END-OF-TERM 1 EXAM · STRUCTURE REVIEW

Exam Structure Review

Grade 12 Advanced · Term 1

30	240	30	120
exam items	practice questions	MCQ in the exam	minutes · 100 marks

For every exam item: read the **learning outcome**, study the **explanation**, then answer the **practice questions**.

Answers are at the end of the file — check yourself only after answering.

Units: Redox Reactions · Electrochemistry · Ionic Compounds and Metals

1	Distinguish between oxidation and reduction in terms of loss and gain of electrons, oxygen a...
2	Define oxidation number
3	Define oxidizing agent and reducing agent in a redox reaction
4 · 5	Identify oxidizing agent and reducing agent in a redox reaction
6 · 10 · 11	Distinguish between oxidation and reduction in terms of change in oxidation number
7 · 8	Assign oxidation number to atoms, ions and compounds according to a set of rules
9	Determines the oxidation number of elements and compounds with more complex formulas.
12	Describe the steps for balancing redox reactions, in acidic medium, by the half-reaction met...
13	Write oxidation-half reaction and reduction-half reaction for a redox reaction
14 · 15	Balance redox reaction in acidic medium using half-reaction method
16	Describe the steps for balancing redox reactions, in basic medium, by the half-reaction meth...
17	Balance redox reaction in basic medium using half-reaction method
18	Describe an electrochemical cell while specifying its types
19	Identify components of a voltaic or galvanic cell (anode, cathode, salt bridge or porous bar...
20	Write the oxidation and reduction half-reactions occurring at cathode and anode for a voltai...
21	Define the reduction potential and standard electrode potential (E°)
22	Describe standard hydrogen electrode (SHE), while identifying the importance of its E° value...
23 · 25	Use the half-cell standard reduction potentials to calculate the electrochemical cell standa...
24	Write the cell notation and the overall chemical equation for a redox reaction occurring in ...
26	Compare between electrolytic cell and voltaic cell in terms of identifying where will reduct...
27	Describe how a spontaneous redox reaction of an electrochemical cell can be reversed
28	Write half-cell reactions while identifying the products of electrolysis of molten ionic com...
29	Write half-cell reactions while identifying the products of electrolysis of aqueous ionic co...
30	Define electroplating while describing how it works, identifying anode, cathode and electrol...

Item 1

Textbook p. 3, 4

Distinguish between oxidation and reduction in terms of loss and gain of electrons, oxygen and hydrogen

EXPLANATION

Oxidation: loss of e^- (gain of O, loss of H). **Reduction**: gain of e^- (loss of O, gain of H). *OIL RIG*.

PRACTICE QUESTIONS

1. According to the electron-transfer (new) definition, oxidation is:

A. Gain of electrons
B. Loss of oxygen
C. Gain of hydrogen
D. Loss of electrons

2. Oxidation is...

A. gain of protons
B. loss of neutrons
C. loss of electrons
D. gain of electrons

3. Which of the following best defines "Reduction"?

A. The loss of electrons by an atom.
B. An increase in the oxidation number.
C. The gain of electrons by an atom.
D. The formation of a precipitate.

4. Why must oxidation and reduction occur together?

A. electrons lost by one species must be gained by another
B. they need the same temperature
C. they produce the same product
D. because of conservation of neutrons

5. Which of the following is incorrect regarding oxidation-reduction reactions?

A. Reduction is the gain of electrons by a reactant.
B. Oxidation is the loss of electrons by a reactant.
C. Oxidation and reduction are coupled processes.
D. Oxidation occurs without reduction.

6. Which of the following describes the reduction process?

A. Loss of electrons and decrease in oxidation number.
B. Loss of electrons and increase in oxidation number.
C. Gain of electrons by the reactant and increase in oxidation number.
D. Gain of electrons and decrease in oxidation number.

7. What does the positive value E°Cu = +0.342 V indicate?

A. Cu^{2+} ions gain electrons more easily than H^+ ions

B. H^+ ions gain electrons more easily than Cu^{2+} ions

C. Oxidation occurs at the copper electrode

D. Electrons flow from copper to the hydrogen electrode

8. What does the negative value E°Zn = −0.762 V indicate?

A. Zn^{2+} ions gain electrons more easily than H^+

B. H^+ ions gain electrons more easily than Zn^{2+}

C. Oxidation at the hydrogen electrode, reduction at zinc

D. Electrons flow from the hydrogen electrode to zinc

9. According to the "LEO GER" acronym mentioned in the text, what does "LEO" stand for?

A. Loss of Energy is Oxidation

B. Loss of Electrons is Oxidation

C. Loss of Electrons is Oxygen

D. Low Energy Oxidation

10. In the reaction $Mg(s) + I_2(s) \rightarrow MgI_2(s)$, what is the change in the oxidation number of Magnesium (Mg)?

A. From 0 to +2

B. From 0 to -1

C. From +2 to 0

D. From -1 to 0

Item 2

Textbook p. 5

Define oxidation number

EXPLANATION

Oxidation number: the charge an atom would have if the electrons were transferred completely.

PRACTICE QUESTIONS

11. Booklet Q185: aluminum forms an ion with a charge of...

A. 2+

B. 1−

C. 3+

D. 2−

12. Booklet Q80: the formula for the compound formed from aluminum ions and sulfide ions is...

A. AlS

B. Al_3S_2

C. Al_2S_3

D. AlS_3

13. When $KMnO_4$ solution is added to KI solution, I^- is converted to I_2. What is the oxidation number of I in I_2, what process occurs, and how many moles of electrons are lost when 1 mol of I_2 forms?

A. 0; oxidation; 2 mol

B. 0; reduction; 1 mol

C. −1; oxidation; 2 mol

D. +1; oxidation; 1 mol

14. Booklet Q194: predict the charge of the most stable ion of P.

A. 2+ **B.** 3−
C. 3+ **D.** 1−

15. Booklet Q81: the formula for the compound formed from magnesium ions and chloride ions is...

A. $MgCl$ **B.** $MgCl_2$
C. Mg_2Cl **D.** Mg_2Cl_3

16. Why are transition metals NOT included in Table 7?

A. They do not form ions
B. Most can form several different positive ions
C. They only form negative ions
D. They are gases

17. Booklet Q200: the formula of the compound formed between strontium ions and nitride ions is...

A. SrN **B.** Sr_3N_2
C. Sr_2N_3 **D.** SrN_2

18. The oxidation number of a monatomic ion is equal to...

A. its atomic number **B.** its mass number
C. the net charge of the ion **D.** its number of neutrons

19. Booklet Q157: for a transition metal ion with more than one common charge, the value of the charge is shown by a...

Common ions of transition metals and tin/lead · الأيونات الشائعة

Copper	Cu^{+}, Cu^{2+}	Iron	Fe^{2+}, Fe^{3+}
Cobalt	Co^{2+}, Co^{3+}	Chromium	Cr^{2+}, Cr^{3+}
Manganese	Mn^{2+}, Mn^{3+}	Nickel	Ni^{2+}, Ni^{3+}
Mercury	Hg_2^{2+}, Hg^{2+}	Silver	Ag^{+}
Zinc	Zn^{2+}	Cadmium	Cd^{2+}
Tin (group 14)	Sn^{2+}, Sn^{4+}	Lead (group 14)	Pb^{2+}, Pb^{4+}

A. Roman numeral following the name **B.** prefix
C. superscript after the name **D.** suffix

20. What is the oxidation number of sodium in NaCl?

A. 1− **B.** 0
C. 1+ **D.** 2+

Item 3

Textbook p. 6

Define oxidizing agent and reducing agent in a redox reaction

EXPLANATION

Oxidizing agent is reduced (accepts e^-); **reducing agent** is oxidized (gives e^-).

PRACTICE QUESTIONS

21. Using Table 1, which species is the STRONGEST reducing agent?

Table 1 · Standard reduction potentials at 25 °C, 1 atm, 1 M · جهود الاختزال القياسية

Half-reaction	E° (V)	Half-reaction	E° (V)
$Li^+ + e^- \rightleftharpoons Li$	−3.0401	$Pb^{2+} + 2e^- \rightleftharpoons Pb$	−0.1262
$K^+ + e^- \rightleftharpoons K$	−2.931	$Fe^{3+} + 3e^- \rightleftharpoons Fe$	−0.037
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	−2.868	$2H^+ + 2e^- \rightleftharpoons H_2$	0.0000
$Na^+ + e^- \rightleftharpoons Na$	−2.71	$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.3419
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	−2.372	$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.5355
$Be^{2+} + 2e^- \rightleftharpoons Be$	−1.847	$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.771
$Al^{3+} + 3e^- \rightleftharpoons Al$	−1.662	$Ag^+ + e^- \rightleftharpoons Ag$	+0.7996
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	−1.185	$Hg^{2+} + 2e^- \rightleftharpoons Hg$	+0.851
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	−0.7618	$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.066
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	−0.744	$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+1.18
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	−0.447	$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.358
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	−0.4030	$Au^{3+} + 3e^- \rightleftharpoons Au$	+1.498
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	−0.257	$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.866
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	−0.1375		

A. F_2
B. Li
C. Li^+
D. F^-

22. In $Cl_2 + 2e^- \rightarrow 2Cl^-$, chlorine is...

A. reduced
B. oxidized
C. a catalyst
D. neither

23. For the reaction $2Br^-(aq) + Cl_2(g) \rightarrow Br_2(l) + 2Cl^-(aq)$, which statement is true?

A. Br^- is a stronger reducing agent than Cl^-.
B. Cl^- is a stronger reducing agent than Br^-.
C. Br_2 is a stronger oxidizing agent than Cl_2.
D. Br^- is a stronger oxidizing agent than Cl^-.

24. Which is the strongest oxidizing agent: Ag^+, Cu^{2+}, Zn^{2+} or Al^{3+}?

A. Ag^+
B. Cu^{2+}
C. Zn^{2+}
D. Al^{3+}

25. The oxidizing agent is the substance that...

A. is a product
B. is reduced
C. is oxidized
D. loses electrons

26. In the reaction $NH_3 + NO_2 \rightarrow N_2 + H_2O$, Nitrogen acts as:

A. Only the oxidizing agent.

B. Only the reducing agent.

C. Both the oxidizing and reducing agent (in different molecules).

D. A spectator ion.

27. Which metal can reduce Cu^{2+} ions spontaneously ($E°cell > 0$)?

A. Ag (+0.7996 V)

B. Au (+1.498 V)

C. Zn (−0.7618 V)

D. Pt (+1.18 V)

28. $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$. The reducing agent is...

A. Mg

B. Cu^{2+}

C. Mg^{2+}

D. Cu

29. In which reaction does one substance act as both the oxidizing agent and the reducing agent?

A. $Cr_2O_7^{2-} \rightarrow CrO_4^{2-}$

B. $H_2O_2 \rightarrow H_2O + OH^-$

C. $N_2O_4 \rightarrow NO_2 + NO$

30. A reducing agent is itself oxidized during a redox reaction.

A. True

B. False

Items 4 · 5

Textbook p. 5, 6, 8

Identify oxidizing agent and reducing agent in a redox reaction

EXPLANATION

$2Na + Cl_2 \rightarrow 2NaCl$: Na is oxidized → **reducing agent**; Cl_2 is reduced → **oxidizing agent**.

PRACTICE QUESTIONS

31. $Zn \rightarrow Zn^{2+} + 2e^-$ is...

A. a reduction half-reaction

B. an oxidation half-reaction

C. the salt-bridge reaction

D. not balanced

32. $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$. Which species is reduced?

A. Zn^{2+}

B. H_2

C. H^+

D. Zn

33. Can hydrochloric acid be stored safely in a copper container? (E° Cu^{2+}/Cu = +0.34 V, H^+/H_2 = 0.00 V)

A. Yes: the reaction of Cu with H^+ would have E°cell = −0.34 V, so copper is not oxidized by the acid.

B. No: copper reacts spontaneously with H^+ because E°cell = +0.34 V.

C. No: copper is a stronger reducing agent than hydrogen.

D. Yes: because HCl is not an electrolyte.

34. In the reaction 2K(s) + Cl_2(g) → 2K+(s) + 2Cl-, Chlorine causes the oxidation of Potassium. Therefore, Chlorine acts as:

A. A Reducing Agent

B. An Oxidizing Agent

C. A Spectator Ion

D. A Catalyst

35. Which is the strongest oxidizing agent?

A. Mg

B. H_2

C. F_2

D. Na

36. The following oxidation-reduction equation $2Fe^{3+}(aq) + 3Cu^{2+}(aq) \rightarrow 3Cu(s) + 2Fe^{3+}(aq)$ Using the half-reaction method in an acidic solution, the equation is

A. Unbalanced in terms of both atoms and charge.

B. Balanced correctly in terms of charge but unbalanced in terms of atoms.

C. Balanced correctly in terms of atoms but unbalanced in terms of charge.

D. Balanced correctly in terms of both atoms and charge.

37. In the reaction 2KBr + Cl_2 → 2KCl + Br_2, the Potassium ion (K+) is considered:

A. The oxidizing agent.

B. The reducing agent.

C. A spectator ion.

D. The element reduced.

38. 2Al + 3Br_2 → 2$AlBr_3$. The oxidizing agent is...

A. $AlBr_3$

B. Al^{3+}

C. Br_2

D. Al

39. Using the half-reaction method, which of the following is the balanced equation in an acidic solution? $SeO_3^{2-}(aq) + ClO_3^-(aq) \rightarrow SeO_4^{2-}(aq) + Cl_2(g)$

A. $5SeO_3^{2-}(aq) + 2ClO_3^-(aq) + 2H^+ \rightarrow 5SeO_4^{2-}(aq) + Cl_2(g) + H_2O$

B. $5SeO_3^{2-}(aq) + 2ClO_3^-(aq) + H_2O \rightarrow 5SeO_4^{2-}(aq) + Cl_2(g) + 2H^+$

C. $2SeO_3^{2-}(aq) + 5ClO_3^-(aq) + 2H^+ \rightarrow 2SeO_4^{2-}(aq) + 5Cl_2(g) + H_2O$

D. $2SeO_3^{2-}(aq) + 5ClO_3^-(aq) + H_2O \rightarrow 2SeO_4^{2-}(aq) + 5Cl_2(g) + 2H$

40. $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$ is not a redox reaction because no oxidation number changes.

A. True

B. False

Items 6 · 10 · 11

Textbook p. 5, 6, 8, 11

Distinguish between oxidation and reduction in terms of change in oxidation number

EXPLANATION

Oxidation number **increases → oxidation**; **decreases → reduction**.

PRACTICE QUESTIONS

41. Which correctly represents an electrochemical half-cell?

A. $NaNO_3$ / Zn
B. $CuSO_4$ / Cu
C. $AgNO_3$ / Ag^+
D. $CuSO_4$ / Cu^{2+}

42. Which half-reaction is most likely to be a reduction? (Mg −2.372, Ag +0.7996, Al −1.662, Hg +0.851 V)

A. $Mg^{2+} + 2e^- \rightleftharpoons Mg$
B. $Ag^+ + e^- \rightleftharpoons Ag$
C. $Al^{3+} + 3e^- \rightleftharpoons Al$
D. $Hg^{2+} + 2e^- \rightleftharpoons Hg$

43. In which reaction does the oxidation number of chromium NOT change?

A. $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$
B. $2Cr^{2+} + 2H^+ \rightarrow 2Cr^{3+} + H_2$
C. $Cr_2O_3 + 3C \rightarrow 2Cr + 3CO$
D. $(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$

44. What term describes the tendency of a substance to gain electrons?

A. Atomic number
B. Electromotive force
C. Oxidation potential
D. Reduction potential

45. In a copper–magnesium cell (E° Cu^{2+} +0.34 V, Mg^{2+} −2.37 V), which is the anode half-reaction?

A. $Mg^{2+} + 2e^- \rightarrow Mg$
B. $Cu \rightarrow Cu^+ + 2e^-$
C. $Cu \rightarrow Cu^{2+} + 2e^-$
D. $Mg \rightarrow Mg^{2+} + 2e^-$

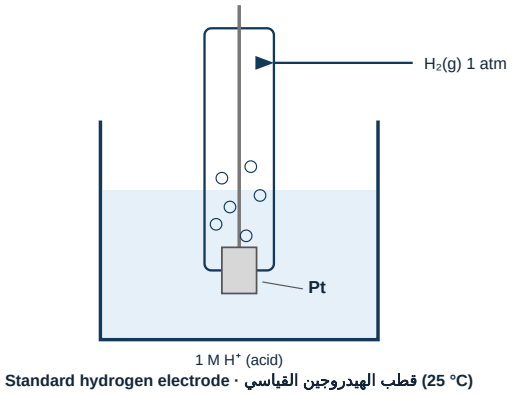
46. In $CdO(s) + CO(g) \rightarrow Cd(s) + CO_2(g)$, which elements change their oxidation numbers?

A. Cd: +2 → 0 and C: +2 → +4
B. Cd: 0 → +2 and C: +4 → +2
C. O: −2 → 0 and Cd: +2 → 0
D. Only C: +2 → +4

47. What is the change in the oxidation number of chlorine in: $2KBr(aq) + Cl_2(g) \rightarrow 2KCl(aq) + Br_2(l)$?

A. From 0 to −1
B. From −1 to 0
C. From 0 to +1
D. From +1 to 0

48. The standard $Cu^{2+}|Cu$ electrode ($E° = +0.342$ V) is connected to the SHE. Which is the oxidation half-reaction?



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

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

C. $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

D. $2H^+(aq) + 2e^- \rightarrow H_2(g)$

49. Regarding the reaction $2KBr + Cl_2 \rightarrow 2KCl + Br_2$, which is correct?

A. The oxidation number of bromine changes from −1 to 0.

B. The oxidation number of bromine changes from 0 to −1.

C. The oxidation number of chlorine changes from −1 to 0.

D. The oxidation number of chlorine changes from +2 to 0.

50. A half-cell connected to $Pt^{2+}|Pt$ (+1.18 V) gives $E°_{cell} = +3.89$ V. Which half-cell was it? (Na −2.71, Mn −1.185, Cr −0.744, Fe −0.447 V)

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

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

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

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

Items 7 · 8

Textbook p. 9, 10

Assign oxidation number to atoms, ions and compounds according to a set of rules

EXPLANATION

Rules: free element = 0; monatomic ion = its charge; O = −2 (−1 in peroxides); H = +1 (−1 in metal hydrides); F = −1; group 1 = +1, group 2 = +2.

PRACTICE QUESTIONS

51. Rule 1: in the name of an ionic compound...

A. the anion is named first

B. the cation is named first, followed by the anion

C. the larger ion is named first

D. the order does not matter

52. When a transition metal atom forms a positive ion, which electrons are usually removed first?

A. the outer s electrons
B. the 1s electrons
C. the inner p electrons
D. the d electrons

53. Gallium (Ga, $[Ar]4s^2 3d^{10} 4p^1$) forms Ga^{3+}. Its configuration is...

A. [Ar] — a true noble-gas configuration
B. [Kr]
C. $[Ar]3d^{10}$ — a pseudo-noble gas configuration
D. $[Ar]4s^2 3d^8$

54. What is the octet rule?

A. Atoms tend to gain, lose, or share electrons to acquire a full set of eight valence electrons (a noble-gas configuration).
B. Atoms always have eight electrons in total.
C. Every atom has eight energy levels.
D. Atoms tend to lose all their electrons to become stable.

55. Which of the following rules for determining oxidation numbers is incorrect?

A. The oxidation number of hydrogen in metal hydrides is 1.
B. The oxidation number of an uncombined element is zero.
C. The sum of the oxidation numbers in a neutral compound is zero.
D. The oxidation number of an element from Group 1 in the periodic table is +1.

56. Why is Cd^{2+} stable even though it does not have a noble-gas configuration?

A. It gained two electrons
B. It has a half-filled d sublevel
C. It has 8 electrons in its d sublevel
D. Its outer s, p and d sublevels are completely filled (18 electrons)

57. A pseudo-noble gas configuration is an outer arrangement of...

A. 18 electrons: $ns^2\ np^6\ nd^{10}$
B. 8 electrons: $ns^2\ np^6$
C. 2 electrons: ns^2
D. an empty outer level

58. Zinc forms Zn^{2+}. Which configuration does Zn^{2+} have?

A. $[Ar]4s^2 3d^8$
B. $[Ar]3d^{10}$
C. $[Ar]4s^2$
D. $[Ne]3s^2 3p^6$

59. How many electrons are in the outer levels of an ion with a pseudo-noble gas configuration?

A. 8
B. 18
C. 2
D. 10

60. Which ion has a pseudo-noble gas configuration?

A. Cl^-
B. Mg^{2+}
C. Ag^+
D. Na^+

Item 9

Textbook p. 9, 10

Determines the oxidation number of elements and compounds with more complex formulas.

EXPLANATION

Harder formulas: Cr in $K_2Cr_2O_7$ → $2(+1) + 2Cr + 7(-2) = 0$ → **+6**; Mn in MnO_4^- → **+7**.

PRACTICE QUESTIONS

61. When more than one polyatomic ion is needed in a formula, you should...

Common polyatomic ions · أيونات عديدة الذرات الشائعة

Ammonium	NH_4^+	Acetate	CH_3COO^-
Nitrite	NO_2^-	Sulfite	SO_3^{2-}
Nitrate	NO_3^-	Sulfate	SO_4^{2-}
Hydroxide	OH^-	Carbonate	CO_3^{2-}
Cyanide	CN^-	Chromate	CrO_4^{2-}
Permanganate	MnO_4^-	Dichromate	$Cr_2O_7^{2-}$
Hydrogen carbonate	HCO_3^-	Hydrogen phosphate	HPO_4^{2-}
Hypochlorite	ClO^-	Oxalate	$C_2O_4^{2-}$
Chlorite	ClO_2^-	Peroxide	O_2^{2-}
Chlorate	ClO_3^-	Phosphate	PO_4^{3-}
Perchlorate	ClO_4^-	Phosphite	PO_3^{3-}
Dihydrogen phosphate	$H_2PO_4^-$		

A. change the subscripts inside the ion
B. place the ion in parentheses and write the subscript outside
C. write the ion twice
D. add a Roman numeral

62. The formula of the compound formed from ammonium (NH_4^+) and oxide (O^{2-}) is...

A. NH_4O
B. N_2H_8O
C. $(NH_4)_2O$
D. NH_4O_2

63. An oxyanion is a polyatomic ion composed of...

Use the figure above

A. a metal bonded to hydrogen
B. an element, usually a nonmetal, bonded to one or more oxygen atoms
C. two metals
D. oxygen only

64. Booklet Q164: an -ate or -ite at the end of a compound name usually indicates that the compound contains...

A. only two elements
B. fewer electrons than protons
C. a polyatomic anion
D. neutral molecules

65. What is the sum of the oxidation numbers in a neutral compound?

- **A.** Greater than zero
- **B.** Equal to zero
- **C.** Less than zero
- **D.** Varies depending on the compound's formula.

66. What is the oxidation number of the underlined element in the following formula? $B_4O_7^{2-}$

- **A.** +3
- **B.** -3
- **C.** +4
- **D.** -4

67. Book Q23 (Challenge): general formula for a compound of a group 2 element (M) and a group 17 element (X)

- **A.** MX
- **B.** M_2X
- **C.** MX_2
- **D.** M_2X_3

68. Booklet Q215: the charge on manganese in $MnCl_3$ is...

- **A.** 1+
- **B.** 2+
- **C.** 2−
- **D.** 3+

69. Flowchart: for Na_3PO_4, the answer to "does the cation have only one oxidation number?" is...

- **A.** Yes — sodium has only one, so: sodium phosphate
- **B.** No — so: sodium(III) phosphate
- **C.** Yes — so: trisodium phosphate
- **D.** No — so: sodium(I) phosphide

70. Booklet Q221: which metal can form more than one cation?

- **A.** Li
- **B.** Ba
- **C.** Sr
- **D.** Al
- **E.** Sn

Item 12

Textbook p. 17

Describe the steps for balancing redox reactions, in acidic medium, by the half-reaction method

EXPLANATION

Acidic medium: split into half-reactions → balance atoms except O and H → O with **H_2O** → H with **H^+** → charge with **e^-** → equalize e^- → add and cancel.

PRACTICE QUESTIONS

71. To balance oxidation-reduction reactions that occur in an acidic medium, you must add

A. OH^- & H_2O
B. H^+ & H_2O
C. OH^- only
D. H_2O only

72. The coefficients of the two half-reactions are adjusted so that... (Final 2024)

A. electrons lost in oxidation equal electrons gained in reduction
B. electrons lost are double electrons gained
C. electrons lost are greater than electrons gained
D. electrons lost are fewer than electrons gained

73. Using the half-reaction method, which is the correctly balanced equation in acidic solution? $Cr_2O_7^{2-}(aq) + I^-(aq) \rightarrow Cr^{3+}(aq) + I_2(s)$

A. $Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$
B. $Cr_2O_7^{2-} + 6I^- + 7H_2O \rightarrow 2Cr^{3+} + 3I_2 + 14H^+$
C. $Cr_2O_7^{2-} + 2I^- + 14H^+ \rightarrow 2Cr^{3+} + I_2 + 7H_2O$
D. $2Cr_2O_7^{2-} + 6I^- + 28H^+ \rightarrow 4Cr^{3+} + 3I_2 + 14H_2O$

74. $ClO_3^- + SO_2 \rightarrow Cl^- + SO_4^{2-}$ (acidic). Which is balanced? (Final 2023)

A. $3SO_2 + ClO_3^- + 3H_2O \rightarrow 3SO_4^{2-} + Cl^- + 6H^+$
B. $3SO_2 + ClO_3^- + 6H^+ \rightarrow 3SO_4^{2-} + Cl^- + 3H_2O$
C. $2SO_2 + 3ClO_3^- + 6H^+ \rightarrow 2SO_4^{2-} + 3Cl^- + 3H_2O$
D. $2SO_2 + 3ClO_3^- + 3H_2O \rightarrow 2SO_4^{2-} + 3Cl^- + 6H^+$

75. $Fe + Cu^{2+} \rightarrow Cu + Fe^{3+}$. The balanced oxidation half-reaction is... (Makeup 2022)

A. $Fe \rightarrow Fe^{3+} + 3e^-$
B. $2Fe \rightarrow 2Fe^{3+} + 6e^-$
C. $Fe \rightarrow Fe^{3+} + 2e^-$
D. $2Fe \rightarrow 2Fe^{3+} + 3e^-$

76. Using the half-reaction method to balance the following oxidation-reduction equation, what is the correctly balanced equation for the reaction below? (In acidic solution) $Cl^-(aq) + NO_3^-(aq) \rightarrow ClO^-(aq) + NO(g)$

A. $2NO_3^- + 3Cl^- + 2H^+ \rightarrow 3ClO^- + 2NO + H_2O$
B. $2NO_3^- + 3Cl^- + H_2O \rightarrow 3ClO^- + 2NO + 2H^+$
C. $2NO_3^- + 3Cl^- + 3H_2O \rightarrow 3ClO^- + 2NO + 2H^+$
D. $2NO_3^- + Cl^- + 3H^+ \rightarrow ClO^- + NO + H_2O$

77. $N_2O + ClO^- \rightarrow NO_2^- + Cl^-$ (acidic). Which is balanced? (Final 2021)

A. $N_2O + ClO^- + 4H^+ \rightarrow 2NO_2^- + Cl^- + 2H_2O$
B. $N_2O + 2ClO^- + H_2O \rightarrow 2NO_2^- + 2Cl^- + 2H^+$
C. $N_2O + ClO^- + 2H^+ \rightarrow 2NO_2^- + Cl^- + H_2O$
D. $N_2O + ClO^- + 2H_2O \rightarrow 2NO_2^- + Cl^- + 4H^+$

78. $Zn \rightarrow Zn^{2+} + 2e^-$ and $Ag^+ + e^- \rightarrow Ag$. By what number must the silver half-reaction be multiplied?

A. 1 **B.** 2

C. 3 **D.** 4

79. The following chemical equation is balanced in an acidic solution $2ClO^-(aq) + N_2O(aq) + H_2O(l) \rightarrow 2Cl^-(aq) + 2NO_2^-(g) + 2H^+(aq)$ What is the number of H_2O molecules that are present in the balanced equation using the half-reaction method in a basic solution?

A. 1 **B.** 2

C. 3 **D.** 4

80. $NO_3^- + Cl^- \rightarrow ClO^- + NO$ (acidic). Which is balanced? (Final 2020)

A. $2NO_3^- + 3Cl^- \rightarrow 2NO + 3ClO^-$

B. $2NO_3^- + 3Cl^- \rightarrow 2NO + 3ClO^- + H_2O$

C. $2NO_3^- + 3Cl^- + 2H^+ \rightarrow 2NO + 3ClO^- + H_2O$

D. $2NO_3^- + 3Cl^- + H^+ \rightarrow 2NO + 3ClO^- + H_2O$

Item 13

Textbook p. 16, 17

Write oxidation-half reaction and reduction-half reaction for a redox reaction

EXPLANATION

Oxidation half-reaction: e^- on the **product** side ($Zn \rightarrow Zn^{2+} + 2e^-$). Reduction: e^- on the **reactant** side ($Cu^{2+} + 2e^- \rightarrow Cu$).

PRACTICE QUESTIONS

81. In an electrolytic cell, an outside source of power causes...

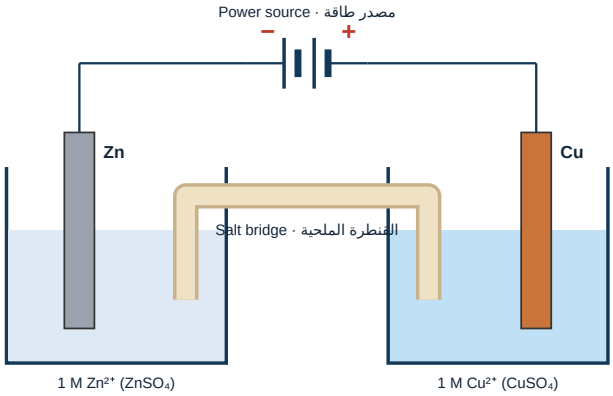
A. a spontaneous redox reaction to stop

B. a nonspontaneous redox reaction to occur

C. electrons to flow from cathode to anode inside the solution

D. the cell potential to become positive

82. Which is correct about the electrolytic Zn–Cu cell (connected to a power source)? (Booklet Q171)



A. The power source makes the oxidation–reduction reaction spontaneous
B. The copper electrode is the cathode
C. The zinc electrode is the anode
D. It converts electrical energy into chemical energy

83. Which of the following occurs in the VOLTAIC cell?

A. A nonspontaneous redox reaction
B. Electrical energy converts to chemical energy
C. The spontaneous reaction continues until one of the electrodes is consumed
D. Electrons flow from the cathode to the anode

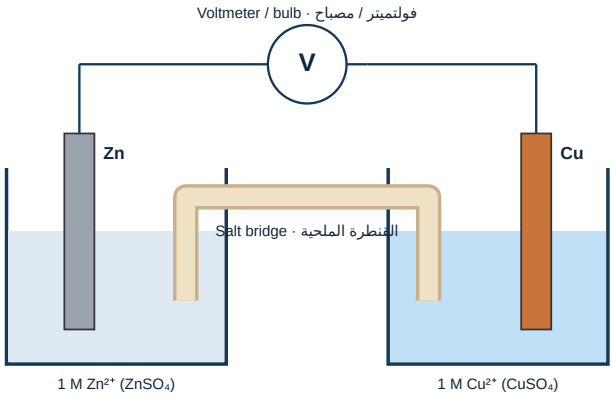
84. The study of the redox processes by which chemical energy is converted to electrical energy and vice versa is called...

A. Nuclear chemistry
B. Organic chemistry
C. Electrochemistry
D. Physical chemistry

85. What is acting as an electrolytic cell?

A. A secondary battery while it is being recharged
B. A battery lighting a bulb
C. A zinc–copper cell with a salt bridge and a bulb
D. A standard hydrogen electrode

86. A zinc electrode in a Zn^{2+} solution and a copper electrode in a Cu^{2+} solution are joined by a salt bridge and connected to a POWER SOURCE (no bulb). Which is correct? (Booklet Q168)



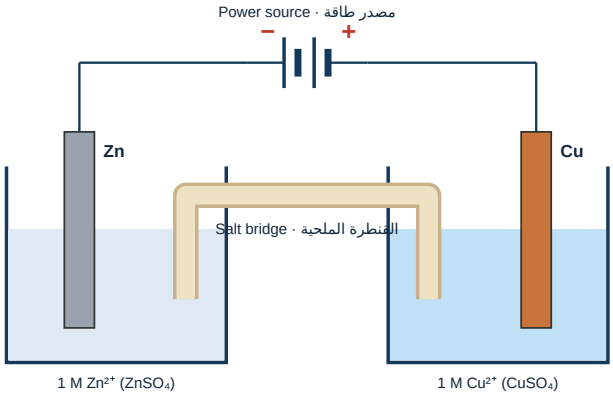
- **A.** An electrolytic cell, in which spontaneous oxidation and reduction occur
- **B.** A voltaic cell, in which spontaneous oxidation and reduction occur
- **C.** An electrolytic cell, in which nonspontaneous oxidation and reduction occur
- **D.** A voltaic cell, in which nonspontaneous oxidation and reduction occur

87. In the zinc–copper voltaic cell of Figure 18, the reaction stops when...

Use the figure above

- **A.** the zinc strip is used up
- **B.** the copper strip is used up
- **C.** the bulb gets hot
- **D.** the salt bridge is removed by the reaction

88. Why is an external voltage source needed to regenerate the zinc–copper cell?



- **A.** The reverse reaction is nonspontaneous
- **B.** The reverse reaction is spontaneous
- **C.** To heat the solutions
- **D.** To make the salt bridge conduct

89. Which is correct about an electrolytic Zn–Cu cell in which the power source pushes electrons into the zinc electrode?

Use the figure above

A. The power source makes the redox reaction spontaneous

B. The copper electrode is the cathode

C. The zinc electrode is the anode

D. It converts electrical energy into chemical energy

90. $2Fe^{3+}(aq) + 3Mn(s) \rightarrow 3Mn^{2+}(aq) + 2Fe(s)$. ($Fe^{3+}|Fe$ −0.037 V; $Mn^{2+}|Mn$ −1.185 V) Which is correct?

A. E°cell = −1.148 V, nonspontaneous

B. E°cell = +1.222 V, spontaneous

C. E°cell = +1.148 V, spontaneous

D. E°cell = −1.222 V, nonspontaneous

Items 14 · 15

Textbook p. 16, 17, 18, 19

Balance redox reaction in acidic medium using half-reaction method

EXPLANATION

$MnO_4^- \rightarrow Mn^{2+}$: **$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$**.

PRACTICE QUESTIONS

91. In acidic solution, H_2O molecules are used to balance... (Makeup 2024)

A. hydrogen atoms

B. oxygen atoms

C. OH^- ions

D. electrons

92. $2ClO^- + N_2O + H_2O \rightarrow 2Cl^- + 2NO_2^- + 2H^+$ (acidic). How many H_2O appear when balanced in basic solution?

A. 4

B. 3

C. 2

D. 1

93. In the redox reaction $2MnO_2 + Zn + H_2O \rightarrow Mn_2O_3 + Zn(OH)_2$ (basic medium), what is the half-reaction of zinc?

A. $Zn(OH)_2 \rightarrow Zn^{2+} + 2OH^-$

B. $Zn(OH)_2 + 2e^- \rightarrow Zn + 2OH^-$

C. $Zn + 2OH^- + 2e^- \rightarrow Zn(OH)_2$

D. $Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$

94. In acidic solution, which species is added to balance hydrogen atoms?

A. H^+

B. OH^-

C. H_2O

D. e^-

95. $MnO_4^- \rightarrow Mn^{2+}$ (acidic). What is added to the products to balance O? (Makeup 2022)

A. $4O_2$

B. $2O_2$

C. H_2O

D. $4H_2O$

96. To balance oxidation-reduction reaction equations that occur in a basic medium, you must add

A. H_2O only
B. H^+ & H_2O
C. OH^- & H_2O
D. OH^- only

97. $Al \rightarrow AlO_2^-$ (acidic). What is added to the reactants to balance O? (Final 2020)

A. OH^-
B. $2OH^-$
C. $2H_2O$
D. H_2O

98. In the Half-Reaction Method, why do we multiply the half-reactions by integers before adding them?

A. To balance the number of atoms.
B. To ensure the number of electrons lost equals the number of electrons gained.
C. To remove the water molecules.
D. To balance the charges in the nucleus.

99. When balancing half-reactions of an oxidation-reduction equation using the half-reaction method in an acidic solution, what is used to balance?

A. Hydrogen atoms
B. Oxygen atoms
C. OH^- ions
D. H_2O molecules

100. Using the half-reaction method to balance oxidation-reduction equations, what is the correct balanced equation for the following reaction in an acidic solution? $I_2(s) + S_2O_3^{2-}(aq) \rightarrow S_2O_4^{2-}(aq) + I^-$

A. $2S_2O_3^{2-} + 2H_2O + I_2 \rightarrow 2S_2O_4^{2-} + 4H^+ + 2I^-$
B. $S_2O_3^{2-} + H_2O + I_2 \rightarrow S_2O_4^{2-} + 2H^+ + 2I^-$
C. $S_2O_3^{2-} + H_2O + I_2 \rightarrow S_2O_4^{2-} + 2H^+ + I^-$
D. $S_2O_3^{2-} + I_2 + 2H^+ \rightarrow S_2O_4^{2-} + H_2O + 2I^-$

Item 16

Textbook p. 16, 17, 18, 19

Describe the steps for balancing redox reactions, in basic medium, by the half-reaction method

EXPLANATION

Basic medium: balance as if acidic, then add **OH^-** to both sides equal to the H^+, combine $H^+ + OH^- \rightarrow H_2O$, cancel water.

PRACTICE QUESTIONS

101. In basic solution, the added OH^- ions combine with H^+ ions to form...

A. H_2O
B. O_2
C. H_2
D. H_3O^+

102. When balancing in basic solution, what is done in the last step? (Final 2023)

- **A.** OH^- ions and water molecules are added to either side
- **B.** H^+ ions and water molecules are added to either side
- **C.** coefficients are adjusted so electrons lost equal electrons gained
- **D.** only atoms are balanced

103. In the characteristic step of balancing oxidation-reduction equations that occur in a basic solution, what must be added to balance the number of H^+ ions?

- **A.** A number of OH^- ions
- **B.** A number of H_2O molecules
- **C.** A number of electrons
- **D.** A number of O^{2-} ions

104. In basic solution, what must be added until the number of H^+ ions is matched? (Final 2024)

- **A.** a number of OH^- ions
- **B.** H_2O molecules
- **C.** e^- electrons
- **D.** O_2 molecules

105. $MnO_2 + 2Br^- + 4H^+ \rightarrow Mn^{2+} + Br_2 + 2H_2O$. In basic solution, how many OH^- must be added to both sides? (Makeup 2024)

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

106. When balancing in a basic solution, what step is added after balancing with H+?

- **A.** Add H_2O to remove H+.
- **B.** Add OH- to both sides to neutralize H+.
- **C.** Multiply the equation by 2.
- **D.** Remove all spectator ions.

107. When balancing oxidation-reduction equations using the half-reaction method, the coefficients of the half-reactions are adjusted so that

- **A.** The number of electrons lost in oxidation equals the number of electrons gained in reduction.
- **B.** The number of electrons lost in oxidation is twice the number of electrons gained in reduction.
- **C.** The number of electrons lost in oxidation is greater than the number of electrons gained in reduction.
- **D.** The number of electrons lost in oxidation is less than the number of electrons gained in reduction.

108. When balancing oxidation-reduction equations in a basic solution, what is done in the last step of the balancing method?

- **A.** Add hydroxide ions (OH^-) and water molecules to either side of the equation.
- **B.** Add hydrogen ions (H^+) and water molecules to either side of the equation.
- **C.** Adjust the coefficients so that the number of electrons lost in oxidation equals the number of electrons gained in reduction.
- **D.** Balance the number of atoms only on both sides of the equation.

109. Using the half-reaction method, which of the following is the balanced equation below in an acidic solution? $Cl^-(aq) + NO_3^-(aq) \rightarrow ClO^-(aq) + NO(g)$

A. $3Cl^-(aq) + 2NO_3^-(aq) + 2H^+(aq) \rightarrow 3ClO^-(aq) + 2NO(g) + H_2O(l)$

B. $2Cl^-(aq) + 3NO_3^-(aq) + 2H^+(aq) \rightarrow 2ClO^-(aq) + 3NO(g) + H_2O(l)$

C. $3Cl^-(aq) + 2NO_3^-(aq) + H_2O(l) \rightarrow 3ClO^-(aq) + 2NO(g) + 2H^+(aq)$

D. $2Cl^-(aq) + 3NO_3^-(aq) + H_2O(l) \rightarrow 2ClO^-(aq) + 3NO(g) + 2H^+(aq)$

110. $MnO_4^- + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$ (acidic). Which is balanced? (Final 2020)

A. $MnO_4^- + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+}$

B. $MnO_4^- + 2Fe^{2+} + 2H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$

C. $MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$

D. $MnO_4^- + 5Fe^{2+} + 16H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 8H_2O$

Item 17

Textbook p. 16, 17, 18, 19

Balance redox reaction in basic medium using half-reaction method

EXPLANATION

Final check: atoms balance, total charge is equal on both sides, and no e^- remain.

PRACTICE QUESTIONS

111. What is the change in the oxidation number of manganese in the following half-reaction? $MnO_4^- \rightarrow Mn^{2+}$

A. -1

B. -5

C. +3

D. +7

112. $5HSO_3^- + 2IO_3^- \rightarrow 5SO_4^{2-} + 3H^+ + I_2 + H_2O$ is balanced in acidic solution. In basic solution, how many water molecules appear? (Advanced 2024)

A. 5

B. 4

C. 3

D. 2

113. When using the half-reaction method to balance the following oxidation-reduction equation in an acidic solution, what is the correctly balanced equation? $N_2O + ClO^- \rightarrow NO_2^- + Cl^-$

A. $N_2O + ClO^- + 4H^+ \rightarrow 2NO_2^- + Cl^- + 2H_2O$

B. $N_2O + 2ClO^- + H_2O \rightarrow 2NO_2^- + 2Cl^- + 2H^+$

C. $N_2O + ClO^- + 2H^+ \rightarrow 2NO_2^- + Cl^- + H_2O$

D. $N_2O + ClO^- + 2H_2O \rightarrow 2NO_2^- + Cl^- + 4H^+$

114. Which of the following is correct regarding the following reaction? $2K + Cl_2 \rightarrow 2KCl$

A. Potassium is reduced and its oxidation number changes from 0 to 1.

B. Potassium is oxidized and its oxidation number changes from 0 to 1.

C. Chlorine is reduced and its oxidation number changes from 1 to 0.

D. Chlorine is oxidized and its oxidation number changes from 1 to 0.

115. In the unbalanced reduction half-reaction below $MnO_4^- \rightarrow Mn^{2+}$ What is added to the products to balance the oxygen atoms using the half-reaction method in an acidic solution?

A. $4H_2O$

B. H_2O

C. $2H_2O$

D. $4O_2$

116. Using the half-reaction method, which of the following is the balanced equation below in an acidic solution? $ClO_3^- + SO_2 \rightarrow Cl^- + SO_4^{2-}$

A. $3SO_2 + ClO_3^- + 3H_2O \rightarrow 3SO_4^{2-} + Cl^- + 6H^+$

B. $3SO_2 + ClO_3^- + 6H^+ \rightarrow 3SO_4^{2-} + Cl^- + 3H_2O$

C. $2SO_2 + 3ClO_3^- + 6H^+ \rightarrow 2SO_4^{2-} + 3Cl^- + 3H_2O$

D. $2SO_2 + 3ClO_3^- + 3H_2O \rightarrow 2SO_4^{2-} + 3Cl^- + 6H^+$

117. Why does the oxidation number of sodium not change in the following reaction equation? $2NaI + Cl_2 \rightarrow 2NaCl + I_2$

A. Na is a spectator ion.

B. Sodium is an uncombined element.

C. Sodium is an active metal.

D. Na is a monatomic ion

118. In the unbalanced reduction half-reaction $Al \rightarrow AlO_2^-$ What should be added to the reactants to balance the oxygen atoms using the half-reaction method in an acidic solution?

A. H_2O

B. $2H_2O$

C. $2OH^-$

D. OH^-

119. Why does the oxidation number of the potassium ion not change in the following reaction equation? $2KBr + Cl_2 \rightarrow 2KCl + Br_2$

A. Potassium is a spectator ion.

B. Potassium is an uncombined element.

C. Potassium is an active metal.

D. Potassium is a monatomic ion.

120. Why are H^+ and H_2O added to some half-reactions, while OH^- and H_2O are added to others when balancing?

A. Because in acidic solution there is an excess of H^+ ions, while in basic solution there is an excess of OH^- ions.

B. Because H^+ and OH^- are oxidizing agents.

C. Because water must always appear on the product side.

D. Because electrons cannot be balanced otherwise.

Item 18 — Textbook p. 25, 26

Describe an electrochemical cell while specifying its types

EXPLANATION

Electrochemical cell: converts chemical ↔ electrical energy. **Voltaic**: spontaneous redox → electricity. **Electrolytic**: electricity drives a non-spontaneous reaction.

PRACTICE QUESTIONS

★ Past exam · End of Term 1 · 2025–2026 · Grade 12 Advanced · Q30

121. The figure shows a zinc strip and a copper strip in their solutions joined only by a copper wire (no salt bridge). The redox reactions cannot continue. Why? (1) As zinc is oxidized, positive zinc ions build up around the zinc electrode. (2) As copper ions are reduced, negative sulfate ions build up around the copper electrode. (3) Electrons flow through the wire from the oxidation half-reaction to the reduction half-reaction.

The figure below represents a voltaic cell, in which oxidation–reduction reactions take place, producing electrical energy. However, these reactions cannot continue. **What explains this**?

يُمثل الشكل أدناه خلية فولتية ، تحدث فيها تفاعلات أكسدة واختزال ينتج عنها طاقة كهربائية. ولكن لا يُمكن لهذه التفاعلات أن تستمر

ما الذي يُفسر ذلك؟

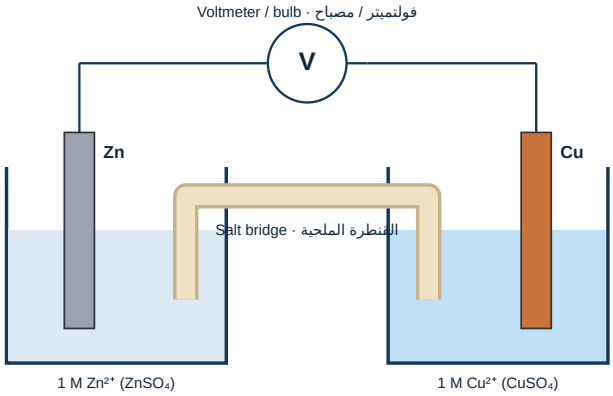


A. Both 1 and 2
B. 1 only
C. 2 only
D. All of 1, 2 and 3

122. A voltaic cell converts...

A. electrical energy into chemical energy
B. chemical energy into electrical energy by a spontaneous redox reaction
C. heat into electricity
D. light into chemical energy

123. While a Zn–Cu voltaic cell operates, the concentration of Zn^{2+} in the anode half-cell...



A. increases
B. decreases
C. stays the same
D. becomes zero

124. A Zn electrode connected to the SHE gives a cell potential of 0.76 V and Zn is oxidized. E° for Zn^{2+}/Zn is...

A. −0.76 V
B. +0.76 V
C. +1.52 V
D. 0.00 V

125. As the Zn–Cu cell runs, what happens to the zinc electrode?

Use the figure above

A. It gets heavier
B. It is eaten away (loses mass)
C. It turns into copper
D. Nothing

126. Which correctly describes the parts of an electrochemical cell? (1) Half-cell: where each of the oxidation and reduction reactions occurs separately. (2) Anode: where oxidation occurs. (3) Cathode: where reduction occurs.

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

127. A Cu electrode connected to the SHE gives 0.34 V, and Cu^{2+} is reduced. Which is correct?

A. $E°(Cu^{2+}/Cu) = -0.34$ V and the SHE is the cathode
B. $E°(Cu^{2+}/Cu) = 0$ V
C. H^+ is reduced
D. $E°(Cu^{2+}/Cu) = +0.34$ V and the SHE is the anode

128. In the copper–zinc cell, which is the anode and which is the cathode?

Use the figure above

A. Anode = copper, cathode = zinc
B. Anode = zinc, cathode = copper
C. Both are anodes
D. The salt bridge is the anode

129. Which correctly describe the parts of an electrochemical cell? (1) Half-cell: where each of oxidation and reduction occurs separately. (2) Anode: where oxidation occurs. (3) Cathode: where reduction occurs.

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

130. How do electrons move in the voltaic cell?

A. Through the salt bridge from the anode to the cathode
B. Through a metal wire from the anode to the cathode
C. Through a metal wire from the cathode to the anode
D. Through the salt bridge from the cathode to the anode

Item 19

Textbook p. 25, 26

Identify components of a voltaic or galvanic cell (anode, cathode, salt bridge or porous barrier, wires, electrolyte compartments); while explaining the role of each component, when does the reaction start and determining the direction of electron and current flow

EXPLANATION

Parts: **anode** (oxidation, −), **cathode** (reduction, +), **salt bridge** (ions move to keep each half-cell neutral), wire (e^- flow anode → cathode).

PRACTICE QUESTIONS

★ Past exam · End of Term 1 · 2025–2026 · Grade 12 Advanced · Q10

131. Regarding the voltaic cell, which statement is correct?

A. The addition of a salt bridge completes the pathway for electrical charge to flow
B. It converts electrical energy into chemical energy
C. The electrolytes in the two beakers are the same
D. The reactions taking place are nonspontaneous

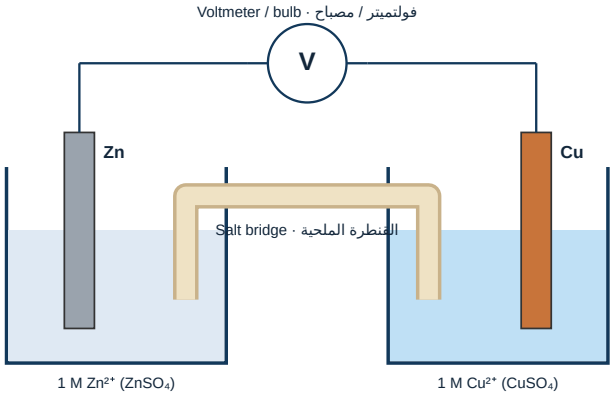
132. In a voltaic cell, where do ions move from one side to the other?

A. Through the copper wire
B. Through the salt bridge
C. Through the zinc electrode
D. Through the silver electrode

133. Which shows the direction and the medium that conducts electrons in a voltaic cell?

A. Anode → cathode through the salt bridge
B. Cathode → anode through the salt bridge
C. Cathode → anode through the external wire
D. Anode → cathode through the external wire

134. In the Zn/Cu cell, negative ions in the salt bridge move toward...



A. the zinc (anode) side
B. the copper (cathode) side
C. the wire
D. the bulb

135. In a zinc–silver voltaic cell, where are the electrons accepted? ($E°$ Zn^{2+} = −0.76 V, Ag^{+} = +0.80 V)

A. At the silver electrode
B. At the zinc electrode
C. At the salt bridge
D. At both electrodes

136. A flow of charged particles is called...

A. an electrode
B. an electric current
C. a half-cell
D. a salt bridge

137. A voltaic cell from $Co^{2+}|Co$ (−0.28 V) and $Pt^{2+}|Pt$ (+1.18 V). Which row is correct?

A. spontaneous · +0.9 V · cathode Co · anode Pt
B. spontaneous · +1.46 V · cathode Pt · anode Co
C. nonspontaneous · −0.9 V · cathode Co · anode Pt
D. nonspontaneous · −1.46 V · cathode Pt · anode Co

138. Without a salt bridge the reaction stops because...

Use the figure above

A. the wire melts
B. charge builds up in the two beakers
C. copper dissolves
D. electrons run out

139. What makes the electrical connection with the non-metallic (ionic) part of the circuit in a voltaic cell?

A. The electrode
B. The salt bridge
C. The electrolyte solution
D. The external wire

140. Electrons made at the anode are pushed toward the cathode by the...

A. salt bridge
B. electromotive force (EMF)
C. standard hydrogen electrode
D. agar gel

Item 20

Textbook p. 27, 31

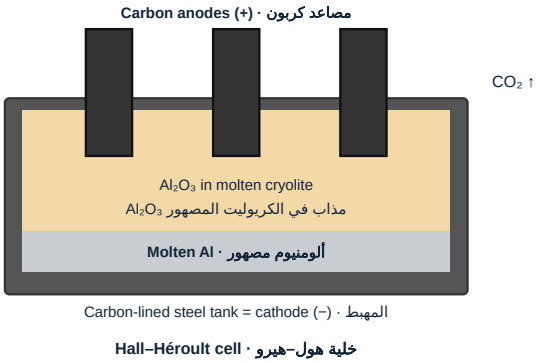
Write the oxidation and reduction half-reactions occurring at cathode and anode for a voltaic cell

EXPLANATION

Zn–Cu cell: anode **$Zn \rightarrow Zn^{2+} + 2e^-$**; cathode **$Cu^{2+} + 2e^- \rightarrow Cu$**.

PRACTICE QUESTIONS

141. Which half-reaction occurs at the cathode of the Hall–Héroult cell?



A. $Al^{3+}(l) + 3e^- \rightarrow Al(l)$
B. $2O^{2-} \rightarrow O_2(g) + 4e^-$
C. $C(s) + O_2(g) \rightarrow CO_2(g)$
D. $Al(l) \rightarrow Al^{3+}(l) + 3e^-$

142. For the cell reaction $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$, what occurs at the anode?

A. Oxidation of Cu
B. Reduction of Cu^{2+}
C. Oxidation of Zn
D. Reduction of Zn^{2+}

143. An aluminum strip is plated with gold: the gold strip is wired to the + terminal, the aluminum strip to the − terminal, in a 1 M solution. Which row is correct? (Booklet Q175)

A. Al mass increases · anode: $Au \rightarrow Au^{3+} + 3e^-$ · cathode: $Au^{3+} + 3e^- \rightarrow Au$ · electrolyte contains Au^{3+}
B. Al mass decreases · anode: $Al \rightarrow Al^{3+} + 3e^-$ · cathode: $Al^{3+} + 3e^- \rightarrow Al$ · electrolyte contains Al^{3+}
C. Al mass increases · anode: $Al \rightarrow Al^{3+} + 3e^-$ · cathode: $Au^{3+} + 3e^- \rightarrow Au$ · electrolyte contains Au^{3+}
D. Al mass decreases · anode: $Au^{3+} + 3e^- \rightarrow Au$ · cathode: $Al \rightarrow Al^{3+} + 3e^-$ · electrolyte contains Al^{3+}

144. Why are the carbon anodes slowly used up?

Use the figure above

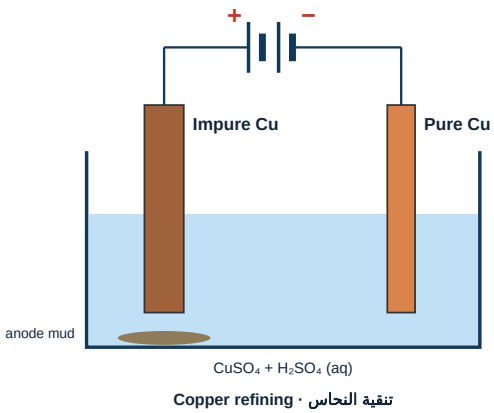
A. The liberated oxygen reacts with the carbon at the high temperature to form CO_2

B. Aluminum deposits on them

C. They dissolve in the cryolite

D. They are reduced to aluminum

145. Which half-reaction takes place at the anode of the copper-refining cell?



Copper refining · تنقية النحاس

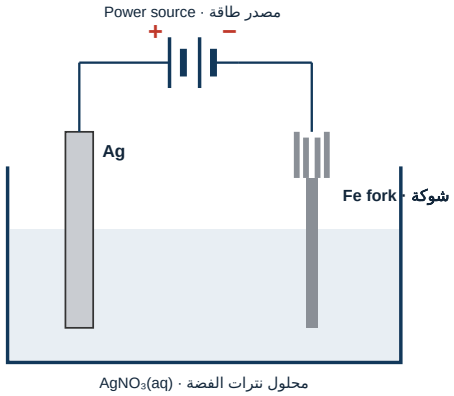
A. $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

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

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

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

146. When an object is plated with silver, what happens to the Ag^+ ions?



Silver plating · الطلاء بالفضة

A. They are oxidized at the cathode

B. They are reduced at the anode

C. They are oxidized at the anode

D. They are reduced at the cathode

147. Objects are electroplated by depositing a thin, uniform protective or decorative layer (silver plating). Which is correct?

Use the figure above

A. The object to be plated is the anode

B. The metal used for plating is the cathode

C. Silver ions are reduced at the cathode

D. Silver ions are oxidized at the anode

148. Which half-reaction occurs at the anode during silver plating?

Use the figure above

A. $Ag(s) \rightarrow Ag^+(aq) + e^-$

B. $Ag^+(aq) + e^- \rightarrow Ag(s)$

C. $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

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

149. Which is correct about voltaic cells? (1) Oxidation at the anode, reduction at the cathode. (2) Electrons move from the reduced electrode to the oxidized electrode. (3) Oxidation at the cathode, reduction at the anode.

A. 1 only

B. 2 only

C. 2 and 3

D. 1 and 2

150. Where do the electrons that reduce Ag^+ at the cathode come from?

A. The external power source

B. The salt bridge

C. The silver ions themselves

D. The object's nucleus

Item 21

Textbook p. 29, 30

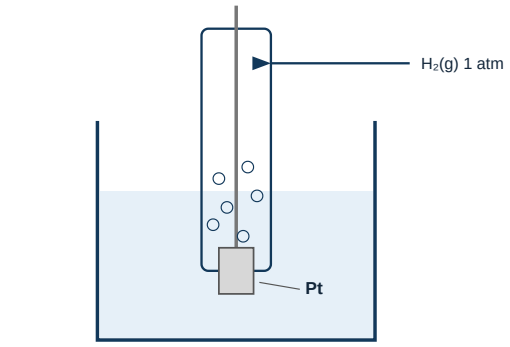
Define the reduction potential and standard electrode potential (E°)

EXPLANATION

Reduction potential: the tendency to gain electrons. **E°** is measured against the SHE at 25 °C, 1 M, 1 atm.

PRACTICE QUESTIONS

151. Which statement about the standard hydrogen electrode is INCORRECT?



Standard hydrogen electrode · قطب الهيدروجين القياسي (25 °C)

A. H_2 is pumped in at 1 atm and 25 °C

B. Its standard reduction potential is 0.000 V

C. The platinum electrode is in a 1 M acid solution

D. It always acts as an oxidation half-reaction

152. Metal X reacts with HCl: $X + 2HCl \rightarrow XCl_2 + H_2$. The reduction potential of X is...

A. greater than zero
B. less than zero
C. equal to zero
D. cannot be determined

153. Which is correct regarding the standard hydrogen electrode?

Use the figure above

A. It is the anode in every cell
B. It is the cathode in every cell
C. Its E° is 0.000 V under all conditions
D. Its E° is 0.000 V with 1 M acid, H_2 at 1 atm and 25 °C

154. Which is correct about the SHE? ($Cu^{2+}|Cu$ +0.3419 V; $Zn^{2+}|Zn$ −0.7618 V)

Use the figure above

A. It is the cathode when connected to Cu
B. It is the anode when connected to Zn
C. Its standard reduction potential is 0.000 V
D. Its standard reduction potential is 1.104 V

155. Which is NONSPONTANEOUS under standard conditions?

A. $2Fe^{3+} + 3Mn \rightarrow 3Mn^{2+} + 2Fe$ (+1.148 V)
B. $I_2 + Fe \rightarrow 2I^- + Fe^{2+}$ (+0.983 V)
C. $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ (+1.104 V)
D. $Zn + Ca^{2+} \rightarrow Zn^{2+} + Ca$ (−2.106 V)

156. Under which conditions is E° measured for an electrode in a 1 M solution of its ions?

A. 0 °C and 1 atm
B. 25 °C and 1 atm
C. 25 °C and 100 atm
D. 0 °C and 0 atm

157. For the voltaic cell $Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$, which is correct?

A. The zinc electrode is oxidized
B. The copper electrode is oxidized
C. Copper ions are oxidized
D. Zinc ions are oxidized

158. A voltaic cell is made of Co/Co^{2+} (E° = −0.28 V) and Cu/Cu^{2+} (E° = +0.34 V). Which occurs?

A. Oxidation of the copper electrode
B. Reduction of the copper electrode
C. Oxidation of the cobalt electrode
D. Reduction of the cobalt ions

159. Which statement about electrochemistry is INCORRECT?

A. It studies oxidation and reduction processes
B. It is useful in industry and in important vital functions
C. It refers to the conversion of chemical energy into electrical energy and vice versa
D. It refers to the conversion of mechanical energy into electrical energy and vice versa

160. Which electrode will be the anode when connected to the SHE? (Zn −0.762, Cu +0.342, F_2 +2.87, Au +1.498 V)

Use the figure above

A. Zn | Zn^{2+}

B. F_2 | F^-

C. Cu | Cu^{2+}

D. Au | Au^{3+}

Item 22

Textbook p. 29, 31

Describe standard hydrogen electrode (SHE), while identifying the importance of its E° value and writing the half-cell reactions of the two possible reactions that could occur at the hydrogen electrode

EXPLANATION

SHE: Pt in 1 M H^+ with H_2 at 1 atm; **E° = 0.00 V**. As cathode $2H^+ + 2e^- \rightarrow H_2$; as anode $H_2 \rightarrow 2H^+ + 2e^-$.

PRACTICE QUESTIONS

★ Past exam · End of Term 1 · 2025–2026 · Grade 12 Advanced · Q28

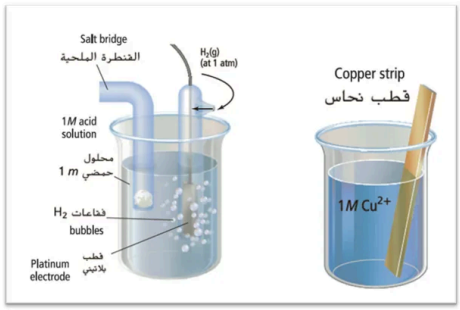
161. A copper electrode ($Cu^{2+} + 2e^- \rightleftharpoons Cu$, E° = +0.3419 V) is connected to the standard hydrogen electrode to form a voltaic cell. Which is correct?

If a copper electrode is connected to a standard hydrogen electrode to form a voltaic cell.

Which of the following is correct?

إذا تم توصيل قطب النحاس مع قطب الهيدروجين القياسي لتكوين خلية فولتية.

أي مما يأتي صحيح؟



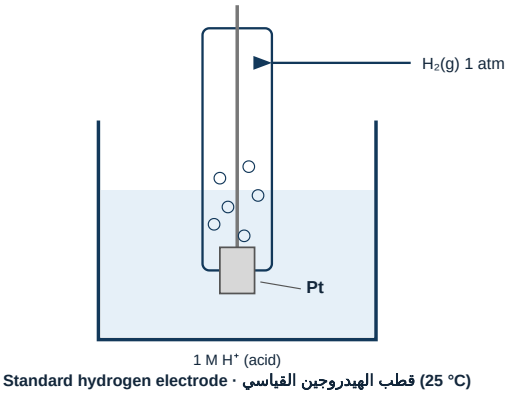
A. Electrons flow towards the copper strip and reduce Cu^{2+} ions to Cu atoms

B. Electrons flow away from the copper strip and copper atoms are oxidized to Cu^{2+} ions

C. The copper electrode is the anode

D. The standard hydrogen electrode is the cathode

162. The SHE is connected to a cadmium electrode in cadmium nitrate solution (E° = −0.4030 V). Which is correct?



A. Cd is the cathode, its mass increases and electrons move to it

B. Cd is the anode and electrons move away from it

C. Cd acts as the standard hydrogen electrode

D. None of these

163. $Mg^{2+}|Mg$ (E° = −2.372 V) is connected to the SHE. Which electrode is the anode?

Use the figure above

A. the magnesium electrode

B. the hydrogen electrode

C. both

D. neither

164. The standard reduction potential of the standard hydrogen electrode (SHE) is...

A. +1.00 V

B. −0.76 V

C. +0.34 V

D. 0.000 V

165. Why is the SHE important?

A. It is used to plate metals

B. It is the reference against which other electrode potentials are measured

C. It produces the highest voltage

D. It never reacts

166. The SHE consists of a platinum electrode in...

A. 1 M NaCl solution

B. pure water with O_2 gas

C. molten hydrogen

D. 1 M H^+ solution with H_2 gas at 1 atm, 25 °C

167. Which half-reaction occurs when the SHE acts as a cathode?

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

B. $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

C. $H_2(g) \rightarrow 2H^+(aq) + 2e^-$

D. $2H^+(aq) + 2e^- \rightarrow H_2(g)$

168. Which of the following correctly represents an electrochemical half-cell?

A. $NaNO_3/Zn$
B. $CuSO_4/Cu$
C. $AgNO_3/Ag^+$
D. $CuSO_4/Cu^{2+}$

169. Which half-reaction occurs when the SHE acts as an anode?

A. $Pt^{2+} + 2e^- \rightarrow Pt$
B. $H_2(g) \rightarrow 2H^+(aq) + 2e^-$
C. $2H^+(aq) + 2e^- \rightarrow H_2(g)$
D. $O_2 + 4e^- \rightarrow 2O^{2-}$

170. The number that specifies the degree of oxidation or reduction of an atom or ion is called

A. Oxidation Number
B. Valence Number
C. Atomic Number
D. Coefficient

Items 23 · 25

Textbook p. 32, 33, 34, 35

Use the half-cell standard reduction potentials to calculate the electrochemical cell standard potential, while determining whether the redox reactions are spontaneous or non-spontaneous

EXPLANATION

$E°cell = E°cathode – E°anode$ (both reduction potentials). Positive → spontaneous.

PRACTICE QUESTIONS

★ Past exam · End of Term 1 · 2025–2026 · Grade 12 Advanced · Q29

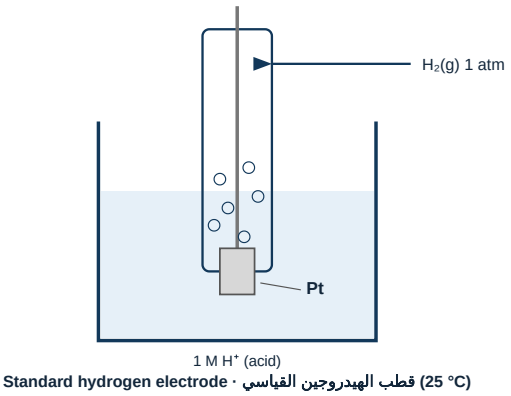
171. For a voltaic cell made from $Au^{3+} + 3e^- \rightleftharpoons Au$ ($E° = +1.498$ V) and $Cd^{2+} + 2e^- \rightleftharpoons Cd$ ($E° = -0.4030$ V), which row is correct?

A. Anode Cd · cathode Au · spontaneous · $E°cell = +1.901$ V
B. Anode Au · cathode Cd · spontaneous · $E°cell = +1.901$ V
C. Anode Cd · cathode Au · nonspontaneous · $E°cell = -1.095$ V
D. Anode Au · cathode Cd · nonspontaneous · $E°cell = -1.095$ V

172. Cell notation $Zn \mid Zn^{2+} \parallel Ca^{2+} \mid Ca$, $E°cell = -2.106$ V. Which is correct about the reaction as written?

A. It is nonspontaneous, and the metal it would produce is Ca
B. It is nonspontaneous, and the metal it would produce is Zn
C. It is spontaneous, and the metal produced is Ca
D. It is spontaneous, and the metal produced is Zn

173. A cell is made of $Cu^{2+}|Cu$ (+0.342 V) and the SHE. Which reduction half-reaction occurs?



A. $Cu^{2+} + 2e^- \rightarrow Cu$
B. $Cu \rightarrow Cu^{2+} + 2e^-$
C. $H_2 + 2e^- \rightarrow 2H^+$
D. $2H^+ \rightarrow H_2 + 2e^-$

174. Standard cell potential for $Al(s) + Pt^{2+}(aq) \rightarrow Al^{3+}(aq) + Pt(s)$? ($Al^{3+}$ −1.662 V, Pt^{2+} +1.18 V)

A. −2.84 V
B. +0.482 V
C. +2.84 V
D. −0.482 V

175. Booklet Q160: $Pb^{2+} + Mg \rightarrow Pb + Mg^{2+}$. $E°(Pb^{2+}|Pb)$ = −0.13 V and the EMF = 2.23 V. The reduction potential of magnesium is...

A. −2.36 V
B. +2.36 V
C. −2.10 V
D. +2.10 V

176. Booklet Q161: $A + B^+ \rightarrow A^+ + B$. E°(A) = −1.6 V and E°cell = 2.4 V. The standard reduction potential of B is...

A. +0.8 V
B. −0.8 V
C. +4.0 V
D. −4.0 V

177. What is used to make an electrical connection with a non-metallic part of the circuit (ions) in an electrochemical (voltaic) cell?

A. The electrode
B. The salt bridge
C. The electrolyte solution
D. The external wire

178. Standard cell potential for $Al(s) + Pt^{2+}(aq) \rightarrow Al^{3+}(aq) + Pt(s)$? ($Al^{3+}|Al$ −1.662 V; $Pt^{2+}|Pt$ +1.18 V)

A. −2.84 V
B. +0.482 V
C. +2.84 V
D. −0.482 V

179. Through which part do ions move from one half-cell to the other in an electrochemical cell?

A. The wire
B. The electrodes
C. The voltmeter
D. The salt bridge

180. Half-cells: $Fe^{3+} + 3e^- \rightleftharpoons Fe$ (−0.037 V) and $Pt^{2+} + 2e^- \rightleftharpoons Pt$ (+1.18 V). Which row is correct? (booklet p. 31 Q1)

A. +1.217 V · $2Fe + 3Pt^{2+} \rightarrow 2Fe^{3+} + 3Pt$ · Fe | Fe^{3+} || Pt^{2+} | Pt · spontaneous

B. −1.217 V · $3Pt + 2Fe^{3+} \rightarrow 3Pt^{2+} + 2Fe$ · Pt | Pt^{2+} || Fe^{3+} | Fe · nonspontaneous

C. +1.143 V · $2Fe^{3+} + 3Pt^{2+} \rightarrow 2Fe + 3Pt$ · Pt | Pt^{2+} || Fe | Fe^{3+} · spontaneous

D. −1.143 V · $2Fe + 3Pt \rightarrow 2Fe^{3+} + 3Pt^{2+}$ · Fe | Fe^{3+} || Pt^{2+} | Pt · nonspontaneous

Item 24

Textbook p. 31, 32, 33, 34

Write the cell notation and the overall chemical equation for a redox reaction occurring in a voltaic cell

EXPLANATION

Notation: anode | anode ion ‖ cathode ion | cathode → **Zn | Zn^{2+} ‖ Cu^{2+} | Cu**; overall $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$.

PRACTICE QUESTIONS

★ Past exam · End of Term 1 · 2025–2026 · Grade 12 Advanced · Q9

181. What is the notation of the voltaic cell made from $Pt^{2+} + 2e^- \rightleftharpoons Pt$ ($E° = +1.18$ V) and $Fe^{3+} + 3e^- \rightleftharpoons Fe$ ($E° = -0.037$ V)?

A. Fe | Fe^{3+} || Pt^{2+} | Pt

B. Pt | Pt^{2+} || Fe^{3+} | Fe

C. Fe | Fe^{3+} || Pt | Pt^{2+}

D. Fe^{3+} | Fe || Pt^{2+} | Pt

182. Which half-cell is written FIRST (on the left) in cell notation?

A. the reduction half-cell

B. the half-cell with the larger electrode

C. the oxidation half-cell (anode)

D. always the hydrogen electrode

183. Half-cells: $Sn^{2+} + 2e^- \rightarrow Sn$ (−0.1375 V) and $Pt^{2+} + 2e^- \rightarrow Pt$ (+1.18 V). What is E°cell?

A. −1.04 V

B. −1.32 V

C. +1.04 V

D. +1.32 V

184. E°cell for the spontaneous reaction between cobalt and copper? (Co^{2+}|Co −0.28 V; Cu^{2+}|Cu +0.3419 V)

A. +0.622 V

B. +0.062 V

C. −0.622 V

D. none of these

185. E°cell for the spontaneous reaction between chromium and nickel? (Ni^{2+}|Ni −0.26 V; Cr^{3+}|Cr −0.74 V)

A. −1.00 V

B. −0.48 V

C. +1.00 V

D. +0.48 V

186. A half-cell was connected to $Pt^{2+} + 2e^- \rightleftharpoons Pt$ (+1.18 V) and the cell gave +3.89 V. Which half-cell was it?

A. $Na^+ + e^- \rightarrow Na$ (−2.71 V)
B. $Mn^{2+} + 2e^- \rightarrow Mn$ (−1.185 V)
C. $Cr^{3+} + 3e^- \rightarrow Cr$ (−0.744 V)
D. $Fe^{2+} + 2e^- \rightarrow Fe$ (−0.447 V)

187. Half-cells: $Be^{2+} + 2e^- \rightleftharpoons Be$ (−1.847 V) and $Pt^{2+} + 2e^- \rightleftharpoons Pt$ (+1.18 V). What is E° of this cell?

A. +3.027 V
B. −3.027 V
C. +0.667 V
D. −0.667 V

188. E°cell for the spontaneous reaction between magnesium and silver? ($Mg^{2+}|Mg$ −2.372 V; $Ag^+|Ag$ +0.7996 V)

A. +1.573 V
B. +2.971 V
C. +0.773 V
D. +3.172 V

189. E°cell for the spontaneous reaction between iron and platinum? ($Fe^{3+}|Fe$ −0.037 V; $Pt^{2+}|Pt$ +1.18 V)

A. −1.143 V
B. +1.143 V
C. +1.217 V
D. +1.148 V

190. Book Q12a: $Ag^+ + e^- \rightleftharpoons Ag$ (+0.7996 V) and $Ni^{2+} + 2e^- \rightleftharpoons Ni$ (−0.257 V). The balanced spontaneous reaction is...

A. $Ag^+ + Ni \rightarrow Ag + Ni^{2+}$
B. $2Ag^+ + Ni \rightarrow 2Ag + Ni^{2+}$
C. $2Ag + Ni^{2+} \rightarrow 2Ag^+ + Ni$
D. $Ag + Ni^{2+} \rightarrow Ag^+ + Ni$

Item 26

Textbook p. 47

Compare between electrolytic cell and voltaic cell in terms of identifying where will reduction and oxidation processes take place, anode, cathode, direction of electron flow and current flow and spontaneity of the reaction occurring

EXPLANATION

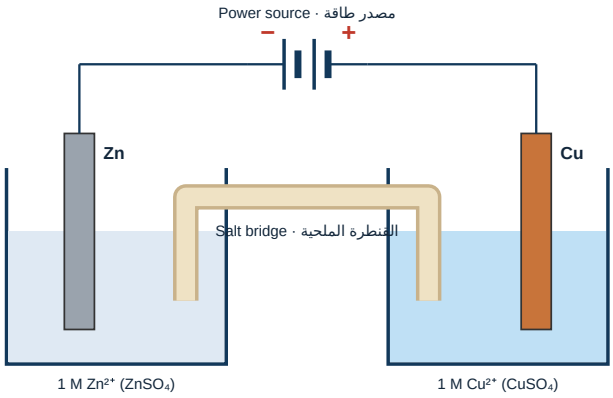
Both: oxidation at the anode, reduction at the cathode. Electrolytic: **anode +, cathode −**, needs an external power source, E°cell < 0.

PRACTICE QUESTIONS

191. The anode is the electrode where...

A. reduction takes place
B. oxidation takes place
C. ions are produced only in the salt bridge
D. electrons are gained

192. A zinc–copper cell is connected to a power source that pushes electrons into the zinc electrode. Which is correct?



A. An electrolytic cell with spontaneous redox reactions
B. A voltaic cell with spontaneous redox reactions
C. An electrolytic cell with nonspontaneous redox reactions
D. A voltaic cell with nonspontaneous redox reactions

193. In BOTH voltaic and electrolytic cells, oxidation occurs at the...

A. anode
B. cathode
C. salt bridge
D. power source

194. Which ion is the easiest to reduce? (Mg^{2+} −2.372, Ag^{+} +0.7996, Al^{3+} −1.662, Hg^{2+} +0.851 V)

A. Mg^{2+}
B. Ag^{+}
C. Al^{3+}
D. Hg^{2+}

195. A voltaic cell runs $3Ni^{2+} + 2Cr \rightarrow 3Ni + 2Cr^{3+}$. Which occurs?

A. Oxidation of the nickel electrode
B. Reduction of chromium ions
C. Decrease in the concentration of chromium ions
D. Reduction of nickel ions

196. Which ion is the easiest to reduce? (Fe^{3+} −0.037, Cu^{2+} +0.3419, Mg^{2+} −2.372, Ag^{+} +0.7996 V)

A. Fe^{3+}
B. Cu^{2+}
C. Mg^{2+}
D. Ag^{+}

197. Electrons in a voltaic cell always flow from the half-cell with the...

A. higher E° to the lower E°
B. lower E° to the higher E°
C. larger electrode to the smaller one
D. cathode to the anode

198. Which ion is the easiest to reduce? (Fe^{2+} −0.45, Sn^{2+} −0.14, Hg^{2+} +0.851, Au^{3+} +1.49 V)

A. Fe^{2+} **B.** Sn^{2+}

C. Au^{3+} **D.** Hg^{2+}

199. A voltaic cell runs $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$. Which occurs?

A. Reduction of zinc atoms

B. Oxidation of copper ions Cu^{2+}

C. Transfer of electrons from Cu atoms to Zn^{2+} ions

D. Transfer of electrons from zinc atoms to Cu^{2+} ions

200. Cell (1): Zn and Cu connected to a bulb. Cell (2): Zn and Cu connected to a power source. Which is correct?

A. Cell (1) represents an electrolytic cell

B. Cell (2) represents a voltaic cell

C. Electrons flow in the voltaic cell (1) from Cu

D. Electrons flow in the electrolytic cell (2) from Cu

Item 27

Textbook p. 47, 48

Describe how a spontaneous redox reaction of an electrochemical cell can be reversed

EXPLANATION

A spontaneous reaction is reversed by applying a voltage **greater than E°cell** (recharging a battery).

PRACTICE QUESTIONS

★ Past exam · End of Term 1 · 2025–2026 · Grade 12 Advanced · Q8

201. Compare cells 1 and 2 (Zn–Cu cells: cell 1 is connected to a voltage source, cell 2 to a bulb). Which is correct?

When comparing cells 1 and 2 below,
Which of the following is correct?

عند مقارنة الخليتين 1 و 2 أدناه،
أي مما يأتي صحيح؟

A. In cell 1, if the voltage source is applied long enough, the cell returns to nearly its original strength

B. In cell 1, the spontaneous reaction continues until the zinc is used up, and then it stops

C. In cell 2, the flow of electrons is reversed and the nonspontaneous reaction restores the cell

D. In cell 2, electrons flow spontaneously from the copper side, creating an electric current

202. A reaction has E°cell = −0.587 V as written. Which is correct?

A. It is spontaneous

B. Neither it nor its reverse can occur

C. The reverse reaction is spontaneous

D. It is spontaneous only at 25 °C

203. If the calculated cell potential of a proposed redox reaction is positive, the reaction is...

A. nonspontaneous

B. spontaneous

C. at equilibrium

D. impossible to judge

204. A mercury–copper cell is reported with E° = −0.46 V (Hg^{2+}/Hg = +0.80 V, Cu^{2+}/Cu = +0.34 V). Why is the value negative?

A. It is written in the nonspontaneous direction (Cu as cathode, Hg as anode); reversed, the spontaneous cell has E° = +0.46 V.

B. Mercury is a liquid, so its potential is always negative.

C. Copper has a negative reduction potential.

D. Mercury cells can only work as electrolytic cells.

205. An electrolytic cell is...

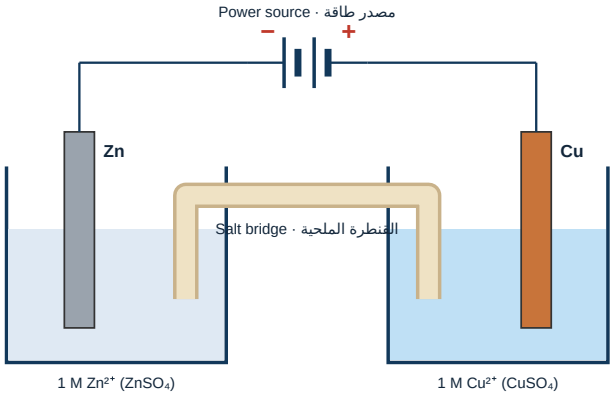
A. an electrochemical cell in which electrolysis occurs

B. a cell that produces electricity from a spontaneous reaction

C. a cell that can be used only once

D. a salt bridge filled with an electrolyte

206. Why is an external voltage source needed to regenerate a used zinc–copper cell?



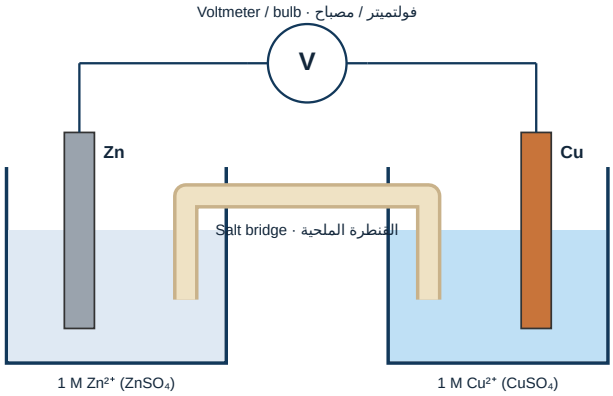
A. Because the reverse reaction is nonspontaneous

B. Because the salt bridge has dried out

C. Because electrons cannot travel in a wire

D. Because zinc ions cannot be reduced

207. In an operating Zn–Cu voltaic cell, which statement is correct?



A. Reduction of copper ions occurs at the anode
B. Oxidation of zinc atoms occurs at the cathode
C. The mass of the copper electrode decreases
D. The mass of the zinc electrode decreases

208. Book Q13a / booklet Q98: $2Al^{3+}(aq) + 3Cu(s) \rightarrow 3Cu^{2+}(aq) + 2Al(s)$. E°cell and spontaneity?

A. +2.004 V, spontaneous
B. −2.004 V, nonspontaneous
C. −1.320 V, nonspontaneous
D. +1.320 V, spontaneous

209. The electric potential difference of a voltaic cell indicates...

A. the mass of the electrodes
B. the energy available to move electrons from the anode to the cathode
C. the volume of the solutions
D. the speed of the ions in the salt bridge

210. Book Q13b / booklet Q99: $Hg^{2+}(aq) + 2Cu^{+}(aq) \rightarrow 2Cu^{2+}(aq) + Hg(l)$. E°cell? ($Hg^{2+}|Hg$ +0.851, $Cu^{2+}|Cu^{+}$ +0.153 V)

A. +0.698 V, spontaneous
B. −0.698 V, nonspontaneous
C. +1.004 V, spontaneous
D. −1.004 V, nonspontaneous

Item 28

Textbook p. 48

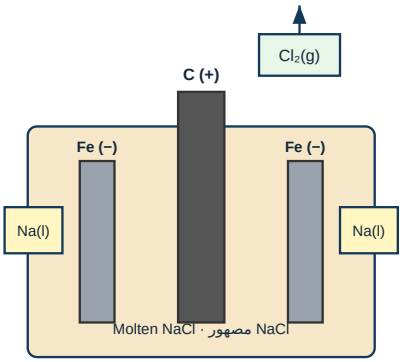
Write half-cell reactions while identifying the products of electrolysis of molten ionic compounds

EXPLANATION

Molten NaCl: cathode **$Na^{+} + e^{-} \rightarrow Na$**; anode **$2Cl^{-} \rightarrow Cl_2 + 2e^{-}$**.

PRACTICE QUESTIONS

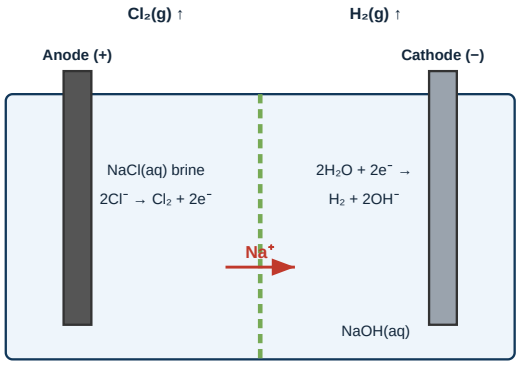
211. In Figure 19 the anode and cathode of the Down's cell are...



Down's cell · خلية داون

A. carbon anode (+) and iron cathode (−)
B. iron anode (+) and carbon cathode (−)
C. both made of sodium
D. platinum anode (−) and copper cathode (+)

212. In Figure 20, which ion passes through the ion-permeable membrane to the cathode side?



Ion-permeable membrane · غشاء منفذ للأيونات

Electrolysis of brine · التحليل الكهربائي للمحلول الملحي

A. Na^+
B. Cl^-
C. OH^-
D. H^+

213. Which is the overall reaction for the electrolysis of brine?

Use the figure above

A. $2H_2O(l) + 2NaCl(aq) \rightarrow H_2(g) + Cl_2(g) + 2NaOH(aq)$
B. $2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$
C. $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$
D. $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

214. Why is the concentration of chloride ions kept high in the brine cell?

Use the figure above

A. To favor the oxidation of Cl^- to the desired product, chlorine

B. To stop water from being reduced

C. To make sodium metal form

D. To lower the melting point

215. Chlorine gas from brine electrolysis is used to manufacture...

Use the figure above

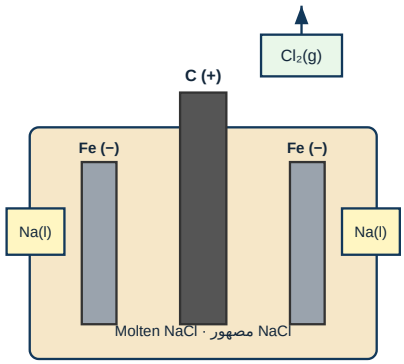
A. polyvinyl chloride (PVC) products such as water pipes

B. aluminum cans

C. copper wires

D. silver-plated forks

216. What are the products of the electrolysis of molten NaCl?



Down's cell · خلية داون

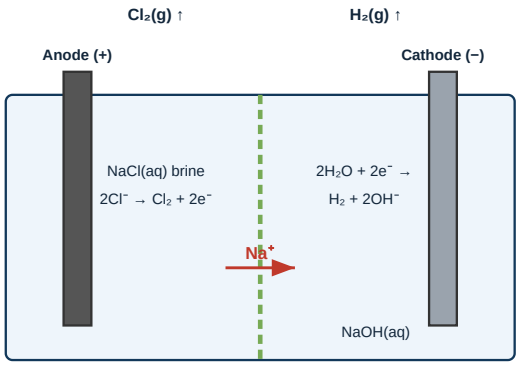
A. Sodium metal and chlorine gas

B. Hydrogen gas, chlorine gas and sodium hydroxide

C. Hydrogen gas and oxygen gas

D. Sodium hydroxide only

217. Why is sodium NOT a product of the electrolysis of brine?



Ion-permeable membrane · غشاء منفذ للأيونات

Electrolysis of brine · التحليل الكهربائي للمحلول الملحي

A. Water is easier to reduce than Na^+

B. Na^+ is oxidized at the anode

C. Sodium dissolves in the membrane

D. The voltage is too high

218. During copper plating, the mass of the key (cathode)...

A. increases

B. decreases

C. stays the same

219. In cell notation, what does the double vertical line (||) represent?

A. the electrode surface

B. the connection between the two half-cells (salt bridge)

C. the voltmeter

D. an electron

220. Which electrolyte is used to electroplate an iron ring with silver?

A. $FeSO_4$

B. $Fe(NO_3)_2$

C. $AgNO_3$

D. HNO_3

Item 29

Textbook p. 49

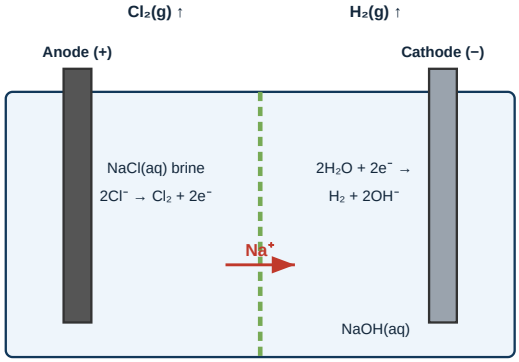
Write half-cell reactions while identifying the products of electrolysis of aqueous ionic compounds

EXPLANATION

Brine (aqueous NaCl): cathode $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$; anode $2Cl^- \rightarrow Cl_2 + 2e^-$ → products **H_2, Cl_2, NaOH**.

PRACTICE QUESTIONS

221. In the electrolysis of brine, which species is OXIDIZED?



Ion-permeable membrane · غشاء منفذ للأيونات

Electrolysis of brine · التحليل الكهربائي للمحلول الملحي

A. Cl^-

B. Na^+

C. H_2O at the cathode

D. OH^-

222. Which reaction occurs at the cathode during the electrolysis of brine?

Use the figure above

A. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

B. $Na^+(aq) + e^- \rightarrow Na(s)$

C. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

D. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

223. The overall reaction for the electrolysis of brine is...

Use the figure above

A. $2H_2O(l) + 2NaCl(aq) \rightarrow H_2(g) + Cl_2(g) + 2NaOH(aq)$

B. $2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

C. $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

D. $NaCl(aq) + H_2O(l) \rightarrow NaOH(aq) + HCl(aq)$

224. Two reactions are possible at the anode in brine. Which one is NOT favoured?

Use the figure above

A. $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$

B. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

225. Correct cell notation for the cell made of tin and magnesium? ($Sn^{2+}|Sn$ −0.1375 V; $Mg^{2+}|Mg$ −2.37 V)

A. $Sn \mid Sn^{2+} \parallel Mg^{2+} \mid Mg$

B. $Mg^{2+} \mid Mg \parallel Sn \mid Sn^{2+}$

C. $Sn \mid Sn^{2+} \parallel Mg \mid Mg^{2+}$

D. $Mg \mid Mg^{2+} \parallel Sn^{2+} \mid Sn$

226. Correct cell notation for the cell made of nickel and calcium? ($Ni^{2+}|Ni$ −0.257 V; $Ca^{2+}|Ca$ −2.868 V)

A. $Ca^{2+} \mid Ca \parallel Ni^{2+} \mid Ni$

B. $Ca \mid Ca^{2+} \parallel Ni^{2+} \mid Ni$

C. $Ni^{2+} \mid Ni \parallel Ca^{2+} \mid Ca$

D. $Ni^{2+} \mid Ni \parallel Ca \mid Ca^{2+}$

227. A voltaic cell is made from $Ag^+|Ag$ (+0.7996 V) and $Cd^{2+}|Cd$ (−0.403 V). What is the correct cell notation?

A. Ag | Ag^+ || Cd | Cd^{2+}
B. Ag | Ag^+ || Cd^{2+} | Cd
C. Cd | Cd^{2+} || Ag^+ | Ag
D. Cd^{2+} | Cd || Ag^+ | Ag

228. A voltaic cell is made from $Co^{2+}|Co$ (−0.28 V) and $Pb^{2+}|Pb$ (−0.1262 V). What is the correct cell notation?

A. Pb | Pb^{2+} || Co^{2+} | Co
B. Pb | Pb^{2+} || Co | Co^{2+}
C. Co^{2+} | Co || Pb^{2+} | Pb
D. Co | Co^{2+} || Pb^{2+} | Pb

229. Correct cell notation for the cell made of iron and sodium? ($Fe^{2+}|Fe$ −0.447 V; $Na^+|Na$ −2.71 V)

A. Fe | Fe^{2+} || Na^+ | Na
B. Fe^{2+} | Fe || Na^+ | Na
C. Na | Na^+ || Fe^{2+} | Fe
D. Na^+ | Na || Fe^{2+} | Fe

230. A voltaic cell is made from $Ni^{2+}|Ni$ (−0.2570 V) and $Ag^+|Ag$ (+0.7996 V). What is the correct cell notation?

A. Ag | Ag^+ || Ni^{2+} | Ni
B. Ag^+ | Ag || Ni^{2+} | Ni
C. Ni | Ni^{2+} || Ag^+ | Ag
D. Ni^{2+} | Ni || Ag^+ | Ag

Item 30

Textbook p. 51, 52

Define electroplating while describing how it works, identifying anode, cathode and electrolyte needed for an electrolytic cell in which a selected metal is to be plated on an object (car or spoon,... etc)

EXPLANATION

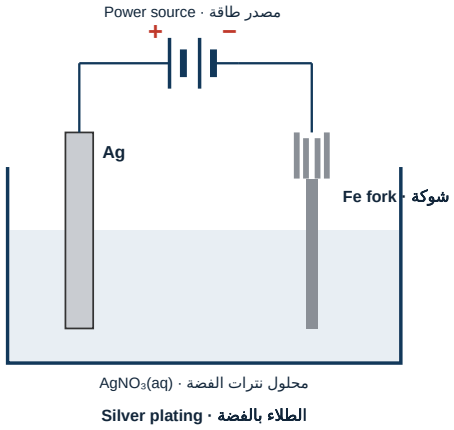
Electroplating: the object to plate = **cathode**; the plating metal = **anode**; electrolyte contains its ions (silver plating: Ag anode, $AgNO_3$ solution).

PRACTICE QUESTIONS

231. In an ideal copper-plating cell the anode loses 0.48 g. What mass of copper is gained by the object?

A. 0.24 g
B. 0.48 g
C. 0.96 g
D. 0 g

232. In silver plating, the anode is...



A. a silver bar or sheet
B. the object to be plated
C. a graphite rod
D. an iron screen

233. In an electrolytic cell used for silver plating, the object to be plated is...

Use the figure above

A. the anode
B. the cathode
C. the electrolyte
D. the salt bridge

234. According to the text, the oxidation number of Oxygen in peroxides (like H_2O_2) is:

A. -2
B. -1
C. 0
D. +2

235. An iron fork is electroplated with a layer of silver in an electrolytic cell. What is the cathode?

Use the figure above

A. The iron fork
B. The electrolyte solution
C. The silver plate
D. The battery

236. What is the oxidation number of chlorine in $HClO_4$?

A. +7
B. +5
C. +3
D. +1

237. An iron fork is electroplated with a layer of silver. Which statement is correct? (Booklet Q178/Q183)

Use the figure above

A. The fork is the positive electrode
B. The fork is the cathode
C. The silver electrode is the cathode
D. The solution is a non-electrolyte

238. What is the change in the oxidation number of copper (Cu) in the following balanced equation? $2Fe(s) + 3CuSO_4(aq) \rightarrow 3Cu(s) + Fe_2(SO_4)_3(aq)$

A. From +2 to 0

B. From 0 to +2

C. From +3 to 0

D. From 0 to +3

239. A key is plated with copper. Part 1 is the key (wired to the – terminal), part 2 is a copper plate (wired to the + terminal) and part 3 is the solution. What do 1, 2 and 3 refer to? (Booklet Q176)

A. 1 anode · 2 cathode · 3 Cu^{2+}

B. 1 cathode · 2 anode · 3 Cu^{2+}

C. 1 anode · 2 cathode · 3 Cu

D. 1 cathode · 2 anode · 3 Cu

240. What is the change in the oxidation number of bromine in the following equation? $2KBr + Cl_2 \rightarrow 2KCl + Br_2$

A. No change

B. From 0 to +1

C. From -1 to 0

D. From 0 to -1

Answer key

Item 1 — Distinguish between oxidation and reduction in terms of loss and gain of electrons, oxygen and hydrogen

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

2. OIL RIG.
4. Electron transfer.

Item 2 — Define oxidation number

11 C	12 C	13 A	14 B	15 B	16 B	17 B	18 C	19 A	20 C

Item 3 — Define oxidizing agent and reducing agent in a redox reaction

21 B	22 A	23 A	24 A	25 B	26 C	27 C	28 A	29 C	30 A

22. Gains electrons.
25. It accepts electrons.
28. Mg is oxidized.

Items 4 · 5 — Identify oxidizing agent and reducing agent in a redox reaction

31 B	32 C	33 A	34 B	35 C	36 C	37 C	38 C	39 A	40 A

32. H: +1 → 0.
35. Most electronegative element.
38. Br_2 gains electrons.

Items 6 · 10 · 11 — Distinguish between oxidation and reduction in terms of change in oxidation number

41 B	42 D	43 A	44 D	45 D	46 A	47 A	48 C	49 A	50 A

Items 7 · 8 — Assign oxidation number to atoms, ions and compounds according to a set of rules

51 B	52 A	53 C	54 A	55 A	56 D	57 A	58 B	59 B	60 C

52. The highest-numbered s electrons are lost before the d electrons.
53. Ga loses $4p^1$ and $4s^2$ (3 electrons) and keeps the full $3d^{10}$.
56. Cd ($[Kr]5s^24d^{10}$) loses $5s^2$ → $[Kr]4d^{10}$: completely filled sublevels are stable.
57. Many transition and post-transition ions keep a full s, p and d set (18 electrons) instead of a true noble-gas octet.
58. Zn is $[Ar]4s^23d^{10}$; it loses the two 4s electrons first, leaving a full $3d^{10}$ (pseudo-noble gas).
59. $s^2 + p^6 + d^{10} = 18$.
60. Ag ($[Kr]5s^14d^{10}$) loses $5s^1$ → $[Kr]4d^{10}$, 18 outer electrons. The others reach true noble-gas octets.

Item 9 — Determines the oxidation number of elements and compounds with more complex formulas.

61 B	62 C	63 B	64 C	65 B	66 A	67 C	68 D	69 A	70 E

Item 12 — Describe the steps for balancing redox reactions, in acidic medium, by the half-reaction method

71 B	72 A	73 A	74 A	75 B	76 A	77 B	78 B	79 A	80 C

Item 13 — Write oxidation-half reaction and reduction-half reaction for a redox reaction

81 B | 82 D | 83 C | 84 C | 85 A | 86 C | 87 A | 88 A | 89 D | 90 C

Items 14 · 15 — Balance redox reaction in acidic medium using half-reaction method

91 B | 92 D | 93 D | 94 A | 95 D | 96 C | 97 C | 98 B | 99 D | 100 B

Item 16 — Describe the steps for balancing redox reactions, in basic medium, by the half-reaction method

101 A | 102 A | 103 A | 104 A | 105 A | 106 B | 107 A | 108 A | 109 A | 110 C

Item 17 — Balance redox reaction in basic medium using half-reaction method

111 B | 112 B | 113 B | 114 B | 115 A | 116 A | 117 A | 118 B | 119 A | 120 A

Item 18 — Describe an electrochemical cell while specifying its types

121 A | 122 B | 123 A | 124 A | 125 B | 126 D | 127 D | 128 B | 129 D | 130 B

124. E°cell = E°cathode − E°anode = 0 − E°(Zn) = 0.76 → E°(Zn) = −0.76 V.
127. Cu^{2+} is reduced (cathode), H_2 is oxidized at the SHE (anode): E°(Cu) = +0.34 V.

Item 19 — Identify components of a voltaic or galvanic cell (anode, cathode, salt bridge or porous barrier, wires, electrolyte compartments); while explaining the role of each component, when does the reaction start and determining the direction of electron and current flow

131 A | 132 B | 133 D | 134 A | 135 A | 136 B | 137 B | 138 B | 139 B | 140 B

Item 20 — Write the oxidation and reduction half-reactions occurring at cathode and anode for a voltaic cell

141 A | 142 C | 143 A | 144 A | 145 A | 146 D | 147 C | 148 A | 149 A | 150 A

Item 21 — Define the reduction potential and standard electrode potential (E°)

151 D | 152 B | 153 D | 154 C | 155 D | 156 B | 157 A | 158 C | 159 D | 160 A

Item 22 — Describe standard hydrogen electrode (SHE), while identifying the importance of its E° value and writing the half-cell reactions of the two possible reactions that could occur at the hydrogen electrode

161 A | 162 B | 163 A | 164 D | 165 B | 166 D | 167 D | 168 D | 169 B | 170 A

164. By international agreement E° of the SHE is set at exactly 0 V.
165. Half-cell potentials cannot be measured alone, so each is measured relative to the SHE.
166. Standard conditions: 1 M H^+, 1 atm H_2, 298 K; Pt is an inert surface.
167. At the cathode reduction occurs: H^+ ions gain electrons.
169. At the anode oxidation occurs: H_2 loses electrons.

Items 23 · 25 — Use the half-cell standard reduction potentials to calculate the electrochemical cell standard potential, while determining whether the redox reactions are spontaneous or non-spontaneous

171 A | 172 A | 173 A | 174 C | 175 A | 176 A | 177 A | 178 C | 179 D | 180 A

Item 24 — Write the cell notation and the overall chemical equation for a redox reaction occurring in a voltaic cell

181 A | 182 C | 183 D | 184 A | 185 D | 186 A | 187 A | 188 D | 189 C | 190 B

Item 26 — Compare between electrolytic cell and voltaic cell in terms of identifying where will reduction and oxidation processes take place, anode, cathode, direction of electron flow and current flow and spontaneity of the reaction occurring

191 B | 192 C | 193 A | 194 D | 195 D | 196 D | 197 B | 198 C | 199 D | 200 D

Item 27 — Describe how a spontaneous redox reaction of an electrochemical cell can be reversed

201 A | 202 C | 203 B | 204 A | 205 A | 206 A | 207 D | 208 B | 209 B | 210 A

Item 28 — Write half-cell reactions while identifying the products of electrolysis of molten ionic compounds

211 A | 212 A | 213 A | 214 A | 215 A | 216 A | 217 A | 218 A | 219 B | 220 C

Item 29 — Write half-cell reactions while identifying the products of electrolysis of aqueous ionic compounds

221 A | 222 A | 223 A | 224 A | 225 D | 226 B | 227 C | 228 D | 229 C | 230 C

Item 30 — Define electroplating while describing how it works, identifying anode, cathode and electrolyte needed for an electrolytic cell in which a selected metal is to be plated on an object (car or spoon,... etc)

231 B | 232 A | 233 B | 234 B | 235 A | 236 A | 237 B | 238 A | 239 B | 240 C