Chemistry · Electrochemistry

Applications of Electrolysis

thanawiya-archive.com

63	3	31
questions	sets	pages

Contents

Multiple choice questions (40 questions) — Questions · p. 2 — Answers · p. 22

Essay questions (6 questions) — Questions · p. 14 — Answers · p. 27

Past exam questions (17 questions) — Questions · p. 17 — Answers · p. 28

Click a question number to jump to its answer, and an answer number to go back to the question.

thanawiya-archive.com

Multiple choice questions — 40 questions

1 Which of the following happens during the electroplating of an iron jug with a layer of gold?

(A) Mass of the negative electrode: decreases, mass of the positive electrode: increases, type of protection: anodic

(B) Mass of the negative electrode: increases, mass of the positive electrode: decreases, type of protection: anodic

(C) Mass of the negative electrode: decreases, mass of the positive electrode: increases, type of protection: cathodic

(D) Mass of the negative electrode: increases, mass of the positive electrode: decreases, type of protection: cathodic

---

2 When an iron spoon is electroplated with a layer of chromium, the reaction taking place on the surface of the spoon is .....

(A) $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$

(B) $Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$

(C) $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

(D) $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$

---

3 Each of the following shows the importance of electroplating with different metals, except .....

(A) Plating metal: Au, importance for the metal being plated: giving it a shiny appearance

(B) Plating metal: Cr, importance for the metal being plated: protecting it from rusting

(C) Plating metal: Zn, importance for the metal being plated: increasing its paramagnetic property

(D) Plating metal: Ag, importance for the metal being plated: raising its economic value

---

4 An electroplating cell was set up to plate an iron spoon with silver. After closing the electric circuit for a sufficient time, plating did not take place.

Which of the following is a reason for the plating not taking place?

(A) The cathode is the iron spoon.

(B) The anode is the silver rod.

(C) The electrolyte is silver carbonate.

(D) The material of the spoon is impure.

---

5 When a metal ring is electroplated with brass alloy, each of the following is correct except .....

(A) The mass of the anode material decreases.

(B) The electrolyte used contains Zn^{2+} , Cu^{2+}

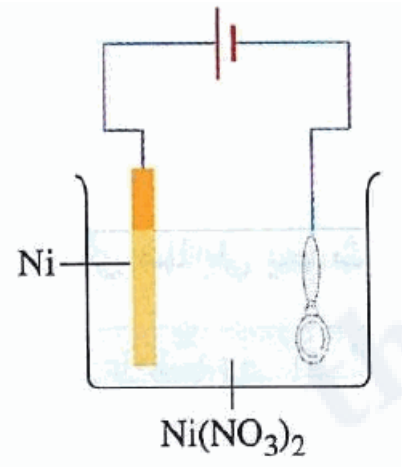
(C) The anode material is copper only.

(D) Zn^{2+} , Cu^{2+} are reduced.

---

6 From the opposite figure:

What modification should be made to the cell so that the spoon is electroplated with a layer of nickel?



(A) Replacing the electrolyte with $NiCO_3$

(B) Reversing the two poles of the electric source.

(C) Increasing the volume of the electrolyte used.

(D) Increasing the number of moles of $Ni(NO_3)_2$

---

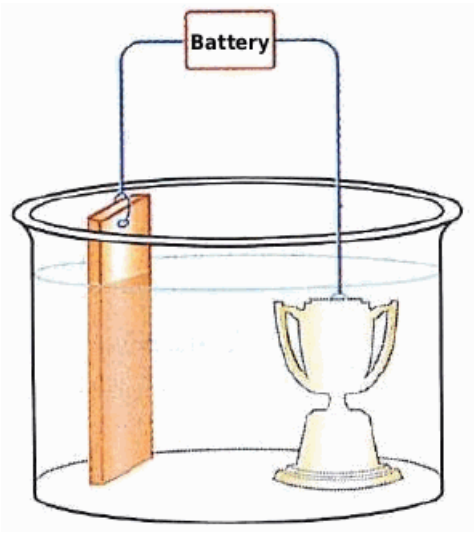
7 An iron key is to be plated with a layer of silver using a solution of a silver salt as an electrolyte.

Which of the following represents the electrode that the key acts as and the material of the other electrode, respectively?

(A) Anode / iron. (B) Anode / silver. (C) Cathode / iron. (D) Cathode / silver.

---

8 The opposite figure represents the electric cell used to plate an iron cup with a layer of gold. Each of the following describes the plating process, except .....



(A) Cathode reaction: $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$

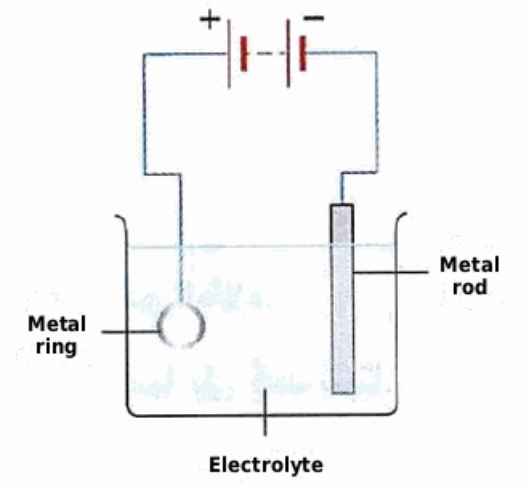
(B) The electrolyte used is $Au(NO_3)_3$ solution

(C) The cathode is the cup made of iron.

(D) Using a gold anode keeps $[Au^{3+}]$ in the electrolyte constant.

---

9 The electric circuit shown in the opposite figure is used in an electroplating process. Which of the following is correct?



(A) The metal ring is plated with a layer of the atoms of the metal rod.

(B) The metal rod acts as the reducing agent.

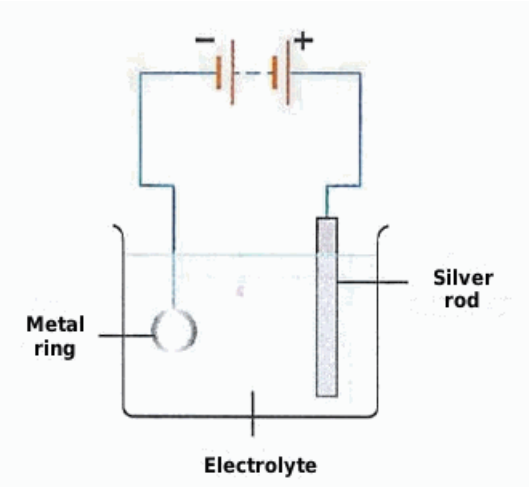
(C) The metal rod is plated with a layer of the atoms of the metal ring.

(D) The electrolyte used is a solution of a salt of the metal rod material.

---

10 In the opposite figure: a current of 3 A was passed for 60 min in the electric circuit. [Ag = 108]

What is the increase in the mass of the metal ring, and what happens to the concentration of the electrolyte at the end of the experiment?



(A) 6.04 g and the concentration of the electrolyte increases.

(B) 12.09 g and the concentration of the electrolyte does not change.

(C) 12.09 g and the concentration of the electrolyte decreases.

(D) 6.04 g and the concentration of the electrolyte does not change.

---

11 Which of the following represents the components of the electroplating cell for plating a copper spoon with a layer of nickel?

(A) Anode: nickel, cathode: the spoon, electrolyte: $NiSO_4(aq)$

(B) Anode: the spoon, cathode: nickel, electrolyte: $NiSO_4(aq)$

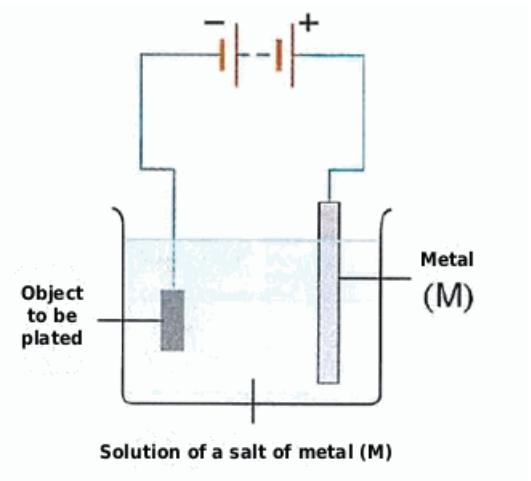
(C) Anode: nickel, cathode: the spoon, electrolyte: $CuSO_4(aq)$

(D) Anode: the spoon, cathode: nickel, electrolyte: $CuSO_4(aq)$

---

12 The cell shown in the opposite figure is used in an electroplating process. The electrolyte used in it has a volume of 1 L and a concentration of 1 M. A current of 3 A was passed for one hour.

From which metal (M) solution is the largest mass deposited on the surface of the object to be plated? [Ag = 108 , Cd = 112 , Pb = 207 , Al = 27]



(A) $AgNO_3$ (B) $Cd(NO_3)_2$ (C) $Pb(NO_3)_2$ (D) $Al(NO_3)_3$

---

13 A quantity of electricity of 2×10^{-3} F was passed in a circuit to plate a medal with a surface area of 150 cm^2 with a layer of silver.

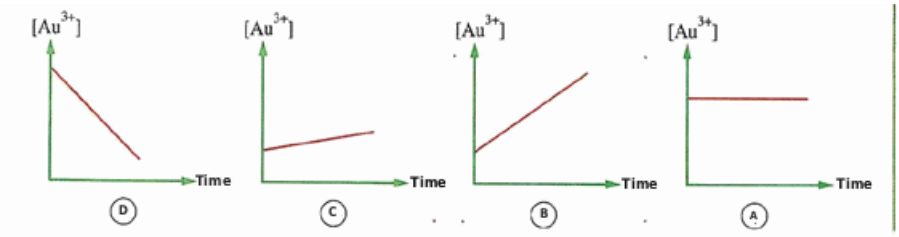
What is the number of silver atoms [Ag = 108] deposited on each 1 cm^2 of the medal?

(A) 8×10^{18} atom (B) 1.8×10^{19} atom (C) 8.7×10^{20} atom (D) 1.2×10^{21} atom

---

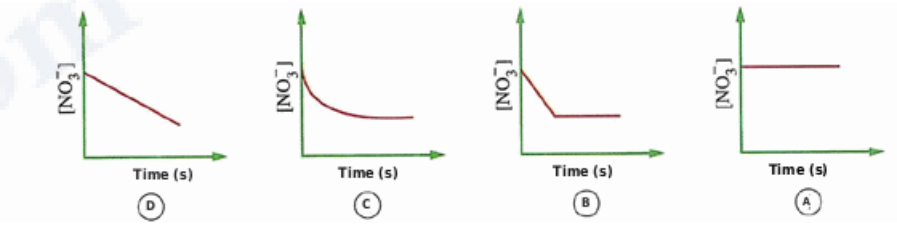
14 A gold rod is used in an aqueous solution of gold(III) chloride when plating an iron key with a layer of gold.

Which of the following graphs represents the concentration of Au^{3+} ions in the solution after some time of passing a constant current?

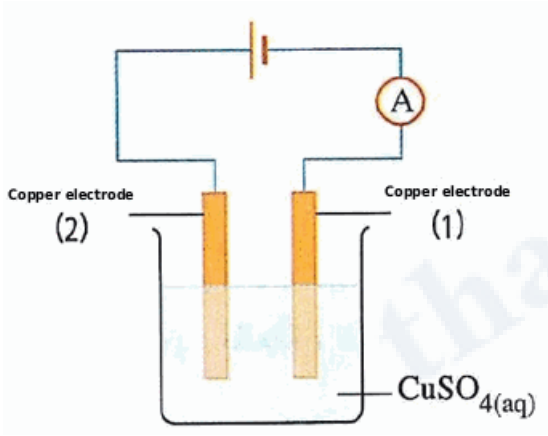


---

15 Which of the following graphs shows the change in $[NO_3^-]$ with time in the cell used in the electrolysis of silver nitrate solution using two electrodes, one of copper (Cu) and the other of silver (Ag)?



16 In the electrochemical cell shown in the opposite figure:
What is the change in the mass of the two copper electrodes (1) and (2) after operating the cell for some time?



(A) (1): increases, (2): increases.
(B) (1): decreases, (2): increases.
(C) (1): increases, (2): decreases.
(D) (1): decreases, (2): decreases.

17 Which of the following represents what is observed after the end of the electrolysis of copper(II) sulphate solution using copper electrodes?

(A) Positive electrode: corrodes, negative electrode: copper is deposited on it, electrolyte: keeps the same intensity of its blue colour

(B) Positive electrode: corrodes, negative electrode: H_2 gas is evolved at it, electrolyte: the intensity of its blue colour increases

(C) Positive electrode: H_2 gas is evolved at it, negative electrode: O_2 gas is evolved at it, electrolyte: keeps the same intensity of its blue colour

(D) Positive electrode: O_2 gas is evolved at it, negative electrode: H_2 gas is evolved at it, electrolyte: keeps the same intensity of its blue colour

18 No change in the concentration of the electrolyte takes place during electrolysis if the material of the two electrodes is (1) and the electrolyte used is (2).
Which of the following is correct?

(A) (1): graphite, (2): copper(II) sulphate solution.
(B) (1): copper, (2): copper(II) sulphate solution.
(C) (1): platinum, (2): dilute sulphuric acid.
(D) (1): graphite, (2): copper(II) chloride solution.

---

19 What is the importance of fluorspar in the cell for the electrolysis of bauxite ore?

(A) It acts as a catalyst.
(B) It increases the amount of aluminium extracted.
(C) It reduces the rate of oxidation of the anode graphite.
(D) Lowering the melting point of bauxite.

---

20 What is the importance of adding cryolite to the cell for the electrolysis of bauxite?

(A) Lowering the melting point of bauxite and reducing the rate of corrosion of the anode.
(B) Dissolving bauxite and increasing its electrical conductivity.
(C) Dissolving bauxite and removing impurities from it.
(D) Reducing the rate of corrosion of the anode and removing impurities from bauxite.

---

21 Which of the following describes the extraction of aluminium by electrolysis?

(A) Molten cryolite is used to raise the melting point of aluminium oxide.
(B) Oxygen gains electrons at the anode of the cell.
(C) Haematite is used as a source of aluminium oxide.
(D) A mixture of fluoride salts of aluminium, sodium and calcium floats above the aluminium.

---

22 Each of the following is a method of extracting metals from their ores, except .....

(A) Reduction by water gas.
(B) Reduction by carbon monoxide.
(C) Reduction by electrolysis.
(D) Reduction by carbon dioxide.

---

23 A non-transition element (A) is a component of an alloy used in making spacecraft.
Each of the following describes element (A), except .....

(A) It is one of the components of cryolite.

(B) (3 F) are needed to form one g/atom of it by the electrolysis of its molten oxide.

(C) It forms a corrosion-resistant alloy with manganese.

(D) It forms a substitutional alloy with nickel.

---

24 All of the following are correct for the extraction of aluminium by the electrolysis of molten aluminium oxide, except .....

(A) Aluminium ions are oxidized at the cathode.

(B) CO_2 gas is formed at the anode.

(C) Cryolite is added to dissolve bauxite.

(D) The electrodes of the cell are made of graphite.

---

25 Each of the following describes the extraction of aluminium from bauxite ore by electrolysis, except .....

(A) 3 F are needed per mole of aluminium.

(B) Molten cryolite is used to dissolve aluminium oxide.

(C) Oxygen gas is produced, which reacts with graphite forming CO_2 gas

(D) The rods connected to the negative pole corrode and must be replaced from time to time.

---

26 Each of the following describes the material of the anode electrodes of the cell for extracting aluminium from molten bauxite, except .....

(A) It must be replaced continuously in the aluminium extraction cell.

(B) Its oxidation produces a gas that reacts with calcium hydroxide solution.

(C) Its oxidation produces a gas that is used in the blast furnace.

(D) It is added to nickel to form steel alloy.

---

27 Iron is extracted from haematite ore and aluminium from bauxite ore.
Which of the following is common to the extraction of both iron and aluminium?

(A) Both Fe and Al are extracted using reducing agents.
(B) The ore used in each of them has the general formula M_2O_3
(C) A solvent is used when extracting each of Fe and Al by electrolysis.
(D) A flux is used in the reduction process.

---

28 A metal (X) lies between sodium and aluminium in the electrochemical series.
What is the suitable method for extracting this metal from its ores?

(A) Electrolysis of its molten oxide.
(B) Electrolysis of a solution of its carbonate.
(C) Reduction of its oxide, heated to redness, by hydrogen gas.
(D) Reduction of its oxide, heated to redness, by carbon monoxide gas.

---

29 When aluminium is extracted by the electrolysis of molten bauxite, 108 g of aluminium are formed.
What is the mass of carbon corroded from the anode electrodes? [Al = 27 , C = 12]

(A) 12 g (B) 24 g (C) 36 g (D) 48 g

---

30 44.8 L of the gaseous compound of water gas (at STP) were evolved in the extraction of aluminium by the electrolysis of molten bauxite. What is the number of moles of aluminium produced by the extraction?

(A) 1 mol (B) 2 mol (C) 4 mol (D) 6 mol

---

31 What is the maximum mass of aluminium [Al = 27] that can be formed at the cathode of a cell for the electrolysis of molten aluminium oxide if 5 mol of electrons are passed through it?

(A) 16.2 g (B) 27 g (C) 45 g (D) 135 g

---

32 The quantity of electricity that can produce 0.2 mol of O_2 gas in the electrolysis of molten aluminium oxide can also produce from molten sodium chloride an amount of sodium equal to .....

(A) 0.1 mol (B) 0.2 mol (C) 0.4 mol (D) 0.8 mol

---

33 When aluminium was extracted from bauxite, 3 mol of aluminium were produced.
Which of the following represents the quantity of electricity consumed in the cell and the number of moles of oxygen produced?

(A) 9 F , 2.25 mol (B) 9 F , 1.5 mol (C) 6 F , 2.25 mol (D) 6 F , 1.5 mol

---

34 What happens during the purification of copper by electrolysis?

(A) Copper of the anode dissolves and $[Cu^{2+}]$ does not change.

(B) Copper of the cathode dissolves and $[Cu^{2+}]$ increases.

(C) Copper of the anode dissolves and $[Cu^{2+}]$ increases.

(D) Copper of the cathode dissolves and $[Cu^{2+}]$ does not change.

---

35 The impurities found below the anode in the cell for purifying silver metal by electrolysis are .....

(A) Au , Ag , Cu , Zn (B) Au , Ag , Zn (C) Au , Ag , Cu (D) Au

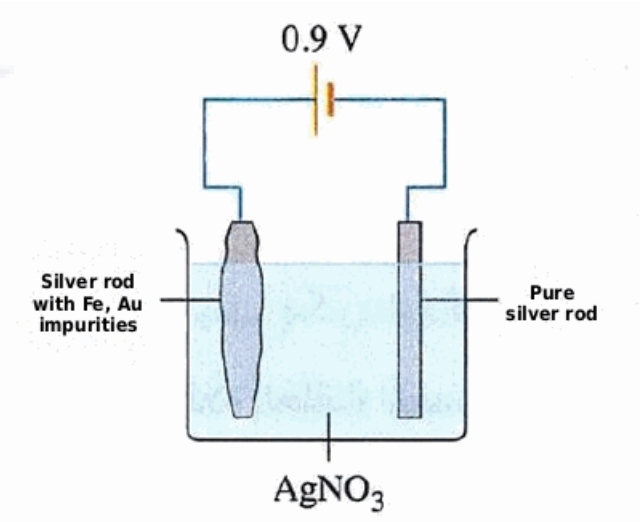
---

36 Which of the following represents the material of each of the two electrodes of the cell for purifying impure lead?

(A) Anode: graphite, cathode: impure lead.
(B) Anode: pure lead, cathode: graphite.
(C) Anode: pure lead, cathode: impure lead.
(D) Anode: impure lead, cathode: pure lead.

---

37 From the opposite electrolytic cell,
which of the following choices is correct?



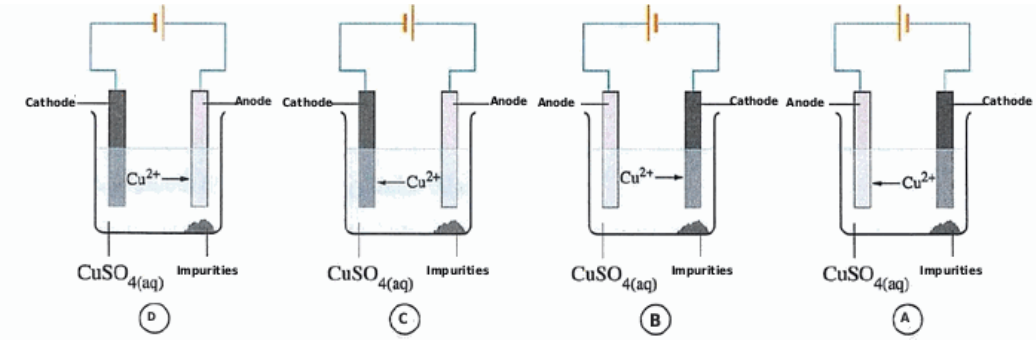
(A) Fe^{2+} ions are formed in the solution and Au^{3+} ions are reduced.

(B) Ag^{+} ions are reduced at the anode.

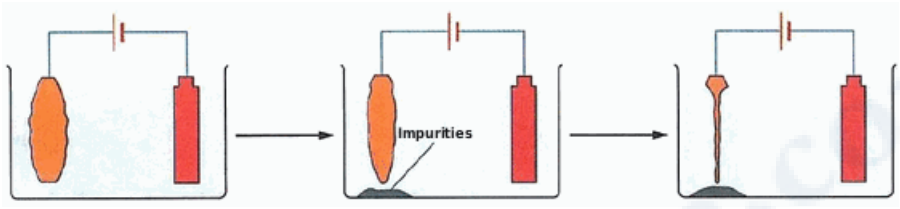
(C) Both Fe and Ag are oxidized.

(D) The mass of the positive electrode increases and $[Fe^{2+}]$ increases.

38 Which of the following represents the purification of copper metal from impurities?



39 The following figure shows the sequence of the purification of copper metal from impurities:
What is the mistake in the figure?



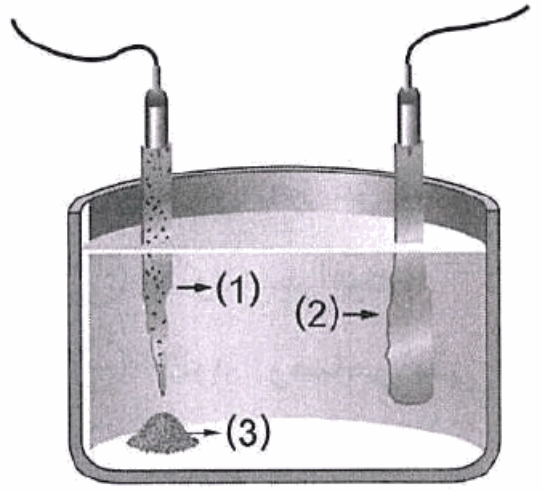
(A) The place where the impurities form.

(B) The colour of the two electrodes.

(C) The size of the (−) electrode.

(D) The size of the (+) electrode.

40 The opposite figure shows one of the applications of electrolytic cells.
Which is correct?



(A) (1): Fe^{3+} , (2): Cu^{2+} , (3): Ag and other metals.

(B) (1): Cu^{2+} , (2): Fe^{3+} , (3): Ag and other metals.

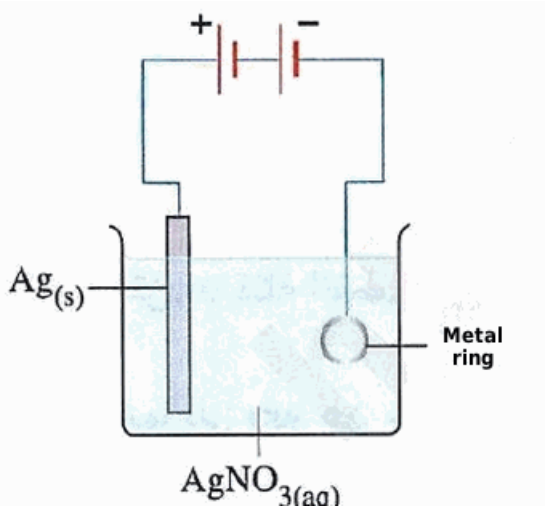
(C) (1): Fe^{3+} , (2): Cu^{2+} , (3): Mg and other metals.

(D) (1): Cu^{2+} , (2): Fe^{3+} , (3): Mg and other metals.

Essay questions — 6 questions

1 The opposite figure represents an electroplating cell.

Explain how the thickness of the plating layer on the metal ring can be controlled in the light of Faraday's first law, and write the ionic equation for the corrosion of the silver electrode.



2 Iron can be electroplated with a thin layer of chromium using chromium(III) sulphate solution as an electrolyte and a zinc plate as an anode:

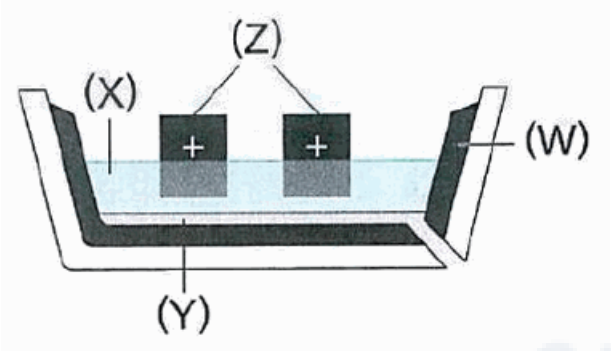
(1) Write the ionic equation for the cathode half-reaction.

(2) Why must more chromium(III) sulphate be added during this electroplating process, while no more copper(II) sulphate solution needs to be added when plating a piece of iron using a copper anode?

3 The opposite figure represents the cell for the electrolysis of bauxite ore:

(1) Which represents molten aluminium, (X) or (Y)? Why?

(2) What is the symbol of the electrode that must be replaced from time to time? Why?



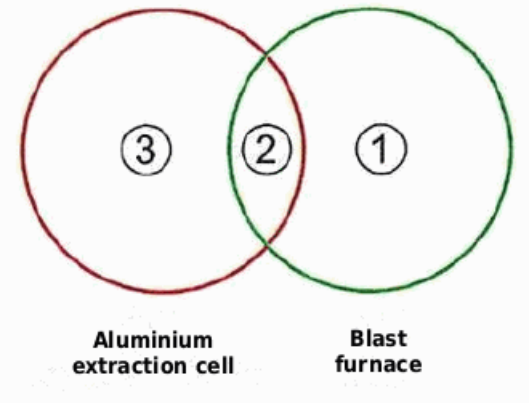
4 From the opposite Venn diagram:

(1) Write the equation for each of:

(A) Reduction reaction ①.

(B) Reduction reaction ③.

(2) What is gas ②? Write the equation for obtaining it from the thermal decomposition of an iron(II) compound.

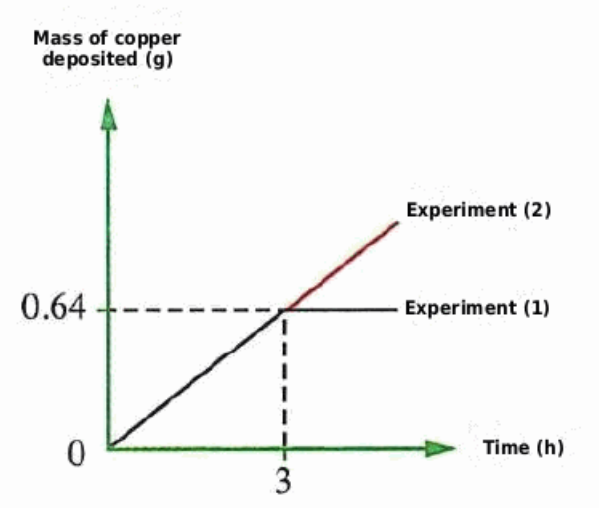


5 The opposite graph represents two experiments on the electrolysis of a $CuSO_4$ solution containing 0.64 g of Cu^{2+} ions; two copper electrodes were used in one of them and two graphite electrodes in the other.

Determine, with explanation:

(1) The two electrodes used in experiment (1).

(2) The two electrodes used in experiment (2).



6 In one of the cells used for the electrolytic purification of copper, the initial mass of the anode was 7 g and that of the cathode 15 g. Oxidizing all the copper atoms [Cu = 63.5] present in the impure copper sample used needed a quantity of electricity of 20000 C

Calculate:

(1) The final mass of the cathode.

(2) The percentage of impurities in the impure copper plate.

Past exam questions — 17 questions

1 When bauxite ore is electrolysed, which of the following statements represents the result of the reaction?

(A) Hydrogen gas is evolved at the cathode and oxygen gas at the anode.

(B) Aluminium metal is deposited at the cathode and oxygen gas is formed at the anode.

(C) Aluminium metal is deposited at the cathode and hydrogen gas is formed at the anode.

(D) Oxygen gas is evolved at the cathode and hydrogen gas is evolved at the anode.

---

2 Three metals (A , B , C) are arranged according to their strength as reducing agents as follows: (A) > (B) > (C)

Metal (B), which contains impurities of (A , C), is purified using an electrolytic cell containing an electrolyte solution of (B^{2+}) ions under suitable conditions.

Which of the following is correct?

(A) Metal (C) is oxidized during the purification process.

(B) Metal (C) is reduced during the purification process.

(C) Metal (A) is oxidized at the anode and (C) is deposited at the anode.

(D) Metal (A) is reduced at the anode and (C) is deposited at the cathode.

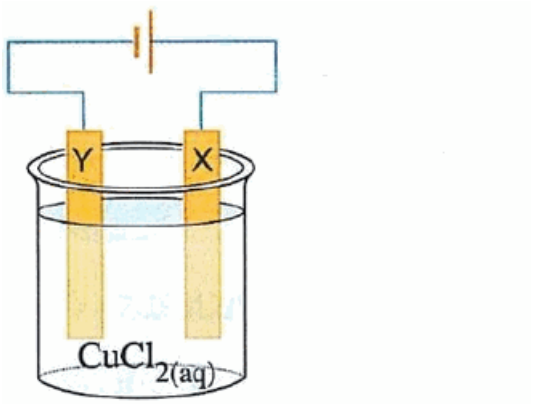
---

3 When a jug is plated with a layer of silver of mass 26.25 g by passing a current of 25 amperes through an electrolyte containing silver ions, which of the following represents the time needed to complete this process? [Ag = 108 g/mol]

(A) 14.2 minutes. (B) 15.2 minutes. (C) 15.6 minutes. (D) 13.2 minutes.

---

4 In the cell shown in the figure, the electrodes (X , Y) are made of graphite.
Which of the following describes what happens in this cell?



(A) Electrode (Y) is plated with a layer of (X).

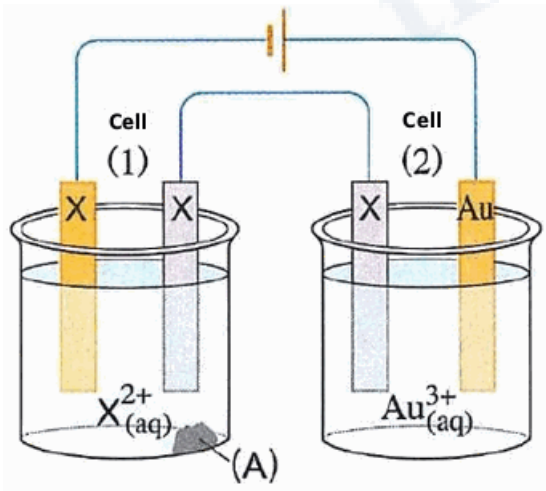
(B) The concentration of Cu^{2+} ions stays constant.

(C) The concentration of Cl^- ions stays constant.

(D) Cl_2 gas is evolved at electrode (X).

---

5 From the opposite figure:
Each of the following is correct for cells (1) and (2), except that .....



(A) cell (2) is used to plate electrode (X).

(B) cell (1) is used to purify electrode (X).

(C) the voltage of the battery is slightly greater than the standard potential of electrode (X).

(D) the oxidation potential of substance (A) is higher than the oxidation potential of electrode (X).

---

6 A copper rod containing impurities of iron and silver was purified by electrolysis.
Which of the following relationships represents the change in the masses of the electrodes after some time of passing the electric current?

(A) The decrease in the mass of the anode equals the increase in the mass of the cathode.

(B) The decrease in the mass of the anode is less than the increase in the mass of the cathode.

(C) The decrease in the mass of the anode is greater than the increase in the mass of the cathode.

(D) The decrease in the mass of the anode equals the masses of the undissolved impurities.

---

7 A metal was connected to the cathode of an electrolytic cell to plate it with chromium metal using an acidic electrolyte solution containing $Cr_2O_7^{2-}$ ions. Oxygen gas is evolved at the anode of this cell.
Which of the following represents the number of moles of gas evolved when the mass of the metal being plated increases by 151 g? [Cr = 52 , O = 16]

(A) 4.36 (B) 0.726 (C) 17.4 (D) 3.86

---

8 During the electroplating of iron with copper, an impure copper rod was used.
Which of the following represents the probable change in the masses of these electrodes at the end of the plating process?

(A) The mass of the anode decreases by 5 g, and the mass of the cathode increases by 5 g

(B) The mass of the anode decreases by 5 g, and the mass of the cathode increases by 4 g

(C) The mass of the anode increases by 5 g, and the mass of the cathode decreases by 4 g

(D) The mass of the anode increases by 4 g, and the mass of the cathode decreases by 5 g

---

9 In the electrolysis cell for extracting aluminium from bauxite, the quantity of electricity in faradays needed to evolve a gaseous mixture of carbon monoxide and carbon dioxide of 0.5 mol equals .....

(A) 3 F (B) 0.75 F (C) 1.5 F (D) 6 F

---

10 While an electric current passes through an electric cell for purifying a silver electrode containing impurities of platinum, magnesium, cadmium and gold,
which of the following is present dissolved in the solution?

(A) Ag^+ , Au^{3+} , Pt^{2+} (B) Mg , Cd (C) Ag^+ , Mg^{2+} , Cd^{2+} (D) Au , Pt

11 When a copper spoon is plated with a layer of silver,
which of the following is wrong?

(A) The spoon is connected to the current source to act as a cathode.

(B) The concentration of silver ions decreases gradually because they are reduced.

(C) Silver is a reducing agent, while silver ions are an oxidizing agent.

(D) The decrease in the mass of the silver electrode equals the increase in the mass of the spoon.

---

12 When a metal object is plated using a rod of pure gold, both immersed in gold(III) chloride solution $AuCl_3$
which of the following represents what happens to the mass of the anode and the reaction taking place at the cathode?

(A) Mass of the anode: does not change, cathode reaction: $3Cl_2 + 6e^- \rightarrow 6Cl^-$

(B) Mass of the anode: increases, cathode reaction: $2Au \rightarrow 2Au^{3+} + 6e^-$

(C) Mass of the anode: decreases, cathode reaction: $6Cl^- \rightarrow 3Cl_2 + 6e^-$

(D) Mass of the anode: decreases, cathode reaction: $2Au^{3+} + 6e^- \rightarrow 2Au$

---

13 Using the oxidation potentials in the following table:
(A): +0.52 V , (B): +0.12 V , (C): −0.34 V
To purify a metal whose reduction potential is 0.8 V, the electrolytic cell is connected to a galvanic cell made of .....

(A) C , A and A is connected to the metal to be purified.

(B) C , B and C is connected to the pure metal.

(C) B , A and B is connected to the pure metal.

(D) C , A and C is connected to the metal to be purified.

---

14 In a cell for purifying a sample of chromium containing impurities (X) and (Y), (X) and (Y) were observed to settle at the bottom of the vessel after the purification was complete, and when element (Y) is placed in a solution of a salt of element (X), the colour of the solution changes.
The correct order of the oxidation potentials of (X), (Y) and (Cr) is .....

(A) X > Cr > Y (B) Cr > X > Y (C) Y > Cr > X (D) Cr > Y > X

---

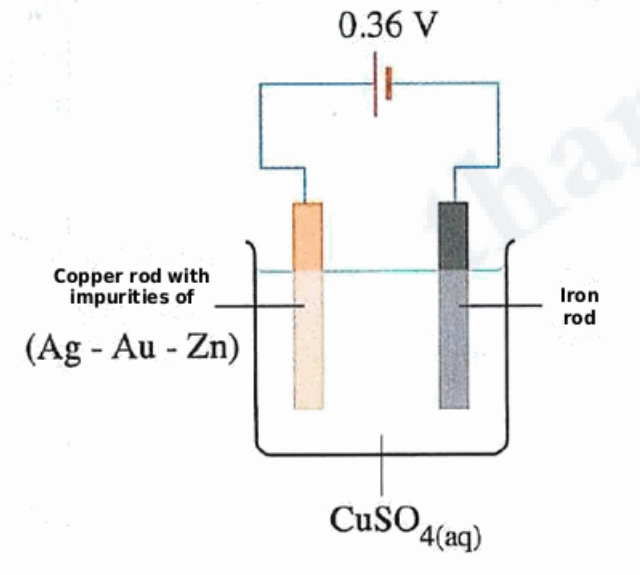
15 An impure element (X) has a reduction potential of $(-0.7\ V)$. The galvanic cell used to purify it is made of two elements (Y) and (Z)
whose reduction potentials are .....

(A) (Y): +0.029 V , (Z): −0.402 V
(B) (Y): −0.23 V , (Z): +0.029 V
(C) (Y): −1.029 V , (Z): −0.402 V
(D) (Y): −0.23 V , (Z): −1.029 V

16 When a quantity of electricity was passed through molten bauxite Al_2O_3, 44.8 L of oxygen gas (at standard conditions) were evolved.
The mass of aluminium formed is .....

(A) 108 g
(B) 54 g
(C) 27 g
(D) 72 g

17 Study the following electrolytic cell:
Which of the following choices is correct?



(A) Zn^{2+} ions are formed in the solution and Ag^{+} ions are reduced at the cathode.
(B) Cu^{2+} ions are reduced at the cathode and their concentration in the solution increases.
(C) Both Cu and Zn are oxidized at the anode and Zn^{2+} ions are reduced at the cathode.
(D) The mass of the cathode increases and the concentration of Cu^{2+} ions in the solution decreases.

Answer key and solutions

Multiple choice questions

1 D	2 B	3 C	4 C	5 C	6 C	7 D	8 A	9 C	10 B
11 A	12 A	13 A	14 A	15 A	16 C	17 A	18 B	19 D	20 B
21 D	22 D	23 D	24 A	25 D	26 D	27 B	28 A	29 D	30 C
31 C	32 D	33 A	34 A	35 D	36 D	37 C	38 C	39 C	40 A

1 **Answer (D)**

The iron jug is the cathode (negative electrode), so its mass increases as gold is deposited on it.

The gold electrode is the anode (positive electrode), so its mass decreases.

Gold is less active than iron, so the protection is cathodic.

2 **Answer (B)**

The spoon is the cathode, so chromium ions are reduced at it.

$Cr^{3+} + 3e^- \rightarrow Cr$

3 **Answer (C)**

Zinc (Zn) is used in plating to protect iron from rusting, not to increase the paramagnetic property.

The other statements are correct.

4 **Answer (C)**

Silver is plated from a solution of a dissolved silver salt such as $AgNO_3$.

Silver carbonate does not dissolve in water, so there are no Ag^+ ions to be deposited on the spoon, and plating does not take place.

5 **Answer (C)**

The anode used to plate the ring with brass (copper + zinc) is made of the brass alloy itself, not copper only.

So Cu and Zn are oxidized from it, go into the solution, and are then deposited on the ring.

6 **Answer (C)**

The anode is nickel, the cathode is the spoon, and the electrolyte is a nickel salt, so the connection is correct.

The spoon is not completely immersed in the solution (part of it is above the surface).

The volume of the electrolyte must be increased so that the whole spoon is immersed and completely plated.

7 **Answer (D)**

The object to be plated (the key) is connected to the negative pole, so it is the cathode.

The anode is made of the plating metal, which is silver.

8 **Answer (A)**

The iron cup is the cathode, where gold ions are reduced, not iron:

$Au^{3+} + 3e^- \rightarrow Au$

9 **Answer (C)**

The ring is connected to the positive pole, so it is the anode and its atoms dissolve.

The rod is connected to the negative pole, so it is the cathode and the atoms of the ring are deposited on it.

The electrolyte is a salt of the ring metal.

10 **Answer (B)**

$Q = I \times t = 3 \times 3600 = 10800\ C$

Number of moles of electrons $= 10800 \div 96500 = 0.112\ mol$

Mass of silver deposited $= 0.112 \times 108 = 12.09\ g$

The anode is silver, so the concentration of Ag^+ ions stays constant.

11 **Answer (A)**

The anode is the plating metal (nickel).

The cathode is the object to be plated (the spoon).

The electrolyte is a nickel salt solution, $NiSO_4$.

12 **Answer (A)**

$Q = 3 \times 3600 = 10800\ C = 0.112\ F$

$Ag^+ : 0.112\ mol \times 108 = 12.1\ g$

$Cd^{2+} : 0.056\ mol \times 112 = 6.3\ g$

$Pb^{2+} : 0.056\ mol \times 207 = 11.6\ g$

$Al^{3+} : 0.0373\ mol \times 27 = 1\ g$

The largest mass is of silver, $AgNO_3$.

13 **Answer (A)**

Number of moles of silver = 2×10^{-3} mol (because $Ag^+ + e^- \rightarrow Ag$)

Number of atoms = $2 \times 10^{-3} \times 6.02 \times 10^{23} = 1.2 \times 10^{21}$ atom

For each 1 cm^2 : $1.2 \times 10^{21} \div 150 = 8 \times 10^{18}$ atom

14 **Answer (A)**

The anode is gold, so an amount equal to what is deposited on the cathode dissolves from it.

So the concentration of Au^{3+} stays constant with time (a horizontal line).

15 **Answer (A)**

The anode is copper, so it is oxidized, and the cathode is silver, where Ag^+ ions are reduced.

Nitrate ions do not take part in the reaction, so their concentration stays constant (a horizontal line).

16 **Answer (C)**

In the battery symbol, the long line is the positive pole.

Electrode (2) is connected to the positive pole, so it is the anode; it is oxidized and its mass decreases.

Electrode (1) is connected to the negative pole, so it is the cathode; copper is deposited on it and its mass increases.

17 **Answer (A)**

The anode is copper, so it corrodes: $Cu \rightarrow Cu^{2+} + 2e^-$

Copper is deposited on the cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

What dissolves from the anode equals what is deposited on the cathode, so the colour of the electrolyte stays constant.

18 **Answer (B)**

In choice (B): at the anode $Cu \rightarrow Cu^{2+} + 2e^-$, and at the cathode $Cu^{2+} + 2e^- \rightarrow Cu$

The concentration of Cu^{2+} is constant.

In choices (A) and (D) the concentration of Cu^{2+} decreases, and in (C) the concentration of the acid increases due to the electrolysis of water.

19 **Answer (D)**

Fluorspar (CaF_2) is added with cryolite to lower the melting point of the bauxite mixture (to about 950°C) and save energy.

20 **Answer (B)**

Cryolite dissolves aluminium oxide and increases its electrical conductivity, because molten aluminium oxide is a poor conductor of electricity.

21 **Answer (D)**

Molten aluminium is denser, so it collects at the bottom of the cell.
A mixture of aluminium, sodium and calcium fluorides (cryolite and fluorspar) floats above it.
Oxygen, on the other hand, loses electrons at the anode: $2O^{2-} \rightarrow O_2 + 4e^-$

22 **Answer (D)**

Reduction by carbon dioxide is not an extraction method, because it is a combustion product and does not act as a reducing agent.

23 **Answer (D)**

Element (A) is aluminium.
Aluminium forms an intermetallic alloy with nickel, not a substitutional one.
The other statements are correct ($Al^{3+} + 3e^- \rightarrow Al$, so 3 F are needed per mol).

24 **Answer (A)**

At the cathode, aluminium ions are reduced: $Al^{3+} + 3e^- \rightarrow Al$
Oxidation takes place at the anode.

25 **Answer (D)**

The rods connected to the negative pole (the cathode) do not corrode.
What corrodes is the anode graphite, because the evolved oxygen reacts with it and forms CO_2.

26 **Answer (D)**

Carbon (graphite) is added to iron to form steel, not to nickel.

27 **Answer (B)**

Haematite ore (Fe_2O_3) and bauxite ore (Al_2O_3) have the general formula M_2O_3.
Aluminium is extracted by electrolysis, not by reduction; no solvent is used in extracting iron, and no flux is used in electrolysis.

28 **Answer (A)**

Metal (X) is roughly more active than aluminium, so it cannot be reduced by carbon or hydrogen.
It is extracted by the electrolysis of its molten oxide.

29 **Answer (D)**

30 **Answer (C)**

31 **Answer (C)**

$Al^{3+} + 3e^- \rightarrow Al$

3 mol of electrons form 1 mol (27 g) of aluminium.

5 mol of electrons form 5/3 mol

Mass = $5/3 \times 27 = 45$ g

32 **Answer (D)**

$2O^{2-} \rightarrow O_2 + 4e^-$

0.2 mol of O_2 needs 0.8 mol of electrons (0.8 F).

$Na^+ + e^- \rightarrow Na$

0.8 F produce 0.8 mol of sodium.

33 **Answer (A)**

$Al^{3+} + 3e^- \rightarrow Al$

3 mol of aluminium need $3 \times 3 = 9$ F

Number of moles of O_2 : $9 \div 4 = 2.25$ mol

34 **Answer (A)**

At the anode, impure copper is oxidized: $Cu \rightarrow Cu^{2+} + 2e^-$

At the cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

So the concentration of Cu^{2+} stays almost constant.

35 **Answer (D)**

In the purification of silver: copper and zinc are more active than silver, so they dissolve in the solution.

Silver itself dissolves from the anode.

Gold is less active than silver, so it is not oxidized and collects below the anode.

36 **Answer (D)**

In the purification of any metal by electrolysis:

The anode is the impure metal and the cathode is the pure metal.

37 **Answer (C)**

The anode (positive electrode) is the impure silver rod, so Fe and Ag are oxidized from it.
Gold is less active, so it is not oxidized and settles below the anode.
At the cathode, Ag^+ ions are reduced.

38 **Answer (C)**

The impurities settle below the anode, and the anode corrodes as copper dissolves from it.
Cu^{2+} ions move from the anode to the cathode, so pure copper is deposited on the cathode.
This is what figure (C) shows.

39 **Answer (C)**

In purification, the anode corrodes and the impurities collect below it.
Pure copper is deposited on the cathode, so its mass increases and its size grows.
The mistake in the figure is that the size of the $(-)$ electrode did not increase.

40 **Answer (A)**

Essay questions

1 **Model answer**

The amount of silver deposited on the cathode (the thickness of the plating layer) is directly proportional to the quantity of electricity passing through the electrolyte (silver nitrate solution).
So by increasing the quantity of electricity passing through the electrolyte (by increasing the electrolysis time at constant current), the thickness of the plating layer increases, and vice versa.
The ionic equation for the corrosion of the silver electrode: $Ag(s) \rightarrow Ag^+(aq) + e^-$

2 **Model answer**

(1) $Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$
(2) Because Cr^{3+} ions in the electrolyte are consumed while plating iron with chromium, as the zinc anode does not replace them.
Whereas the $CuSO_4$ electrolyte is not consumed when plating iron with copper, because the loss of Cu^{2+} ions is replaced by the Cu^{2+} ions produced from the oxidation of the copper anode.

3 **Model answer**

(1) (Y), because the density of molten aluminium is greater than the density of the molten electrolyte (molten bauxite in cryolite), so it settles at the bottom of the cell.

(2) (Z), because the graphite anode electrodes corrode as a result of their reaction with the oxygen evolved by the oxidation process, forming carbon monoxide and carbon dioxide gases.

4 **Model answer**

(1) (A) Reduction reaction ①: $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$ (at a temperature above 700°C)

(B) Reduction reaction ③: $2Al^{3+}(l) + 6e^- \rightarrow 2Al(l)$

(2) Gas ② is carbon dioxide, CO_2

The equation: $FeCO_3(s) \rightarrow FeO(s) + CO_2(g)$ (by heating)

5 **Model answer**

(1) The two graphite electrodes, because the mass of copper deposited on the cathode is only the mass of the Cu^{2+} ions present in the electrolyte (0.64 g), and then the mass stays constant.

(2) The two copper electrodes, because the mass of copper deposited on the cathode exceeds 0.64 g with time, as the copper anode replaces the consumed Cu^{2+} ions.

6 **Model answer**

(1) Equivalent mass of copper = 63.5 ÷ 2 = 31.75 g

Mass of copper deposited = (31.75 × 20000) ÷ 96500 = 6.58 g

Final mass of the cathode = 15 + 6.58 = 21.58 g

(2) Mass of pure copper in the anode = 6.58 g, so the mass of impurities = 7 − 6.58 = 0.42 g

Percentage of impurities = (0.42 ÷ 7) × 100 = 6 %

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	C	C	D	D	C	A	B	C	C

11	12	13	14	15	16	17
B	D	D	D	D	D	D

1 **Answer (B)**

At the cathode: $Al^{3+} + 3e^- \rightarrow Al$, so aluminium is deposited.

At the anode: $2O^{2-} \rightarrow O_2 + 4e^-$, so oxygen gas is formed.

The electrolysis is of a melt, so hydrogen gas is not formed.

2 **Answer (C)**

(A) is the most active metal, so it is oxidized at the anode and dissolves in the solution.

(C) is less active than (B), so it is not oxidized and settles below the anode.

3 **Answer (C)**

Number of moles of silver = 26.25 ÷ 108 = 0.243 mol

Quantity of electricity = 0.243 × 96500 = 23455 C

Time = 23455 ÷ 25 = 938 s = 15.6 min

4 **Answer (D)**

Electrode (X) is connected to the positive pole (the long line), so it is the anode: $2Cl^- \rightarrow Cl_2 + 2e^-$

Electrode (Y) is the cathode: $Cu^{2+} + 2e^- \rightarrow Cu$

Graphite is inert, so (Y) is not plated with (X), and the concentrations of both Cu^{2+} and Cl^- decrease.

5 **Answer (D)**

Cell (1): the anode is impure (X) and the impurities (A) collect below it, so it is a purification cell.

Cell (2): the anode is gold and the cathode is (X), so it is a gold-plating cell.

Substance (A) is not oxidized and falls below the anode, so its oxidation potential is lower than that of (X), not higher.

6 **Answer (C)**

At the anode, copper and iron are oxidized (iron is more active than copper), so the mass of the anode decreases.

Silver is less active, so it falls below the anode.

At the cathode, only copper is deposited, so its mass increases.

So the decrease in the mass of the anode is greater than the increase in the mass of the cathode.

7 **Answer (A)**

$Cr_2O_7^{2-}$: for each chromium atom $Cr^{6+} + 6e^- \rightarrow Cr$

Number of moles of chromium = 151 ÷ 52 = 2.9 mol

Number of moles of electrons = 2.9 × 6 = 17.4 mol

$2O^{2-} \rightarrow O_2 + 4e^-$: number of moles of O_2 = 17.4 ÷ 4 = 4.36 mol

8 **Answer (B)**

In plating with impure copper:

The anode loses copper and some impurities (they dissolve or fall), so its mass decreases.

Only copper is deposited on the cathode, so its mass increases.

So the decrease at the anode is greater than the increase at the cathode: 5 g versus 4 g

9 **Answer (C)**

At the anode, oxide ions are oxidized and react with carbon:

$C + O^{2-} \rightarrow CO + 2e^-$ (2 F for each 1 mol of CO)

$C + 2O^{2-} \rightarrow CO_2 + 4e^-$ (4 F for each 1 mol of CO_2)

If the mixture were 0.5 mol of CO only: $0.5 \times 2 = 1$ F

If the mixture were 0.5 mol of CO_2 only: $0.5 \times 4 = 2$ F

So the quantity of electricity lies between 1 F and 2 F, and the only value in this range is 1.5 F

10 **Answer (C)**

The impurities more active than silver (Mg , Cd) are oxidized and dissolve in the solution as ions, and silver is also oxidized.

The less active impurities (Au , Pt) are not oxidized and settle below the anode.

In the solution: Ag^+ , Mg^{2+} , Cd^{2+}

11 **Answer (B)**

The concentration of silver ions stays constant, because the silver that dissolves from the anode equals the silver deposited on the cathode.

So statement (B) is wrong.

12 **Answer (D)**

The anode is the gold rod, so its mass decreases: $Au \rightarrow Au^{3+} + 3e^-$

Gold is reduced at the cathode: $Au^{3+} + 3e^- \rightarrow Au$

13 **Answer (D)**

The metal to be purified acts as the anode in the electrolytic cell, so it is connected to the positive pole of the galvanic cell.

emf of cell (A , C) = 0.52 + 0.34 = 0.86 V, which is greater than 0.8 V

emf of cell (A , B) = 0.40 V , emf of cell (B , C) = 0.46 V

In cell (A , C), A is the anode (negative) and C is the cathode (positive).

So C is connected to the metal to be purified.

14 **Answer (D)**

(X) and (Y) settled at the bottom of the vessel, so they were not oxidized; they are less active than Cr, i.e. the oxidation potential of Cr is greater than theirs.

(Y) replaces (X) in a solution of its salt, so (Y) is more active than (X).

The order: Cr > Y > X

15 **Answer (D)**

The emf of the galvanic cell must be greater than 0.7 V

(D): emf = $-0.23 - (-1.029) = 0.799$ V

(A): 0.431 V , (B): 0.259 V , (C): 0.627 V

The only value greater than 0.7 V is (D).

16 **Answer (D)**

44.8 L ÷ 22.4 = 2 mol of O_2 gas

$2O^{2-} \rightarrow O_2 + 4e^-$

Number of moles of electrons = 2 × 4 = 8 mol

$Al^{3+} + 3e^- \rightarrow Al$

Number of moles of Al = 8 ÷ 3 mol

Mass of aluminium = 8/3 × 27 = 72 g

17 **Answer (D)**

The left electrode (impure copper) is connected to the positive pole (the long line), so it is the anode.

Cu and Zn are oxidized (they are more active than silver and gold), while Ag and Au settle below the anode.

At the cathode (iron): $Cu^{2+} + 2e^- \rightarrow Cu$, so its mass increases.

Zinc dissolves together with copper, so the concentration of Cu^{2+} in the solution decreases.