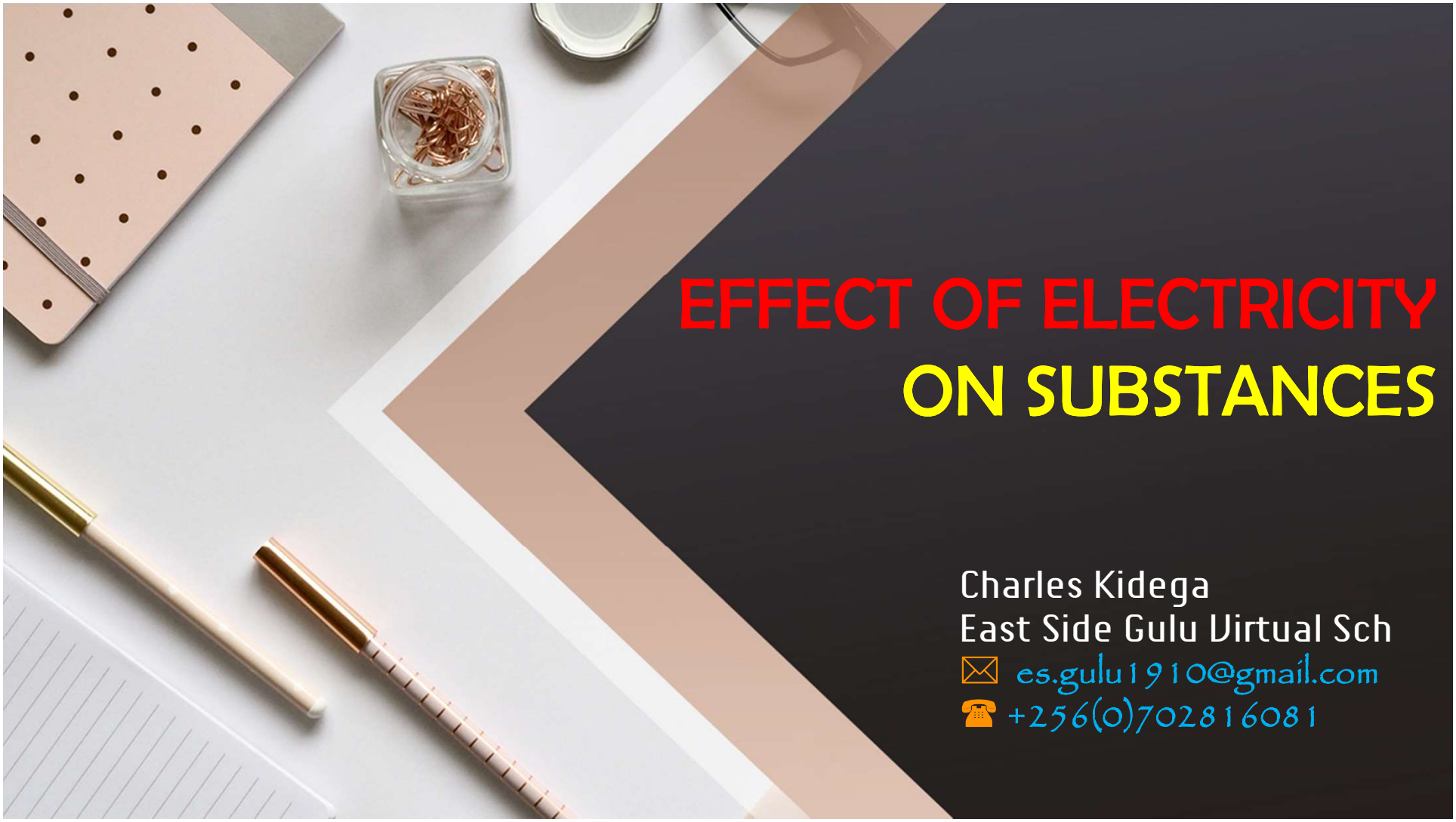
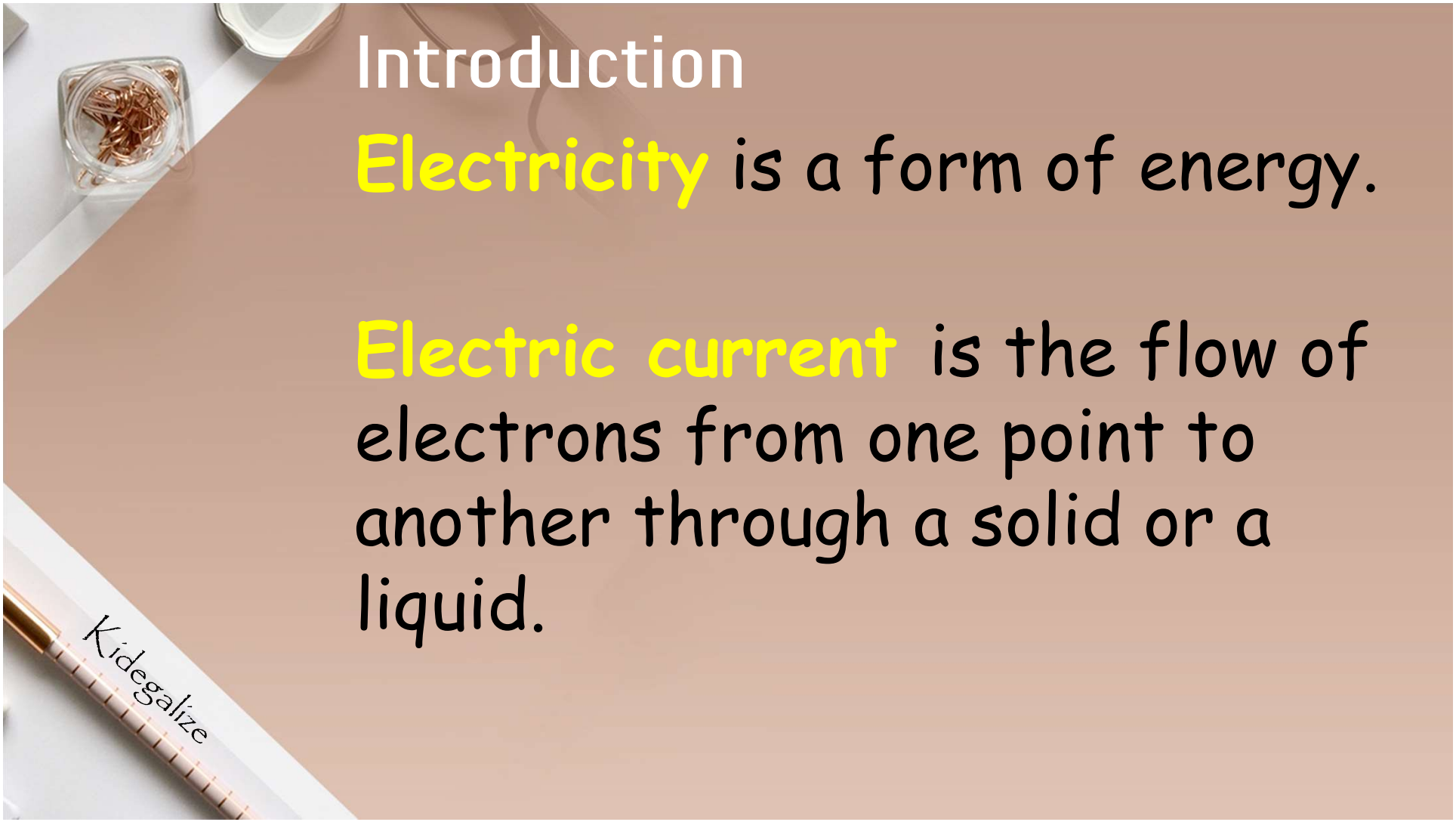


EFFECT OF ELECTRICITY ON SUBSTANCES

Charles Kidega
East Side Gulu Virtual Sch
✉ es.gulu1910@gmail.com
☎ +256(0)702816081



Introduction

Electricity is a form of energy.

Electric current is the flow of electrons from one point to another through a solid or a liquid.

Conductors

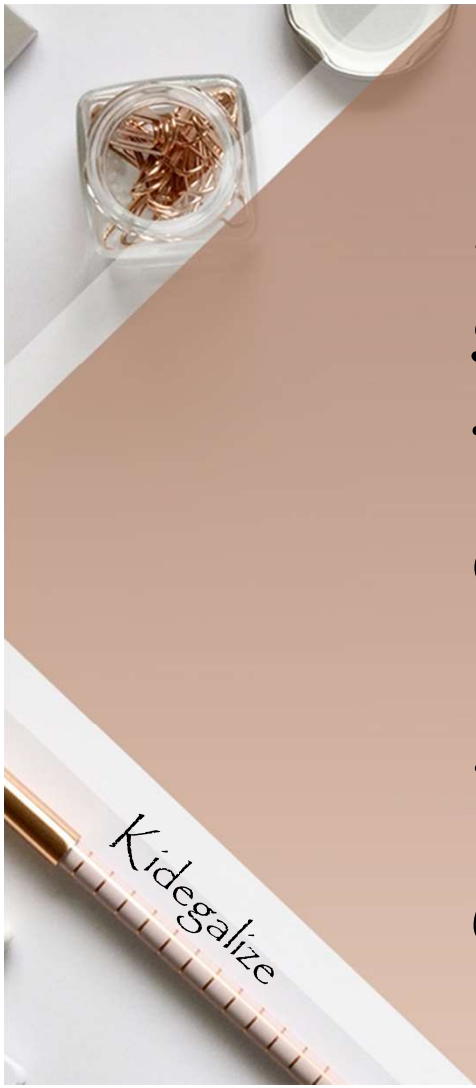
A **conductor** is a solid material that allows electric current to pass through it e.g. graphite, metals such as Al, Zn, Cu.

Conductors have free mobile electrons which move about in the solid transferring electric current.

Insulators

Insulators/non-conductors are solid materials that do not allow the passage of electric current e.g. rubber, plastics, wood.

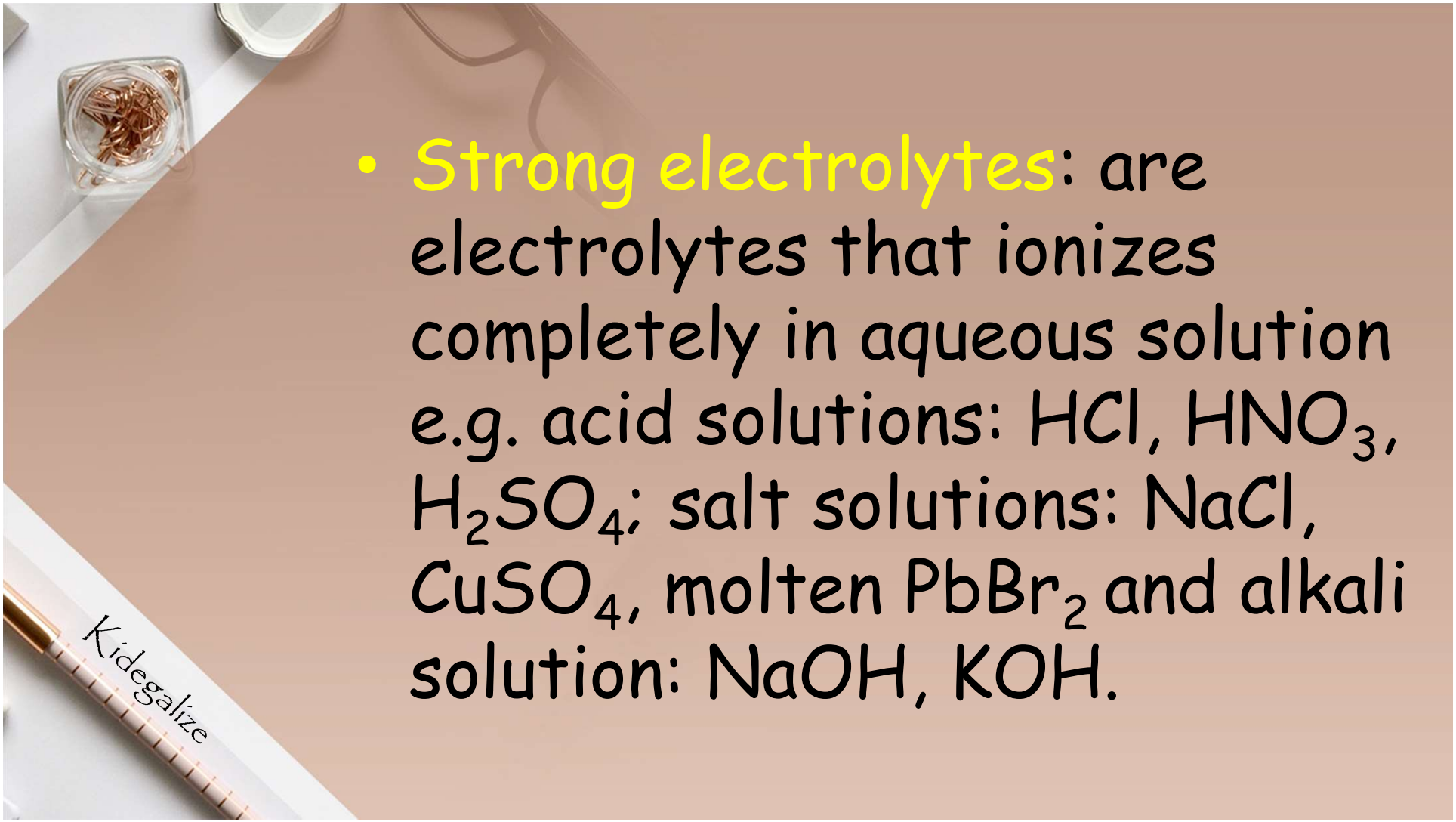
Non-conductors have electrons that are locked up in covalent bonds and are not free to move.



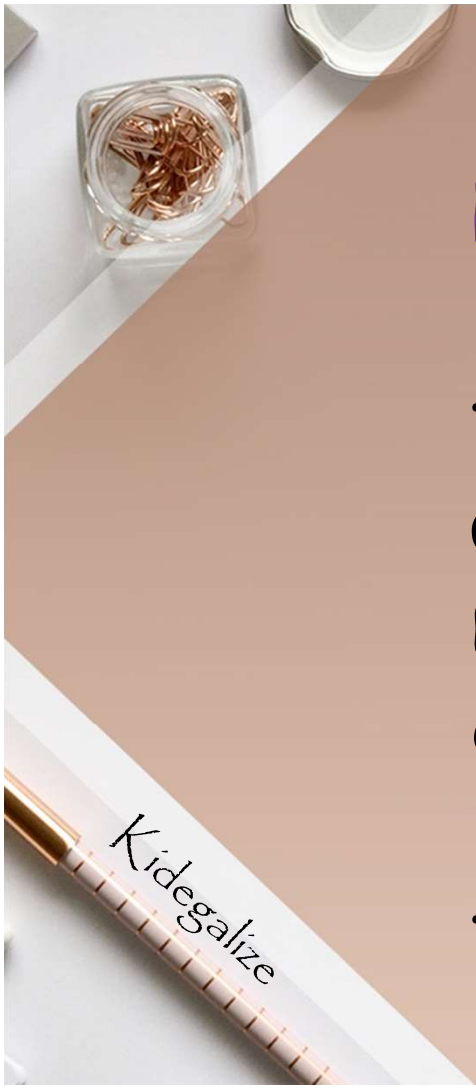
Electrolytes

An electrolyte is a molten or solution of an ionic compound that conducts an electric current and is decomposed by it.

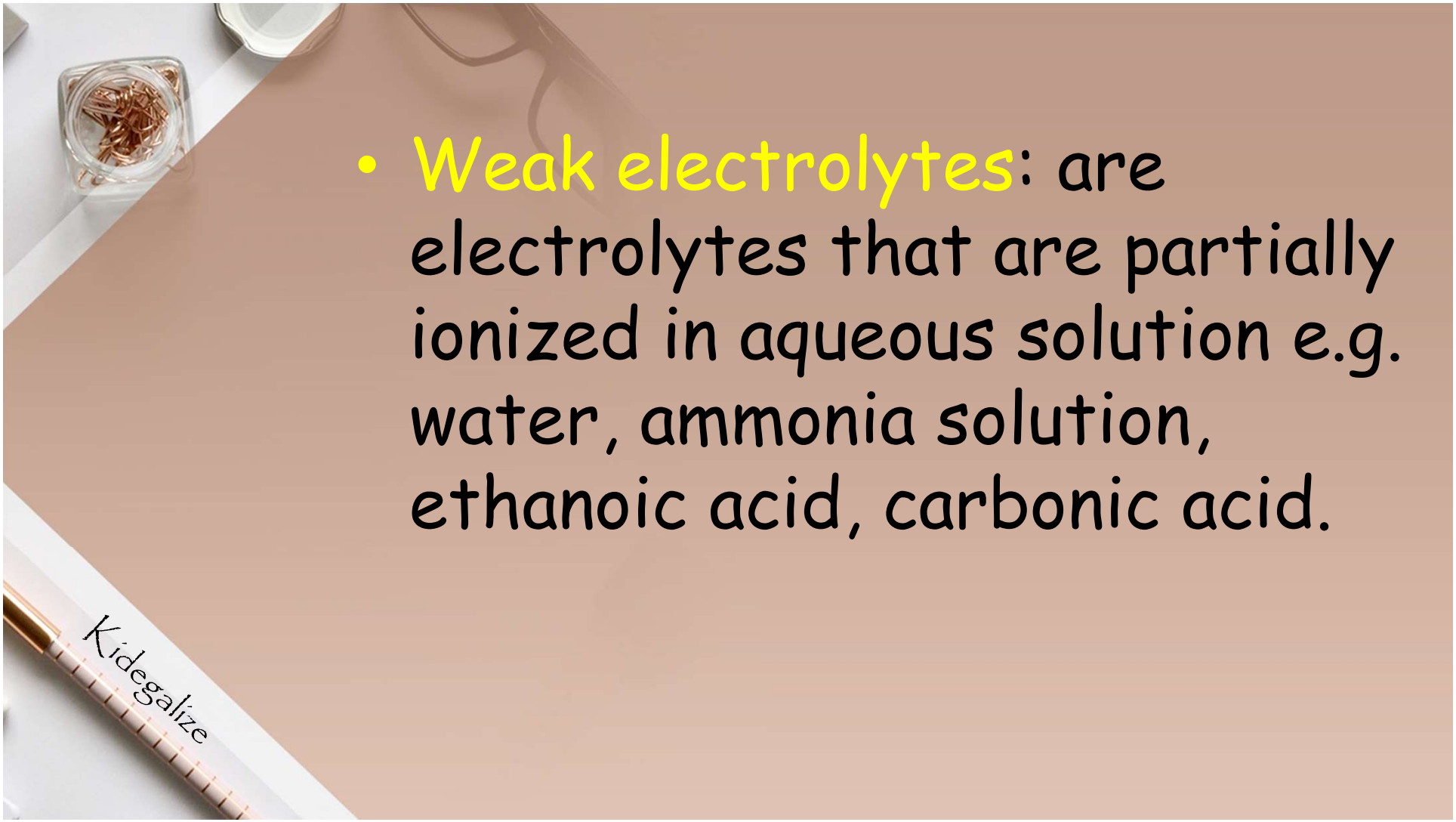
There are two types of electrolytes.



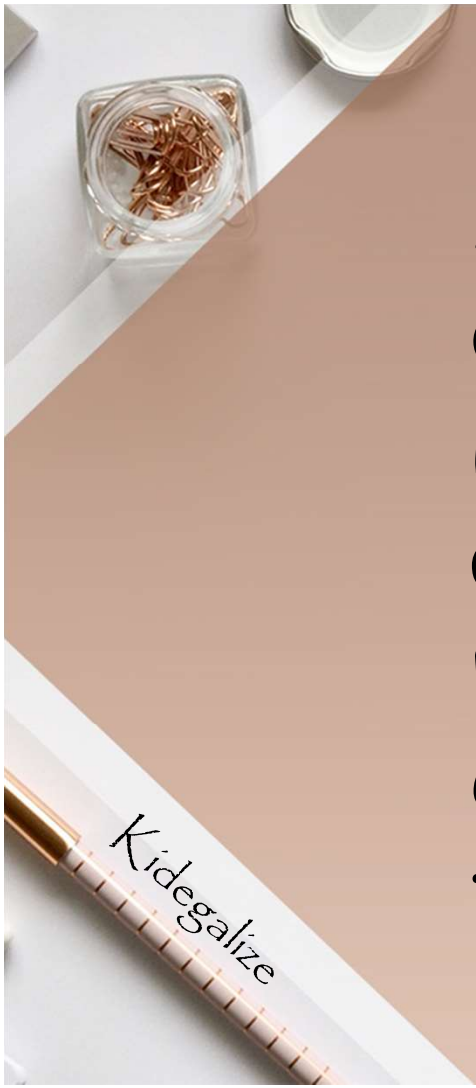
- Strong electrolytes: are electrolytes that ionizes completely in aqueous solution e.g. acid solutions: HCl, HNO_3, H_2SO_4; salt solutions: NaCl, $CuSO_4$, molten $PbBr_2$ and alkali solution: NaOH, KOH.



Remember: In solid state, ions in ionic compounds are firmly held together by electrostatic force of attraction and are not free to move, thus do not conduct electric current while in solution water breaks the force between the ions thus setting them free to move.

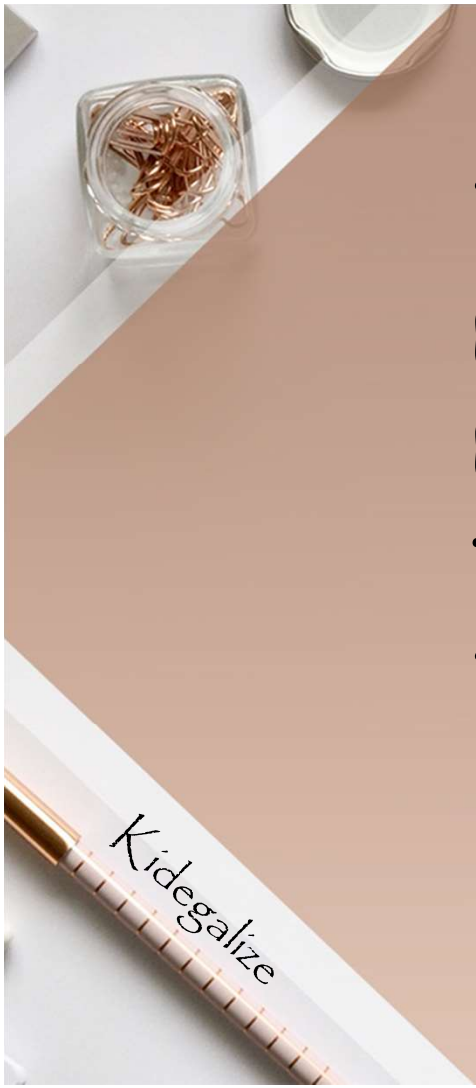


- Weak electrolytes: are electrolytes that are partially ionized in aqueous solution e.g. water, ammonia solution, ethanoic acid, carbonic acid.



Non-electrolytes

A non-electrolyte is a solution or molten compound that does not conduct electric current and is not decomposed by it e.g. paraffin, sugar solution, petrol, ethanol, trichloromethane, tetrachloromethane.



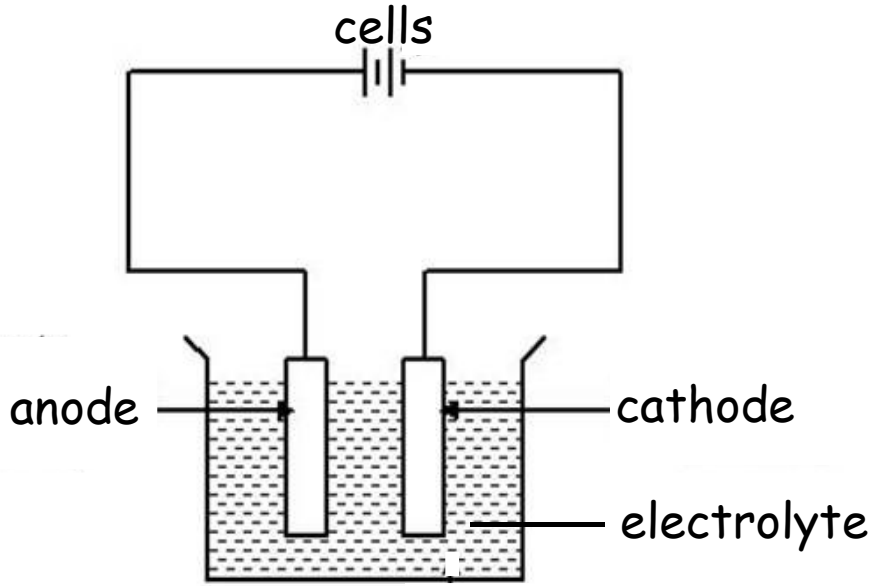
Electrodes

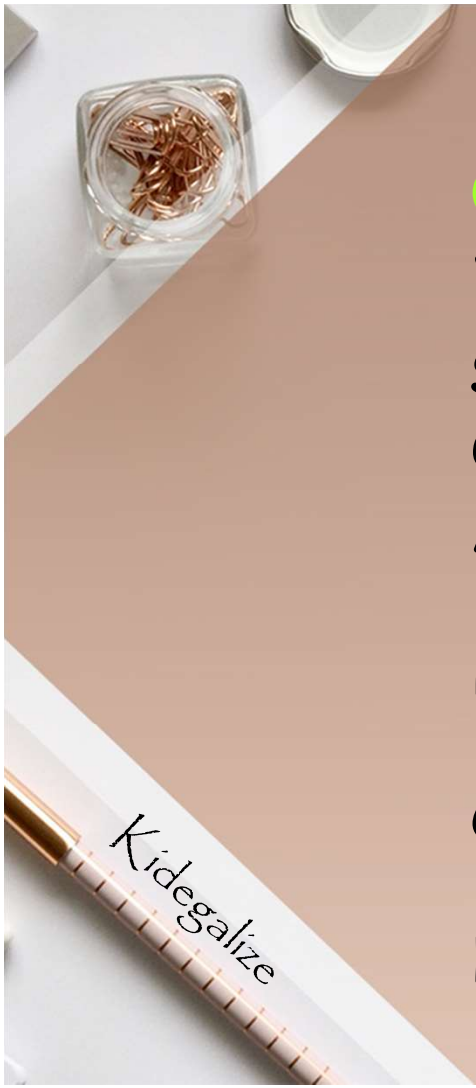
The electrodes are rods/poles made from either graphite or metal which conduct electricity to and from the electrolyte.

There are two electrodes:

- Anode: positive electrode at which the electrons enter the external circuit/leave the electrolyte.
- Cathode: negative electrode at which the electrons leave the external circuit/enter the electrolyte.

Illustration



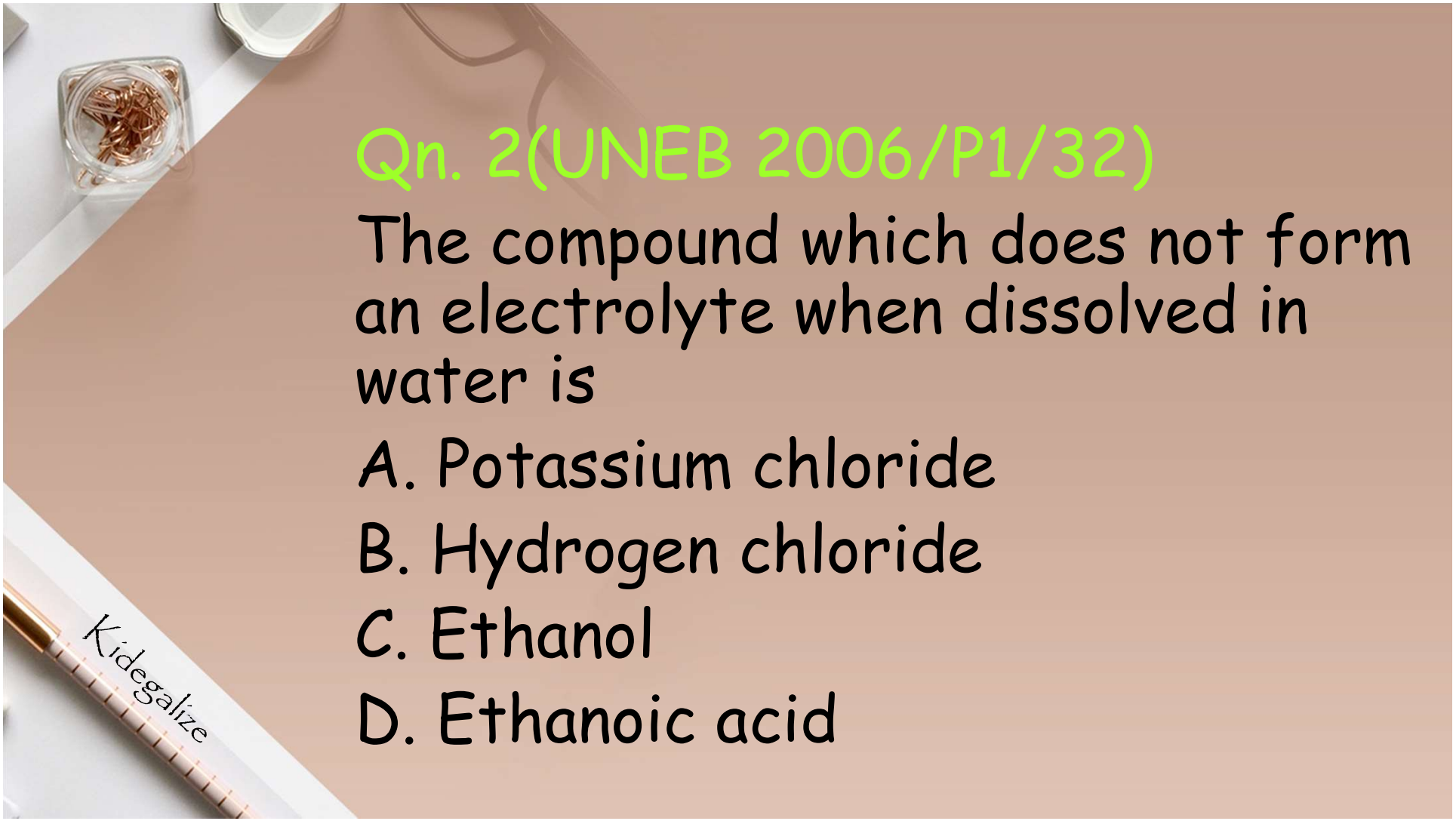


Knowledge Check 1

Qn. 1 (UNEB 2012/P1/2)

Which one of the following substances consists of strong electrolytes.

A. Potassium hydroxide solution and dilute ethanoic acid.
B. Sodium hydroxide solution and dilute sulphuric acid.
C. Sodium hydroxide solution and dilute carbonic acid.
D. Aqueous ammonia and dilute ethanoic acid.



Qn. 2(UNEB 2006/P1/32)

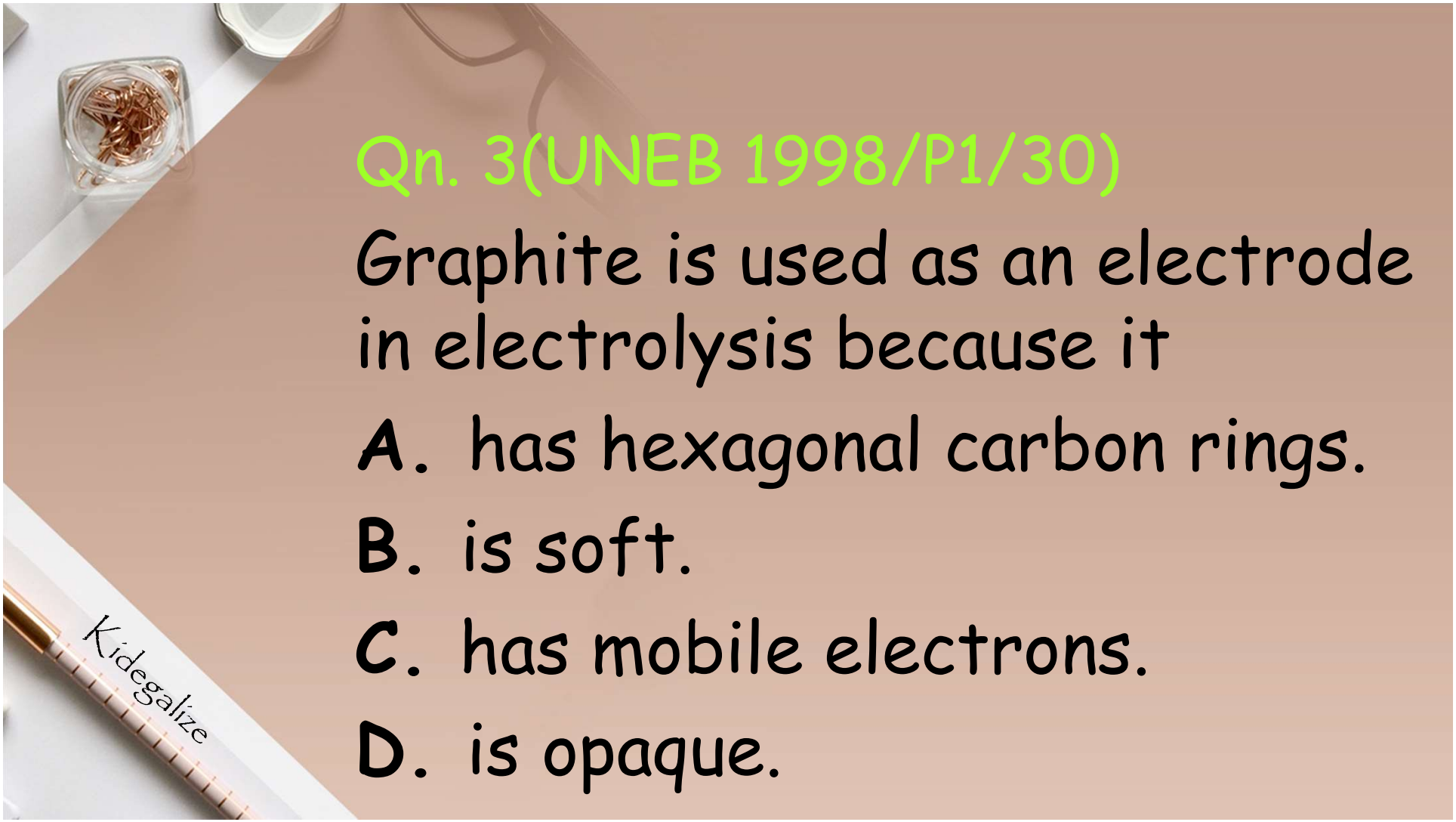
The compound which does not form an electrolyte when dissolved in water is

A. Potassium chloride

B. Hydrogen chloride

C. Ethanol

D. Ethanoic acid



Qn. 3(UNEB 1998/P1/30)

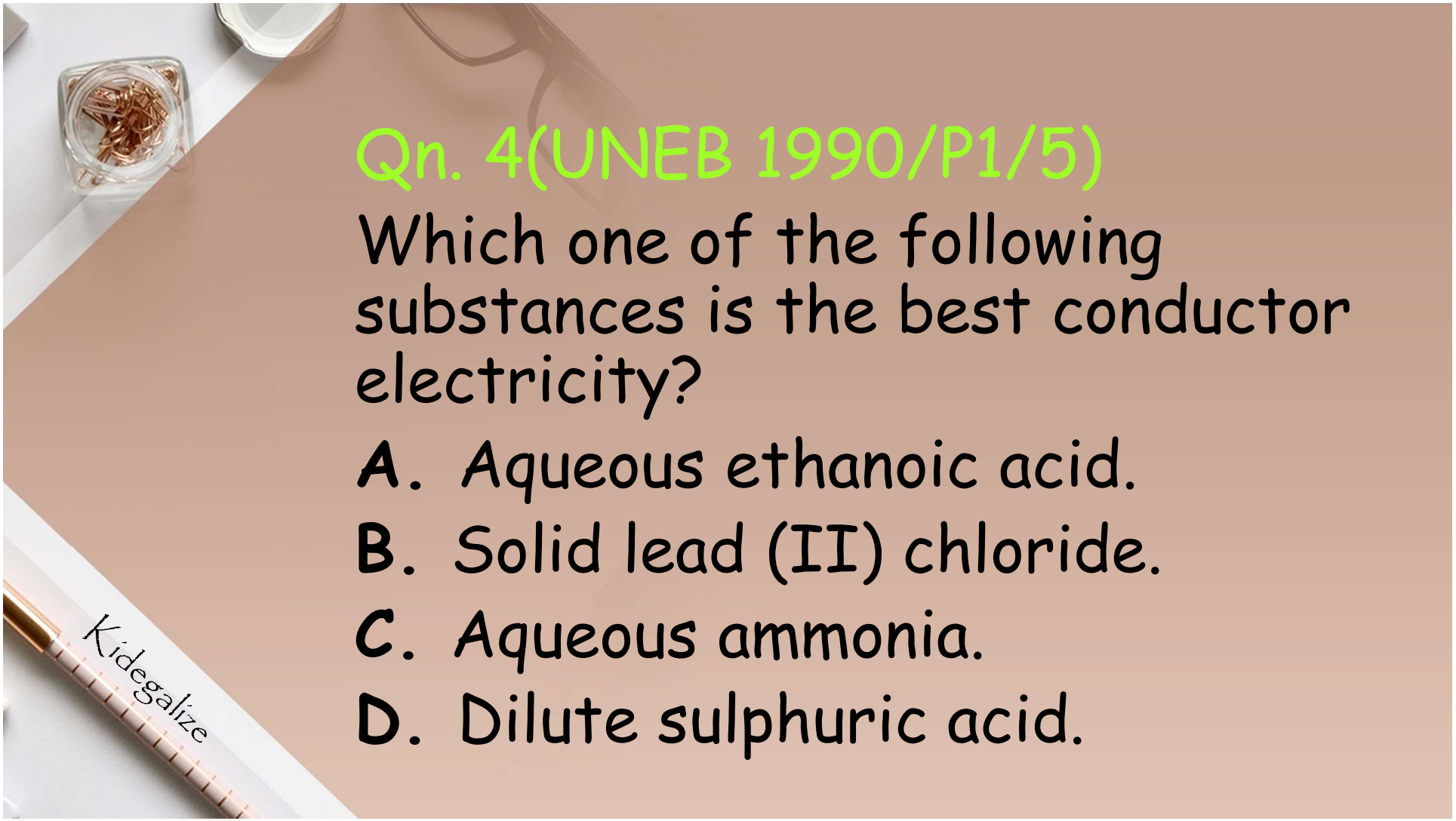
Graphite is used as an electrode in electrolysis because it

A. has hexagonal carbon rings.

B. is soft.

C. has mobile electrons.

D. is opaque.



Qn. 4(UNEB 1990/P1/5)

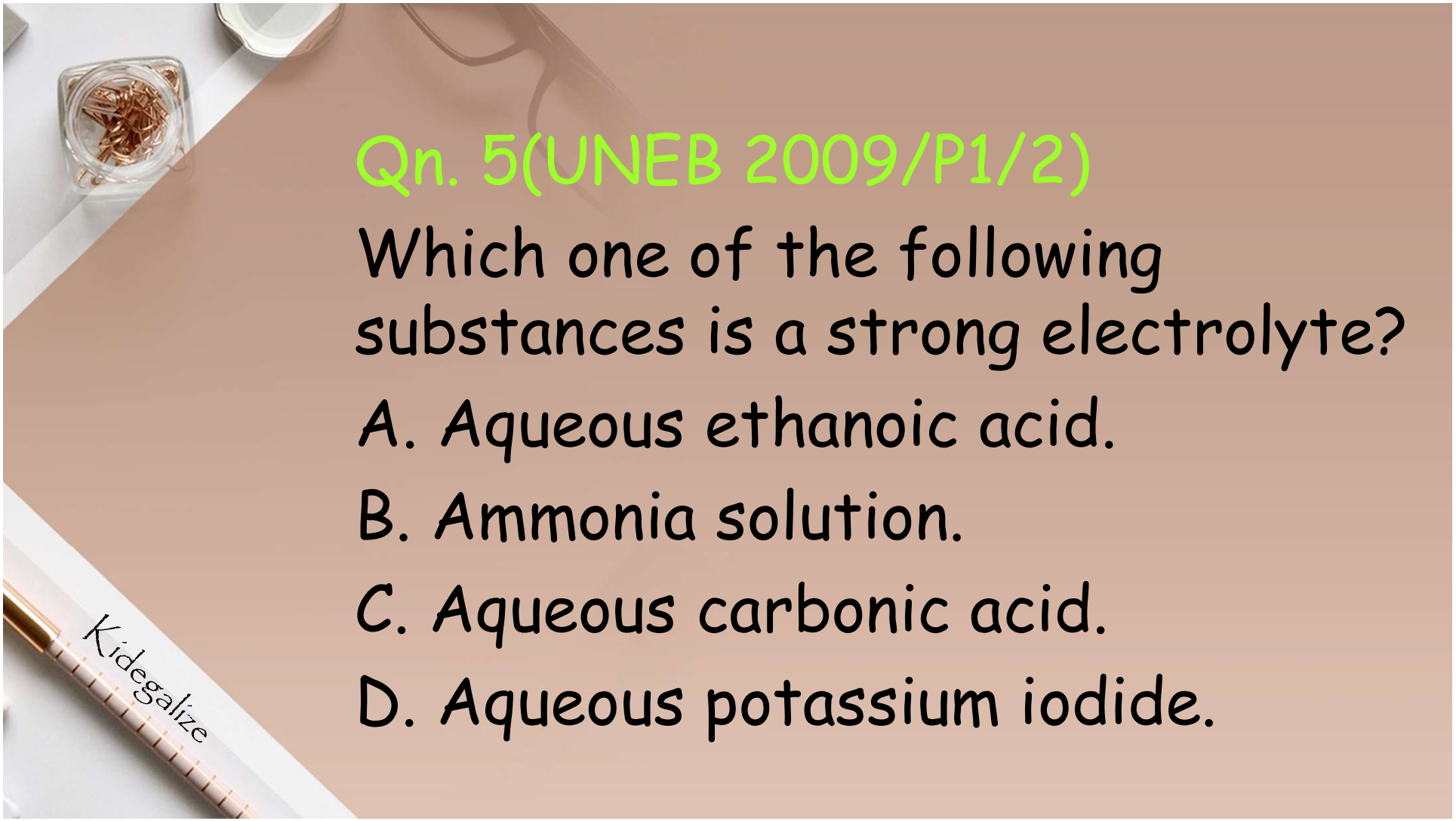
Which one of the following substances is the best conductor electricity?

A. Aqueous ethanoic acid.

B. Solid lead (II) chloride.

C. Aqueous ammonia.

D. Dilute sulphuric acid.



Qn. 5(UNEB 2009/P1/2)

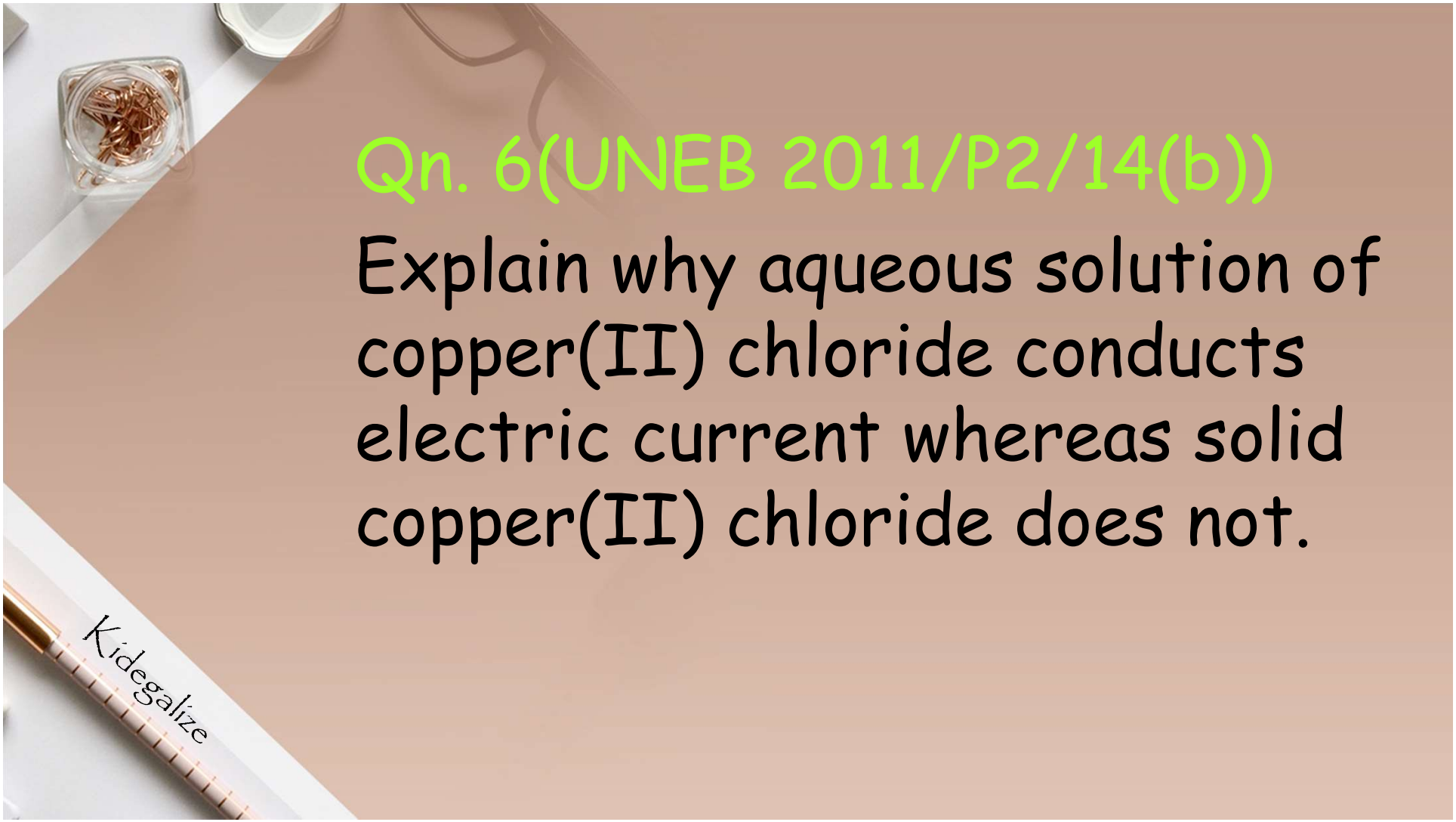
Which one of the following substances is a strong electrolyte?

A. Aqueous ethanoic acid.

B. Ammonia solution.

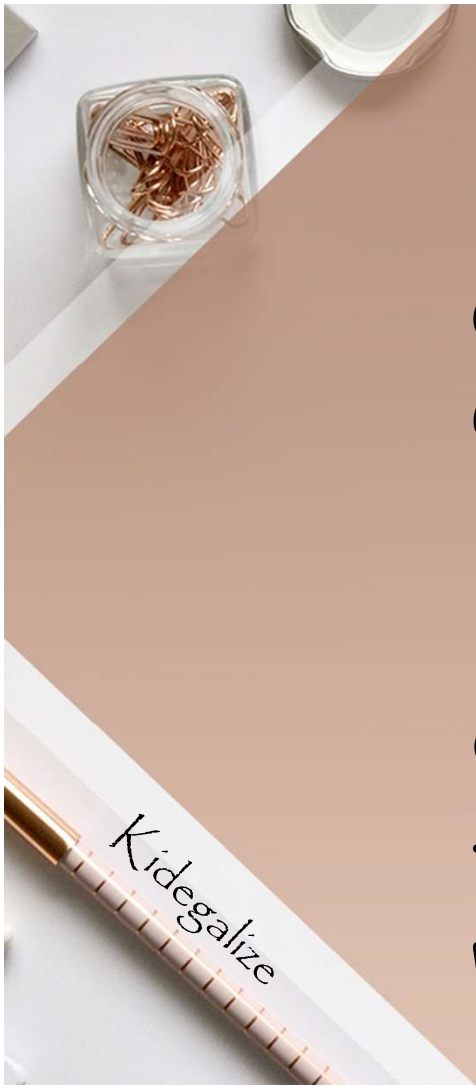
C. Aqueous carbonic acid.

D. Aqueous potassium iodide.



Qn. 6(UNEB 2011/P2/14(b))

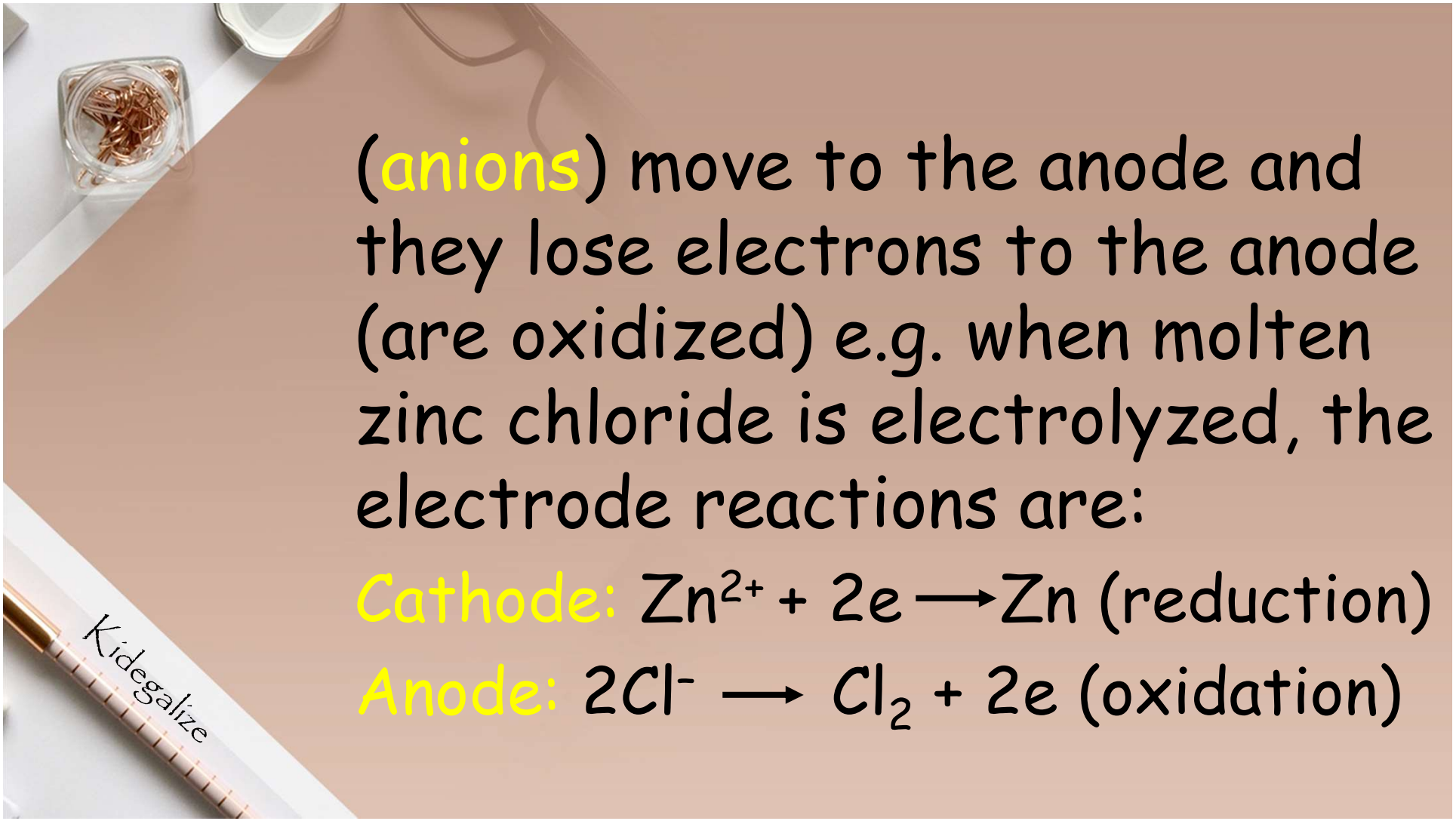
Explain why aqueous solution of copper(II) chloride conducts electric current whereas solid copper(II) chloride does not.



Electrolysis

Electrolysis is the decomposition of an electrolyte by passing electric current through it.

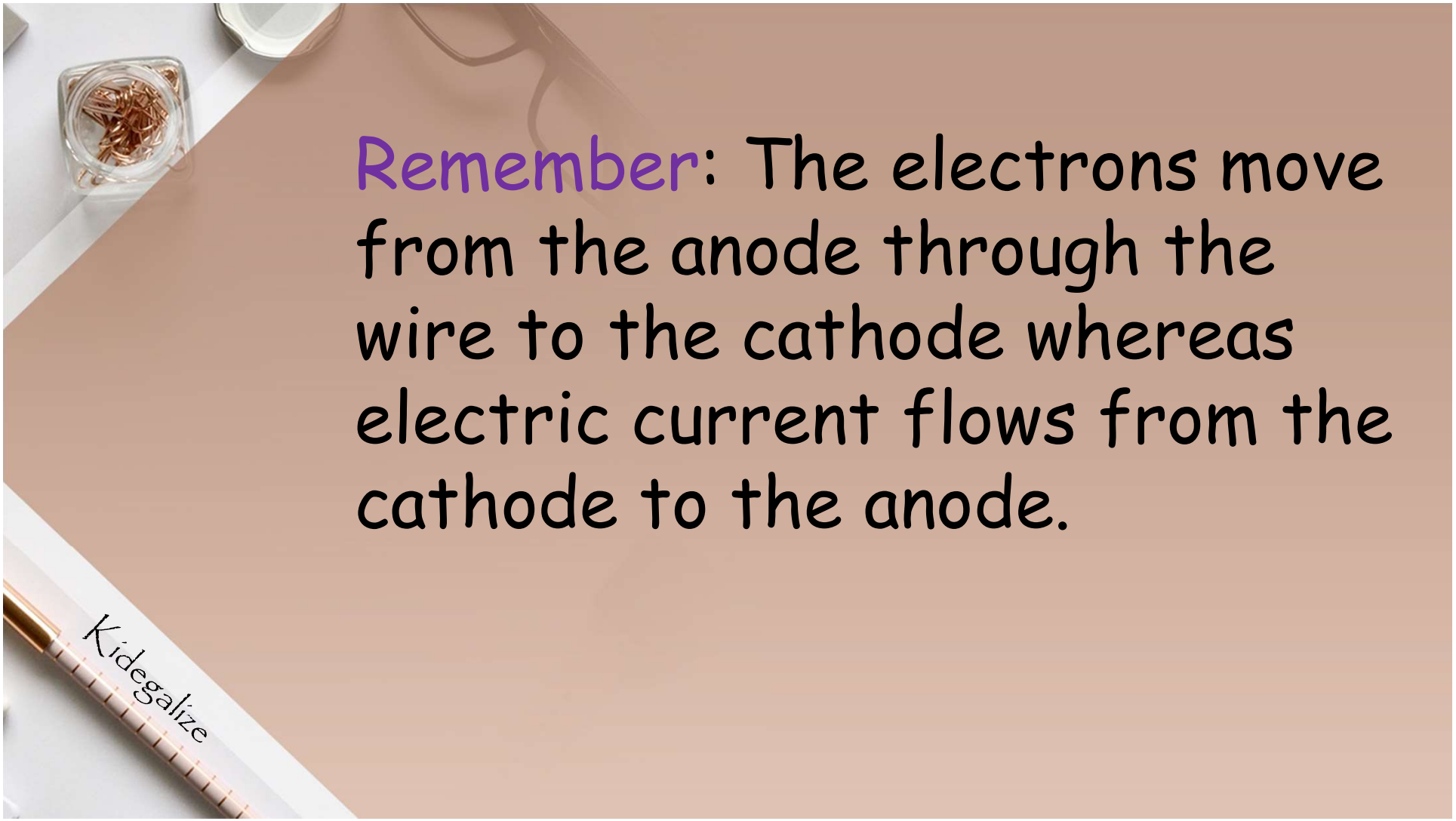
During electrolysis, the positive ions (cations) move to the cathode and they gain electrons from the cathode (are reduced) whereas the negative ions



(anions) move to the anode and they lose electrons to the anode (are oxidized) e.g. when molten zinc chloride is electrolyzed, the electrode reactions are:

Cathode: $Zn^{2+} + 2e \longrightarrow Zn$ (reduction)

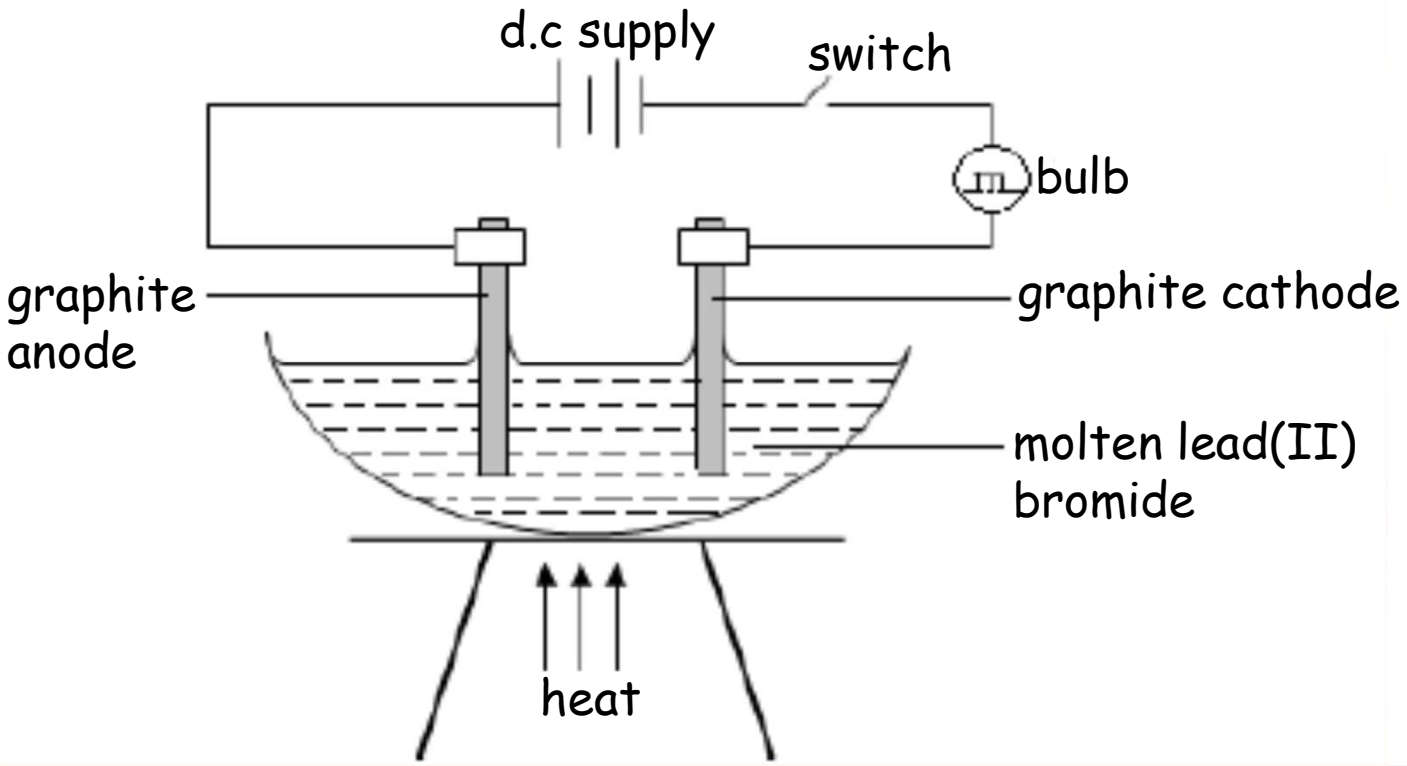
Anode: $2Cl^- \longrightarrow Cl_2 + 2e$ (oxidation)

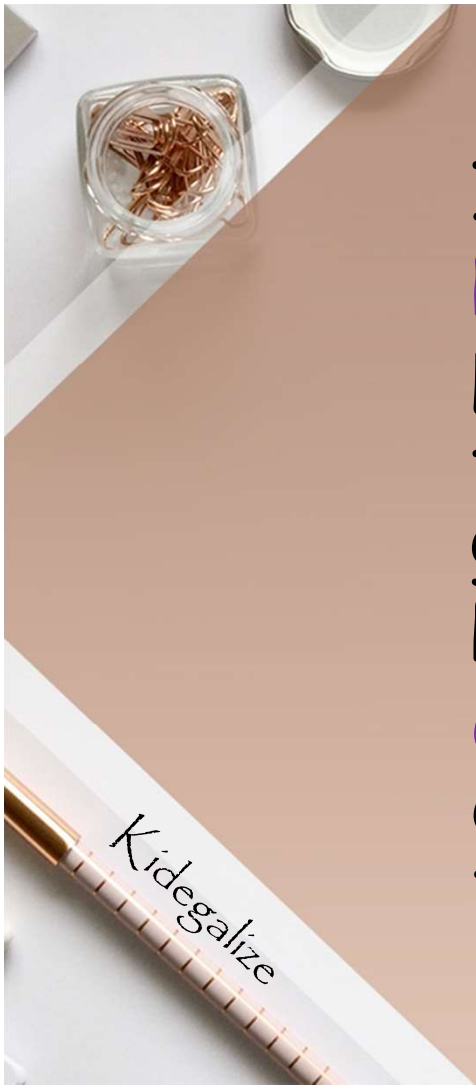


Remember: The electrons move from the anode through the wire to the cathode whereas electric current flows from the cathode to the anode.

Electrolysis of molten $PbBr_2$

Experimental set up





Ions present: Pb^{2+}, Br^-

Reaction at the cathode

Lead(II) ions migrate to the cathode from where they are discharged by gain of electrons.

$Pb^{2+}(l) + 2e \longrightarrow Pb(s)$

Observation: A grey solid is deposited.

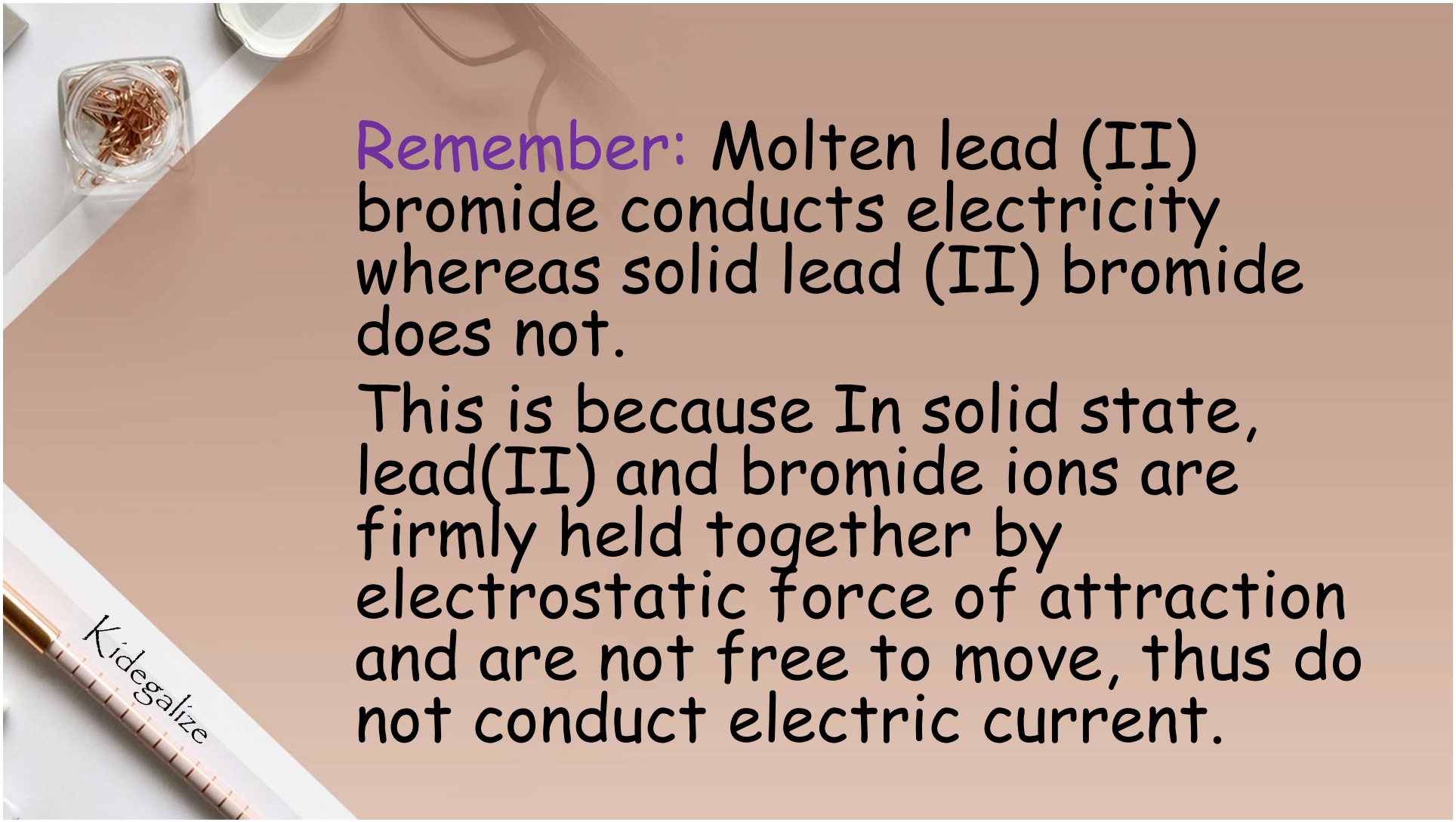
The mass and size of the cathode increases

Reaction at the anode

Bromide ions migrate to the anode from where they are discharged by loss of electrons.

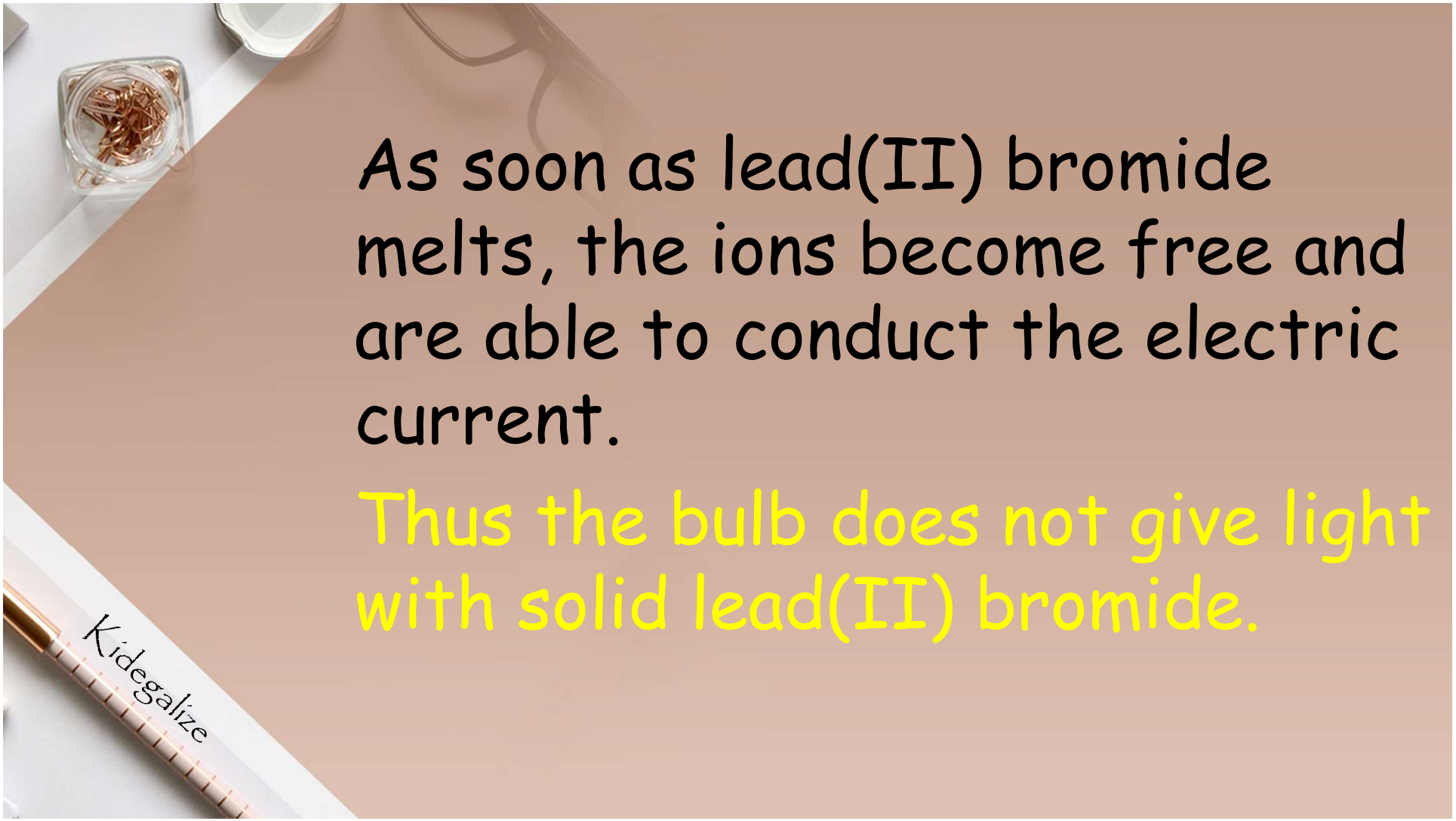
$2Br^-(l) \longrightarrow Br_2(g) + 2e$

Observation: Reddish-brown gas given off.



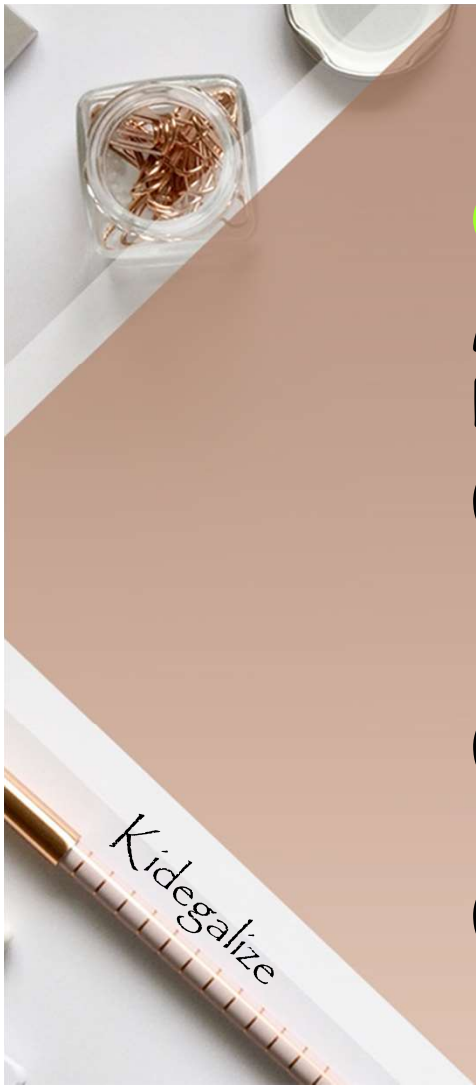
Remember: Molten lead (II) bromide conducts electricity whereas solid lead (II) bromide does not.

This is because In solid state, lead(II) and bromide ions are firmly held together by electrostatic force of attraction and are not free to move, thus do not conduct electric current.



As soon as lead(II) bromide melts, the ions become free and are able to conduct the electric current.

Thus the bulb does not give light with solid lead(II) bromide.



Knowledge Check 2

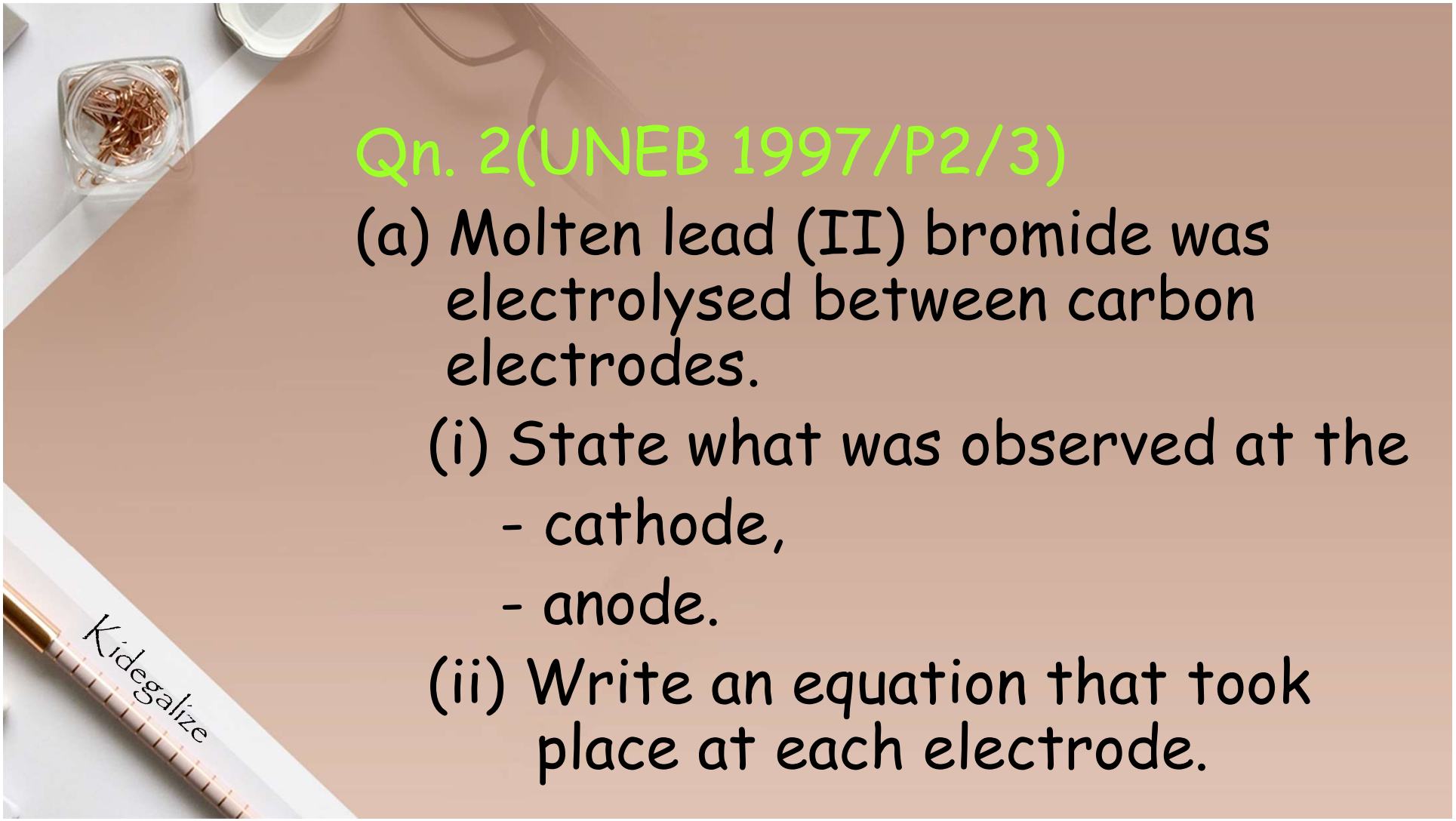
Qn. 1(UNEB 2003/P2/7)

Molten lead (II) bromide was electrolysed between two carbon electrodes.

(a) Explain why lead(II) bromide was electrolysed in the molten state and not in the solid state.

(b) State what was observed at the:
(i) anode, (ii) cathode.

(c) Write equation for the reaction that took place at the anode.



Qn. 2(UNEB 1997/P2/3)

(a) Molten lead (II) bromide was electrolysed between carbon electrodes.

(i) State what was observed at the

- cathode,
- anode.

(ii) Write an equation that took place at each electrode.

Qn. 3(UNEB 1990/P2/8)

The circuit shown in the diagram in figure 3 was used in an experiment to study the effect of electricity on lead(II) bromide.

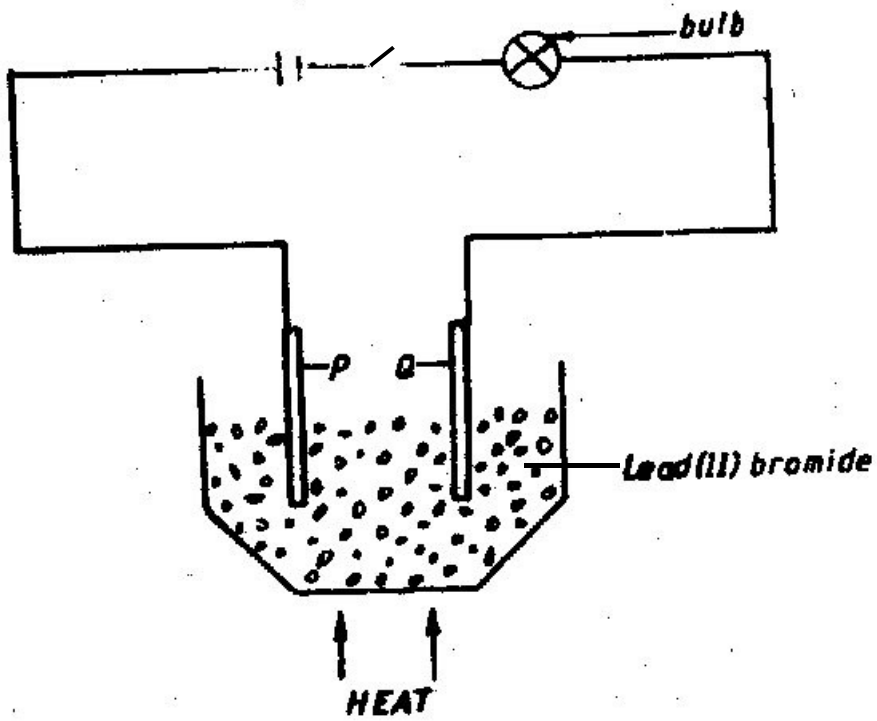
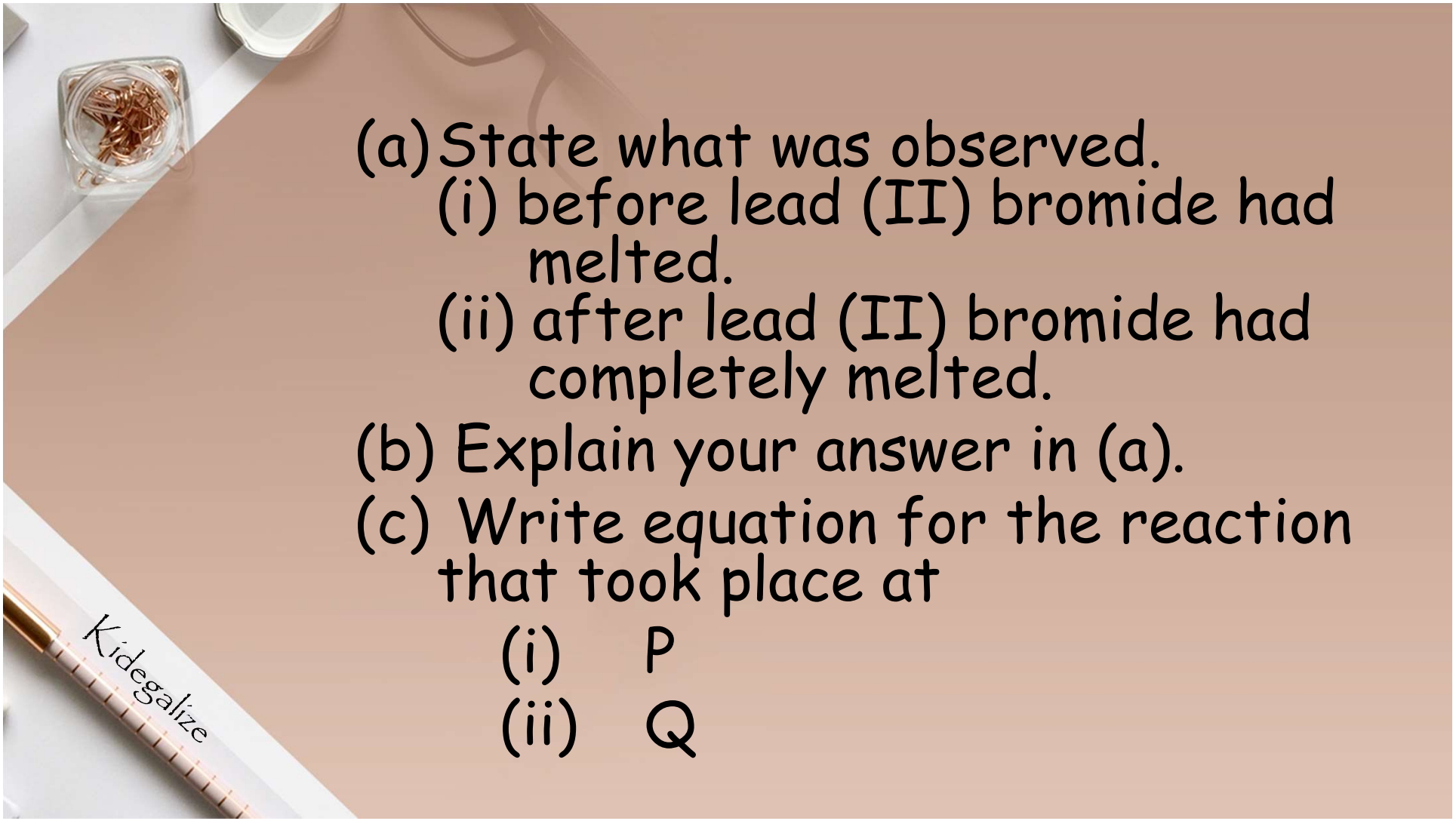


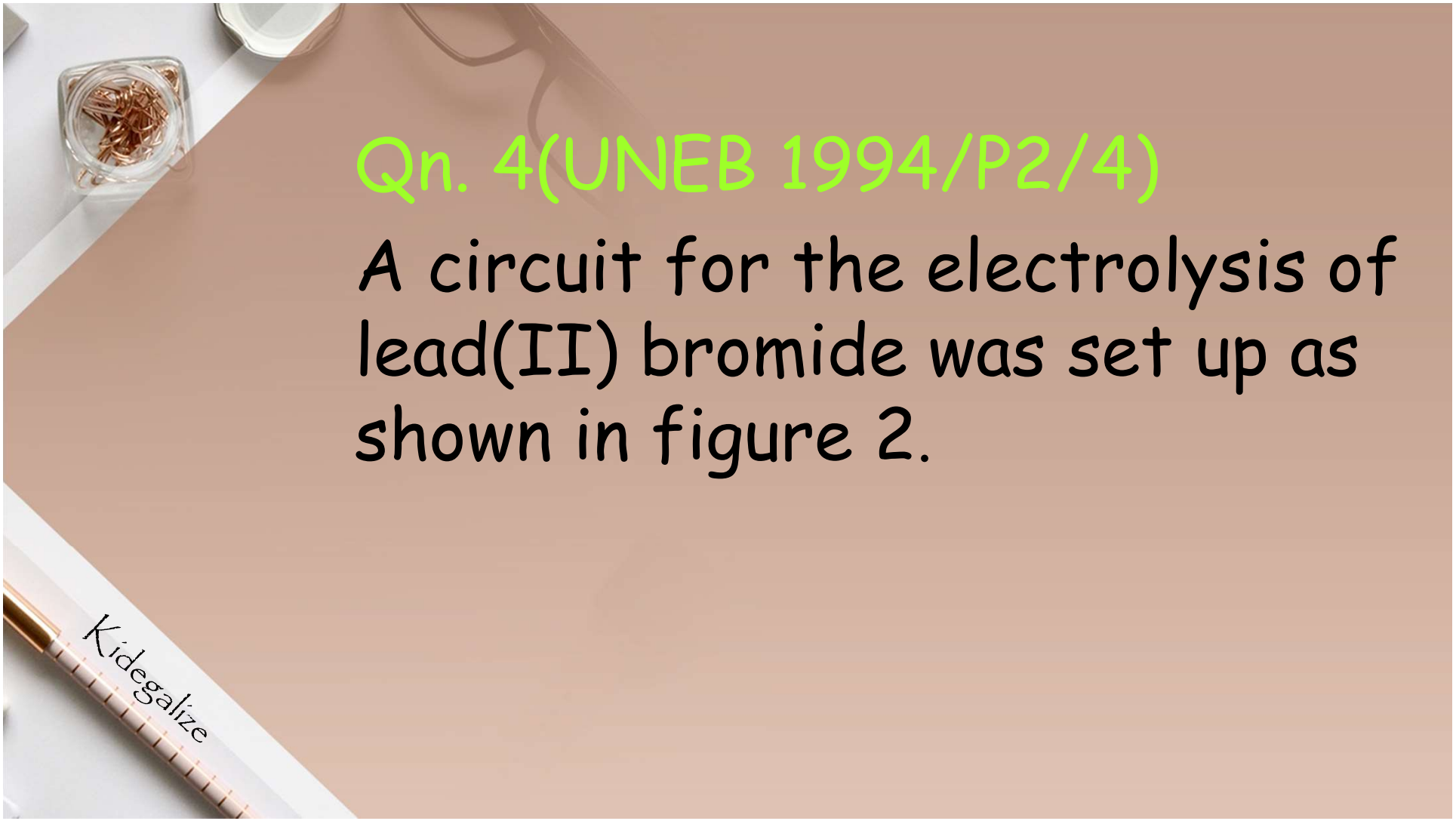
Fig. 3



(a) State what was observed.
  (i) before lead (II) bromide had melted.
  (ii) after lead (II) bromide had completely melted.

(b) Explain your answer in (a).

(c) Write equation for the reaction that took place at
  (i) P
  (ii) Q



Qn. 4(UNEB 1994/P2/4)

A circuit for the electrolysis of lead(II) bromide was set up as shown in figure 2.

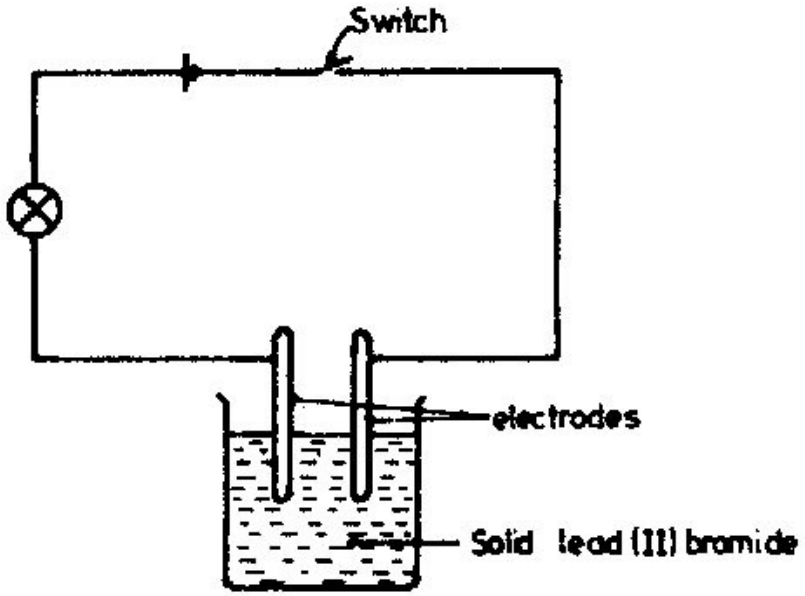
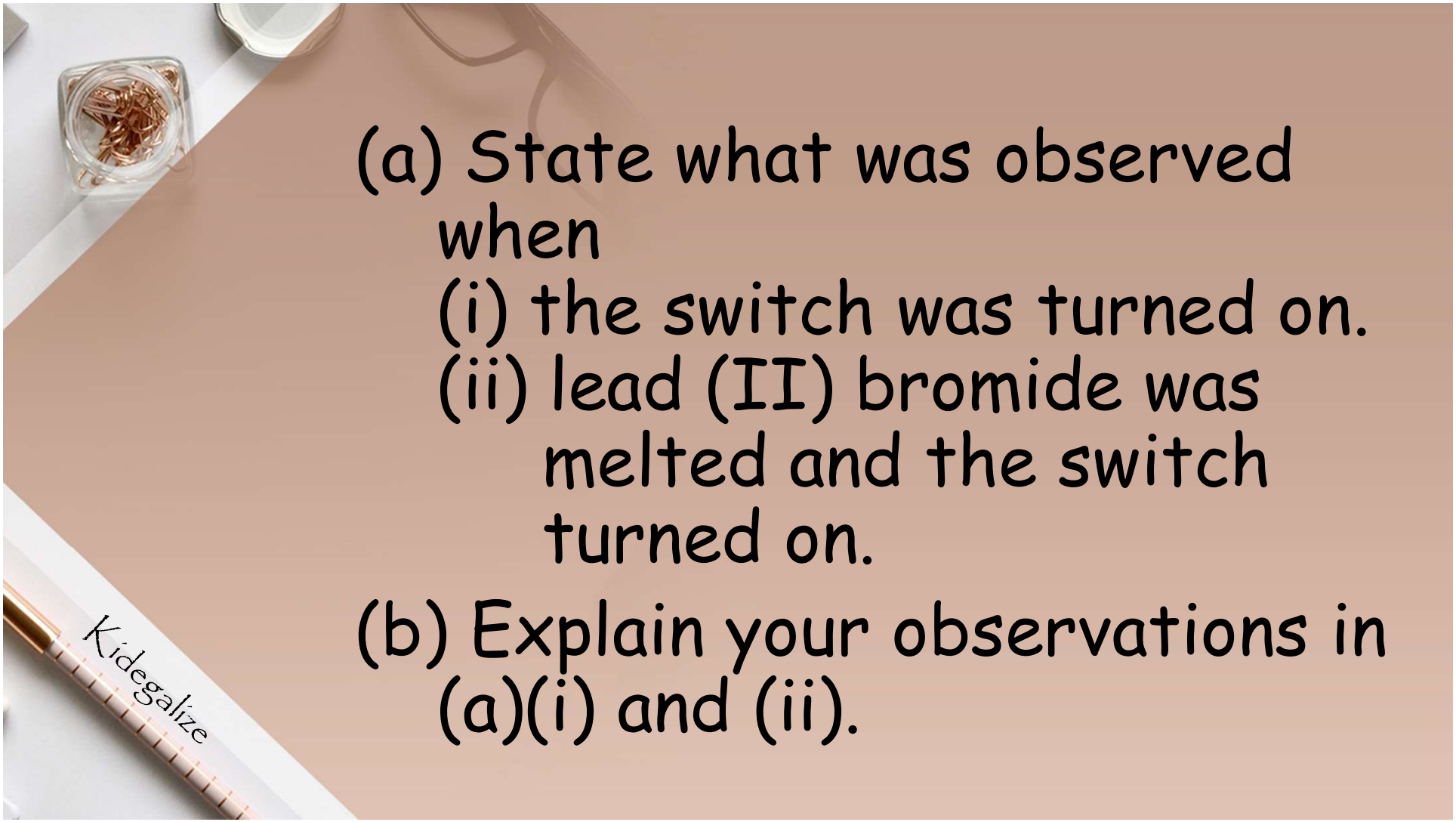


Fig. 2



(a) State what was observed when
(i) the switch was turned on.
(ii) lead (II) bromide was melted and the switch turned on.

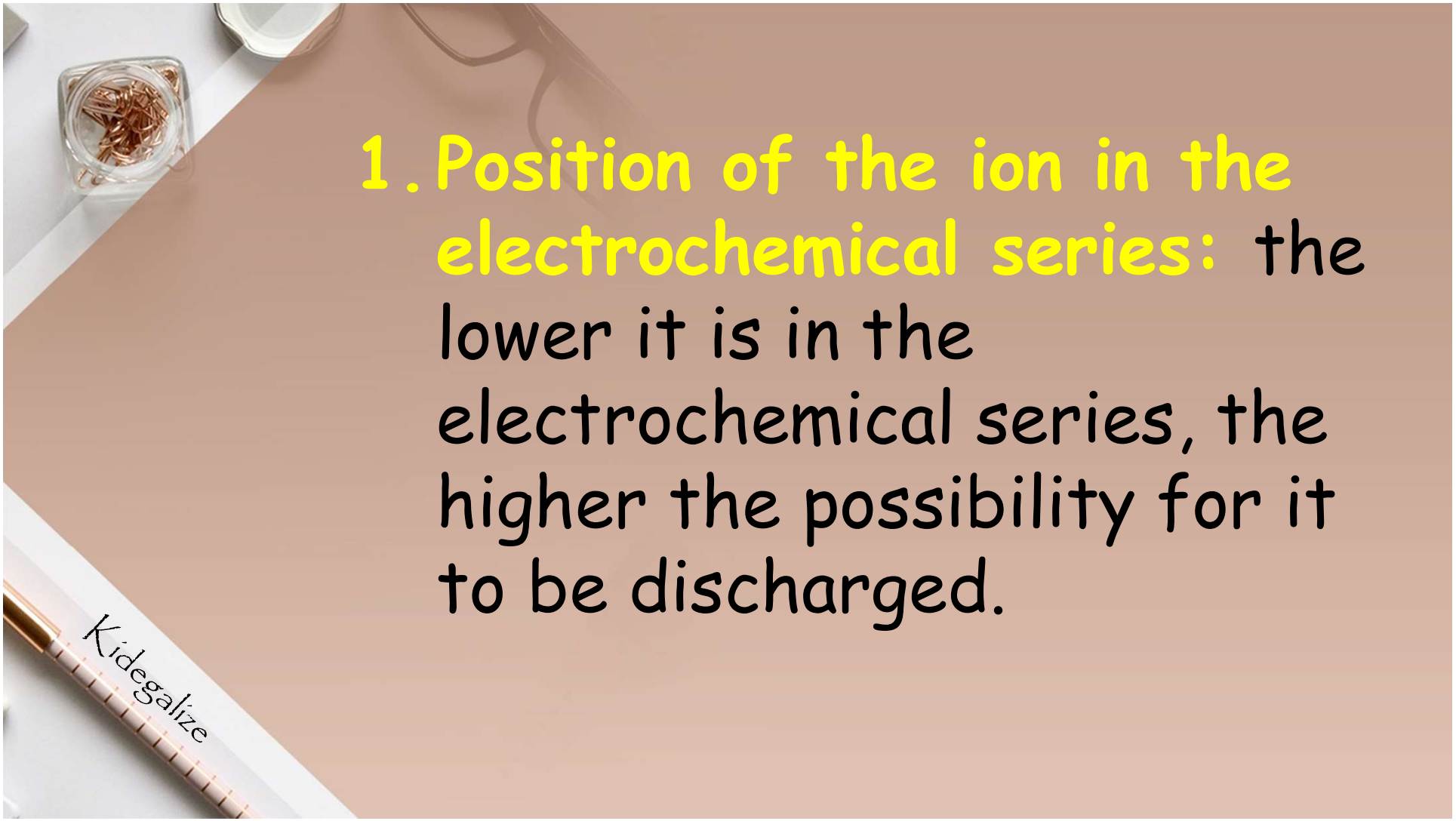
(b) Explain your observations in (a)(i) and (ii).

Electrolysis of aqueous solution

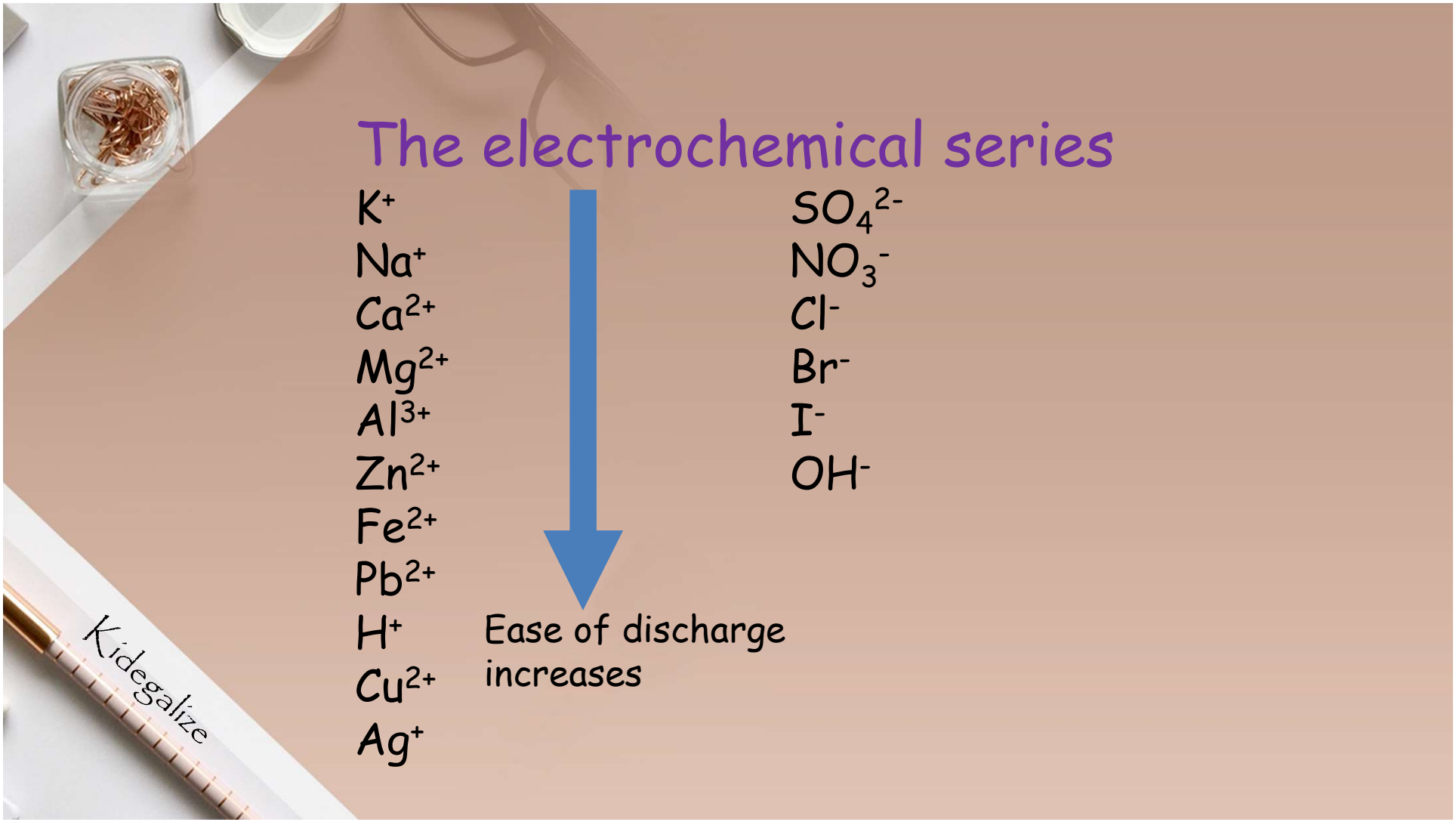
In an aqueous solution different types of ions with similar charges are present.

However, only one type of ion can be discharged at each electrode.

Factors that determine the selective discharge of ions are:



1. **Position of the ion in the electrochemical series:** the lower it is in the electrochemical series, the higher the possibility for it to be discharged.



The electrochemical series

K^+
Na^+
Ca^{2+}
Mg^{2+}
Al^{3+}
Zn^{2+}
Fe^{2+}
Pb^{2+}
H^+
Cu^{2+}
Ag^+

Ease of discharge increases

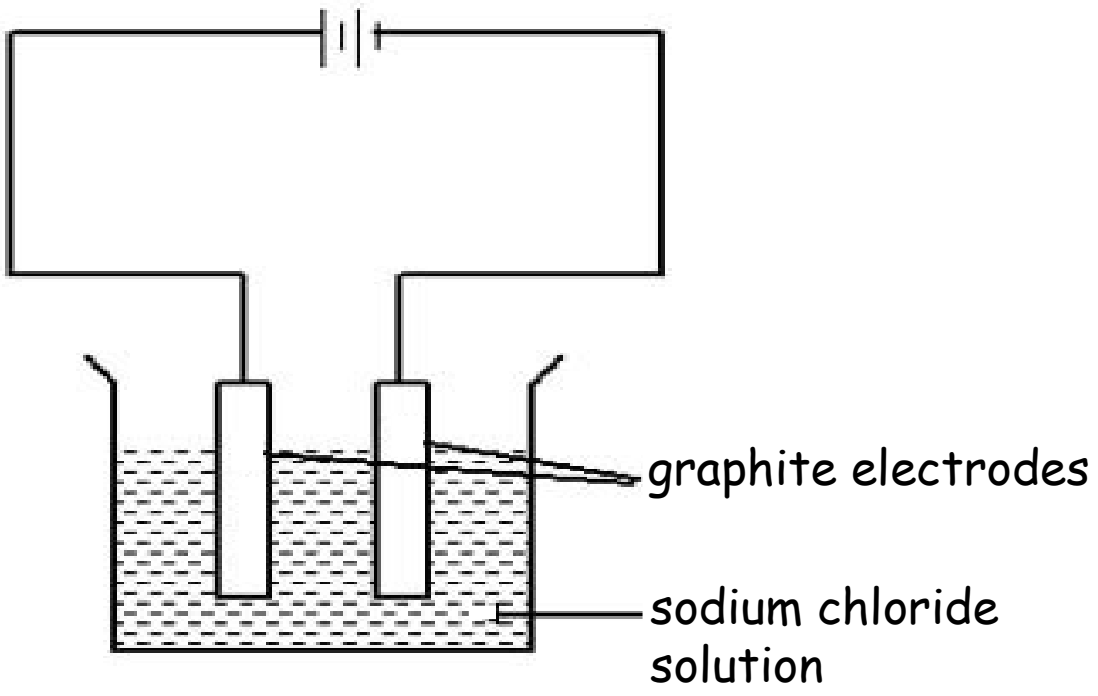
SO_4^{2-}
NO_3^-
Cl^-
Br^-
I^-
OH^-

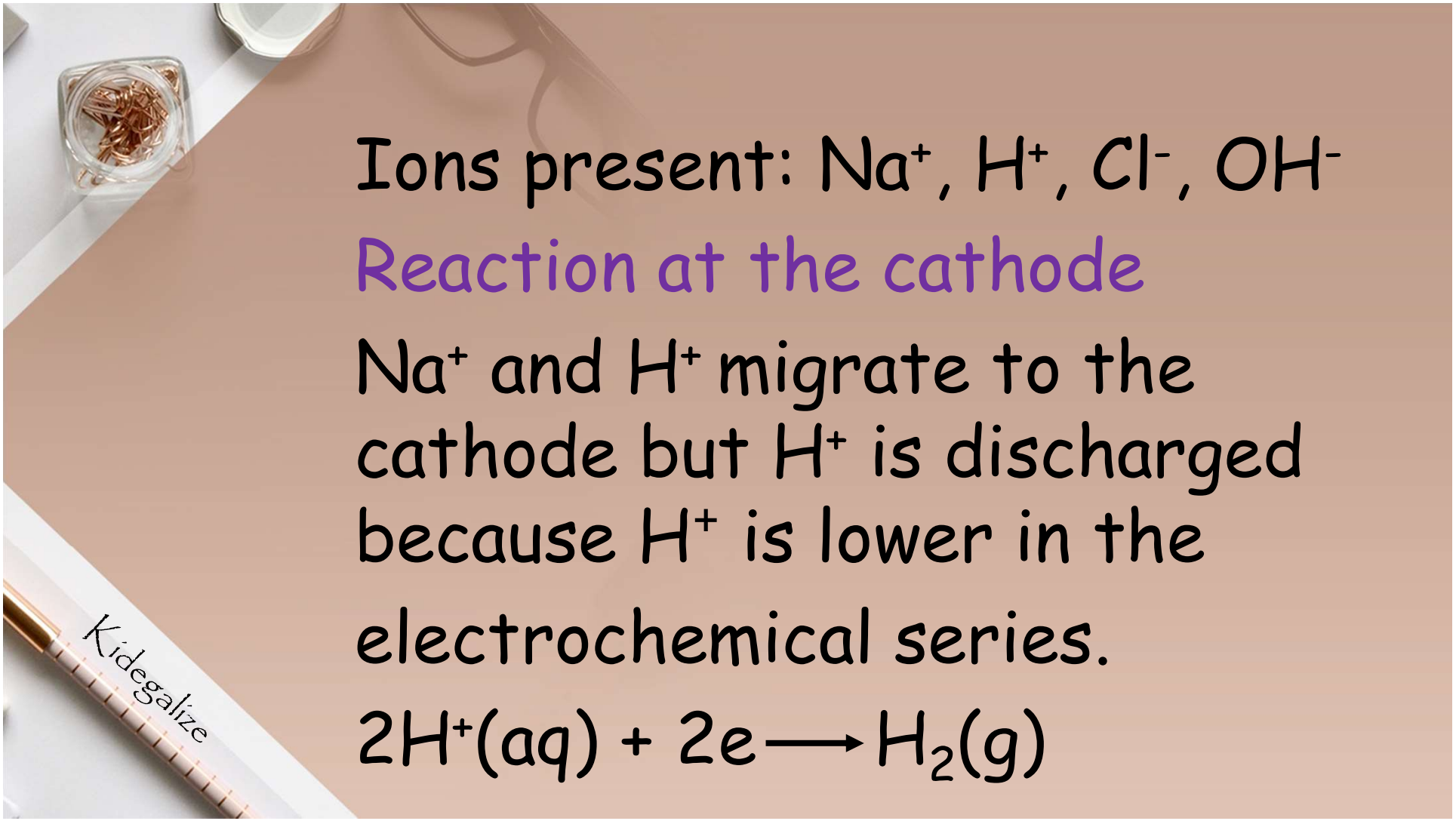
Electrolysis of aqueous NaCl

A known mass of NaCl is dissolved in a known volume of water.

Graphite electrodes are then connected to a 6V d.c power supply and dipped into a solution in a beaker.

Experimental set up



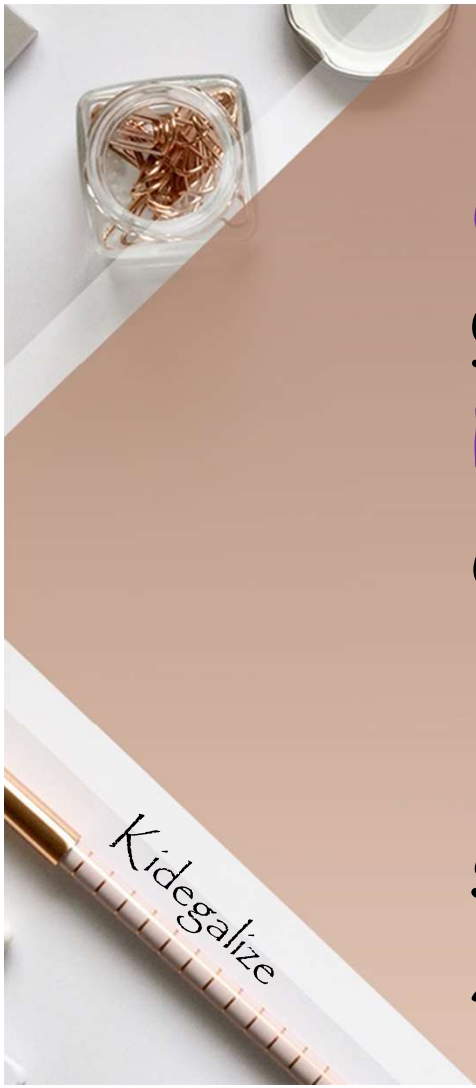


Ions present: Na^+, H^+, Cl^-, OH^-

Reaction at the cathode

Na^+ and H^+ migrate to the cathode but H^+ is discharged because H^+ is lower in the electrochemical series.

$2H^+(aq) + 2e \longrightarrow H_2(g)$

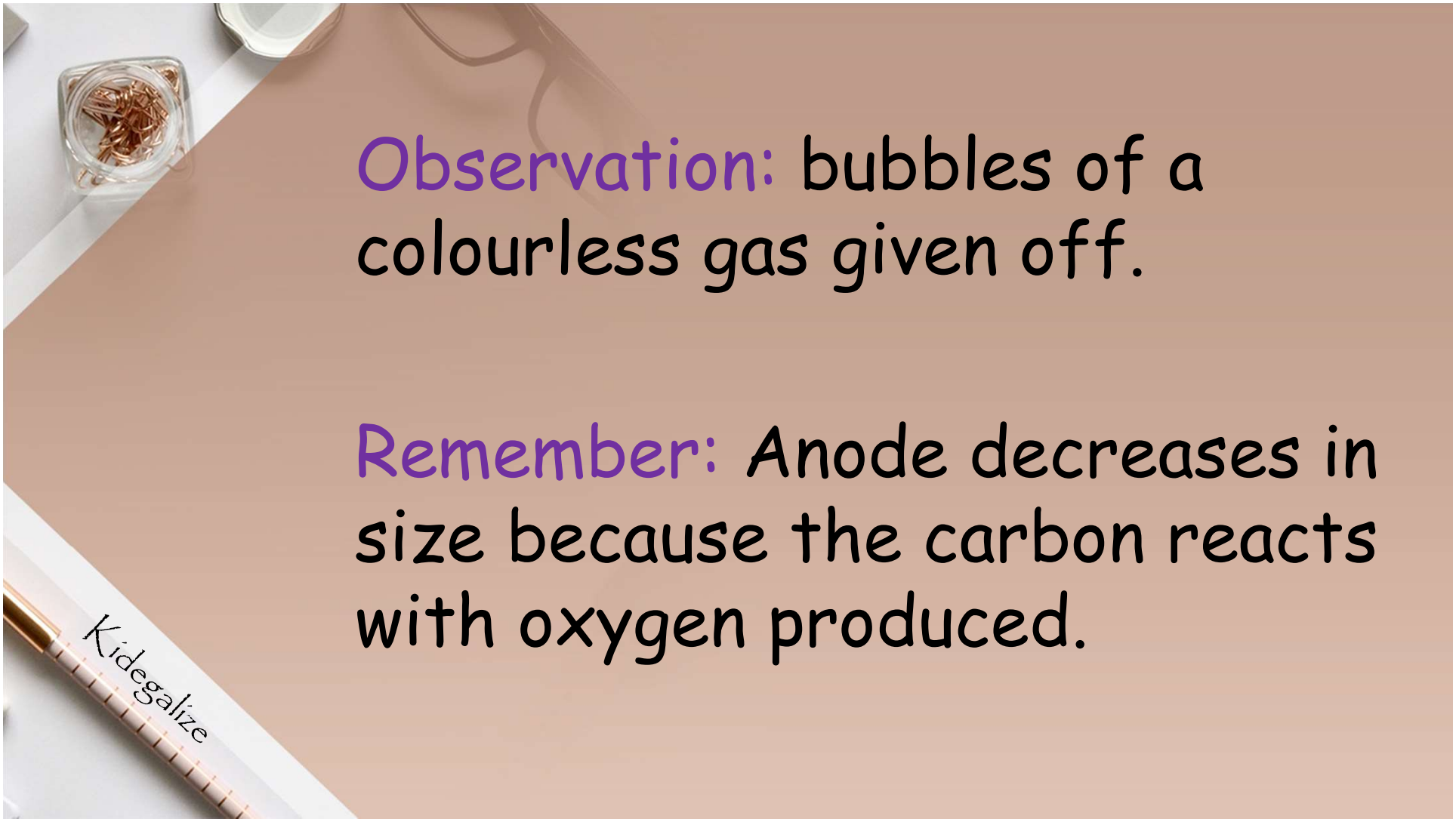


Observation: bubbles of a colourless gas given off.

Reaction at the anode

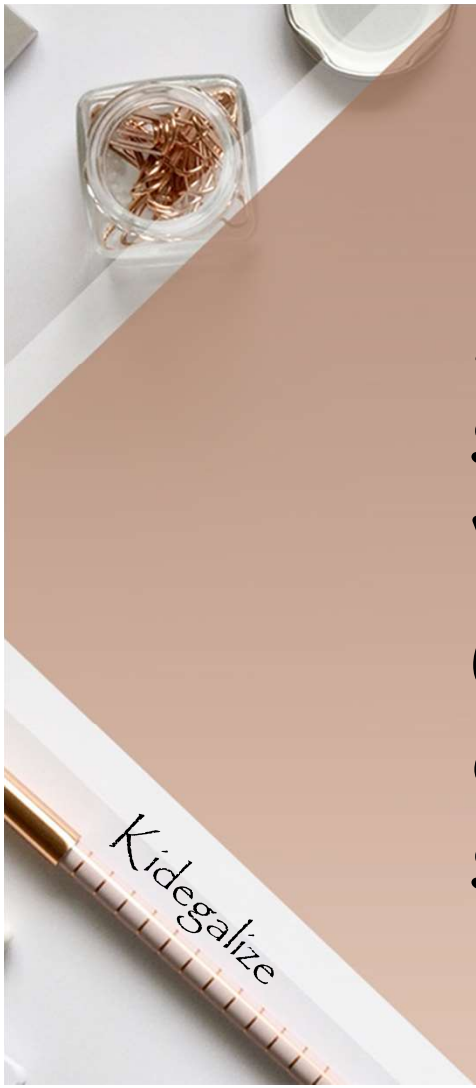
Cl^- and OH^- migrate to the anode but OH^- is discharged because OH^- is lower in the electrochemical series.

$$4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e$$



Observation: bubbles of a colourless gas given off.

Remember: Anode decreases in size because the carbon reacts with oxygen produced.

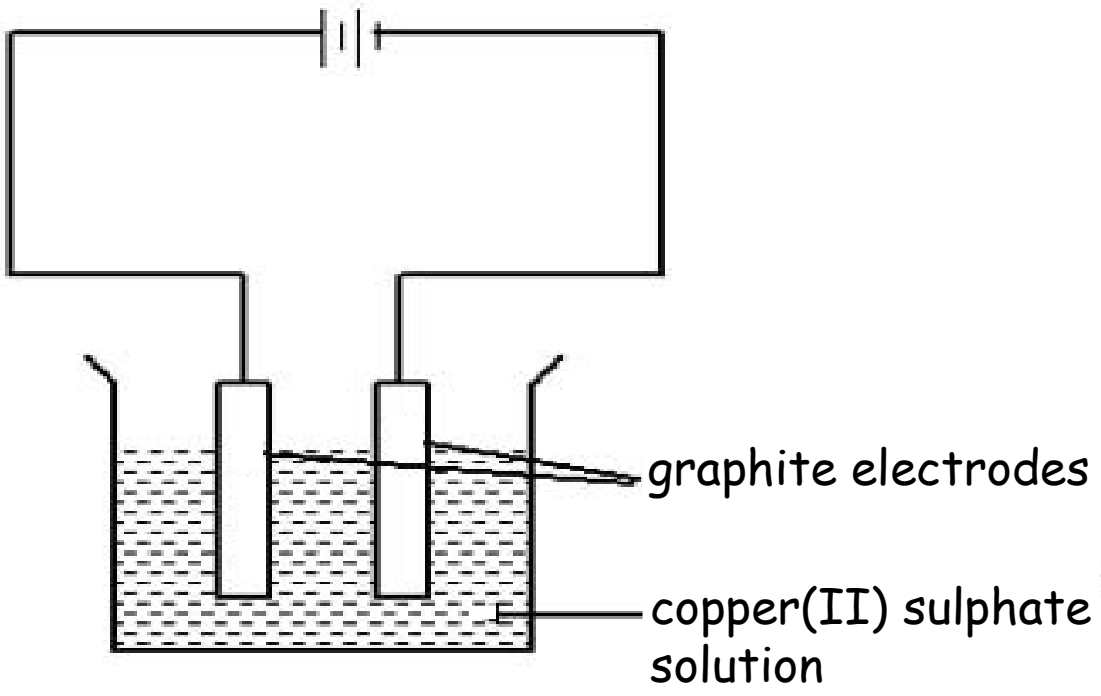


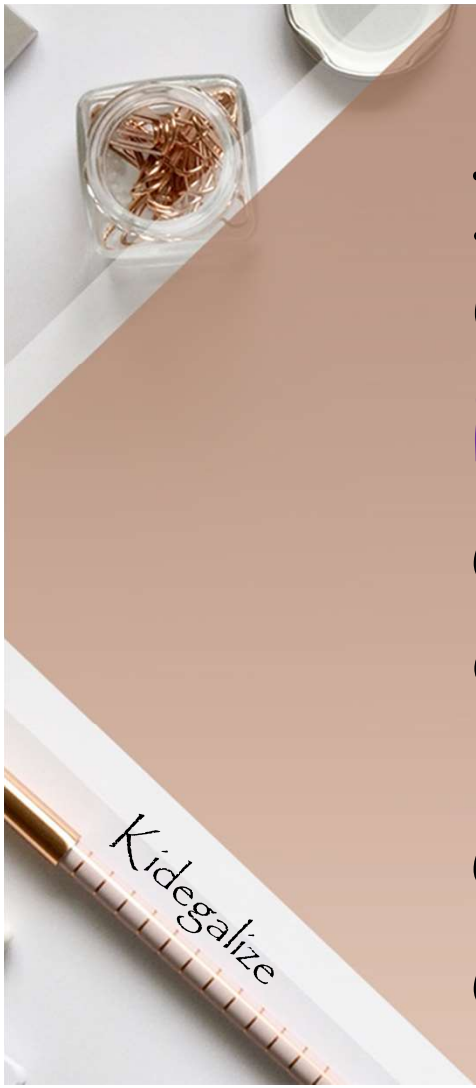
Electrolysis of aqueous $CuSO_4$

A known mass of copper(II) sulphate is dissolved in a known volume of water.

Graphite electrodes are then connected to a 6V d.c power supply and dipped into a solution in a beaker.

Experimental set up





Ions present: Cu^{2+}, H^+, SO_4^{2-}, OH^-

Reaction at the cathode

Cu^{2+} and H^+ migrate to the cathode but Cu^{2+} is discharged because Cu^{2+} is lower in the electrochemical series.

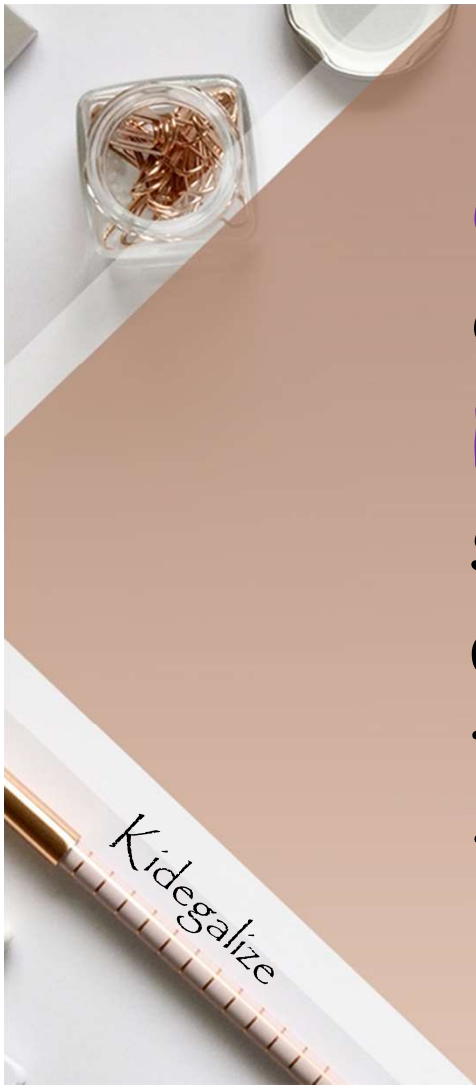
$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

Observation: brown solid deposited at the cathode.

Reaction at the anode

SO_4^{2-} and OH^- migrate to the anode but OH^- is discharged because OH^- is lower in the electrochemical series.

$$4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e$$



Observation: bubbles of a colourless gas given off.

Remember: Blue colour of the solution fades as copper(II) ions are discharged as copper metal at the cathode.

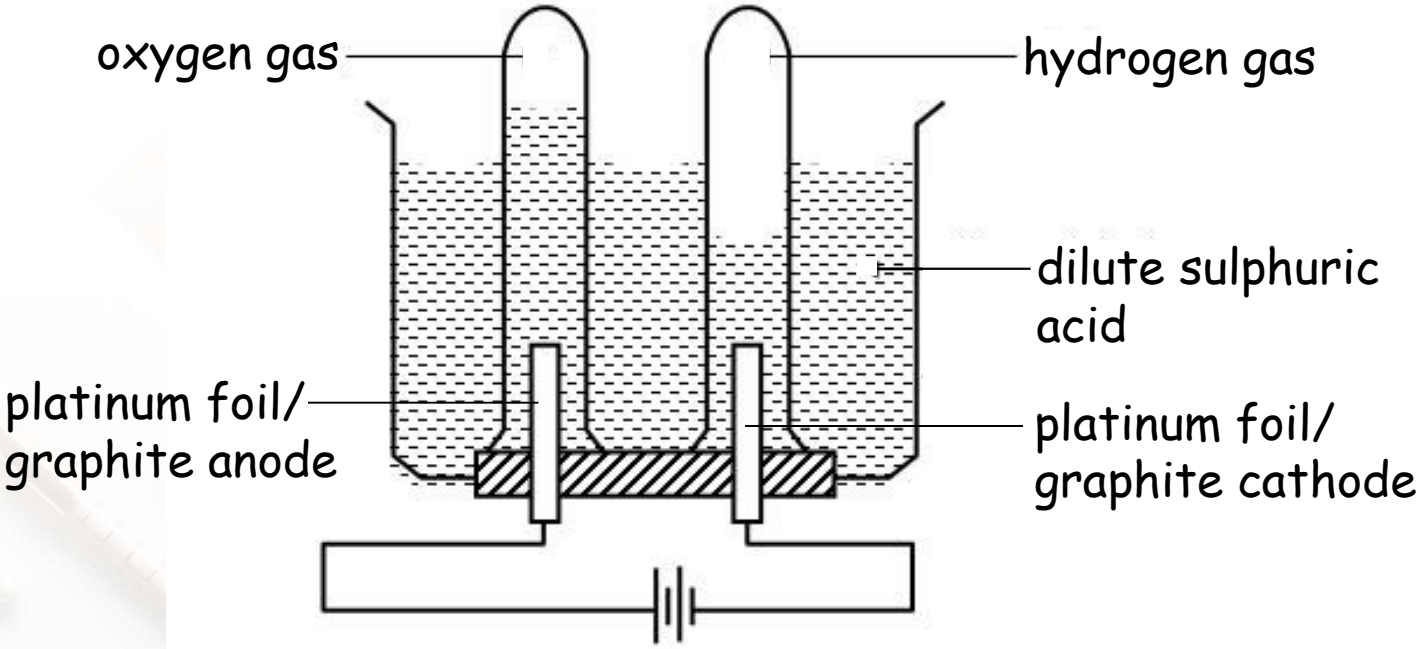
The resultant solution is acidic because sulphuric acid is formed.

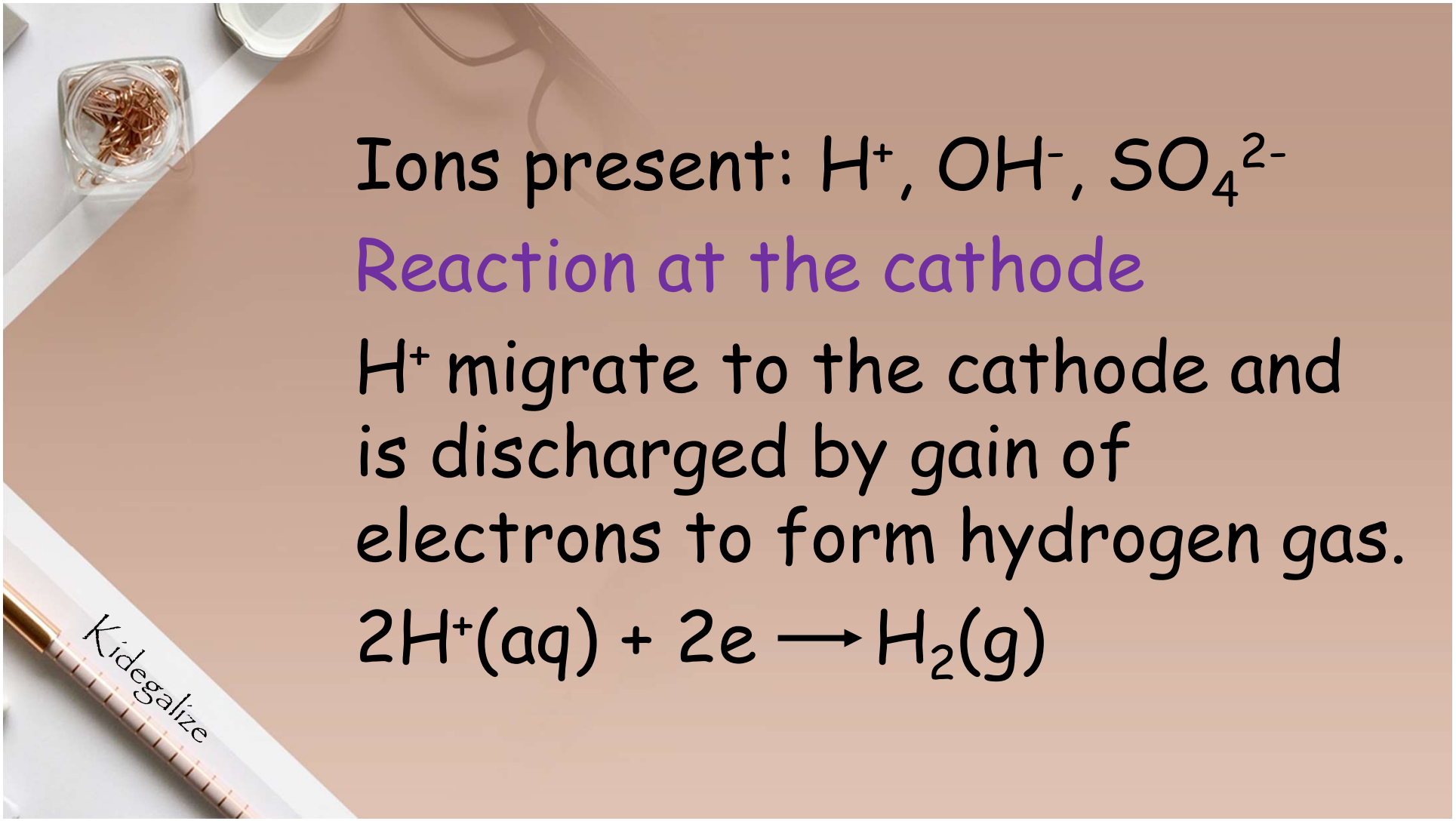
Electrolysis of acidified water

Fill the voltmeter with acidified water (dilute sulphuric acid) and connect the electrolyte to a 6V d.c power supply.

Pass an electric current through the electrolyte.

Experimental set up



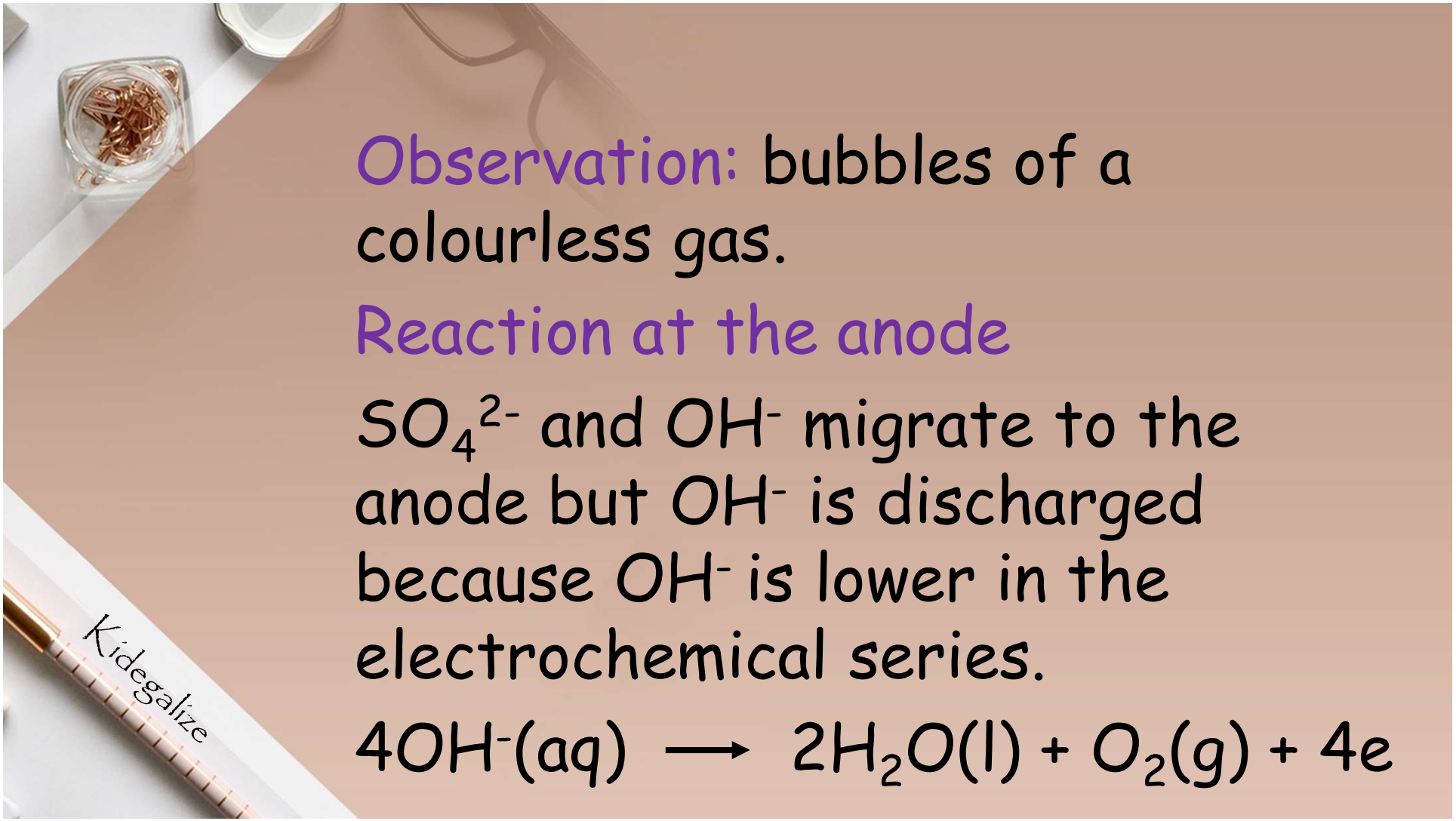


Ions present: H^+, OH^-, SO_4^{2-}

Reaction at the cathode

H^+ migrate to the cathode and is discharged by gain of electrons to form hydrogen gas.

$$2H^+(aq) + 2e \longrightarrow H_2(g)$$

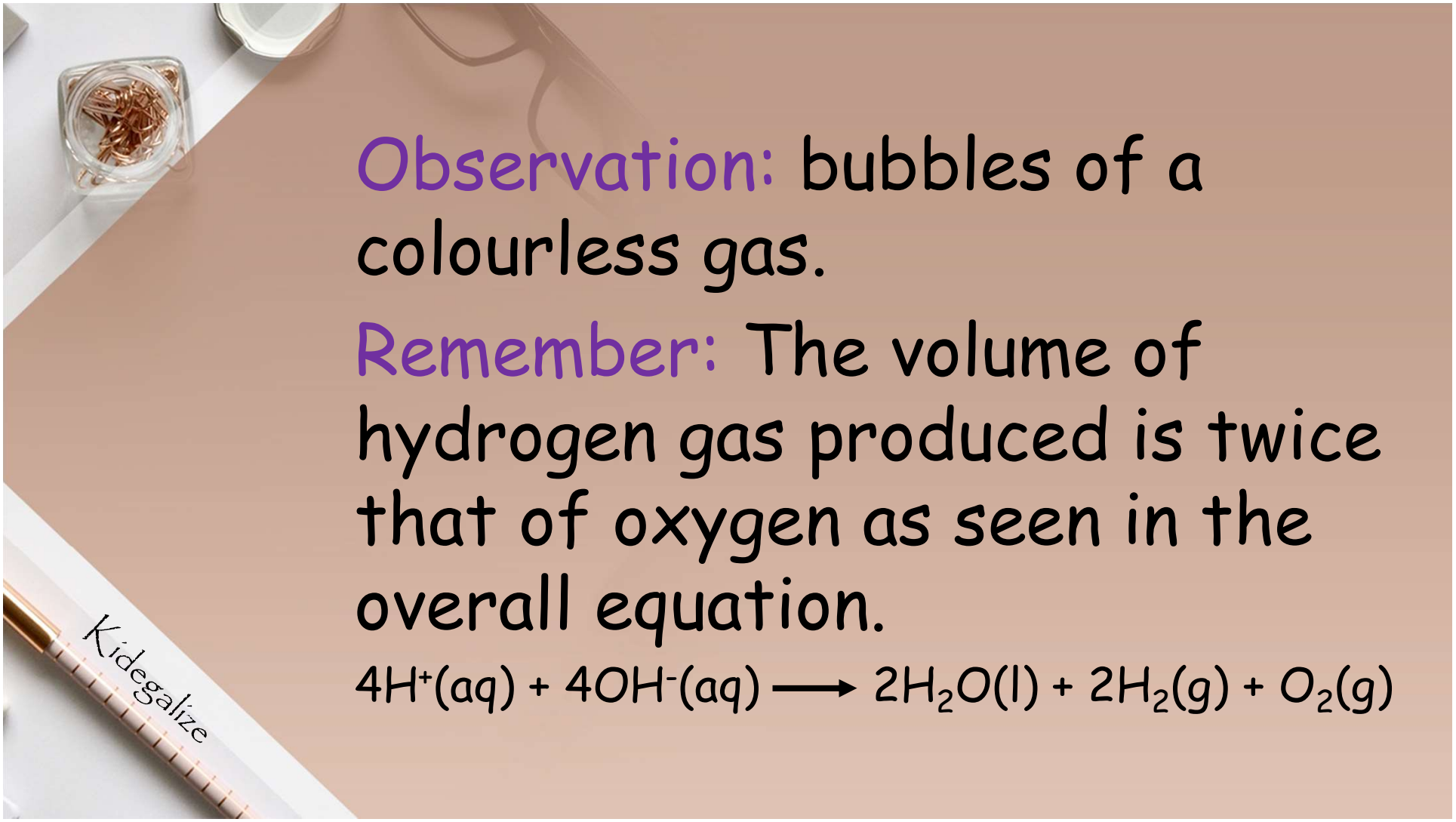


Observation: bubbles of a colourless gas.

Reaction at the anode

SO_4^{2-} and OH^- migrate to the anode but OH^- is discharged because OH^- is lower in the electrochemical series.

$$4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e$$



Observation: bubbles of a colourless gas.

Remember: The volume of hydrogen gas produced is twice that of oxygen as seen in the overall equation.

$$4H^+(aq) + 4OH^-(aq) \longrightarrow 2H_2O(l) + 2H_2(g) + O_2(g)$$

Knowledge Check 3

Qn. 1 (UNEB 1998/P1/31)

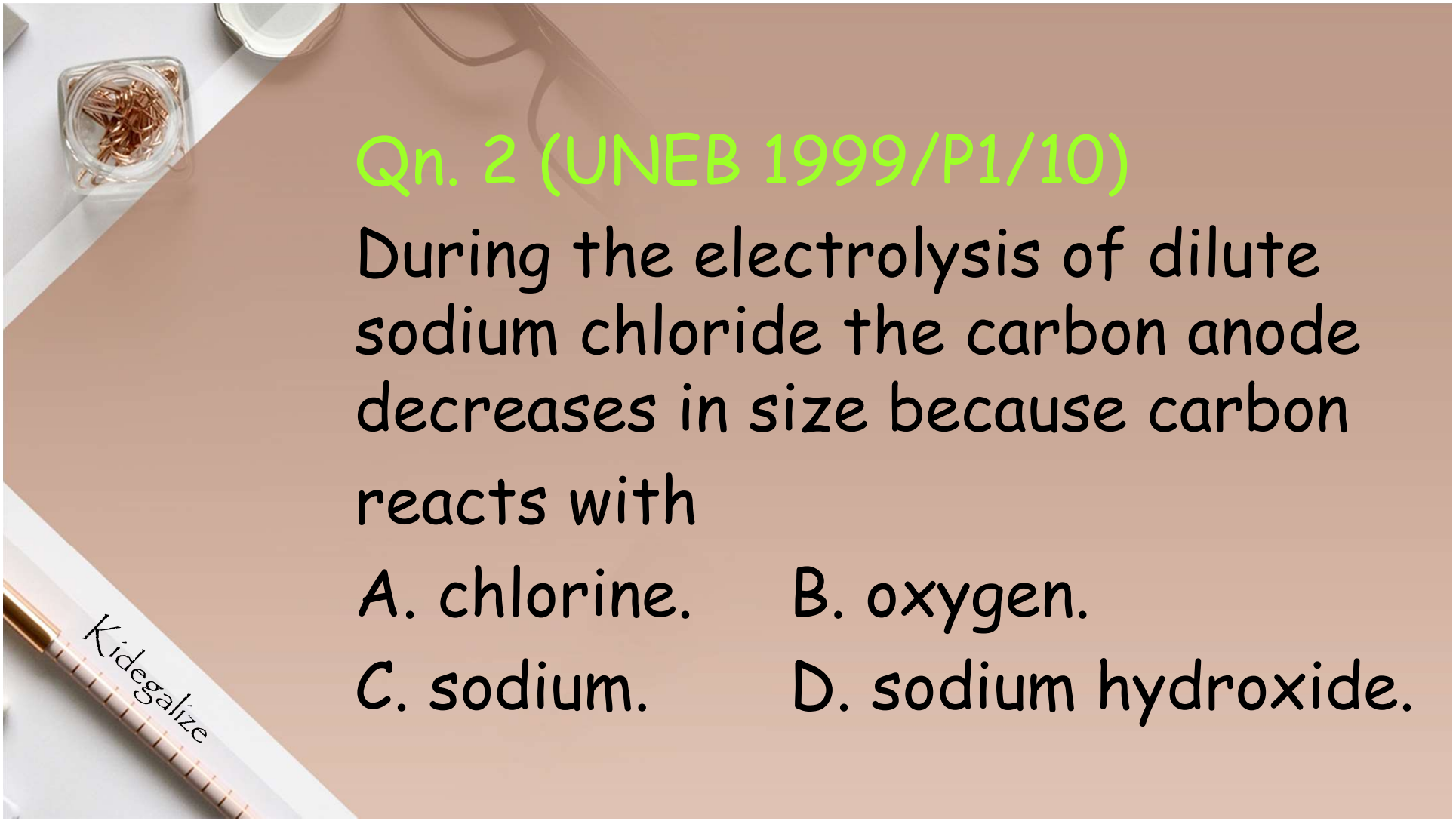
Which one of the following is formed at the cathode during electrolysis of dilute sodium chloride using platinum electrodes?

A. Sodium.

B. Hydrogen.

C. Chlorine.

D. Oxygen.



Qn. 2 (UNEB 1999/P1/10)

During the electrolysis of dilute sodium chloride the carbon anode decreases in size because carbon reacts with

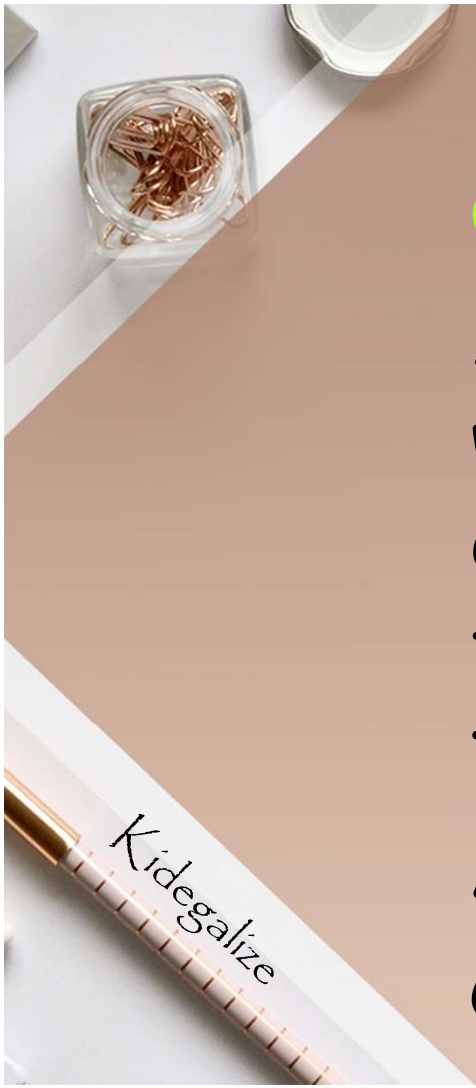
A. chlorine.
B. oxygen.
C. sodium.
D. sodium hydroxide.

Qn. 4 (UNEB 1996/P1/31)

Which one of the following substances is produced at the cathode when a dilute solution of potassium chloride is electrolysed using carbon electrodes?

A. Potassium. **B.** Chlorine.

C. Hydrogen. **D.** Oxygen.

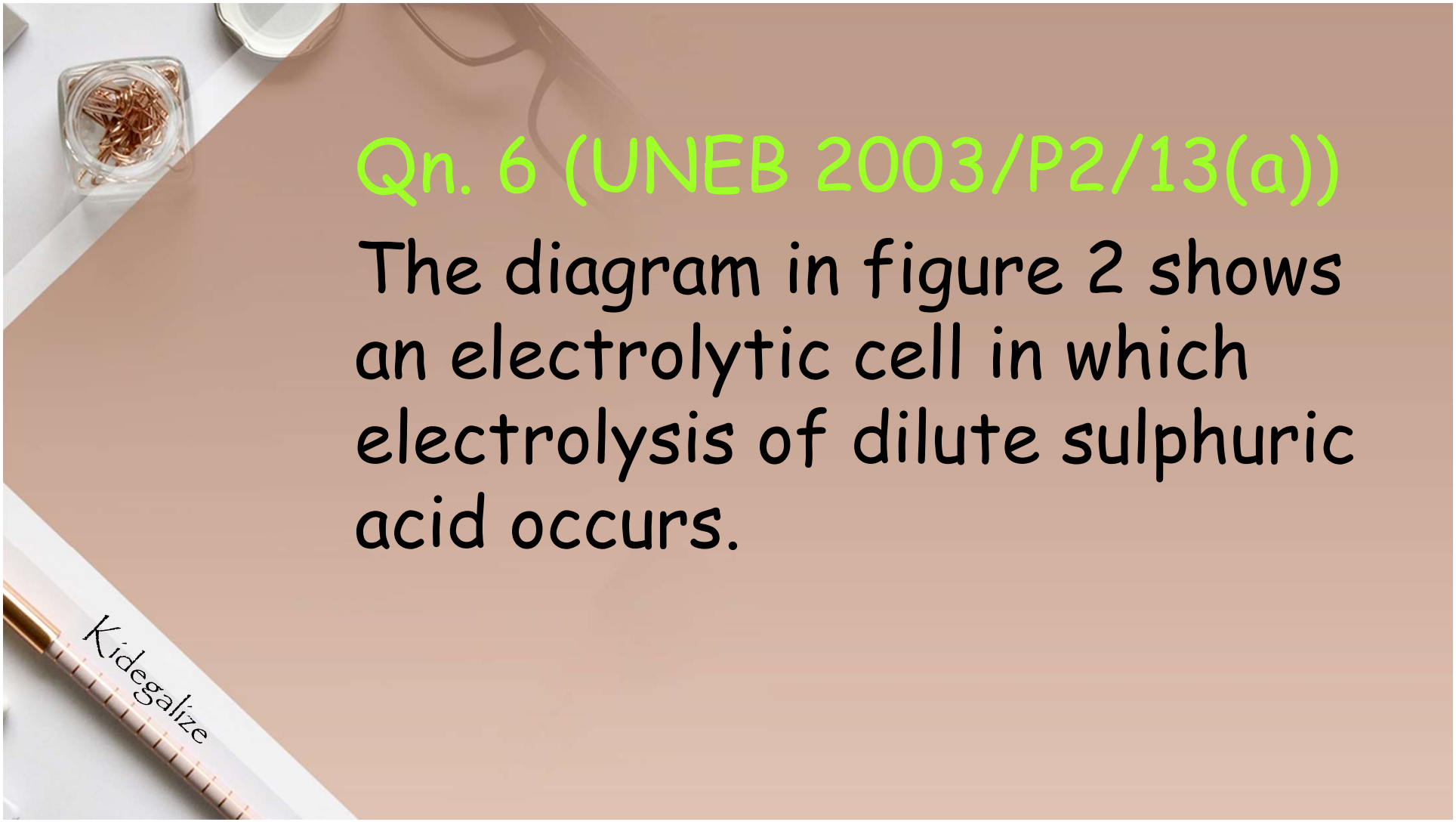


Qn. 5 (UNEB 2004/P1/12)

A dilute solution of sodium chloride was electrolysed using carbon electrodes. Which one of the following substances was formed at the anode?

A. Chlorine. **B.** Carbon dioxide.

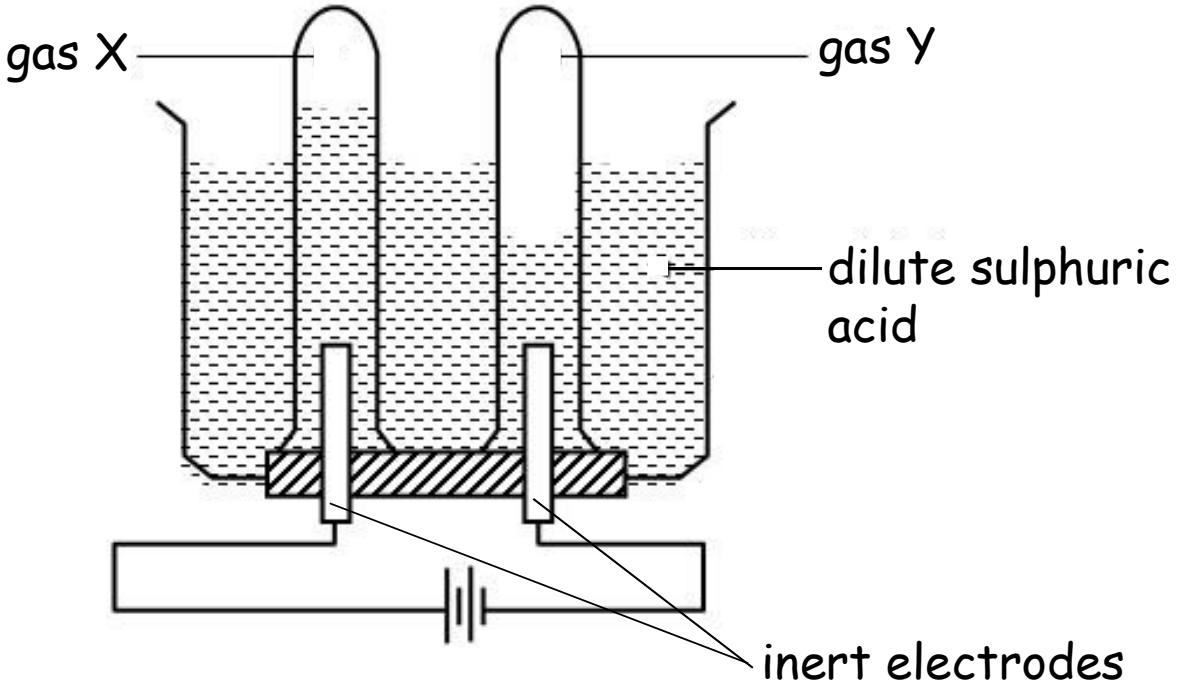
C. Oxygen. **D.** Hydrogen chloride.

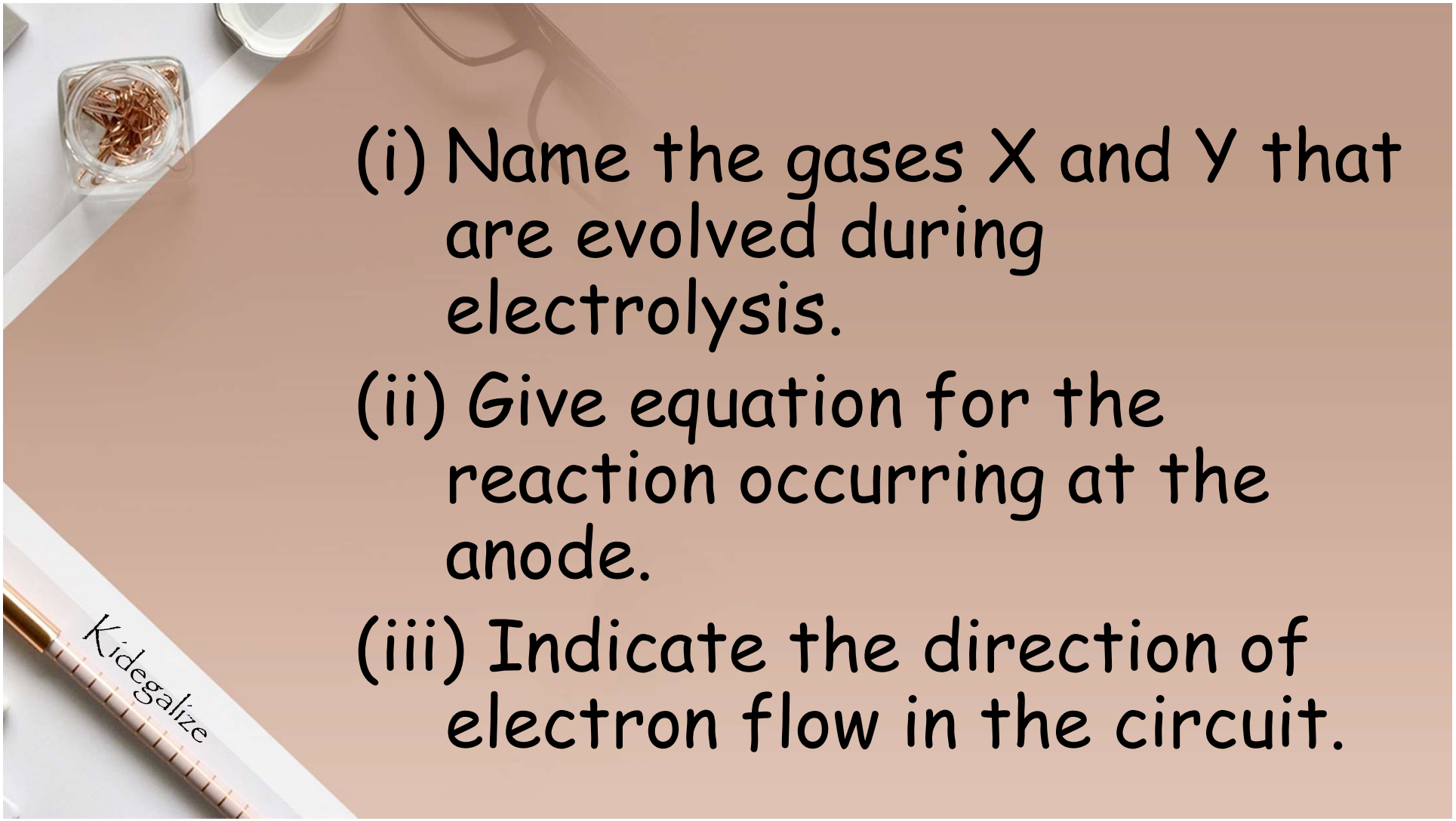


Qn. 6 (UNEB 2003/P2/13(a))

The diagram in figure 2 shows an electrolytic cell in which electrolysis of dilute sulphuric acid occurs.

Figure 2

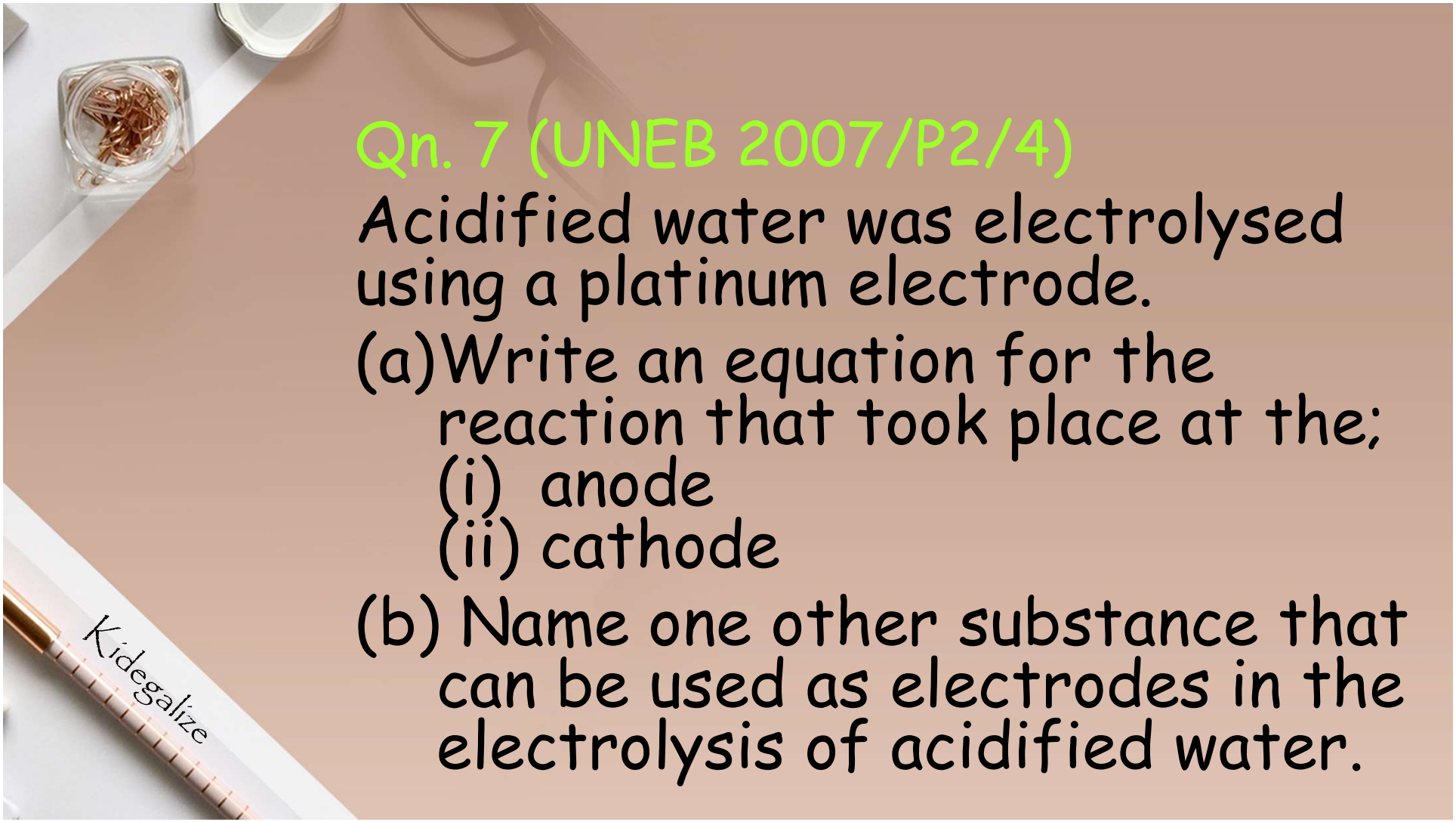




(i) Name the gases X and Y that are evolved during electrolysis.

(ii) Give equation for the reaction occurring at the anode.

(iii) Indicate the direction of electron flow in the circuit.

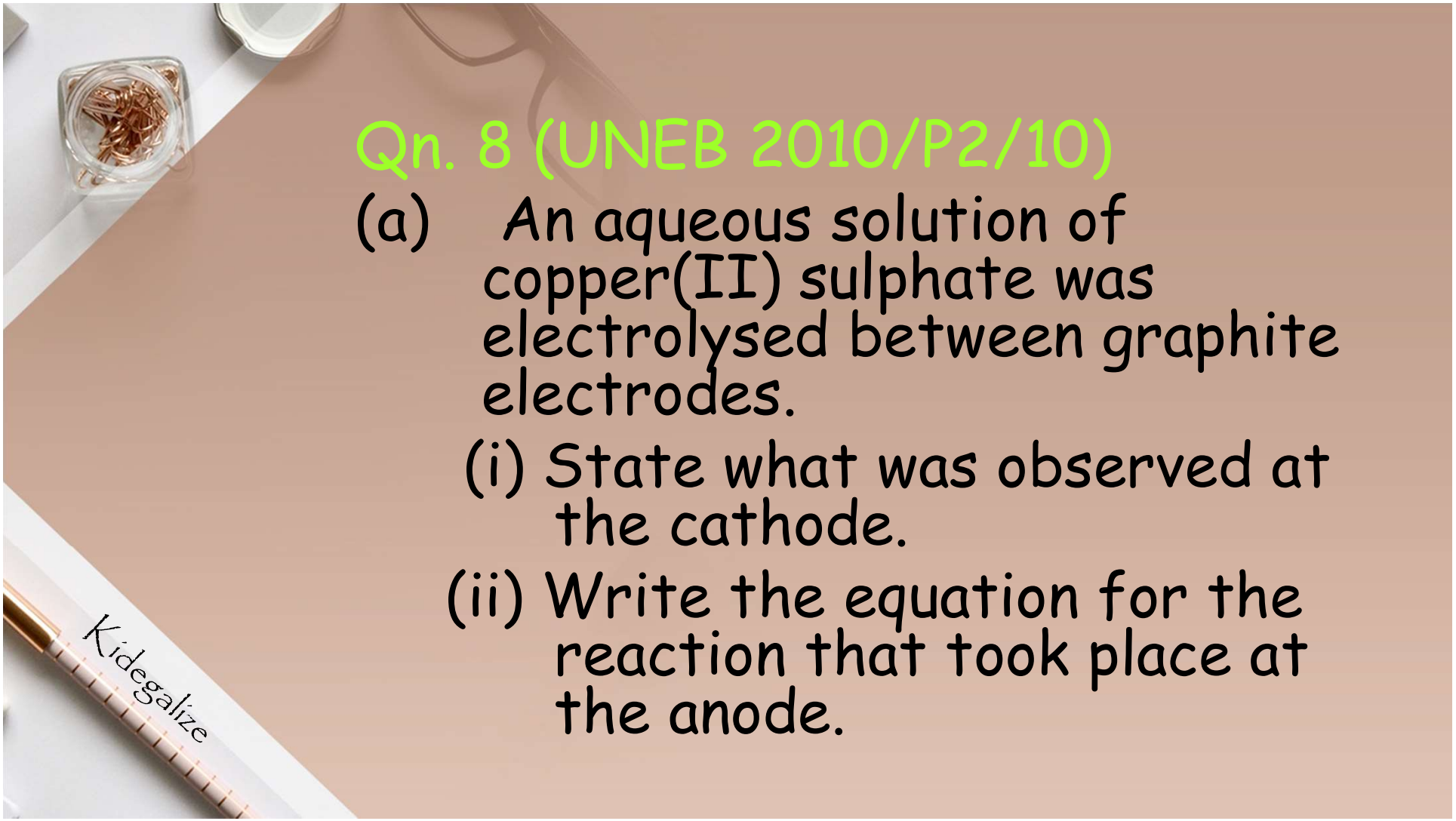


Qn. 7 (UNEB 2007/P2/4)

Acidified water was electrolysed using a platinum electrode.

(a) Write an equation for the reaction that took place at the;
   (i) anode
   (ii) cathode

(b) Name one other substance that can be used as electrodes in the electrolysis of acidified water.

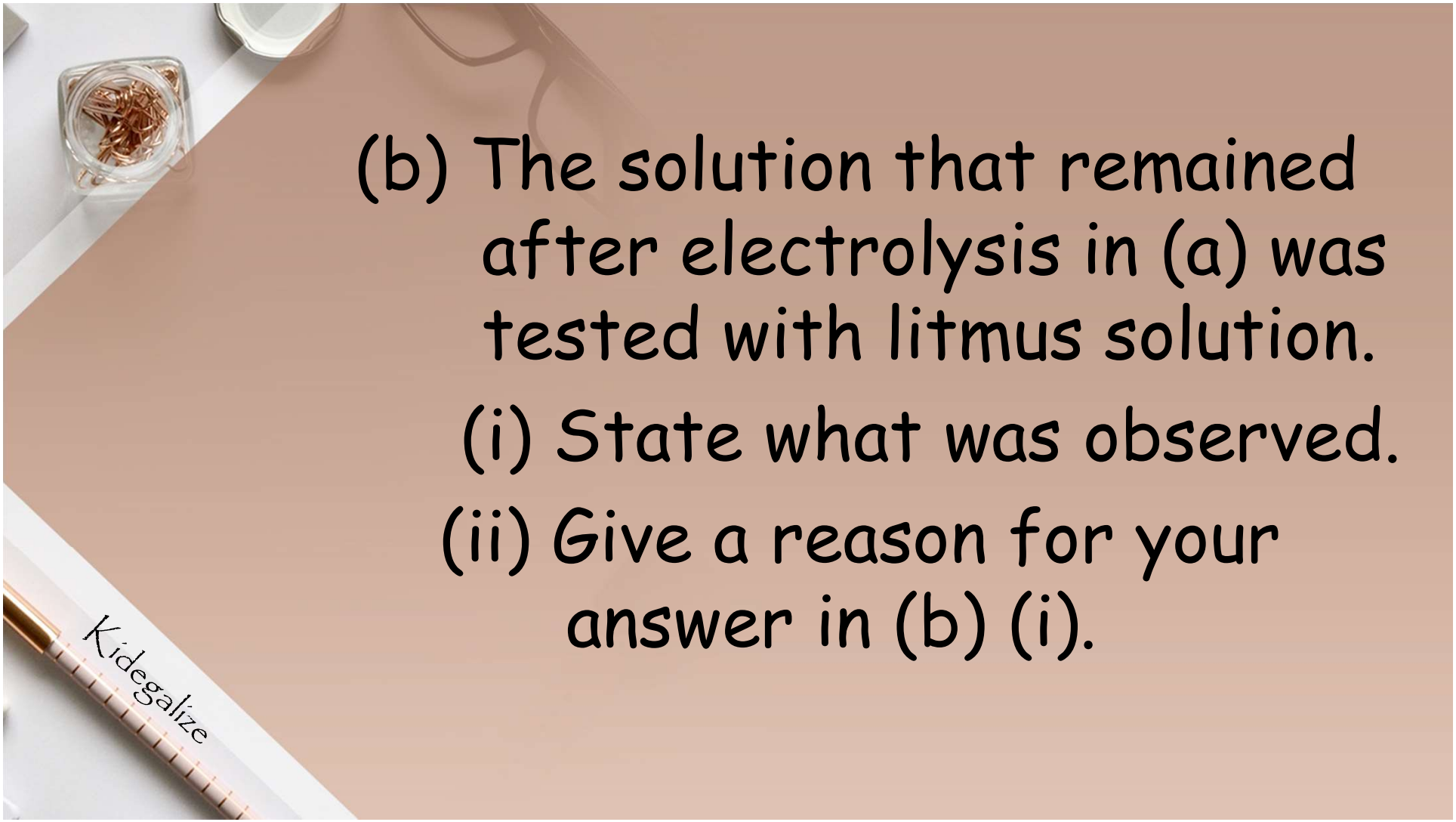


Qn. 8 (UNEB 2010/P2/10)

(a) An aqueous solution of copper(II) sulphate was electrolysed between graphite electrodes.

(i) State what was observed at the cathode.

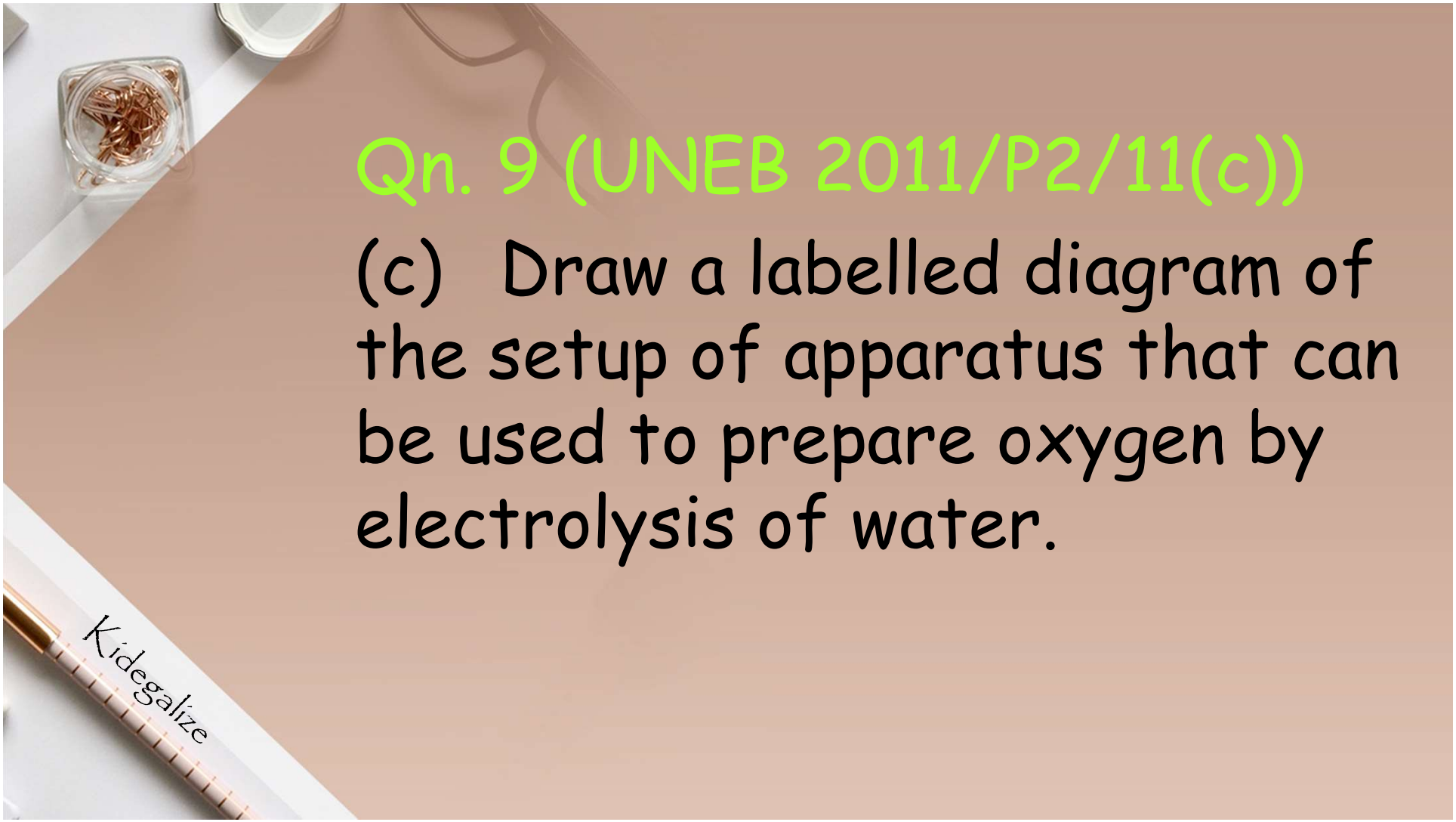
(ii) Write the equation for the reaction that took place at the anode.



(b) The solution that remained after electrolysis in (a) was tested with litmus solution.

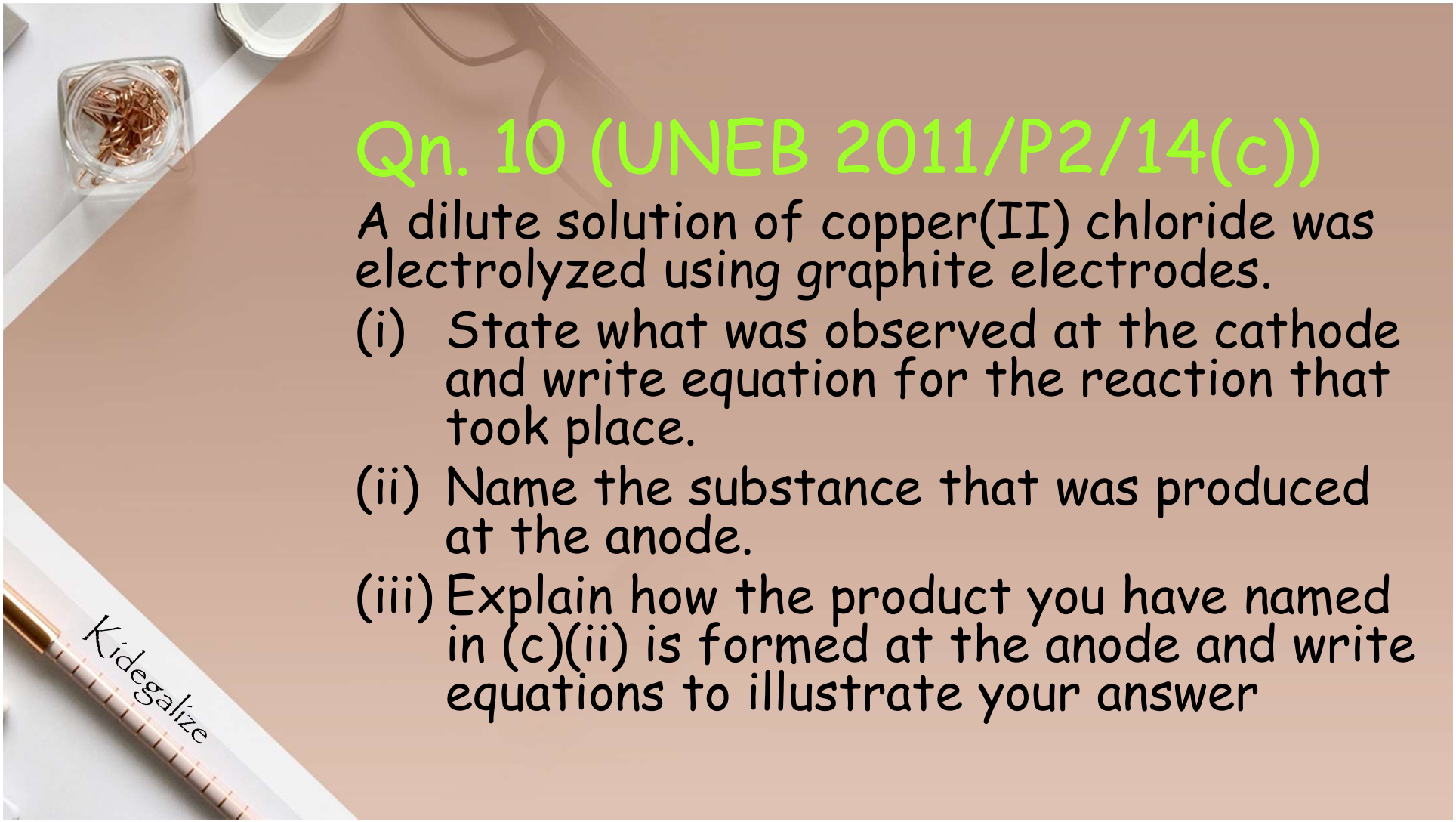
(i) State what was observed.

(ii) Give a reason for your answer in (b) (i).



Qn. 9 (UNEB 2011/P2/11(c))

(c) Draw a labelled diagram of the setup of apparatus that can be used to prepare oxygen by electrolysis of water.



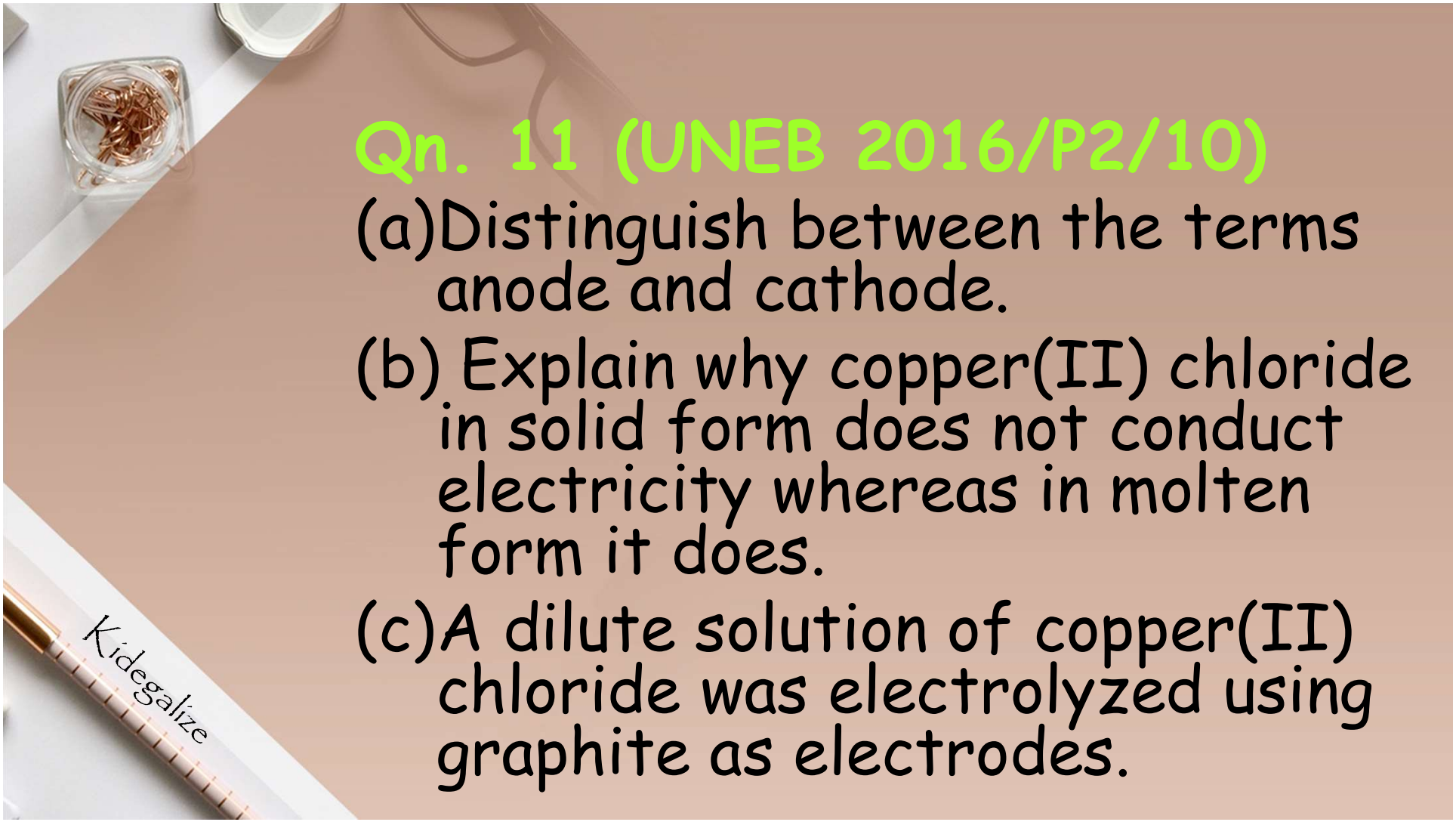
Qn. 10 (UNEB 2011/P2/14(c))

A dilute solution of copper(II) chloride was electrolyzed using graphite electrodes.

(i) State what was observed at the cathode and write equation for the reaction that took place.

(ii) Name the substance that was produced at the anode.

(iii) Explain how the product you have named in (c)(ii) is formed at the anode and write equations to illustrate your answer

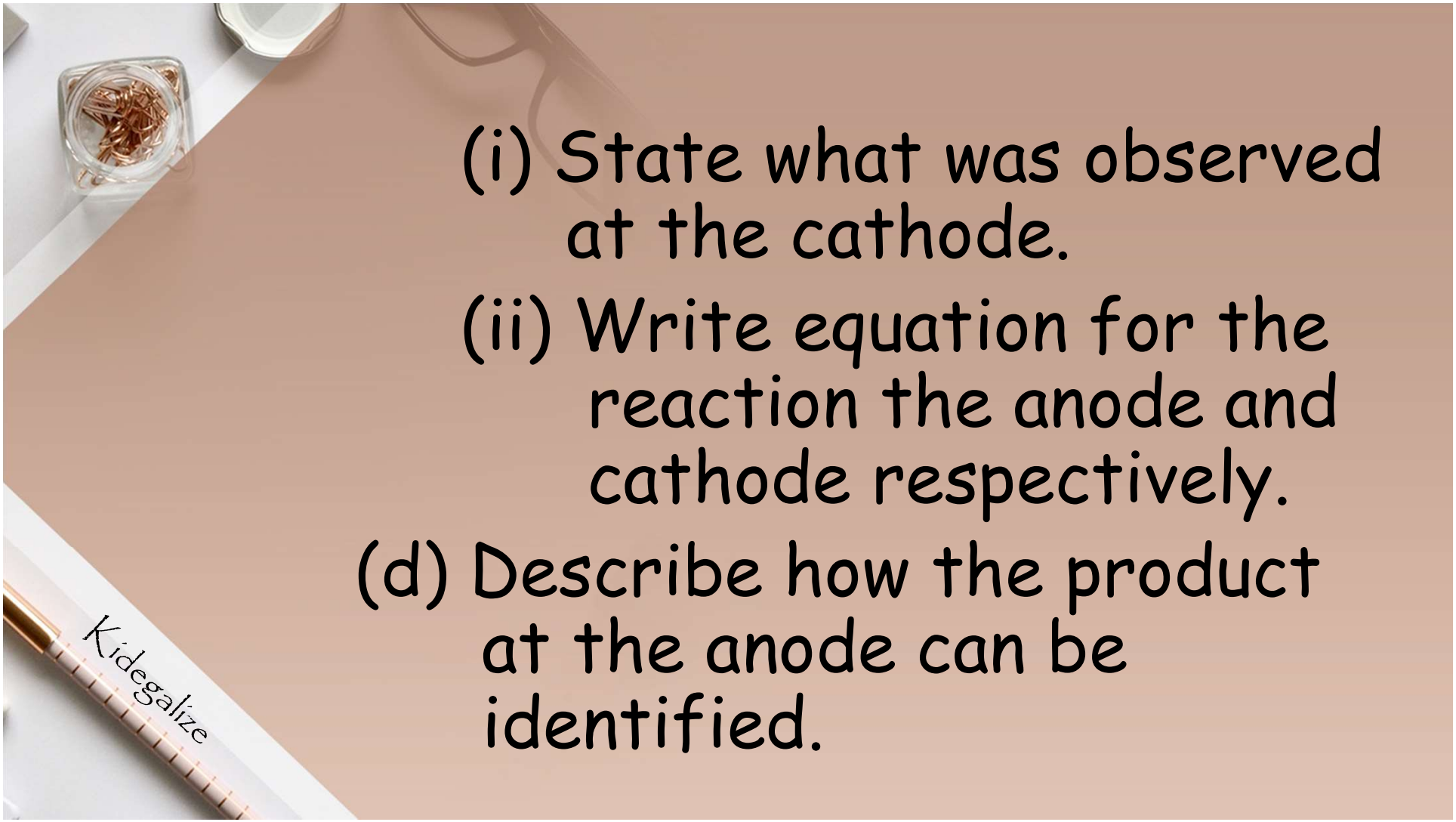


Qn. 11 (UNEB 2016/P2/10)

(a)Distinguish between the terms anode and cathode.

(b) Explain why copper(II) chloride in solid form does not conduct electricity whereas in molten form it does.

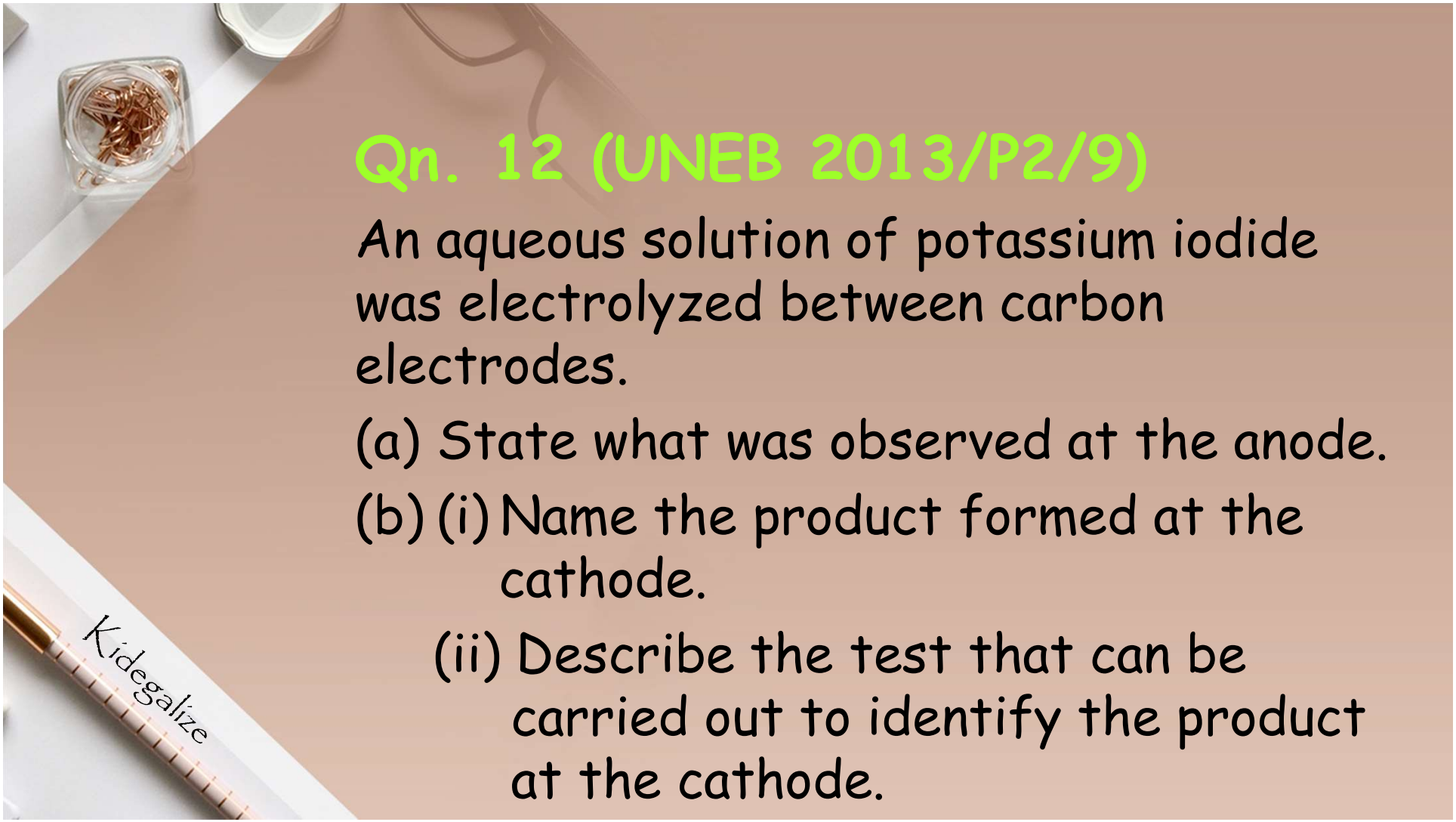
(c)A dilute solution of copper(II) chloride was electrolyzed using graphite as electrodes.



(i) State what was observed at the cathode.

(ii) Write equation for the reaction the anode and cathode respectively.

(d) Describe how the product at the anode can be identified.



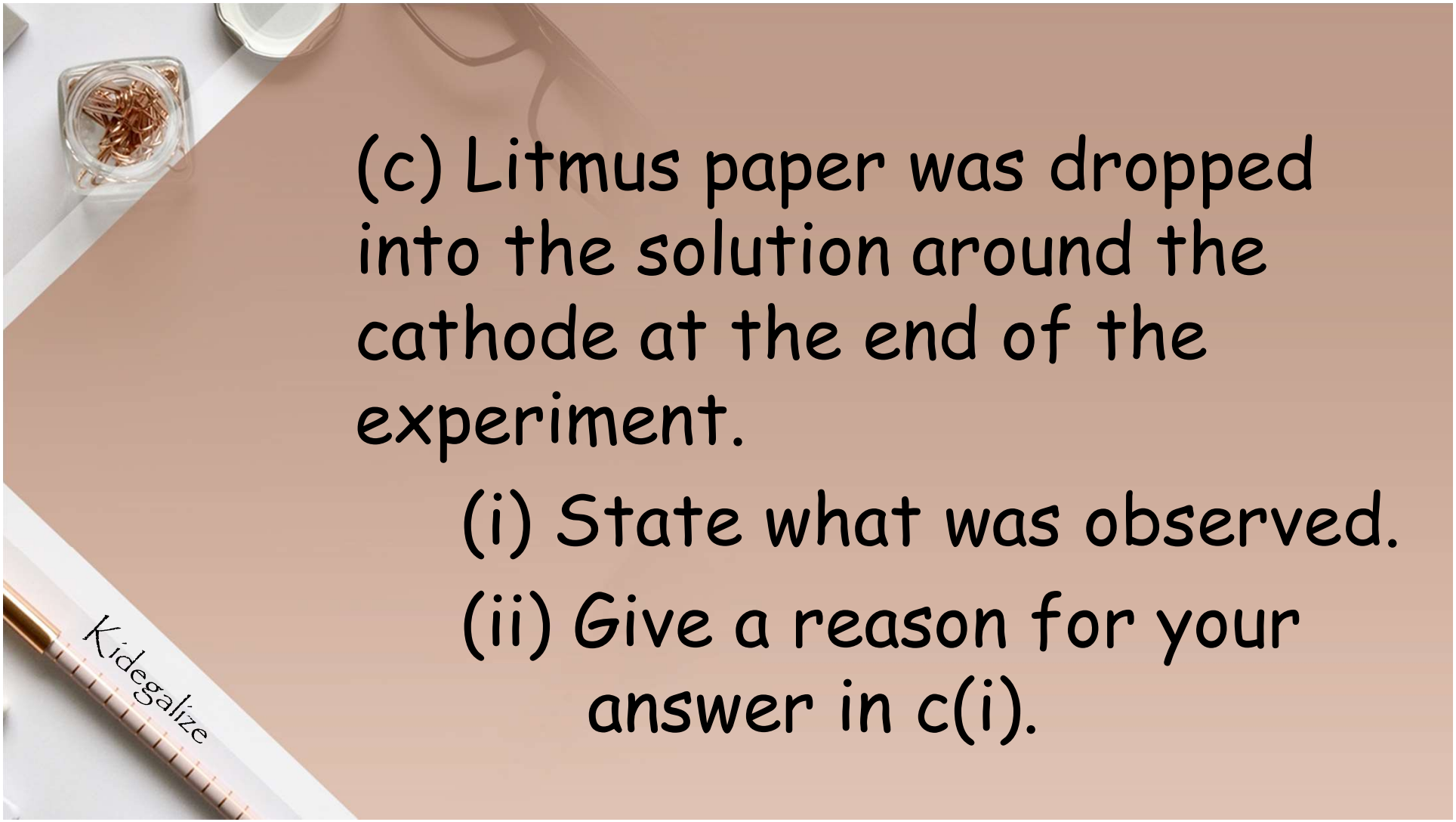
Qn. 12 (UNEB 2013/P2/9)

An aqueous solution of potassium iodide was electrolyzed between carbon electrodes.

(a) State what was observed at the anode.

(b) (i) Name the product formed at the cathode.

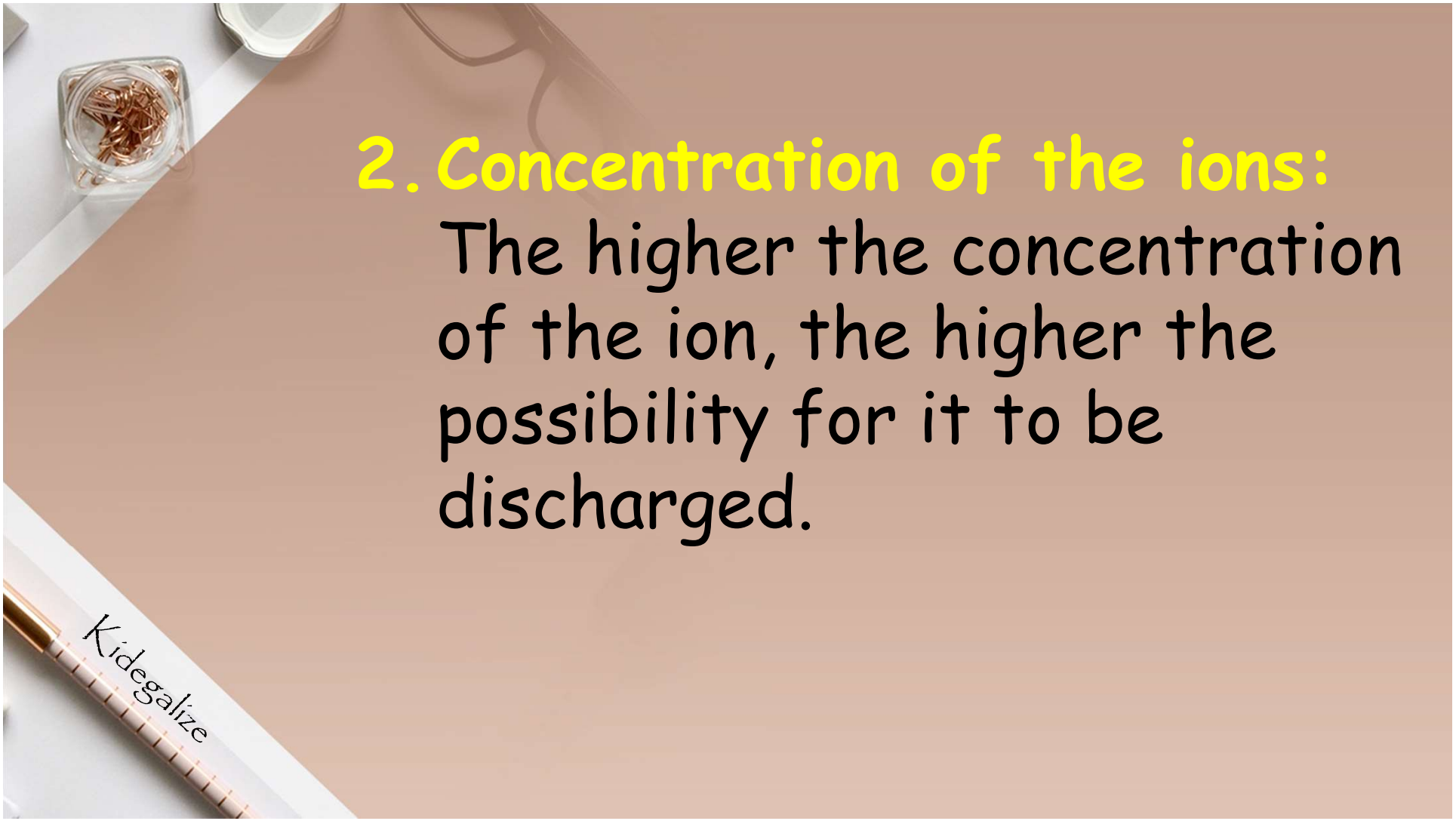
(ii) Describe the test that can be carried out to identify the product at the cathode.



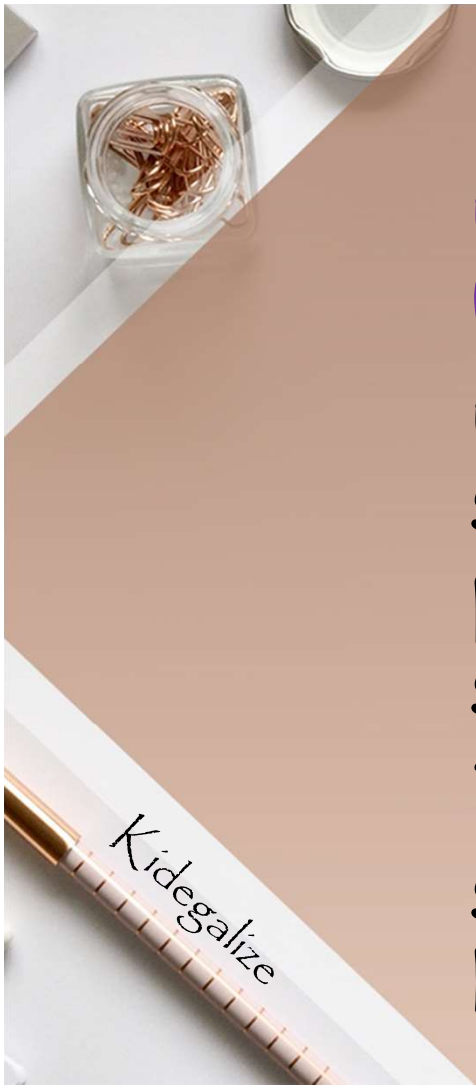
(c) Litmus paper was dropped into the solution around the cathode at the end of the experiment.

(i) State what was observed.

(ii) Give a reason for your answer in c(i).



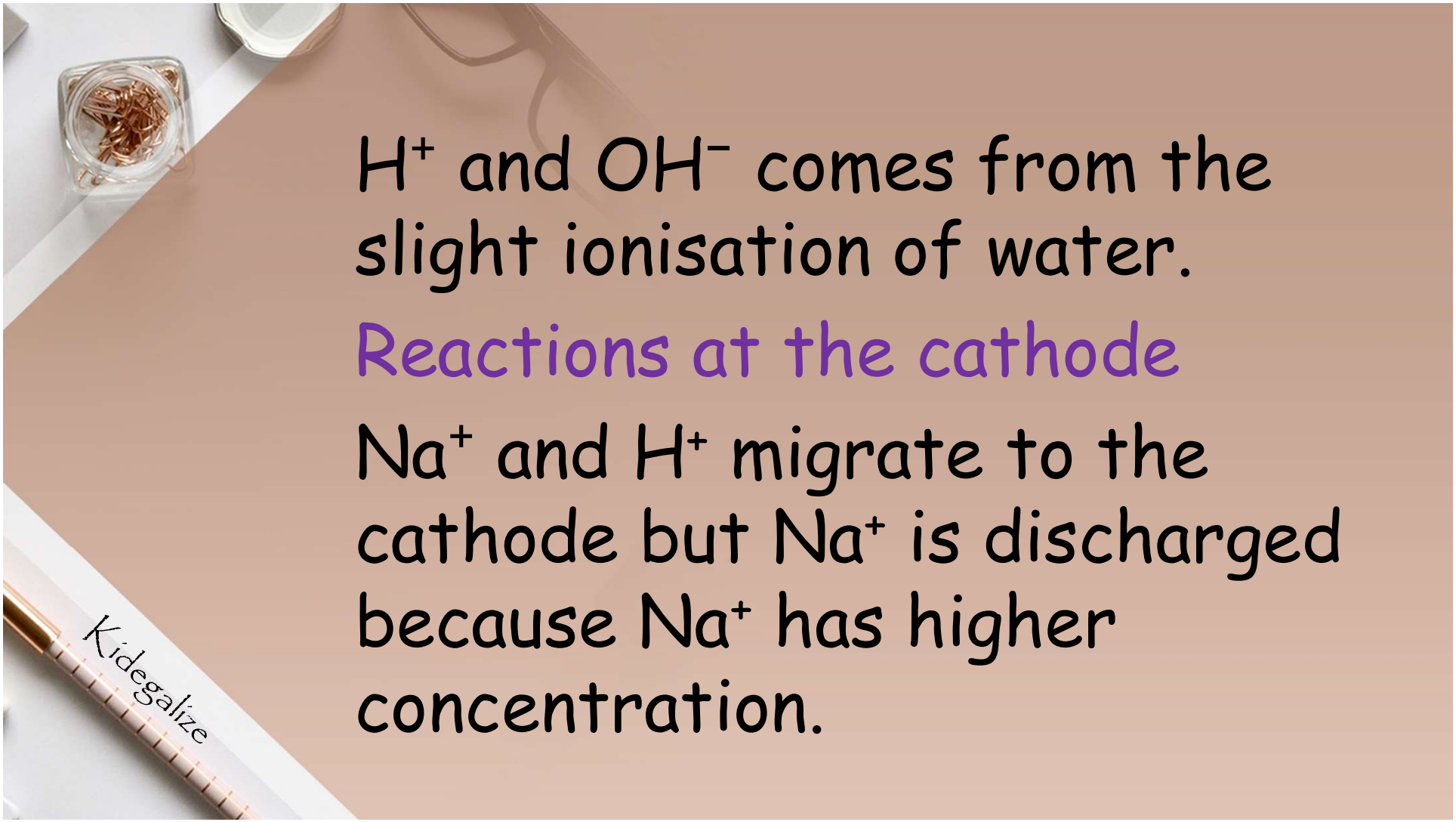
2. **Concentration of the ions:**
   The higher the concentration of the ion, the higher the possibility for it to be discharged.



Electrolysis of concentrated NaCl using graphite/platinum electrodes

Electrolysis of concentrated sodium chloride (brine) is used to produce chlorine, hydrogen and sodium hydroxide.

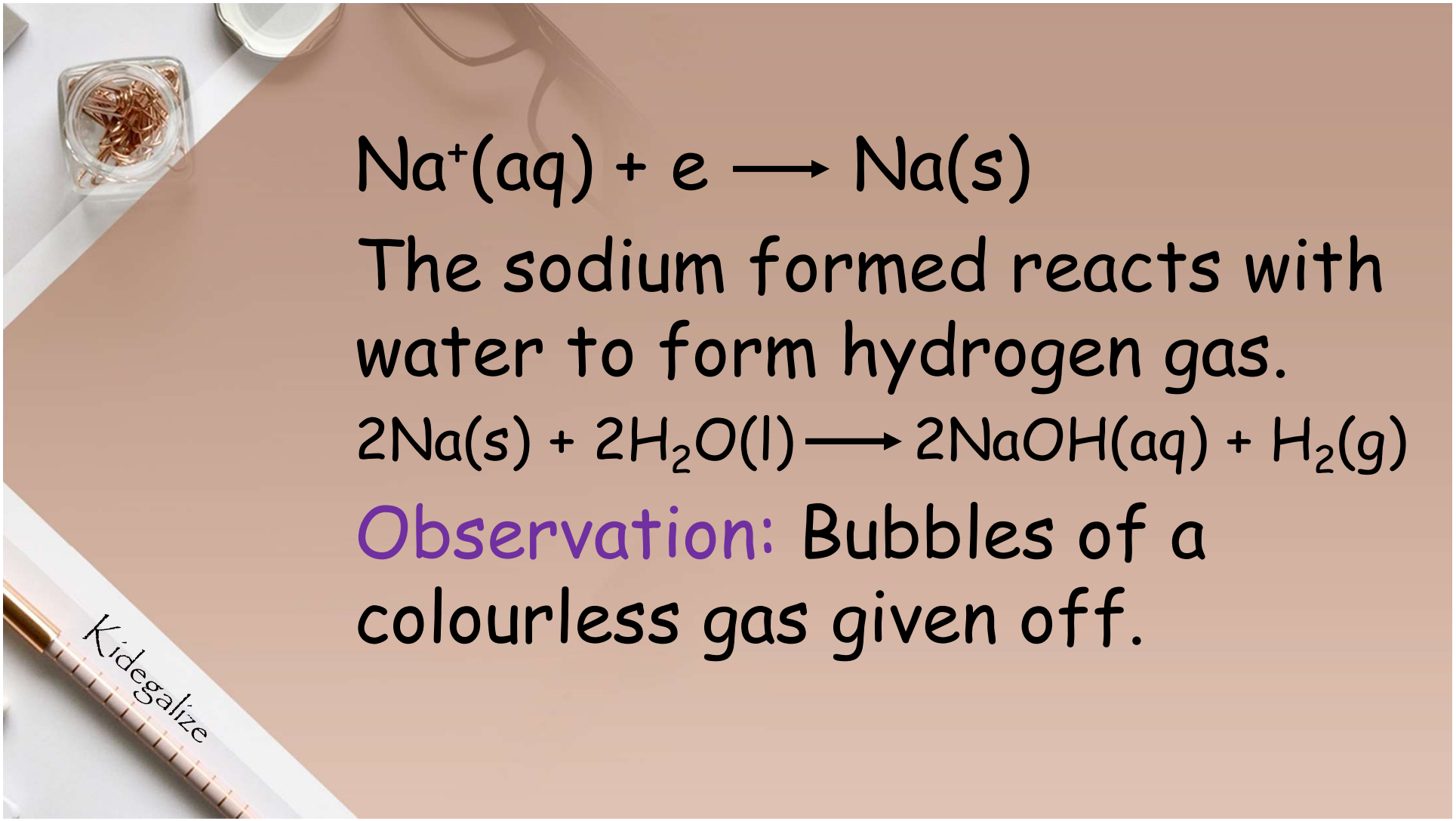
The ions present in the aqueous solution of sodium chloride are Na^+, Cl^-, H^+ and OH^-.



H^+ and OH^- comes from the slight ionisation of water.

Reactions at the cathode

Na^+ and H^+ migrate to the cathode but Na^+ is discharged because Na^+ has higher concentration.

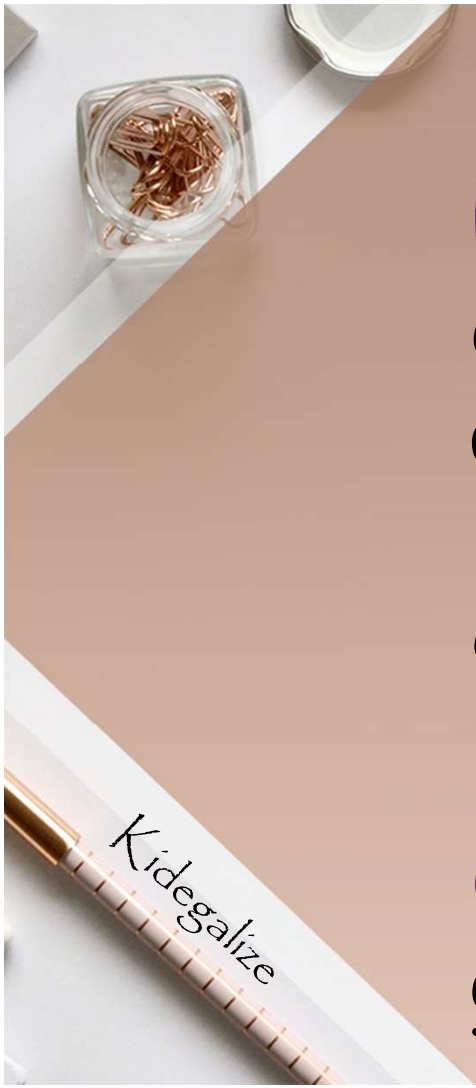


$Na^+(aq) + e \longrightarrow Na(s)$

The sodium formed reacts with water to form hydrogen gas.

$2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$

Observation: Bubbles of a colourless gas given off.

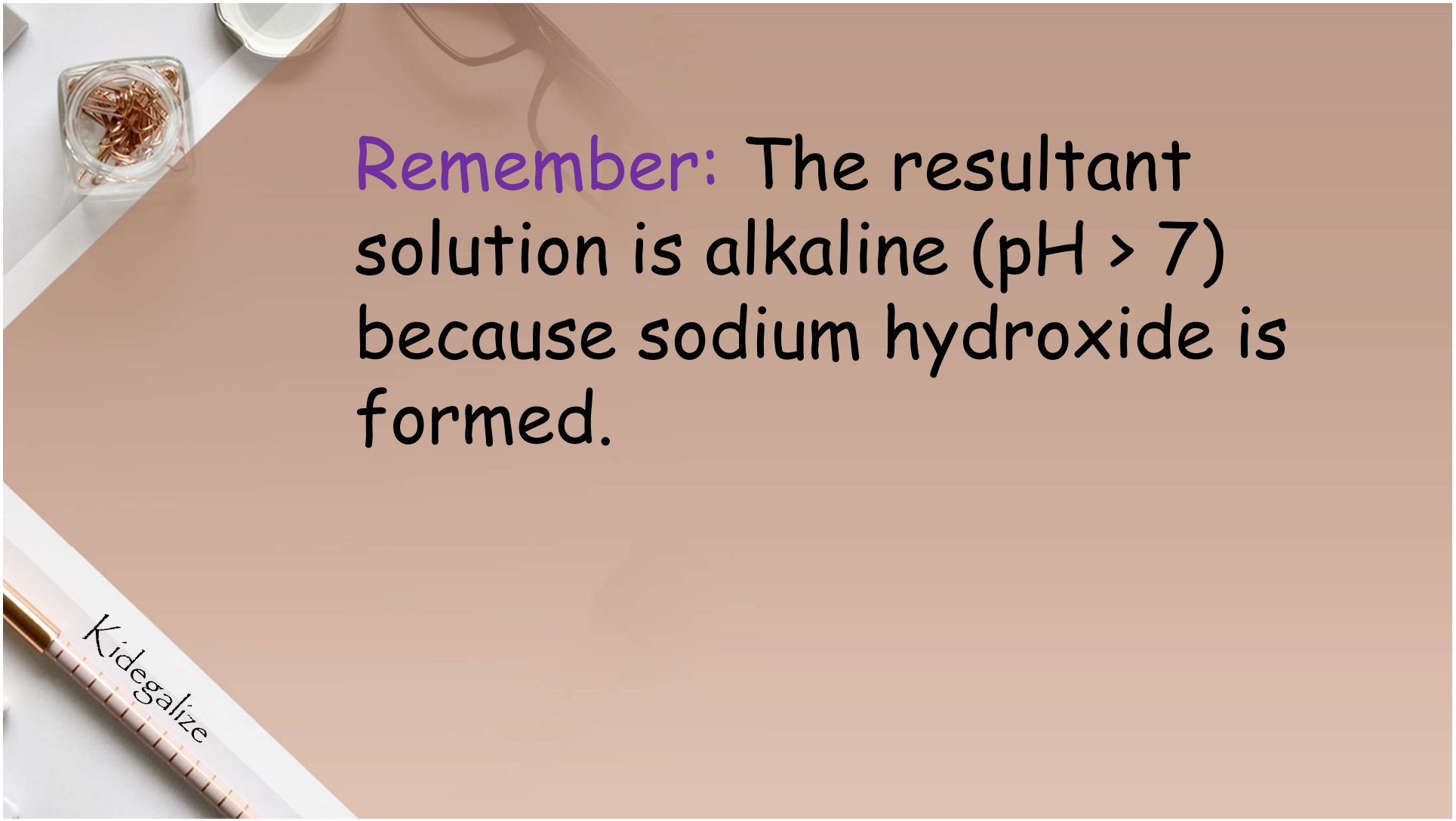


Reaction at the anode

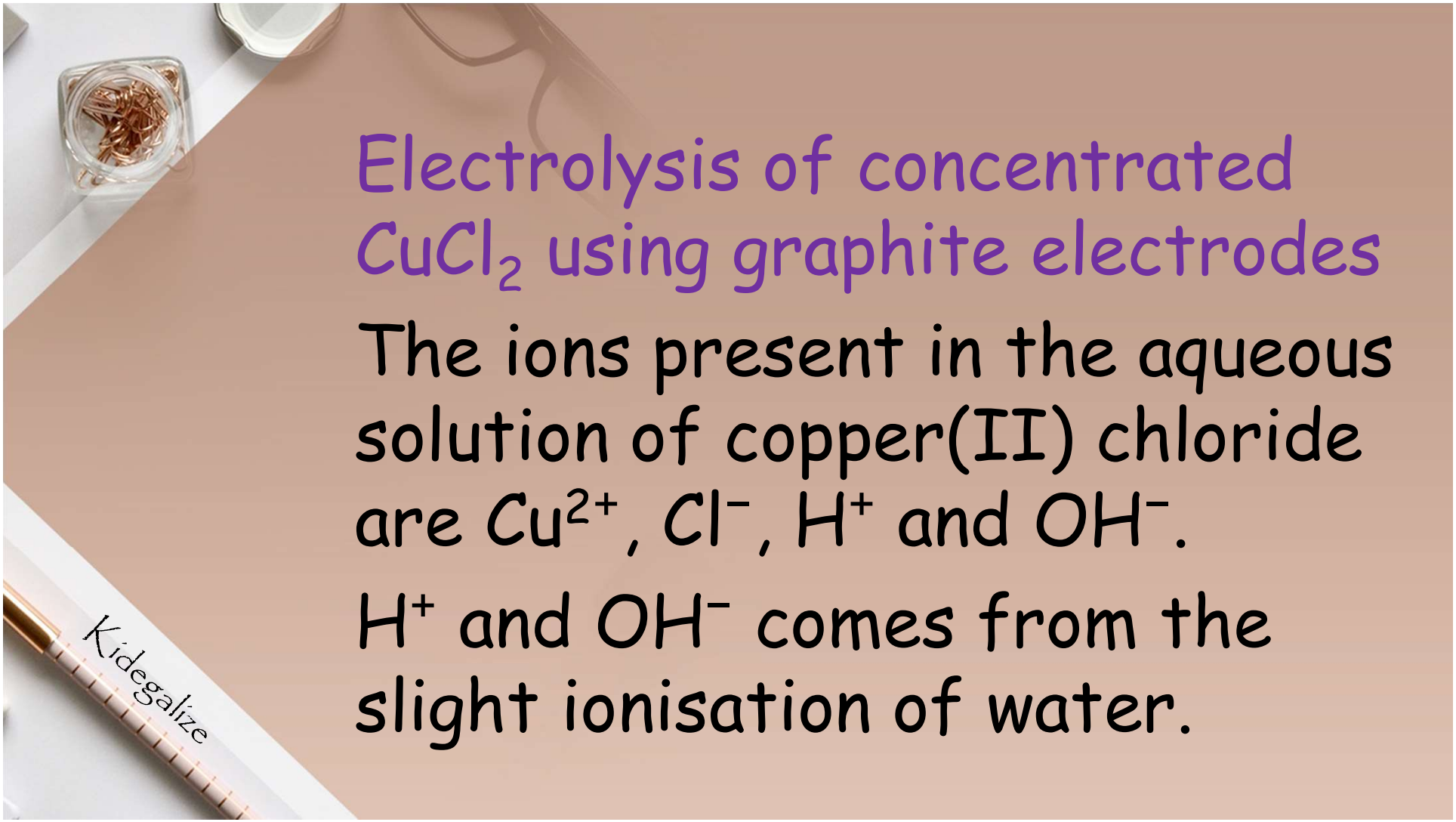
Cl^- and OH^- migrate to the anode but Cl^- is discharged because Cl^- has higher concentration.

$$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$$

Observation: A greenish-yellow gas given off.



Remember: The resultant solution is alkaline (pH > 7) because sodium hydroxide is formed.



Electrolysis of concentrated $CuCl_2$ using graphite electrodes

The ions present in the aqueous solution of copper(II) chloride are Cu^{2+}, Cl^-, H^+ and OH^-.

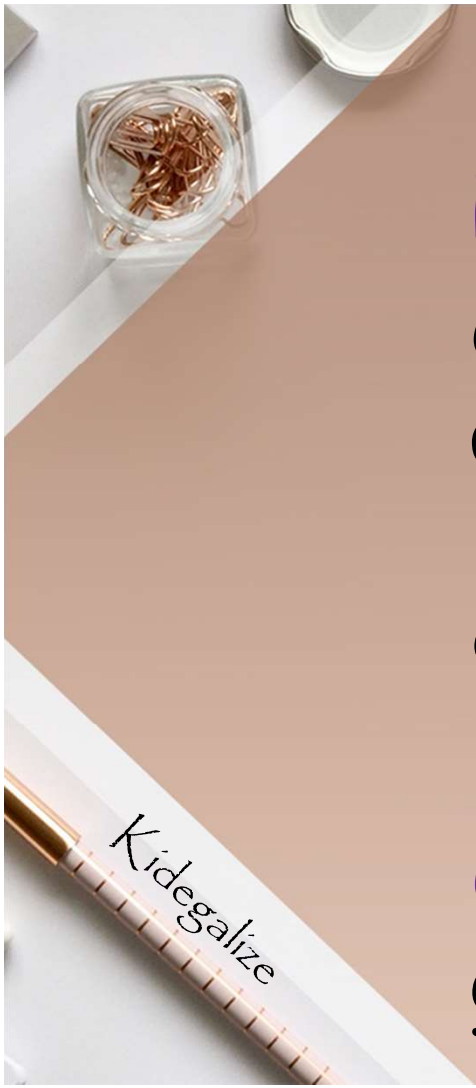
H^+ and OH^- comes from the slight ionisation of water.

Reactions at the cathode

Cu^{2+} and H^+ migrate to the cathode but Cu^{2+} is discharged because Cu^{2+} has higher concentration.

$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

Observation: A reddish-brown solid is deposited.

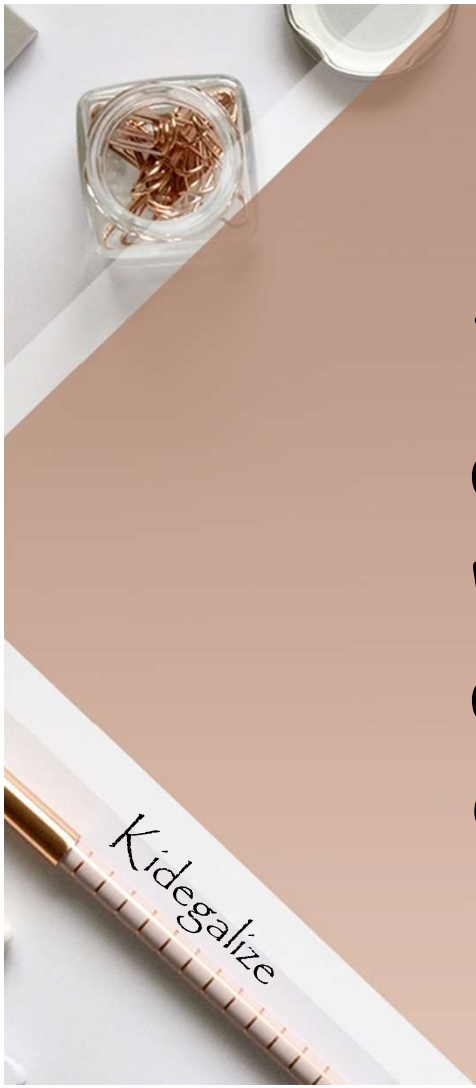


Reaction at the anode

Cl^- and OH^- migrate to the anode but Cl^- is discharged because Cl^- has higher concentration.

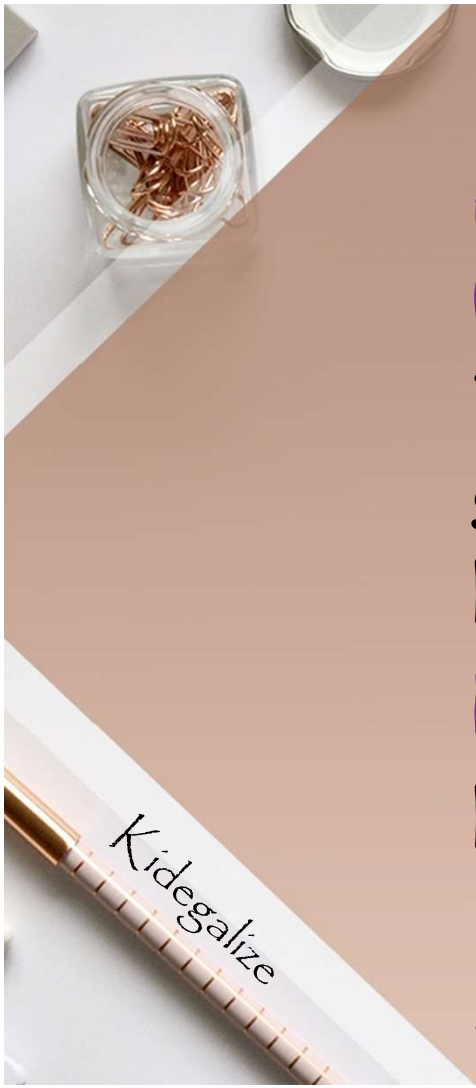
$$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$$

Observation: A greenish-yellow gas given off.



3. Nature of the electrodes:

The nature of the electrodes affect discharges of ions only when the electrode used is active and the electrolyte is dilute.

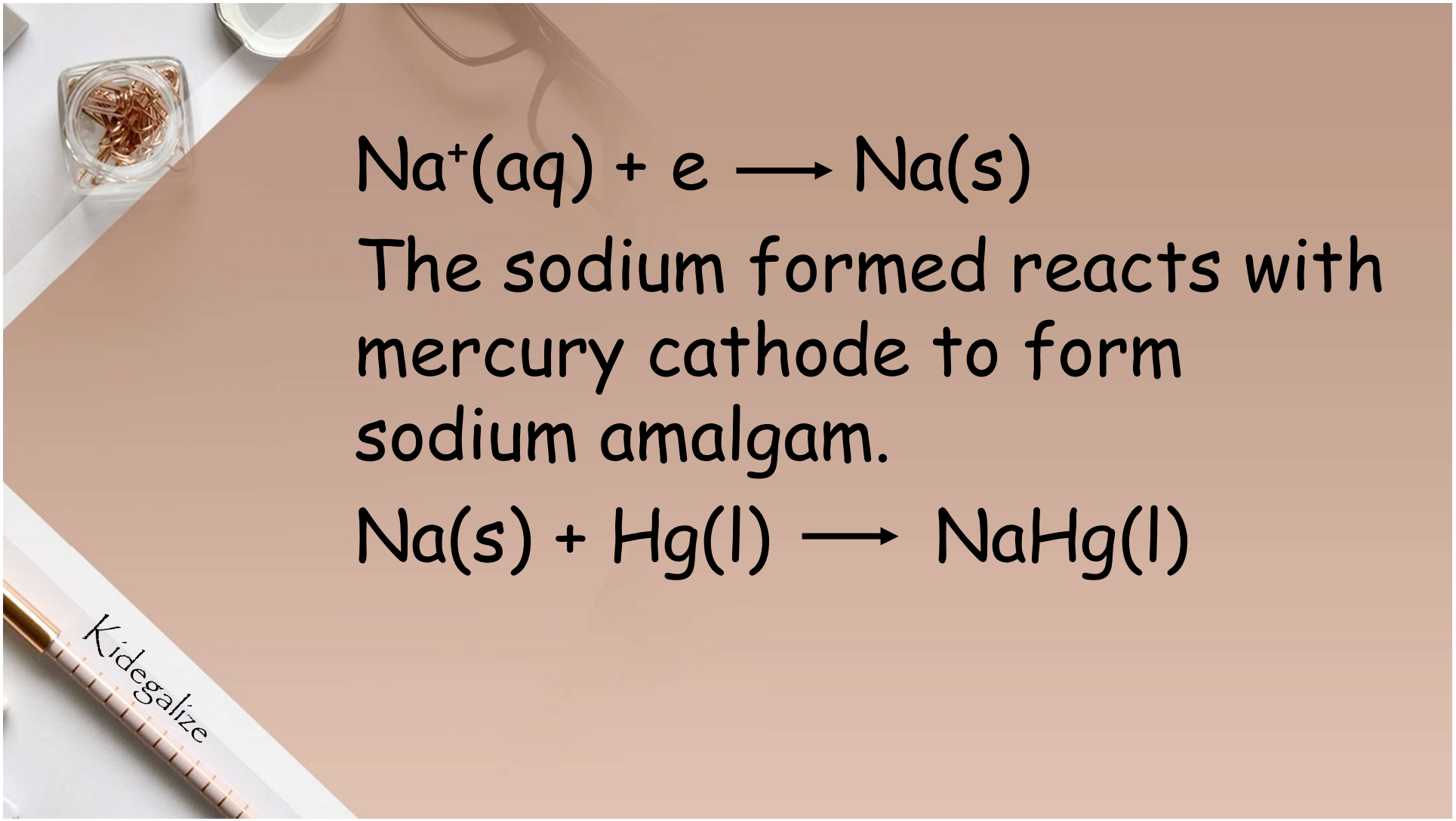


Electrolysis of concentrated NaCl using mercury cathode

The ions present in the aqueous solution of sodium chloride are Na^+, Cl^-, H^+ and OH^-.

Reactions at the cathode

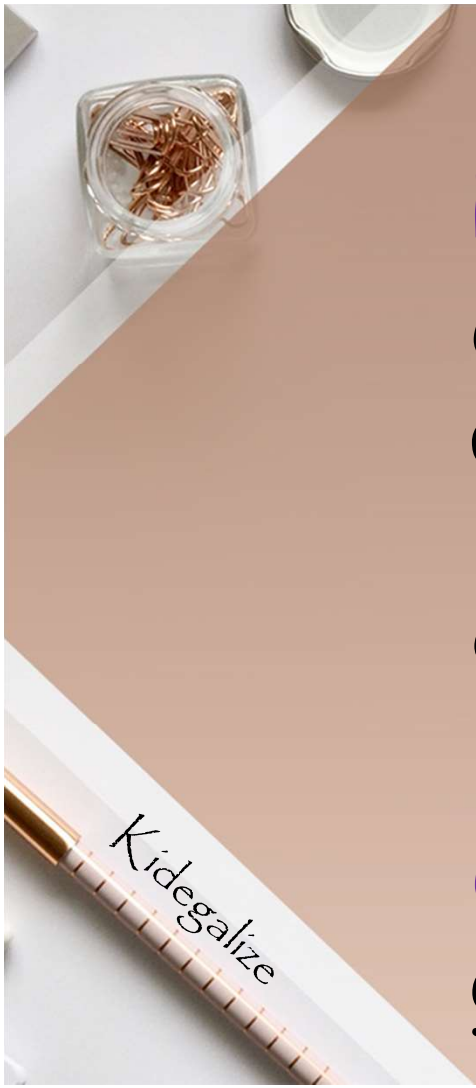
Na^+ and H^+ migrate to the cathode but Na^+ is discharged because Na^+ has higher concentration.



$Na^+(aq) + e \longrightarrow Na(s)$

The sodium formed reacts with mercury cathode to form sodium amalgam.

$Na(s) + Hg(l) \longrightarrow NaHg(l)$

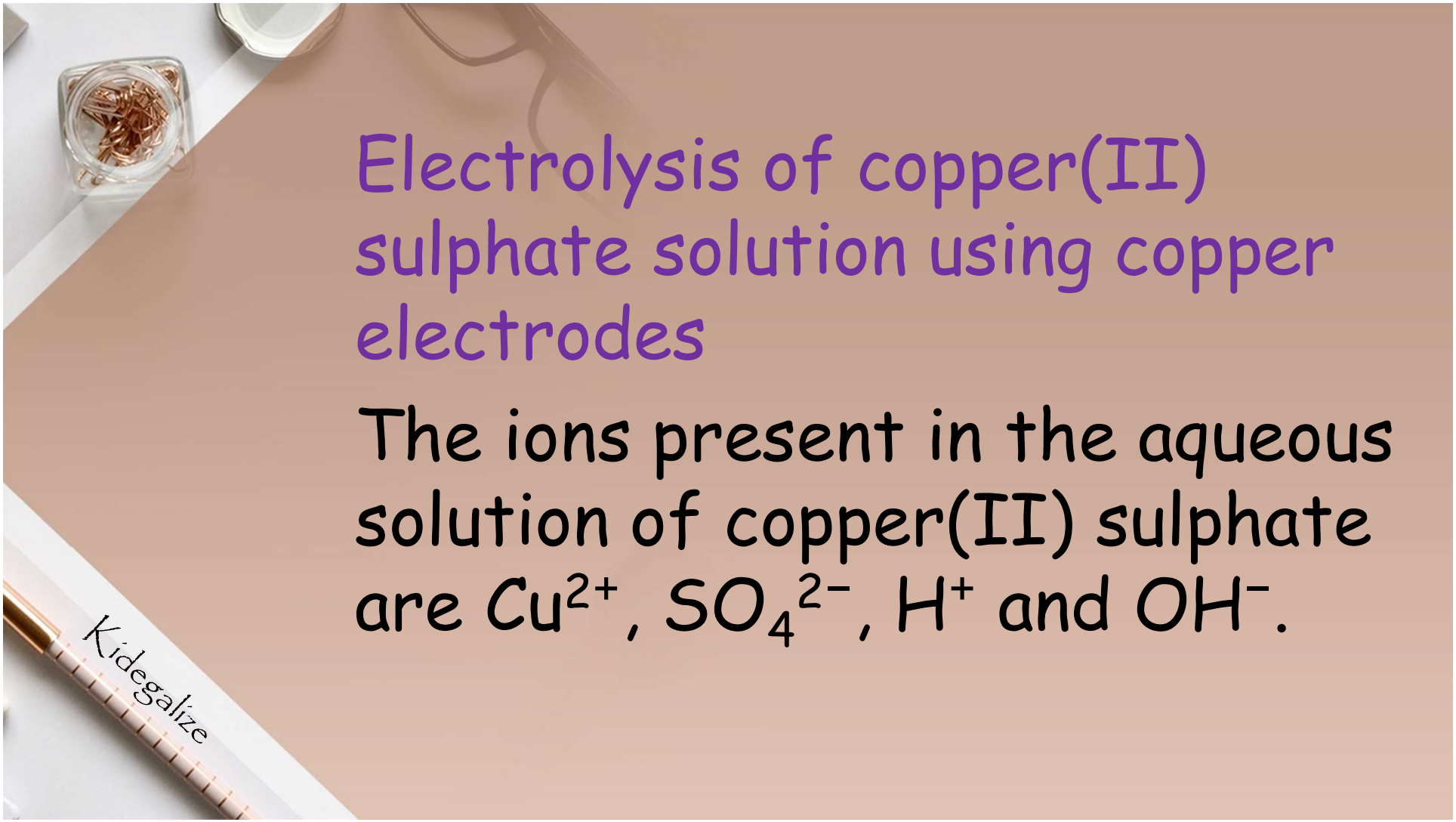


Reaction at the anode

Cl^- and OH^- migrate to the anode but Cl^- is discharged because Cl^- has higher concentration.

$$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$$

Observation: A greenish-yellow gas given off.



Electrolysis of copper(II) sulphate solution using copper electrodes

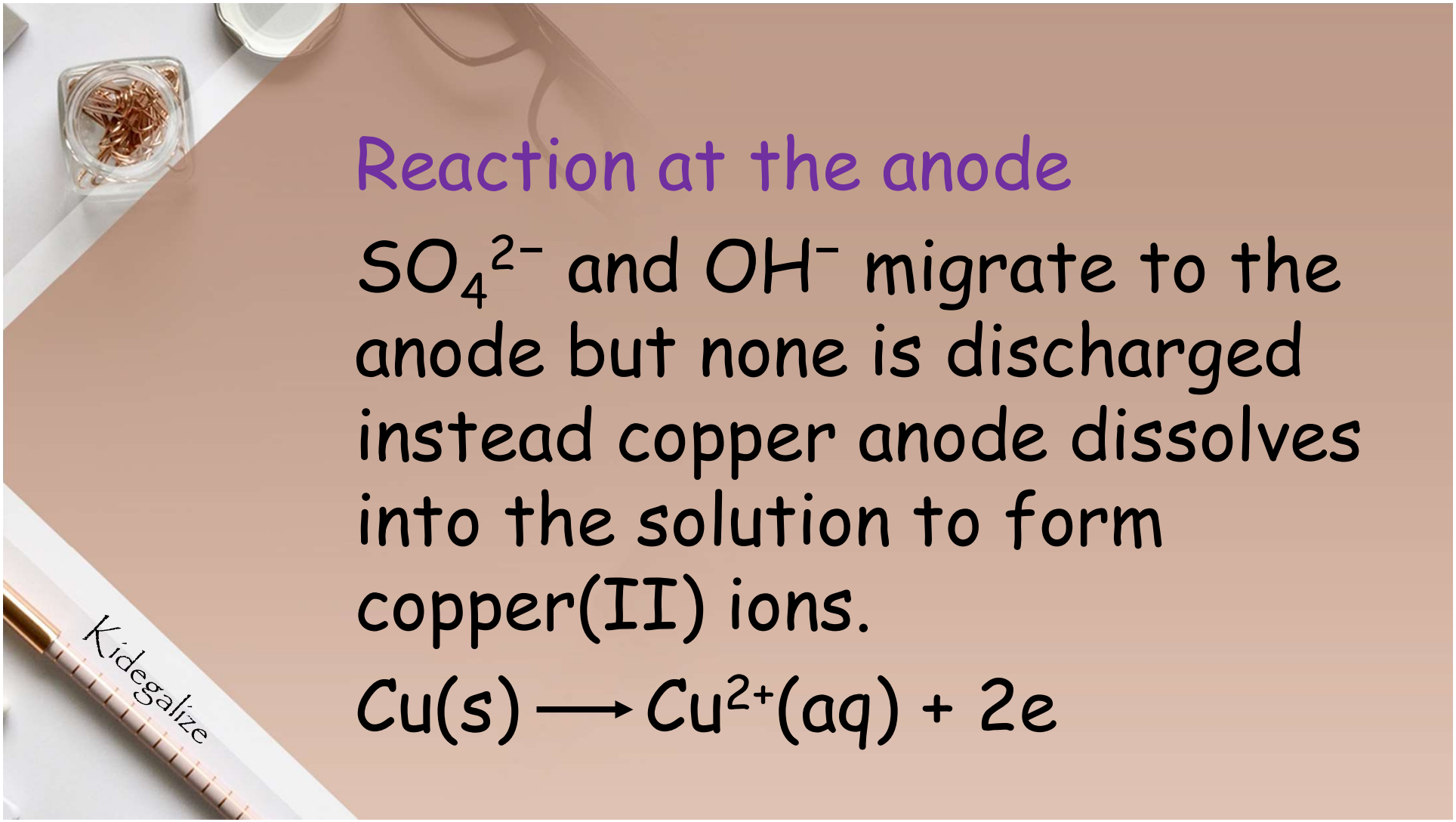
The ions present in the aqueous solution of copper(II) sulphate are Cu^{2+}, SO_4^{2-}, H^+ and OH^-.

Reactions at the cathode

Cu^{2+} and H^+ migrate to the cathode but Cu^{2+} is discharged because Cu^{2+} has higher concentration.

$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

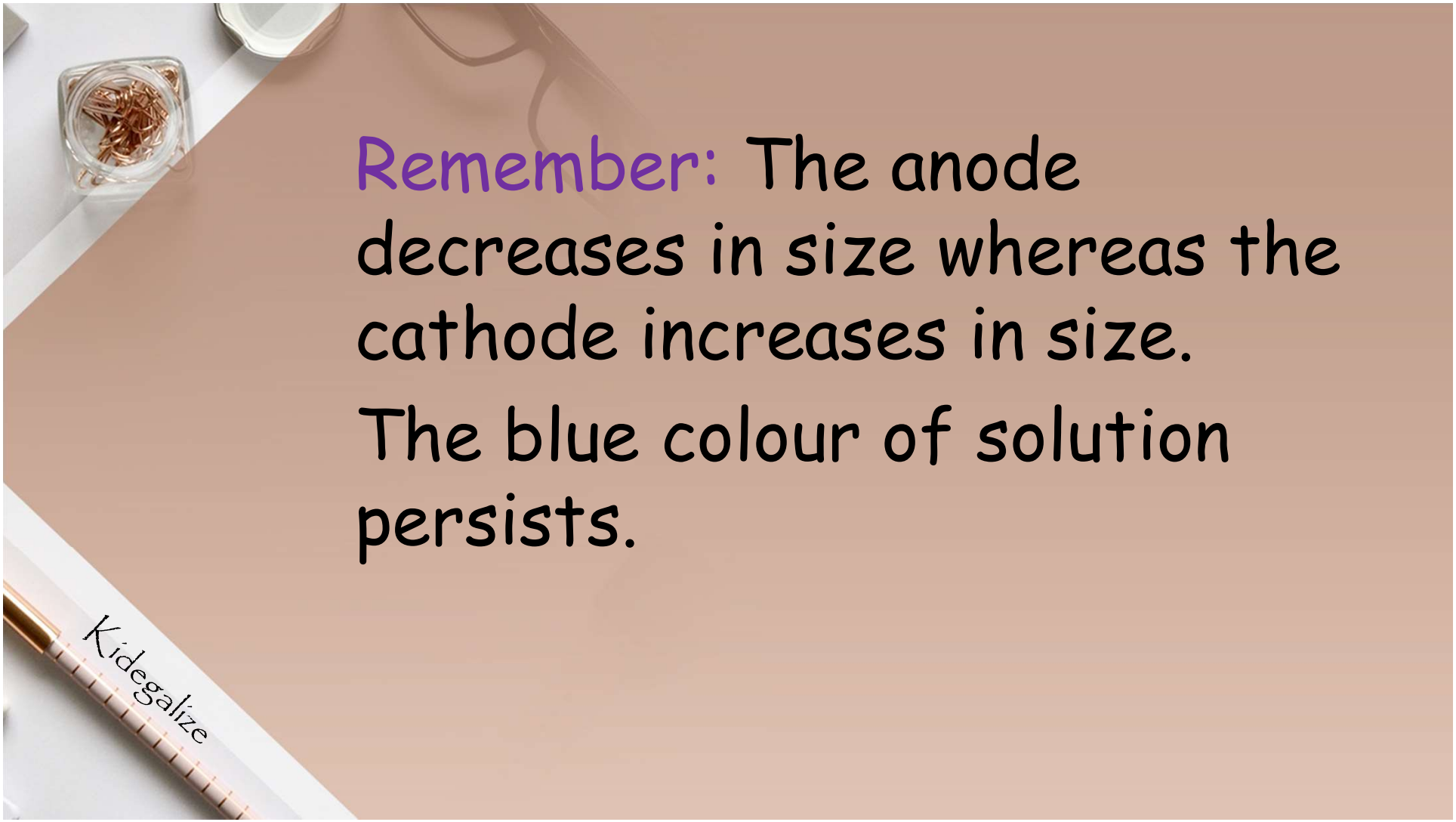
Observation: A reddish-brown solid is deposited.



Reaction at the anode

SO_4^{2-} and OH^- migrate to the anode but none is discharged instead copper anode dissolves into the solution to form copper(II) ions.

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$$



Remember: The anode decreases in size whereas the cathode increases in size.

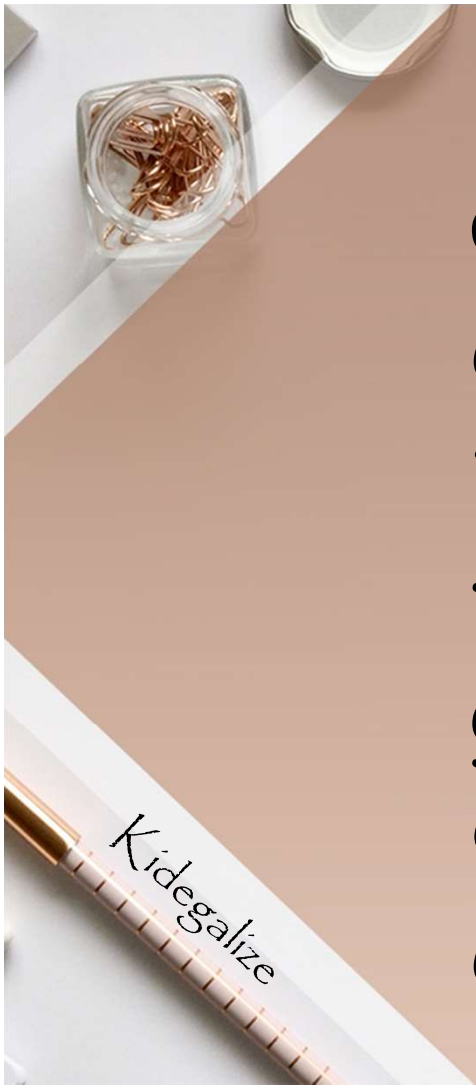
The blue colour of solution persists.

Applications of electrolysis

1. Purification of copper

Copper is purified by electrolysis of copper(II) sulphate solution using impure copper as the anode and pure copper as the cathode.

The anode dissolves into the electrolyte to form copper(II) ions and impurities which collect

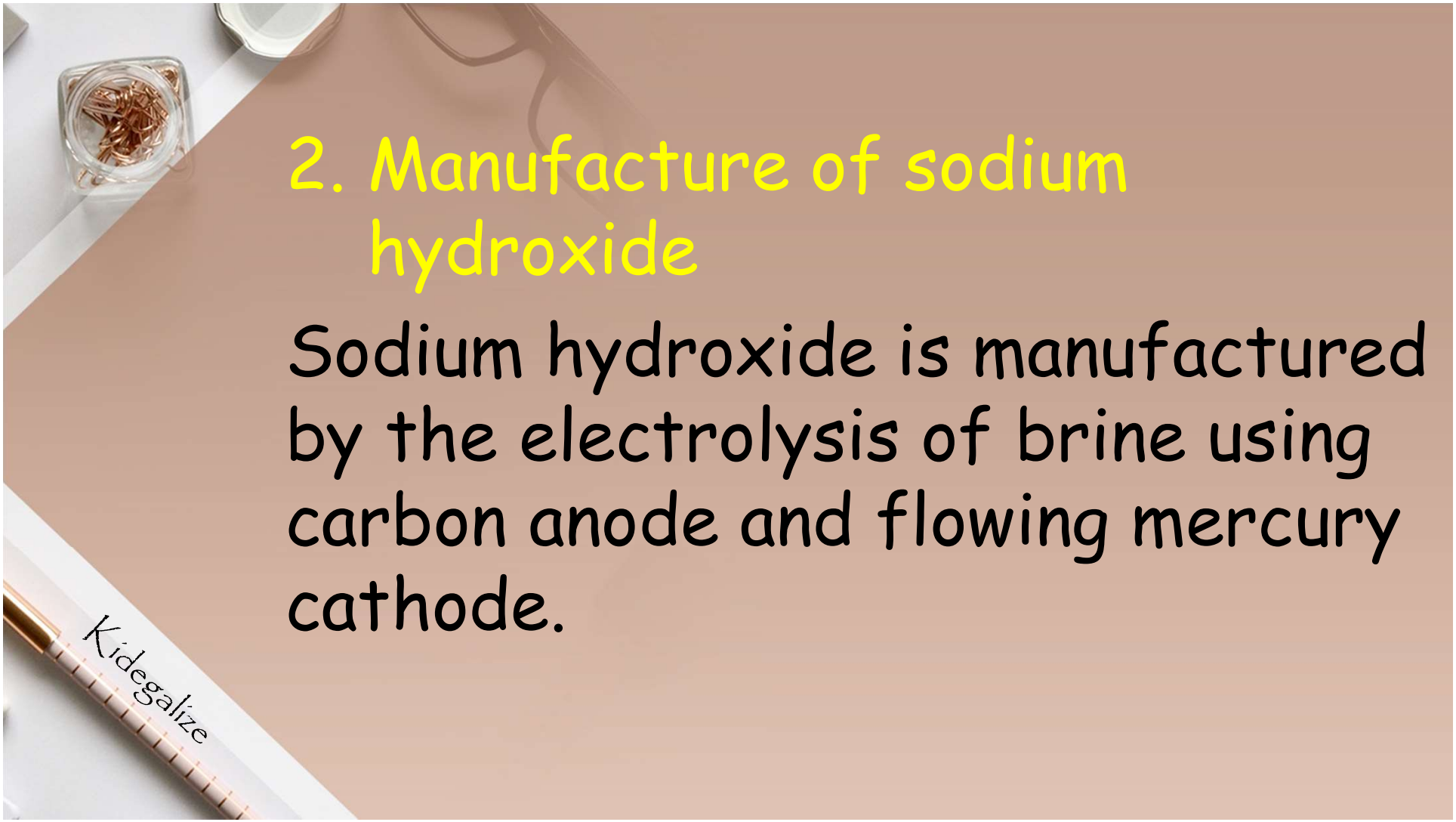


at the bottom of the cell.

$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$

The copper(II) ions migrate to the cathode from where they gain electrons and deposited as copper metal.

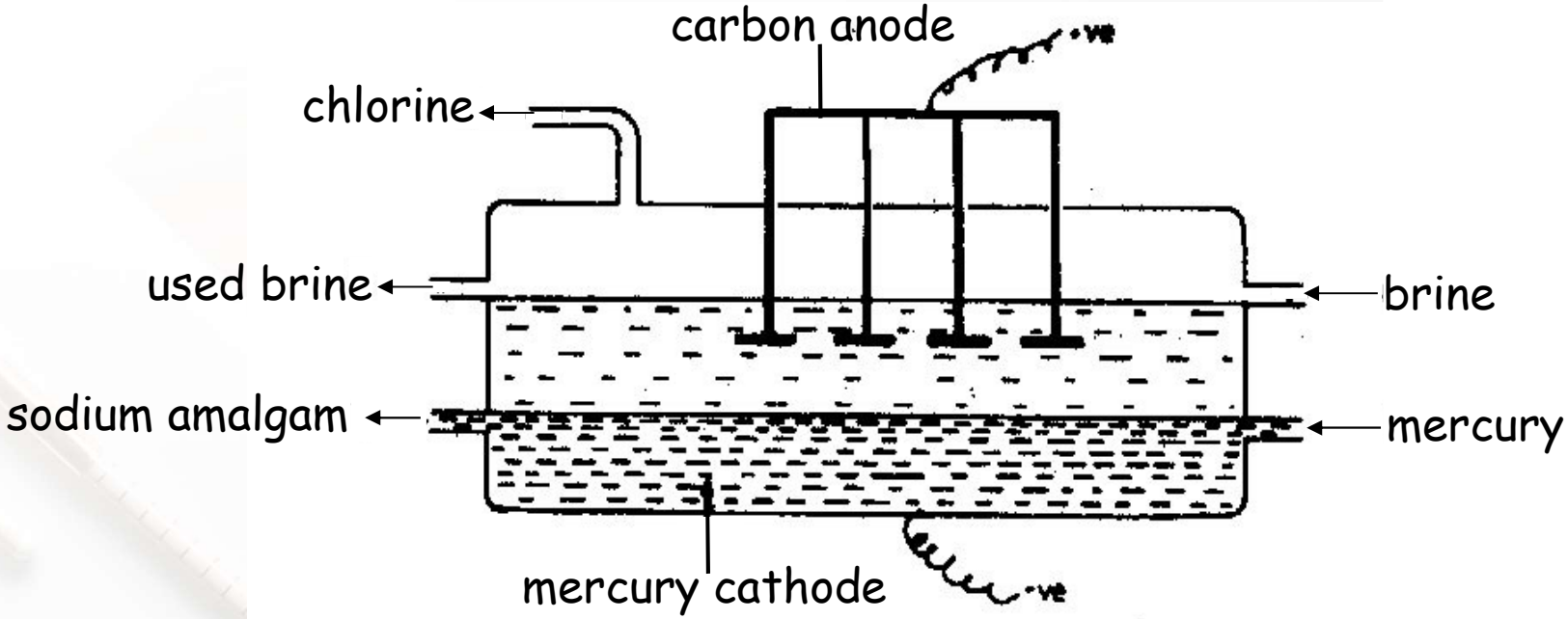
$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

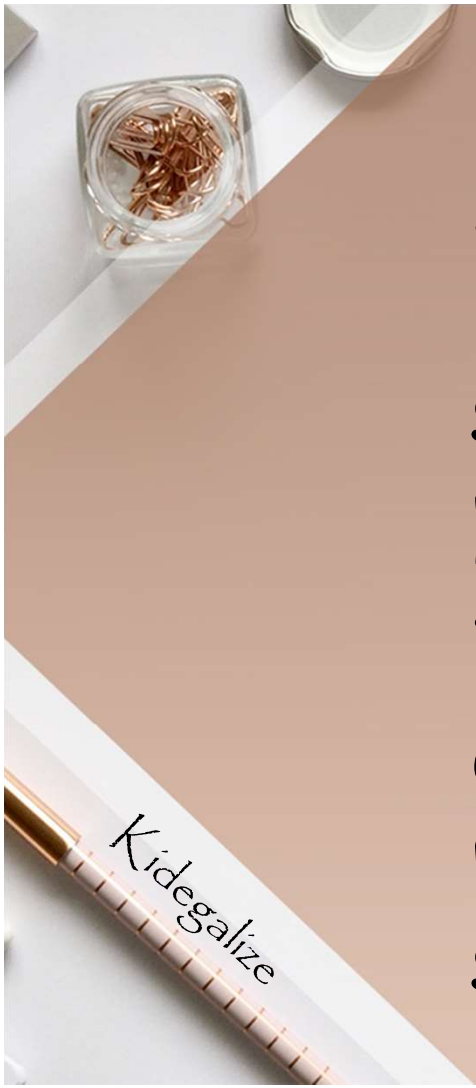


2. Manufacture of sodium hydroxide

Sodium hydroxide is manufactured by the electrolysis of brine using carbon anode and flowing mercury cathode.

Experimental set up

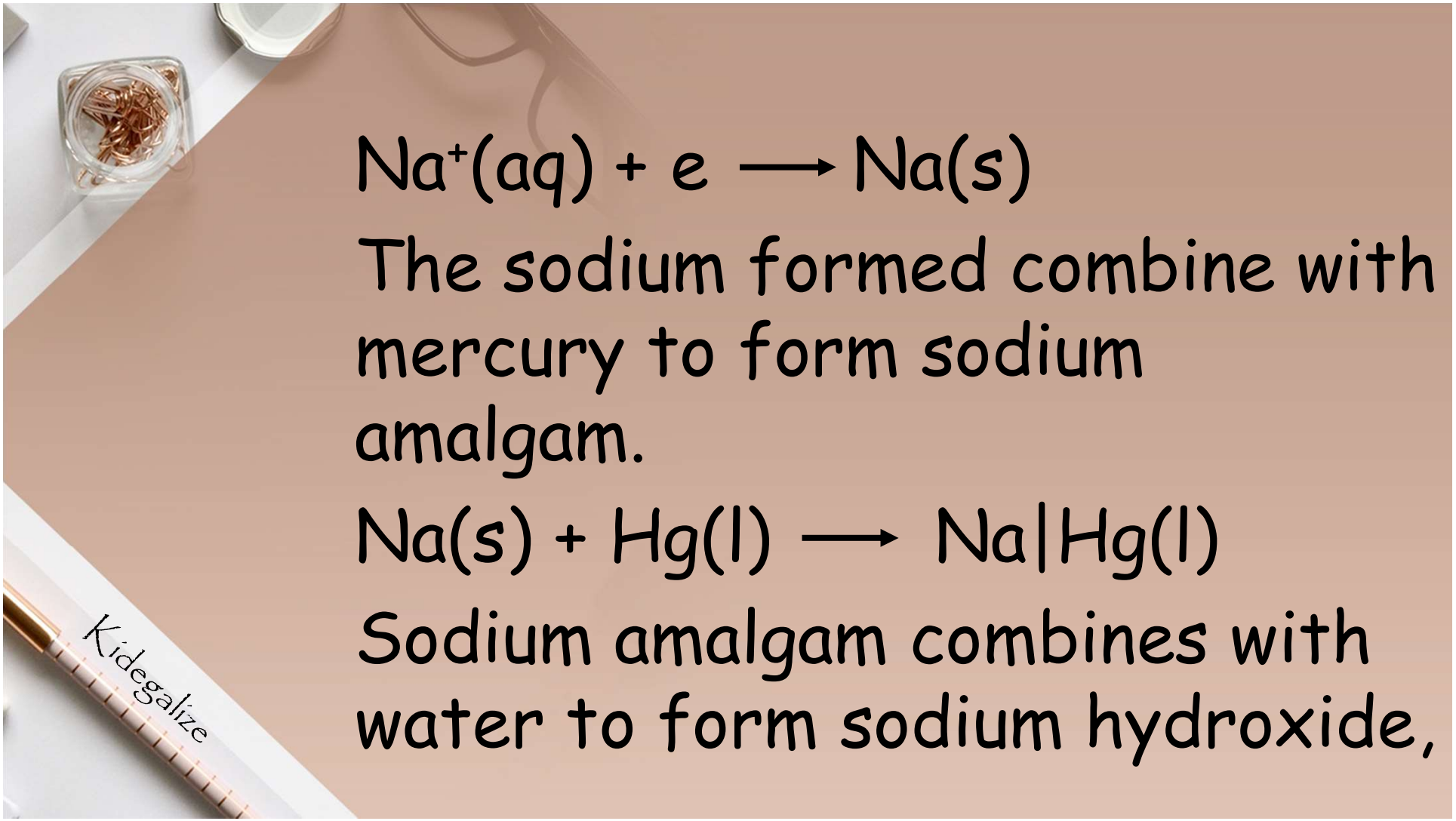




Sodium chloride is decomposed by electric current to form sodium ions and chloride ions.

$NaCl(aq) \longrightarrow Na^{+}(aq) + Cl^{-}(aq)$

The sodium ions formed are discharged at the cathode in preference to H^{+} ions forming sodium atoms.



$Na^+(aq) + e \longrightarrow Na(s)$

The sodium formed combine with mercury to form sodium amalgam.

$Na(s) + Hg(l) \longrightarrow Na|Hg(l)$

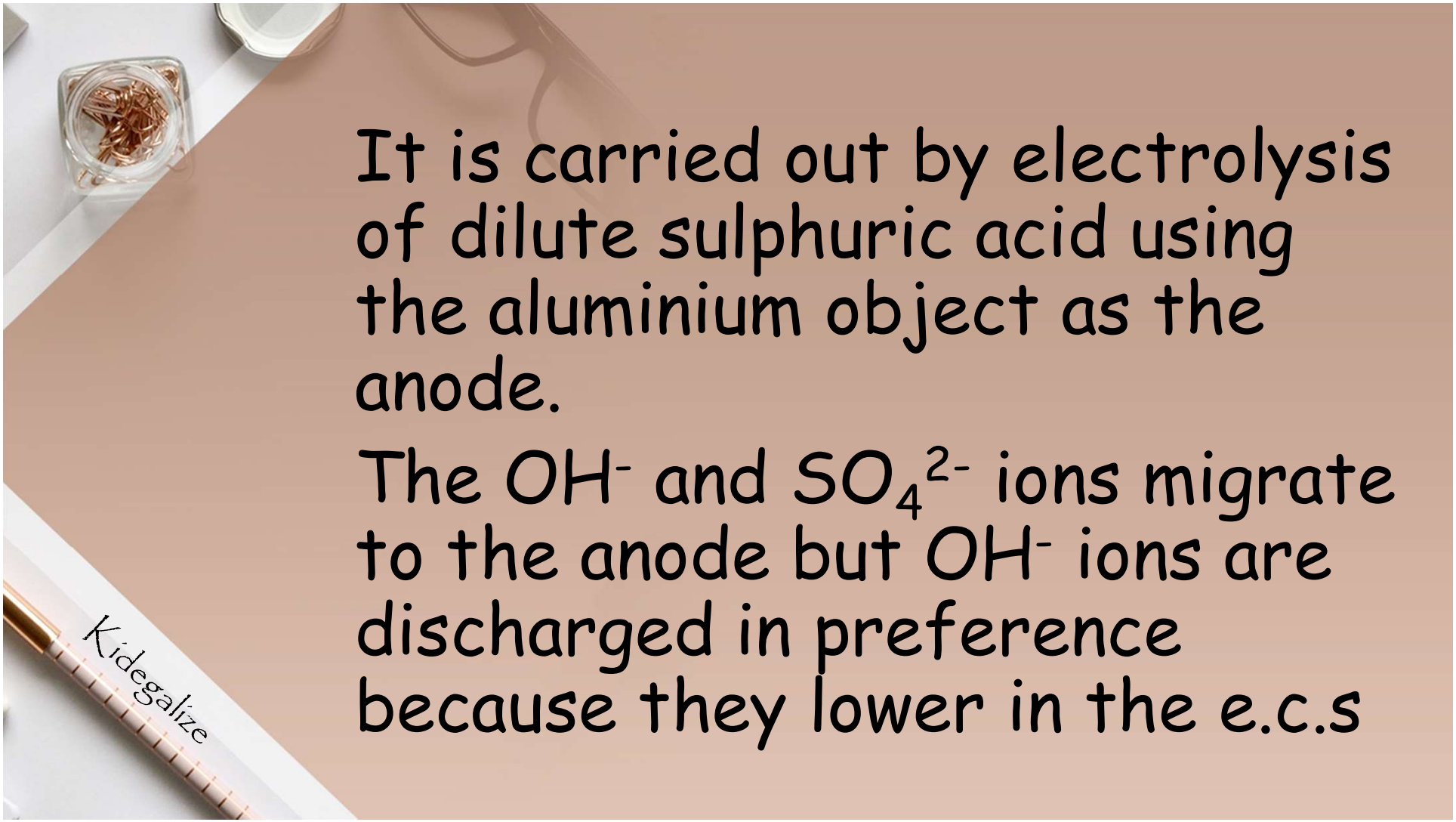
Sodium amalgam combines with water to form sodium hydroxide,

hydrogen and mercury.

$Na|Hg(l) + H_2O(l) \longrightarrow NaOH(aq) + Hg(l) + H_2(g)$

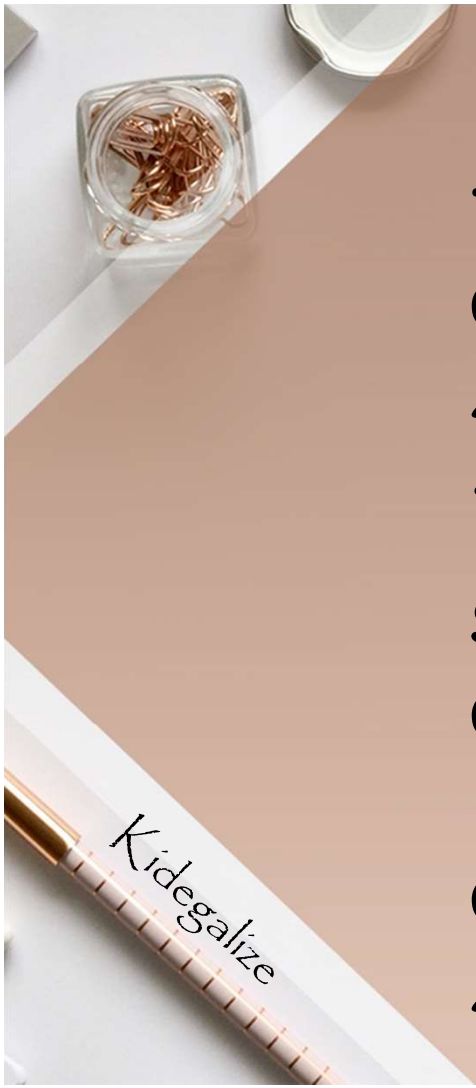
3. Anodising aluminium

This is the coating of aluminium objects with a thin layer of oxide to protect them from corrosion.



It is carried out by electrolysis of dilute sulphuric acid using the aluminium object as the anode.

The OH^- and SO_4^{2-} ions migrate to the anode but OH^- ions are discharged in preference because they lower in the e.c.s



thus oxygen gas is given off at the anode.

$4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e$

The oxygen gas reacts with the surface of the aluminium object and coats it with a thin invisible but protective coating of aluminium oxide.

$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$

4. Electroplating metals

Electroplating is the coating of metals with a thin layer of another metal by electrolysis.

The object to be electroplated is used as the cathode while the metal to be used is made the anode e.g. when copper plating

an iron knife, the iron knife is used as the cathode while anode is made of copper and copper(II) sulphate solution is used as the electrolyte.

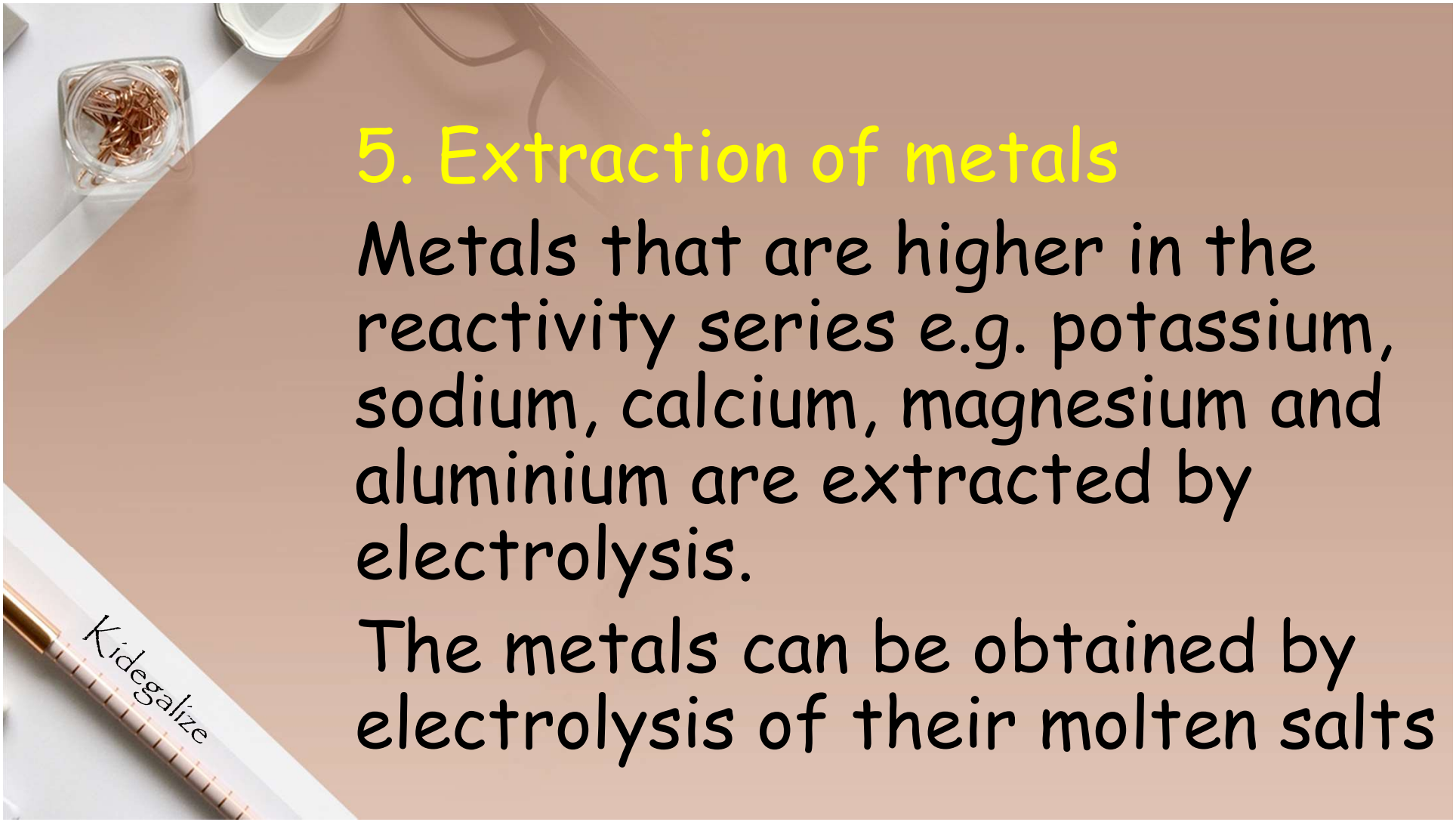
Anode dissolves to form copper(II) ions which migrate to the cathode.

$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$

At the cathode, the copper(II) ions gain electrons and are discharged.

$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$

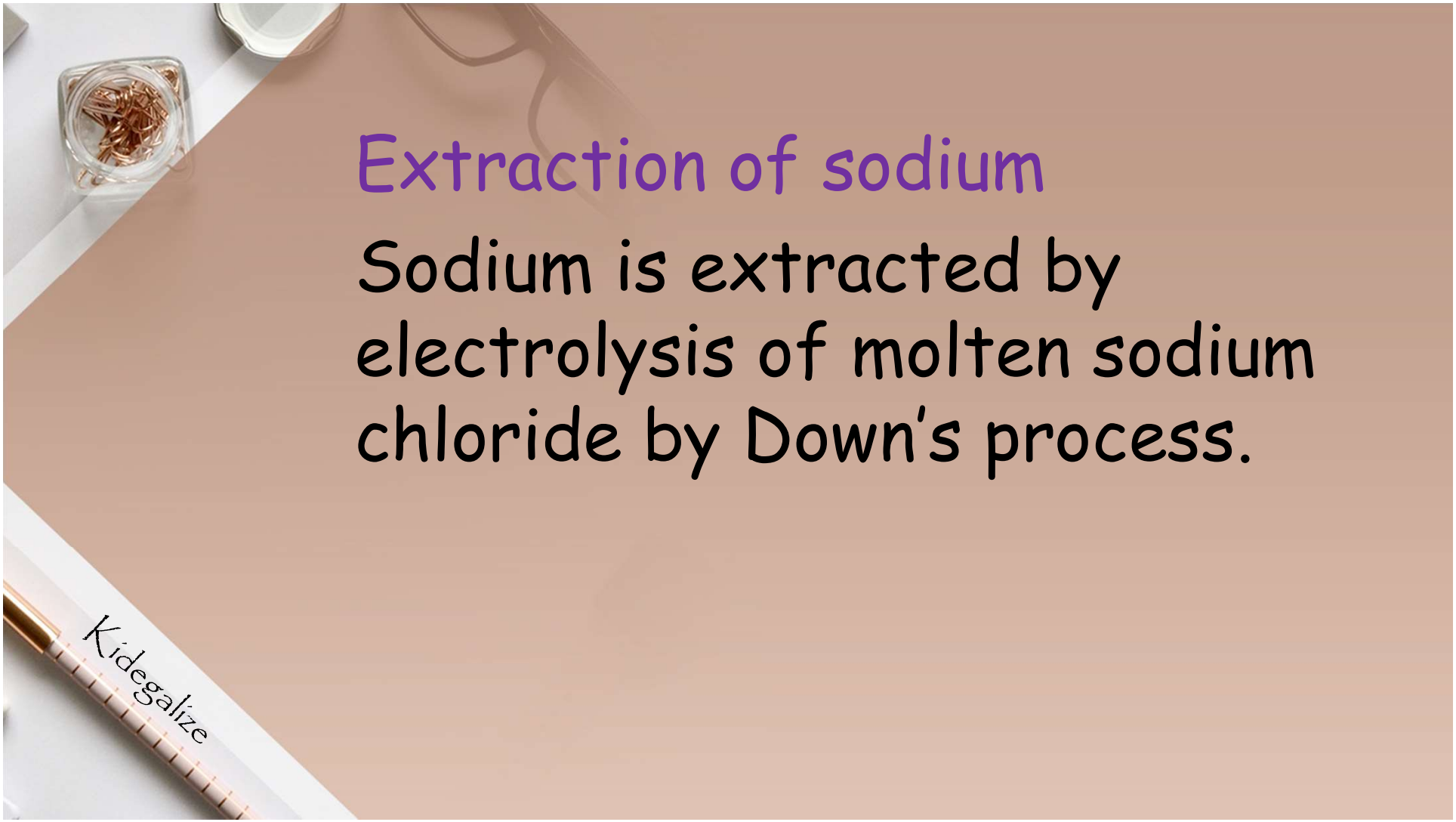
Copper is deposited on the knife as a reddish-brown coating



5. Extraction of metals

Metals that are higher in the reactivity series e.g. potassium, sodium, calcium, magnesium and aluminium are extracted by electrolysis.

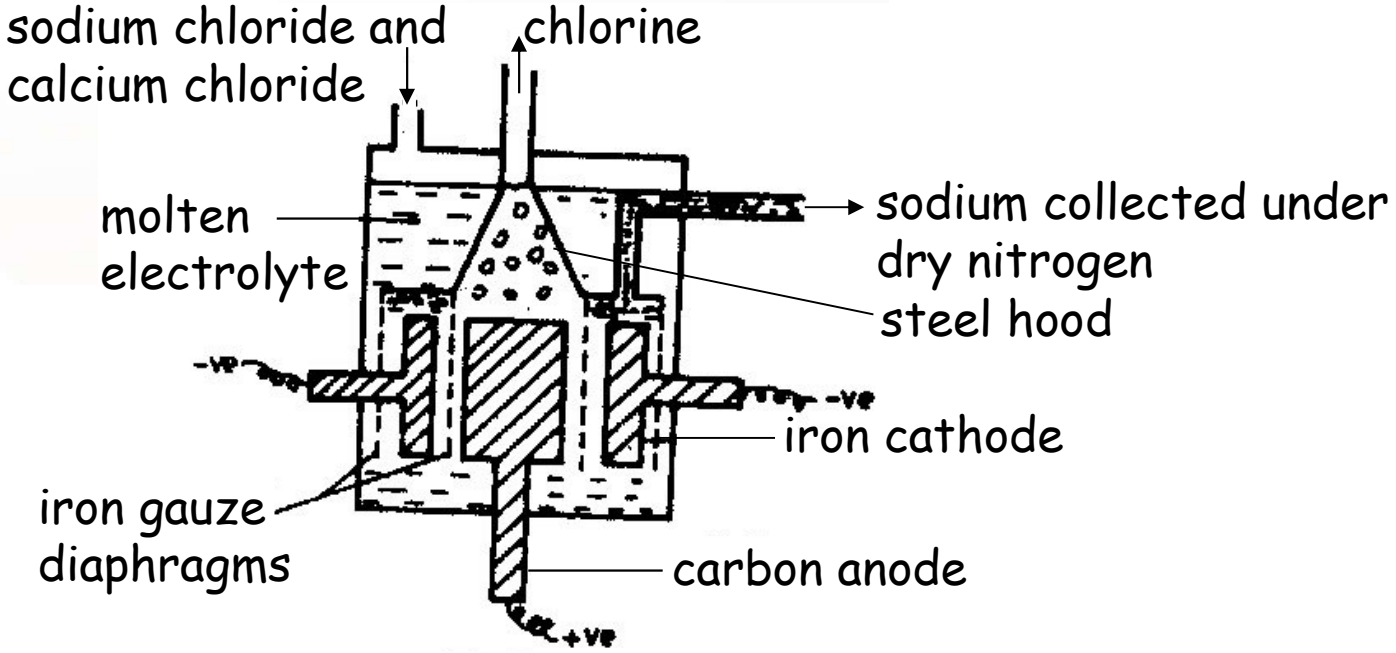
The metals can be obtained by electrolysis of their molten salts

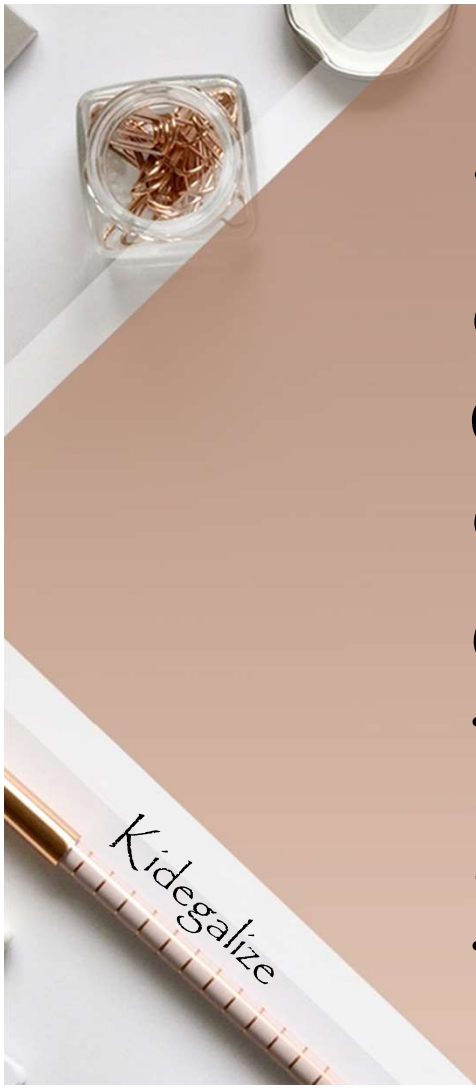


Extraction of sodium

Sodium is extracted by electrolysis of molten sodium chloride by Down's process.

Experimental set up

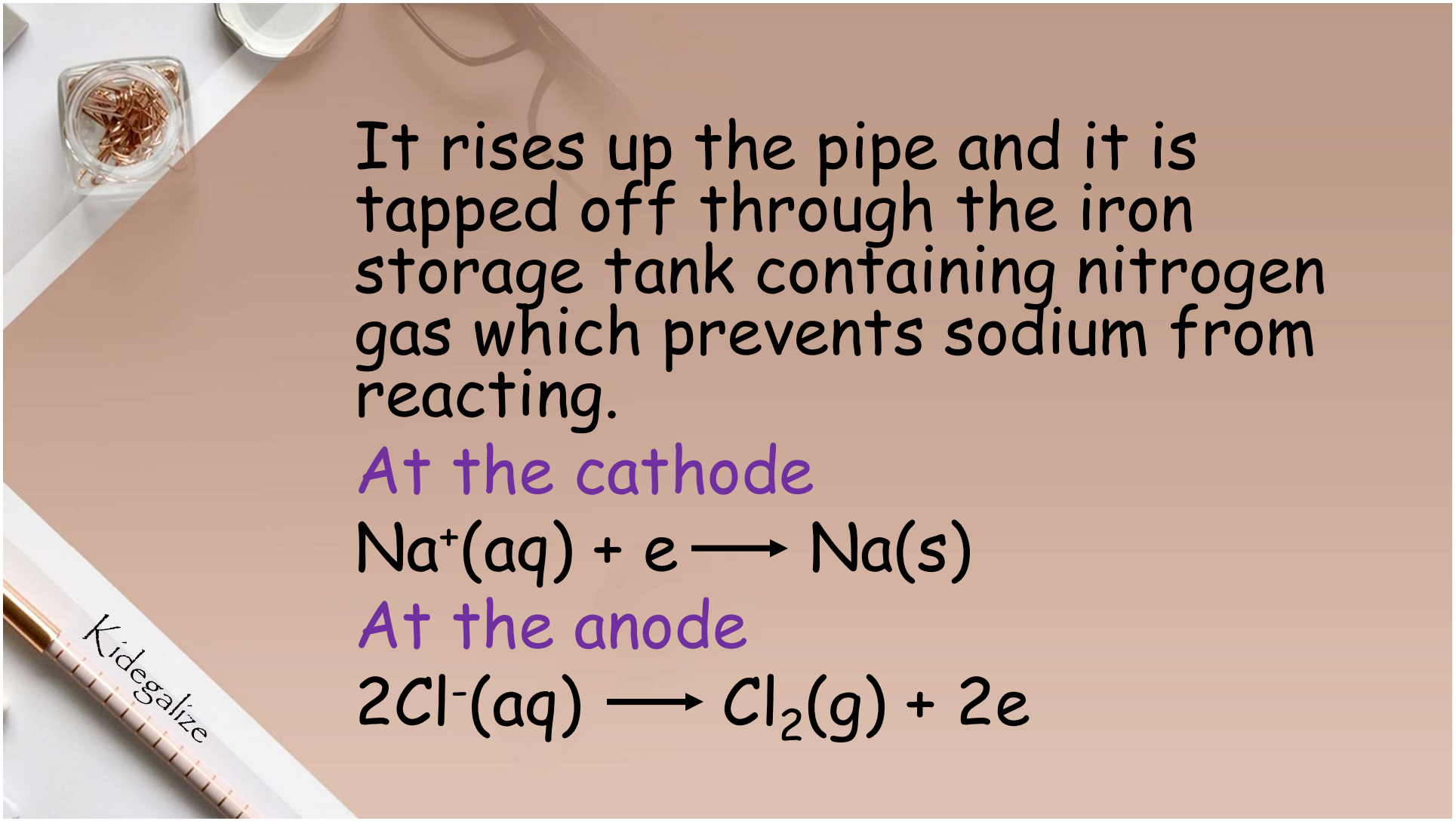




The mixture of molten sodium chloride and calcium chloride is added from the top of Down's cell.

Chlorine produced escapes from the hood.

Sodium collects in the inverted trough placed over the cathode.



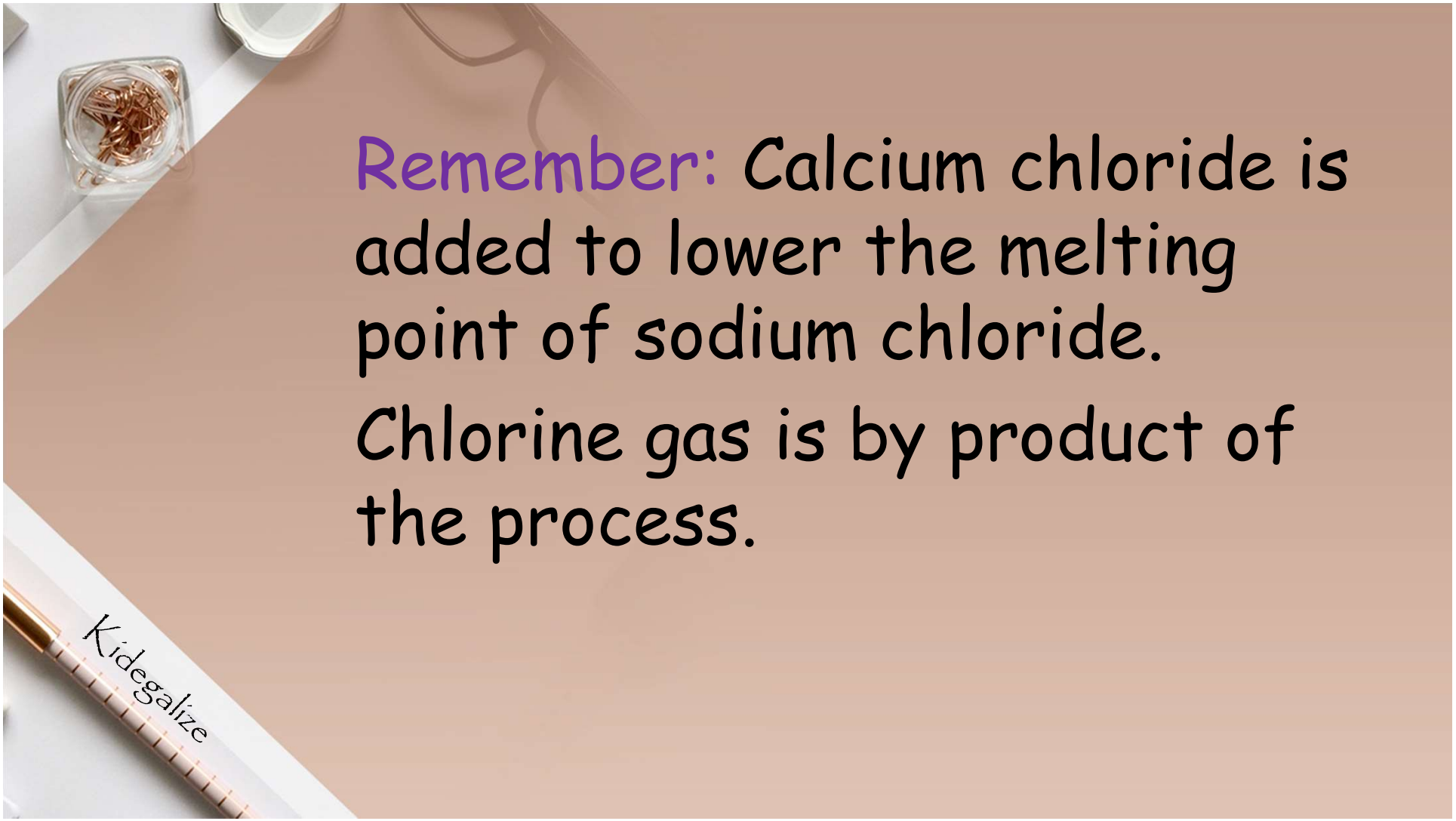
It rises up the pipe and it is tapped off through the iron storage tank containing nitrogen gas which prevents sodium from reacting.

At the cathode

$Na^+(aq) + e \longrightarrow Na(s)$

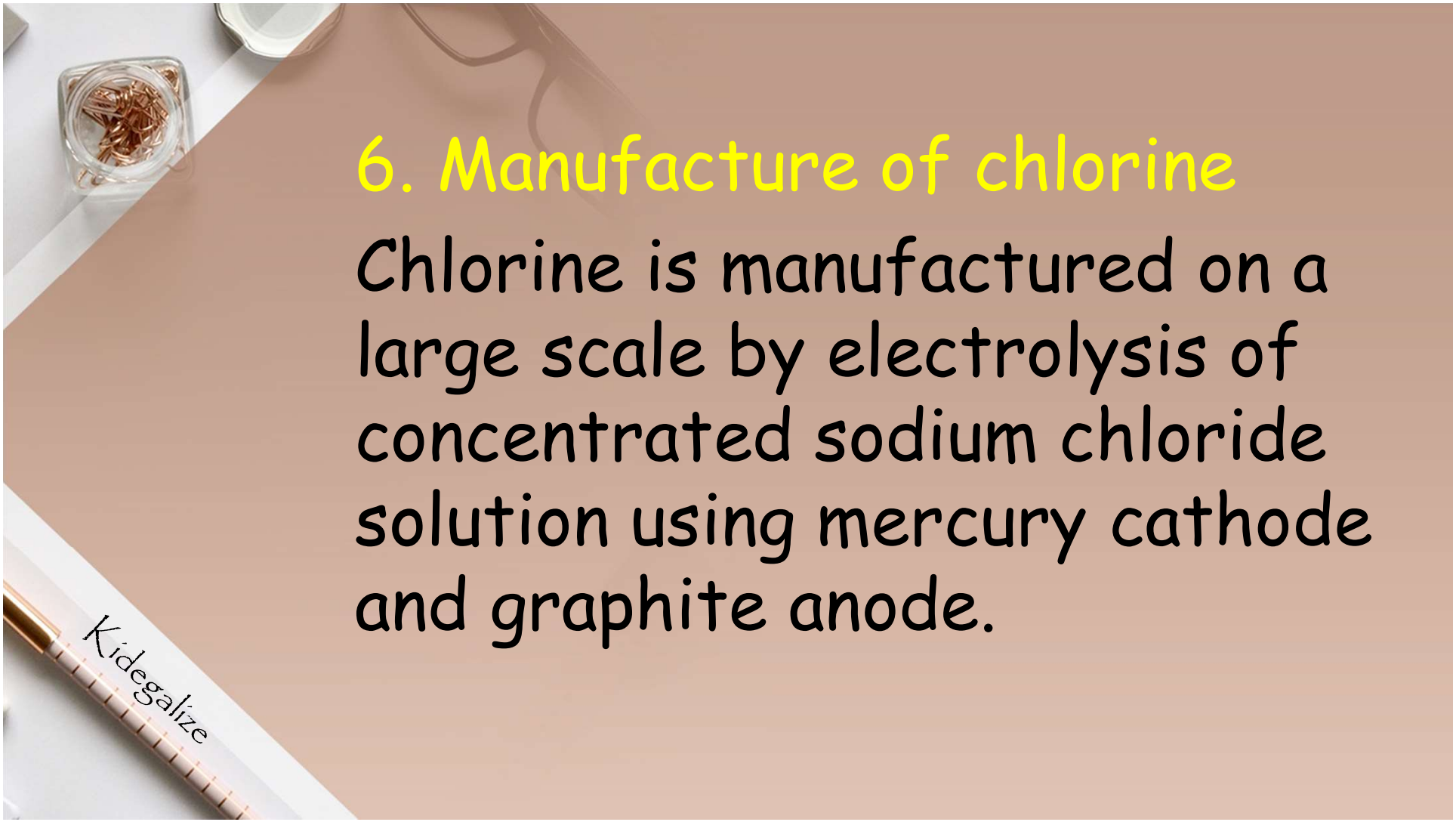
At the anode

$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$



Remember: Calcium chloride is added to lower the melting point of sodium chloride.

Chlorine gas is by product of the process.



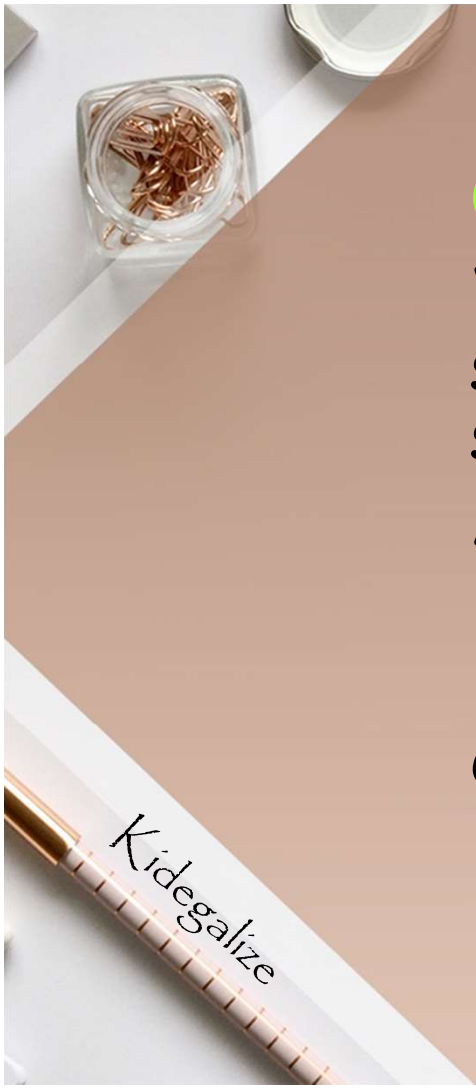
6. Manufacture of chlorine

Chlorine is manufactured on a large scale by electrolysis of concentrated sodium chloride solution using mercury cathode and graphite anode.

Sodium ions and hydrogen ions are attracted to the cathode while chloride ions and hydroxide ions are attracted to the anode.

Chloride ions are discharged by losing electrons to form chlorine which is collected and stored.

$2\,Cl^-(aq) \longrightarrow Cl_2(g) + 2e$

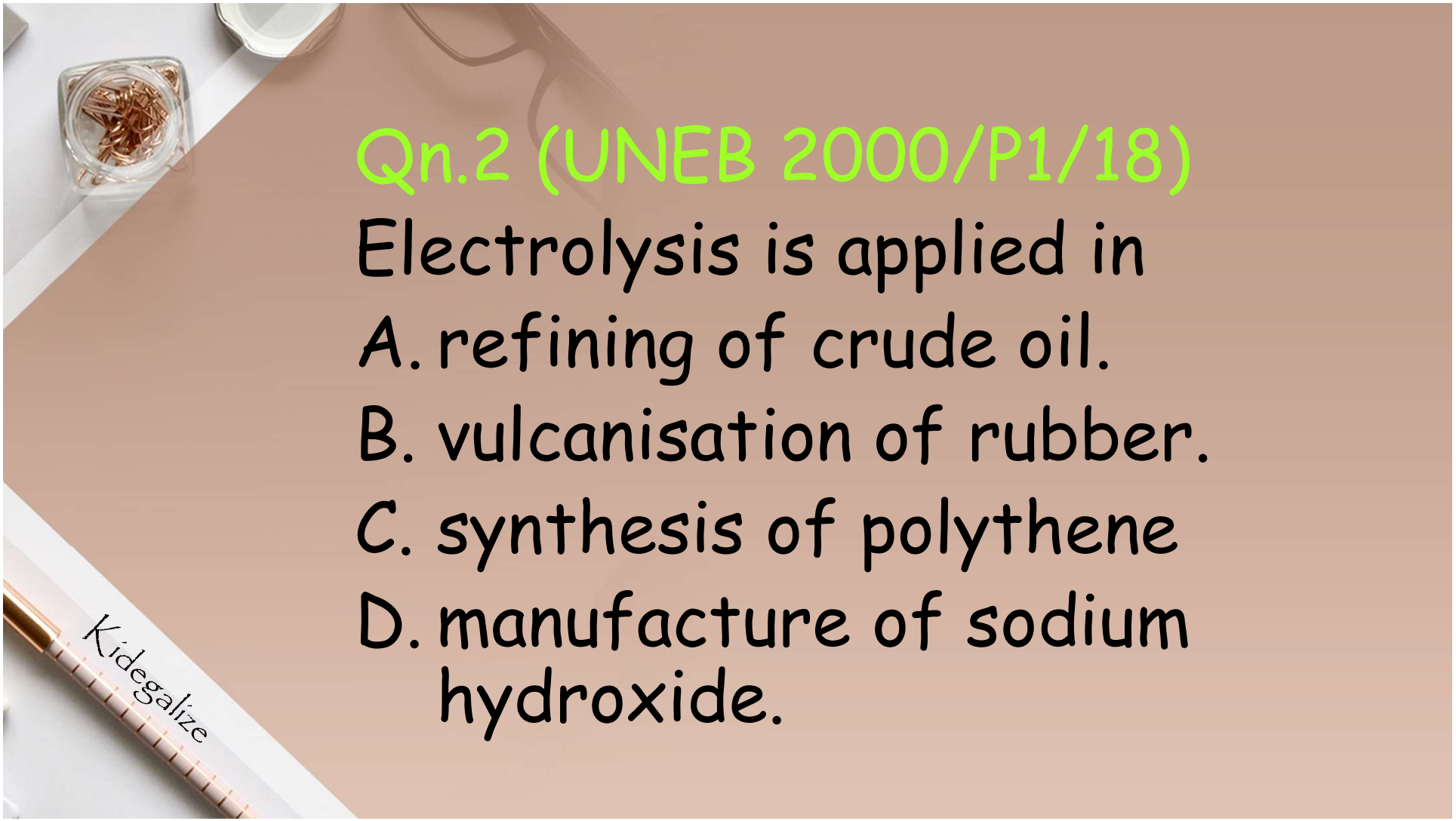


Knowledge Check 4

Qn.1 (UNEB 1995/P1/23)

Which one of the following is the correct statement about electroplating a substance with copper?

A. The anode is made of the substance to be copper plated.
B. the cathode is made of copper.
C. The anode is made of copper.
D. The electrolyte is dilute sulphuric acid.



Qn.2 (UNEB 2000/P1/18)

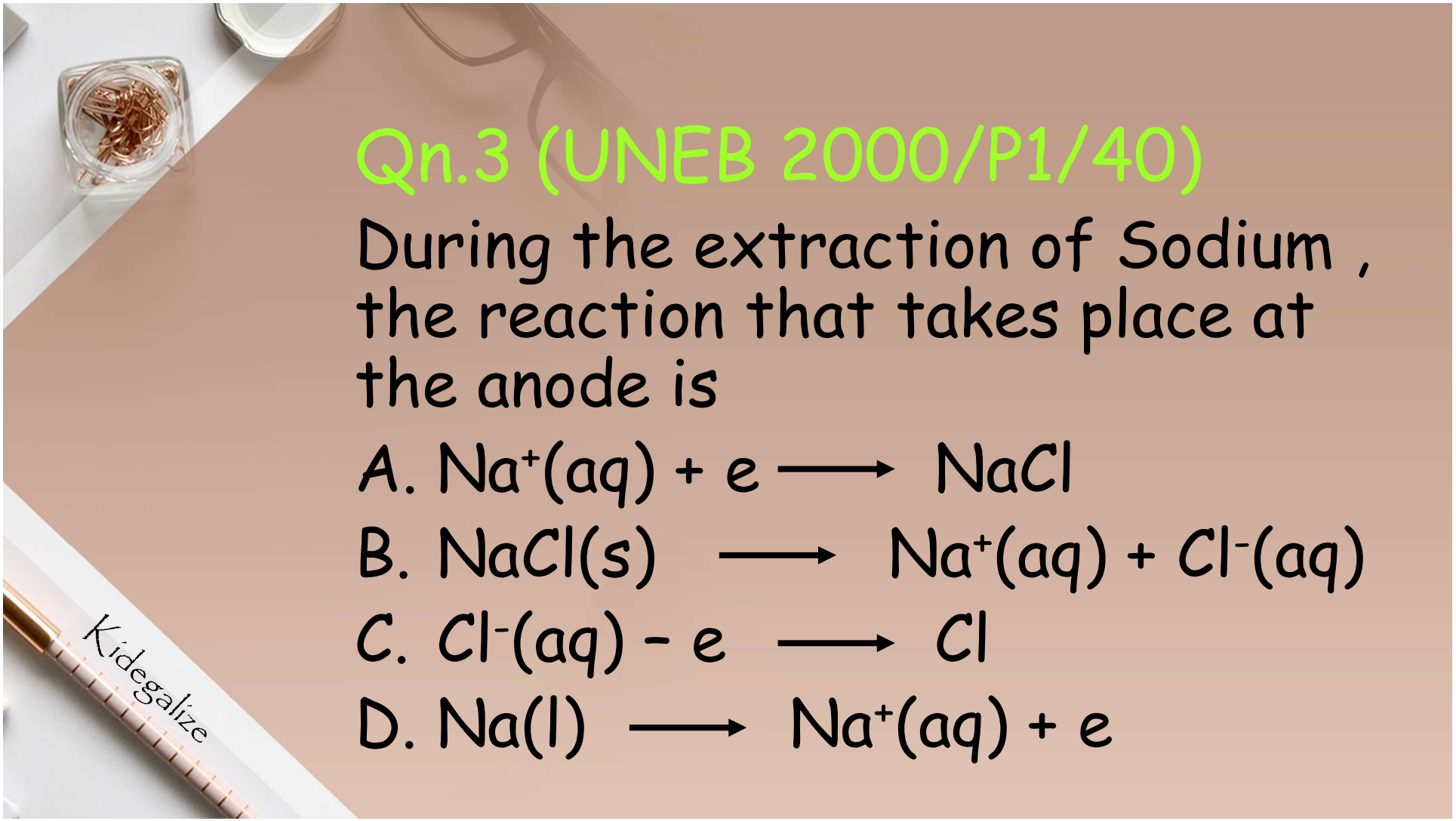
Electrolysis is applied in

A. refining of crude oil.

B. vulcanisation of rubber.

C. synthesis of polythene

D. manufacture of sodium hydroxide.



Qn.3 (UNEB 2000/P1/40)

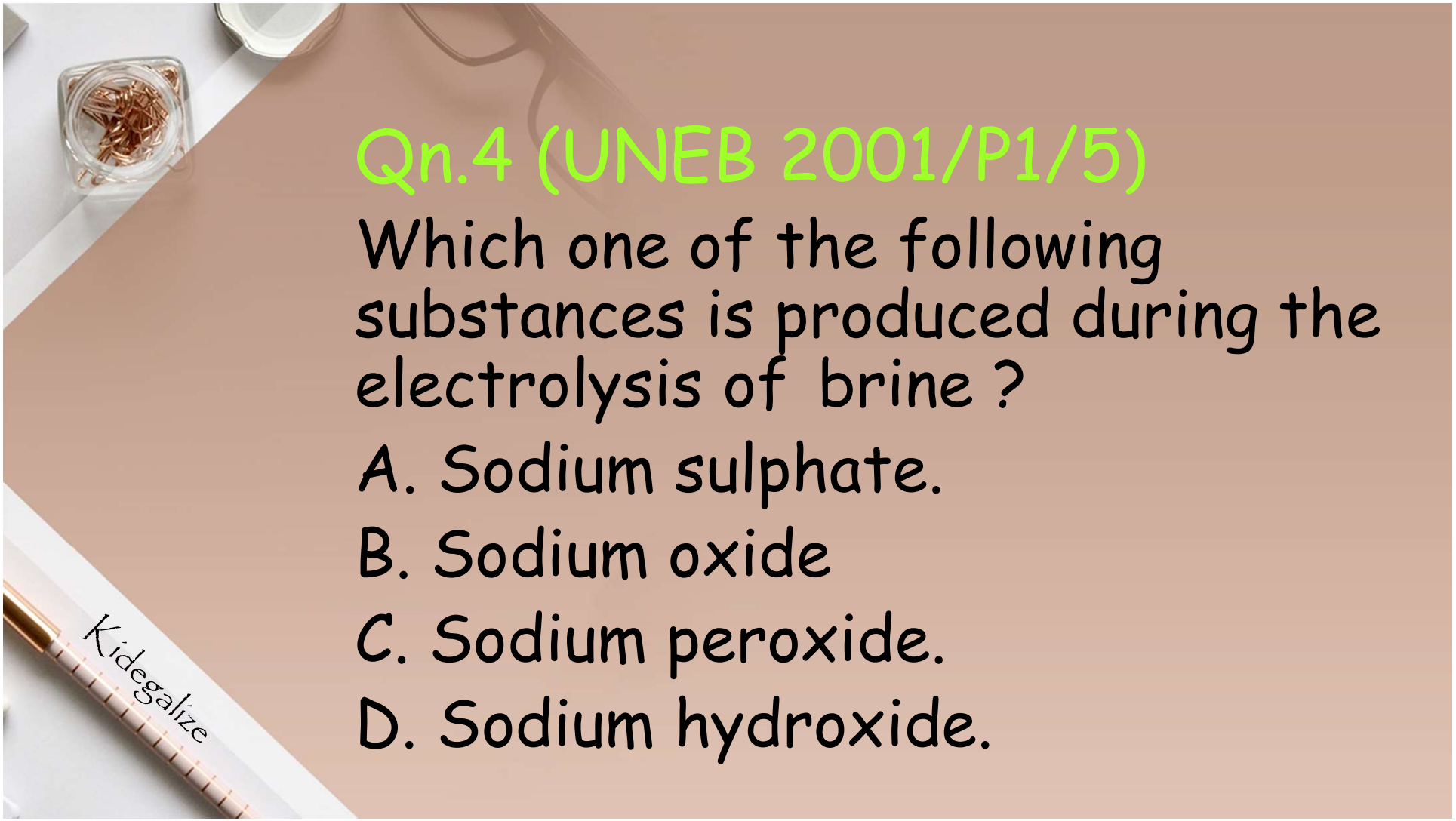
During the extraction of Sodium , the reaction that takes place at the anode is

A. $Na^+(aq) + e \longrightarrow NaCl$

B. $NaCl(s) \longrightarrow Na^+(aq) + Cl^-(aq)$

C. $Cl^-(aq) - e \longrightarrow Cl$

D. $Na(l) \longrightarrow Na^+(aq) + e$



Qn.4 (UNEB 2001/P1/5)

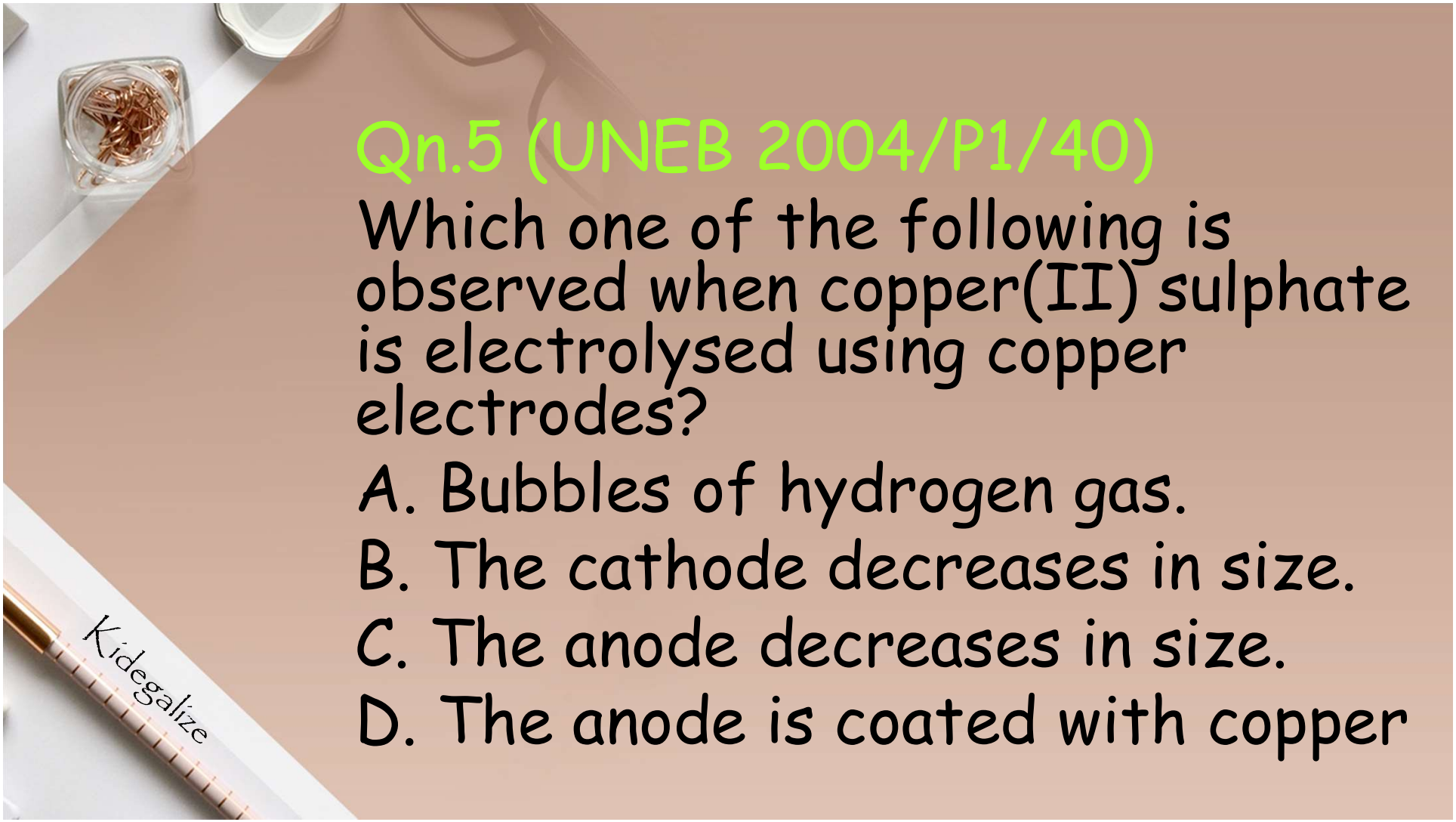
Which one of the following substances is produced during the electrolysis of brine ?

A. Sodium sulphate.

B. Sodium oxide

C. Sodium peroxide.

D. Sodium hydroxide.



Qn.5 (UNEB 2004/P1/40)

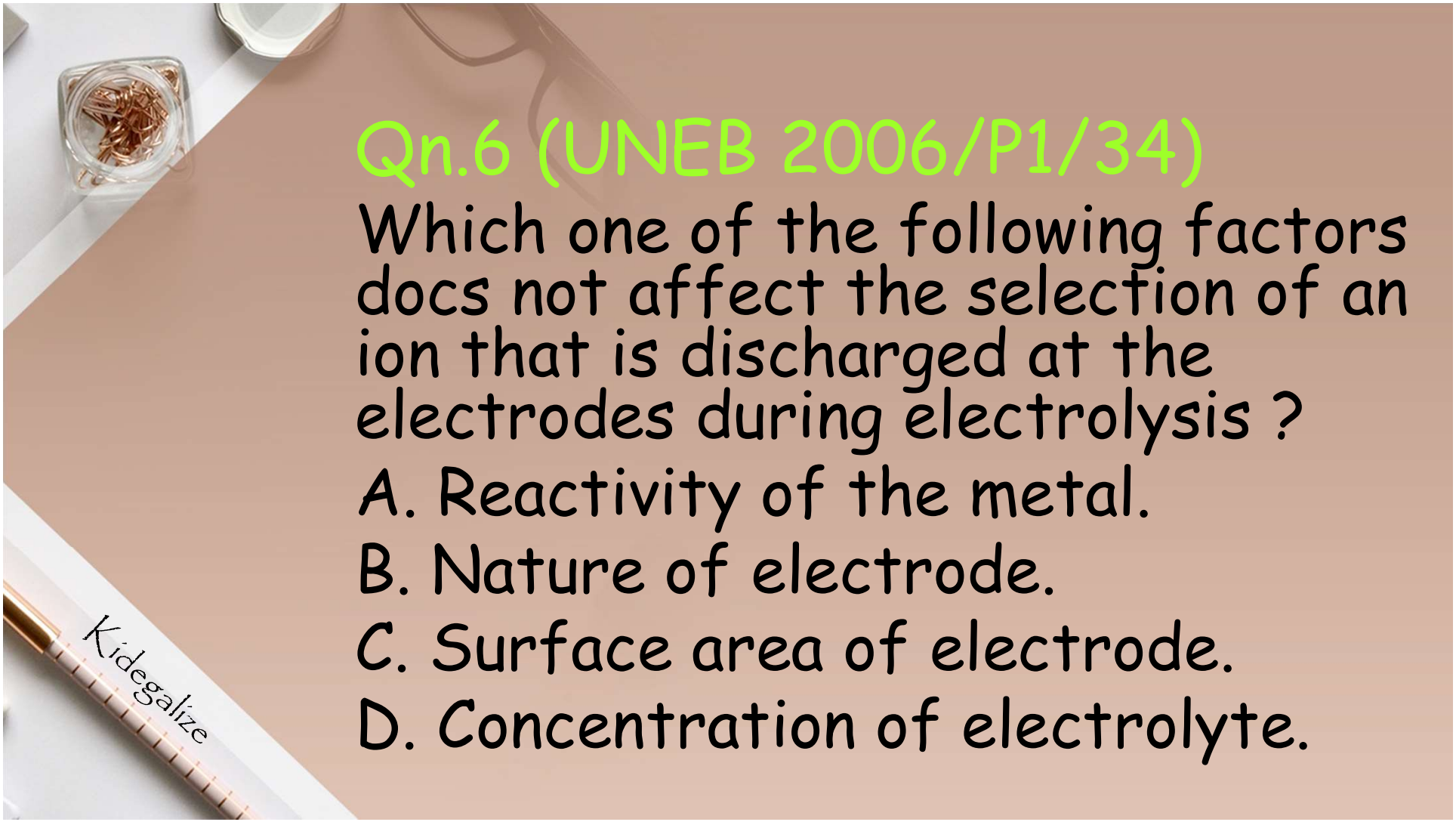
Which one of the following is observed when copper(II) sulphate is electrolysed using copper electrodes?

A. Bubbles of hydrogen gas.

B. The cathode decreases in size.

C. The anode decreases in size.

D. The anode is coated with copper



Qn.6 (UNEB 2006/P1/34)

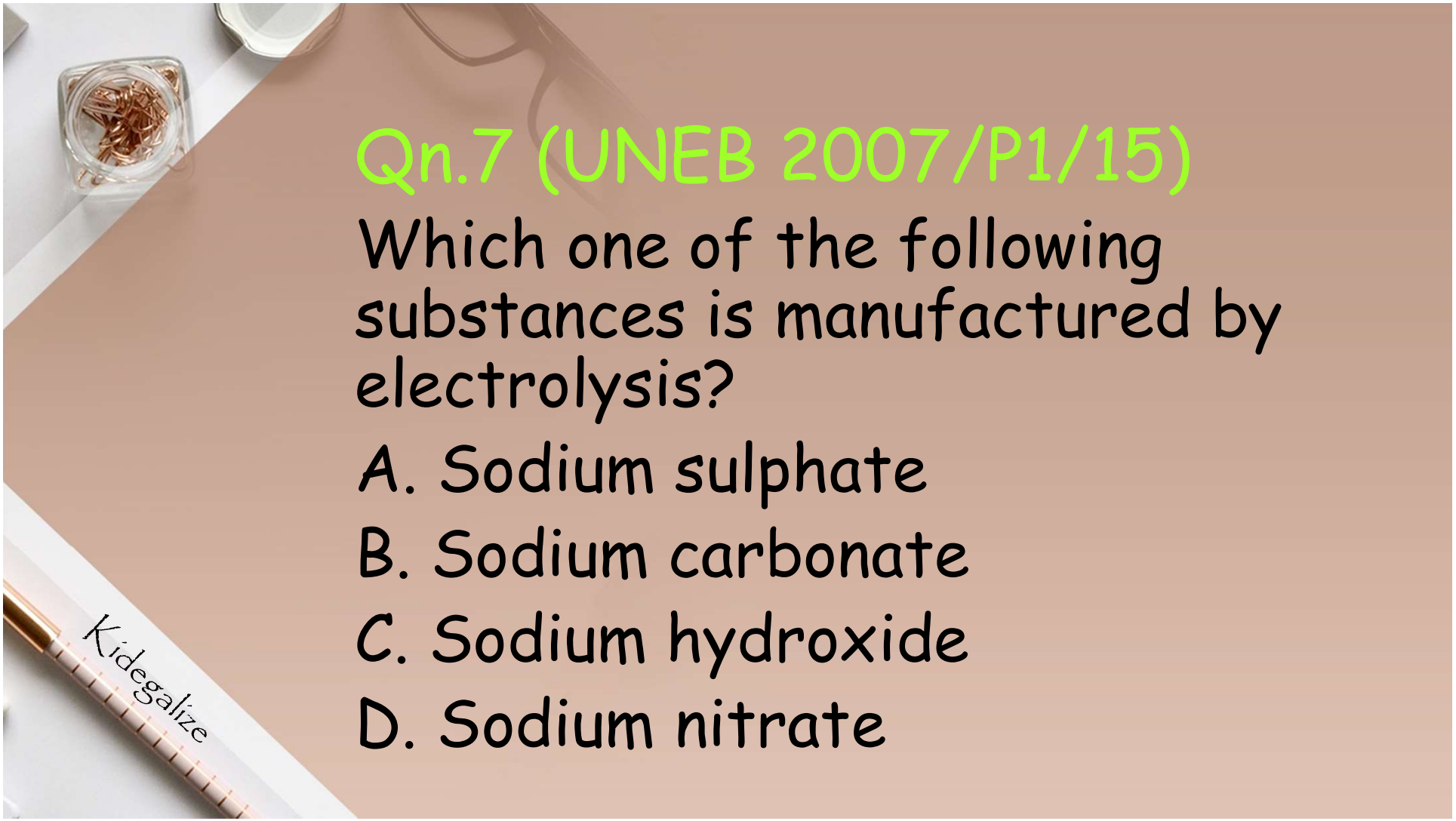
Which one of the following factors docs not affect the selection of an ion that is discharged at the electrodes during electrolysis ?

A. Reactivity of the metal.

B. Nature of electrode.

C. Surface area of electrode.

D. Concentration of electrolyte.



Qn.7 (UNEB 2007/P1/15)

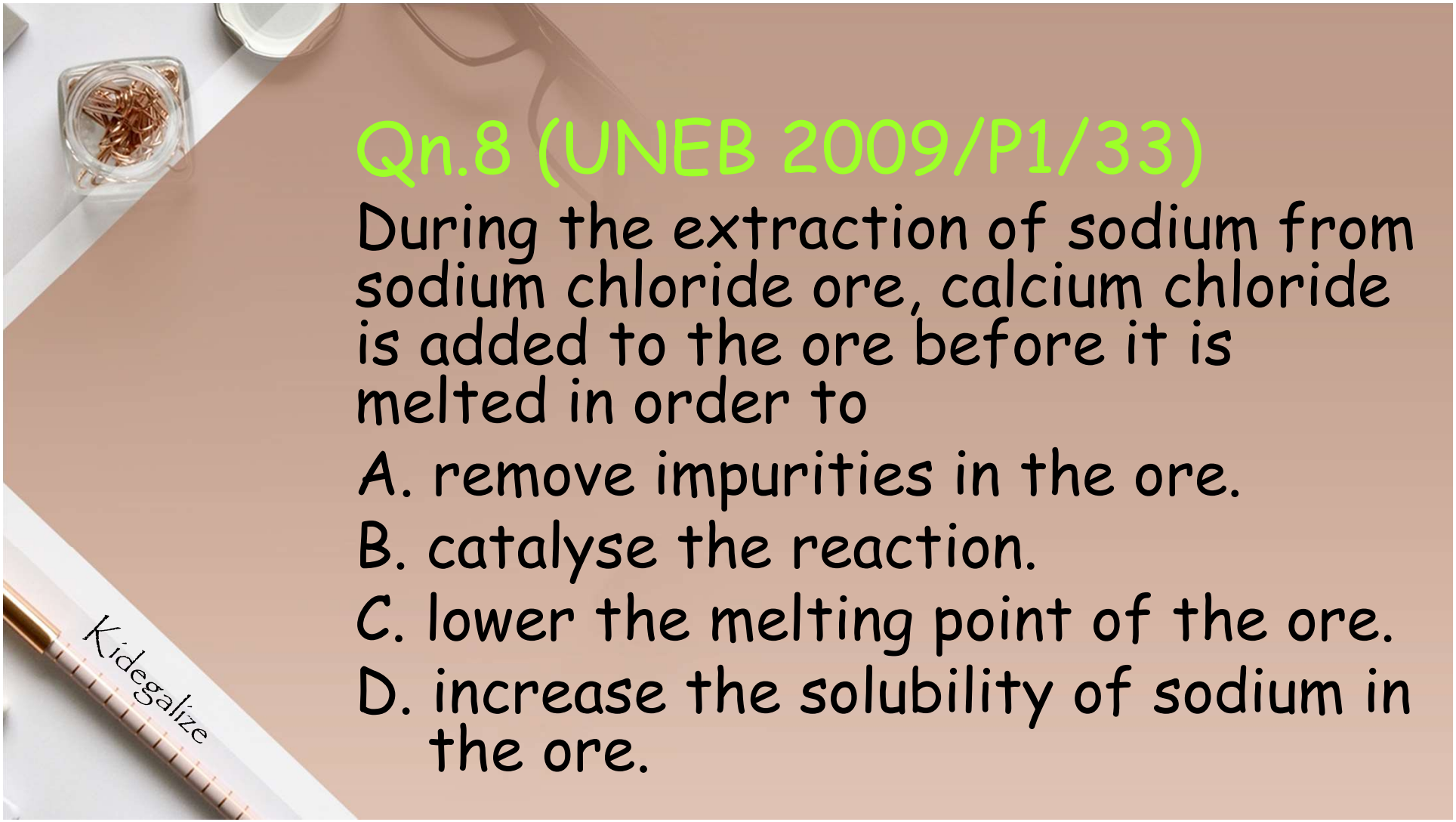
Which one of the following substances is manufactured by electrolysis?

A. Sodium sulphate

B. Sodium carbonate

C. Sodium hydroxide

D. Sodium nitrate



Qn.8 (UNEB 2009/P1/33)

During the extraction of sodium from sodium chloride ore, calcium chloride is added to the ore before it is melted in order to

A. remove impurities in the ore.

B. catalyse the reaction.

C. lower the melting point of the ore.

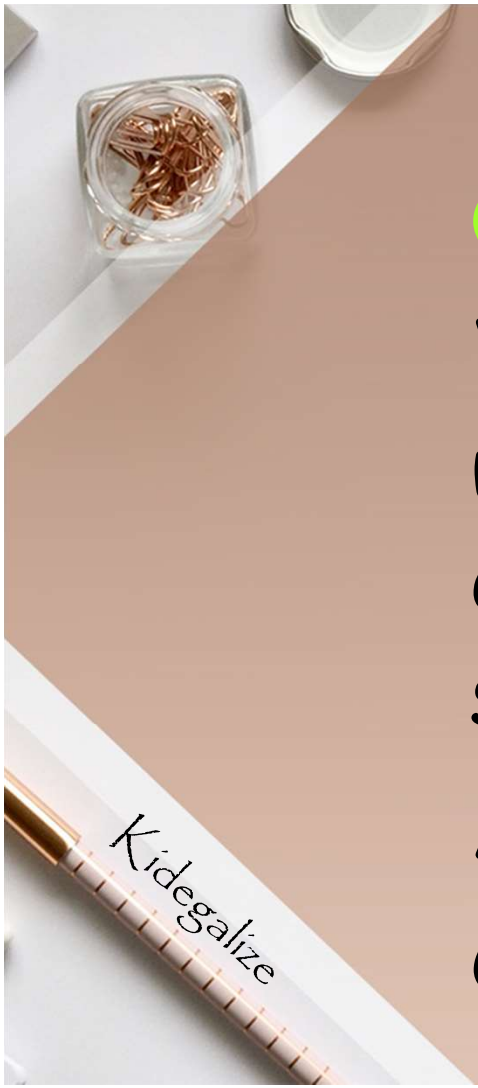
D. increase the solubility of sodium in the ore.

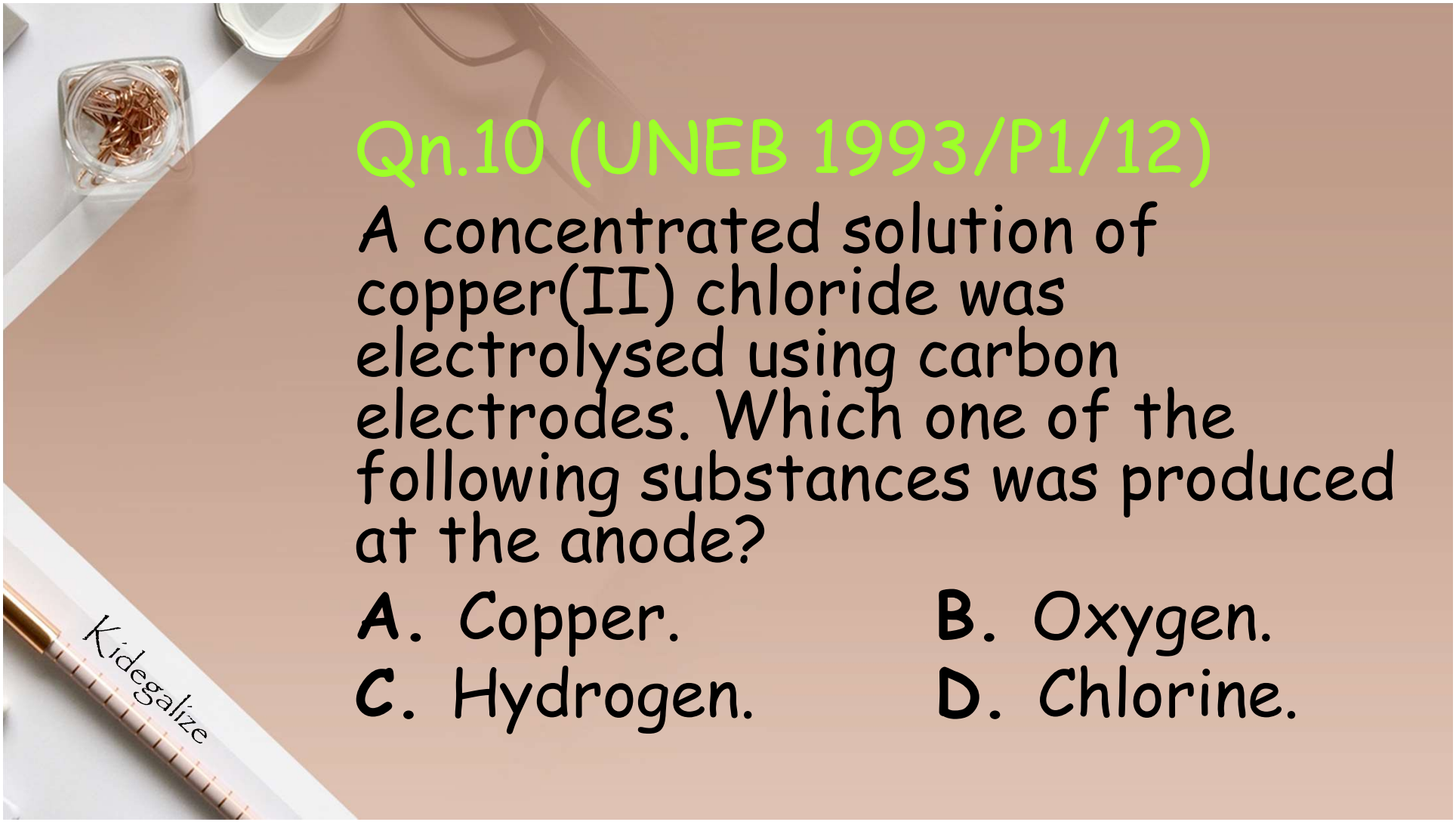
Qn.9 (UNEB 2015/P1/2)

Which one of the following is used as anode during the extraction of sodium from sodium chloride?

A. Iron B. Graphite

C. Mercury D. Platinum





Qn.10 (UNEB 1993/P1/12)

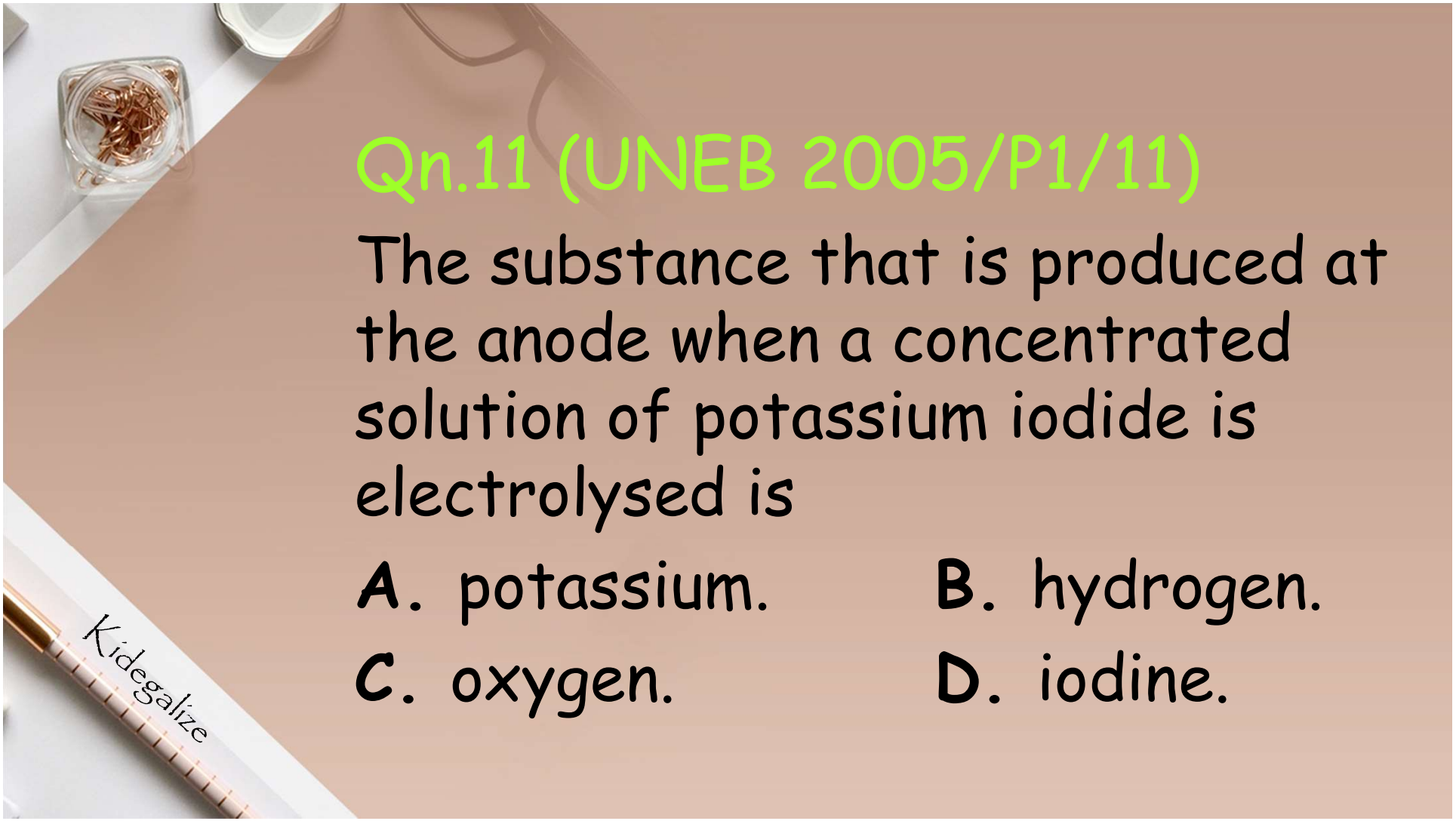
A concentrated solution of copper(II) chloride was electrolysed using carbon electrodes. Which one of the following substances was produced at the anode?

A. Copper.

B. Oxygen.

C. Hydrogen.

D. Chlorine.



Qn.11 (UNEB 2005/P1/11)

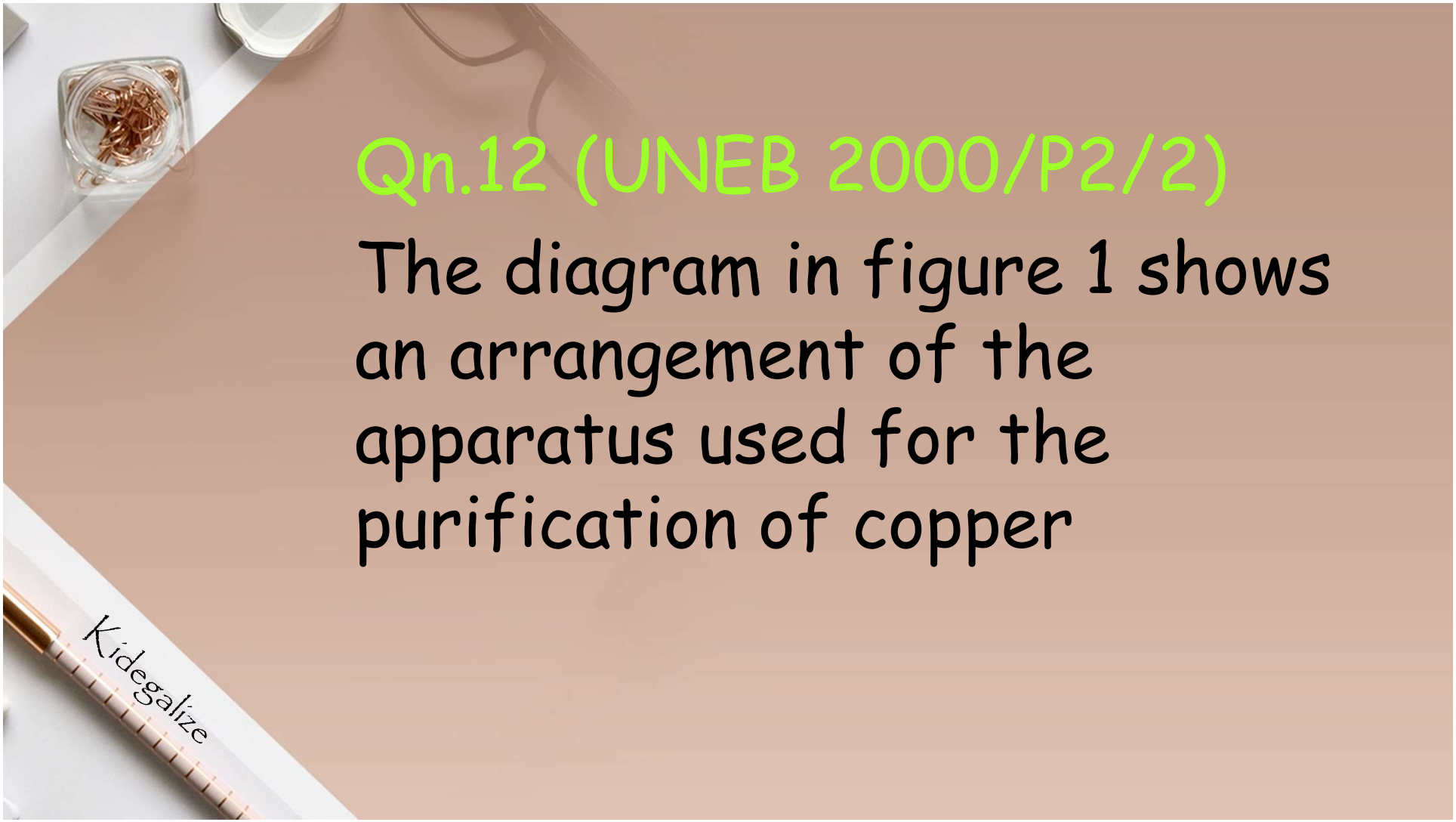
The substance that is produced at the anode when a concentrated solution of potassium iodide is electrolysed is

A. potassium.

B. hydrogen.

C. oxygen.

D. iodine.



Qn.12 (UNEB 2000/P2/2)

The diagram in figure 1 shows an arrangement of the apparatus used for the purification of copper

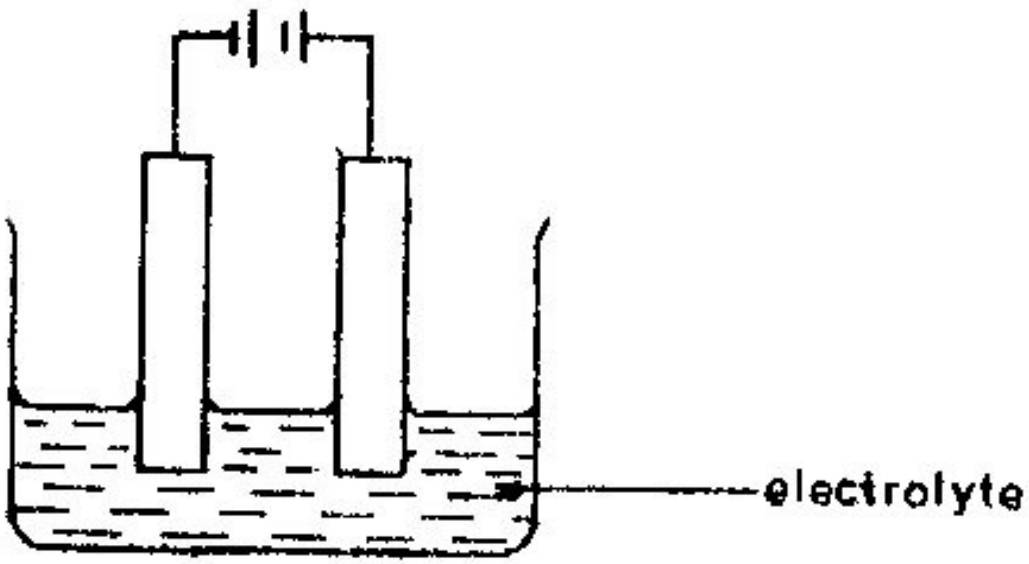
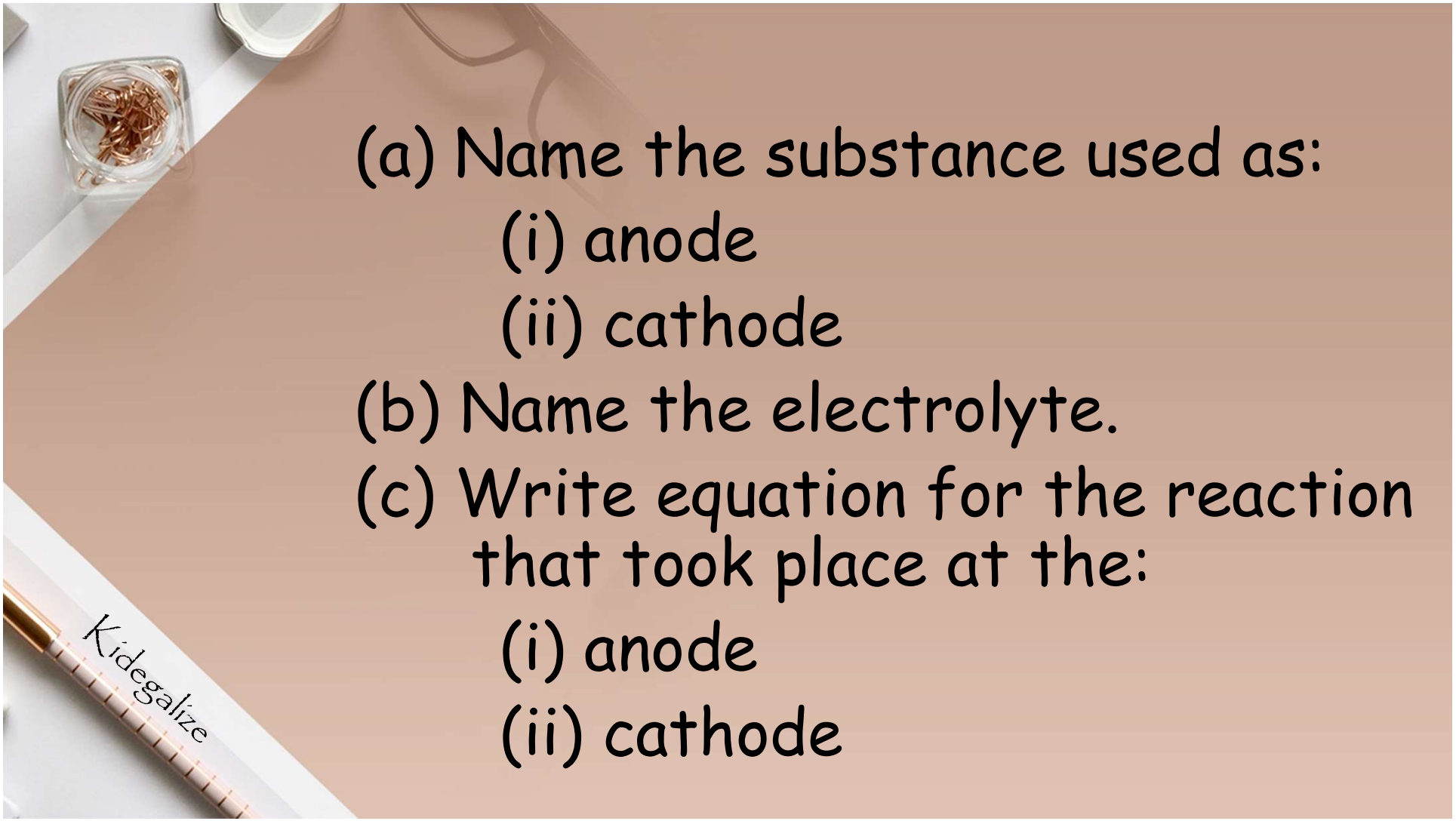


Fig. 1



(a) Name the substance used as:

(i) anode

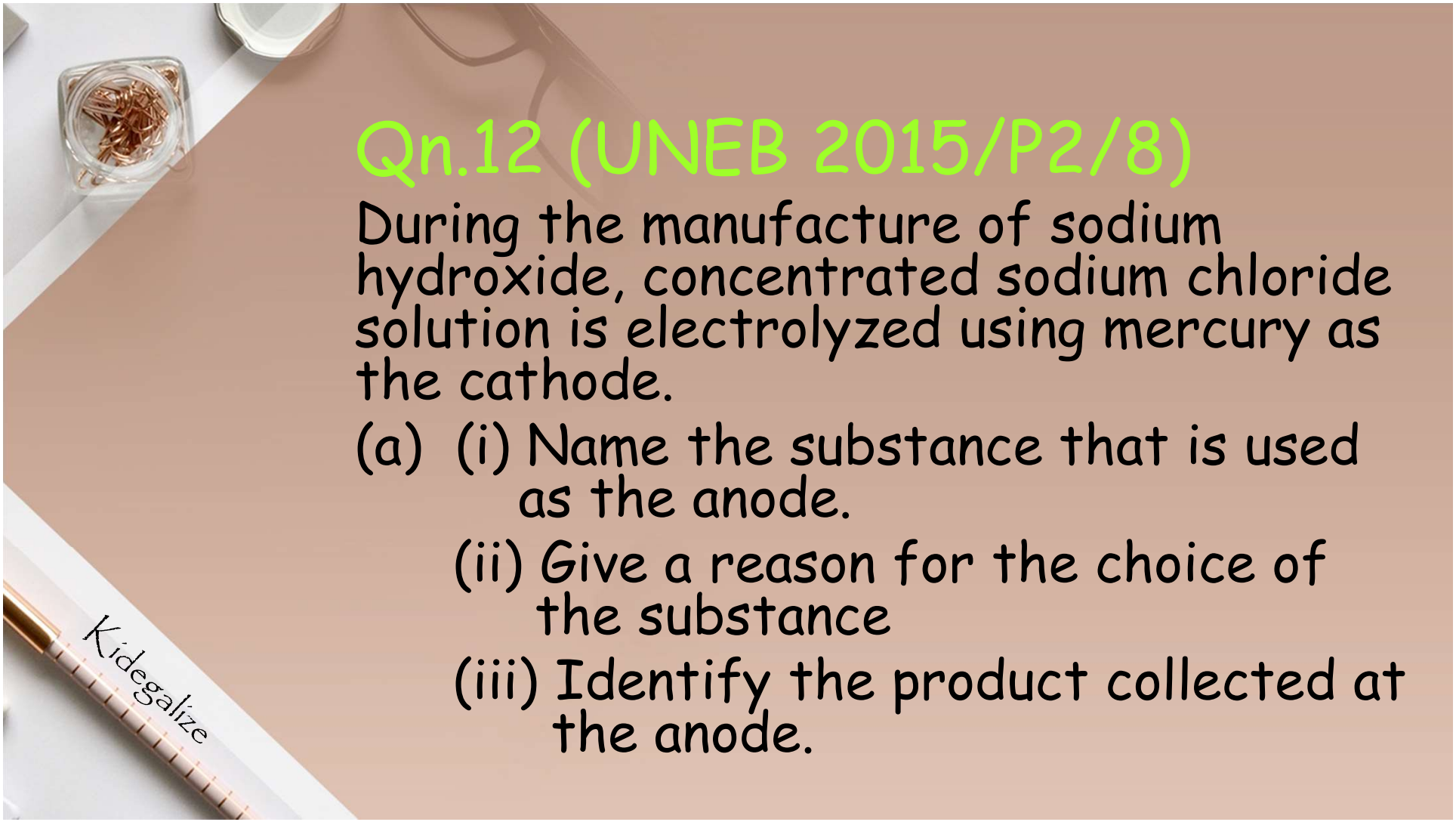
(ii) cathode

(b) Name the electrolyte.

(c) Write equation for the reaction that took place at the:

(i) anode

(ii) cathode



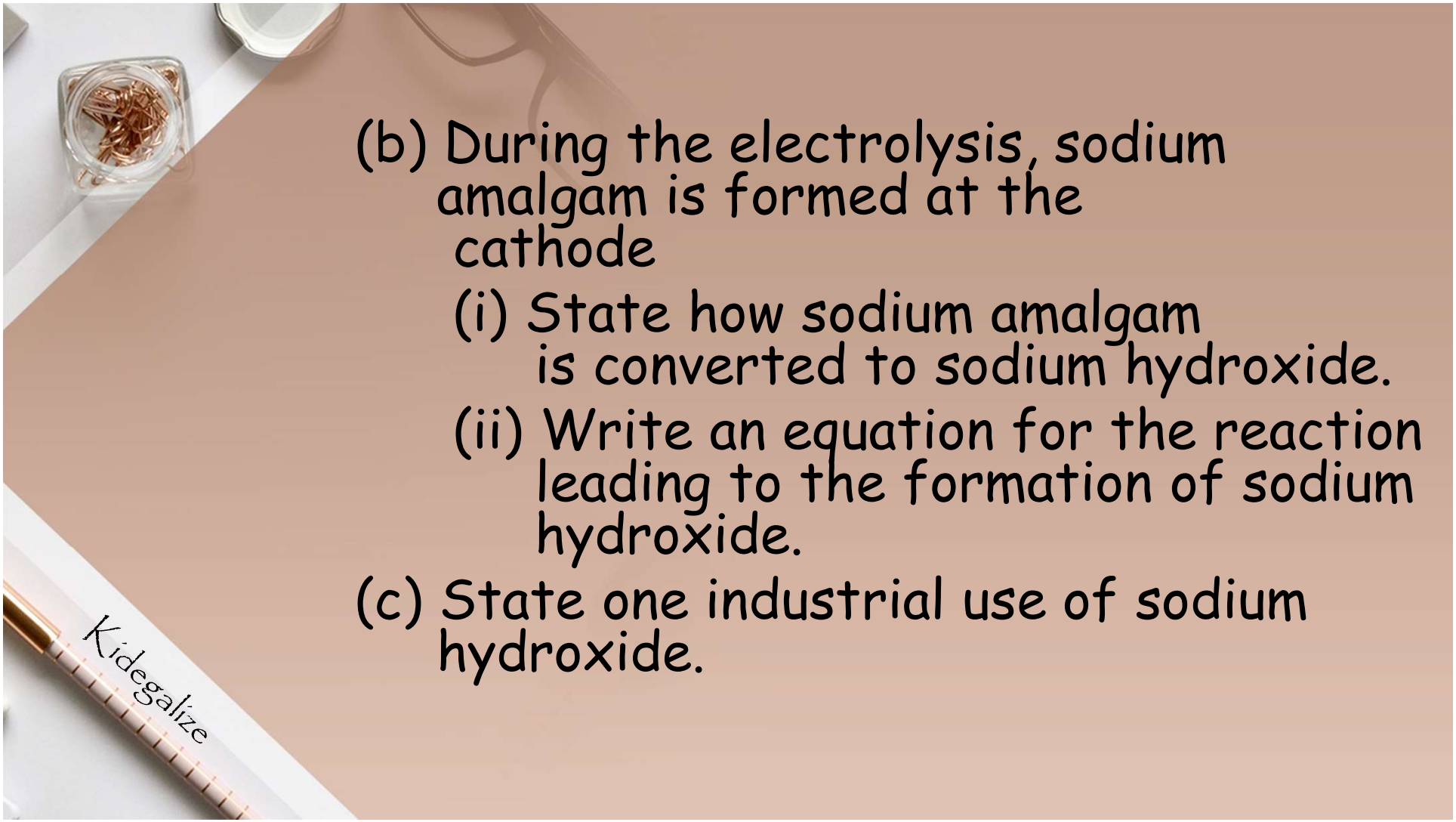
Qn.12 (UNEB 2015/P2/8)

During the manufacture of sodium hydroxide, concentrated sodium chloride solution is electrolyzed using mercury as the cathode.

(a) (i) Name the substance that is used as the anode.

(ii) Give a reason for the choice of the substance

(iii) Identify the product collected at the anode.

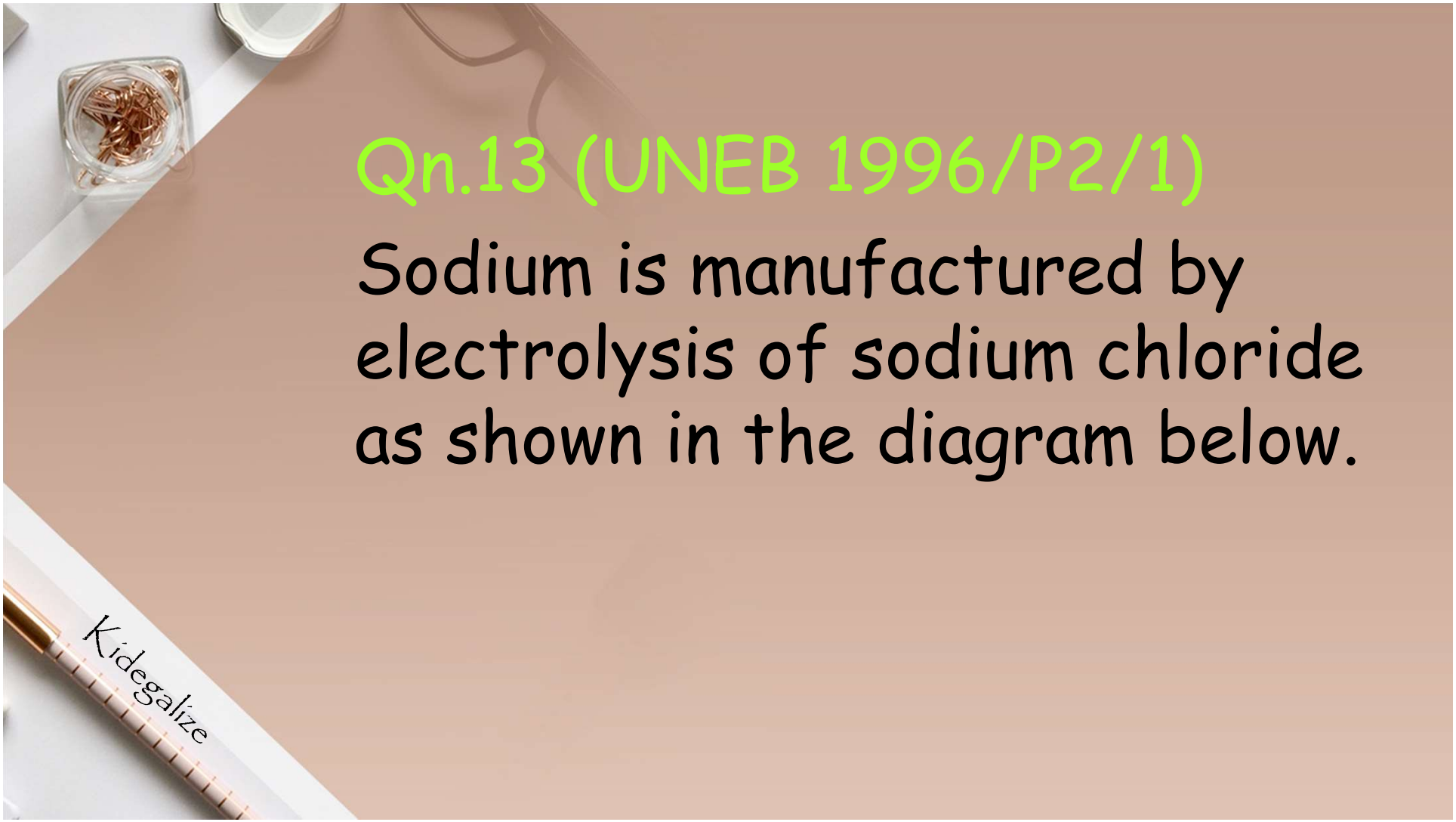


(b) During the electrolysis, sodium amalgam is formed at the cathode

(i) State how sodium amalgam is converted to sodium hydroxide.

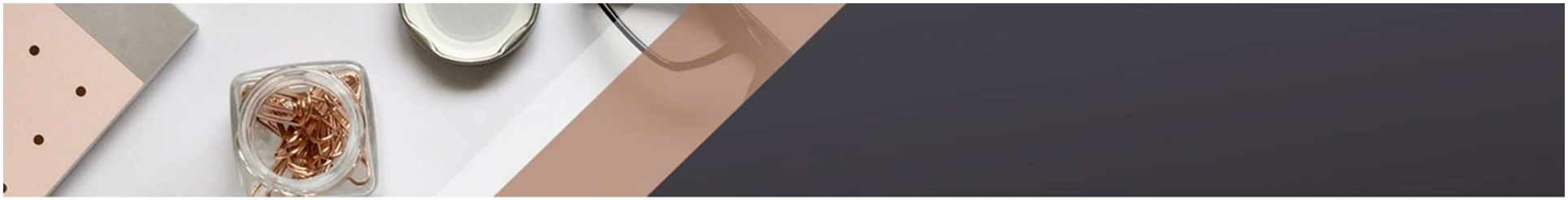
(ii) Write an equation for the reaction leading to the formation of sodium hydroxide.

(c) State one industrial use of sodium hydroxide.



Qn.13 (UNEB 1996/P2/1)

Sodium is manufactured by electrolysis of sodium chloride as shown in the diagram below.



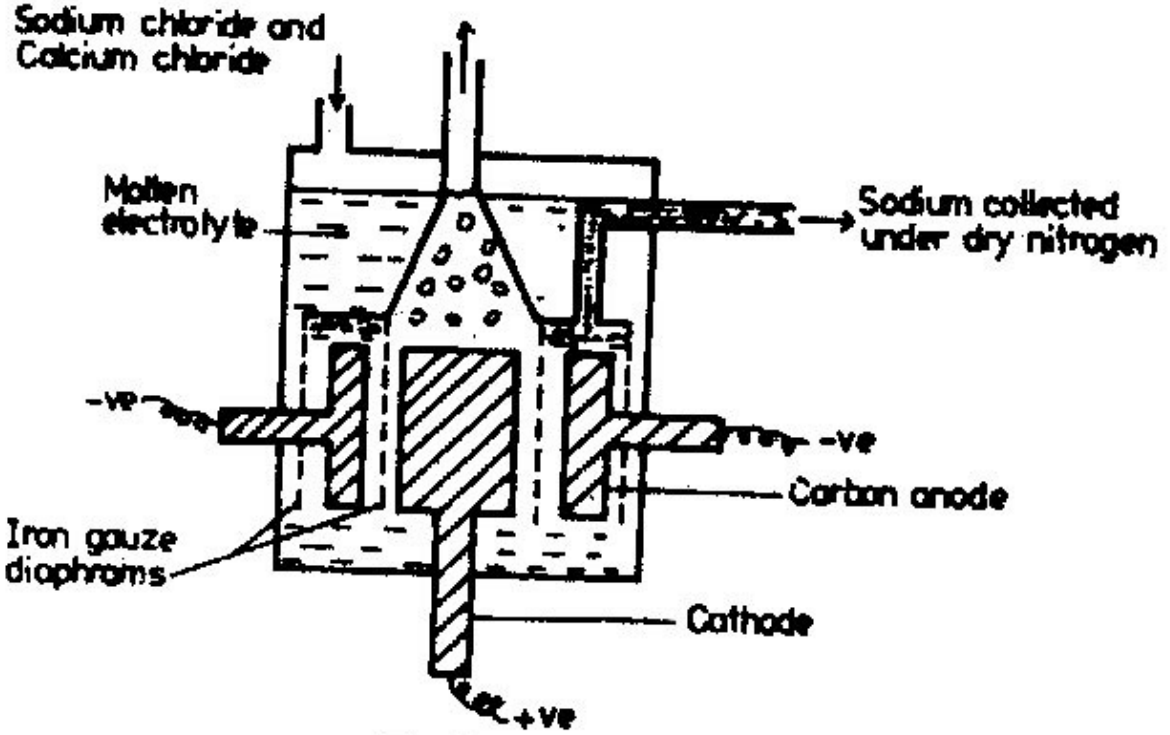
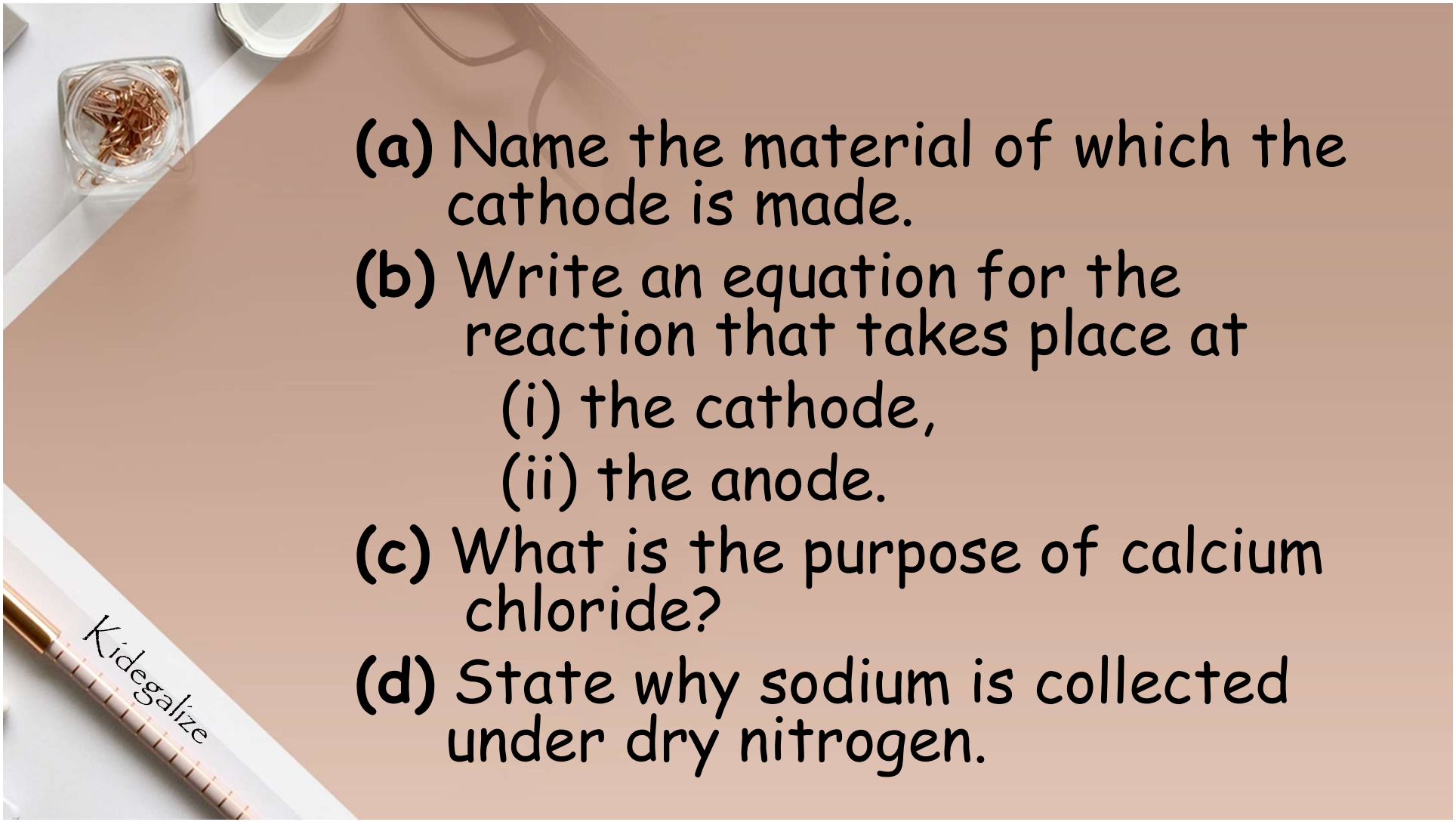

Sodium chloride and
Calcium chloride
Molten
electrolyte
Sodium collected
under dry nitrogen
-ve
-ve
Carbon anode
Iron gauze
diaphragms
Cathode
+ve

Fig. 1



(a) Name the material of which the cathode is made.

(b) Write an equation for the reaction that takes place at

(i) the cathode,

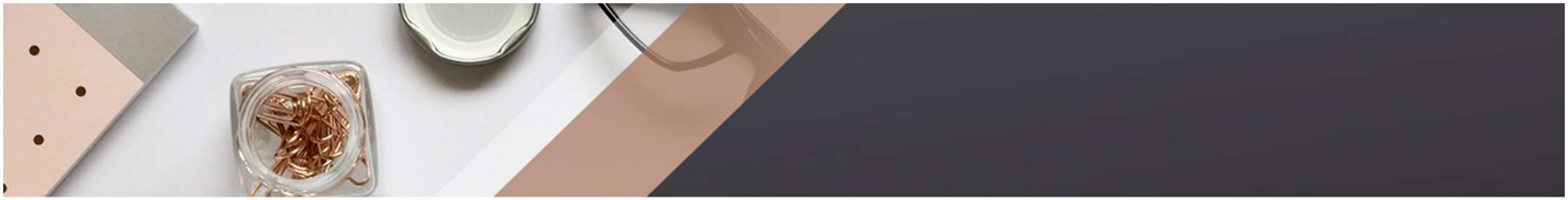
(ii) the anode.

(c) What is the purpose of calcium chloride?

(d) State why sodium is collected under dry nitrogen.

Qn.14 (UNEB 2001/P2/9)

During the manufacture of Sodium hydroxide, a concentrated sodium chloride solution (brine) is electrolysed using a mercury cathode as shown in the diagram in figure 1.



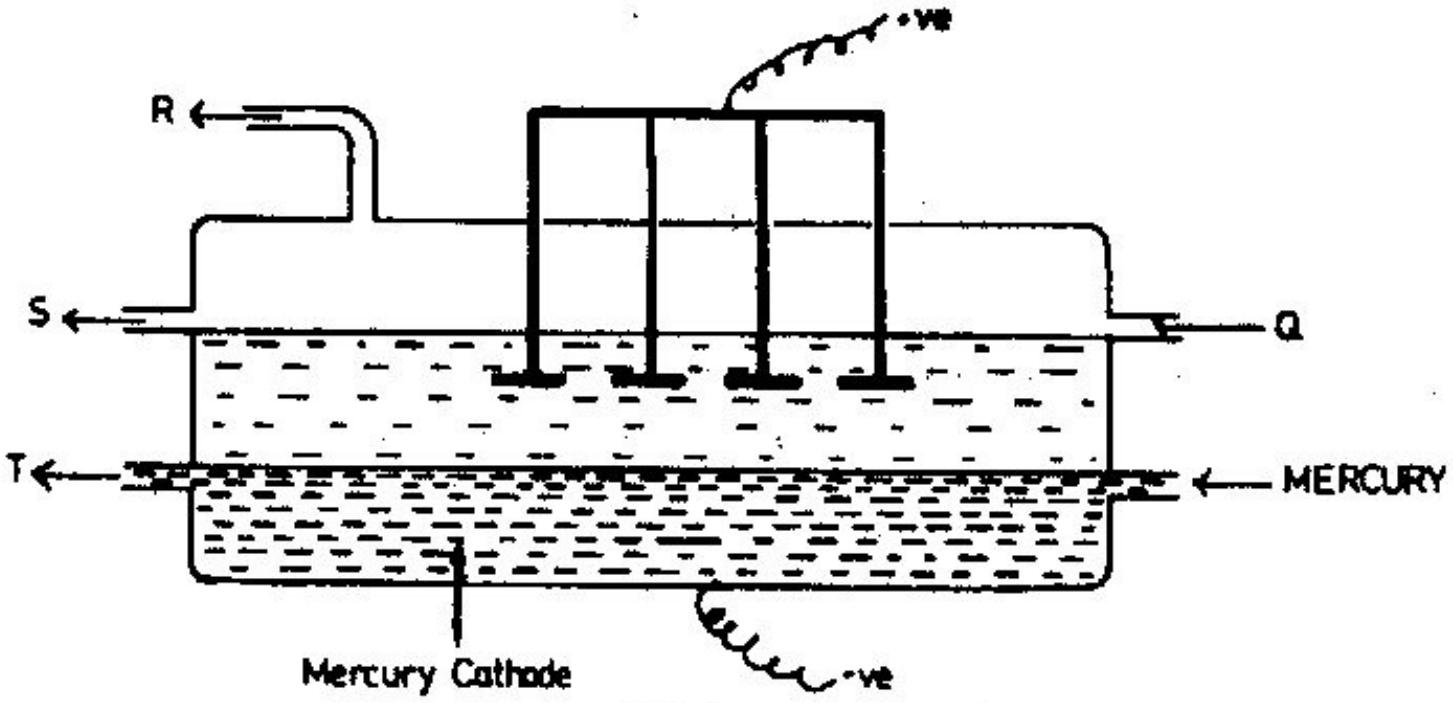
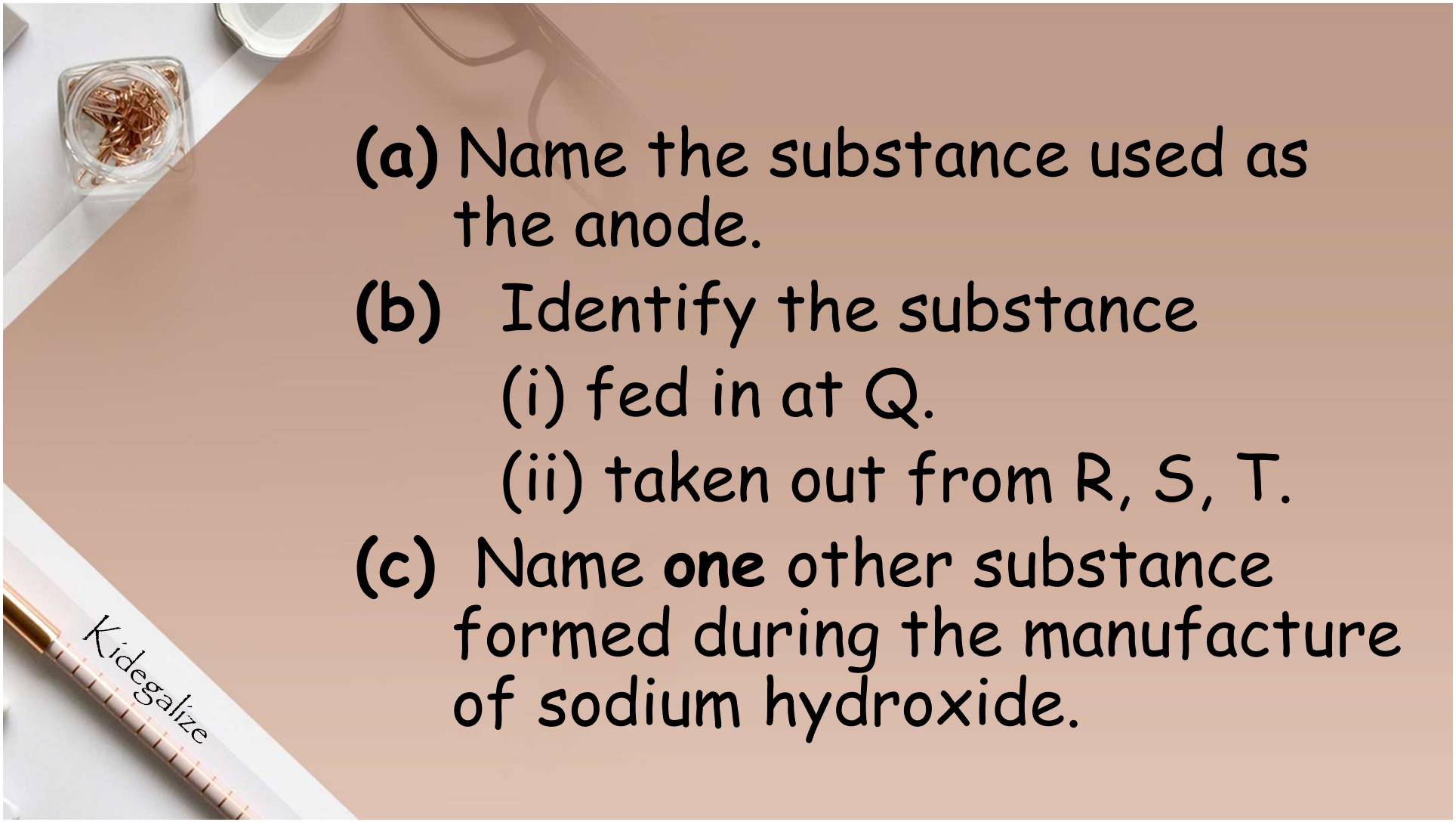


Fig. 1



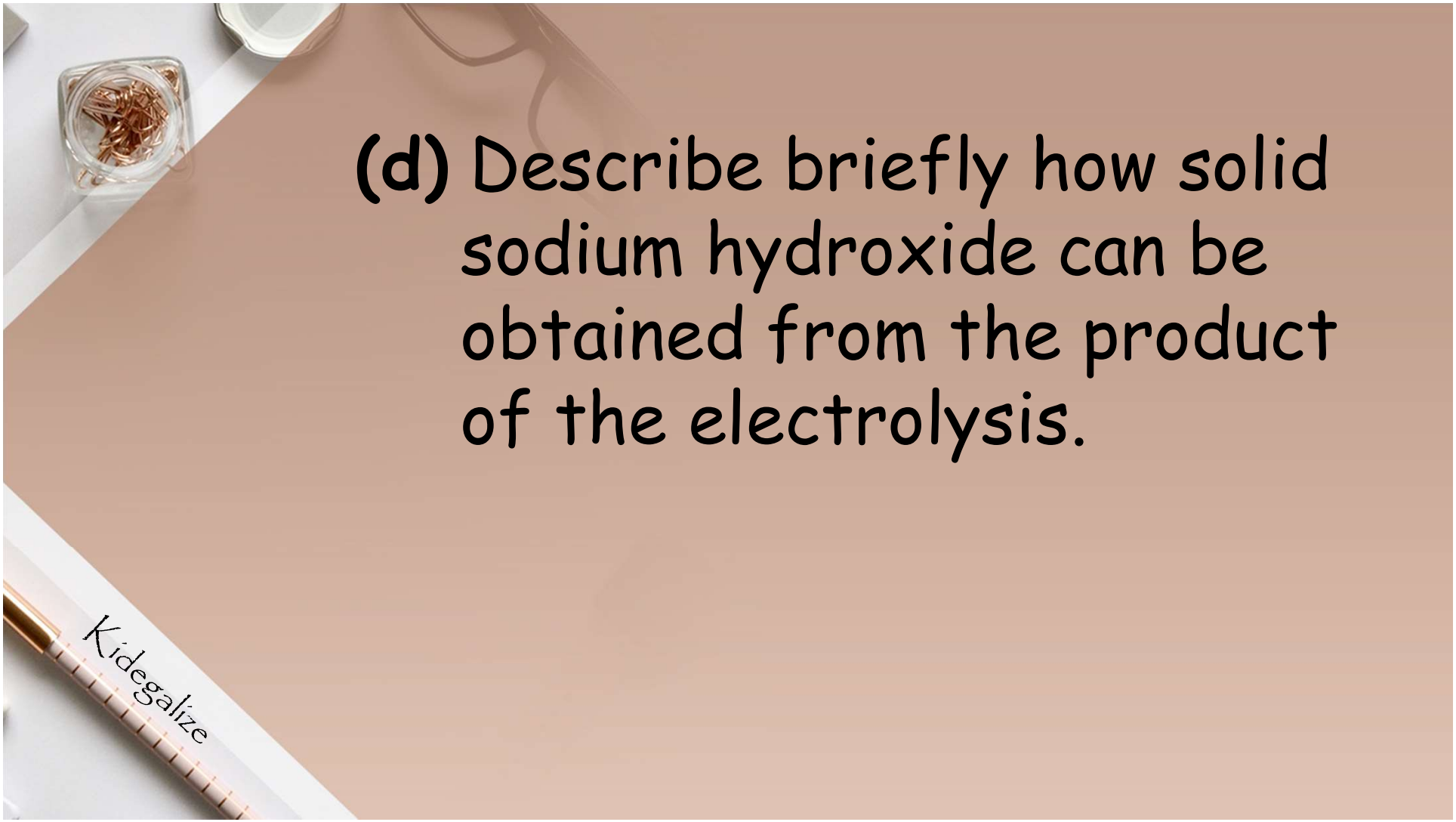
(a) Name the substance used as the anode.

(b) Identify the substance

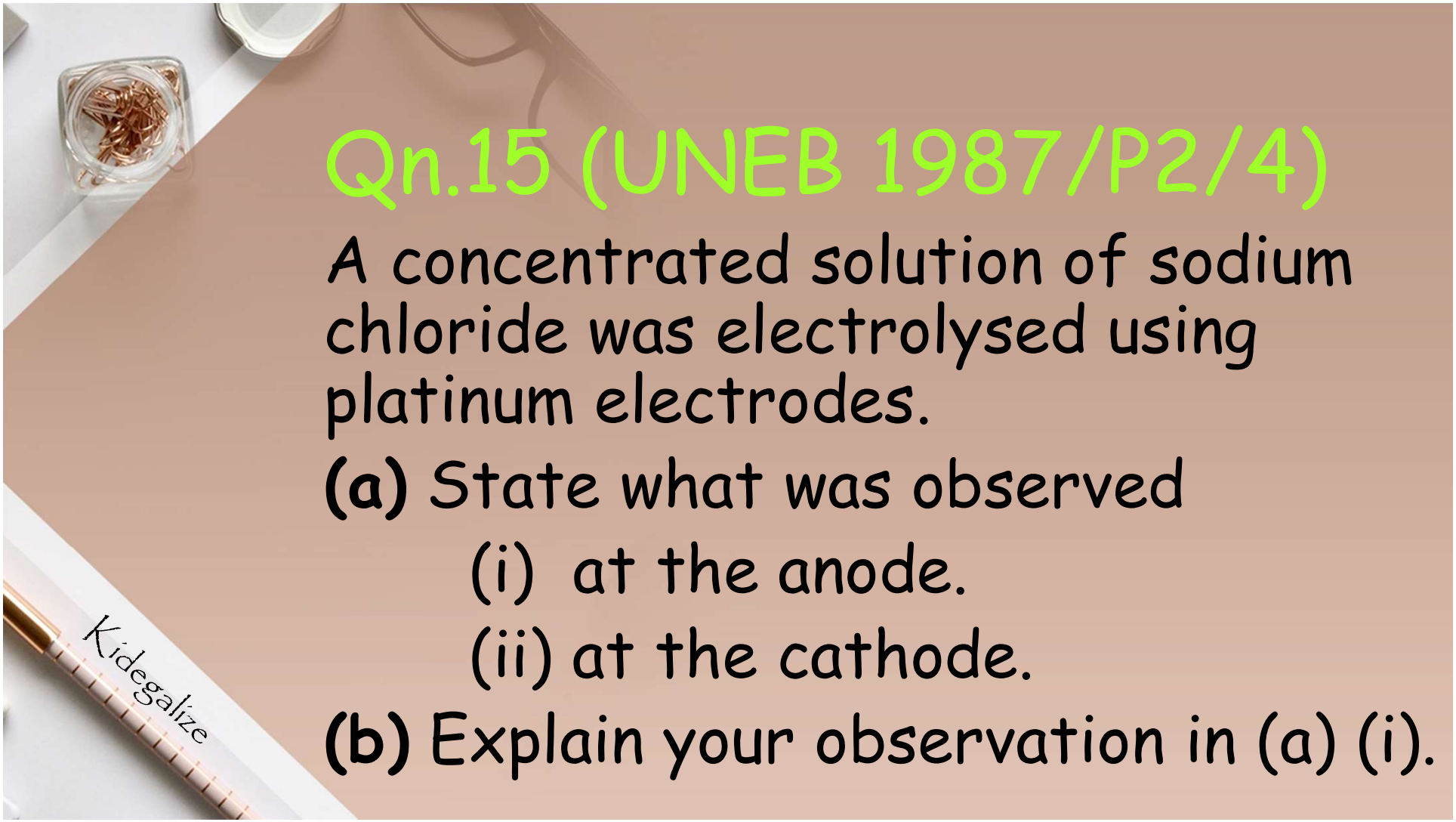
(i) fed in at Q.

(ii) taken out from R, S, T.

(c) Name **one** other substance formed during the manufacture of sodium hydroxide.



(d) Describe briefly how solid sodium hydroxide can be obtained from the product of the electrolysis.



Qn.15 (UNEB 1987/P2/4)

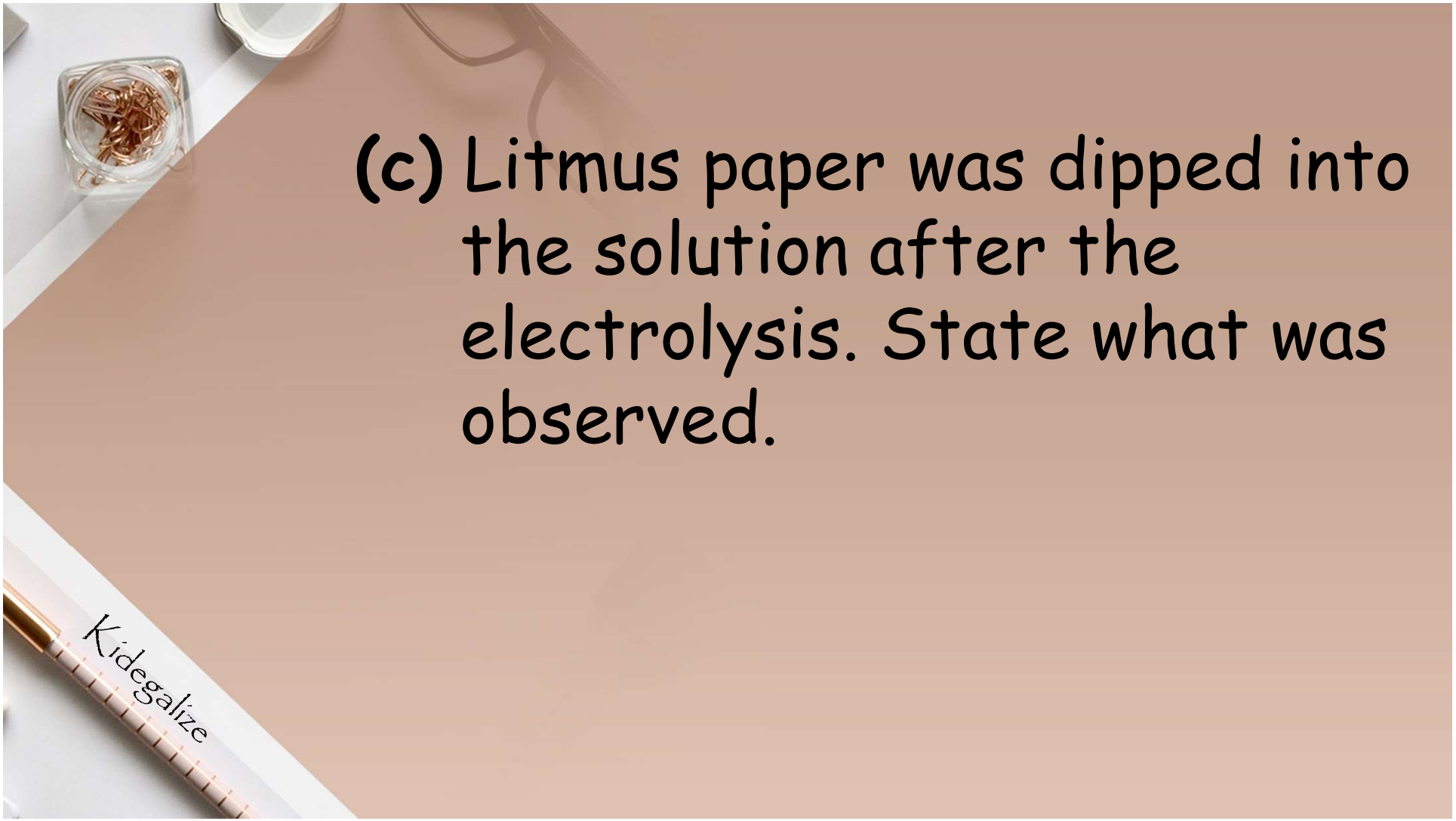
A concentrated solution of sodium chloride was electrolysed using platinum electrodes.

(a) State what was observed

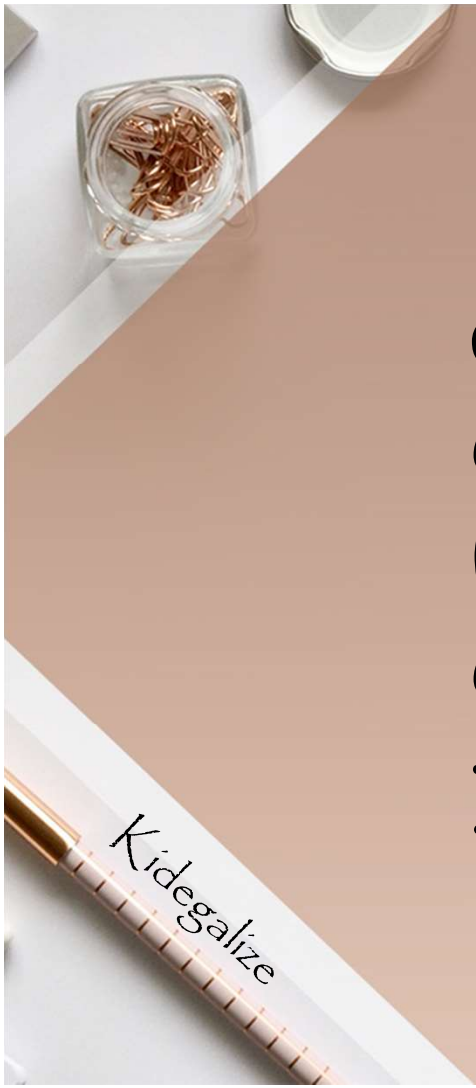
(i) at the anode.

(ii) at the cathode.

(b) Explain your observation in (a) (i).



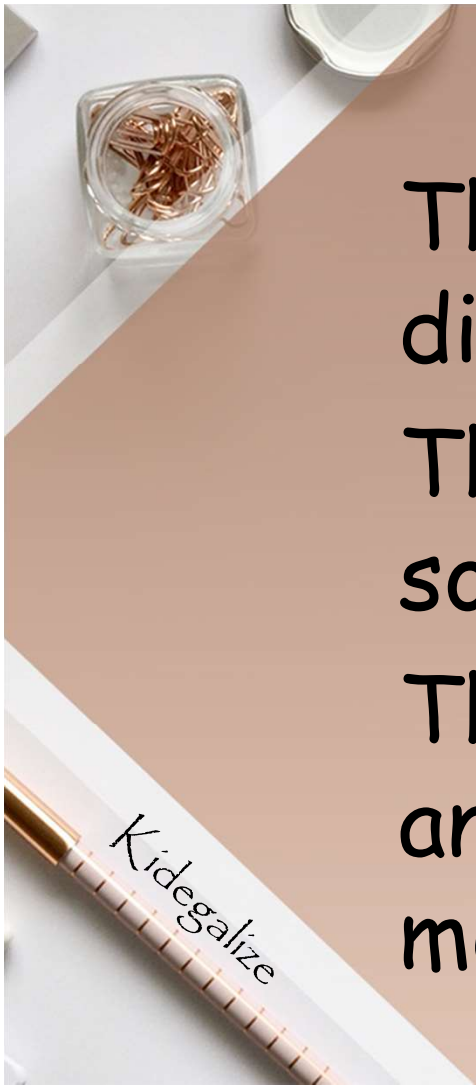
(c) Litmus paper was dipped into the solution after the electrolysis. State what was observed.



Electrochemical cells

Electrochemical cell is an apparatus containing an electrolyte and two electrodes used to produce direct current electricity.

It converts chemical energy into electrical energy.



The cell comprises of an electrode dipped in a solution of its ions.

The electrode together with its solution constitute a half cell.

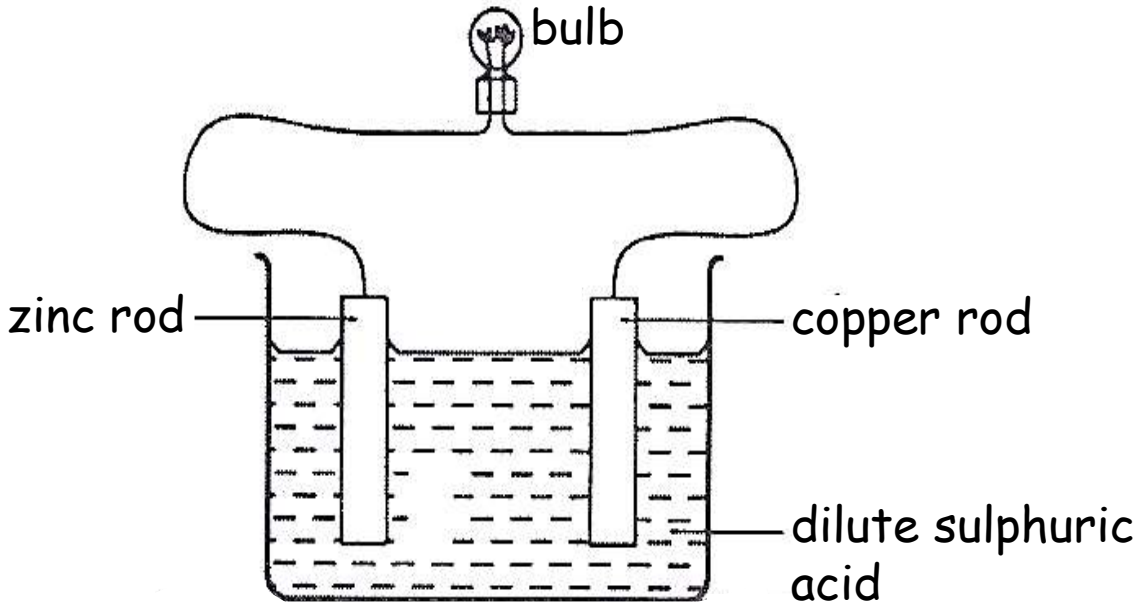
The more reactive metal is the anode (left) and the less reactive metal is the cathode (right).

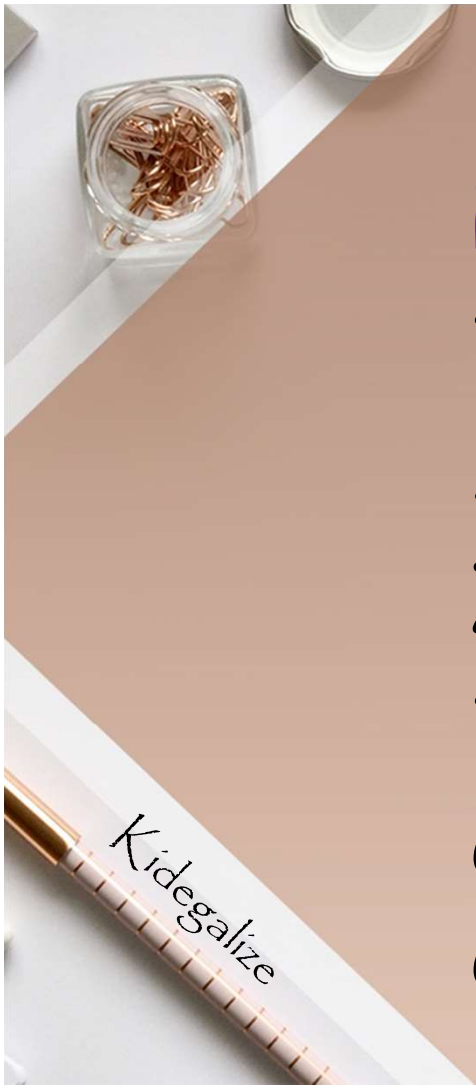
Primary cells

Primary/simple cells are cells which cannot be recharged once the chemical run down.

It consists of copper rod (cathode) and zinc rod (anode) dipped in dilute sulphuric acid.

Set up



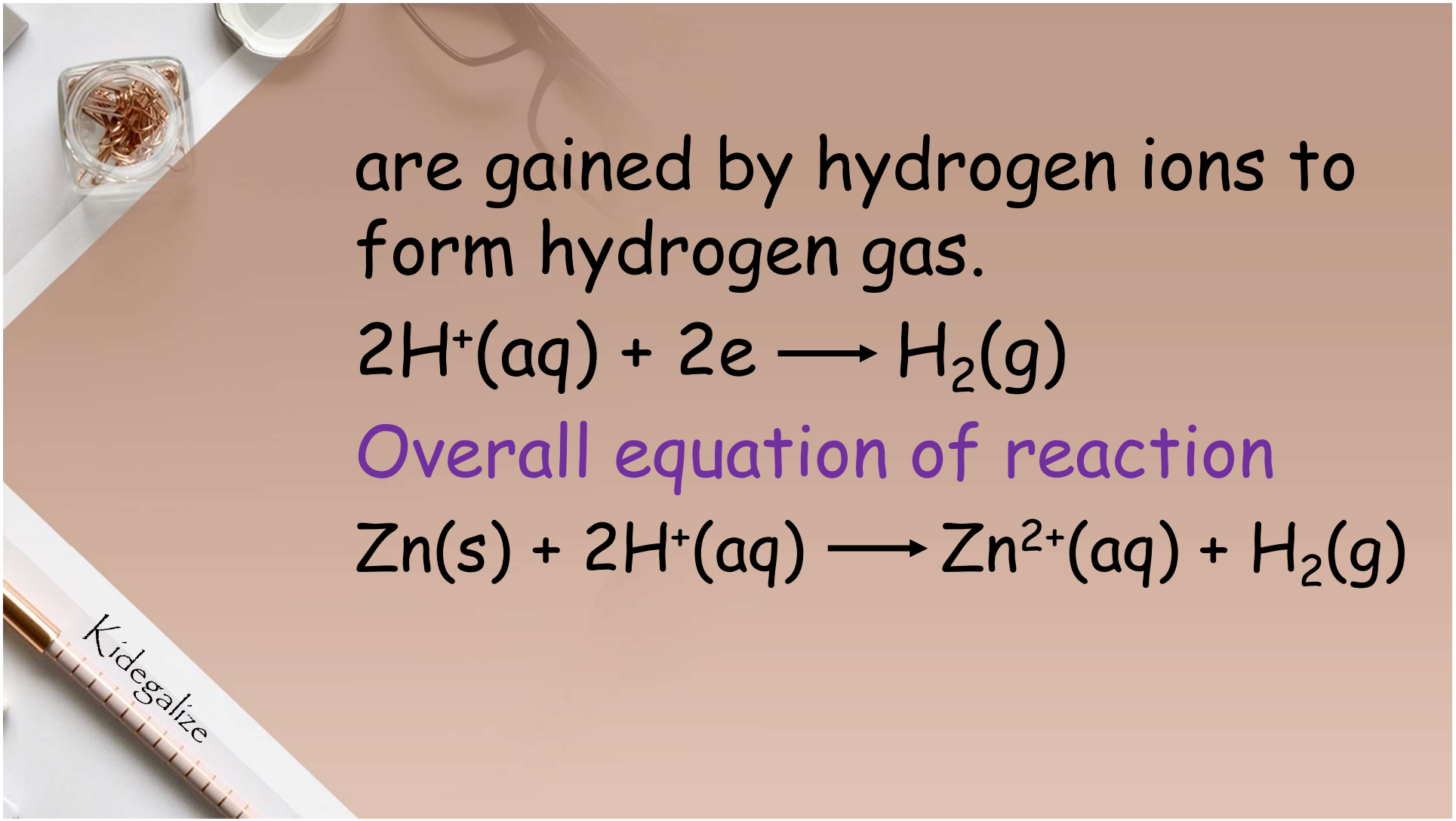


Reaction at the anode

The anode dissolves to form zinc ions.

$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e$

The electrons move from zinc electrode to the copper electrode from where they



are gained by hydrogen ions to form hydrogen gas.

$2H^+(aq) + 2e \longrightarrow H_2(g)$

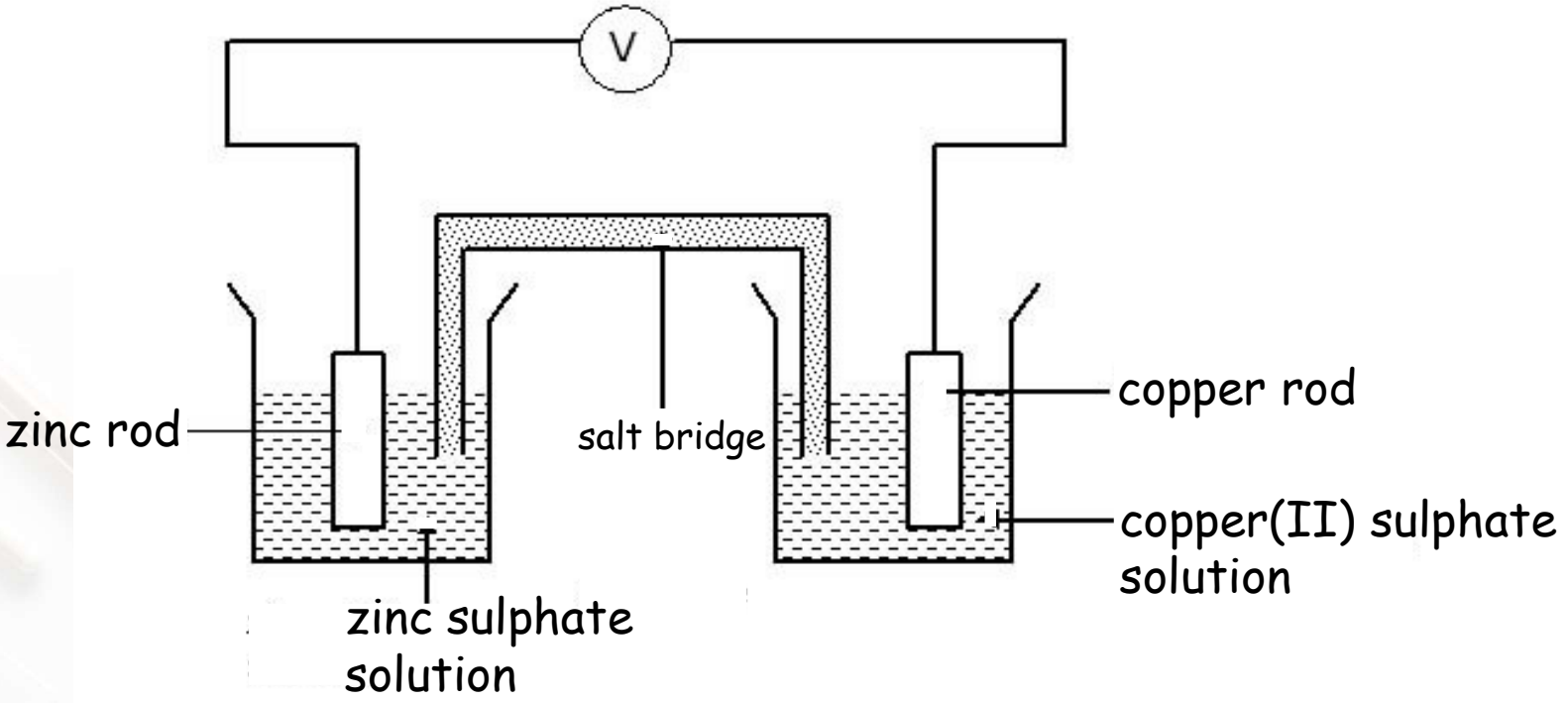
Overall equation of reaction

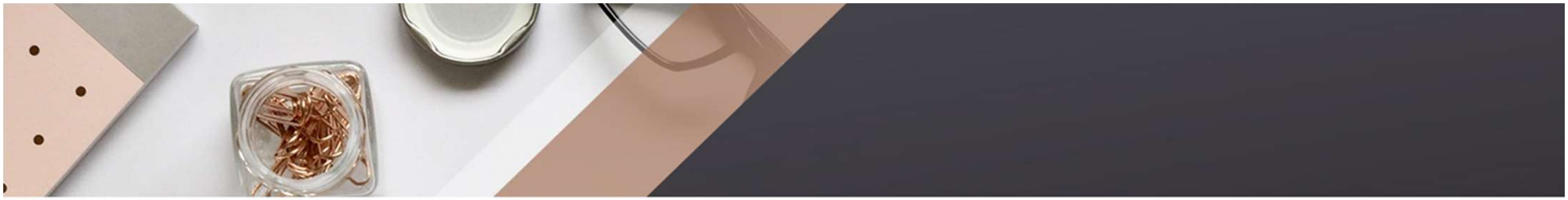
$Zn(s) + 2H^+(aq) \longrightarrow Zn^{2+}(aq) + H_2(g)$

Daniel cell

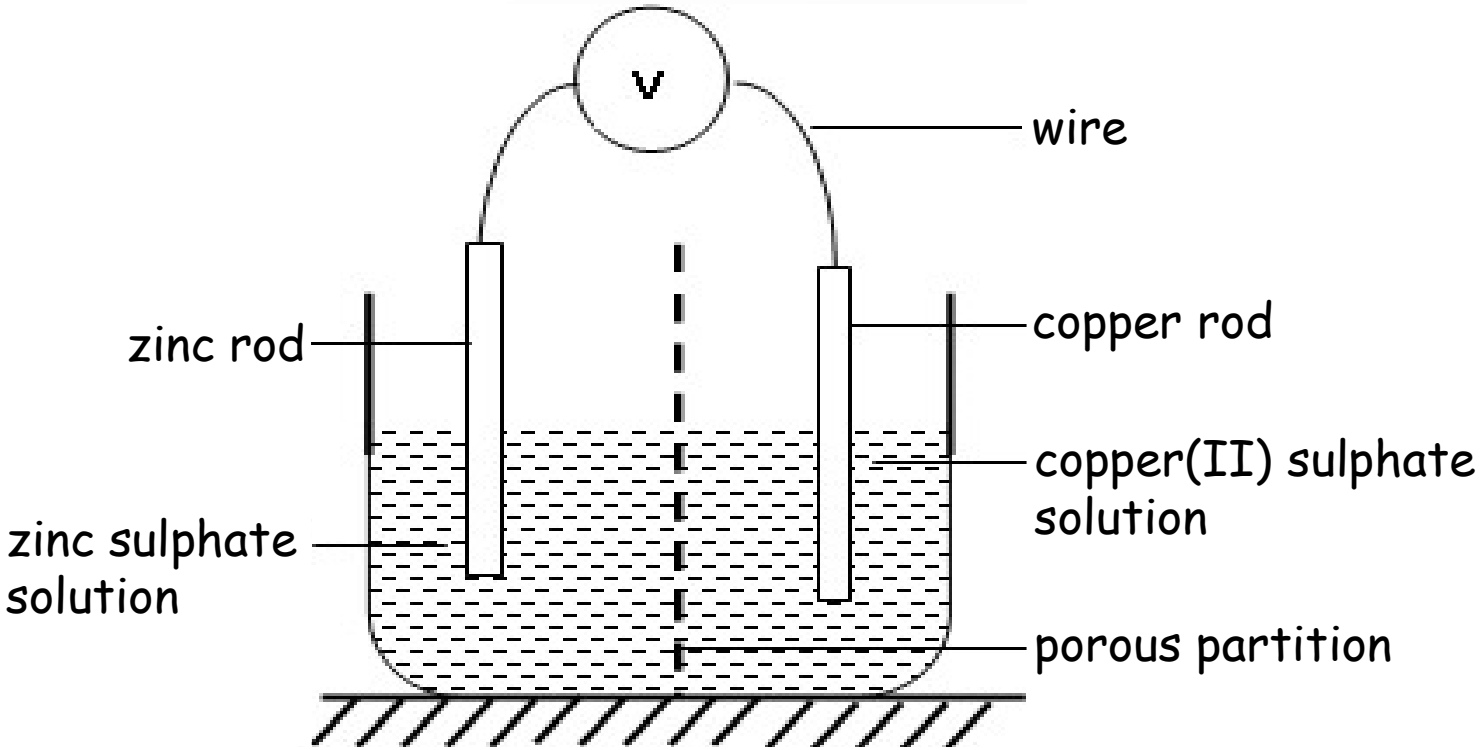
Daniel cell is a modification of the simple cell consisting of a zinc half cell and a copper half cell separated by a porous partition/salt bridge which allows free movement of ions without mixing of solutions.

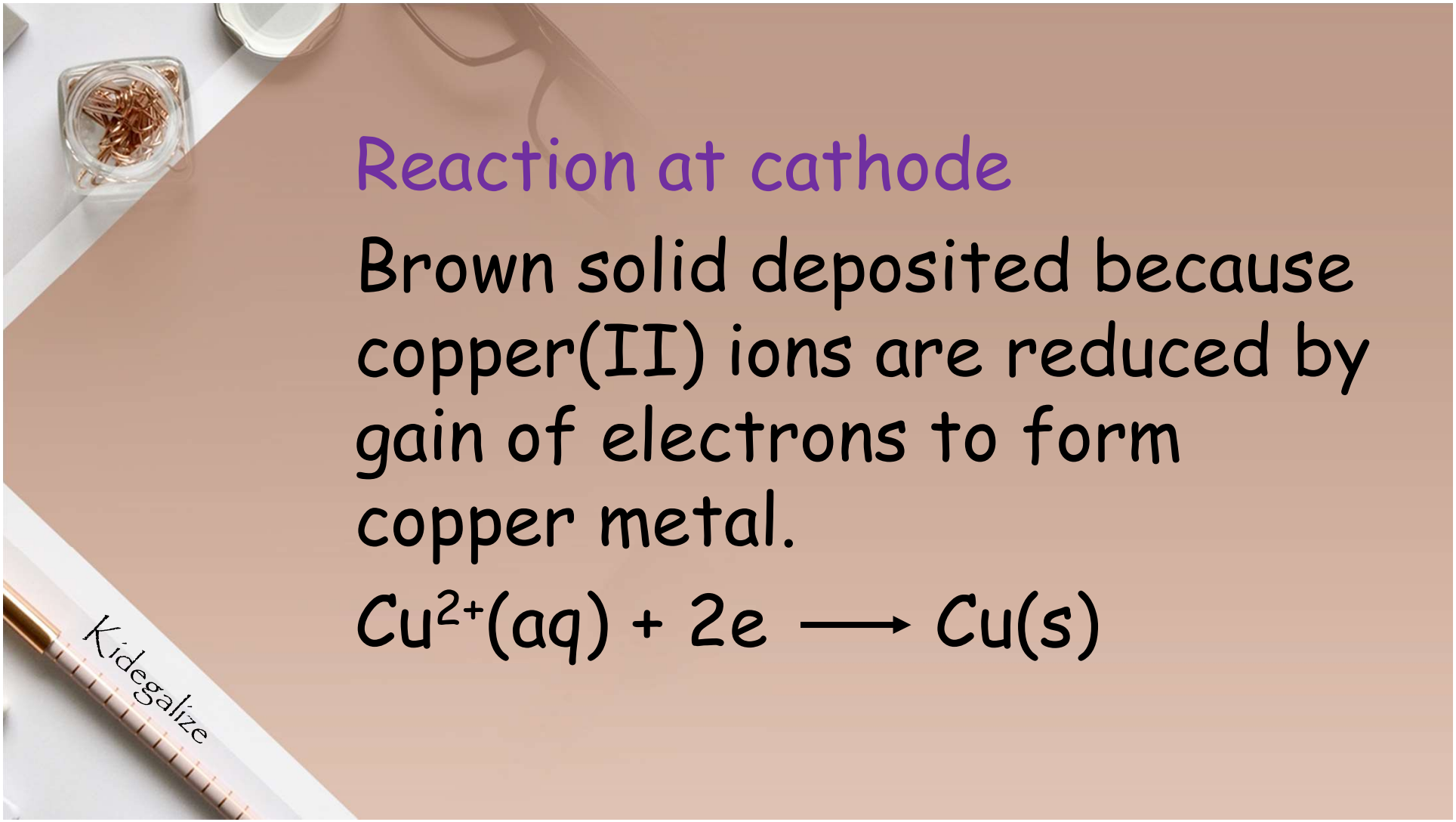
Set up of apparatus





OR

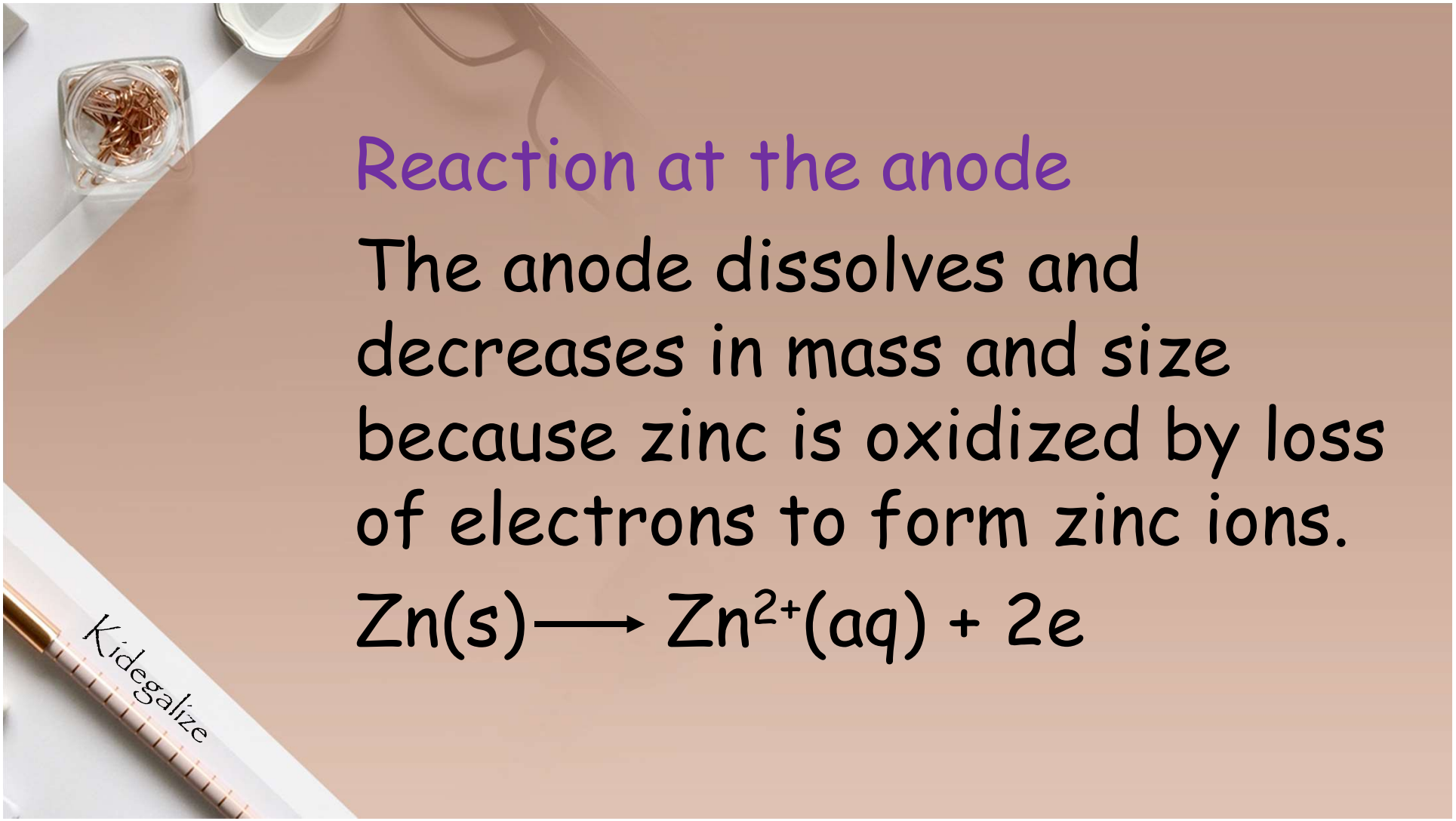

V
wire
zinc rod
copper rod
copper(II) sulphate solution
zinc sulphate solution
porous partition



Reaction at cathode

Brown solid deposited because copper(II) ions are reduced by gain of electrons to form copper metal.

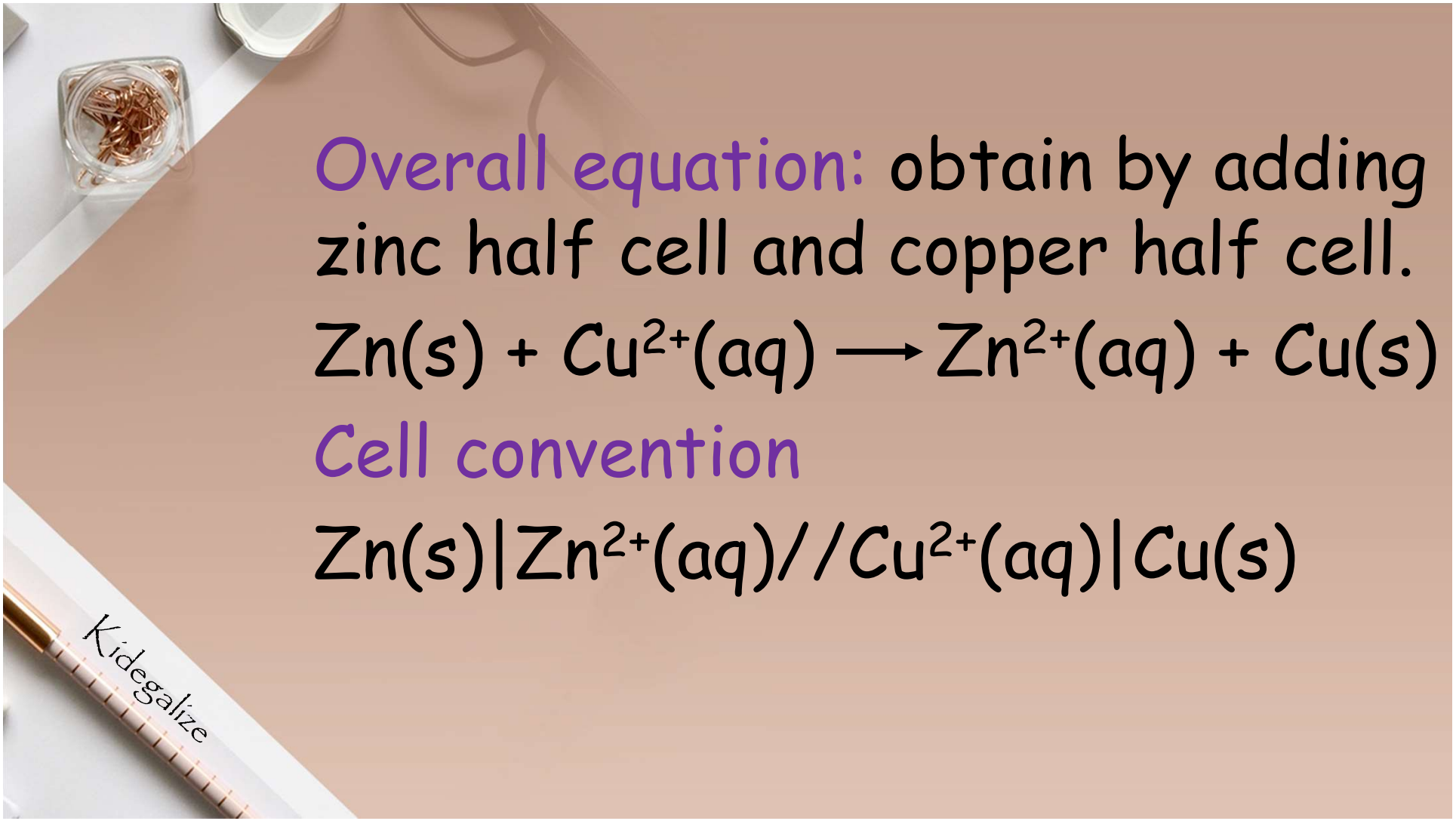
$Cu^{2+}(aq) + 2e \longrightarrow Cu(s)$



Reaction at the anode

The anode dissolves and decreases in mass and size because zinc is oxidized by loss of electrons to form zinc ions.

$$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e$$

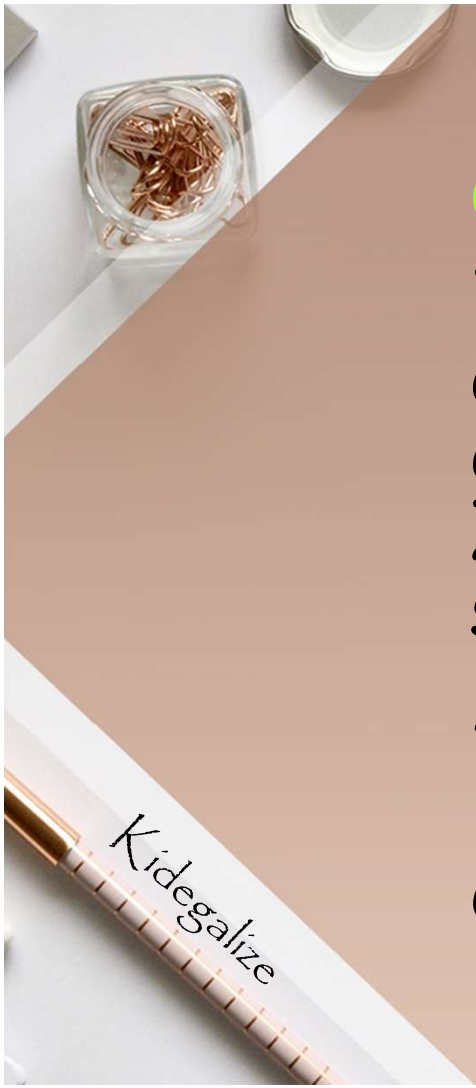


Overall equation: obtain by adding zinc half cell and copper half cell.

$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$$

Cell convention

$$Zn(s)|Zn^{2+}(aq)//Cu^{2+}(aq)|Cu(s)$$



Knowledge Check 5

Qn.1 (UNEB 1999/P1/26)

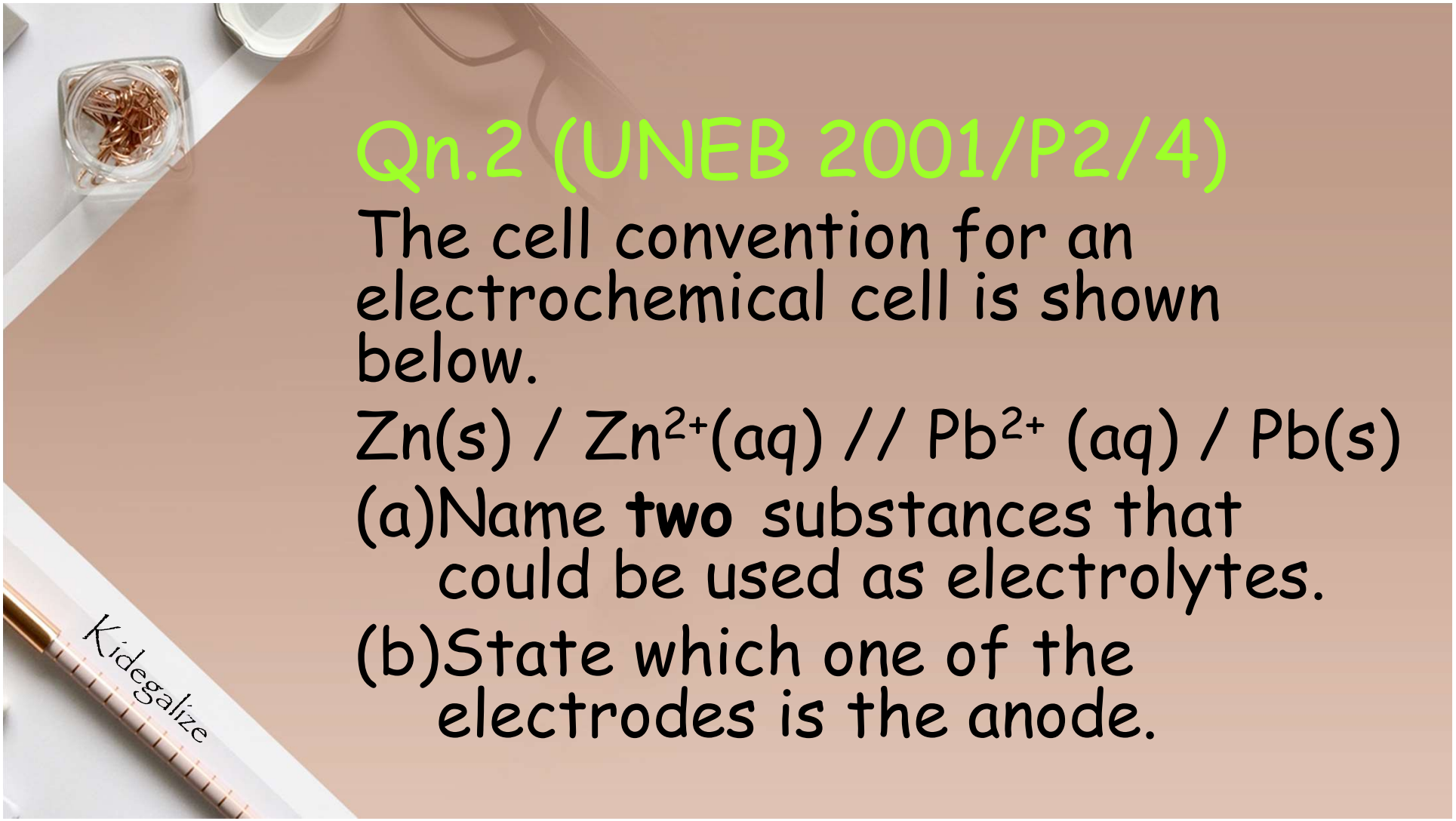
What would be the overall electrochemical change in an electrochemical cell where Copper and Zinc electrodes are immersed in 1M sulphuric acid?

A. $Zn(s) + 2H^+(aq) \longrightarrow Zn^{2+}(aq) + H_2O(l)$

B. $Cu^{2+}(aq) + Zn(s) \longrightarrow Zn^{2+}(aq) + Cu(s)$

C. $Zn(s) \longrightarrow Zn^{2+}(aq) + 2e$

D. $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e$



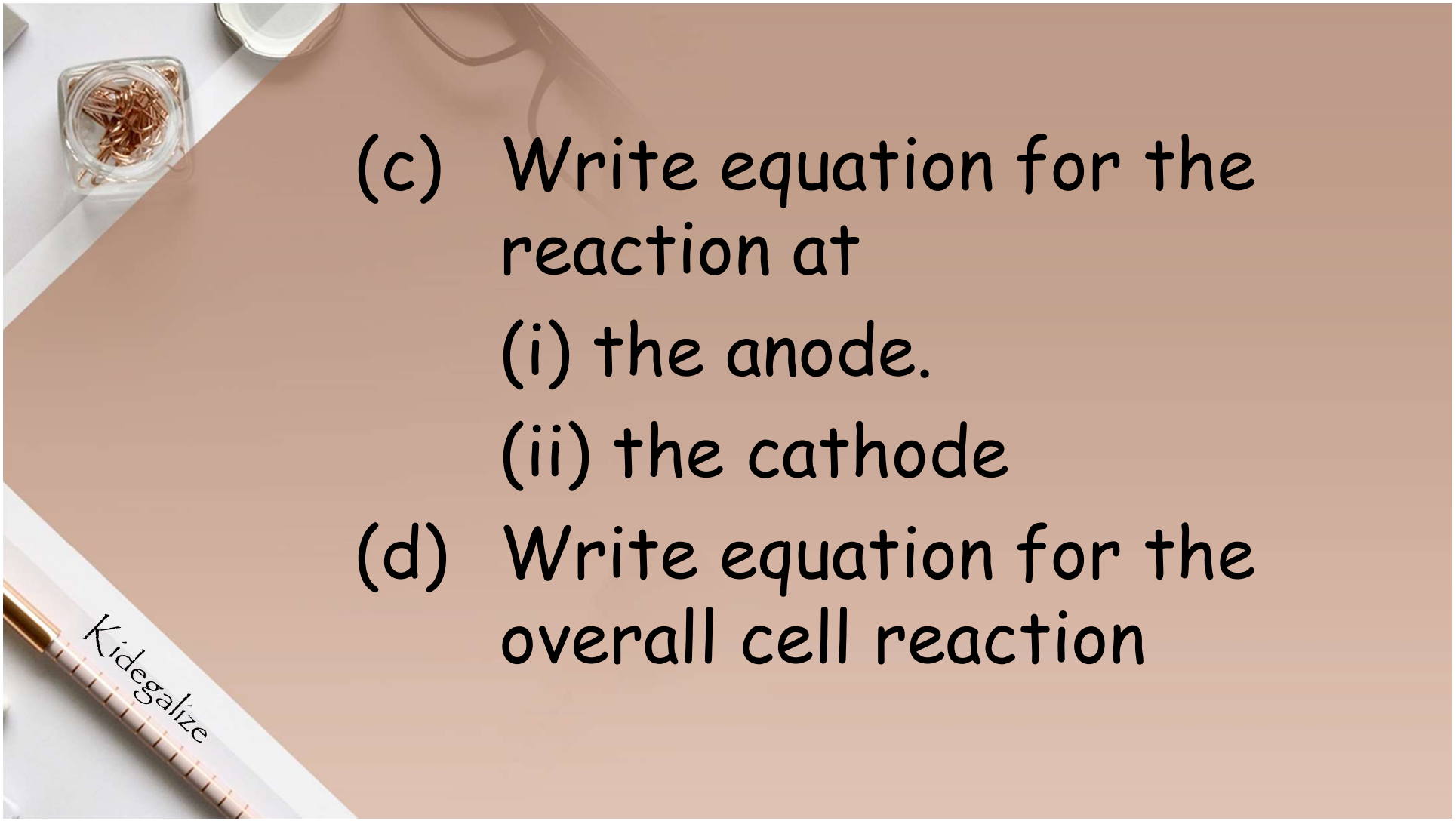
Qn.2 (UNEB 2001/P2/4)

The cell convention for an electrochemical cell is shown below.

$Zn(s) / Zn^{2+}(aq) // Pb^{2+}(aq) / Pb(s)$

(a)Name **two** substances that could be used as electrolytes.

(b)State which one of the electrodes is the anode.



(c) Write equation for the reaction at

(i) the anode.

(ii) the cathode

(d) Write equation for the overall cell reaction

Qn.3 (UNEB 1991/P2/4)

Figure 1 shows a diagram of an electrochemical cell.

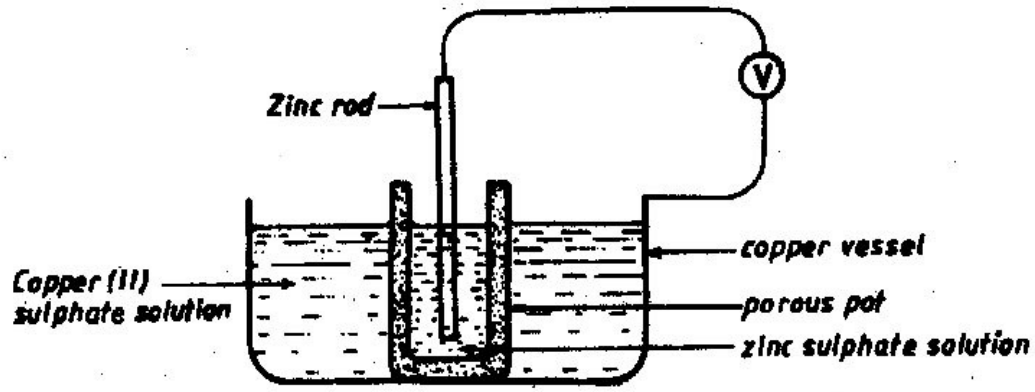
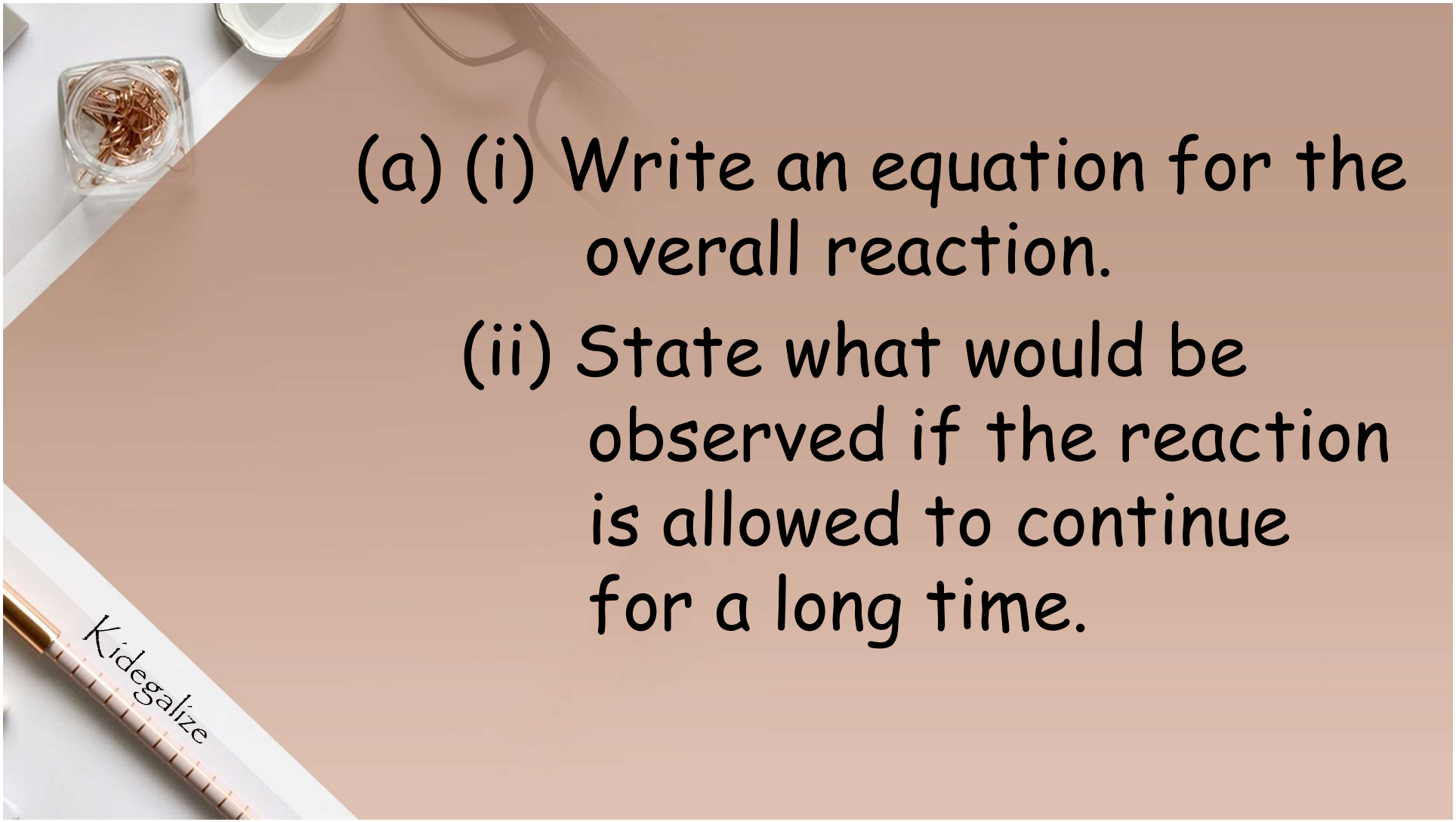
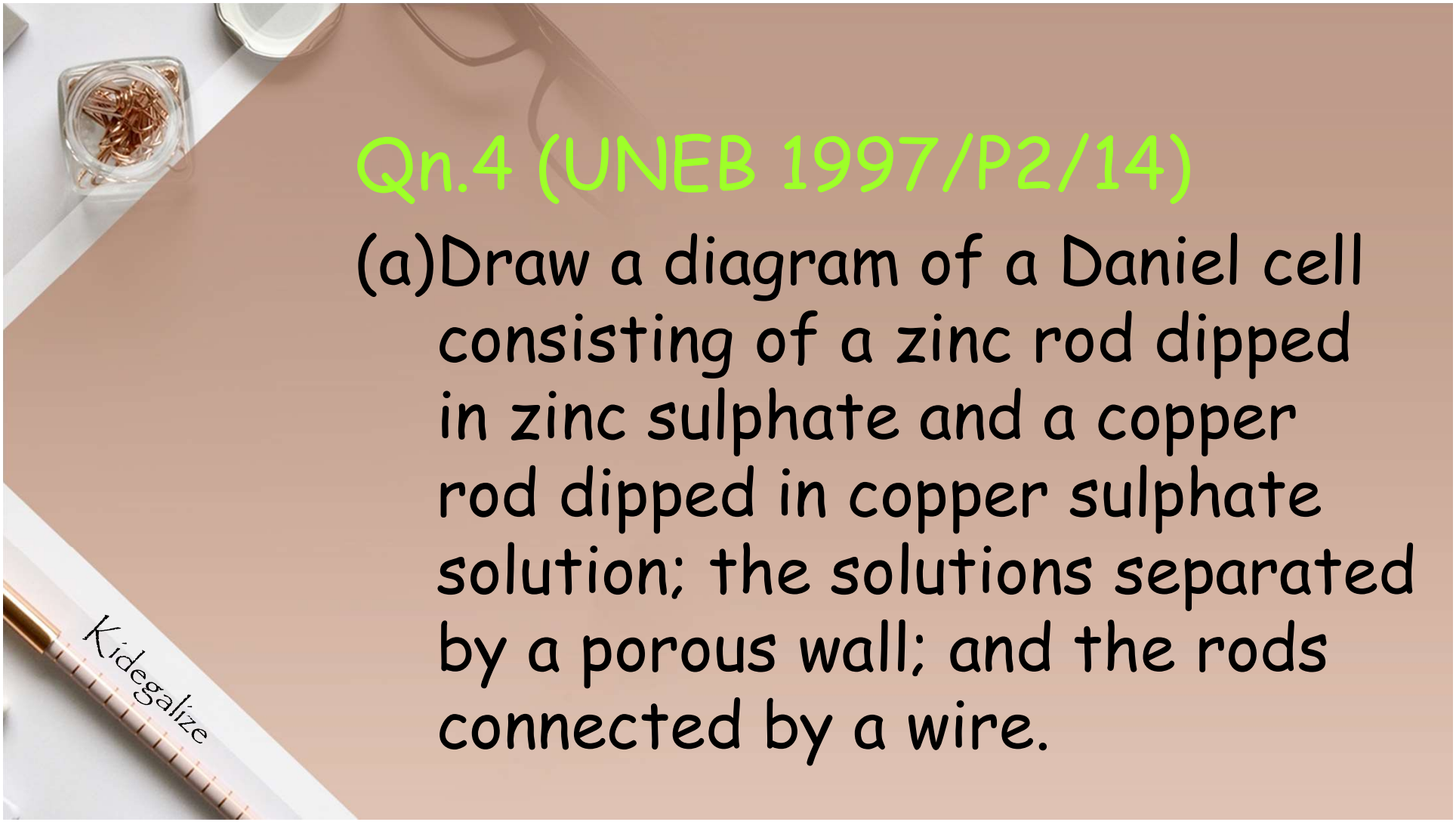


Fig. 1



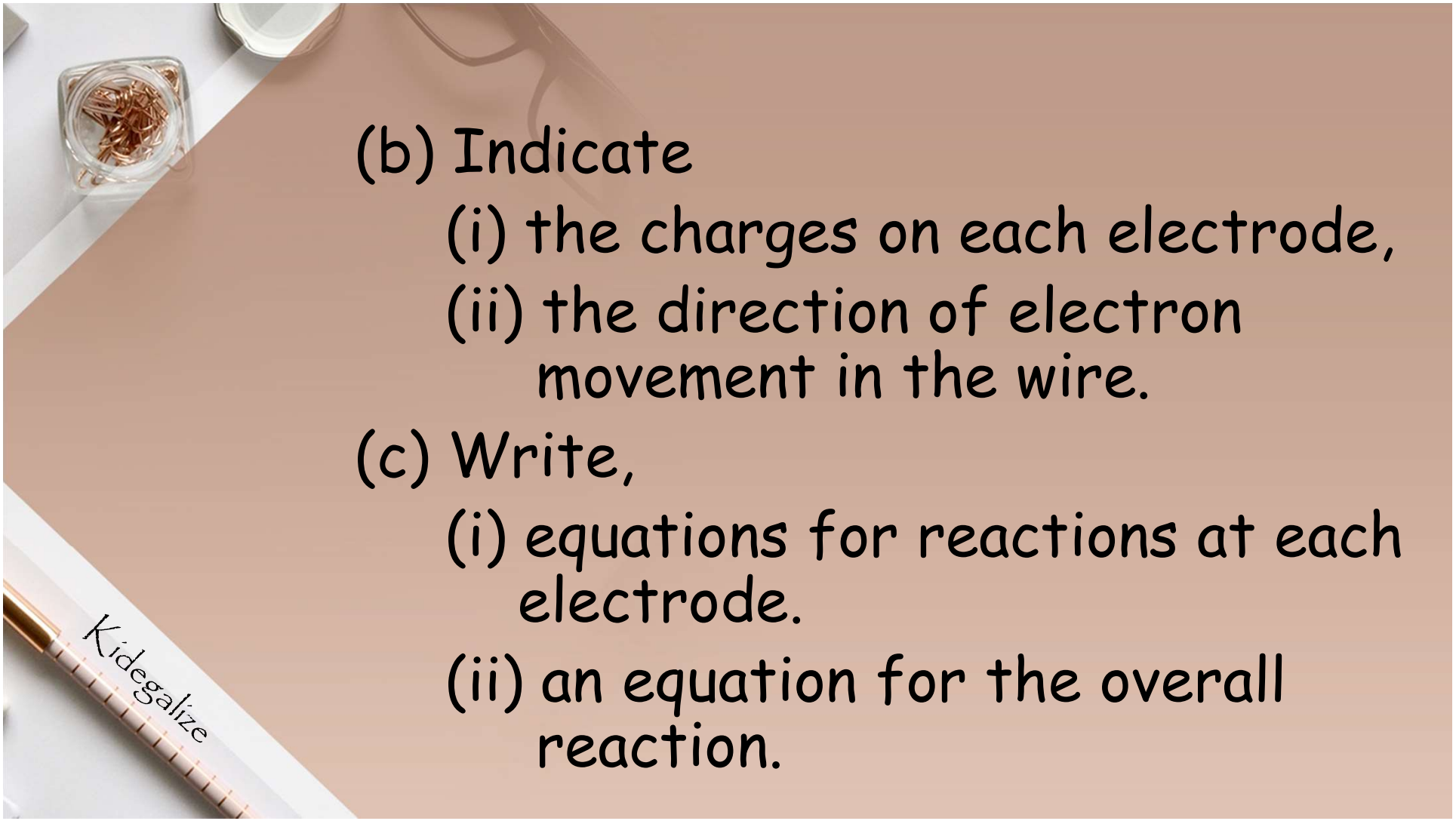
(a) (i) Write an equation for the overall reaction.

(ii) State what would be observed if the reaction is allowed to continue for a long time.



Qn.4 (UNEB 1997/P2/14)

(a)Draw a diagram of a Daniel cell consisting of a zinc rod dipped in zinc sulphate and a copper rod dipped in copper sulphate solution; the solutions separated by a porous wall; and the rods connected by a wire.



(b) Indicate

(i) the charges on each electrode,

(ii) the direction of electron movement in the wire.

(c) Write,

(i) equations for reactions at each electrode.

(ii) an equation for the overall reaction.

Qn.5 (UNEB 1998/P2/5)

Figure 2 below shows a simple voltaic cell.

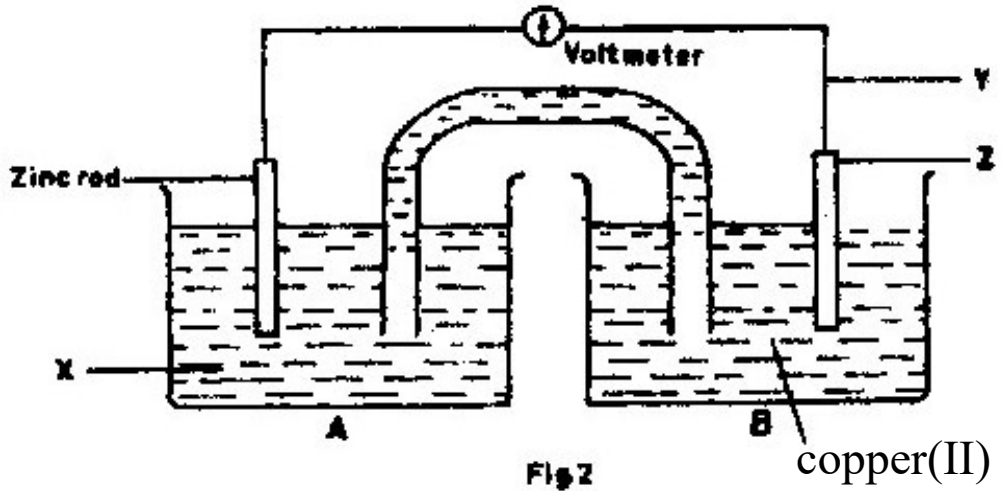
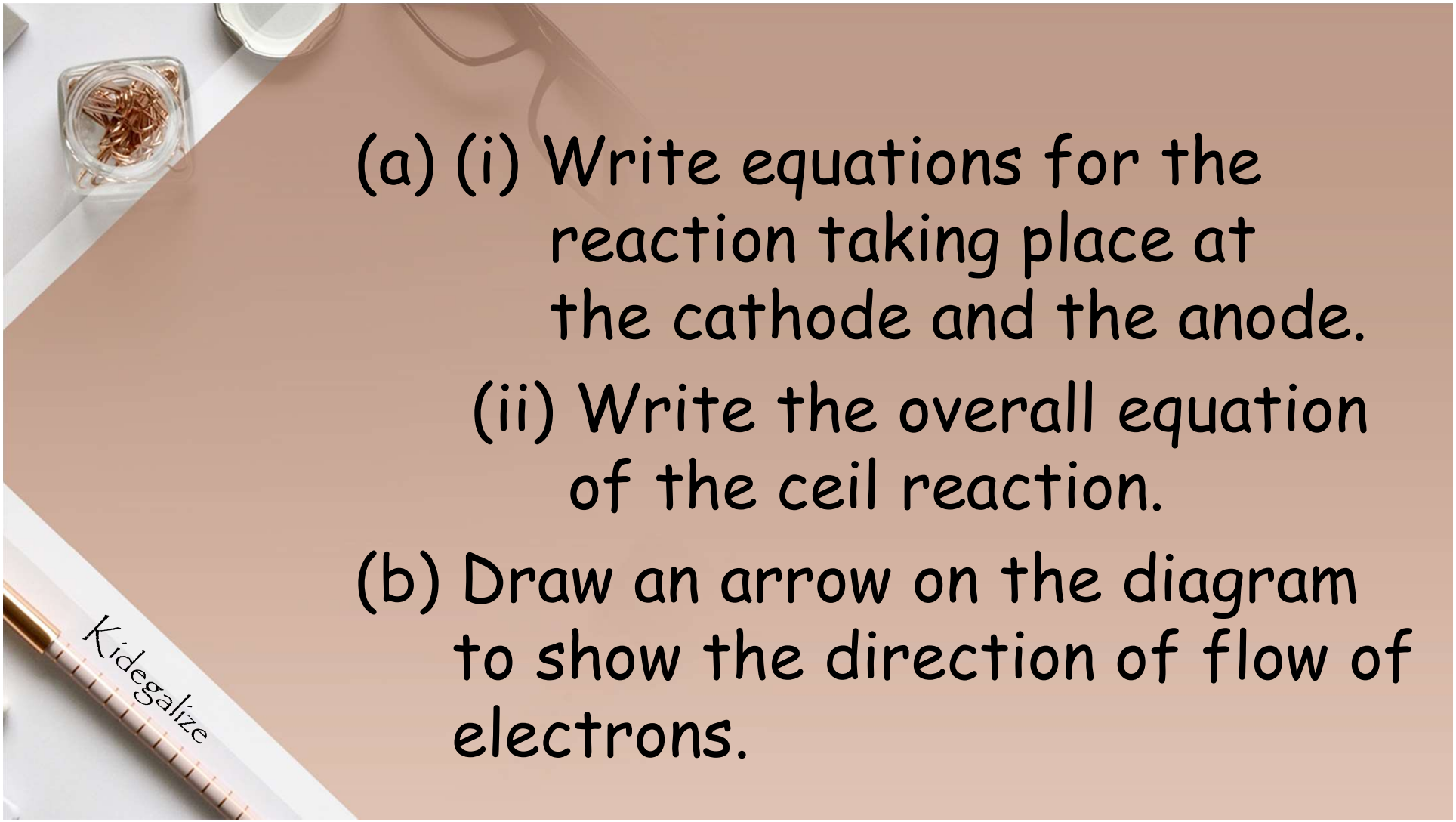


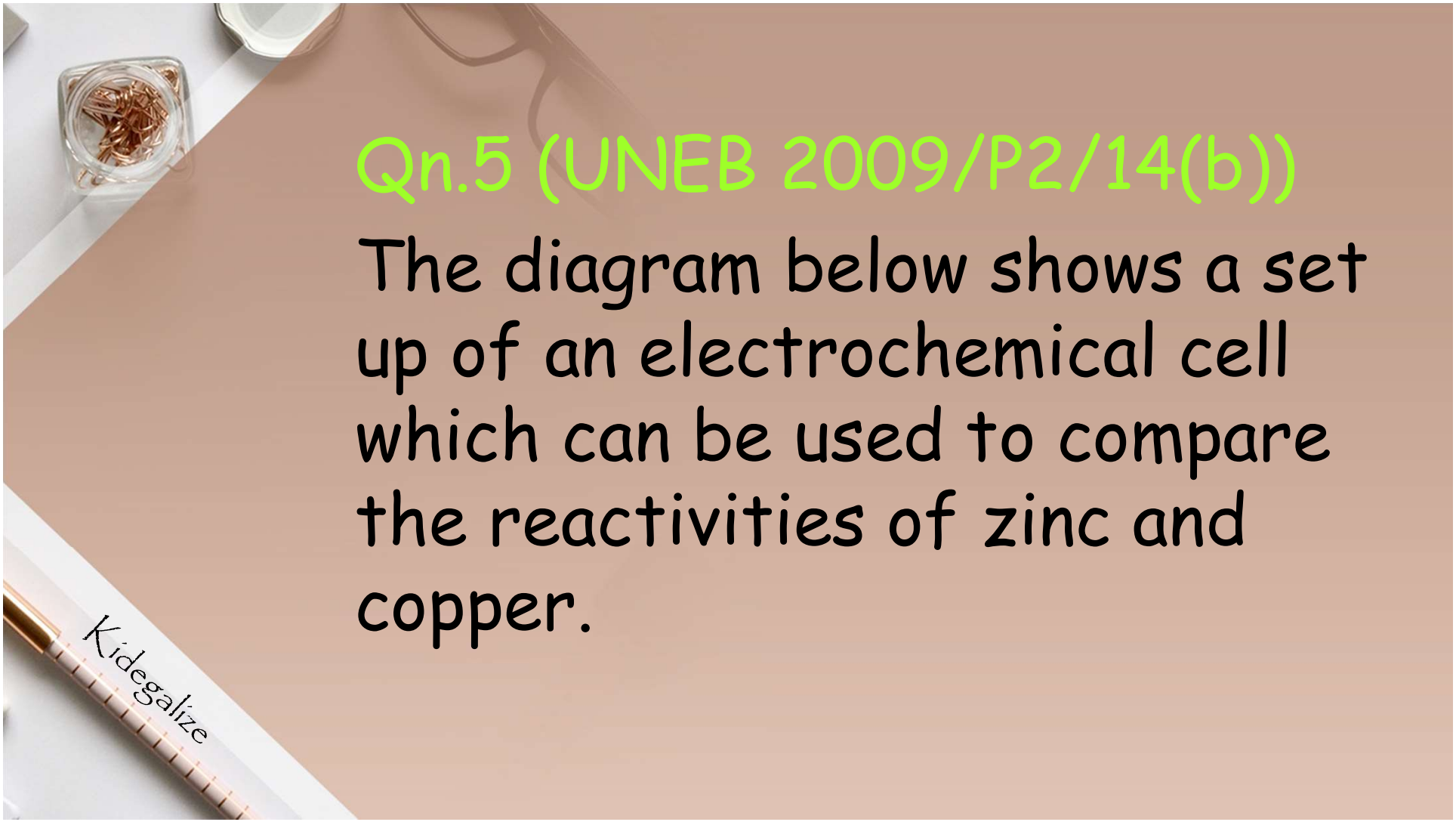
Fig 2



(a) (i) Write equations for the reaction taking place at the cathode and the anode.

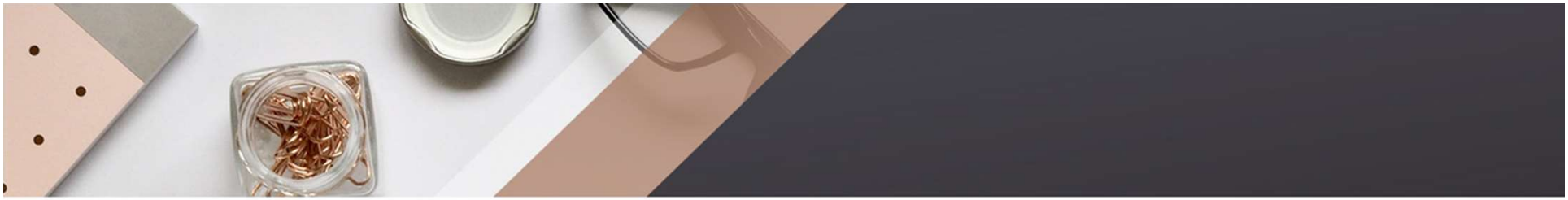
(ii) Write the overall equation of the ceil reaction.

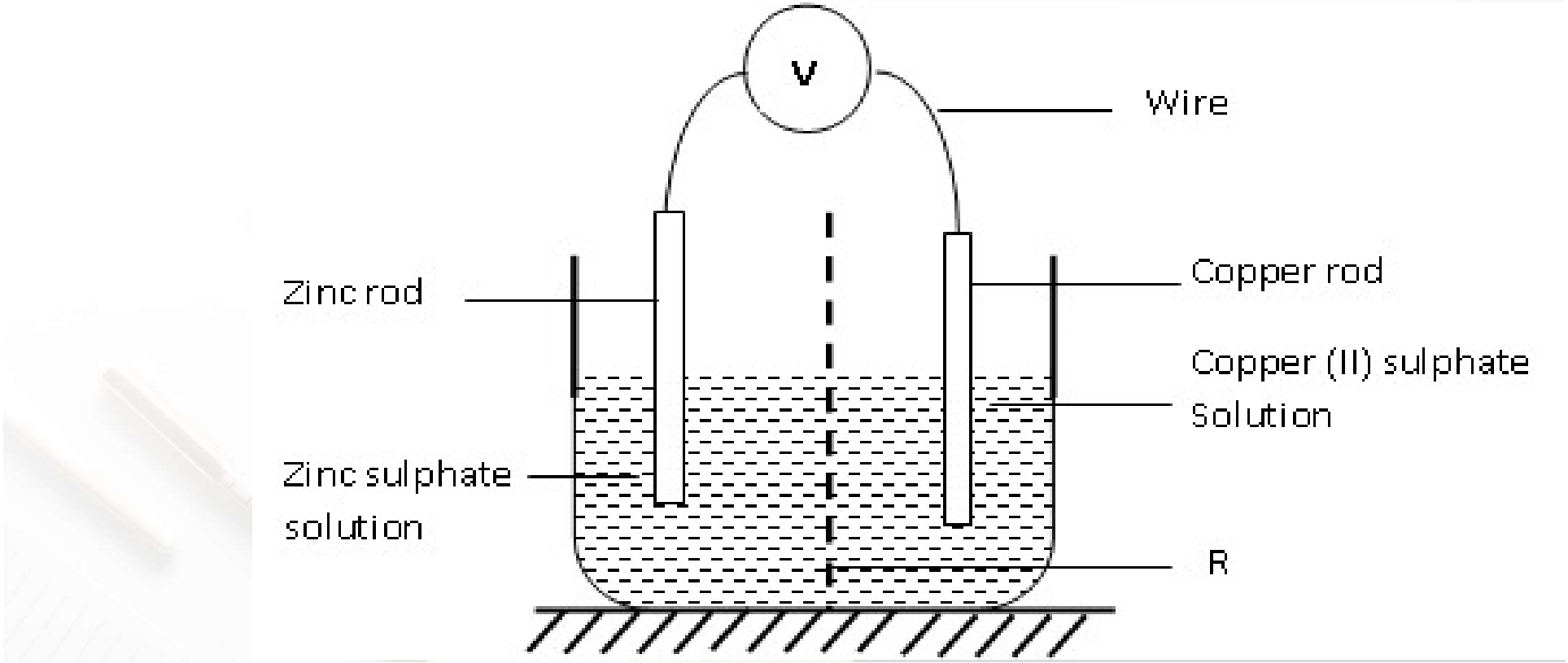
(b) Draw an arrow on the diagram to show the direction of flow of electrons.

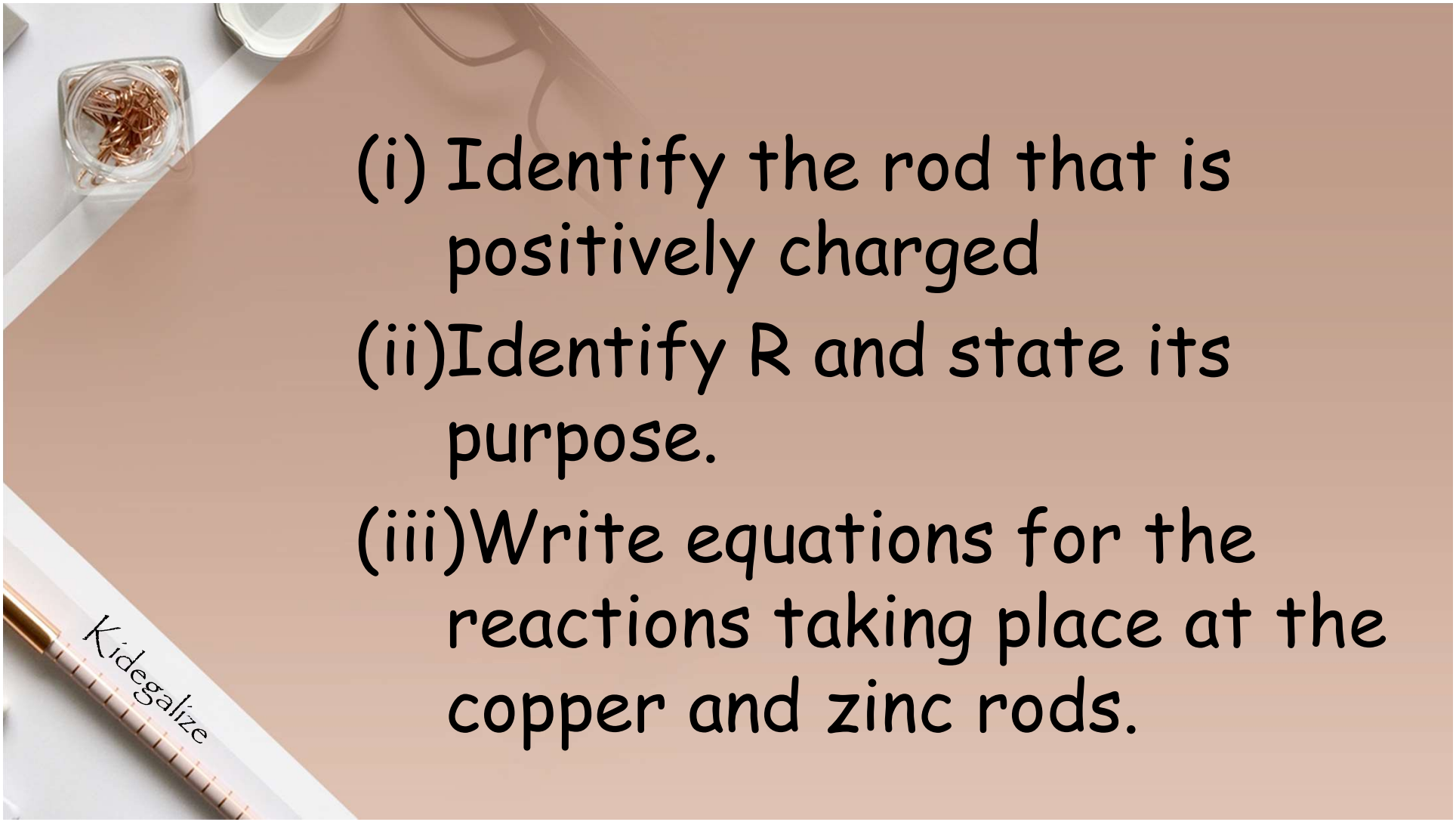


Qn.5 (UNEB 2009/P2/14(b))

The diagram below shows a set up of an electrochemical cell which can be used to compare the reactivities of zinc and copper.



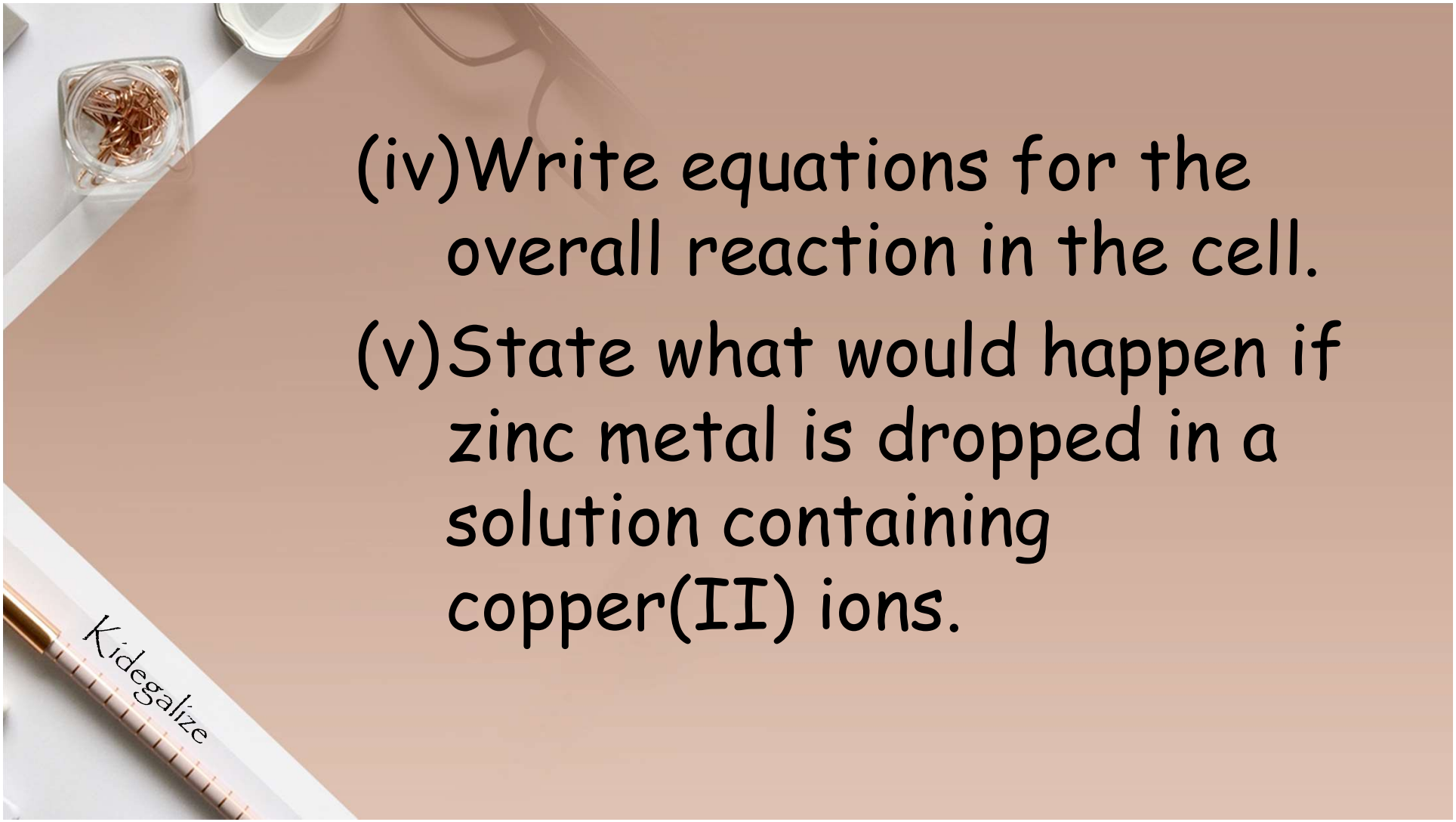

V
Wire
Zinc rod
Copper rod
Copper (II) sulphate
Solution
Zinc sulphate
solution
R



(i) Identify the rod that is positively charged

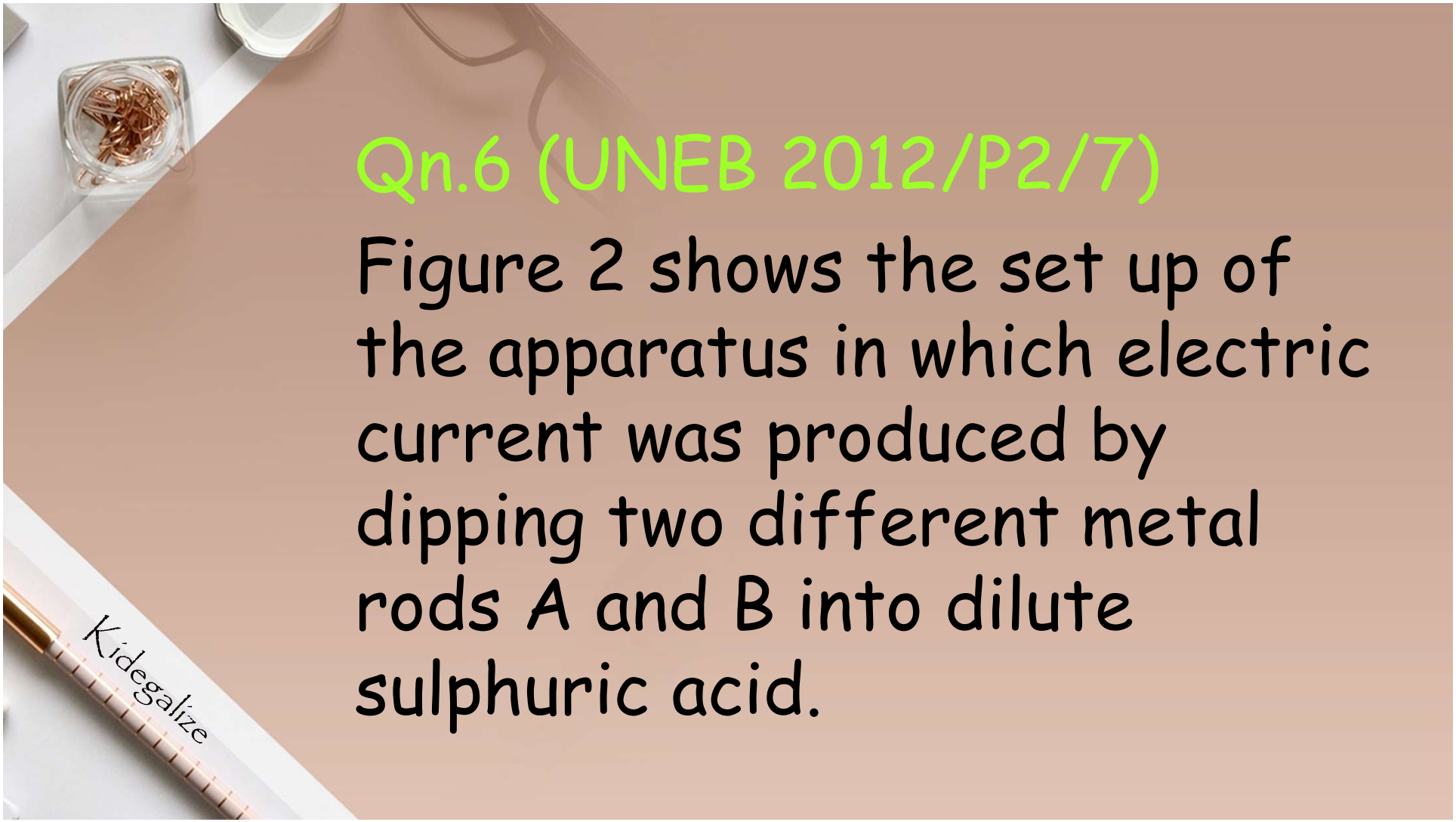
(ii) Identify R and state its purpose.

(iii) Write equations for the reactions taking place at the copper and zinc rods.



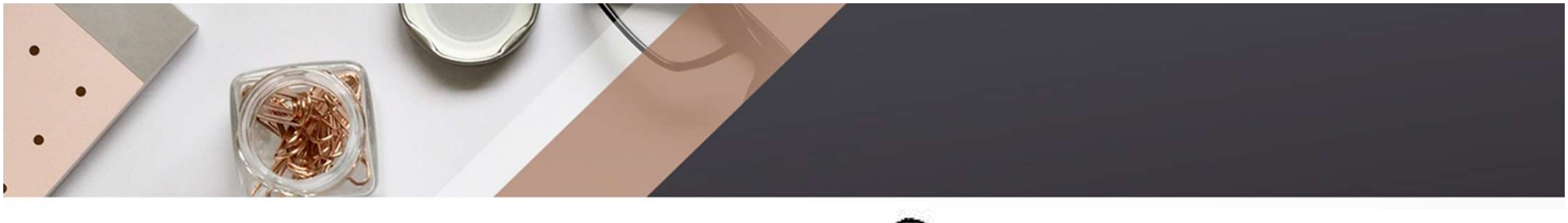
(iv) Write equations for the overall reaction in the cell.

(v) State what would happen if zinc metal is dropped in a solution containing copper(II) ions.



Qn.6 (UNEB 2012/P2/7)

Figure 2 shows the set up of the apparatus in which electric current was produced by dipping two different metal rods A and B into dilute sulphuric acid.



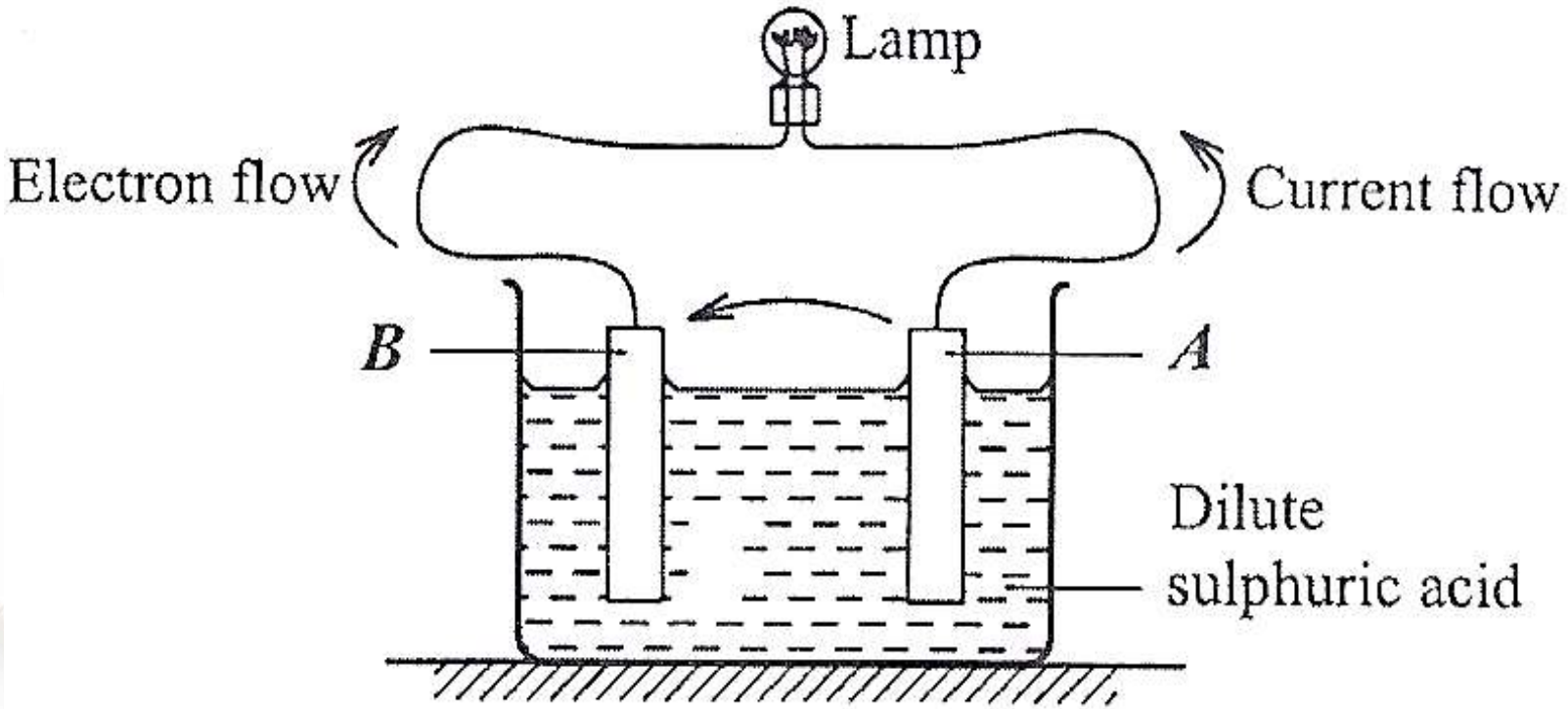
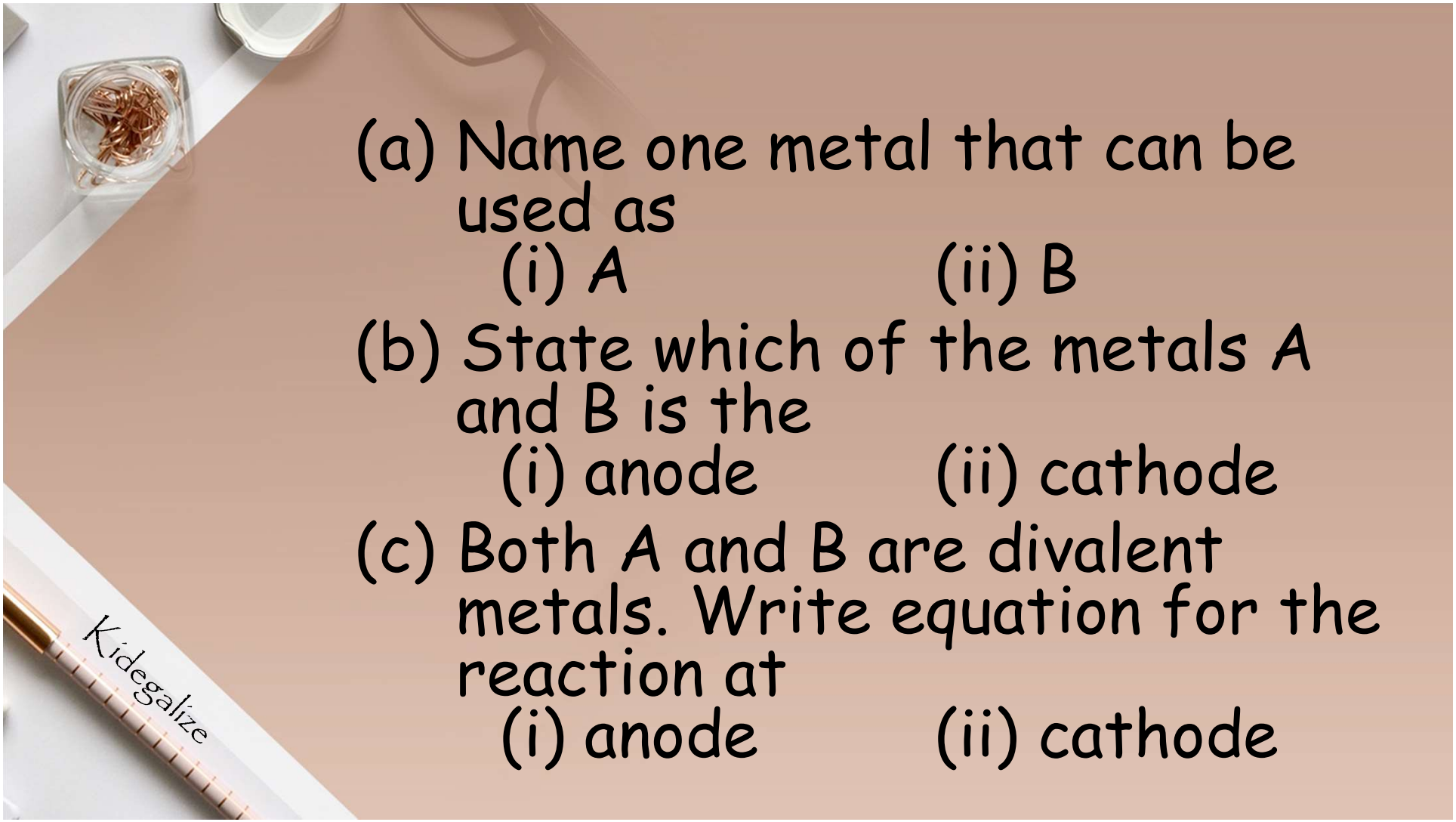


Fig. 2



(a) Name one metal that can be used as
(i) A (ii) B

(b) State which of the metals A and B is the
(i) anode (ii) cathode

(c) Both A and B are divalent metals. Write equation for the reaction at
(i) anode (ii) cathode

Extraction of metals

Metals are extracted from their ores.

An ore is a naturally occurring mineral from which a metal can be extracted.

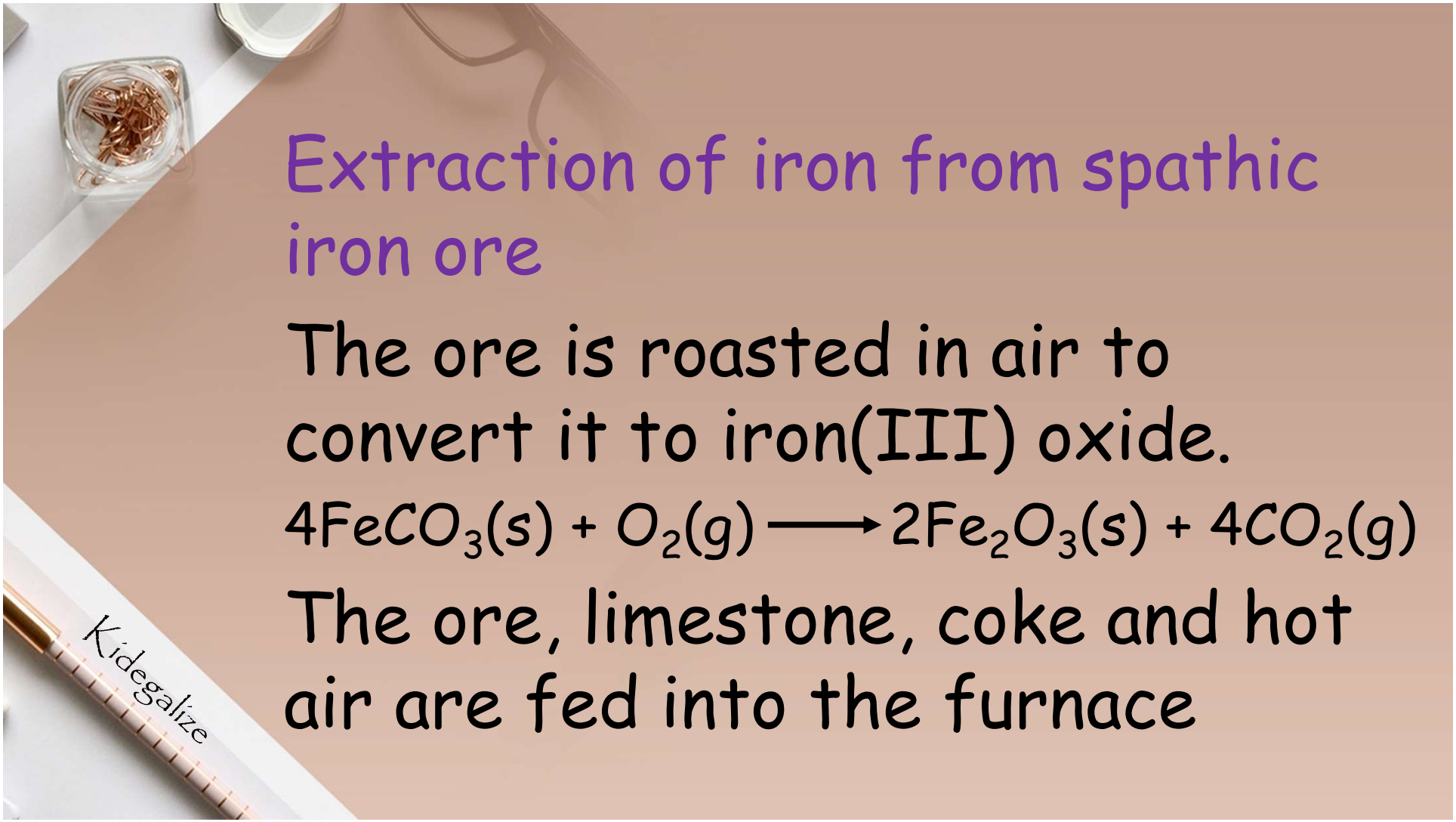
- Reactive metals like K, Na, Ca, Mg, Al are extracted by electrolysis.

- Less reactive metals like Zn, Fe, Pb are extracted from their ores by reduction using carbon.
- Unreactive metals like Cu, Ag, Hg are extracted by decomposition in the presence of oxygen.

Extraction of iron

The main ores of iron are:

- Haematite (iron(III) oxide), Fe_2O_3
- Magnetite (triiron tetraoxide), Fe_3O_4
- Spathic iron/siderite (iron(II) carbonate), $FeCO_3$



Extraction of iron from spathic iron ore

The ore is roasted in air to convert it to iron(III) oxide.

$$4FeCO_3(s) + O_2(g) \longrightarrow 2Fe_2O_3(s) + 4CO_2(g)$$

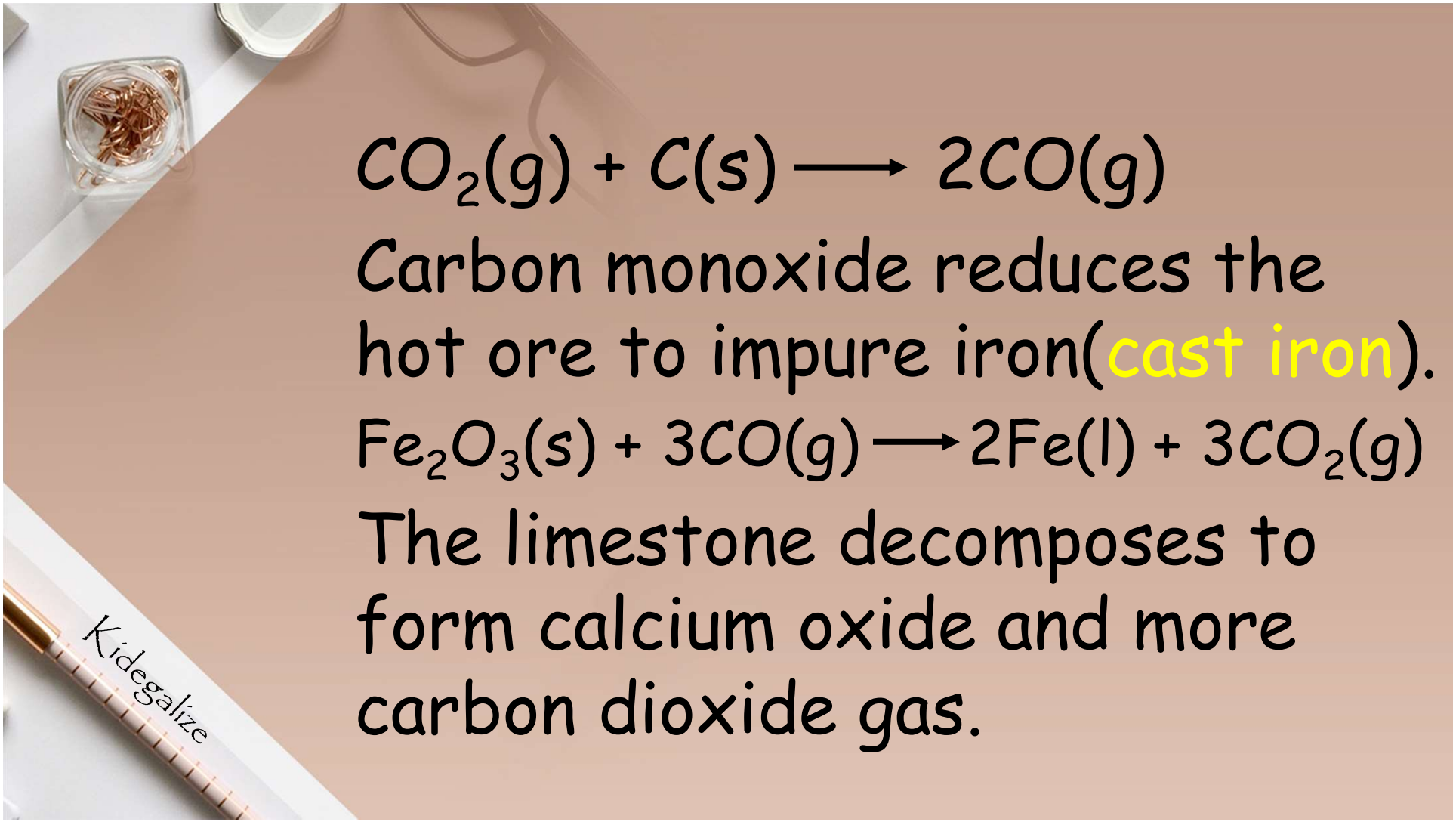
The ore, limestone, coke and hot air are fed into the furnace

from the top and bottom respectively.

Hot coke reacts with oxygen of air to form carbon dioxide gas.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

Carbon dioxide is then reduced by more coke to form carbon monoxide gas.

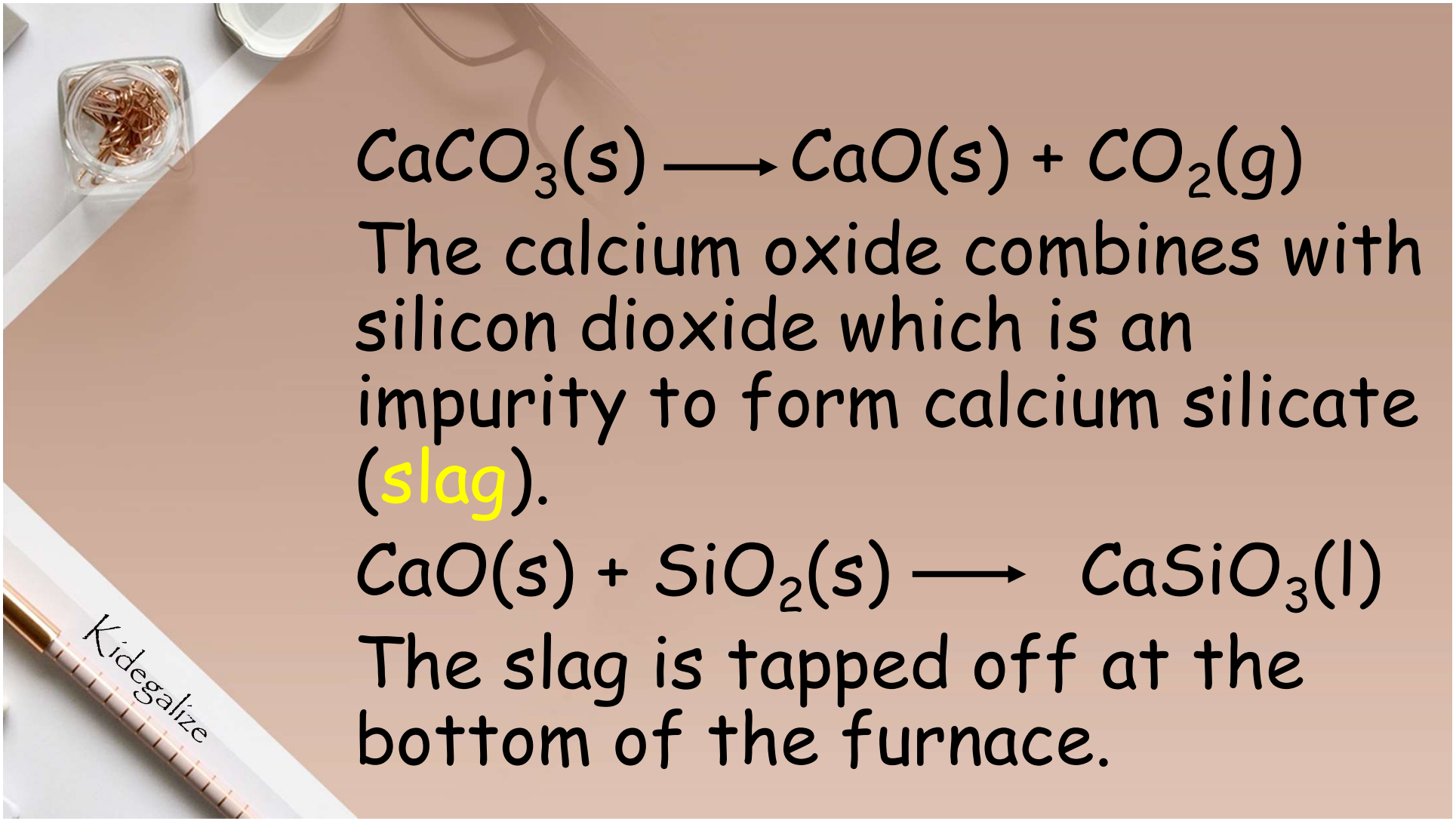


$CO_2(g) + C(s) \longrightarrow 2CO(g)$

Carbon monoxide reduces the hot ore to impure iron(cast iron).

$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(l) + 3CO_2(g)$

The limestone decomposes to form calcium oxide and more carbon dioxide gas.

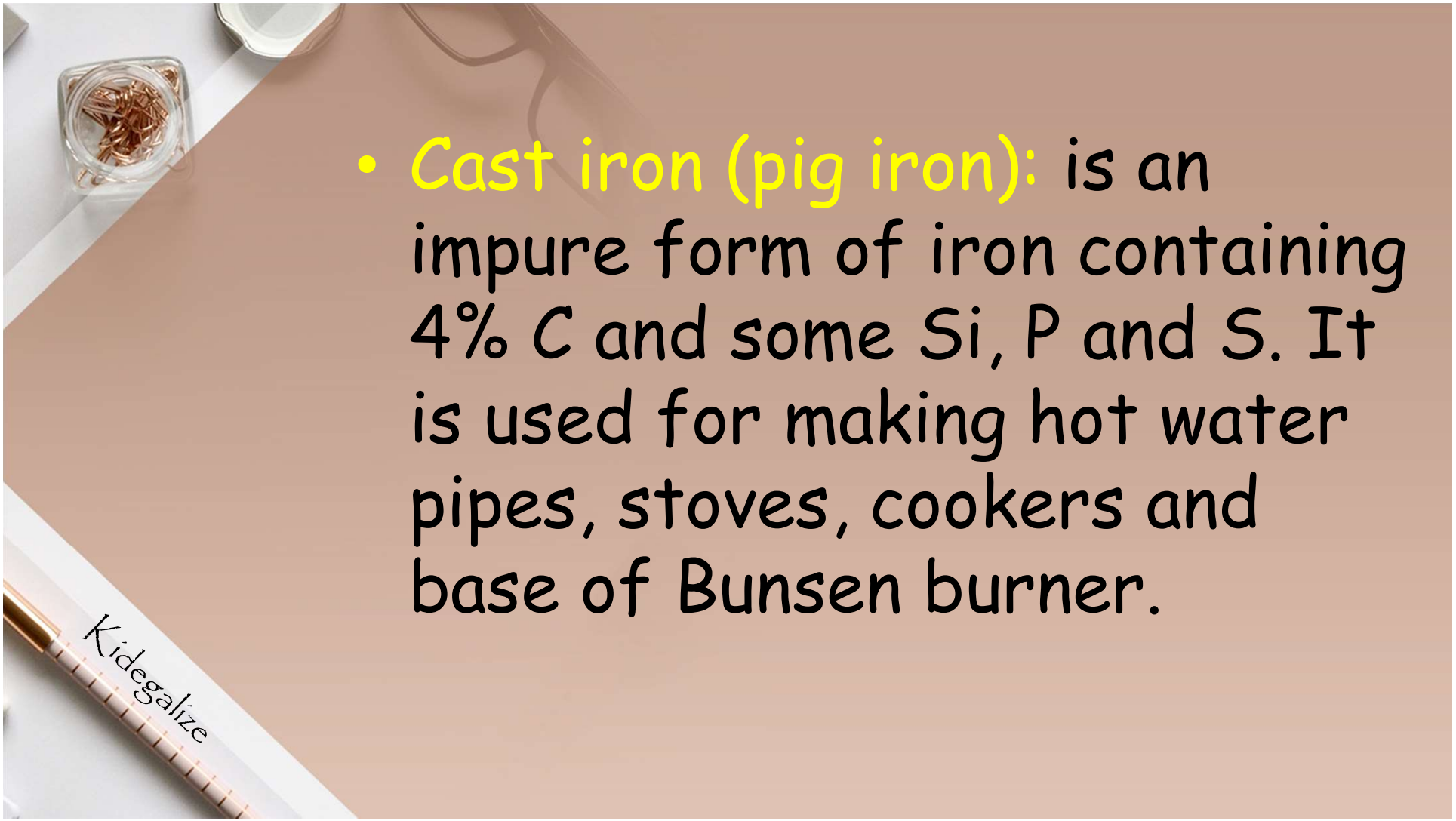


$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$

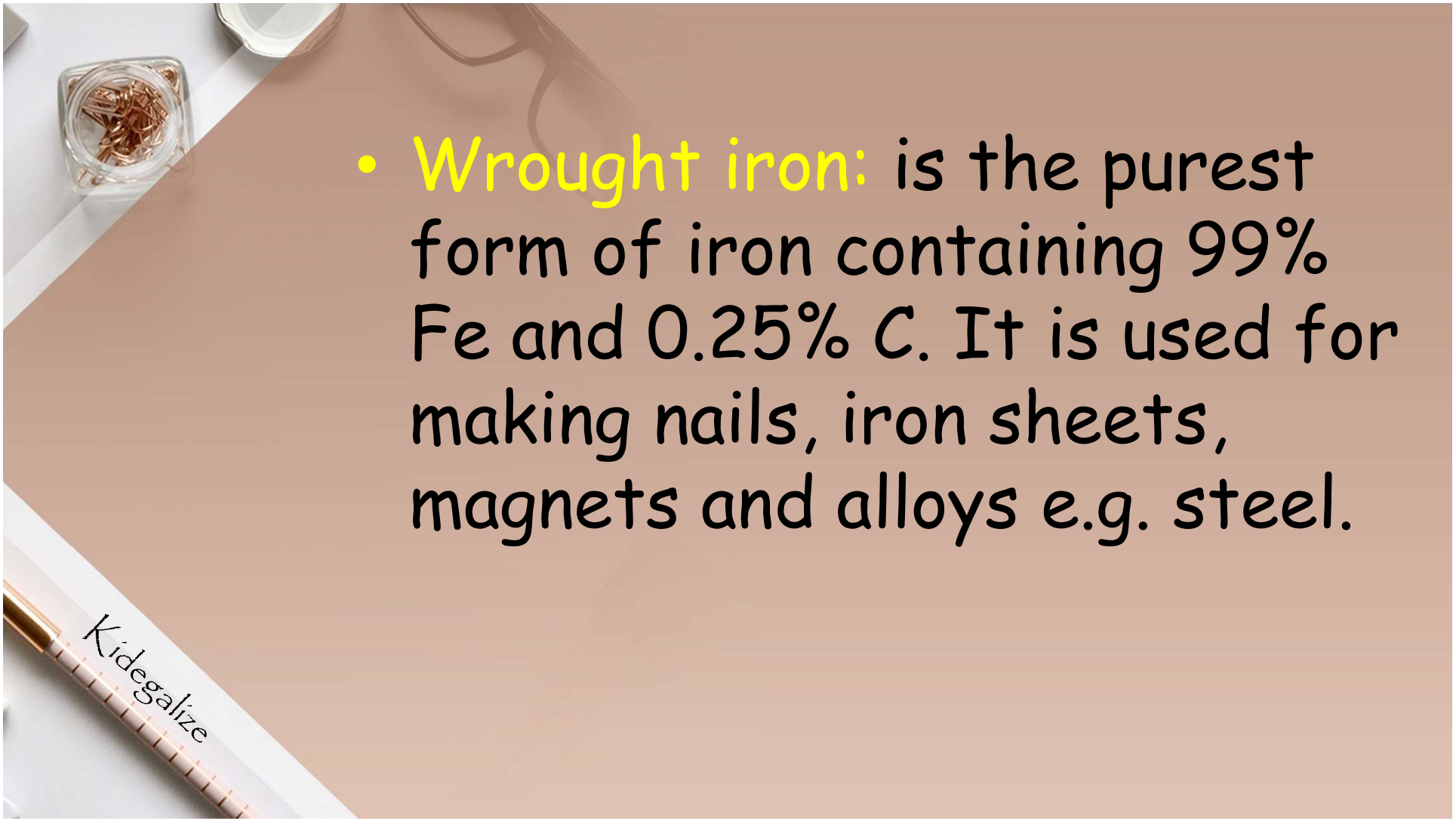
The calcium oxide combines with silicon dioxide which is an impurity to form calcium silicate (slag).

$CaO(s) + SiO_2(s) \longrightarrow CaSiO_3(l)$

The slag is tapped off at the bottom of the furnace.



- Cast iron (pig iron): is an impure form of iron containing 4% C and some Si, P and S. It is used for making hot water pipes, stoves, cookers and base of Bunsen burner.



- Wrought iron: is the purest form of iron containing 99% Fe and 0.25% C. It is used for making nails, iron sheets, magnets and alloys e.g. steel.

Knowledge Check 6

Qn.1 (UNEB 2001/P1/4)

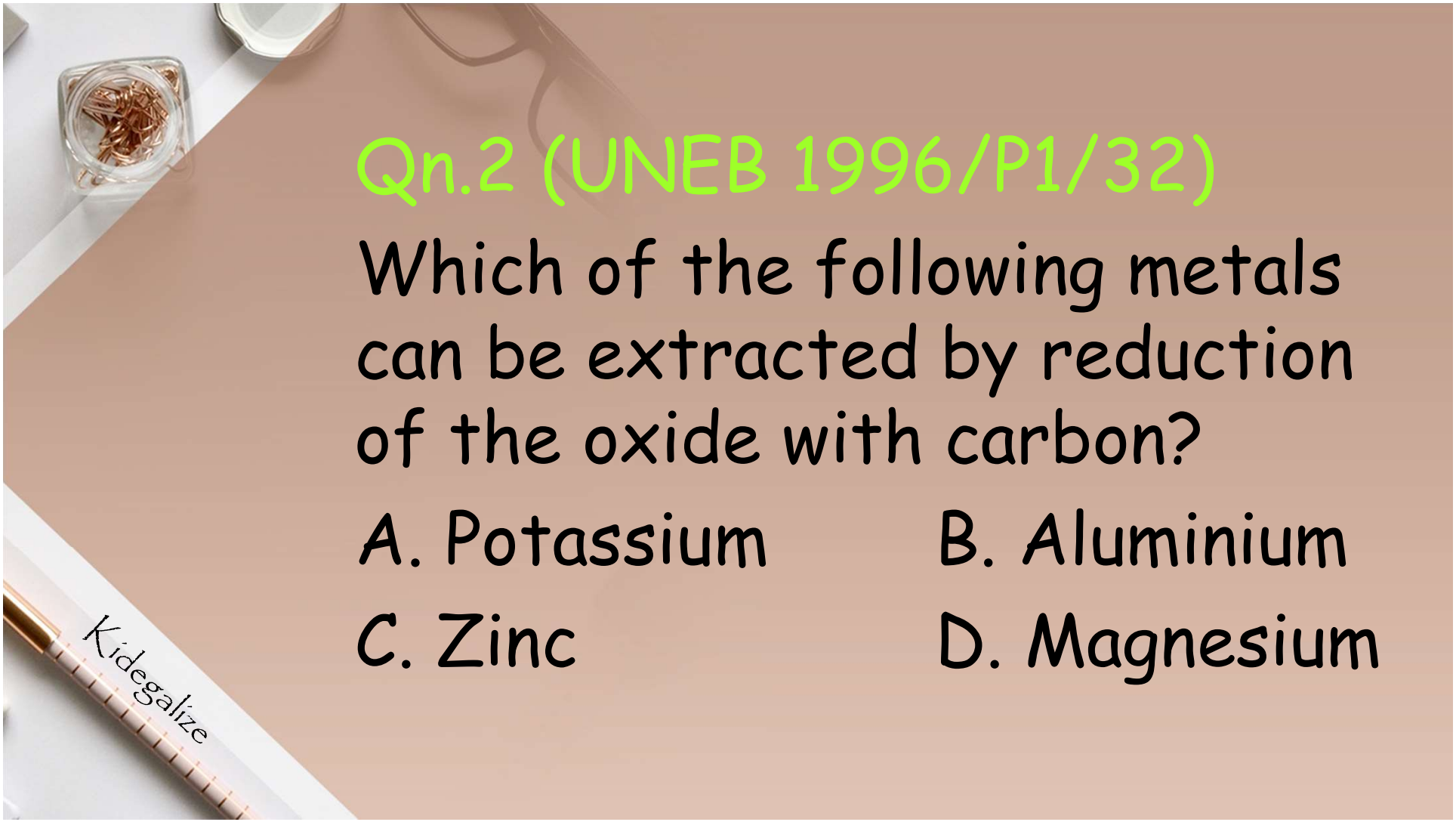
The role of coke in the extraction of iron in the blast furnace is to

A. produce carbon monoxide which reduces the oxides.

B. produce quick lime which combines with silica.

C. combine with iron to form steel.

D. reduce excessive heat produced in the furnace.



Qn.2 (UNEB 1996/P1/32)

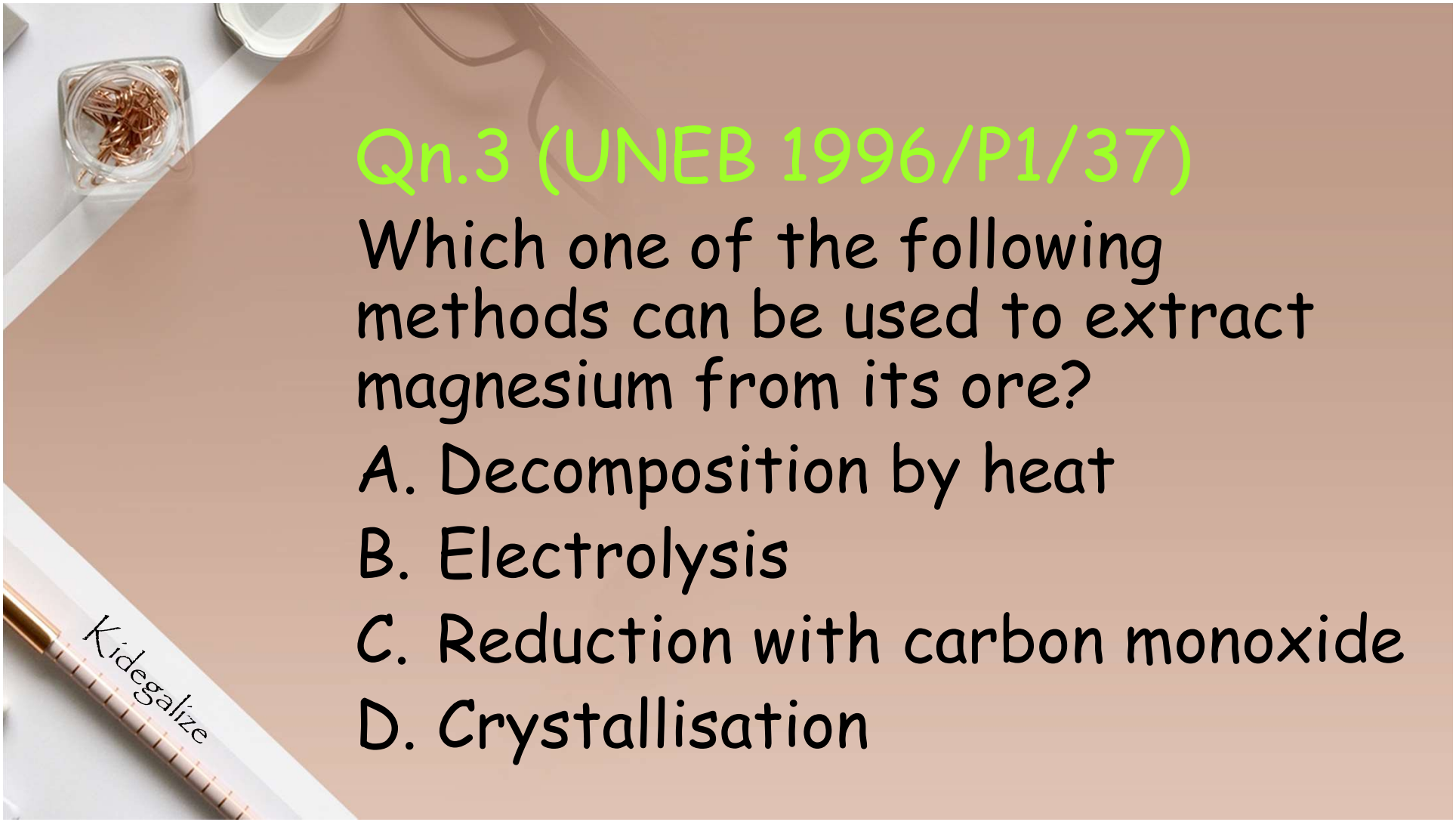
Which of the following metals can be extracted by reduction of the oxide with carbon?

A. Potassium

B. Aluminium

C. Zinc

D. Magnesium



Qn.3 (UNEB 1996/P1/37)

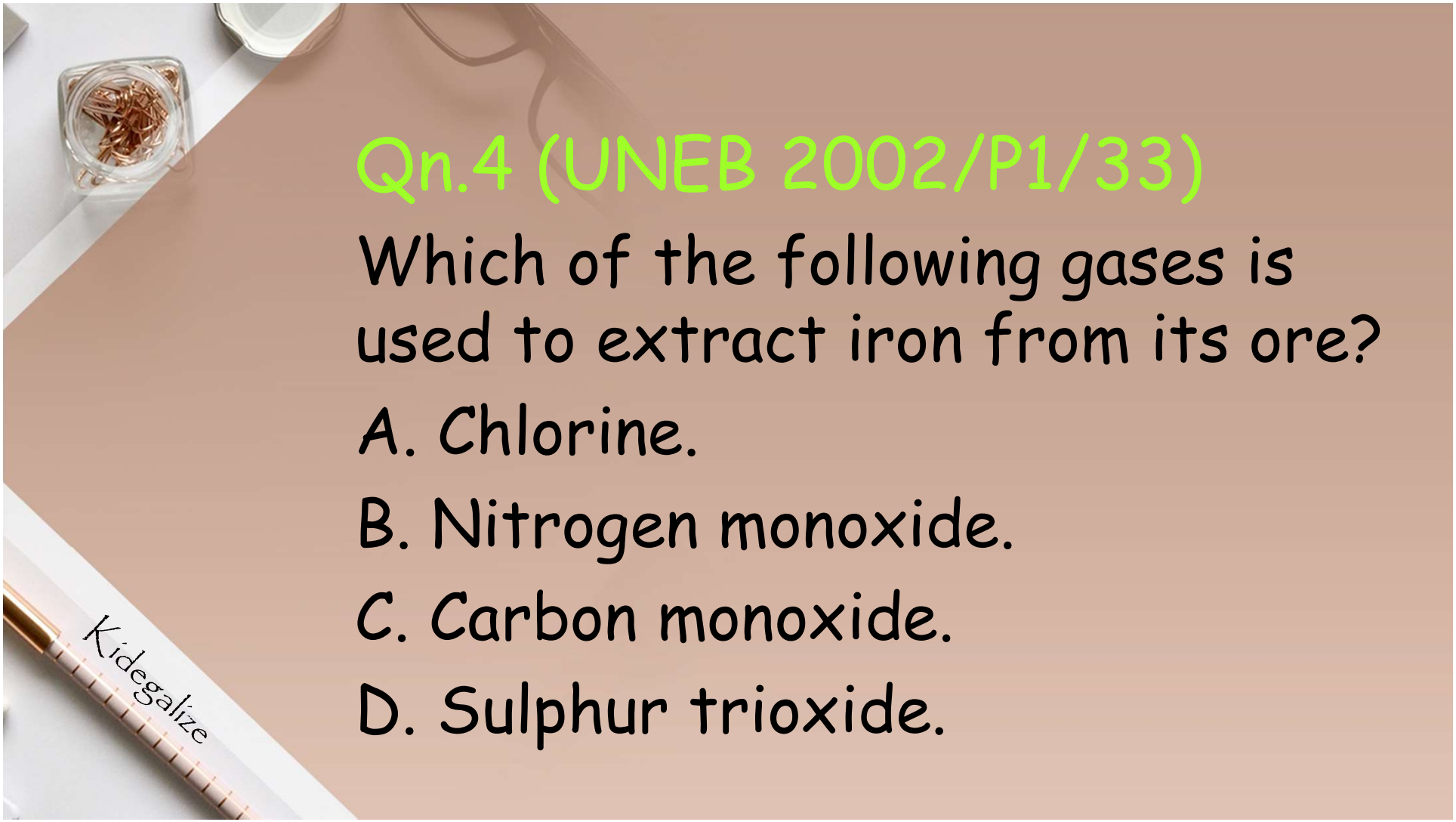
Which one of the following methods can be used to extract magnesium from its ore?

A. Decomposition by heat

B. Electrolysis

C. Reduction with carbon monoxide

D. Crystallisation



Qn.4 (UNEB 2002/P1/33)

Which of the following gases is used to extract iron from its ore?

A. Chlorine.

B. Nitrogen monoxide.

C. Carbon monoxide.

D. Sulphur trioxide.

Qn.5 (UNEB 2013/P1/6)

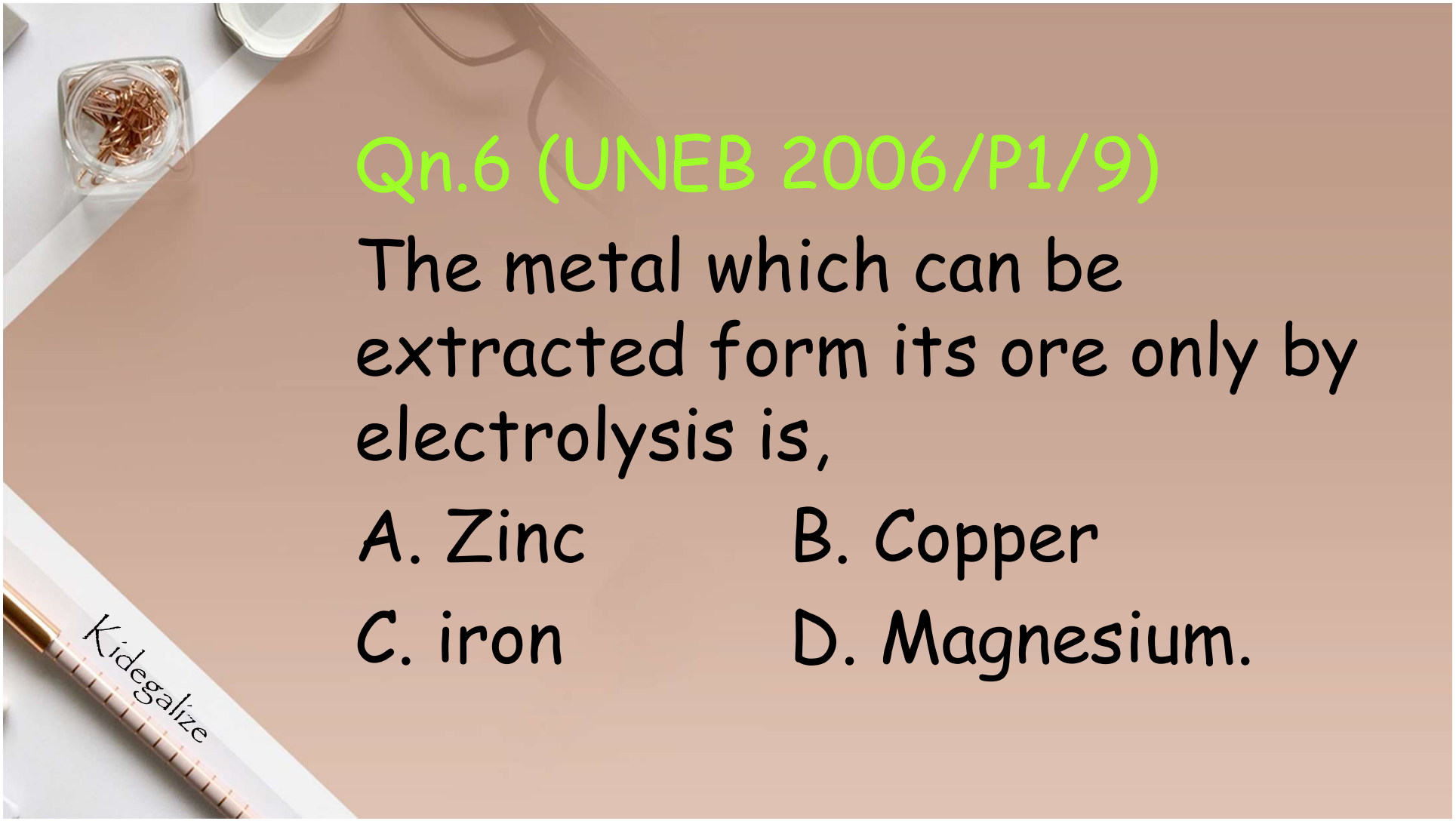
Which one of the following substances is not used in the extraction of iron ?

A. Coke

B. Air

C. Silica

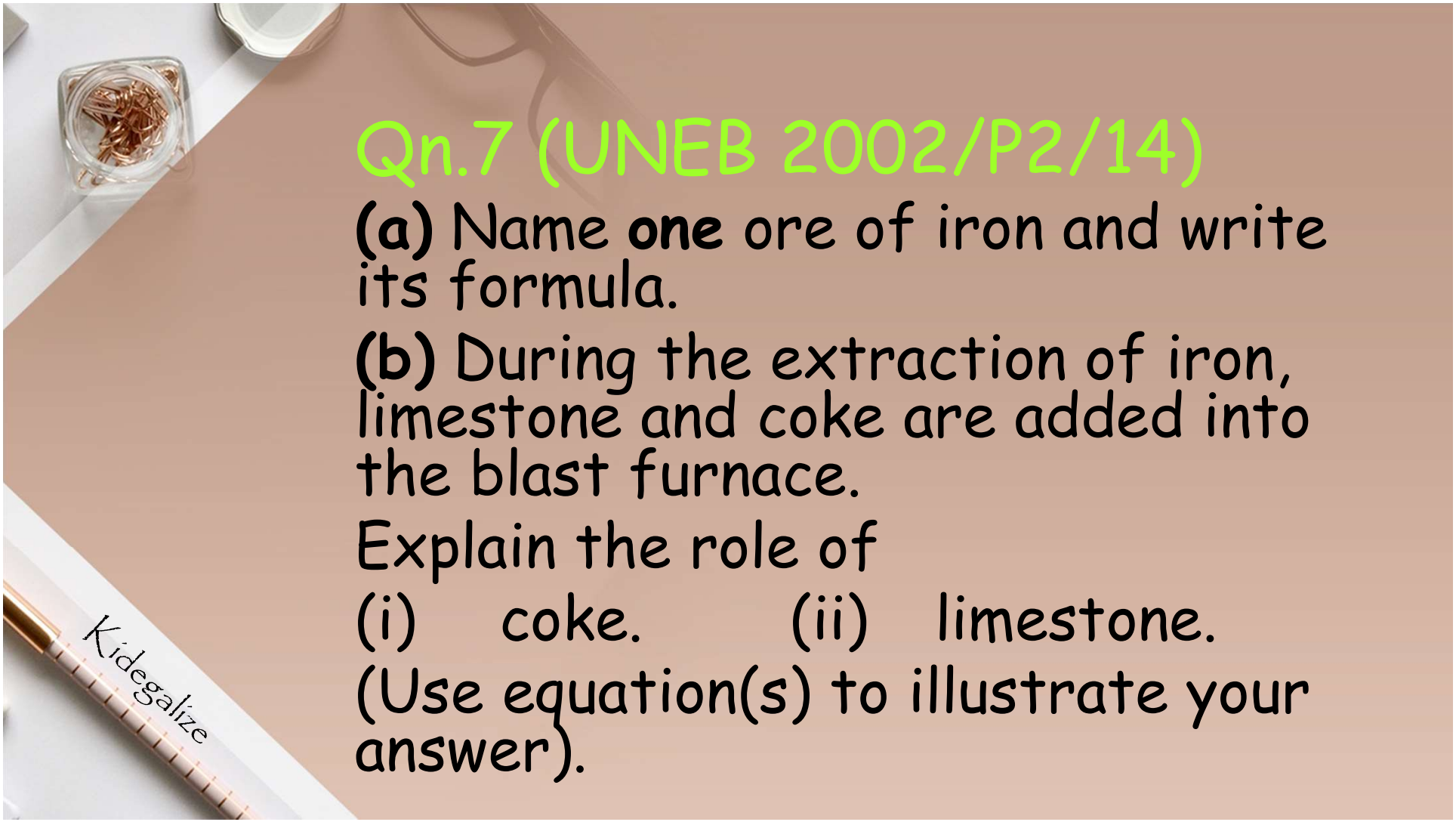
D. Limestone



Qn.6 (UNEB 2006/P1/9)

The metal which can be extracted form its ore only by electrolysis is,

A. Zinc
B. Copper
C. iron
D. Magnesium.



Qn.7 (UNEB 2002/P2/14)

(a) Name **one** ore of iron and write its formula.

(b) During the extraction of iron, limestone and coke are added into the blast furnace.

Explain the role of

(i) coke. (ii) limestone.

(Use equation(s) to illustrate your answer).

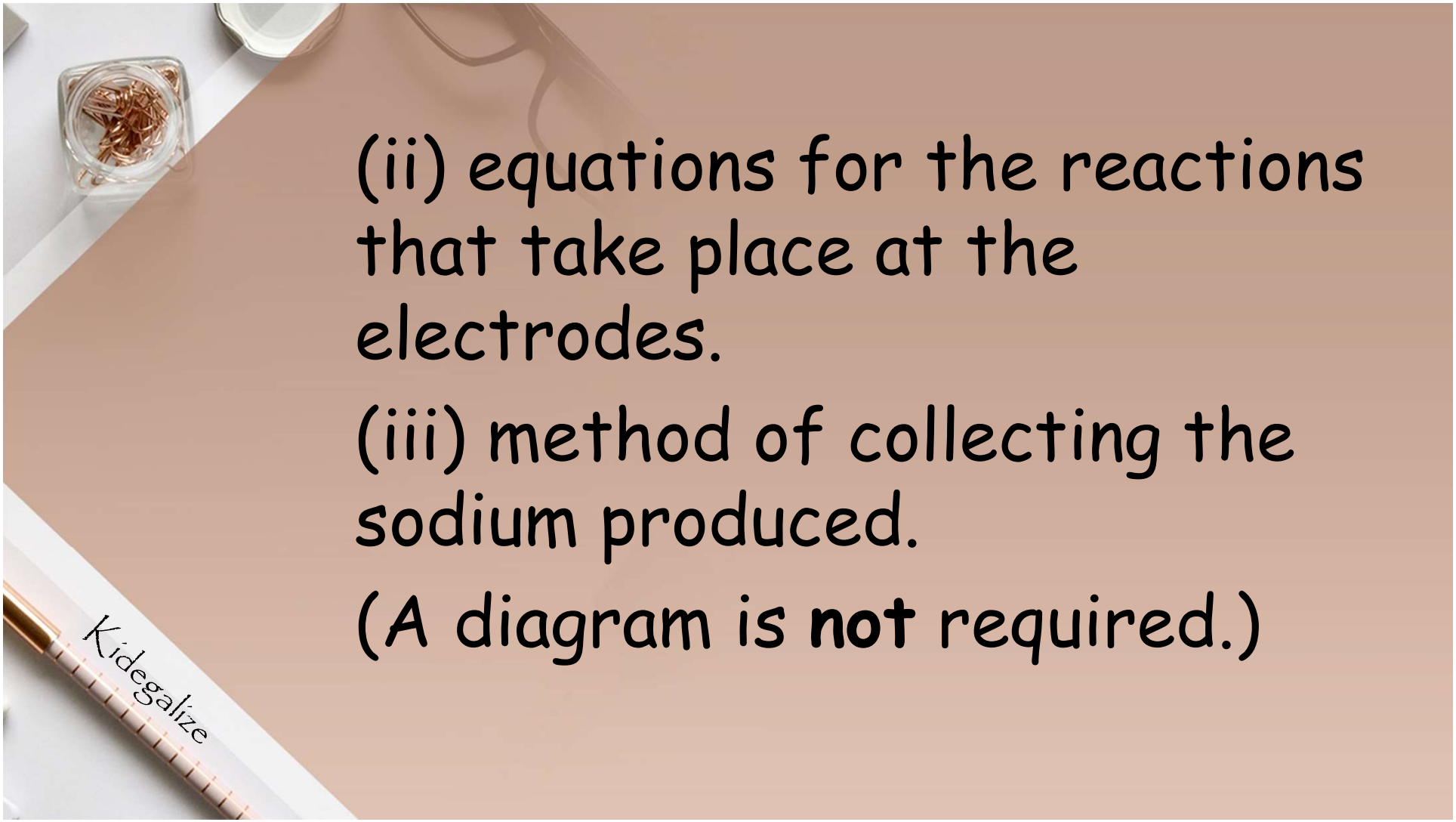
Qn.8 (UNEB 1995/P2/14)

(a) Name one ore from which sodium can be extracted.

(b) Describe how sodium is extracted from the ore you have named in (a).

Your answer should include the following:

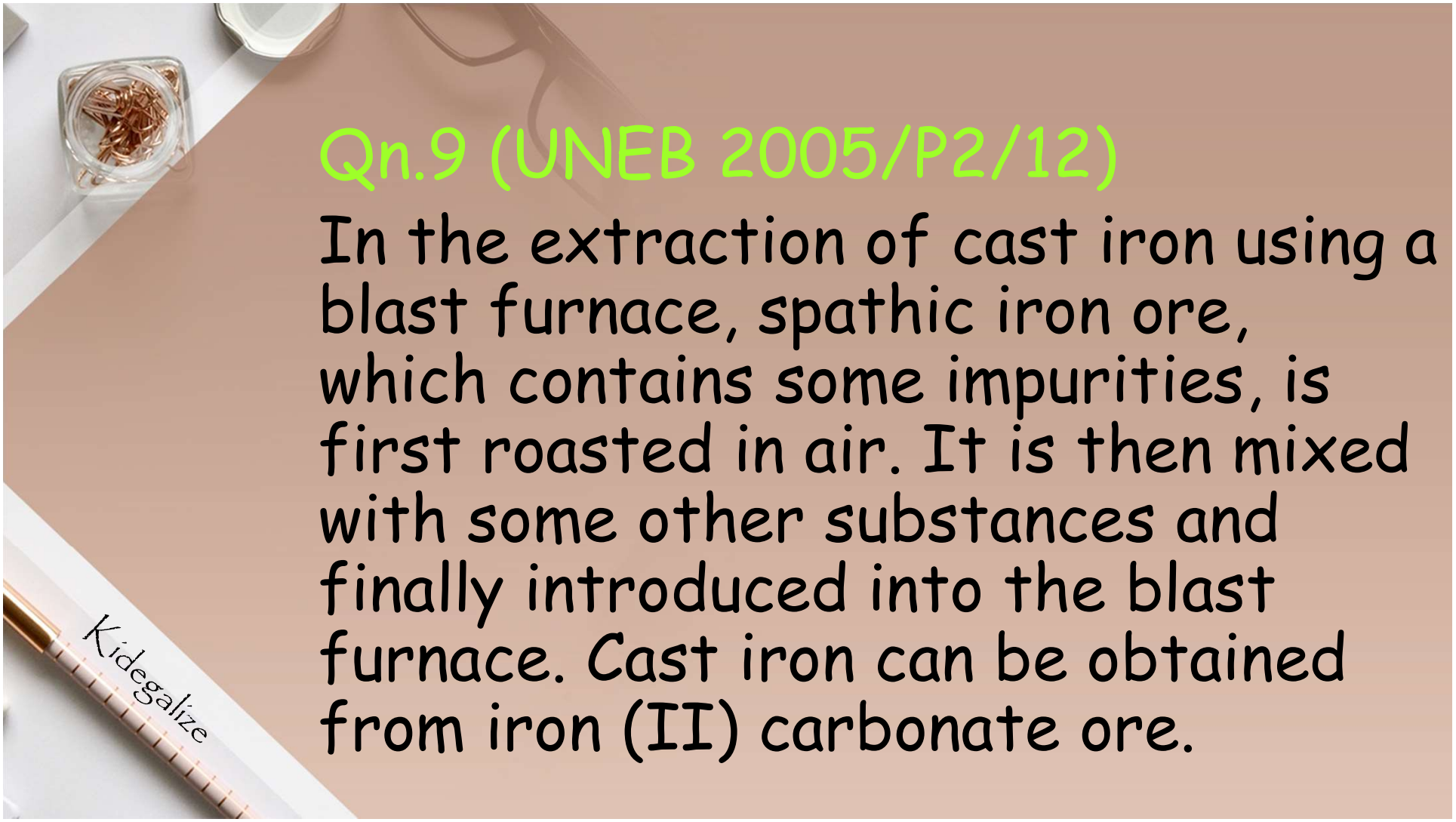
(i) names of the materials used as the electrodes.



(ii) equations for the reactions that take place at the electrodes.

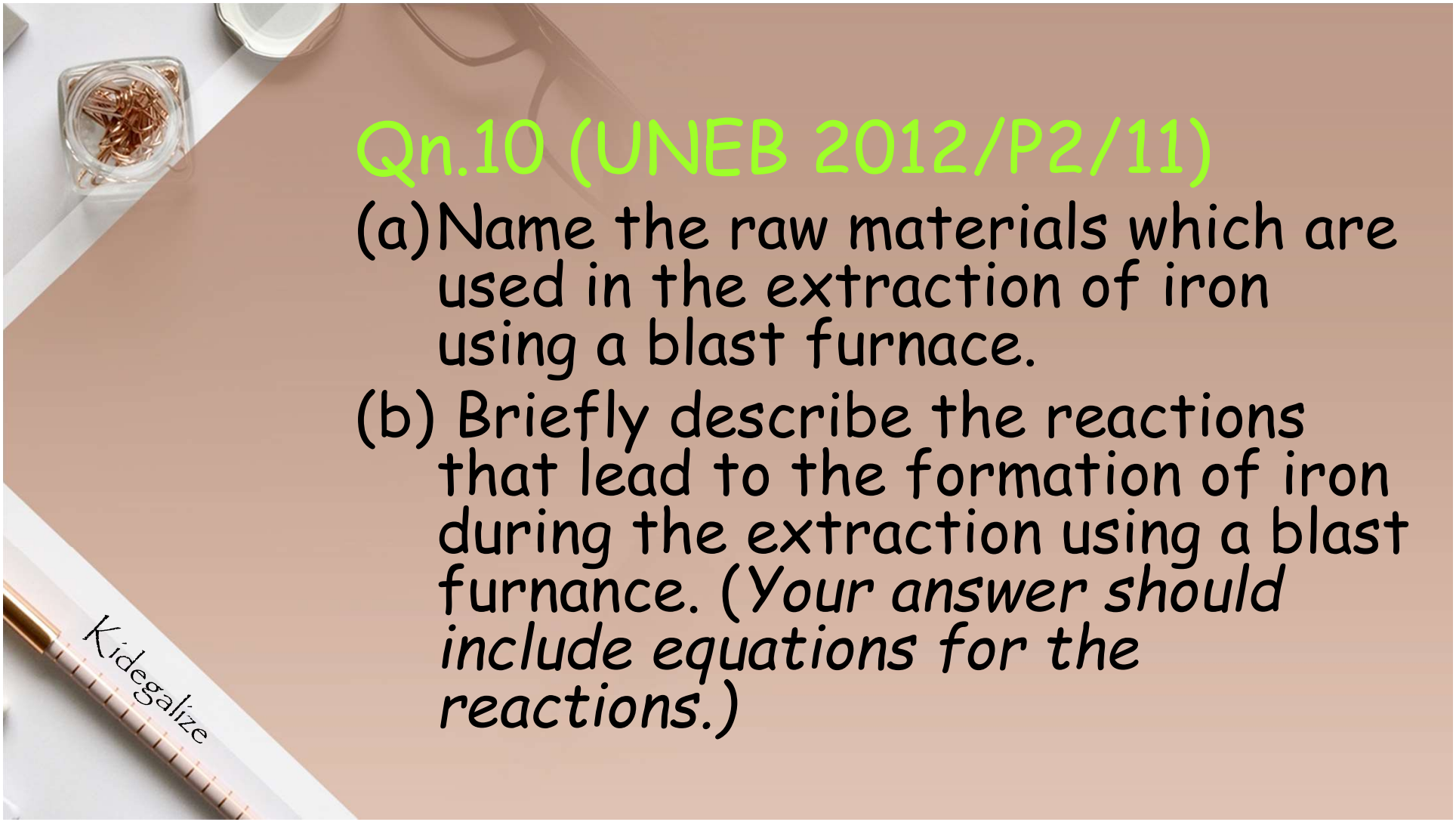
(iii) method of collecting the sodium produced.

(A diagram is **not** required.)



Qn.9 (UNEB 2005/P2/12)

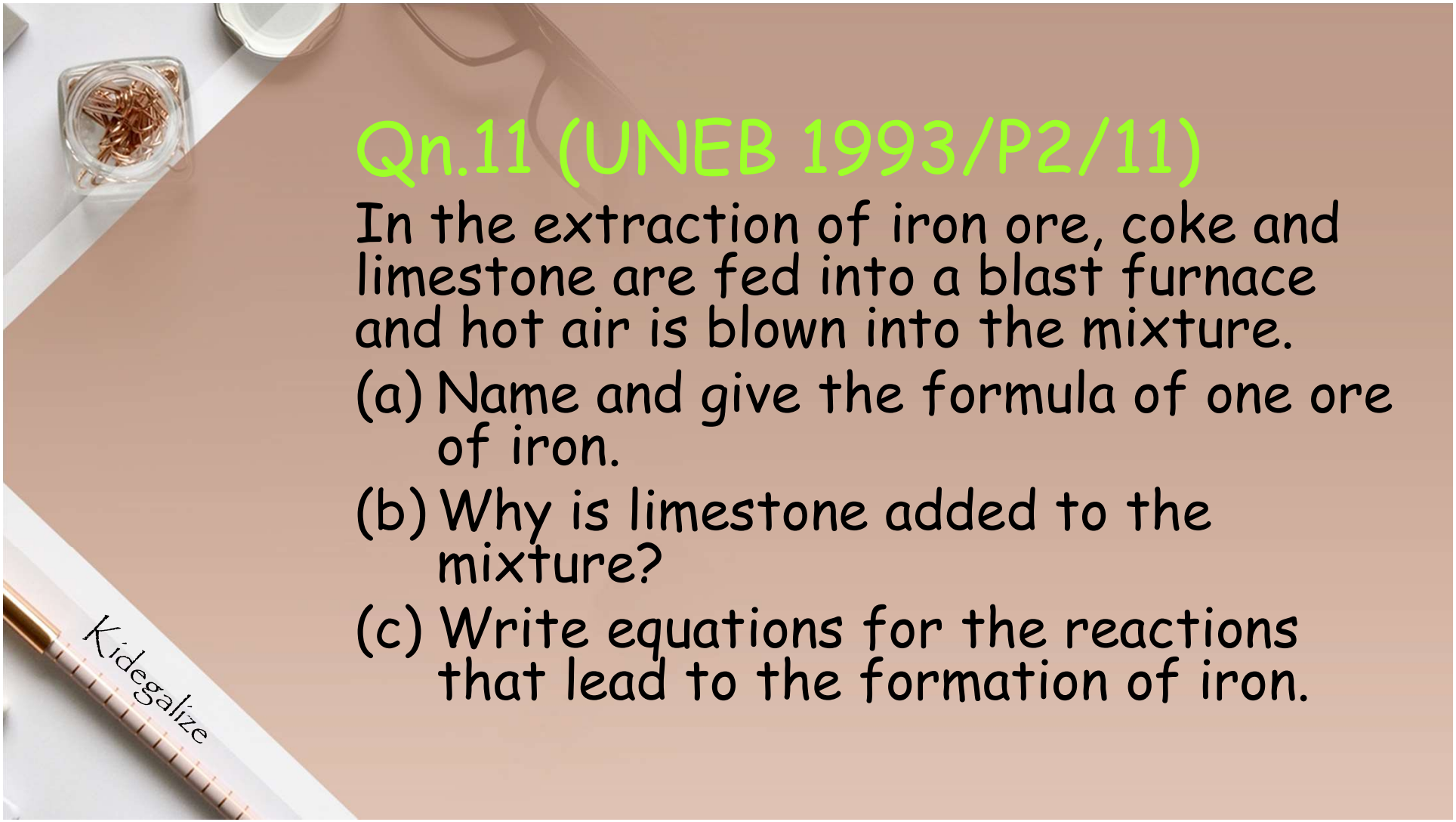
In the extraction of cast iron using a blast furnace, spathic iron ore, which contains some impurities, is first roasted in air. It is then mixed with some other substances and finally introduced into the blast furnace. Cast iron can be obtained from iron (II) carbonate ore.



Qn.10 (UNEB 2012/P2/11)

(a) Name the raw materials which are used in the extraction of iron using a blast furnace.

(b) Briefly describe the reactions that lead to the formation of iron during the extraction using a blast furnance. (*Your answer should include equations for the reactions.*)



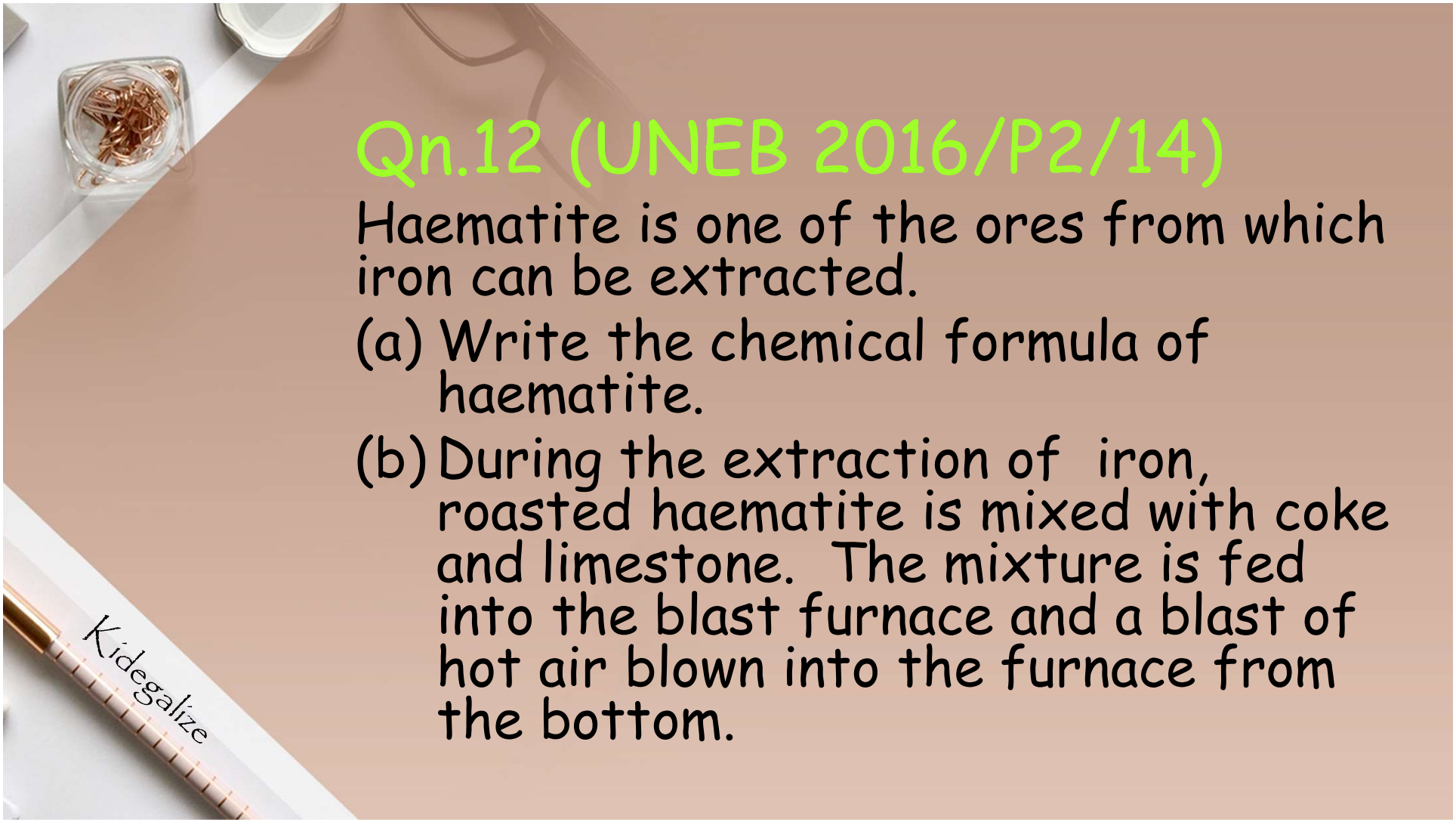
Qn.11 (UNEB 1993/P2/11)

In the extraction of iron ore, coke and limestone are fed into a blast furnace and hot air is blown into the mixture.

(a) Name and give the formula of one ore of iron.

(b) Why is limestone added to the mixture?

(c) Write equations for the reactions that lead to the formation of iron.

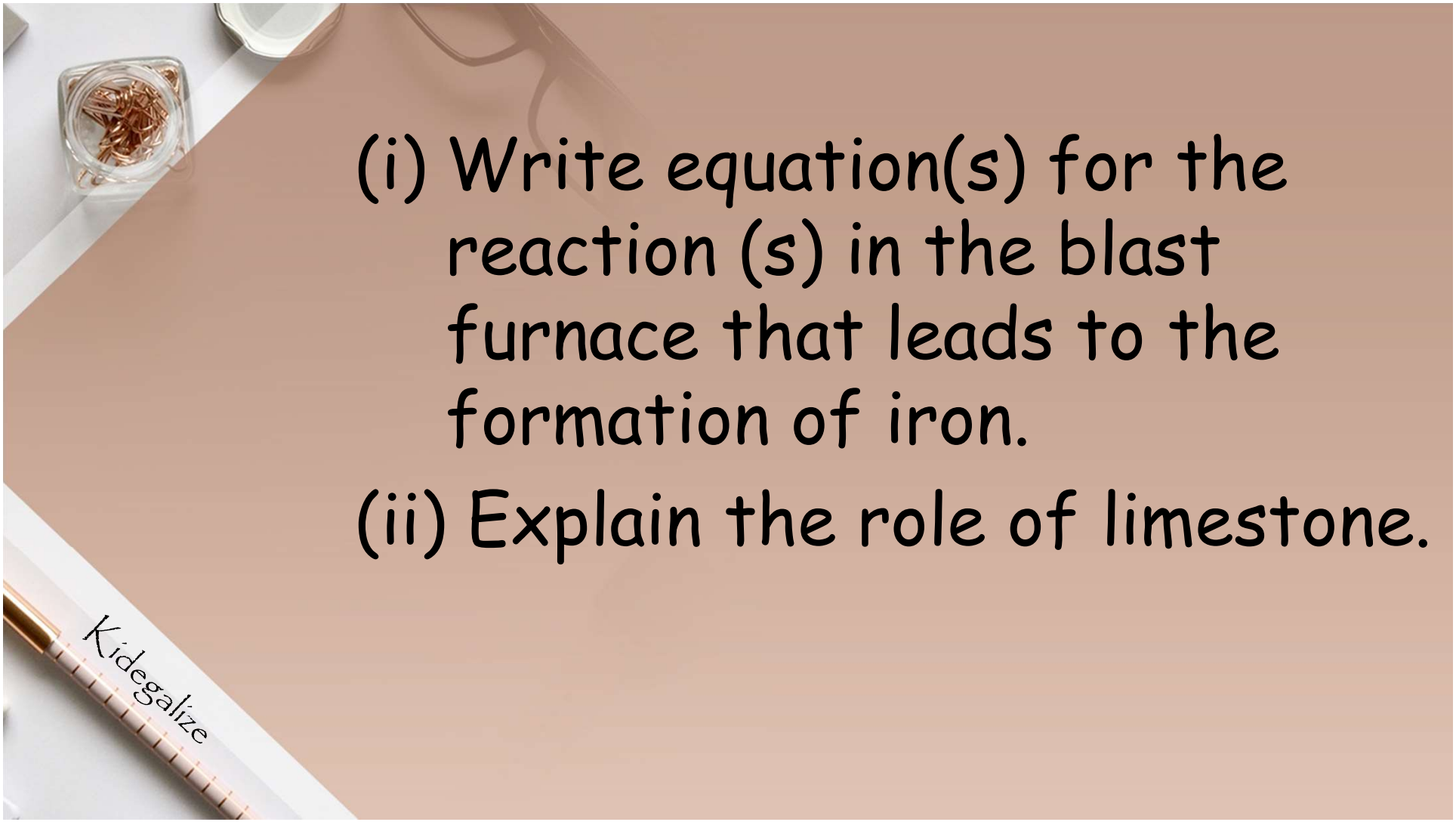


Qn.12 (UNEB 2016/P2/14)

Haematite is one of the ores from which iron can be extracted.

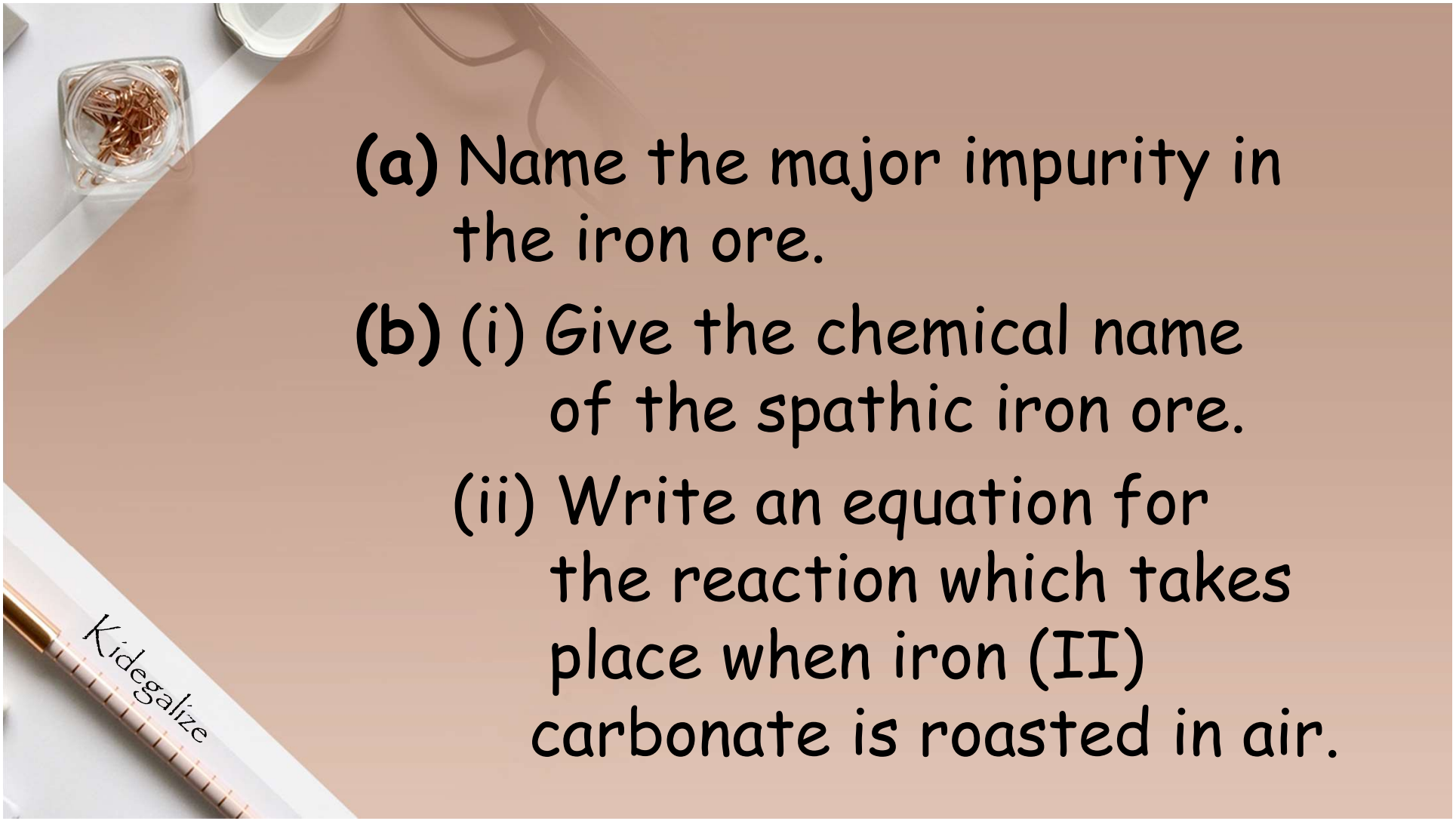
(a) Write the chemical formula of haematite.

(b) During the extraction of iron, roasted haematite is mixed with coke and limestone. The mixture is fed into the blast furnace and a blast of hot air blown into the furnace from the bottom.



(i) Write equation(s) for the reaction (s) in the blast furnace that leads to the formation of iron.

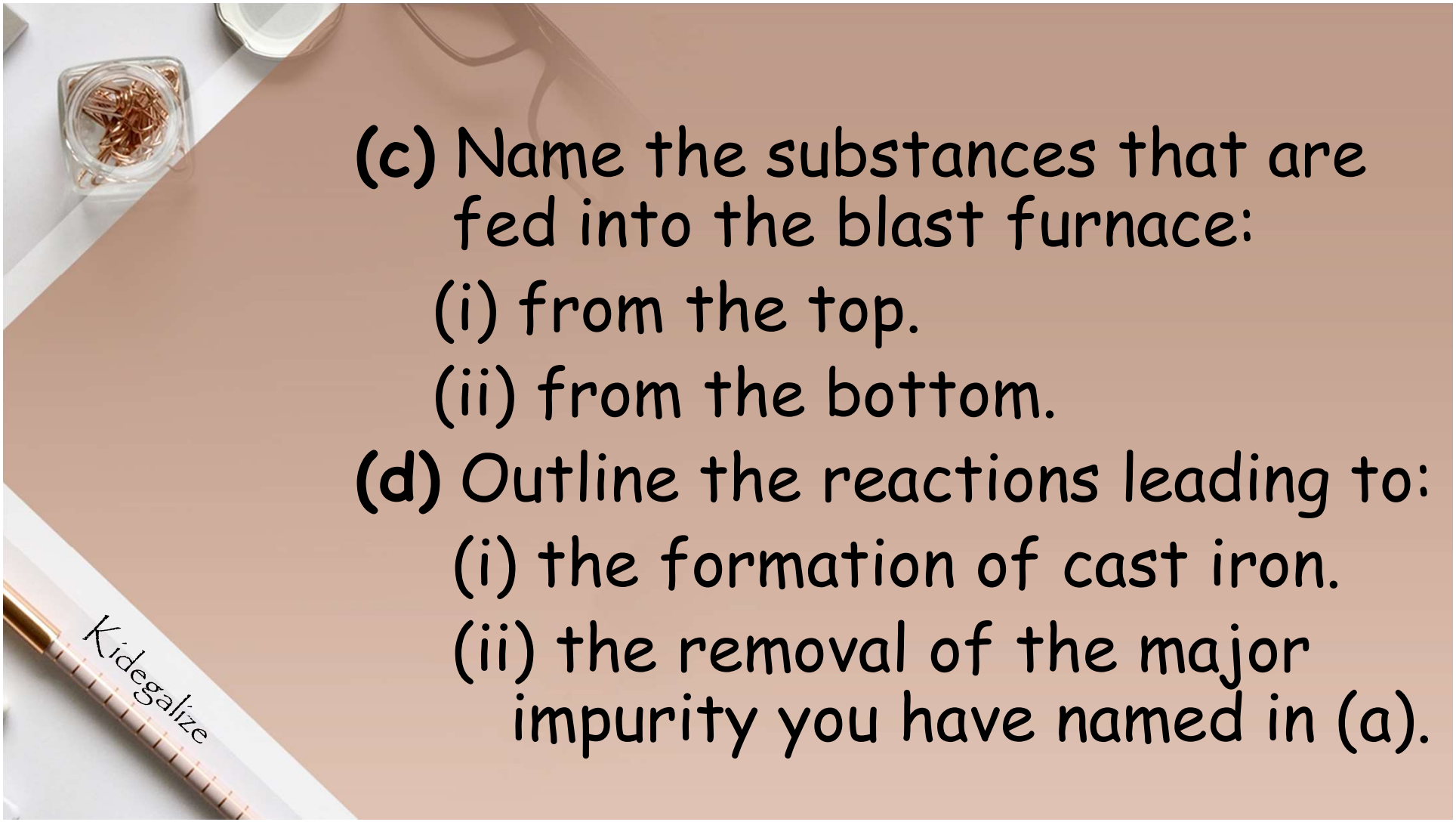
(ii) Explain the role of limestone.



(a) Name the major impurity in the iron ore.

(b) (i) Give the chemical name of the spathic iron ore.

(ii) Write an equation for the reaction which takes place when iron (II) carbonate is roasted in air.



(c) Name the substances that are fed into the blast furnace:

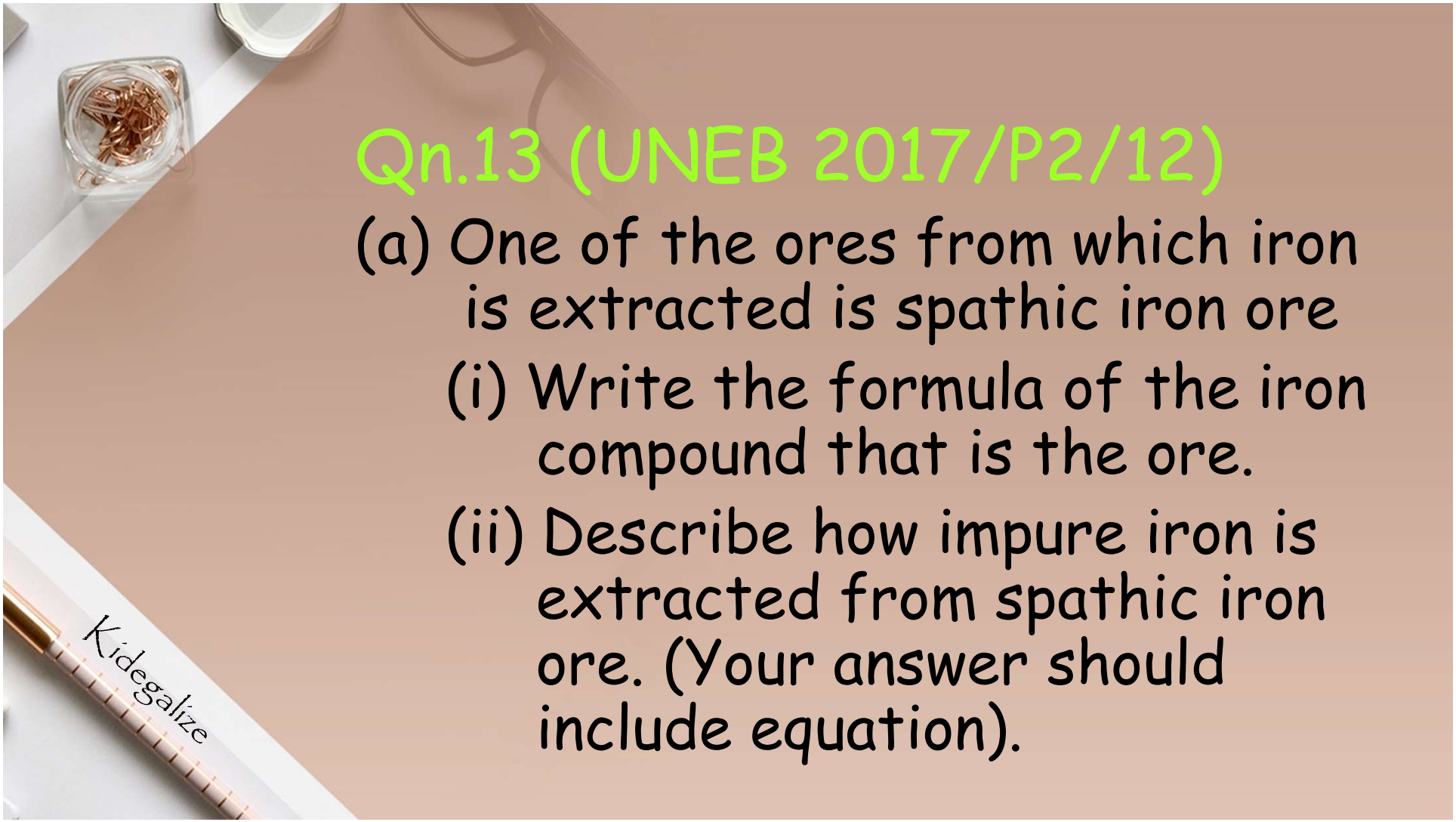
(i) from the top.

(ii) from the bottom.

(d) Outline the reactions leading to:

(i) the formation of cast iron.

(ii) the removal of the major impurity you have named in (a).



Qn.13 (UNEB 2017/P2/12)

(a) One of the ores from which iron is extracted is spathic iron ore

(i) Write the formula of the iron compound that is the ore.

(ii) Describe how impure iron is extracted from spathic iron ore. (Your answer should include equation).


END
Kidegalize