]

(c) Give **two** uses of aluminium and give a reason why aluminium is suitable for each use.

use 1 .....

reason .....

use 2 .....

reason .....

[4]

[Total: 11]

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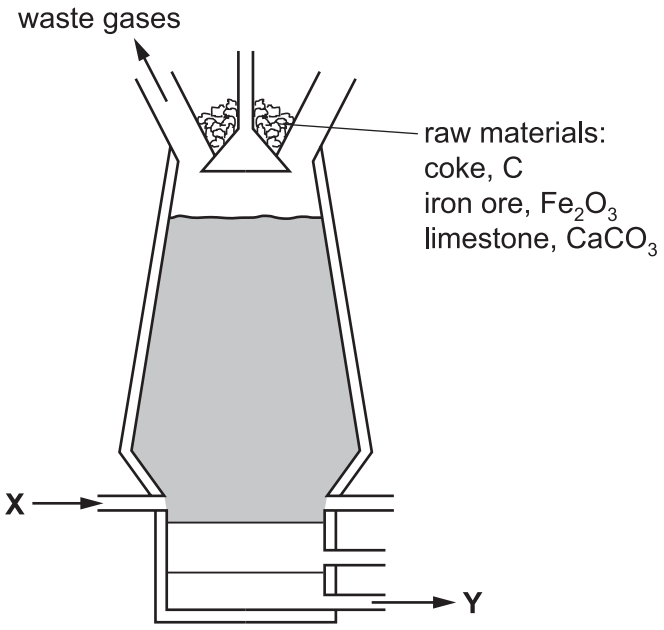
Extraction of iron and aluminium Click for more variations

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8(a)	bauxite/Alumina is dissolved in <u>molten</u> cryolite cryolite lowers the melting temperature molten aluminium forms *anode reaction*: $2O^{2-} \rightarrow O_2 + 4e^-$ *cathode reaction:* $Al^{3+} + 3e^- \rightarrow Al$	**5**
8(b)	carbon or graphite electrode reacts with oxygen / burns (in oxygen) / combusts	**2**
8(c)	*use 1*: manufacture of aircraft *reason 1*: low density *use 2*: food containers **OR** cooking foil *reason 2*: Al resistant to corrosion	**4**

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9 The diagram shows a blast furnace.



(a) The following equations represent reactions which take place in the blast furnace.

A $C + O_2 \rightarrow CO_2$

B $CaCO_3 \rightarrow CaO + CO_2$

C $CaO + SiO_2 \rightarrow CaSiO_3$

D $CO_2 + C \rightarrow 2CO$

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

(i) Which reaction is used to increase the temperature inside the blast furnace? ..... [1]

(ii) Which reaction is an example of thermal decomposition? ..... [1]

(iii) In which reaction is carbon both oxidised and reduced? ..... [1]

(iv) Which equation shows the removal of an impurity from the iron? ..... [1]

(v) Which equation shows the reaction of an acidic substance with a basic substance?

..... [1]

(b) Use the diagram of the blast furnace to help you answer these questions.

(i) What enters the blast furnace at **X**?

..... [1]

(ii) What leaves the blast furnace at **Y**?

..... [1]

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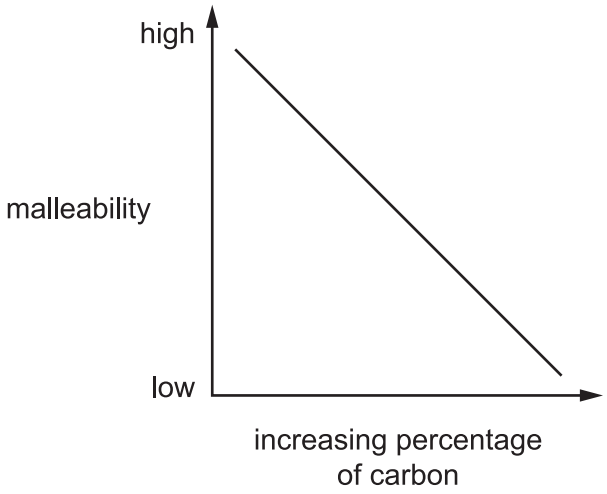
(iii) Name **two** waste gases that leave the blast furnace.

1. .....

2. .....

[2]

(c) The graph shows how the malleability of iron changes as the percentage of carbon in the iron changes.



(i) Describe how the malleability of iron changes as the percentage of carbon changes.

.....

..... [1]

(ii) Iron obtained from the blast furnace contains high levels of carbon.

Explain how the amount of carbon in the iron can be decreased.

.....

.....

..... [2]

[Total: 12]

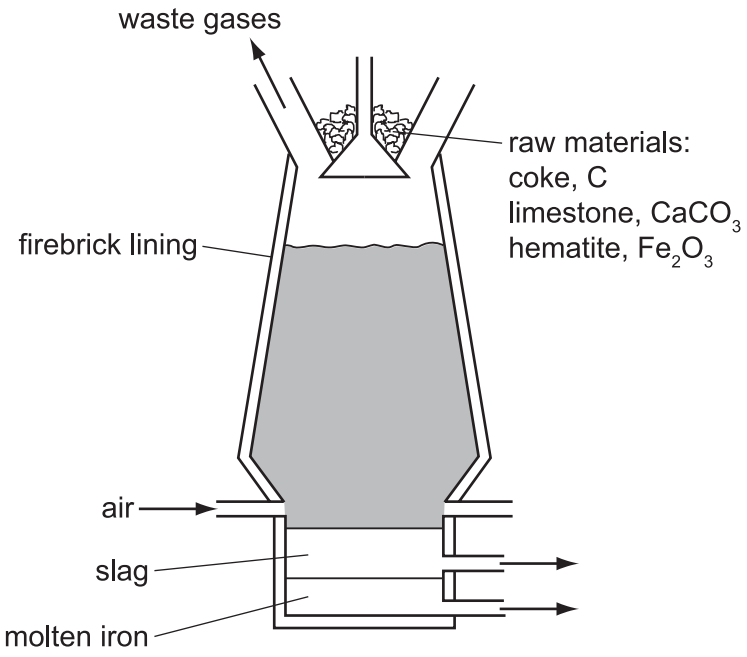
Extraction of iron and aluminium Click for more variations

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9(a)(i)	A;	**1**
9(a)(ii)	B;	**1**
9(a)(iii)	D;	**1**
9(a)(iv)	C;	**1**
9(a)(v)	C;	**1**
9(b)(i)	(hot) air;	**1**
9(b)(ii)	(molten) iron;	**1**
9(b)(iii)	any 2 from: carbon dioxide; carbon monoxide; nitrogen;	**2**
9(c)(i)	as the percentage of carbon increases, so the malleability decreases;	**1**
9(c)(ii)	 **M1** oxygen (gas) blown in; **M2** carbon dioxide formed / $C + O_2 \rightarrow CO_2$;	**2** 1 1

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10 Iron is extracted from its ore, hematite, in the blast furnace.



(a) The temperature inside the blast furnace can rise to 2000 °C.
Write an equation for the exothermic reaction which causes this high temperature.

..... [1]

(b) Carbon monoxide is formed in the blast furnace. This reduces the ore hematite, Fe_2O_3, to iron.

(i) Explain how carbon monoxide is formed in the blast furnace.

.....

..... [2]

(ii) Write an equation for the reduction of hematite by carbon monoxide.

..... [2]

(c) Explain why it is necessary to add limestone, calcium carbonate, to the blast furnace. Include an equation in your explanation.

.....

.....

..... [3]

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(d) Most of the iron from the blast furnace is converted into mild steel. A method of preventing the steel from rusting is coating it with zinc.

(i) What is the name of this method of rust prevention?

..... [1]

(ii) Explain, using the idea of electron transfer, why zinc-coated steel does not rust even when the coating is scratched and the steel is in contact with oxygen and water.

.....

.....

.....

..... [3]

[Total: 12]

Extraction of iron and aluminium Click for more variations

10 **(a)** $C + O_2 \rightarrow CO_2$ [1]

(b) **(i)** CO_2 already formed (from C burning or from $CaCO_3$); [1]
then carbon reacts with carbon dioxide; [1]
or
$C + CO_2 \rightarrow 2CO$ = [2] If equation not balanced = [1]

(ii) $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ [2]
not balanced = [1]
not: reduction by carbon

(c) to remove / neutralise silica / silicon dioxide / silicon(IV) oxide / sand; [1]
reacts with limestone to form slag / calcium silicate; [1]
$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$ [1]
or $CaO + SiO_2 \rightarrow CaSiO_3$
or $CaCO_3 \rightarrow CaO + CO_2$

(d) **(i)** galvanising / galvanisation / sacrificial protection; [1]

(ii) sacrificial protection / zinc is sacrificed;
zinc corrodes rather than iron;
zinc is oxidised in preference to iron;
zinc reacts with oxygen and / water in preference to iron;
zinc more reactive / electropositive than iron;
zinc loses electrons more readily than iron;
electrons move on to iron
any **three** [3]

[Total: 12]

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