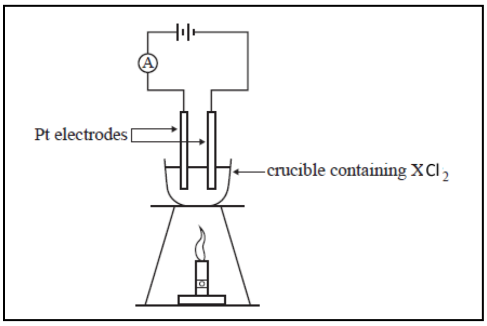
Revision 6 Trends and electrolysis

1) Electrolysis of a molten salt using an unknown metal salt, XCl_2 was performed using the apparatus shown on the right.

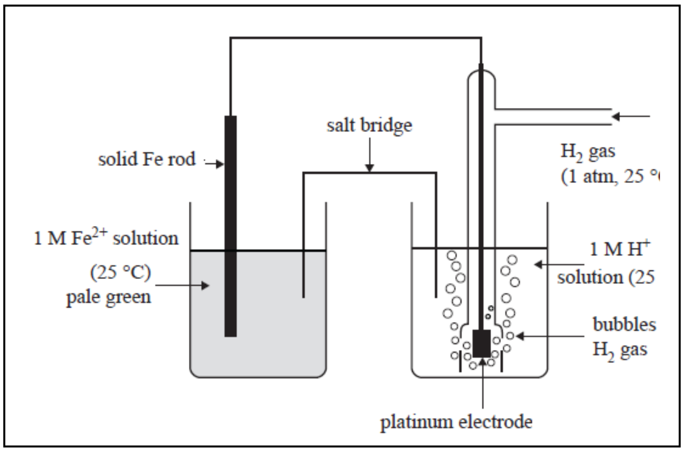


A current of 1.90 A was supplied for 2.43 hours.
5.47 grams of metal X was produced.
a) Write a balanced half equation for the reaction occurring at the:
anode *$2Cl^{-}$ (l) $\rightarrow$ Cl_2(g^{-} + 2e*
Cathode *X^{2+}(l) + 2e $\rightarrow$ X(s)*
b) Identify metal X.
Step 1 Find the charge delivered.
Q = It = 1.90 X 2.43 X 60 X 60 = 16621C
Step 2 Find the mol of electrons
=> 16621 / 96500 = 0.172
Step 3 Find the mol of X
=> According to the stoichiometry 2 mol of electrons produces one mol of X
=> 0.172 / 2 = 0.0861
Step 4 Find the molar mass of X and hence identify X
=> molar mass = mass / n = 5.47 / 0.0861 = 63.5 amu => Copper

c) Indicate true or false for the following statements about galvanic and electrolytic cells? Explain why for each.
i. Reduction occurs at the negative electrode in both cells.
for a galvanic cell, reduction occurs at the cathode which is positive. In an electrolytic cell reduction also occurs at the cathode but it is negative. False
ii. Reduction occurs at the cathode in both cells.
True
iii. Anions migrate to the cathode in both cells.
In a galvanic cell anions flow from cathode to the anode. As electrons are removed at the anode due to oxidation negative ions move in to balance the build-up of positive charge. In an electrolytic cell oxidation still occurs at the anode hence anions will still move to the anode, albeit a different polarity to that of a galvanic cell, to balance the build up of positive charge.
iv. The anode is positive in both cells.
The anode is negative in a galvanic cell and positive in an electrolytic cell.

d) Fuel cells have a number of applications that offer advantages over conventional methods of electricity generation.
Which one of the following is not a feature of modern fuel cells?
A. They generate very little noise.
B. They are a cheap source of electricity. *Fuel cells are currently not a cheap alternative.*
C. They enable electricity to be generated on site.
D. They have the potential to reduce emissions of carbon dioxide into the atmosphere.

2) The galvanic cell shown on the right was setup in a laboratory.
The half-cell on the right is called the standard hydrogen electrode (SHE). It is the standard against which all standard redox potentials are compared. Hydrogen gas, H_2, is continually bubbled into this half-cell. When asked what would happen at the platinum electrode four students volunteered an answer.



Student 1 "Electrons would move from the platinum electrode through the acid solution towards the salt bridge." *False. Electrons do not move through the salt bridge. Ions move through the salt bridge to maintain charge balance in the two half cells.*

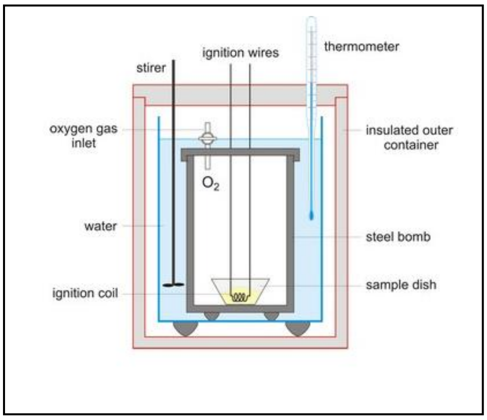
Student 2 " The platinum electrode would act as the anode in this cell and have positive polarity." *False. Firstly the anode in a galvanic cell is negative*. *According the electrochemical series in the Data Sheet Fe is the strongest reductant. Oxidation will occur at the half cell on the left and electrons will flow from left to right into the hydrogen half cell.*

Student 3 "The pH of the solution surrounding the platinum electrode would increase." *True. As the following reaction takes place* $2H^+(aq) + 2e \rightarrow H_2(g)$ *the pH would rise the concentration of* H^+ *decreases.*

Student 4 "The hydrogen gas would be oxidised at the platinum electrode's surface." *False. As the following reaction takes place* $2H^+(aq) + 2e \rightarrow H_2(g)$ *at the platinum electrode.*

Which of the four students is/are correct? Explain why.

3) 0.580 grams of butane was placed in a bomb calorimeter and ignited. After complete combustion the temperature of 100.0 grams of water,initially at 25.0 °C reached 64.0 °C.



a) Write a balanced chemical equation for the complete combustion of liquid butane.

$2C_4H_{10}(l) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$

$$\text{percentage energy loss} = \frac{(\text{theoretical value of } \Delta H - \text{experimental value of } \Delta H)}{\text{theoretical value of } \Delta H} \times \frac{100}{1}$$

b) The above expression gives the percentage energy loss to the environment. Use the known enthalpy change for butane to calculate the percentage energy loss to the environment.

Step 1 Calculate the mol of butane
=> 0.580 / /58.0 = 0.0100 mol
Step 2 Calculate the amount of energy given off.
=> E = 4.18 X 100.0 X (64.0 – 25.0) = 16302 J.
Step 3 calculate the experimental ΔH
=> 16.302 / 0.0100 = 1630.2 kJ/mol
Step 4 using the data sheet calculate the percentage loss.
=> ((2880 – 1630.2) / 2880) X 100 = 43.4 %

4) Consider the two equations on the right.
a) What type of reaction is
i. *addition*
ii. *substitution*

i. $CH_2CH_2(g) + Cl_2(g) \xrightarrow{\text{UV light}} CH_2ClCH_2Cl($

ii. $CH_3CH_3(g) + Cl_2(g) \xrightarrow{\text{UV light}} CH_3CH_2Cl\ (l)$

b) Name the products of each reaction even if they are not shown in the unbalanced reaction.

i. 1,2-dichloroethane
ii. HCl and chloroethane

c) The product of reaction ii. Above is used to synthesise an organic acid. Give the reaction pathway, clearly labelling all the reagents used, and name the product of each step.
Note – naming aldehydes an dketones is not aprt of the this course.
Chloroethane – $OH^-(aq)$ → Ethanol – $Cr_2O_7^{-2}/H^+$ → ethanal – $Cr_2O_7^{-2}/H^+$ → ethanoic acid

d) Which product, of the reactions above, can be used to synthesise a diol? Write the reaction clearly naming the product and all the reagents used.
1,2-dichloroethane --$OH^-(aq)$ → ethan-1,2-diol