Question 38
It is proposed to indirectly determine the concentration of Fe^{3+} ions in a solution by using UV-visible spectroscopy to measure the concentration of red-coloured $FeSCN^{2+}$ ions generated by the equilibrium reaction

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq); \qquad \Delta H = \text{negative}$$

This procedure would provide the **most** accurate estimate of the concentration of Fe^{3+} ions in the original solution if

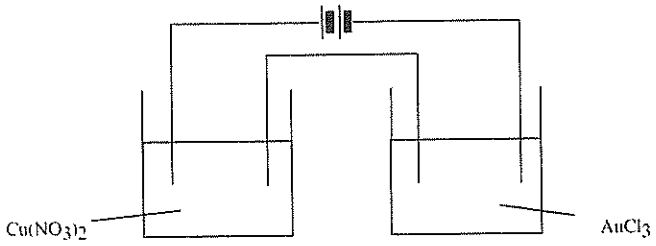
A. the value of the equilibrium constant is small, an excess of SCN^- is used, and the analysis is carried out at a low temperature.
B. the value of the equilibrium constant is large, an excess of Fe^{3+} is used, and the analysis is carried out at a high temperature.
C. the value of the equilibrium constant is small, an excess of Fe^{3+} is used, and the analysis is carried out at a high temperature.
D. the value of the equilibrium constant is large, an excess of SCN^- is used, and the analysis is carried out at a low temperature. (VCAA 2011, Q5)

Electrolysis

Question 39
Which one of the statements below regarding galvanic and electrolytic cells is correct?

A. Reduction occurs at the cathode in galvanic cells but at the anode in electrolytic cells.
B. Oxidation occurs at the cathode in both cells.
C. Reduction occurs at the cathode and oxidation occurs at the anode in both cells.
D. Oxidation occurs at the anode in galvanic cells but at the cathode in electrolytic cells.

Question 40
A student sets up the circuit shown below to electrolyse solutions of copper nitrate and gold(III) chloride using inert electrodes.



The mass of gold to the mass of copper deposited at the two cathodes will be in the ratio

A. 1.00 : 1.00 B. 2.07 : 1.00 C. 3.10 : 1.00 D. 4.65 : 1.00

on of Fe^{3+} ions in a solution by
oncentration of red-coloured

= negative

timate of the concentration of

an excess of SCN^- is used, and

n excess of Fe^{3+} is used, and the

n excess of Fe^{3+} is used, and the

an excess of SCN^- is used, and
(VCAA 2011, Q5)

lvanic and electrolytic cells is

ic cells but at the anode in

on occurs at the anode in both

cells but at the cathode in

olyse solutions of copper nitrate

$AuCl_3$

t the two cathodes will be in the

10 : 1.00 D. 4.65 : 1.00

Question 41
An aqueous solution of zinc nitrate is electrolysed for 75.0 minutes by a current of 4.50 A. The mass of zinc deposited, in grams, is closest to

A. 0.23 B. 6.85 C. 13.70 D. 27.40

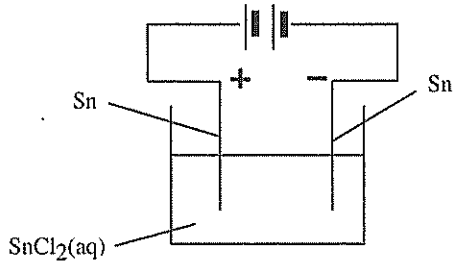
Question 42
In the electrolytic production of aluminium the current, in amps, needed to deposit 5.0 kg of aluminium in 60.0 minutes is closest to

A. 15 B. 5.0×10^3 C. 1.5×10^4 D. 8.9×10^5

Question 43
In the electrolysis of thallium nitrate solution, 0.168 g of thallium is deposited at the cathode in 144 seconds by a current of 1.65 A. The charge on the thallium ion in the solution of thallium nitrate is

A. –3 B. –1 C. +1 D. +3

Question 44
A solution of tin(II) chloride was electrolysed using the circuit shown below.



The reaction that is most likely to occur at the positive electrode is

A. $Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$
B. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$
C. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
D. $Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$

Question 45
9650 C of electrical charge is used to electrolyse 1.00 L of a 0.50 M lead nitrate solution. If the volume of the solution remains unchanged, then the $Pb^{2+}(aq)$ concentration after electrolysis will be

A. 0 M B. 0.30 M C. 0.40 M D. 0.45 M

Question 46
When comparing the electrolysis of molten NaF and that of a 1.0 M aqueous solution of NaF, which one of the following statements is correct?

A. The product at the anodes is the same in both cells and the product at the cathodes is the same in both cells.
B. The product at the anodes is the same in both cells but the products at the cathodes are different.

C. The product at the cathodes is the same in both cells but the products at the anodes are different.
D. The products at the cathodes of the cells are different and also the products at the anodes are different.

(VCAA 2008, Q16)

Question 47
Lithium metal is manufactured by electrolysis of lithium salts. Which of the following would be the best choice for the electrolyte and the anode in a commercial cell?

	Electrolyte	Anode
A.	LiCl solution	iron rod
B.	molten LiCl	iron rod
C.	LiCl solution	carbon rod
D.	molten LiCl	carbon rod

(VCAA 2009, Q20)

Question 48
Why is it not possible to plate an object with magnesium metal using an aqueous 1.0 mol L^{-1} MgI_2 solution as the electrolyte?

A. Water is a stronger reductant than I^-.
B. Water is a stronger oxidant than I^-.
C. Water is a stronger reductant than Mg^{2+}.
D. Water is a stronger oxidant than Mg^{2+}.

(VCAA 2010, Q20)

Question 49
If we compare a galvanic cell with an electrolytic cell, it is true to state that

A. in a galvanic cell reduction occurs at the negative electrode.
B. in both cells the anode is positive and the cathode is negative.
C. in an electrolytic cell oxidation occurs at the cathode.
D. in both cells reduction occurs at the cathode.

(VCAA 2011, Q17)

Question 50
A student prepares 1.0 M aqueous solutions of $AgNO_3$, $Fe(NO_3)_2$ and KNO_3. Equal volumes of each solution are placed in separate beakers, identical platinum electrodes are placed in each beaker and each solution undergoes electrolysis with the same current applied for 5.0 minutes under SLC. Each cathode is then dried and weighed to determine mass change. Assume that the concentrations of the solutions have decreased only slightly. In order of increasing mass, the metals deposited on the three cathodes are likely to be

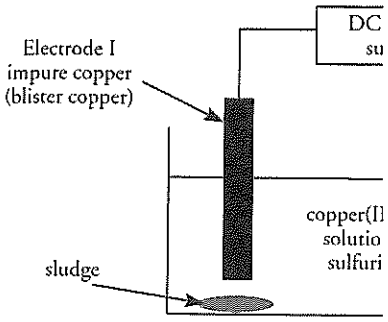
A. potassium, silver, iron.
B. silver, iron, potassium.
C. iron, potassium, silver.
D. potassium, iron, silver.

(VCAA 2013, Q30)

Use the following information to answer Questions 51 to 53.

An electrolytic cell is set up to obtain pure copper from an impure piece of copper called 'blister copper'. The electrolyte solution contains both copper(II) sulfate and sulfuric acid. The blister copper, Electrode I, contains impurities such as zinc,

cobalt, silver, gold, nickel and iron. ' deposited on Electrode II. Sludge, w present in the blister copper, forms b in solution as ions. The diagram belo



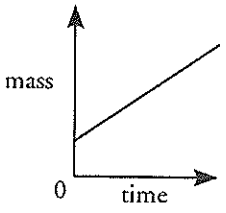
Question 51
The solid metal impurities that are fc

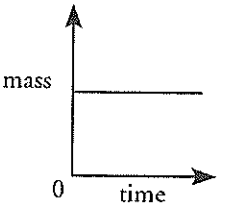
A. gold, nickel and cobalt.
C. nickel and iron.

Question 52
Which of the following correctly sho at the cathode and the polarity of Ele

	Cathode reaction
A.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
B.	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
C.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$
D.	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

Question 53
Which one of the following graphs be a period of time, starting from the mc

A.


C.


both cells but the products at the

e different and also the products at
(VCAA 2008, Q16)

of lithium salts. Which of the
lyte and the anode in a commercial

(VCAA 2009, Q20)

magnesium metal using an aqueous

(VCAA 2010, Q20)

cell, it is true to state that

egative electrode.
cathode is negative.
he cathode.
de. (VCAA 2011, Q17)

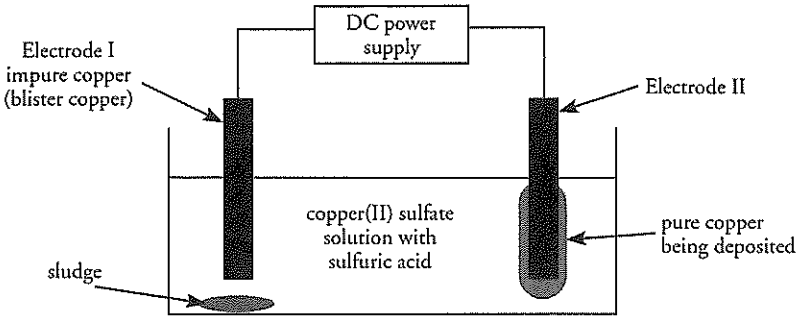
$AgNO_3$, $Fe(NO_3)_2$ and KNO_3. Equal
parate beakers, identical platinum
solution undergoes electrolysis with
SLC. Each cathode is then dried and
it the concentrations of the solutions
ing mass, the metals deposited on the

(VCAA 2013, Q30)

s 51 to 53.

pper from an impure piece of copper
1 contains both copper(II) sulfate and
I, contains impurities such as zinc,

cobalt, silver, gold, nickel and iron. The cell voltage is adjusted so that only copper is deposited on Electrode II. Sludge, which contains some of the solid metal impurities present in the blister copper, forms beneath Electrode I. The other impurities remain in solution as ions. The diagram below represents the cell.



Question 51
The solid metal impurities that are found in the sludge are

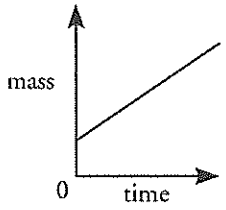
A. gold, nickel and cobalt.
B. cobalt, nickel and iron.
C. nickel and iron.
D. silver and gold. (VCAA 2015, Q28)

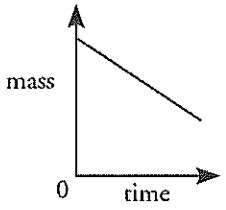
Question 52
Which of the following correctly shows both the equation for the reaction occurring at the cathode and the polarity of Electrode I?

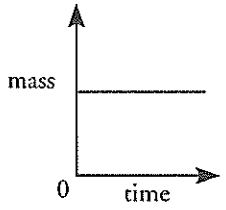
	Cathode reaction	Polarity of Electrode I
A.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	positive
B.	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	negative
C.	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	negative
D.	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	positive

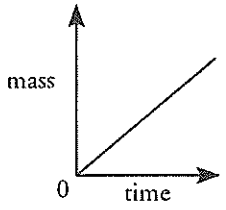
(VCAA 2015, Q29)

Question 53
Which one of the following graphs best shows the change in mass of Electrode I over a period of time, starting from the moment the power supply is connected?

A.


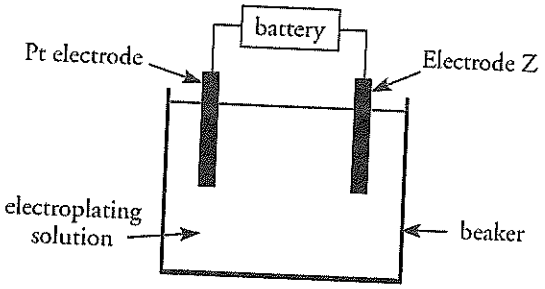
B.


C.


D.


(VCAA 2015, Q30)

Question 54
The diagram below shows the basic set-up of an electroplating cell.



Initially the cell is set up with a lead, Pb, electrode as Electrode Z and 1.0 mol L^{-1} lead nitrate, $Pb(NO_3)_2$, as the electroplating solution. The cell runs for a set time and current, with 1.0 g of Pb deposited onto Electrode Z. Four subsequent electroplating cells are set up, each containing a platinum, Pt, electrode, a different Electrode Z and an appropriate 1.0 mol L^{-1} electroplating solution. These four electroplating cells are operated for the same time and at the same current as the original Pb electroplating cell. Which combination of Electrode Z and electroplating solution would be expected to deposit **more** metal by mass onto Electrode Z than the original Pb electroplating cell?

	Electrode Z	Electroplating solution
A.	chromium, Cr	1.0 mol L^{-1} $Cr(NO_3)_3$
B.	silver, Ag	1.0 mol L^{-1} $AgNO_3$
C.	gold, Au	1.0 mol L^{-1} $AuCl_3$
D.	tin, Sn	1.0 mol L^{-1} $SnSO_4$

(VCAA 2017, Q30)

Extended Response Questions

Rate of Chemical Reactions and Equilibrium

Question 1
Carbon monoxide, CO, is a poisonous gas that is often found in the exhaust gases of motor vehicles. Carbon monoxide is poisonous because it reacts with haemoglobin, Hb, in the blood, displacing oxygen and thus depriving the body's cells of this gas. The equilibrium constant for the reaction is 220 and a simplified equation is shown below.

$$\underset{\text{oxyhaemoglobin}}{HbO_2(aq)} + CO(g) \rightleftharpoons \underset{\text{carboxyhaemoglobin}}{HbCO(aq)} + O_2(g)$$

(a) Why would the exhaust gases of a car contain carbon monoxide? (2 marks)
(b) A person suffering from carbon monoxide poisoning is treated with oxygen. Give an explanation of this treatment in terms of the principles of chemical equilibrium. (2 marks)
(c) Carbon monoxide can be fatal if about 20% of the haemoglobin in the body is converted into carboxyhaemoglobin. Determine whether an individual

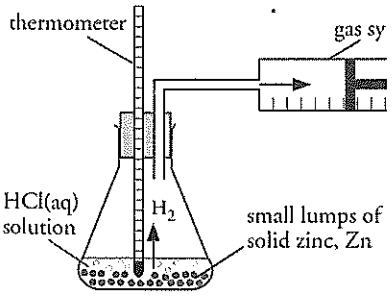
breathing polluted air with the
$[O_2]$ = 0.0075 M, is in any da

Question 2
Under certain conditions of temper
ethane can occur according to the eq

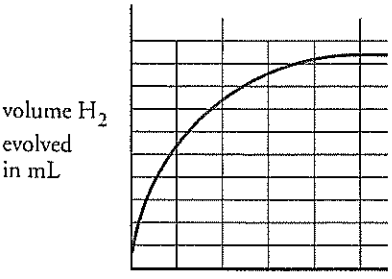
$C_2H_6(g) + O_2(g) \rightarrow 2CO(g) + 3H$

In one experiment 0.10 mol of et
equilibrium in a 1.0 L flask. 0.16 n
value for the equilibrium constant fo

Question 3
A student added 0.260 g of zinc tc
equipment shown below. The tempe
101.3 kPa.



The student noted the volume of ga
the graph shown below.



(a) Write an equation for the react
(b) Calculate the mass of hydrogen
(c) What is the maximum volume
experiment?
(d) How did the rate of evolution
reaction?
(e) Give an explanation for your ar
(f) Suggest two changes to the
evolution of hydrogen.

t_2 t_3
Time (s)

the rate of a reaction to (3 marks)
intervals indicated in the

Explanation

(VCAA 2015, Q7; total = 7 marks)

sulfur dioxide, SO_2, and oxygen, O_2,
uation below.

talyst, the reaction quickly achieves

0 mol of $O_3(g)$ was placed in a 4.00 L
) K until equilibrium was reached. At
ain 1.66 mol of $SO_3(g)$. Calculate the
(4 marks)

ges to the reaction conditions used in
ıtage yield of the product in a closed
ged, if required. What changes would
ure and volume of the system in order
Justify your answer. (4 marks)
(VCAA 2017, Q4; total = 8 marks)

lace when a current is drawn may be

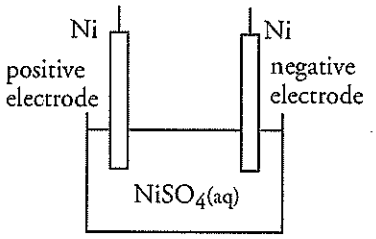
OH)

be converted into Zn^{2+}, how long could
rent of 15 mA? (Total = 4 marks)

Question 12

An electrolysis cell is constructed from two pure nickel electrodes and an aqueous solution of $NiSO_4$. The cell is used to measure the amount of electricity flowing in a circuit. The reaction at the negative electrode (cathode) is

$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$.



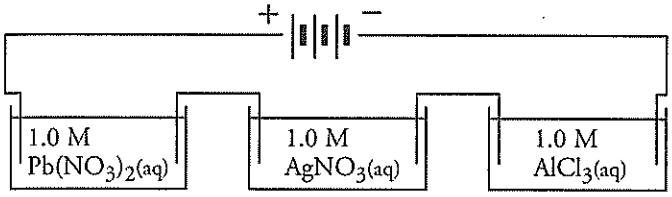
What current is required to deposit 20 mg of nickel in 30 minutes? (Total = 4 marks)

Question 13

A piece of copper can be polished by making it the anode in an electrolysis cell. If it is assumed that the only reaction occurring at the anode is the conversion of copper metal into Cu^{2+} ions, calculate the mass of copper removed from the piece of copper by a current of 9.5 A passing for 4 minutes. (Total = 4 marks)

Question 14

Three cells are connected as shown in the diagram below, and a steady current is passed for a fixed time. The aqueous solutions contain Pb^{2+}, Ag^+ and Al^{3+} respectively, and Pt electrodes are used.



(a) Write the equations for the reactions occurring at the cathode in each of the three cells. (3 marks)

(b) If 0.03 mol of silver is deposited at the cathode in the centre cell, how much material (in moles) would you expect to be produced in each of the other cells? Explain your answer. (2 marks)
(Total = 5 marks)

Question 15

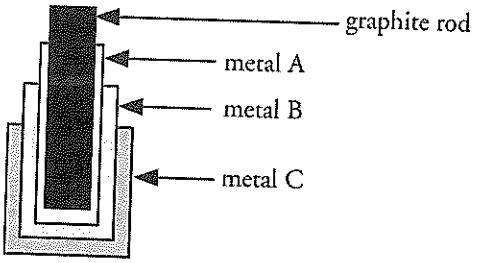
Two platinum electrodes were placed in 1.00 L of a 0.210 M $AgNO_3$ solution. An electric current of 0.57 A was passed through the solution for some time, and silver metal formed on one of the electrodes. The volume of the solution was unchanged, and the final concentration of silver ion in the solution was 0.110 M.

(a) At which electrode was the silver deposited? (1 mark)
(b) What is the polarity of this electrode? (1 mark)
(c) Calculate the time taken to deposit the silver. (4 marks)
(Total = 6 marks)

Question 16

0.75 L of an aqueous solution is prepared and contains 0.025 mol each of $SnCl_2$, $ZnCl_2$ and $CuCl_2$. Two graphite rods are placed in the solution and an electric current is passed through. When the electrolysis is finished, all of the metal ions

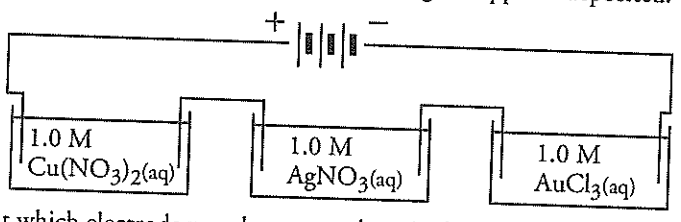
(Sn^{2+}, Zn^{2+} and Cu^{2+}) have been deposited onto one of the graphite rods. The metals form three successive coatings: A, B and C (see diagram below).



(a) Identify the three metals A, B and C. Explain your answer. (2 marks)
(b) Calculate the amount of electricity, in coulombs, needed to deposit the zinc layer alone. (3 marks)
(c) How many coulombs would be needed to deposit the other two metals? Explain your answer. (2 marks)
(Total = 7 marks)

Question 17

A student sets up a circuit for electroplating copper, silver and gold in three separate cells as shown in the diagram below. The cells are connected in series. A current flows through the circuit for 1.0 hour and 1.30 g of copper is deposited.



(a) At which electrode was the copper deposited? (1 mark)
(b) The student measures the masses of the three metals deposited in this experiment, and then calculates the moles of each metal produced. What result would you expect the student to find for the ratio 'n(Cu) : n(Ag) : n(Au)'? Explain your answer. (2 marks)
(c) Calculate the current, in amps, that flowed through the circuit. (3 marks)
(d) What were the masses of silver and gold deposited in the other two cells? (4 marks)
(Total = 10 marks)

Question 18

Electrolysis of aqueous solutions containing nickel ions, $Ni^{2+}(aq)$, leads to the formation of nickel metal on the cathode (or negative electrode). However, calcium metal cannot be produced in this way from the electrolysis of aqueous solution containing calcium ions, $Ca^{2+}(aq)$.

(a) What would you expect to occur at the cathode when an aqueous solution of calcium chloride is electrolysed? Use an equation to illustrate your answer. (2 marks)
(b) How can calcium metal be obtained from calcium chloride by electrolysis? (1 mark)
(Total = 3 marks)

C

Question 19

A student connects two cells in se
The first cell contains 2.0 M hy
second cell the student uses silver
passes a current of 2.85 A through
first cell and 2.00 g of silver is depc

(a) Draw a labelled diagram to
be set up. For each cell ind
cathode.
(b) Calculate the time for which
(c) Identify the gas formed at th
the reaction that produces th
(d) What volume of the gas in p

Question 20

A metal ornament of total surface
nickel coating of 0.0250 mm thicl
ornament is suspended in an aque
is made one of the electrodes of an

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

(a) To which electrode (cathod
(b) What volume of nickel is ne
(c) What mass of nickel will be
(Density of nickel = 8.90 g
(d) Calculate the time needed t
0.750 A is passed through th

Question 21

A student is asked to determine a
copper sulfate solution using copp
which is washed and dried at th
deposited by a current of 0.863 A

(a) Calculate a value for the Far
(b) The data table gives the v
Suggest a reason why the v
from the value in the data ta
(c) The student repeats the exp
and this time obtains a valu
student then discovers that
amounts of nickel sulfate an
have (if any) on the result?