

1. Which compound is written with the oxidation state (VII)?

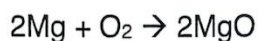
- A.  $\text{CuSO}_4$   
B.  $\text{FeSO}_4$   
C.  $\text{Fe}_2(\text{SO}_4)_3$   
D.  $\text{KMnO}_4$

+7

2. Different types of reaction are listed.

- 1 oxidation ✓  
2 decomposition  
3 combustion ✓  
4 reduction

The equation shows the reaction of magnesium with oxygen.



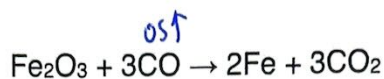
Which types of reaction does magnesium undergo in this reaction?

- A. 1 and 3  
B. 1 only  
C. 2 and 4  
D. 4 only
3. Which equation shows reduction of an iron compound?

- A.  $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$   
B.  $\text{Fe} + 2\text{HCl} \rightarrow \text{FeCl}_2 + \text{H}_2$   
C.  $4\text{FeO} + \text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$   
D.  $\overset{+3}{\text{Fe}_2\text{O}_3} + 3\text{CO} \rightarrow 2\overset{0}{\text{Fe}} + 3\text{CO}_2$

CORRECTION

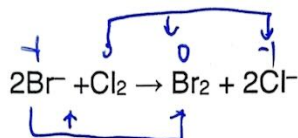
4. In a blast furnace, iron is extracted when iron(III) oxide reacts with carbon monoxide. The equation is shown.



Which substance is oxidised and which is reduced?

	oxidised	reduced
<b>A</b>	CO ✓	Fe <sub>2</sub> O <sub>3</sub> ✓
<b>B</b>	CO <sub>2</sub>	Fe
<b>C</b>	Fe	CO <sub>2</sub>
<b>D</b>	Fe <sub>2</sub> O <sub>3</sub>	CO

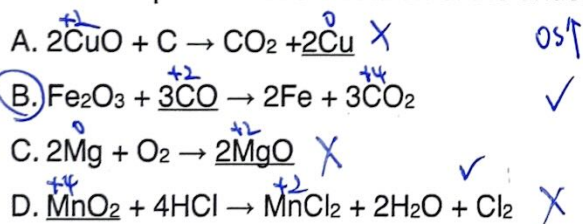
5. The ionic equation for the reaction of aqueous potassium bromide with chlorine gas is shown.



Which statement is correct?

- A. Bromide ions are oxidised by gaining electrons.  
**B.** Bromide ions are oxidised by losing electrons.  
 C. Chlorine is oxidised by gaining electrons.  
 D. Chlorine is oxidised by losing electrons.

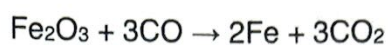
6. In which equation does oxidation of the underlined substance occur?



CORRECTION

7. Iron(III) oxide reacts with carbon monoxide.

The equation is shown.



Which substance is reduced?

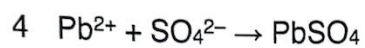
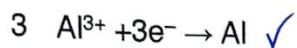
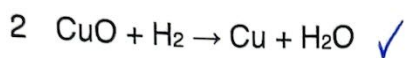
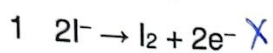
- A. CO  
 B. CO<sub>2</sub>  
 C. Fe  
 D. Fe<sub>2</sub>O<sub>3</sub>
8. Which changes represent reduction?
- 1  $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$  ✓  
 2  $\text{Mn(VII)} \rightarrow \text{Mn(II)}$  ↓ ✓  
 3  $\text{sulfate(IV)} \rightarrow \text{sulfate(VI)}$  ✗
- A. 1 and 2  
 B. 1 and 3  
 C. 1 only  
 D. 2 only

9. Which changes represent oxidation?

- 1  $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$  ✓  
 2  $\text{Cr(VI)} \rightarrow \text{Cr(III)}$  ↓ ✗  
 3  $\text{Fe(II)} \rightarrow \text{Fe(III)}$  ↑ ✓
- A. 1 and 2  
 B. 1 and 3  
 C. 1 only  
 D. 2 only

CORRECTION

10. Which changes involve reduction?



A. 1 and 2

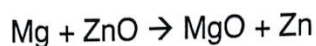
B. 1 and 4

C. 2 and 3

D. 3 and 4

11. When magnesium is heated with zinc oxide a reaction occurs.

The equation is shown.



Which substance is oxidised?

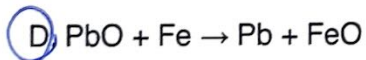
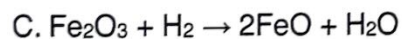
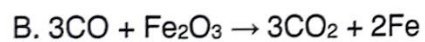
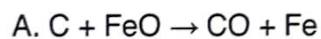
A. magnesium

B. magnesium oxide

C. zinc

D. zinc oxide

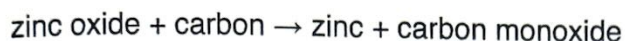
12. In which equation is the iron oxidised?



CORRECTION

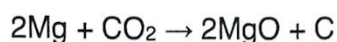


13. Zinc is formed when zinc oxide is heated with carbon.



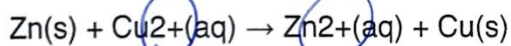
Which substance is oxidised in this reaction?

- A. carbon  
 B. carbon monoxide  
 C. zinc  
 D. zinc oxide
14. The reaction between magnesium and carbon dioxide is shown in the equation.



Which statement describes what happens in this reaction?

- A. Carbon is oxidised. X  
 B. Magnesium is reduced. X  
 C. Neither oxidation nor reduction happens. X  
 D. The carbon in carbon dioxide is reduced.
15. The ionic equation for the reaction between zinc and aqueous copper ions is shown.

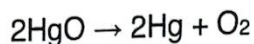


Which statement about this reaction is correct?

- A. Copper ions are oxidised and their oxidation state changes.  
 B. Copper ions are reduced because they lose electrons. X  
 C. Zinc atoms are oxidised and their oxidation state changes. ✓  
 D. Zinc atoms are reduced because they gain electrons.

CORRECTION

16. Mercury(II) oxide,  $\text{HgO}$ , decomposes when heated. The equation is shown.



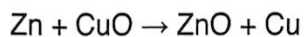
Why is this a reduction reaction?

- A. The products weigh less than the reactants.
- B. There are fewer reactants than products.
- C. There is a gain of oxygen.
- D. There is a loss of oxygen.

17. Which equation shows an oxidation reaction?

- A.  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
- B.  $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$  X
- C.  $\text{CaO} + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O}$  X
- D.  $\text{N}_2\text{O}_4 \rightarrow 2\text{NO}_2$  X

18. The equation for the reaction between zinc and copper(II) oxide is shown.



Which row shows the oxidising agent and the reducing agent?

	oxidising agent	reducing agent
A	$\text{CuO}$ ✓	$\text{Cu}$
<input checked="" type="radio"/> B	$\text{CuO}$ ✓	$\text{Zn}$ ✓
C	$\text{Zn}$	$\text{CuO}$
D	$\text{Zn}$	$\text{ZnO}$

CORRECTION

19. Chlorine displaces iodide ions from potassium iodide.



What is the oxidising agent?

A. chloride ions

**B. chlorine**

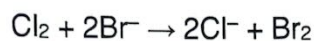
C. iodide ions

D. iodine

os ↓  
↓  
reduced

20. Chlorine displaces bromine from aqueous potassium bromide.

The ionic equation for the reaction is shown.



Which statement about this reaction is correct?

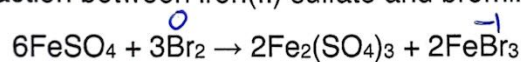
A. Bromide ions act as an oxidising agent.

**B. Bromide ions are oxidised when electrons are lost.**

C. Chlorine acts as a ~~reducing~~ agent.

D. Chlorine is ~~reduced~~ when ~~electrons~~ are lost.

21. The equation for the reaction between iron(II) sulfate and bromine is shown.



Which row identifies the oxidising agent and the reducing agent?

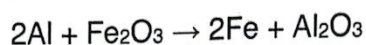
	oxidising agent	reducing agent
<b>A</b>	$\text{Br}_2$ ✓	$\text{FeSO}_4$
<b>B</b>	$\text{FeSO}_4$	$\text{Br}_2$
<b>C</b>	$\text{FeBr}_3$	$\text{Fe}_2(\text{SO}_4)_3$
<b>D</b>	$\text{Fe}_2(\text{SO}_4)_3$	$\text{FeBr}_3$

CORRECTION

铝热反应

22. The thermite reaction can be used to produce iron from iron(III) oxide.

The equation for the reaction is shown.

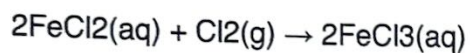


Which statements about this reaction are correct?

- 1 Aluminium is the oxidising agent. ✗
- 2 Aluminium is less reactive than iron. ✗
- 3 Electrons are transferred from aluminium to iron. ✓
- 4 The iron in the iron(III) oxide is reduced. ✓

- A. 1 and 3  
 B. 1 and 4  
 C. 2 and 3  
 D. 3 and 4

23. Iron(II) chloride solution reacts with chlorine gas. The equation is shown.



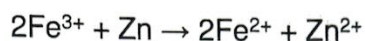
Which statements about this reaction are correct?

- 1  $\text{Fe}^{2+}$  ions are reduced to  $\text{Fe}^{3+}$  ions. ↑ ✗
- 2 Chlorine acts as a reducing agent. ✗
- 3  $\text{Fe}^{2+}$  ions each lose an electron. ✓
- 4  $\text{Cl}_2$  molecules are reduced to  $\text{Cl}^-$  ions. ✓

- A. 1 and 2  
 B. 2 and 3  
 C. 2 and 4  
 D. 3 and 4

CORRECTION

24. The equation for a redox reaction is shown.

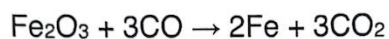


Which statements are correct?

- 1  $\text{Fe}^{3+}$  is reduce to form  $\text{Fe}^{2+}$ . ↓ ✓
- 2 Zn ~~oxidises~~ the  $\text{Fe}^{3+}$  ions.
- 3  $\text{Fe}^{3+}$  is an oxidising agent. ✓

- A. 1, 2 and 3  
 B. 1 and 2 only  
 C. 1 and 3 only  
 D. 2 and 3 only

25. In the blast furnace, iron is formed when iron(III) oxide reacts with carbon monoxide in a redox reaction.



Which substance is the oxidising agent and which substance is the reducing agent?

	oxidising agent	reducing agent
<b>A</b>	CO	$\text{Fe}_2\text{O}_3$
<b>B</b>	$\text{CO}_2$	Fe
<b>C</b>	Fe	$\text{CO}_2$
<b>D</b>	$\text{Fe}_2\text{O}_3$ ✓	CO ✓

CORRECTION



26. An excess of iron(II) chloride is added to acidified potassium manganate(VII).

Which statements are correct?

- 1 The purple colour disappears. ✓
- 2 Iron(II) is reduced to iron(III).
- 3 Manganate(VII) ions are oxidised to manganese(II) ions.
- 4 Potassium manganate(VII) is an oxidising agent. ✓

A. 1 and 2

B. 1 and 4

C. 2 and 3

D. 3 and 4

27. A solution of copper(II) sulfate can be electrolysed using copper electrodes or carbon electrodes.

Which statements are correct?

- 1 Using copper electrodes, oxygen gas forms at the anode. ✗
- 2 Using copper electrodes, copper atoms lose electrons at the anode. ✓
- 3 Using carbon electrodes, copper metal forms at the cathode. ✓
- 4 Using carbon electrodes, copper ions gain electrons at the cathode. ✓

A. 1 and 2

B. 1 and 3

C. 2, 3 and 4

D. 4 only

**CORRECTION**



28. Electrolysis of copper(II)sulfate can be done using either carbon electrodes or copper electrodes.

Which statement describes what happens at the positive electrode?

- A. Copper is deposited if the electrode is made from carbon.
- B. Copper is deposited if the electrode is made from copper.
- C. Oxygen gas is produced if the electrode is made from carbon.
- D. Oxygen gas is produced if the electrode is made from copper.

29. Which substance is not produced during the electrolysis of concentrated aqueous sodium chloride?

- A. chlorine
- B. hydrogen
- C. sodium
- D. sodium hydroxide

30. Dilute sulfuric acid and lead(II) bromide are separately electrolysed. Which statements are correct?

- 1 Colourless gases are evolved when dilute sulfuric acid is electrolysed.
- 2 Lead(II) bromide can be electrolysed when molten.
- 3 Lead is formed at the positive electrode when lead(II) bromide is electrolysed.
- 4 Sulfate ions are produced at the negative electrode when dilute sulfuric acid is electrolysed.

- A. 1 and 2 only
- B. 1 and 3 only
- C. 2 and 3 only
- D. 3 and 4 only

CORRECTION

31. Which statement about the electrolysis of copper(II) sulfate solution using carbon electrodes is correct?

- A. A colourless gas is produced at the anode. ✓  
 B. A colourless gas is produced at the cathode. ✗  
 C. The colour of the electrolyte remains the same. ✗  
 D. The mass of both electrodes remains constant. ✗

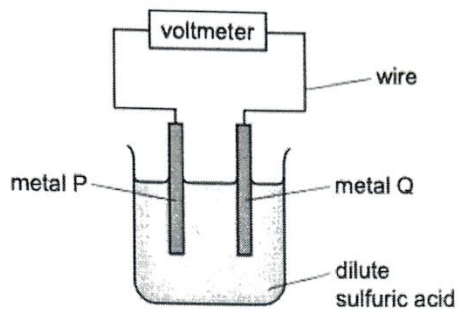
32. Which rows correctly show cathode and anode products from the electrolysis of the named electrolyte?

	electrolyte	<sup>reduction</sup> <sub>gain e<sup>-</sup></sub> cathode product	anode product
1	copper(II) sulfate solution using <u>copper electrodes</u>	copper ✓	<u>oxygen</u> ✗
2	molten lead(II) bromide	lead ✓	bromine ✓
3	dilute sodium bromide solution	hydrogen ✓	oxygen ✓
4	copper(II) sulfate solution using carbon electrodes	hydrogen ✗	oxygen

- A. 1 and 2 only  
 B. 1 and 4 only  
 C. 2 and 3 only  
 D. 3 and 4 only

CORRECTION

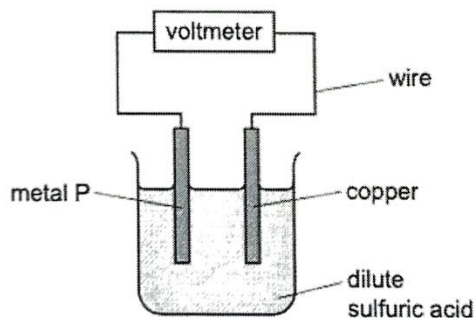
33. The diagram shows a simple cell.



Which pair of metals produces the largest voltage?

	metal P	metal Q
<b>A</b>	magnesium	iron
<b>B</b>	magnesium	copper
<b>C</b>	zinc	iron
<b>D</b>	zinc	copper

34. The diagram shows a simple cell.

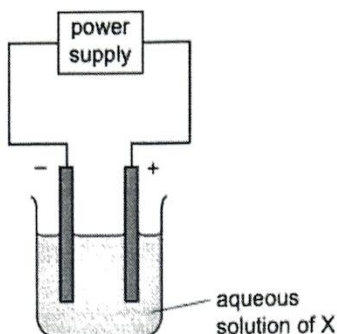


Which metal P produces the smallest voltage?

- A. calcium
- B. iron
- C. magnesium
- D. zinc

**CORRECTION**

35. The diagram shows the electrolysis of an aqueous solution of X using inert electrodes.



Hydrogen is produced at the cathode and chlorine is produced at the anode. What is X?

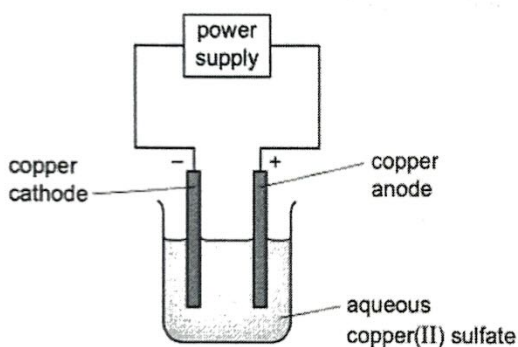
A. concentrated copper(II) chloride solution ~~X~~

B. concentrated hydrochloric acid ✓

C. dilute hydrochloric acid ~~X~~

D. dilute sodium chloride solution ~~X~~

36. An aqueous solution of copper(II) sulfate was electrolysed using copper electrodes.



Which equation for the reaction at the anode is correct?

A.  $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$

B.  $\text{Cu} + 2\text{e}^{-} \rightarrow \text{Cu}^{2+}$

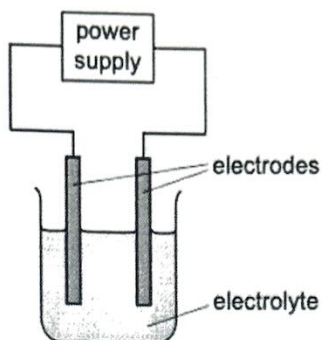
C.  $\text{Cu}^{2+} \rightarrow \text{Cu} + 2\text{e}^{-}$

D.  $\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$

*oxidation*

CORRECTION

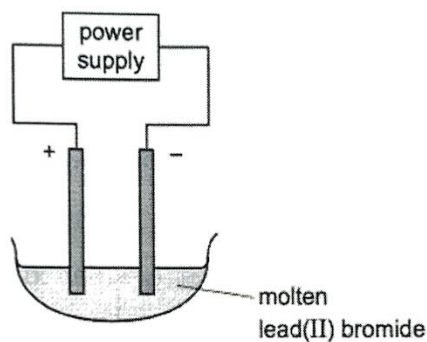
37. The apparatus used for electrolysis is shown.



Which statement is correct?

- A. Copper forms at the ~~anode~~ in some electrolysis reactions.
- B. Hydrogen forms at the cathode in some electrolysis reactions.
- C. Oxygen forms at the ~~cathode~~ in some electrolysis reactions.
- D. The negative electrode is called the ~~anode~~.

38. The electrolysis of molten lead(II) bromide is shown.



Which statement describes what happens at the negative electrode?

- A. Bromide ions ~~gain~~ electrons to form bromine molecules.
- B. Bromine molecules ~~gain~~ electrons to form bromide ions.
- C. Lead atoms lose electrons to form lead ions.
- D. Lead ions gain electrons to form lead atoms. ✓

CORRECTION



39. Which substance does not produce a gas at both electrodes during electrolysis?

- A. concentrated aqueous sodium chloride
- B. concentrated hydrochloric acid
- C. dilute sulfuric acid
- D. molten lead(II) bromide**

40. Samples of dilute sulfuric acid and concentrated hydrochloric acid are separately electrolysed.

Which row describes the product at each electrode during the electrolysis of both substances?

	product at each anode	product at each cathode
<b>A</b>	different ✓	different
<b>B</b>	different ✓	same ✓
<b>C</b>	same	different
<b>D</b>	same	same

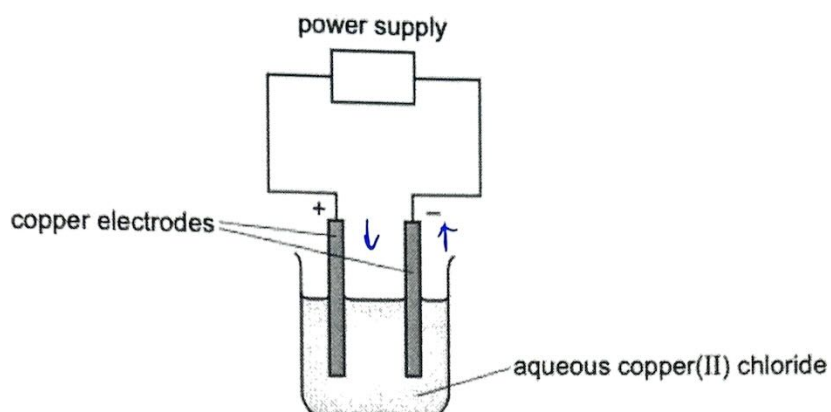
41. What is produced at each electrode when molten rubidium chloride is electrolysed using platinum electrodes?

	positive electrode	negative electrode
<b>A</b>	chlorine ✓	hydrogen ✓
<b>B</b>	chlorine	rubidium
<b>C</b>	hydrogen	chlorine
<b>D</b>	rubidium	chlorine

CORRECTION



42. Concentrated aqueous copper(II) chloride is electrolysed using copper electrodes as shown.



What happens to the mass of each electrode during this process?

	positive electrode	negative electrode
A	decreases ✓	decreases
B	decreases ✓	increases ✓
C	increases	decreases
D	increases	increases

43. Concentrated hydrochloric acid and dilute sulfuric acid were electrolysed in separate experiments using carbon electrodes.

Which statement is correct for both electrolysis experiments?

- A. Chlorine gas is produced at the positive electrode. ✗  
 B. Hydrogen gas is produced at the positive electrode.  
 C. Hydrogen gas is produced at the negative electrode. ✓  
 D. Oxygen gas is produced at the negative electrode. ✗

CORRECTION

44. During the electrolysis of concentrated aqueous sodium chloride, chlorine gas is produced at the positive electrode.

What happens at the negative electrode and to the solution?

	product at the negative electrode	the solution becomes
A	hydrogen ✓	acidic
<b>B</b>	hydrogen ✓	alkaline ✓
C	sodium	acidic
D	sodium	alkaline ✓

45. Aqueous nickel(II) sulfate is used as the electrolyte to electroplate a piece of steel with nickel.

Which materials are used as the negative electrode and positive electrode

	negative electrode	positive electrode
A	carbon	steel
B	nickel	steel
C	platinum	nickel
<b>D</b>	steel ✓	nickel ✓

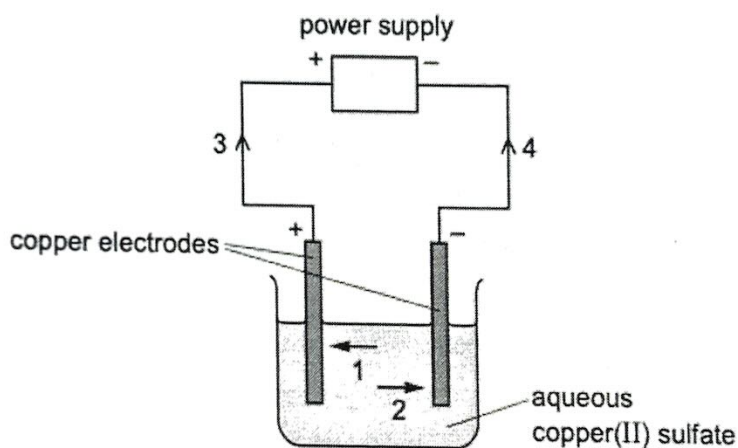
CORRECTION

46. Aqueous copper(II) sulfate is electrolysed using carbon electrodes.

What is the product at each electrode?

	product at the positive electrode	product at the negative electrode
A	copper	oxygen
B	hydrogen	oxygen
<b>C</b>	oxygen ✓	copper ✓
D	oxygen	hydrogen

47. The diagram shows a circuit used to electrolyse aqueous copper(II) sulfate.



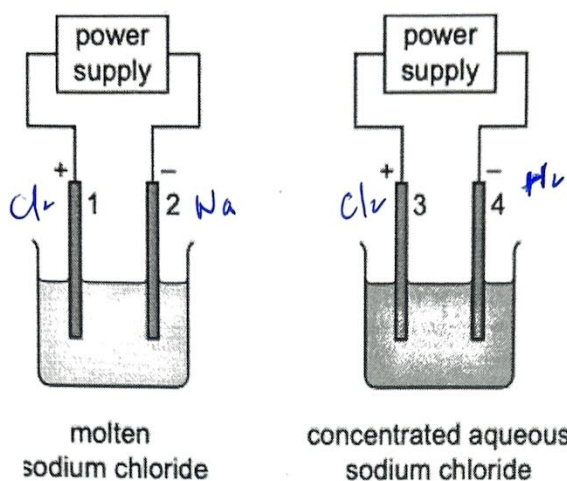
Which arrows indicate the movement of the copper ions in the electrolyte and of the electrons in the external circuit?

	copper ions	electrons
A	1	3 ✓
B	1	4
<b>C</b>	2 ✓	3 ✓
D	2	4

CORRECTION

48. Two electrolysis experiments were carried out as shown.

The graphite electrodes are labelled 1– 4.



Which row describes the products at the electrodes in these experiments?

	electrode 1	electrode 2	electrode 3	electrode 4
A	chlorine ✓	hydrogen	chlorine ✓	hydrogen ✓
<b>B</b>	chlorine ✓	sodium ✓	chlorine ✓	hydrogen ✓
C	chlorine ✓	sodium ✓	hydrogen	chlorine
D	sodium	chlorine	sodium	chlorine

49. What is observed at each electrode when molten lead(II) bromide is electrolysed using platinum electrodes?

	negative electrode	positive electrode
A	bubbles of a colourless gas	bubbles of a brown gas ✓
B	bubbles of a colourless gas	bubbles of a colourless gas
<b>C</b>	shiny grey liquid ✓	bubbles of a brown gas ✓
D	shiny grey liquid ✓	bubbles of a colourless gas

CORRECTION

50. Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement is correct?

- A. A reduction reaction occurs at the positive electrode. ✗
- B. The blue colour of the solution becomes darker. ✗
- C. The concentration of copper ions in the solution decreases. ✗
- D. The mass of the negative electrode increases. ✓

51. Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement about the electrolysis is not correct?

- A. An oxidation reaction occurs at the positive electrode. ✓
- B. The current is carried through the electrolyte by ions. ✓
- C. The negative electrode gains mass. ✓
- D. The number of copper(II) ions in the electrolyte decreases. ✗

52. Aqueous copper(II) sulfate is electrolysed using copper electrodes.

Which statement is correct?

- A. Oxygen gas is produced at the positive electrode. ✗
- B. The blue colour of the solution gradually fades. ✗
- C. The concentration of copper ions in the solution stays the same. ✓
- D. The mass of the negative electrode decreases.

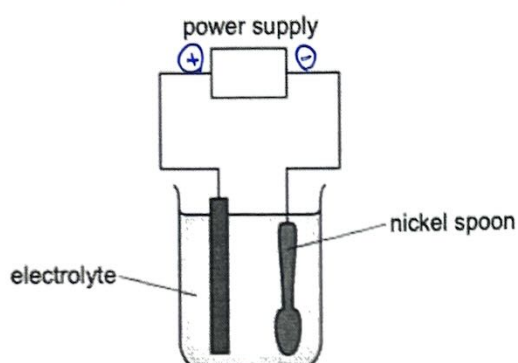
CORRECTION



53. Which statement about electrolysis reactions is correct?

- A. When concentrated aqueous sodium chloride is electrolysed, sodium forms at the cathode.
- B. When concentrated hydrochloric acid is electrolysed, a green gas forms at the cathode.
- C. When dilute sulfuric acid is electrolysed, a colourless gas forms at both electrodes.
- D. When molten lead(II) bromide is electrolysed, lead forms at the anode.

54. The diagram shows an experiment to electroplate a nickel spoon with silver.



Which row correctly describes the positive electrode, the negative electrode and the electrolyte?

	positive electrode	negative electrode	electrolyte
A	nickel spoon	pure nickel	silver nitrate solution
B	nickel spoon	pure silver	nickel nitrate solution
C	pure nickel	nickel spoon ✓	silver nitrate solution ✓
<input checked="" type="radio"/> D	pure silver ✓	nickel spoon ✓	silver nitrate solution ✓

CORRECTION



55. Which electrodes and electrolyte can be used to electroplate a copper medal with gold?

	positive electrode	negative electrode	electrolyte
A	copper	gold	an aqueous copper compound ✓
B	copper	gold	an aqueous gold compound ✓
C	gold ✓	copper ✓	an aqueous copper compound
D	gold ✓	copper ✓	an aqueous gold compound ✓

56. Four substances are electrolysed using inert electrodes. Which row describes the electrode products?

	substance	anode product	cathode product
A	concentrated aqueous sodium chloride	hydrogen ✗	chlorine
B	concentrated hydrochloric acid	chlorine ✓	oxygen ✗
C	dilute sulfuric acid	oxygen ✓	hydrogen ✓
D	molten lead bromide	lead ✗	bromine

*oxidation*

57. During the electrolysis of concentrated hydrochloric acid, gases are produced at both electrodes. Which statement describes the test result for the gas collected at the negative electrode?  $H_2$

- A. It bleaches damp litmus paper.
- B. It burns with a 'pop'.
- C. It relights a glowing splint.
- D. It turns limewater milky.

CORRECTION

58. Aqueous copper(II) sulfate is electrolysed using copper electrodes.

What are the ionic half-equations for the reactions that occur at each electrode?

	anode	cathode
<b>A</b>	$\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
<b>B</b>	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$	$\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
<b>C</b>	$4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$	$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
<b>D</b>	$4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$

59. Dilute sulfuric acid is electrolysed using inert electrodes.

What are the ionic half-equations for the reactions that take place at each electrode?

	positive electrode	negative electrode
<b>A</b>	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	$4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$
<b>B</b>	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$	$4\text{OH}^- + 4\text{H}^+ \rightarrow 4\text{H}_2\text{O}$
<b>C</b>	$4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$
<b>D</b>	$4\text{OH}^- + 4\text{H}^+ \rightarrow 4\text{H}_2\text{O}$	$2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$

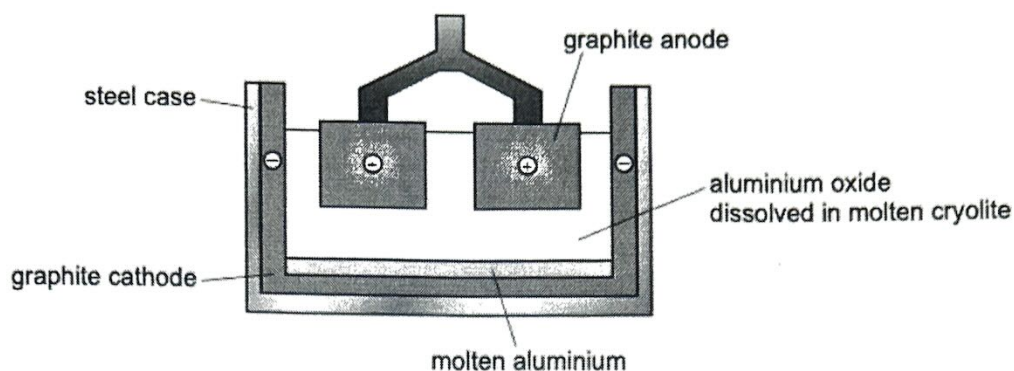
60. Aluminium metal is extracted from aluminium oxide by electrolysis.

Which ionic half-equation describes a reaction that occurs at the named electrode?

	ionic half-equation	electrode
<b>A</b>	$2\text{O}^{2-} \rightarrow \text{O}_2 + 2\text{e}^-$	anode
<b>B</b>	$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$	anode
<b>C</b>	$2\text{O}^{2-} \rightarrow \text{O}_2 + 4\text{e}^-$	cathode
<b>D</b>	$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$	cathode

CORRECTION

61. Aluminium is extracted by electrolysis as shown.



Which row shows the ionic half-equations at the cathode and the anode?

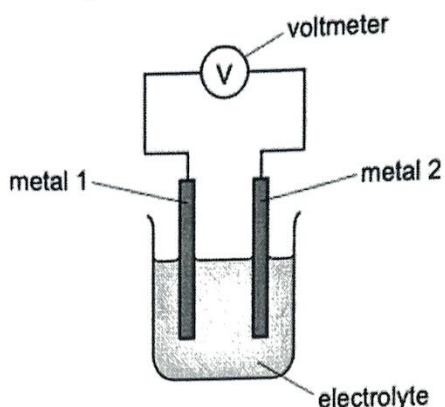
	cathode	anode
A	$Al^{3+} \rightarrow Al + 3e^{-}$	$2O^{2-} \rightarrow O_2 + 4e^{-}$
B	$Al^{3+} \rightarrow Al + 3e^{-}$	$2O^{2-} + 4e^{-} \rightarrow O_2$
C	$Al^{3+} + 3e^{-} \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4e^{-}$
D	$Al^{3+} + 3e^{-} \rightarrow Al$	$2O^{2-} + 4e^{-} \rightarrow O_2$

62. What are the ionic half-equations for the electrode reactions during the electrolysis of concentrated aqueous sodium chloride?

	anode	cathode
A	$Cl_2 + 2e^{-} \rightarrow 2Cl^{-}$	$H_2 \rightarrow 2H^{+} + 2e^{-}$
B	$2Cl^{-} \rightarrow Cl_2 + 2e^{-}$	$2H^{+} + 2e^{-} \rightarrow H_2$
C	$H_2 \rightarrow 2H^{+} + 2e^{-}$	$Cl_2 + 2e^{-} \rightarrow 2Cl^{-}$
D	$2H^{+} + 2e^{-} \rightarrow H_2$	$2Cl^{-} \rightarrow Cl_2 + 2e^{-}$

CORRECTION

63. Pairs of metals are connected together to make a simple cell, as shown.



The table shows the reading on the voltmeter when different metals are used.

		metal 2			
		beryllium	cerium	cobalt	manganese
metal 1	beryllium	0.00 V	+0.64 V	-1.57 V	-0.67 V
	cerium		0.00 V	-2.21 V	-1.30 V
	cobalt			0.00 V	+0.90 V
	manganese				0.00 V

If metal 2 is more reactive than metal 1, the voltage measured is positive.

The greater the difference in reactivity of the metals, the larger the reading on the voltmeter. What is the order of reactivity?

	most reactive	→		least reactive
<b>A</b>	cerium	beryllium	cobalt	manganese
<b>B</b>	cerium	beryllium	manganese	cobalt
<b>C</b>	cobalt	manganese	beryllium	cerium
<b>D</b>	cobalt	manganese	cerium	beryllium

**CORRECTION**



64. Which gas is used as a fuel?

- A. argon
- B. hydrogen
- C. nitrogen
- D. oxygen

65. Which statement about the combustion of fuels is correct?

- A. It always produces carbon dioxide.
- B. It always produces carbon monoxide.
- C. It is always endothermic.
- D. It is always exothermic.

66. What is released when any fuel is burned?

- A. carbon dioxide
- B. heat energy
- C. smoke
- D. water

67. Statement 1    Hydrogen is used as a fuel.

Statement 2    When hydrogen burns in the air to form water, heat energy is produced.

Which is correct?

- A. Both statements are correct and statement 2 explains statement 1.
- B. Both statements are correct but statement 2 does not explain statement 1.
- C. Statement 1 is correct but statement 2 is incorrect.
- D. Statement 2 is correct but statement 1 is incorrect.

**CORRECTION**

68. Which substance does not use oxygen to produce heat energy?

- A. coal
- B. hydrogen
- C. natural gas
- D. uranium

69. Which statement about the hydrogen fuel cell is not correct?

- A. Chemical energy is converted into electrical energy. ✓
- B. Hydrogen is oxidised. ✓
- C. The reaction that takes place is endothermic. ✗
- D. Water is the only product. ✓

70. Fuel cells are used as energy sources in cars.

Which row gives a fuel used in a fuel cell and the products formed?

	fuel in a fuel cell	products formed
<input type="radio"/> A	hydrogen ✓	carbon dioxide and water
<input checked="" type="radio"/> B	hydrogen ✓	water only ✓
<input type="radio"/> C	petrol	carbon dioxide and water
<input type="radio"/> D	petrol	water only

71. Which statement about a fuel cell in a car is correct?

- A. The fuel cell produces heat, which powers the car.
- B. The fuel cell is supplied with hydrogen directly from the air. ✗
- C. The only emission from a fuel cell is nitrogen gas, which is non-polluting.
- D. The fuel cell produces electricity, which powers an electric motor. ✓

CORRECTION



72. Hydrogen-oxygen fuel cells can be used to power cars. Platinum is used as a catalyst.

The amount of energy produced per gram is shown for three fuels.

fuel	energy produced per g of fuel/kJ
hydrogen	143
methane	55
petrol	44

Which statement is correct and is an advantage of a hydrogen-oxygen fuel cell?

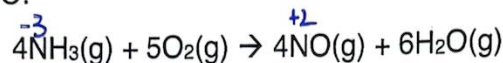
- A. Hydrogen is difficult to store. *x disadvantage*
- B. Hydrogen produces less energy per gram than methane or petrol. *x*
- C. Platinum is rare and expensive. *✓ disadvantage*
- D. The only product is water. *✓*

73. Which gases are used to generate electricity in a fuel cell?

- A. carbon dioxide and oxygen
- B. hydrogen and methane
- C. hydrogen and oxygen
- D. methane and carbon dioxide

CORRECTION

74. Ammonia reacts with oxygen at high temperatures in the presence of a suitable catalyst to form nitric oxide, NO.



(a) Explain how this chemical equation shows ammonia acting as a reducing agent.

increase in oxidation number

$\text{NH}_3$  is oxidized

$\text{NH}_3$  is reducing agent.

(b) Suggest a suitable catalyst for the reaction from the list of metals. Give a reason for your answer.

aluminium    calcium    platinum    potassium    sodium

platinum

↓  
transition metal

75. Magnesium cannot be produced by electrolysis of aqueous magnesium chloride using inert electrodes.

(a) Name the product formed at the negative electrode (cathode) during the electrolysis of aqueous magnesium chloride.

hydrogen (gas)

(b) Suggest how magnesium can be produced from magnesium chloride by electrolysis.

molten magnesium chloride



CORRECTION

76. Aqueous potassium iodide reacts with aqueous copper(II) sulfate to produce iodine.

(a) Balance the chemical equation for this reaction.



(b) Deduce the charge on the copper ion in CuI.

1+

(c) In terms of electron transfer, explain why copper is reduced in this reaction.

gains electrons

(d) Identify the reducing agent.

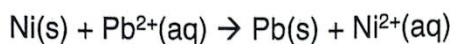
KI / I<sup>-</sup>

CORRECTION

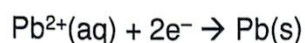
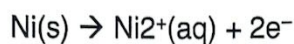
77. Displacement reactions occur between metals and metal ions.

Displacement reactions can be used to determine the order of reactivity of metals such as lead (Pb), nickel (Ni), and silver (Ag).

The ionic equation for a displacement reaction is shown.



The ionic half-equations for this reaction are shown.



The ionic half-equations show that electrons are donated by nickel atoms and accepted by lead ions.

(a) Identify the reducing agent in the displacement reaction. Give a reason for your answer.

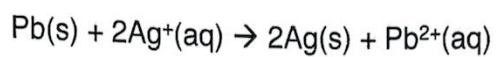
*Ni loses  $\text{e}^{-}$   $\rightarrow$  oxidation  $\rightarrow$  reducing agent*

(b) What is the general term given to the type of reaction in which electrons are transferred from one species to another?

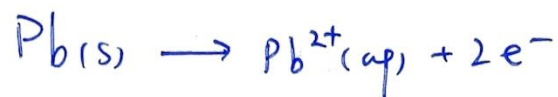
*Redox*

CORRECTION

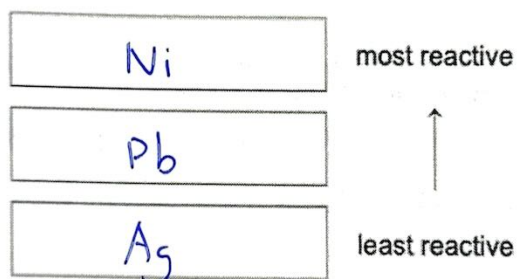
(c) The ionic equation for another displacement reaction is shown.



Write the two ionic half-equations for this reaction.



(d) Use the information in (a), (b) and (c) to put the three metals lead, nickel and silver in order of reactivity.



CORRECTION



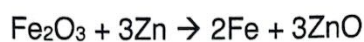
78. This question is about metals.

(a) Iron often rusts.

Name the two substances, other than iron, that must be present for iron to rust.

water  
oxygen gas (air)

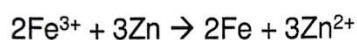
(b) Iron can be obtained by heating iron(III) oxide with zinc powder.



(i) What can be deduced about the reactivity of zinc from this reaction?

Zn is more reactive than Fe.

(ii) The ionic equation for this reaction is shown.

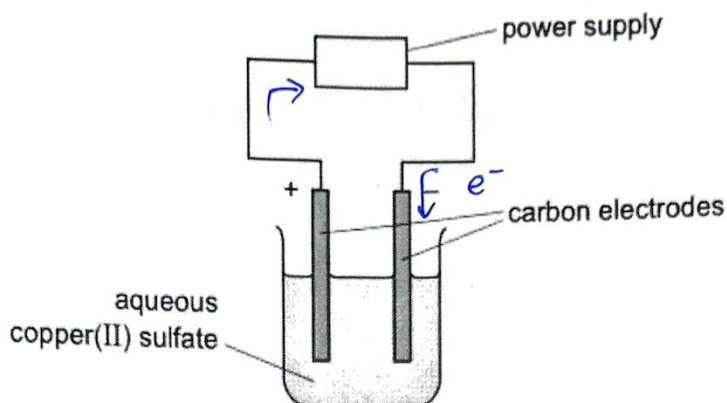


Identify the oxidising agent in this reaction. Explain your answer in terms of electron transfer.

$\text{Fe}^{3+}$   
it gains  $e^-$

CORRECTION

79. A student electrolyses aqueous copper(II) sulfate using the apparatus shown.



Oxygen gas forms at the positive electrode (anode).

(a) Write an ionic half-equation for the reaction at the negative electrode (cathode).

Include state symbols.



(b) Describe what the student observes at the negative electrode.

red-brown solid is formed.

(c) Give two other observations which the student makes during the electrolysis.

bubbles appeared on positive electrode  
color of solution fades.

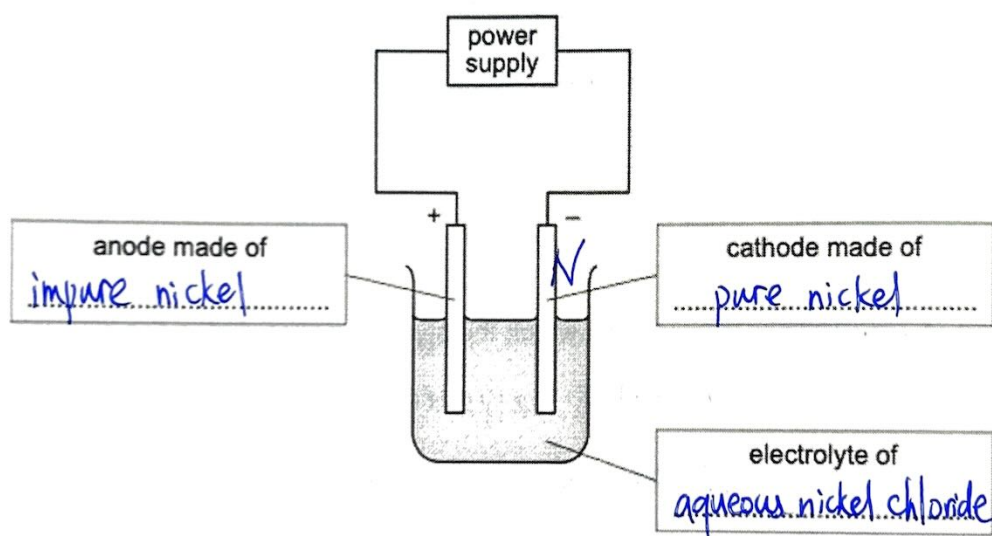
CORRECTION

- (d) What difference would the student observe at the positive electrode if the aqueous copper(II) sulfate were replaced by concentrated aqueous copper(II) chloride?

$Cl_2$  gas will be formed to show green color.

80. Copper is refined (purified) by electrolysis. Nickel can be refined using a similar method.

- (a) The diagram shows the refining of nickel by electrolysis. Complete the labels in the boxes.



- (b) Indicate, by writing N on the diagram, where nickel is produced.

CORRECTION

81. Concentrated aqueous potassium bromide is an electrolyte.

(a) What is meant by the term electrolyte?

~~substance~~ <sup>ionic compound</sup> that conducts electricity to undergo  
decomposed in molten or aq solution. electrolysis.

(b) Describe the electrolysis of concentrated aqueous potassium bromide.

Include:

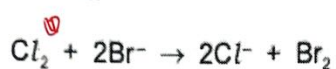
- an ionic half-equation for the reaction at the cathode  $2H^+ + 2e^- \rightarrow H_2$
- the name of the product at the anode bromine.
- the name of the potassium compound formed. potassium hydroxide.

CORRECTION

- (c) molten potassium bromide is electrolysed, the product at the cathode is different.  
Name the product at the cathode when molten potassium bromide is electrolysed.

potassium

82. When chlorine gas is passed through aqueous potassium bromide, a redox reaction occurs. The ionic equation is shown.



- (a) Write an ionic half-equation showing what happens to the chlorine molecules,  $\text{Cl}_2$ , in this reaction.



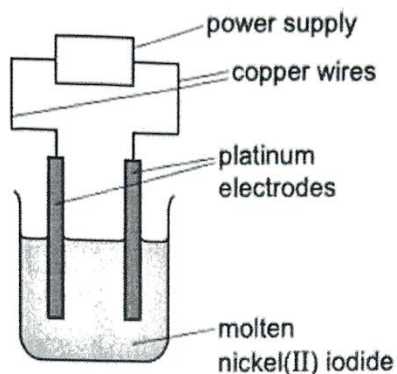
- (b) Explain why the bromide ions,  $\text{Br}^-$ , act as reducing agents in this reaction.

lose  $\text{e}^- \Rightarrow$  is oxidized.

CORRECTION



83. Molten nickel(II) iodide can be electrolysed using the apparatus shown.



During electrolysis, charge is transferred through the copper wires and through the molten nickel(II) iodide.

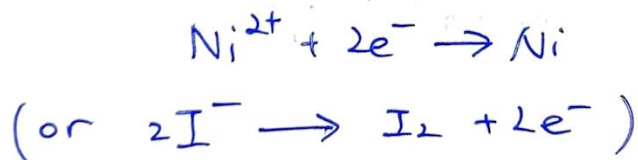
(a) Name the type of particles which transfer charge through the copper wires.

electrons

(b) Name the type of particles which transfer charge through the molten nickel(II) iodide.

ions

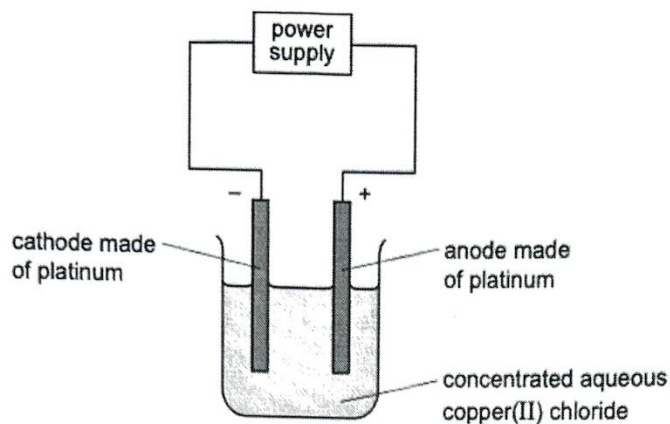
(c) Predict the products of the electrolysis of molten nickel(II) iodide. Write an ionic half-equation for the formation of one of these products.



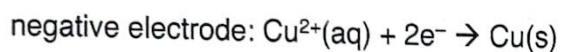
CORRECTION

84. Solutions of ionic compounds can be broken down by electrolysis.

- (a) Concentrated aqueous copper(II) chloride was electrolysed using the apparatus shown.



The ionic half-equations for the reactions at the electrodes are shown.



- (i) Platinum is a solid which is a good conductor of electricity.

State one other property of platinum which makes it suitable for use as electrodes.

*unreactive*

*cannot react during electrolysis.*

- (ii) State and explain what would happen to the mass of the negative electrode during this electrolysis.

*bubbles*

CORRECTION

- (iii) The concentrated aqueous copper(II) chloride electrolyte is green. Suggest what would happen to the colour of the electrolyte during this electrolysis. Explain your answer.

fade

copper ions removed from solution.

- (iv) Identify the species that is oxidised during this electrolysis. Explain your answer.

$\text{Cl}^-$

loss of  $e^-$  / OS  $\uparrow$

(b) Metal objects can be electroplated with silver.

- (i) Describe how a metal spoon can be electroplated with silver.

Include:

- what to use as the positive electrode and as the negative electrode
- what to use as the electrolyte
- an ionic half-equation to show the formation of silver.

spoon as cathode.

pure Ag as anode

$\text{AgNO}_3$  electrolyte



CORRECTION

- (ii) Give one reason why metal spoons are electroplated with silver.

improve appearance  
prevent corrosion.  
antibacterial

85. Iron does not rust when it is completely coated with zinc. When the zinc is scratched, the iron still does not rust.

- (a) Explain why the iron does not rust when it is completely coated with zinc.

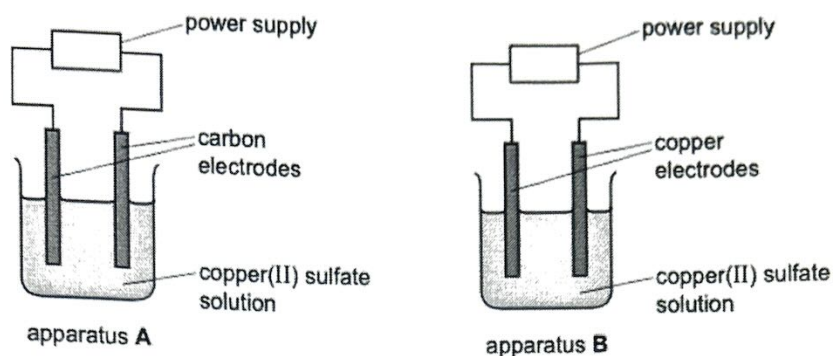
Zn acts as a barrier which prevents contact between iron and water & air

- (b) Explain why the iron still does not rust when the zinc is scratched.

comparison of reactivity: Zn is more reactive than Fe  
Zn loses  $e^-$  & oxidised  
Fe (electrical conductor) will not lose  $e^-$ .

CORRECTION

86. A student electrolysed copper(II) sulfate solution using the two sets of apparatus shown.



In apparatus A the student used carbon electrodes.

In apparatus B the student used copper electrodes.

The student made the following observations.

apparatus A	apparatus B
The mass of the negative electrode increased.	The mass of the negative electrode increased.
The mass of the positive electrode stayed the same.	The mass of the positive electrode decreased.
Bubbles were seen at the positive electrode.	No bubbles were seen at the positive electrode.

(a) Explain why the mass of the negative electrode increased in both sets of apparatus.

*Cu is formed.*

(b) Name the gas that formed the bubbles seen in apparatus A.

*oxygen*

CORRECTION



(c) Explain why the mass of the positive electrode decreased in apparatus B.

Copper is removed due to formation of ions.

(d) Suggest what happens to the colour of the solution in apparatus A and apparatus B as the electrolysis progresses.

Explain your answer.

fade in A

Copper ions removed, and <sup>do</sup> not replace.

Same color in B

Copper ions both removed and added  
(at same rate)

CORRECTION

87. This question is about electrolysis.

(a) (i) What is meant by the term electrolysis?

breakdown of ionic compound when in molten or aq solution by electricity.

(ii) Name the type of particle responsible for the conduction of electricity during electrolysis in:

the metal wires *electrons*

the electrolyte *ions.*

(b) The table gives information about the products of the electrolysis of two electrolytes.

Platinum electrodes are used in each case.

(i) Give two reasons why platinum is suitable to use as an electrode.

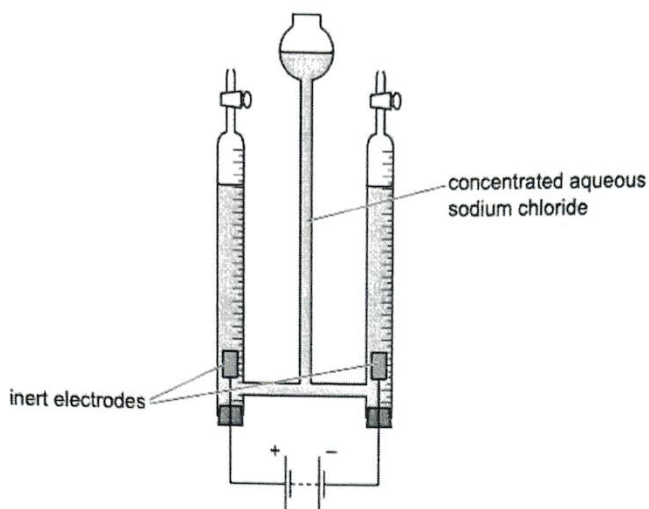
*inert*  
*conducts electricity.*

(ii) Complete the table.

electrolyte	observation at the anode (+)	name of product at the anode (+)	observation at the cathode (-)	name of product at the cathode (-)
concentrated aqueous potassium chloride	<i>green bubbles</i>	<i>Chlorine</i>	bubbles of colourless gas	<i>hydrogen</i>
aqueous copper(II) sulfate	bubbles of colourless gas	<i>oxygen</i>	<i>brown solid</i>	<i>copper</i>

CORRECTION

88. A student used the following apparatus to electrolyse concentrated aqueous sodium chloride using inert electrodes.



- (a) Suggest the name of a metal which could be used as the inert electrodes.

platinum

- (b) Name the gas formed at the positive electrode.

chlorine

- (c) Write an ionic half-equation for the reaction occurring at the negative electrode. Include state symbols.



- (d) How, if at all, does the pH of the solution change during the electrolysis? Explain your answer.

increases

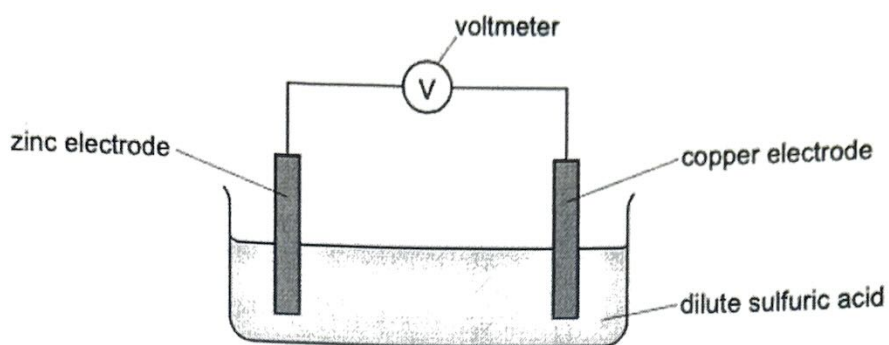
NaOH is formed

NaOH is alkali.

CORRECTION

89. A student used the following electrochemical cell.

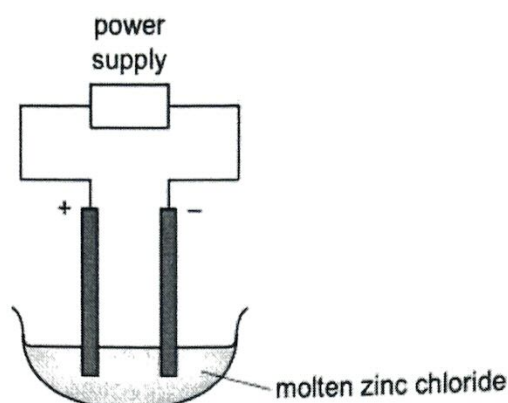
The reading on the voltmeter was  $+1.10\text{ V}$ .



- (a) Draw an arrow on the diagram to show the direction of electron flow.
- (b) Suggest the change, if any, in the voltmeter reading if the zinc electrode was replaced with an iron electrode. Explain your answer.
- (c) The zinc electrode was replaced with a silver electrode. The reading on the voltmeter was  $-0.46\text{ V}$ .  
Suggest why the sign of the voltmeter reading became negative.

**CORRECTION**

90. A chemist heated solid zinc chloride until it became molten. The apparatus shown was then used to pass electricity through the molten zinc chloride using inert electrodes.



A silver-coloured solid was formed at the negative electrode (cathode).

- (a) Name the process of breaking down a substance using electricity.

Electrolysis

- (b) A Bunsen burner was used to heat the zinc chloride.

Describe how a Bunsen burner is adjusted to give a very hot flame.

open air hole

- (c) Suggest and explain the expected observation at the positive electrode (anode).

bubbles / green gas

Chlorine

CORRECTION



(d) Suggest why iron electrodes cannot be used in this experiment.

iron is reactive & can react

(e) (i) What difference would the chemist observe at the negative electrode if aqueous zinc chloride were used, rather than molten zinc chloride?

Explain your answer.

bubble.

$H_2$

(ii) When electricity is used to break down concentrated aqueous zinc chloride, chlorine is produced at the positive electrode.

Describe a test for chlorine and state the observation.

damp litmus paper

bleached.

(f) The bottle of zinc chloride is labelled corrosive.

State one safety precaution that should be taken when using zinc chloride.

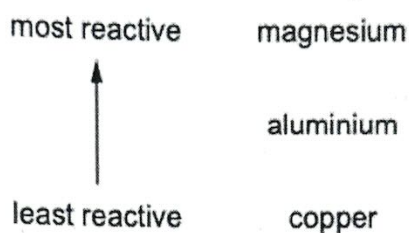
wear gloves / goggles.

CORRECTION

- (iii) The anodes are made of carbon and have to be replaced regularly.  
Explain why the carbon anodes have to be replaced regularly.

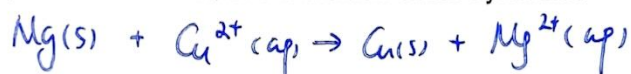
anode can react with oxygen  
to produce  $\text{CO}_2$ .

- (c) The positions of some common metals in the reactivity series are shown.



- (i) When magnesium is placed in aqueous copper(II) sulfate a displacement reaction occurs immediately.

Write an ionic equation for the reaction. Include state symbols.



- (ii) State two observations you would make when magnesium is placed in aqueous copper(II) sulfate.

blue color fades.  
red brown solid formed.  
Mg (solid) disappears

CORRECTION

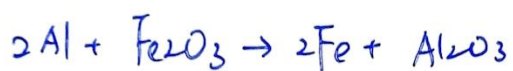
- (iii) When aluminium foil is added to aqueous copper(II) sulfate no immediate reaction takes place.

Explain why.

unreactive coating of aluminium oxide.

- (d) Aluminium powder reacts with iron(III) oxide to produce aluminium oxide and iron.

Write a chemical equation for this reaction.



CORRECTION