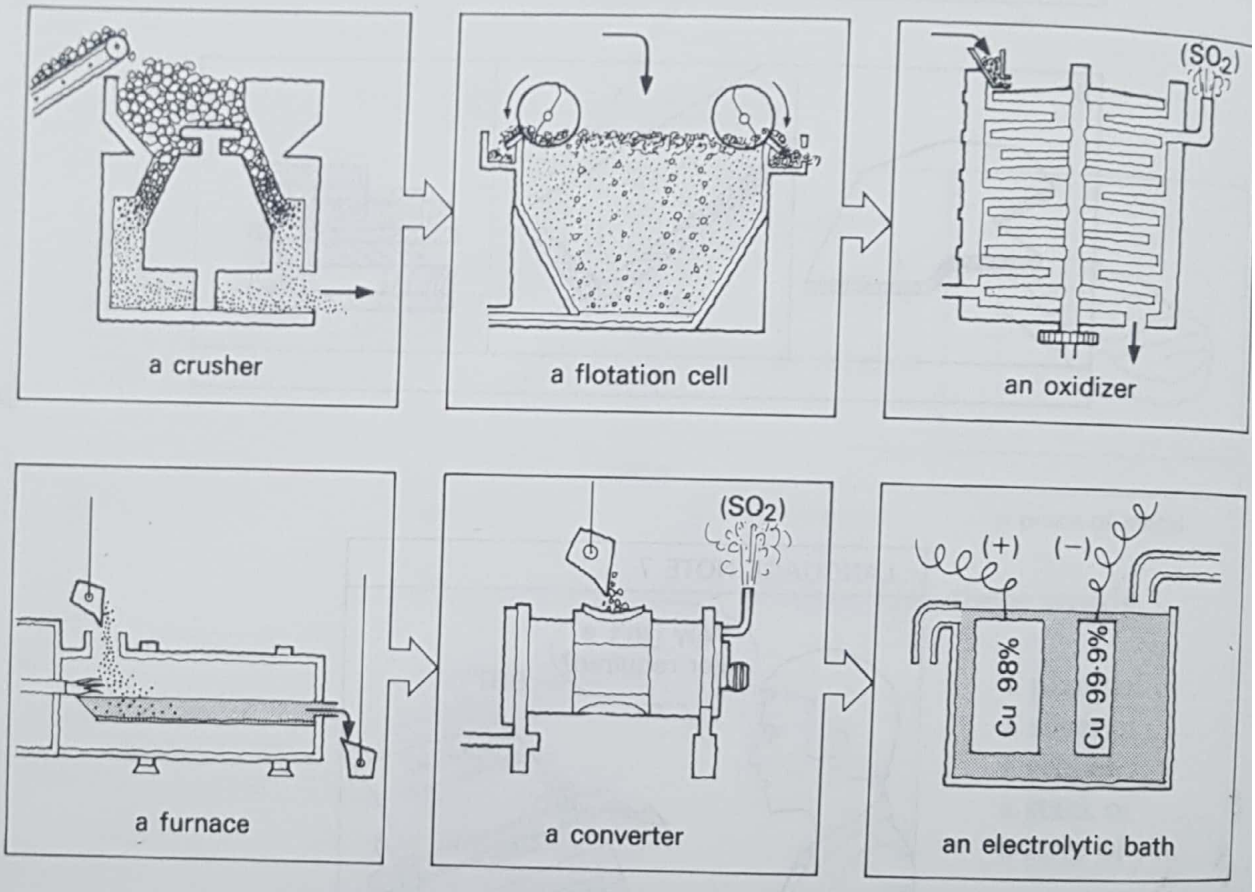
UNIT FOUR Industrial Chemistry

SECTION A: THE PRODUCTION OF COPPER



Copper Sulphide (Cu_2S) Ores

The ore is first crushed. It is crushed into fine grains.

Next, the minerals are separated from the rock particles. They are separated in flotation cells. The rock particles sink to the bottom and the copper-rich grains are carried to the surface. This copper-rich ore is called concentrate.

The concentrate is now oxidized. Hot air is passed through the oxidizer. Some of the sulphur is transformed into sulphur dioxide gas (SO_2) and is allowed to escape.

The concentrate is then smelted in a furnace. Silica (SiO_2) is added to the mixture. More sulphur is transformed into gas (SO_2) and allowed to escape. Copper ore also contains iron sulphide (FeS). This is

transformed into iron silicate ($FeSiO_3$) and removed from the surface of what is now impure copper.

The impure copper is then transferred to a converter. Hot air is again passed through the mixture. Silica is again added. More iron is removed in this way. The copper sulphide plus oxygen is converted into pure copper plus sulphur dioxide gas:

$$Cu_2S + O_2 \longrightarrow 2Cu + SO_2$$

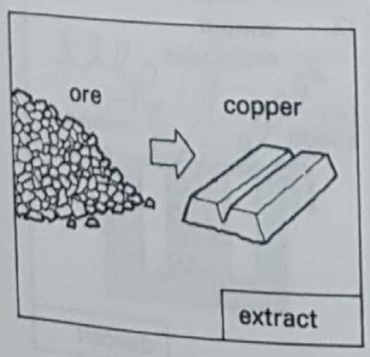
The copper is now 98% pure. It is removed from the converter and allowed to cool into blocks. The blocks are called anodes.

The copper anodes are refined in an electrolytic bath. The cathodes are pure copper and the electrolyte is usually copper sulphate ($CuSO_4$). An electric current is passed through the bath and the anodes slowly dissolve into the electrolyte. The copper molecules are eventually deposited on the cathodes. This copper is now 99.9% pure.

Exercise 1 Answer these questions.

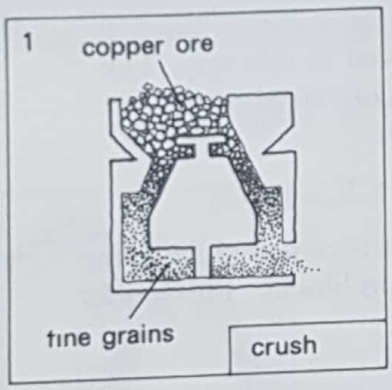
1. What happens to the ore in the crusher?
2. What happens to the ore in the flotation cells?
3. What happens to the concentrate in the oxidizer?
4. What happens to the concentrate in the furnace?
5. What happens to the iron sulphide in the furnace?
6. What happens to the copper sulphide in the converter?
7. What happens to the copper anodes in the electrolytic bath?
8. What happens to the copper molecules in the electrolyte?

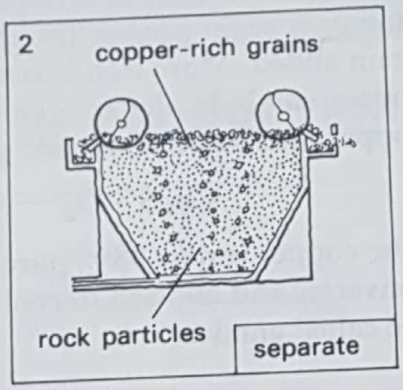
Exercise 2 Look at this example.

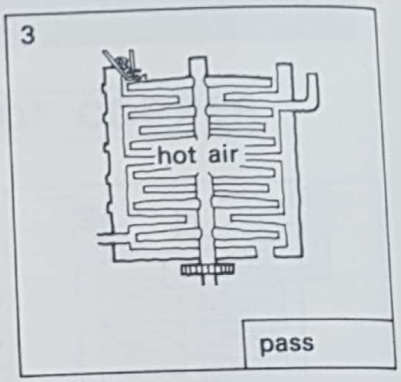


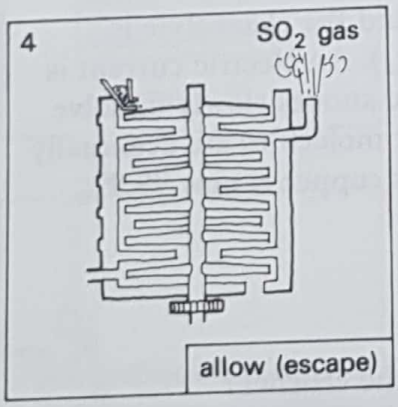
Copper is extracted from the ore.

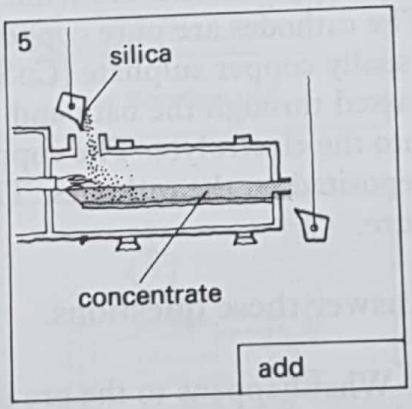
Now make sentences from these pictures in the same way.

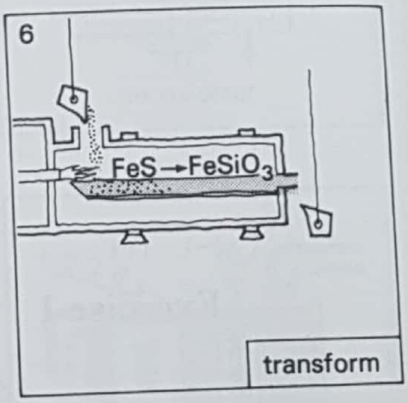


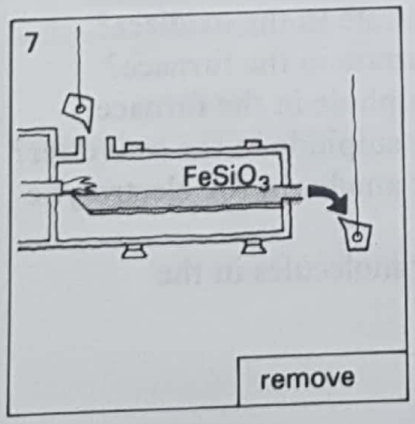


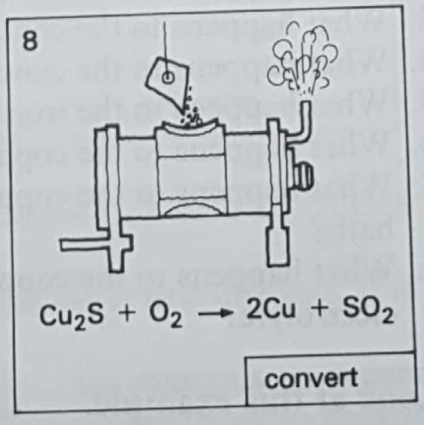


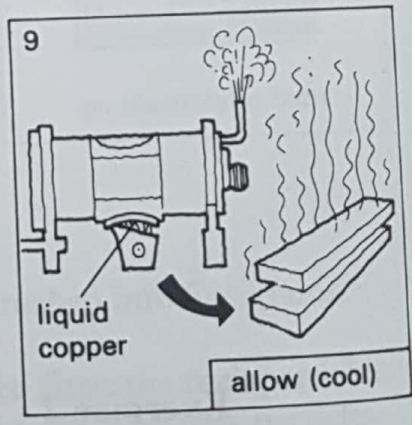


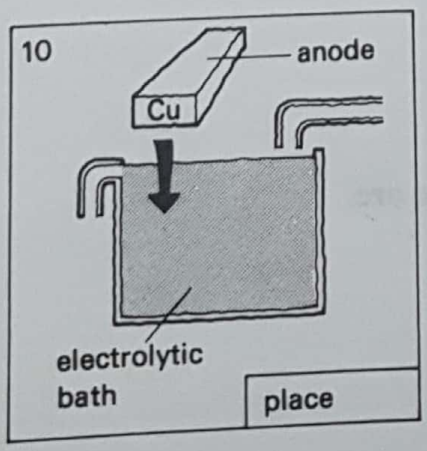


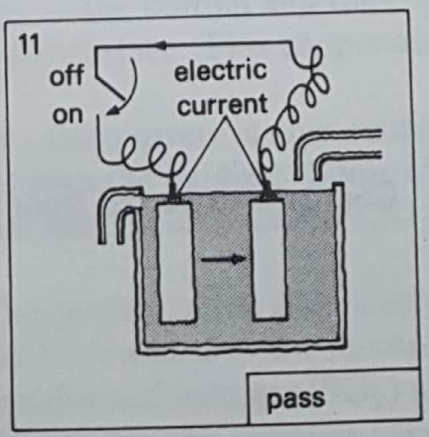


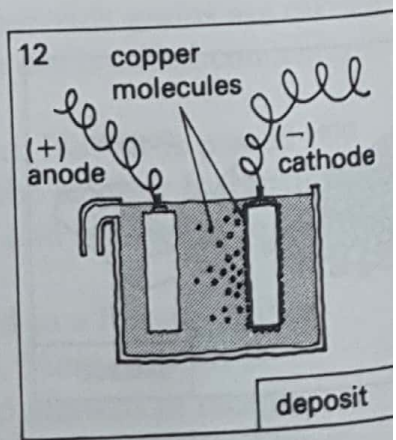






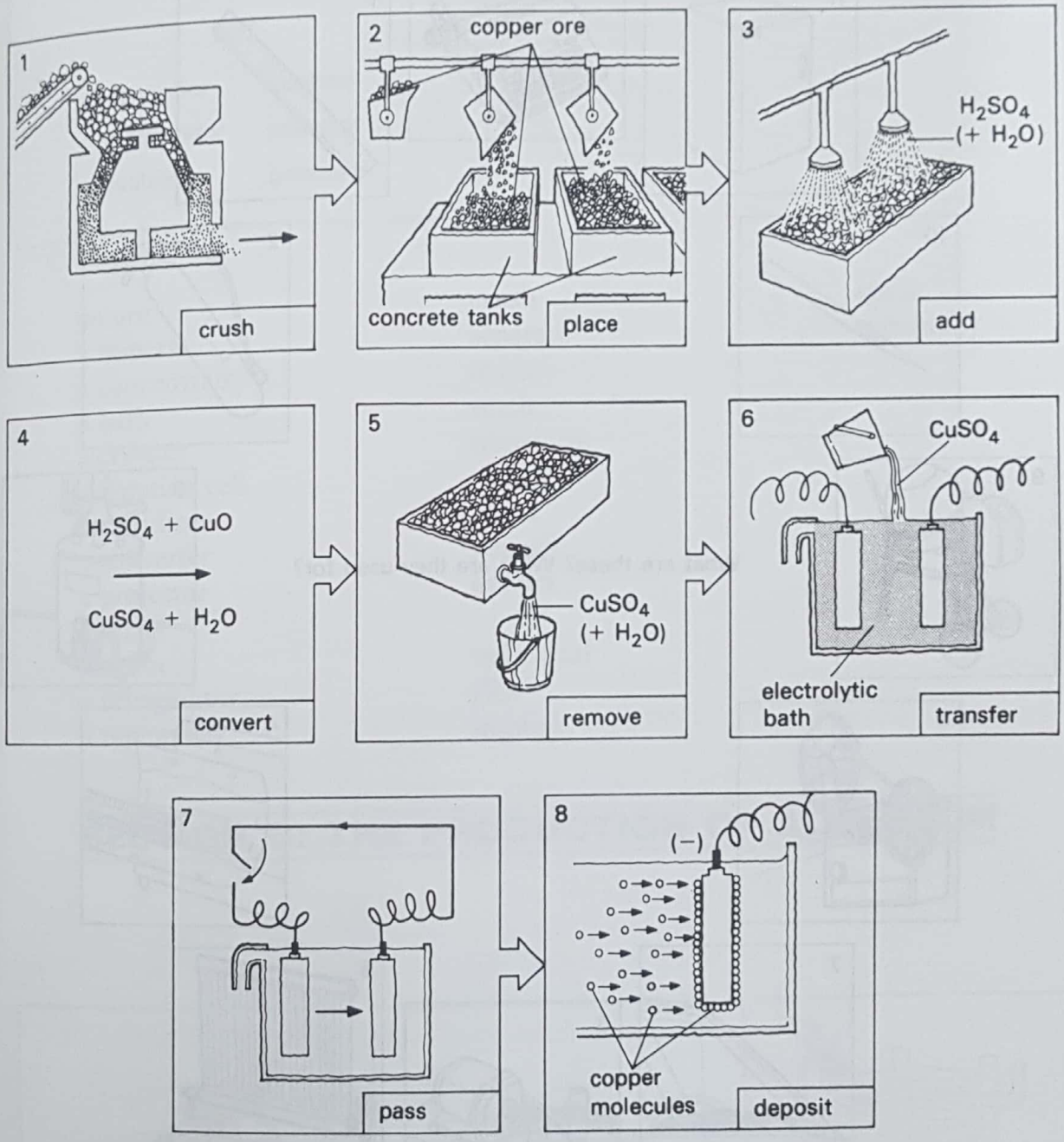




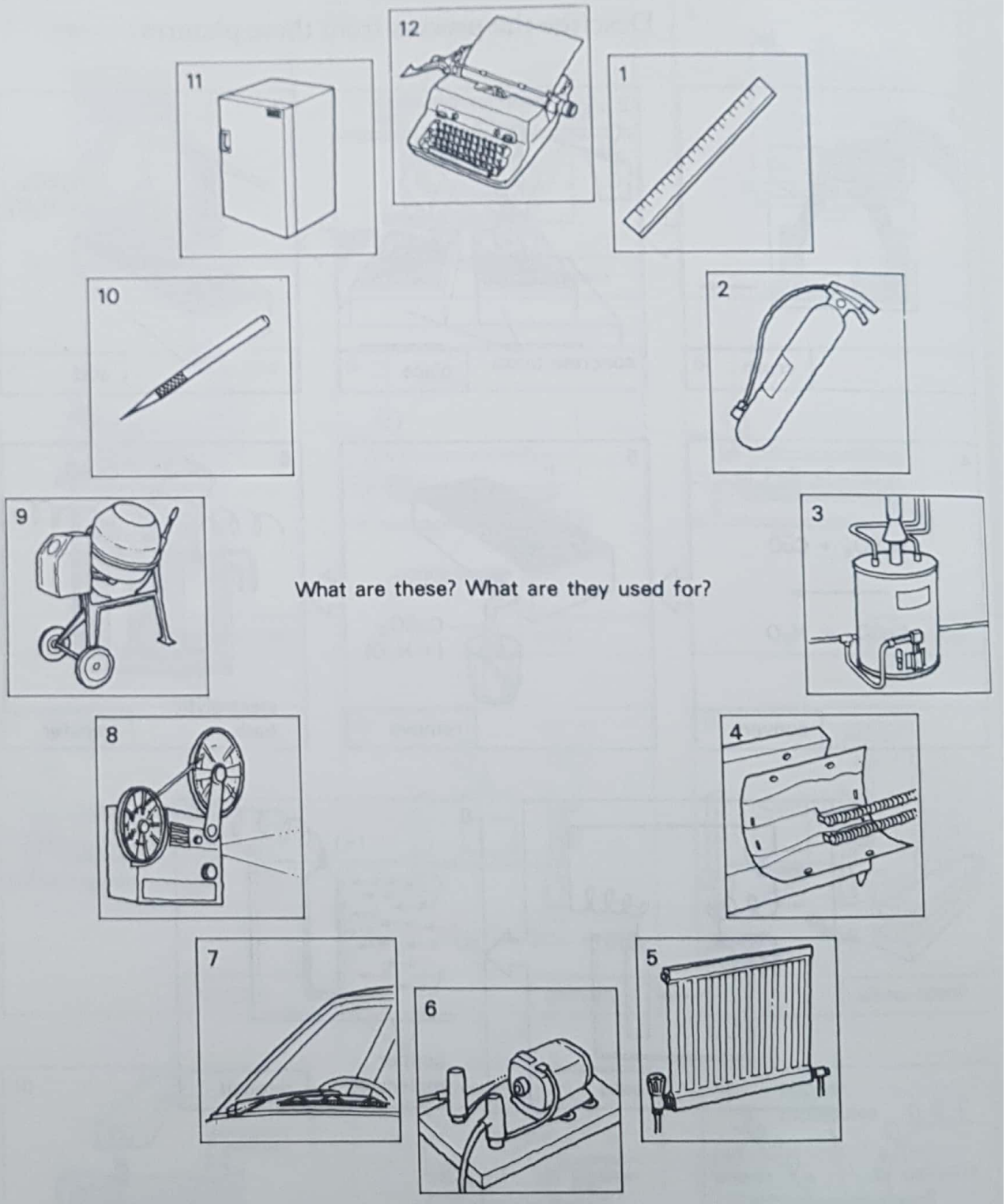


Exercise 3 Some copper ores do not contain copper sulphide. They contain *copper oxide* (CuO). Copper oxide ores are much simpler to purify.

Describe the process from these pictures.



Exercise 4 What are these?
What are they used for?



Example: This is a ruler.
It is used for measuring dimensions.

LANGUAGE NOTE 8

crusher	condenser
oxidizer	container
typewriter	mixer
converter	scriber

BUT

conductor	insulator
refrigerator	projector
radiator	generator

LANGUAGE NOTE 9

deposit → deposited

BUT

transfer → transferred

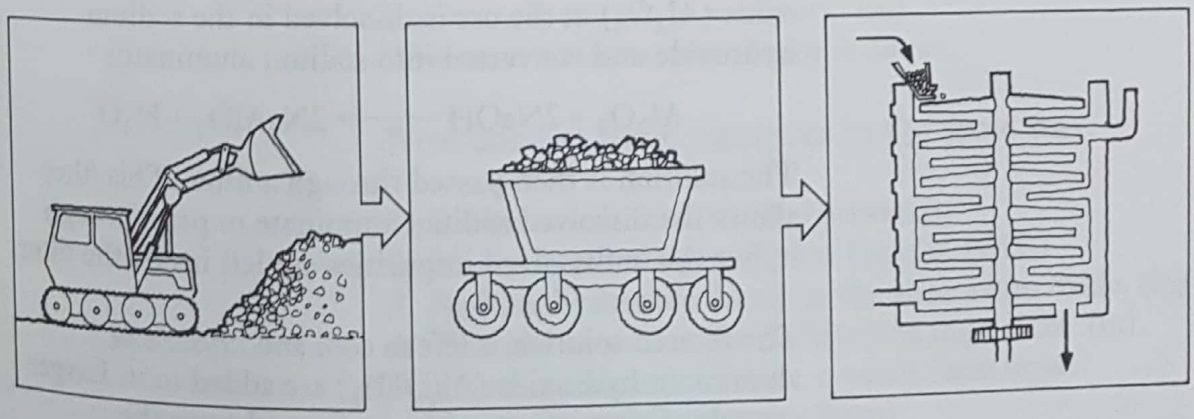
an ore
a mineral
a concentrate
a bath
a crusher
a flotation cell
an oxidizer
a converter
a projector
a mixer
a scriber
a refrigerator
a typewriter

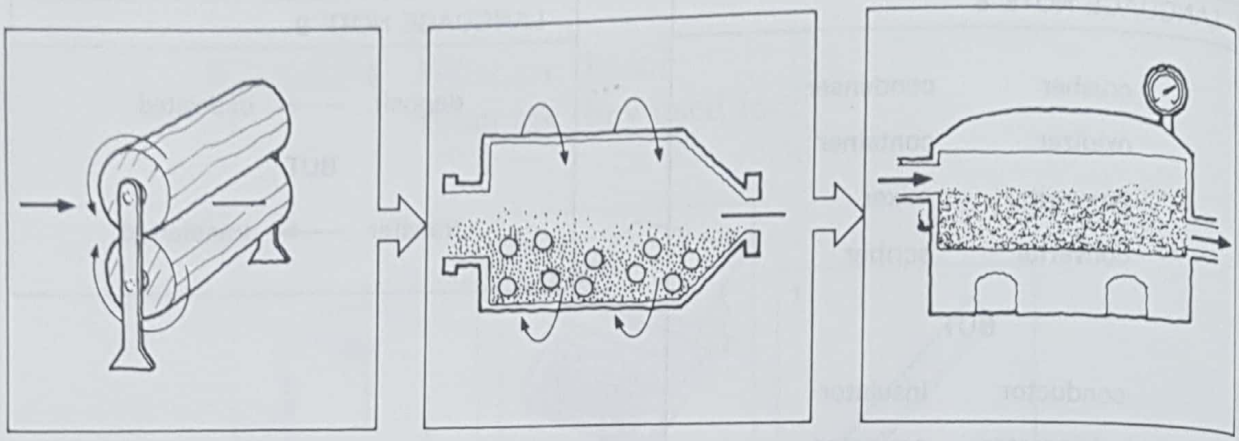
crush
separate
oxidize
smelt
transform
transfer
refine
deposit
extract

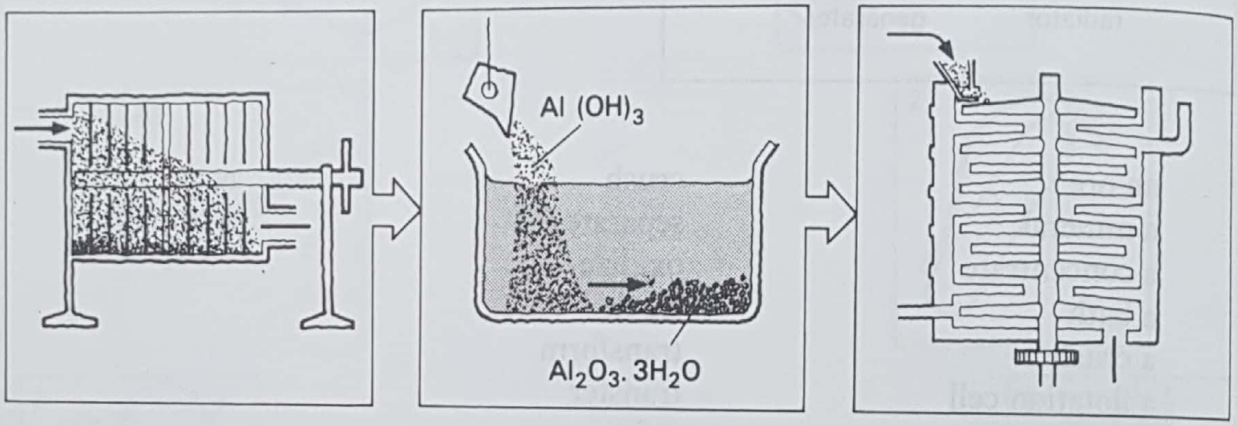
industrial
rich
impure

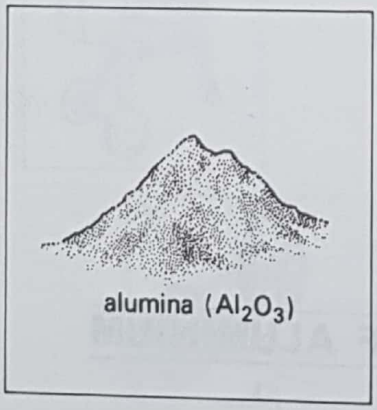
again
eventually

SECTION B: THE PRODUCTION OF ALUMINIUM









Treating the ore

Aluminium is produced from bauxite. Bauxite is generally found near the surface and so it is comparatively cheap to mine. The ore is then taken to a refinery in its natural state. At the refinery it is heated and dried. The water content is extracted in this way. The dried bauxite is then crushed between rollers. Finally, it is powdered with heavy steel balls.

Purifying the ore

The powdered ore is now mixed with heated sodium hydroxide (NaOH) in a pressurized bath. The aluminium oxide (Al_2O_3) in the ore is dissolved in the sodium hydroxide and converted into sodium aluminate:

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

The solution is then passed through a filter. This filter allows the dissolved sodium aluminate to pass through it, but the undissolved impurities are left inside the filter.

The filtered solution is left to cool and crystals of aluminium hydroxide ($Al(OH)_3$) are added to it. Larger crystals of aluminium oxide are formed from the aluminium hydroxide crystals. These larger crystals are a

combination of aluminium oxide and water ($Al_2O_3.3H_2O$).

Finally, the crystallized aluminium oxide is put into another drier. At a temperature of more than 1000°C the water is allowed to escape in the form of steam. Pure alumina now remains in the form of a white powder.

Exercise 5 Irregular verbs do not usually have forms ending in *-ed*. How many irregular verbs are used in this text? Find their different forms in Appendix One.

Are these statements true or false? Rewrite the untrue statements.

1. Bauxite is a type of aluminium ore.
2. Bauxite is comparatively cheap to mine because it is found near the surface.
3. Bauxite is treated at a refinery.
4. Bauxite does not contain water.
5. Sodium hydroxide dissolves aluminium oxide and converts it into sodium aluminate.
6. The sodium hydroxide bath is heated and pressurized.
7. Sodium aluminate does not dissolve.
8. The undissolved impurities pass through the filter.
9. Aluminium oxide crystals are a combination of aluminium oxide and water.
10. The drier converts aluminium oxide crystals into powdered aluminium and steam.

Exercise 6 Read the example below.

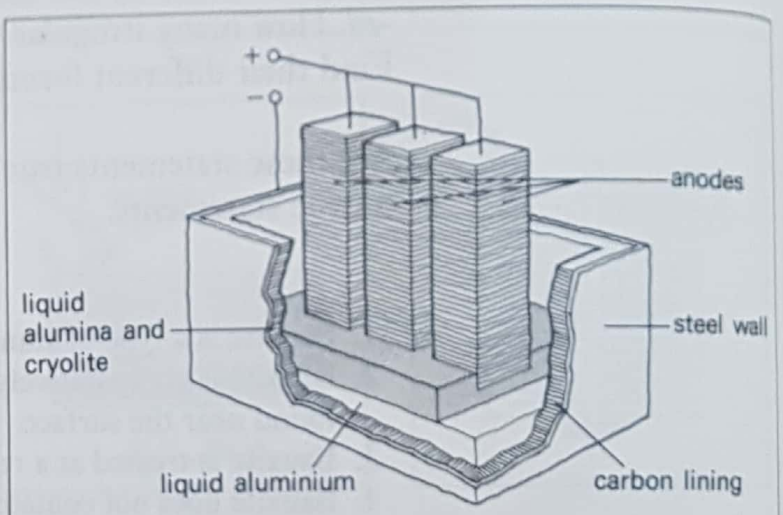
Lorries take the ore to a refinery. (in)
The ore *is taken* to the refinery *in lorries*.

Now convert these sentences in the same way.

1. Rollers crush the bauxite. (between)
2. Heavy steel balls powder the bauxite. (with)
3. Sodium hydroxide dissolves the aluminium oxide. (in)
4. The filter removes the undissolved impurities. (in)
5. The aluminium hydroxide crystals form larger aluminium oxide crystals. (from)
6. The drier converts the crystals into pure alumina. (in)

Exercise 7 Complete these paragraphs from the wordlist below

affected	*electric*	*point*
are	*eventually*	*separates*
blocks	*into*	*sinks*
bottom	*furnaces*	*solidify*
combination	*lining*	*than*
converting		*transformed*



An electric furnace for refining aluminium

Refining the alumina

An electrolytic process is used for . . . . the alumina powder into aluminium. The alumina is liquefied inside a furnace and a strong . . . . current is passed through it. The current . . . . the alumina into aluminium and oxygen molecules:

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

The pure aluminium . . . . to the bottom of the furnace. It is allowed to run into containers and is then left to . . . . into blocks. The oxygen molecules . . . . attracted to the carbon anodes in the furnace. These anodes are slowly oxidized and . . . . into carbon monoxide gas (CO). They are . . . . replaced with new anodes.

These electric . . . . are generally rectangular steel containers. The sides and the bottom have a thick . . . . of carbon. This forms the cathode. The anodes are large . . . . of carbon. The electrolyte is a mixture of alumina and cryolite. Cryolite is a chemical . . . . of aluminium, sodium and fluorine. It is used to lower the melting . . . . of the alumina from approximately 2000°C to about

1000°C. The cryolite is not . . . . by the electric current but the alumina is converted . . . . aluminium and oxygen. The pure aluminium is heavier . . . . the cryolite mixture and so it sinks to the . . . . of the furnace. More alumina is added to the mixture and the refined aluminium is removed.

Exercise 8 Convert these verbs into adjectives and then add them to the sentences below.

Example:

solder

A . . . . joint is often stronger than the metal around it.

A *soldered* joint is often stronger than the metal around it.

crystallize	*heat*	*powder*
dissolve	*liquefy*	*pressurize*
dry	*oxidize*	*purify*
filter		

1. The . . . . bauxite is crushed between rollers.
2. The . . . . ore is transferred to a bath of . . . . sodium hydroxide.
3. This . . . . bath converts the aluminium oxide into sodium aluminate.
4. The . . . . sodium aluminate is passed through a filter.
5. The . . . . impurities are left inside the filter.
6. The . . . . solution is left to cool.
7. . . . . aluminium oxide is put into a drier.
8. The . . . . aluminium oxide is in the form of white powder.
9. In the furnace the . . . . alumina separates into aluminium and oxygen molecules.
10. The . . . . anodes are replaced with new anodes.

LANGUAGE NOTE 10

noun	verb
powder	powder
filter	filter
solder	solder
hammer	hammer
BUT	
oxide	oxidize
pressure	pressurize
crystal	crystallize
anode	anodize

LANGUAGE NOTE 11

alumina = aluminium oxide = Al_2O_3

caustic soda = sodium hydroxide = NaOH

silica = silicon dioxide = SiO_2

lime = calcium oxide = CaO

a refinery
a roller
a ball
a solution
a filter
an impurity
a crystal
a combination
a powder

a drier
bauxite
cryolite
fluorine

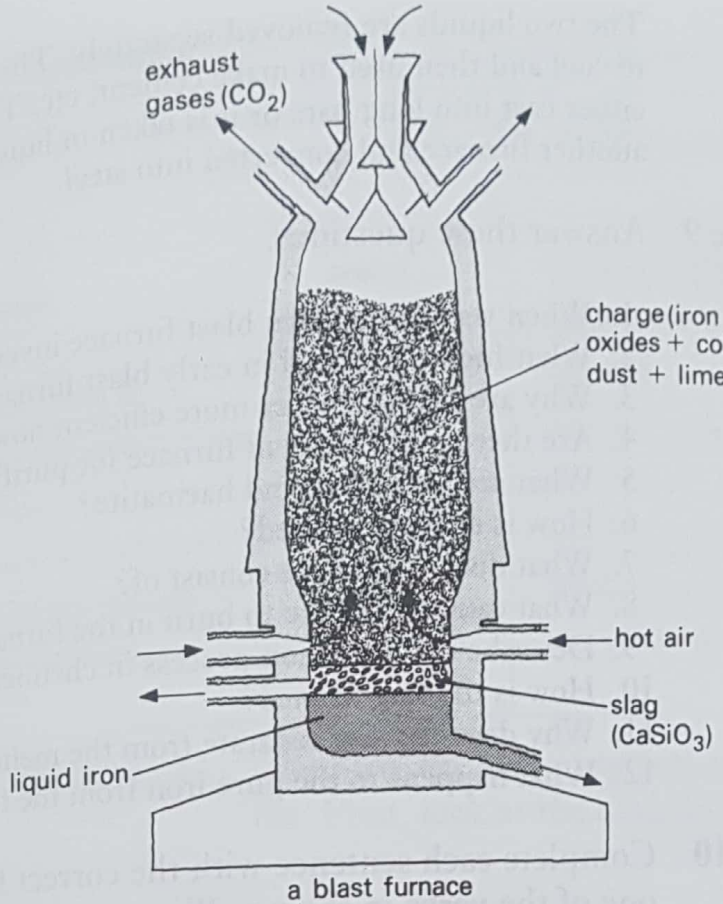
treat
find
mine
dry
powder
pressurize
leave
cool
form
crystallize

natural

SECTION C: THE PRODUCTION OF IRON

Iron became an important engineering material at a very early date. Simple furnaces were used for producing iron thousands of years ago. The modern blast furnace was invented around 1800. Early blast furnaces burnt coal or charcoal. Cold air was used for the blast.

Nowadays, blast furnaces are much more efficient. The charge contains coke instead of coal, and hot air is used instead of cold air. A hundred years ago, the production of one tonne of iron required two or three tonnes of coke. Nowadays, only about half a tonne of coke is needed. Other types of modern furnace, for example electric furnaces, use little or no coke at all. They burn gases or oils instead of coke.



a blast furnace

Iron oxides are found in two main ores. These are magnetite (Fe_3O_4) and haematite (Fe_2O_3). They are usually mined in the form of rock. The ores are first processed by a crusher. The large pieces of rock are broken into smaller pieces. Large unbroken pieces are removed by a filter. The ore is then ground into a fine powder. The powdered ore is mixed with coke dust and lime (CaO). The mixture is then heated. This process causes it to form into small lumps.

The charge is fed into the top of the furnace. Hot air is blown into the bottom of the furnace at great pressure. The coke is rapidly oxidized by this blast of air and very high temperatures are produced. The burnt coke produces carbon monoxide (CO) gas. The iron oxide is reduced to pure iron by the hot gas.

$$FeO + CO \longrightarrow Fe + CO_2$$

At the same time, the lime transforms the silica impurities into calcium silicate slag.

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

The iron and the slag both fall to the bottom of the furnace in liquid form. The slag is less dense than the iron and so it remains on the surface of the melted iron.

The two liquids are removed separately. The slag is left to cool and then used to make cement, etc. The iron is either cast into long bars or it is taken in liquid form to another furnace and converted into steel.

Exercise 9 Answer these questions.

1. When was the modern blast furnace invented?
2. What fuels were used in early blast furnaces?
3. Why are blast furnaces more efficient nowadays?
4. Are there other types of furnace for purifying iron?
5. What are magnetite and haematite?
6. How is iron ore treated?
7. What does the charge consist of?
8. What causes the coke to burn in the furnace?
9. Describe the reduction process in chemical terms.
10. How is the slag formed?
11. Why does the slag separate from the melted iron?
12. What happens to the pure iron from the furnace?

Exercise 10 Complete each sentence with the correct form of one of the verbs in the wordlist.

blow	*cast*	*grind*
break	*feed*	*leave*
burn	*find*	*take*

1. Coal or charcoal . . . . . in early blast furnaces.
2. Normally, iron ores . . . . . in the form of rock.
3. Large pieces of rock . . . . . into smaller pieces in a crusher.
4. The ore . . . . . into a fine powder.
5. The charge . . . . . into the top of the furnace.
6. Hot air . . . . . into the bottom of the furnace at great pressure.
7. The liquid slag . . . . . to cool into large blocks.
8. Sometimes, the pure iron . . . . . into long bars.
9. Sometimes, the iron . . . . . to another furnace and converted into steel.

Exercise 11 Read these examples.

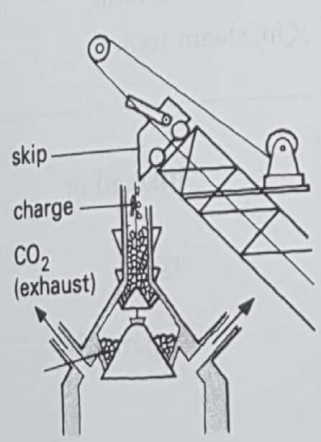
First, make eight true sentences (Type A) from the table. Then transform each sentence into another (Type B) sentence.

Examples:

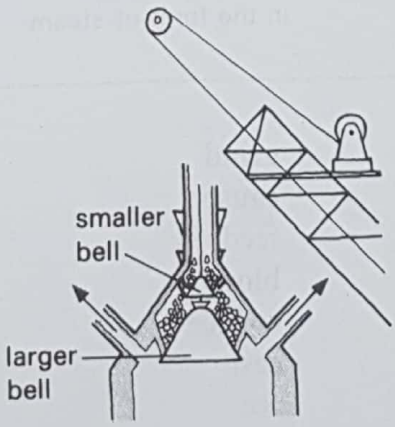
A.	A crusher processes the ore.
B.	The ore is processed by a crusher.

1.	A crusher	breaks	the rock into smaller pieces.
2.	A filter	converts	large unbroken pieces.
3.	A hot blast of air	melts	the coke.
4.	Heated carbon monoxide	oxidizes	iron into steel.
5.	The lime	produces	the iron and the slag.
6.	The heat of the furnace	reduces	the iron oxide to pure iron.
7.	A large blast furnace	removes	3000 tonnes of iron per day.
8.	A separate furnace	transforms	the silica impurities to calcium silicate.

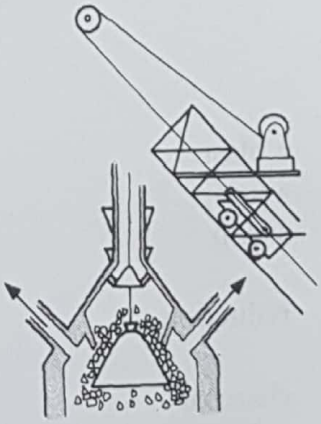
Exercise 12 Complete the following paragraphs from the word-list. First, look at the diagrams carefully.



both bells raised



smaller bell lowered



larger bell lowered

allowed
by
caused
charge
exhaust
fall
into
never
sealed
through
top
transferred
under

In a blast furnace, large amounts of CO_2 gas are . . . . by the reduction process. These . . . . gases are extremely hot. The exhaust outlets are near the . . . . of the furnace. The gases are removed . . . . pressure and are used to heat the air blast of the furnace. The gases are not . . . . to escape into the atmosphere through the top of the furnace. The furnace top is sealed . . . . two *bells* (*see diagram*).

The charge is . . . . to the top of the furnace in *skips*. These skips are emptied . . . . the furnace top. The smaller bell is then lowered and the charge is allowed to . . . . onto the larger bell. The furnace is still . . . . because the larger bell is raised. Then the smaller bell is raised again. Finally, the larger bell is lowered and the . . . . is allowed to fall into the furnace. The two bells are . . . . lowered at the same time. In this way, the furnace top is completely sealed and the exhaust gases never escape . . . . it.

LANGUAGE NOTE 12

in the form of a liquid	= in liquid form
in the form of a powder	= in powder form
in the form of a rock	= in rock form
BUT	
in the form of a gas	= in gaseous form
in the form of steam	~~in steam form~~

a blast
a lump
a skip

reduction

charcoal
coke
dust
magnetite
haematite
slag

grind
cause
feed
blow
reduce
cast
see

instead of

ago

separately