AQA GCSE CHEMISTRY (HIGHER) · 8462

CHEMISTRY



MARK SCHEME

4.4.3 ELECTROLYSIS (PACK 3)

SCORE	PERCENTAGE
/146	%

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Q1.

(a) chlorine

1

(b) copper is less reactive than hydrogen

1

(c) 1.8 (mg)

allow an answer in range 1.7−1.9

1

(d) $\frac{3.02 + 3.01 + x}{3} = 3.06$

allow any other suitable method

1

3.15 (mg)

*if no other mark awarded allow 9.18 for **1** mark*

1

*an answer of 3.15 (mg) scores **2** marks*

(e) $\frac{50}{1000}$ **or** $\frac{1}{20}$ **or** 0.05

1

(0.05) × 300

the second mark is dependent on the first mark being scored

1

15 (g)

1

or

$\frac{300}{1000}$ **or** $\frac{3}{10}$ **or** 0.03 (1)

(0.3) × 50 (1)

the second mark is dependent on the first mark being scored

15 (g) (1)

*if no other mark awarded allow 150 **or** 15 000 for **1** mark*

[8]

Q2.

(a) switch

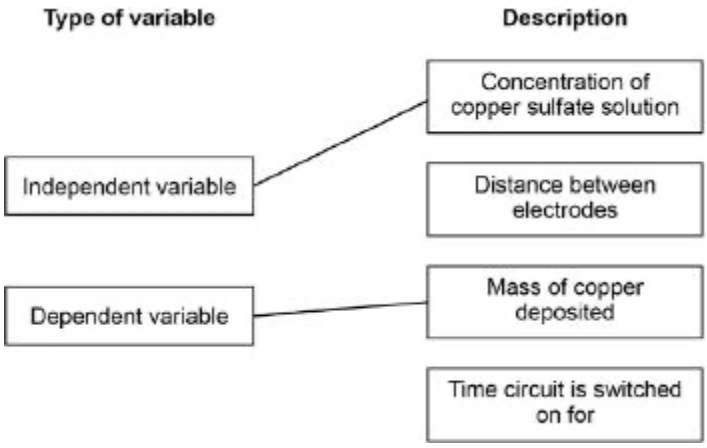
1

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(b) electrolysis

1

(c)



1 mark for each correct line

2

(d) some copper fell off the electrode

1

(e) 0.16 (g)

1

(f) a positive charge

answer line takes precedence

1

(g) the ions cannot move

1

(h) (charge flow =) 0.6 × 300

1

(charge flow =) 180 (coulombs)

1

*an answer of 180 (coulombs) scores **2** marks*

[10]

Q3.

(a) oxygen

1

(b) correct symbol for cell / battery with positive terminal connected to anode

ignore + and − symbols on cell / battery
*do **not** accept voltmeter if connected in series*

1

correct symbol for ammeter connected in series

1

correct symbol for variable resistor connected in series

allow variable power supply in place of variable resistor

1

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ignore additional components that would not affect the circuit working

any order of components

(c) calculation / statement including data to show effect of doubling current on mass of copper deposited

*allow **1** mark for recognising that comparing doubling of one quantity to doubling of another is needed*
or
*allow **1** mark for recognising that a scaling factor needs to be applied*

or

calculation of **two** quotients, e.g.

$$\frac{0.24}{0.047} = 5.11$$

could be opposite way round (giving around 0.2)

$$\frac{0.48}{0.095} = 5.05$$

2

(therefore) results support student **A**
or
results show direct proportionality

this mark must be supported by relevant calculations / statements

1

(however) there is an anomalous result at 0.36 A, 0.057 g

allow in terms of quotient (6.32 instead of ~5 or 0.16 instead of ~0.2)

1

(d) $\frac{0.142}{63.5}$

allow an answer that rounds to 0.00224

1

$= 2.24 \times 10^{-3}$

allow an answer that rounds to 2.2 × 10−3

1

*an answer of 2.24×10^{-3} scores **2** marks*
*an answer of 0.00224 scores **1** mark*

(e) increase the time the circuit is switched on for

1

[11]

Q4.

(a) 3

1

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(b) 5

1

(c) water

1

(d) opposite charges attract

1

(e) silver is less reactive than hydrogen

1

(f) oxygen

1

(g) universal indicator

allow other indicators

1

blue / purple

1

[8]

Q5.

(a) silver

1

$Ag^+ + e^- \rightarrow Ag$

1

oxygen

1

$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

1

(b) 4 ions at start: H^+ OH^- Na^+ Cl^-

1

H^+ ion discharged at negative electrode

1

Cl^- ion discharged at positive electrode

1

so OH^- and Na^+ remain in solution

1

[8]

Q6.

(a) 4.9 (cm^3)

1

(b) $\frac{2.2 + 2.0 + 2.2}{3}$

1

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2.1

*an answer of 2.1(3333...0 scores **2** marks*

1

(c) (concentration) 60 (g / dm^3)
and
(volume) 3.2 (cm^3)

1

would not be on the line of best fit

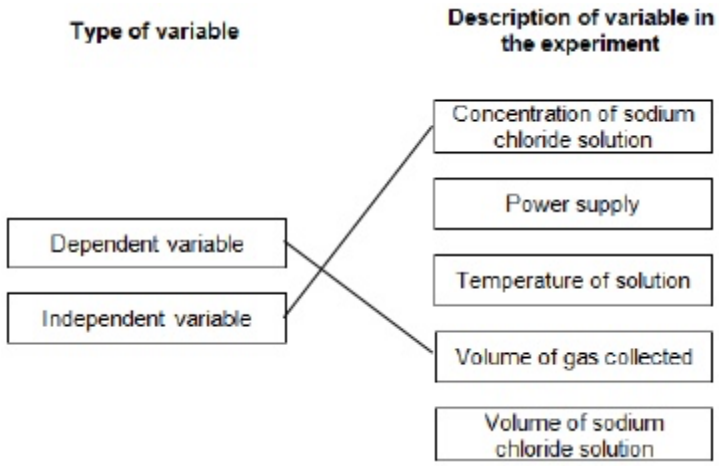
allow does not fit the pattern

1

(d) as the concentration of sodium chloride solution increases, the volume of gas collected increases

1

(e)



1
1

(f) (as) opposite charges attract

1

(and sodium ions) are positive

1

(g) cannot move

1

(h) chlorine

1

hydrogen

1

[13]

Q7.

(a) labelled axes and sensible scales, using at least half the grid for the points

1

all points correct

tolerance of ± ½ small square

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*allow **1** mark if 5 or 6 of the points are correct*

2

line of best fit

1

(b) as the concentration of sodium chloride solution increases, the volume of hydrogen collected increases

1

(c) (dependent variable)
volume of (hydrogen) gas collected

1

(independent variable)
concentration of sodium chloride solution

1

(d) chloride ions are negatively charged

1

(and so are) attracted to the positive electrode

1

(at the electrode) the chloride ions lose electrons
allow chloride ions are oxidised

1

to form chlorine atoms / molecules
allow instead of last two marking points an answer of
*$2Cl^- \rightarrow Cl_2 + 2e^-$ for **2** marks*

1

(e) hydrogen is less reactive than sodium
allow sodium is more reactive than hydrogen

1

(f) $M_{r\ NaCl}$ 58.5

1

moles of NaCl in 1 dm^3 = $\frac{29.25}{58.5}$ = 0.5

1

moles in 50 cm^3 = $\frac{0.5}{1000}$ × 50
allow chloride ions are oxidised

1

= 0.025 (moles)
*an answer of 0.025 (moles) scores **4** marks*

1

[16]

Q8.

(a) electrolysis

1

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(b) Cathode – hydrogen

1

Anode – bromine

1

(c) copper ions are positive

1

so the copper ions are attracted to the negative cathode

allow so the copper ions gain electrons from the cathode to form copper atoms

1

[5]

Q9.

(a) electrodes connected to d.c. power supply by wires

for this diagram ignore the material used for the electrodes as long as they are made from carbon or metals that are inert

1

electrodes labelled anode (+) and cathode (−)

1

(b) copper ions cause the blue colour

answer must be in terms on copper ions

1

copper ions are reduced / converted to copper ions

1

so the concentration of copper ions decreased

1

*if no other mark awarded allow **1** mark for copper ions are used up during electrolysis*

(c) copper ions are positive

1

so are attracted to the inert cathode **or** inert negative electrode

1

copper ions gain electrons at the inert cathode **or** inert negative electrode

1

so they are reduced to form copper atoms

1

(d) 50 cm^3 contains 4 g $CuSO_4$

1

*M*r $CuSO_4$ = 159.5

1

4 g $CuSO_4$ reacts with $\frac{4}{159.5}$ × 56 g Fe

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= 1.40(43877)

1

= 1.4 (g)

1

*accept 1.4(g) with no working shown for **4** marks*
*allow 1.40(43887) without working shown for **3** marks*

[13]

Q10.

(a) bromine

1

ions

1

atoms

1

(b) correct scale on y axis

1

points correctly plotted using the scale
± ½ *small square*

1

best-fit line drawn

1

(c) value for oxygen divided by corresponding time

1

× 60

1

= 0.05 (cm^3 / s)
*allow 0.05 with no working shown for **3** marks*

1

[9]

Q11.

(a) 1 950 / 2 500 × 100

1

78 (%)

1

(b) expected mass of aluminium

1950 × 54 / 102

1

= 1032.35

1

mass not collected

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1032.35 − 1 000

= 32.4

*allow 32.4 with no working shown for **3** marks*

1

*incorrect number of sig. figs max **2** marks*

(c) because oxygen is formed at the anode

1

which reacts with the carbon anode to produce carbon dioxide

1

and wears it away

1

(d) power = $1.5 \times 10^5 \times 4$

1

= 6.0×10^5 W

1

24 hours = $24 \times 60 \times 60 = 8.64 \times 10^4$ seconds

1

energy transferred = $6.0 \times 10^5 \times 8.64 \times 10^4$

allow ecf from power calculation

1

= 5.184×10^{10}

*allow 5.184×10^{10} with no working for **5** marks*

1

(e) 3 moles of electrons are needed to produce 27 g or 0.027 kg aluminium

1

so moles of electrons to produce 1 000 kg = 1 000 / 0.027 × 3

1

= 111 000

*allow 111 000 with no working shown for **3** marks*

1

*incorrect no. of sig. figs max **2** marks*

[16]

Q12.

(a) Ionic

1

(b) electrolyte

1

(c) because the ions are free to flow

1

(d) because potassium is higher in the reactivity series than hydrogen

1

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so it is less easily discharged than hydrogen

1

(e) because water is covalent / molecular / contains molecules

1

so there are no free electrons to move **or** does not have an overall electrical charge

1

(f) conductivity of the solution increases with concentration

1

in a linear relationship **or** directly proportional

1

[9]

Q64.

(a) (i) gold is unreactive

1

(ii) $2Fe_2O_3 + 3C \longrightarrow 4Fe + 3CO_2$

products may be in either order

***1** mark for correct symbols*

***1** mark for correct balancing*

allow correct multiples

2

(iii) aluminium is high in the reactivity series

or

aluminium is more reactive than carbon

allow aluminium is very reactive

1

(so) cannot be extracted with carbon

or

(so) requires electrolysis

*allow electrolysis is required (**1** mark)*

*(but) electricity / technology not available (**1** mark)*

1

(b) lower density **and** higher strength

1

[6]

Q65.

(a) rare

or

very small amount in Earth's crust

ignore figures without qualification

1

(b) (i) electrolysis

1

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(ii) (electrolysis) uses more energy

or

there are many stages in the process
ignore references to reactivity
accept uses a large amount of energy

1

[3]

Q66.

(a) rare

or

very small amount in Earth's crust
ignore figures without qualification

1

(b) (i) electrolysis

1

(ii) (electrolysis) uses more energy

or

there are many stages in the process
ignore references to reactivity
accept uses a large amount of energy

1

(c) $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$
correct formulae for 1 mark
correct balancing of correct formulae for 1 mark
allow multiples
*accept for **2** marks:*
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

2

[5]

Q67.

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1–2 marks)
A brief reason is given against extraction or for recycling. There is little scientific terminology used.

Level 2 (3–4 marks)
Some reasons are given with clear statements against extraction and or for

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recycling. Some scientific terminology is used

Level 3 (5–6 marks)
Several reasons are given with a detailed explanation against extraction and for recycling. Scientific terminology is used accurately

examples of chemistry points made in the response

ignore uses and properties of aluminium. Comparative statements count for both methods

extraction:

- limited resources of aluminium oxide
- higher temperatures required
  allow quoted temperatures eg extracted at 950°C
- large amount of energy required
- expensive
- requires mining / quarrying
- process takes longer / has more stages
- produces more carbon dioxide / greenhouse gases

recycling:

- saves resources
- cheaper to recycle
- uses less energy
- only needs to be melted
  allow quoted temperatures eg melted / recycled at 700°C
- less electricity needs to be *used*
- less effect on environment
- example of *effect on environment*
  eg less destruction of habitats
- avoids need for disposal / use of landfill
- no need for quarrying
- sustainable

6

[6]

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Q1.

Foundation

(a) Halogens are produced at the positive electrode if an aqueous solution contains a halide ion. 27% of students correctly selected chlorine as the gas produced.

(b) Students could have linked their understanding of the reactivity series, with which ion is discharged when an aqueous solution is electrolysed. In this case, the production of copper at the negative electrode informs students that copper is less reactive than hydrogen. 30% of students were able to correctly deduce this.

(c) Students needed to look at the data and see that the mass produced at three minutes was missing from the table. Experimental errors account for the trend not being exactly directly proportional. 42% of students noticed the relationship and correctly deduced the mass within the allowed range of 1.7 to 1.9 (mg).

(d) This question discriminated well. 28% of students achieved full marks for this question giving an answer of 3.15 (mg), however, some did so without showing their working. This was not an issue where they obtained the correct answer, but some did not and therefore gained no credit as it was not possible to see how they had obtained their answer. 15% of students did not attempt to answer this question.

(e) A unit conversion is essential to make progress in this calculation. A conversion between cm^3 and dm^3 requires a division of either 50 by 1000 to convert cm^3 to dm^3 or 300 by 1000 to convert mass per dm^3 to mass per cm^3. 1% of students understood this concept to achieve the maximum three marks for this question. 28% of students did not attempt to answer this question.

Higher

(a) Halogens are produced at the positive electrode if the solution contains a halide ion. 51% of students correctly selected chlorine as the gas produced.

(b) Students could have linked their knowledge of the reactivity series, with which ion is discharged when an aqueous solution is electrolysed. In this case, the production of copper at the negative electrode informs students that copper is less reactive than hydrogen. 46% of students were able to correctly deduce this.

(c) Students needed to look at the data and see that the mass produced at three minutes was missing from the table. Experimental errors account for the trend not being exactly directly proportional. In this instance 63% of students noticed the relationship and correctly deduced the mass. The mark scheme did allow a small range around the expected answer.

(d) 68% of students achieved full marks for this question giving an answer of 3.15 (mg), however, a significant number did so without showing their working. This was not an issue where they obtained the correct answer, but some didn't and therefore gained no credit as it was not possible to see how they had obtained their answer.

A working mark was available and showing 9.18 (mg) was the most likely way that this was gained by students.

(e) A unit conversion between cm3 and dm3 in this question requires a division of

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either:

- 50 by 1000 to convert cm^3 to dm^3 or
- 300 by 1000 to convert mass per dm^3 to mass per cm^3

This conversion is essential to make progress in this calculation. 14% of students understood this concept and achieved the maximum three marks for this question.

A significant number either divided 300 by 50 with an answer of 6 or multiplied 300 by 50. The latter led to a compensatory mark for 15 000.

Q2.

(a) More than three quarters of students identified the given circuit symbol as a switch. Of the remaining responses, more chose the fuse than the other two options.

(b) More than three quarters of students chose the correct response of 'electrolysis', with 'distillation' being the next most popular choice.

(c) Around 17% of students gained both marks for this question. Students who scored one mark usually did so for correctly identifying the independent variable of 'concentration of copper sulfate solution'.

Although both 'concentration of copper sulfate solution' and 'mass of copper deposited' were chosen by a good number of students, these were often paired to the incorrect variable.

Other incorrect answers included various combinations of the type of variable and the description. Despite the instruction to draw one line from each type of variable, several students showed two lines from each.

(d) Slightly more than one third of students chose the correct response that some copper fell off the electrode. The other two options were as popular as each other.

(e) Around half of students were able to identify the pattern in the results and state the correct value of 0.16 g.

A common incorrect answer was 16 g, indicating that students had recognised the pattern, but had forgotten to include the decimal point.

Another common incorrect response was 0.07 g, which was the result given in the table; perhaps students had not taken on board the previous question which referred to this result as being anomalous.

(f) Around 70% of students correctly identified that copper ions have a positive charge. Of the incorrect responses, 'a negative charge' was more popular.

(g) Just over half of students realised that solid copper sulfate does not conduct electricity because the ions cannot move. The other three choices had a similar number of responses, with 'the ions are too big' being the least popular choice.

(h) Around 8% of students did not attempt this question. Most of those who attempted it were able to substitute the given values into the equation and work out the correct answer, thus scoring two marks.

Some students substituted other values for current, such as 0.06 A or 6 A, rather than the given 0.6 A. It was not clear whether they had deliberately converted the

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value, or just made an error in writing it down. A few students divided the two values rather than multiplying them. It should be noted that in a low demand question where the equation is provided, it is always in the form needed, so no re-arrangement is necessary.

Q3.

(a) The correct answer (Oxygen) was chosen by, just over 10 % of students. 'Sulfur' and 'sulfur dioxide' were equally popular incorrect choices and accounted for around two thirds of student responses.

(b) Some who made an attempt did not seem to realise they would need a cell / battery or an ammeter, and the vast majority omitted a variable resistor. Where students had included some of these components, they often did not know the correct circuit symbols or how to connect them in the circuit.

Fewer than 2% achieved all three marks, with 40% gaining no marks.

(c) Only 1% gained all four marks, with nearly 70% scoring no marks at all.

A common misconception was that because the mass of copper deposited increased as the current increased, this showed direct proportionality.

A large number of students referred to the first set of results as being proportional, but the rest were not, indicating that they have an incorrect understanding of proportionality.

Few supported their claims with any calculations; of those who attempted to do so, these were often incorrect, e.g. 'the mass of copper is double the current'.

A few realised that if the current doubles, the mass of copper deposited should also double. However, most of these went on to say that for the first two results, doubling the mass of copper would give 0.048g, whereas it is only 0.047g, so this shows they are not proportional.

Very few realised that if mass is proportional to current, then mass/current would be a constant. The few who calculated this constant for all six pairs of data were able to identify the anomalous result at 0.36A.

(d) Of those who made an attempt, many did not realise that they needed to use the table to find the mass of copper which was deposited when the current was 0.72A. They then took the values of current and relative atomic mass and added, subtracted, multiplied or divided in various combinations.

Students who correctly identified the mass as being 0.142g were usually able to calculate the number of moles correctly. However, many either did not realise that the question asked for the answer in standard form, or they did not know how to do this.

(e) Just over half of students chose the correct response of 'increase the time'. 'Increase the distance between the electrodes' was the least chosen, with the other two responses being almost equally chosen.

Q64.

(a) (i) Only just over a quarter of the students could explain why gold is found in the earth's crust as the element. Common incorrect answers stated that 'gold

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is a pure metal' or 'it is made up of just one type of atom'.

(ii) Many errors were made in writing the correct symbol for iron and the correct formula for carbon dioxide. The same rules always apply to writing symbol equations. Upper and lower case letters must be clearly written, and subscripts must not be taller than half way up a capital letter. Quite a lot of diatomic iron was seen, as well as the symbol for cobalt being used instead of carbon and oxygen in carbon dioxide. Carbon dioxide was incorrectly represented as CO2, CO^2 or CO3.

(iii) Only half the students gained a mark, which was usually for a reference to electrolysis. Quite a lot gave the technology answer of 'electrolysis is needed but electricity was not invented until later' to gain two marks.

(b) A comparison of the properties of titanium and steel was asked for, and therefore comparative statements were required in the response. Comparisons of both strength and density were required for the mark. Many students only referred to the strength of titanium, and did not mention that it is less dense, so did not gain the mark.

Q65.

(a) Many students said that gold is rare or that there is a very low percentage in the Earth's crust. Some said that it is hard to find, which was insufficient for the mark. Common incorrect responses were that it is a pure metal or it is unreactive. A few assigned its value to its appearance or long lasting qualities.

(b) (i) Only a few of the students who attempted this question knew that the process to extract aluminium is electrolysis. A variety of incorrect responses were seen, many of which related to crude oil, such as fractional distillation.

(ii) Less than one tenth of students gained the mark for saying that aluminium is more expensive to extract than iron because it uses a lot of energy or uses a large amount of electricity. Many just repeated the question or referred to the reactivity of the metals, which was insufficient to gain the mark. Some students said that the process was more difficult or took longer. Others quoted information from the table or answered in terms of the uses or properties of aluminium.

Q66.

(a) The majority of students said that gold is rare or that there is not a lot of it in the Earth's crust. Some said that it is hard to find, which was insufficient for the mark. Common incorrect responses were that "It is a pure metal" or "It is unreactive". A few assigned its value to its appearance or long lasting qualities.

(b) Less than a third of students gained the mark for saying that aluminium is more expensive to extract than iron because it uses a lot of energy or uses a large amount of electricity. Many students referred to the reactivity of the metals, or said that electrolysis was used. These were not sufficient to gain the mark. Some students said that the process was more difficult or it took longer. A lot of incorrect responses referred to the end cost of aluminium being higher, which is partly due to the extraction process, and so were insufficient.

(c) The question gave students the formula for iron oxide and told them that iron is extracted from iron oxide by reduction with carbon. Students who used this information gained 1 or 2 marks. If they did not give the correct formula and symbols

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they could not gain a mark. A variety of formulae for iron oxide were seen, and sometimes it was given as a product rather than a reactant. Some students gave the symbol for iron as Fe_2, Fe_3 or Fe_4. Carbon dioxide was frequently seen as a reactant, instead of carbon. Some students attempted to write ionic equations for the reaction, whilst others wrote word equations. A very common error was to represent the symbols and numbers incorrectly. Upper case letters were needed for C and O, with upper case F, followed by lower case e for iron. Subscripts should be no higher than halfway up the capital letter.

Q67.

In this question students were assessed on both their scientific knowledge and 'QWC' - their ability to use good English, organise information and use appropriate specialist terms. In most cases the level of QWC matched their level of scientific knowledge.

Students were asked to suggest why most aluminium is recycled. They were expected to use information given in the question, as well as their own knowledge. Many students referred to the uses or properties of aluminium, rather than explaining why most aluminium is recycled. The most common science points made related to costs or the amount of energy required. To gain full marks both the advantages of recycling and disadvantages of extraction had to be mentioned.

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