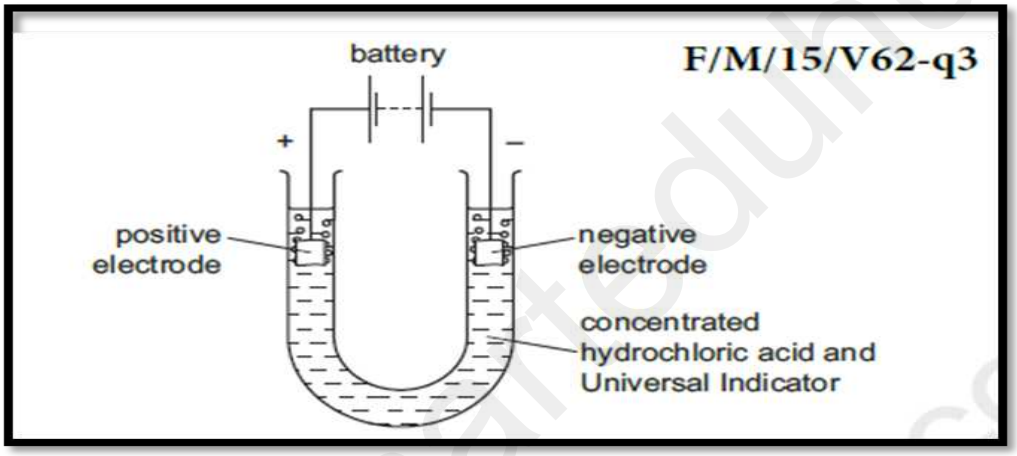
Electrolysis of concentrated aqueous ionic compounds

Note: When electrolysing concentrated aqueous ionic compounds,

- The cations (+ve ions) always follow the reactivity series.
- The anions DO NOT FOLLOW the reactivity series. Only those anions that are in excess are oxidised.
- The basic electrolysis concepts stay the same, i.e. the cations go to the cathode and the anions go to the anode / reduction at cathode and oxidation at anode/ half equations etc...

Example 1:Electrolysis of concentrated HCl



- The electrodes are made of platinum and not aluminium as aluminium would react while platinum would not.
- **Anode:**

Cl^- would be in EXCESS and therefore they would be liberated at the anode.

$2Cl^- - 2e^- \text{----->} Cl_2$ ------oxidation

- **Cathode:**

H^+ are the only positive ions (cations), hence they would be liberated at the cathode.

$2H^+ + 2e^- \text{----->} H_2$ ------reduction

AND

If you are asked to show how to collect the hydrogen gas produced at the cathode, use a graduated test tube or a measuring cylinder filled with the acid or water and invert it over the cathode as shown below

1 Electricity was passed through a solution of concentrated hydrochloric acid using the apparatus shown.

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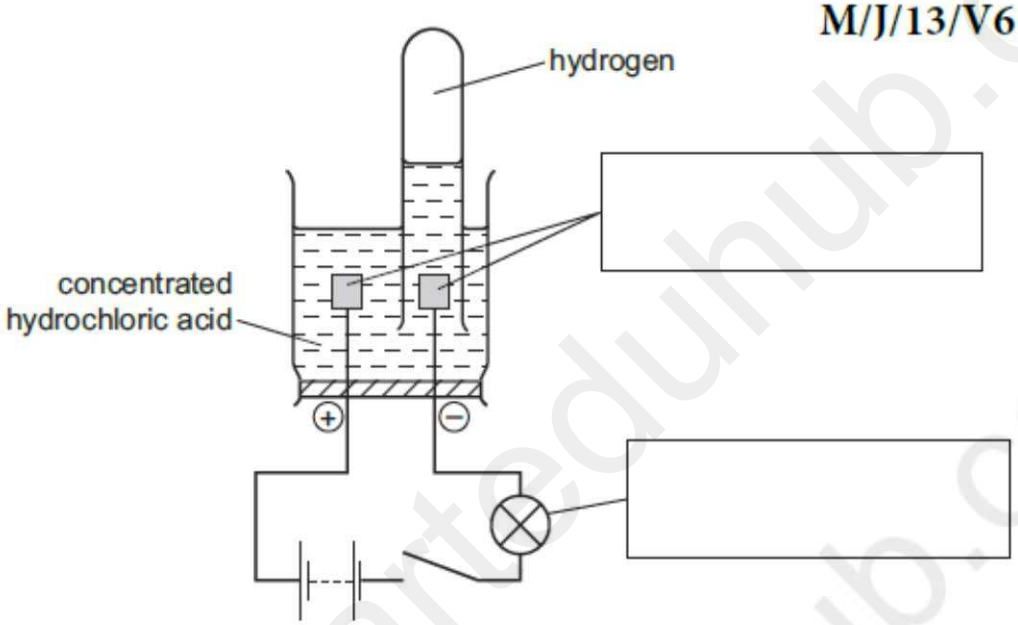

(a) Complete the boxes to identify the parts of the apparatus labelled. [2]

(c) Describe how a sample of the gas given off at the positive electrode could be collected and its volume measured.

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..... [2]

Type of questions based on electrolysis of concentrated solutions with inert electrodes.

The word inert means that it is to be considered as " The electrolysis of concentrated hydrochloric acid"

10 The diagram shows that two gases are formed when concentrated hydrochloric acid is electrolysed between inert electrodes.

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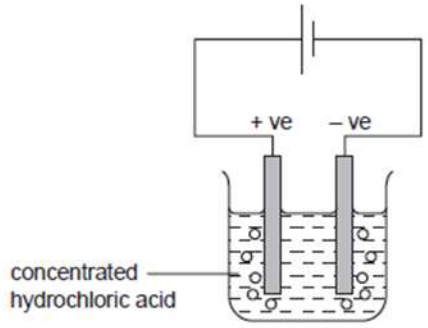

Which line correctly describes the colours of the gases at the electrodes?

	anode (+ve)	cathode (–ve)
A	colourless	colourless
B	colourless	yellow-green
C	yellow-green	colourless
D	yellow-green	yellow-green

Example 1:Identify the products formed

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11 The diagram shown is not complete.

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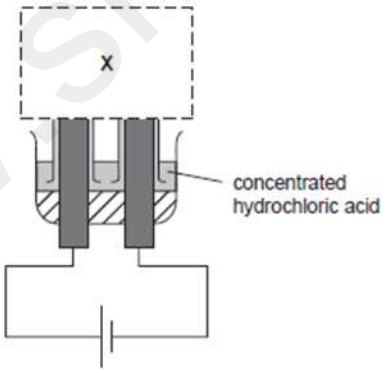
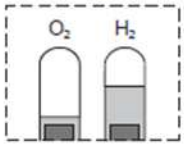


What should be shown at **X** when the solution has been electrolysed for some time?

A



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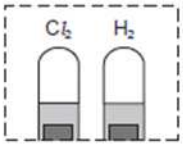

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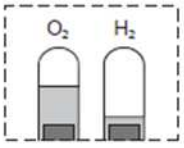
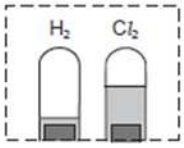


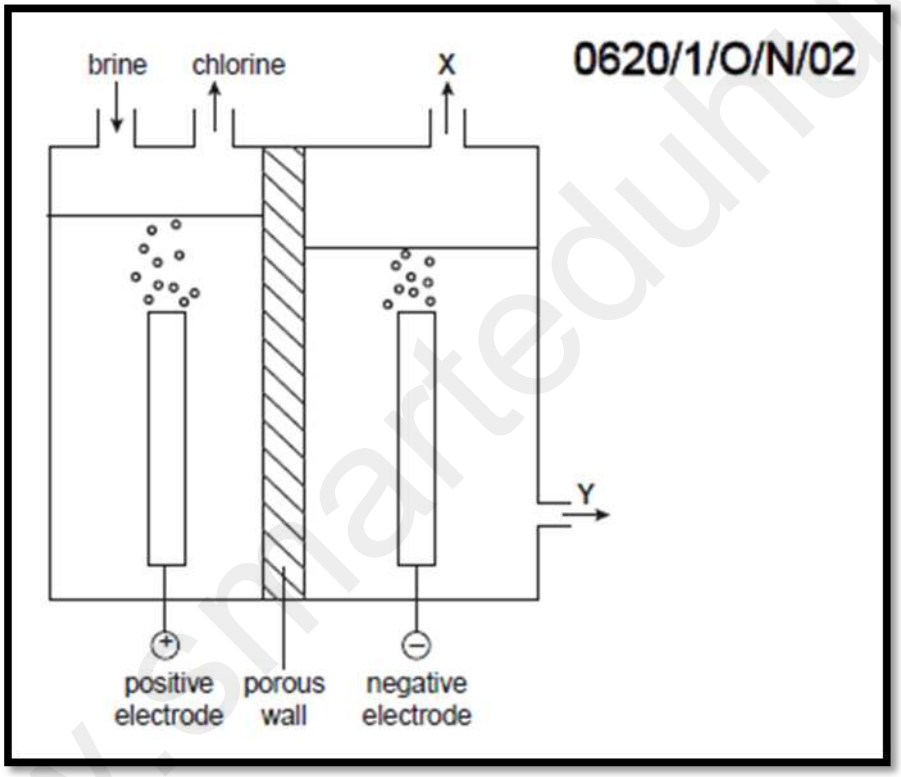
D



Example2: Complete the diagram.

Electrolysis of brine

- Brine is a concentrated aqueous solution of sodium chloride.
- It is obtained from sea water or from seams of rock salt underground.
- The electrolysis of brine is used to produce 3 important products on a large scale namely; H_2, Cl_2 and NaOH.



General observations: fizzing/bubbling/effervescence.

Ions present in the solution:

Cations: Na^+, H^+

Anions: Cl^-, OH^- (Cl^- present in excess)

Anode(+ve electrode): $2Cl^- - 2e^- \longrightarrow Cl_2$ ---Oxidation

Cathode(-ve electrode): $2H^+ + 2e^- \longrightarrow H_2$ ---Reduction

Ions remaining in the electrolyte: Na^+ and OH^- which react to form NaOH.

Change in the electrolyte: The electrolyte changes from being Concentrated NaCl to NaOH.
No. Of products formed:3- namely;H_2, Cl_2 and NaOH.

3 products

- **Chlorine:** Water treatment/solvents/plastic/PVC/bleach/ disinfectants/HCl/kill bacteria/sterilising water/chlorination of water/swimming pools/pesticides/herbicides/insecticides/germicides/phamaceuticals
- **Sodium hydroxide:** Soap making/degreasing/making paper/detergents/bio-diesel/paint stripper/clearing drains/alumina from bauxite/oven cleaner /bleach.
- **Hydrogen:** Chemicals made from hydrogen include ammonia, methanol. hydrogen chloride and margarine.
  Hydrogen is also used in fuel and fuel cells.

----------Extra info starts here----------
Following additional information might be useful in explaining the use of a diaphragm cell.

- Diaphragm prevents hydroxide ions entering anode compartment and prevents chloride ions entering cathode compartment.

The need to keep all the products separate

- If chlorine comes into contact with hydrogen, it produces a mixture of hydrogen chloride which will explode violently on exposure to sunlight or heat.
- Also if chlorine reacts with sodium hydroxide it will produce a mixture of sodium chloride and sodium chlorate(I) - also known as sodium hypochlorite. This mixture is commonly sold as bleach.
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Therefore, if you are trying to manufacture chlorine and sodium hydroxide rather than bleach, you have to keep the chlorine and sodium hydroxide apart as well.

The diaphragm and membrane cells are designed so that all the products are kept separate.

The diaphragm

- The diaphragm is made of a porous mixture of asbestos and polymers. The solution can seep through it from the anode compartment into the cathode side.
- Notice that there is a higher level of liquid on the anode side. That makes sure that the flow of liquid is always from left to right - preventing any of the sodium hydroxide solution formed finding its way back to where chlorine is being produced.

----------EXTRA INFO ENDS HERE----------

Type of application based questions on Brine asked so far:

MCQ Paper

Example 1: Identify the products of electrolysing brine

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12 The diagram represents the electrolysis of brine (aqueous sodium chloride).

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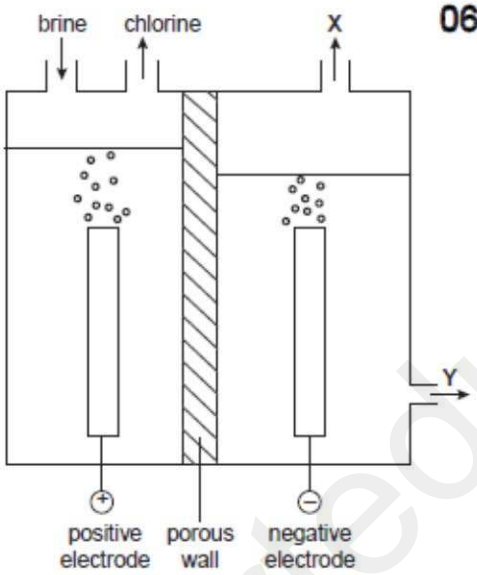

What are products **X** and **Y**?

	X	Y
A	hydrogen	aqueous sodium hydroxide
B	hydrogen	hydrochloric acid
C	oxygen	aqueous sodium hydroxide
D	oxygen	hydrochloric acid

Example 2:

11 The electrolysis of concentrated aqueous sodium chloride makes three products.

Which products are shown at the correct electrodes? **0620/01/O/N/06**

	anode (+ve)	cathode (–ve)
A	chlorine	sodium hydroxide
B	sodium hydroxide	chlorine
C	hydrogen	sodium
D	sodium	hydrogen

Example 3:

Some questions might need the knowledge of the test for gases along with electrolysis.

14 The diagram shows the electrolysis of concentrated aqueous sodium chloride.

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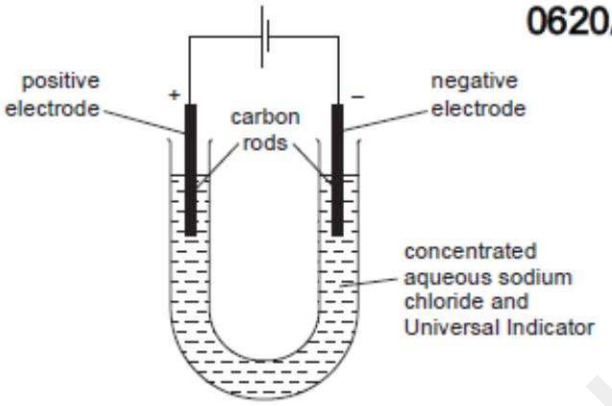

What is the colour of the Universal Indicator at each electrode after five minutes?

	colour at anode (+ electrode)	colour at cathode (– electrode)
A	blue/purple	red
B	red	blue/purple
C	red	colourless
D	colourless	blue/purple