SL Paper 1

Which changes could take place at the positive electrode (cathode) in a voltaic cell?

I. $\mathrm{Zn^{2+}(aq)}$ to Zn(s)

II. $\mathrm{Cl_2(g)}$ to $\mathrm{Cl^-(aq)}$

III. Mg(s) to $\mathrm{Mg^{2+}(aq)}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

What occurs at the anode (positive electrode) during the electrolysis of molten strontium bromide?

A. Formation of bromine and oxidation

B. Formation of bromine and reduction

C. Formation of strontium and oxidation

D. Formation of strontium and reduction

What happens to the manganese in the following reaction?

$$\mathrm{2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 5O_2(g)}$$

A. It is oxidized and its oxidation number increases.

B. It is oxidized and its oxidation number decreases.

C. It is reduced and its oxidation number increases.

D. It is reduced and its oxidation number decreases.

What is the order of decreasing reactivity of the metals (most reactive first)?

$\mathrm{Zn(s) + Sn^{2+}(aq) \rightarrow Zn^{2+}(aq) + Sn(s)}$
$\mathrm{Cu(s) + Zn^{2+}(aq) \rightarrow}$ No Reaction
$\mathrm{Sn(s) + Cu^{2+}(aq) \rightarrow Sn^{2+}(aq) + Cu(s)}$
$\mathrm{Ag(s) + Cu^{2+}(aq) \rightarrow}$ No Reaction

A. Zn > Cu > Sn > Ag

B. Sn > Zn > Ag > Cu

C. Ag > Cu > Zn > Sn

D. Zn > Sn > Cu > Ag

What is the oxidation half-equation in the redox reaction?

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

A. $I_2(aq) + 2e^- \rightarrow 2I^-(aq)$

B. $2I^-(aq) \rightarrow I_2(aq) + 2e^-$

C. $2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2e^-$

D. $S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$

What occurs during the operation of a voltaic cell based on the following overall reaction?

$$2Ag^+(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$$

	External circuit	Ion movement in solution
A.	electrons move from Cu(s) to Ag(s)	$Ag^+(aq)$ move towards Cu(s)
B.	electrons move from Ag(s) to Cu(s)	$Ag^+(aq)$ move towards Ag(s)
C.	electrons move from Cu(s) to Ag(s)	$Ag^+(aq)$ move towards Ag(s)
D.	electrons move from Ag(s) to Cu(s)	$Cu^{2+}(aq)$ move towards Cu(s)

What is the name of Cu_2S?

A. Copper(I) sulfide

B. Copper(I) sulfate

C. Copper(II) sulfide

D. Copper(II) sulfate

What is the correct **decreasing** order of reactivity of the metals X, Y and Z based on the following equations?

$$XCl + Y \rightarrow YCl + X$$
$$YCl + Z \rightarrow YCl + Z$$
$$ZCl + X \rightarrow XCl + Z$$

A. X > Y > Z

B. $Y > Z > X$

C. $Z > Y > X$

D. $Y > X > Z$

Which can describe oxidation?

A. Loss of hydrogen

B. Decrease in oxidation number

C. Gain of electrons

D. Loss of oxygen

Which element is reduced in the following decomposition?

$$(NH_4)_2Cr_2O_7(s) \rightarrow N_2(g) + Cr_2O_3(s) + 4H_2O(g)$$

A. N

B. H

C. Cr

D. O

What is produced at the positive electrode (anode) and negative electrode (cathode) during the electrolysis of molten lithium chloride and molten lead bromide?

	$LiCl(l)$		$PbBr_2(l)$	
	+	–	+	–
A.	lithium	chlorine	lead	bromine
B.	lithium	chlorine	bromine	lead
C.	chlorine	lithium	lead	bromine
D.	chlorine	lithium	bromine	lead

Which of the following is **not** a redox reaction?

A. $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$

B. $C(s) + O_2(g) \rightarrow CO_2(g)$

C. $2CO(g) \rightarrow CO_2(g) + C(s)$

D. $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$

Which of the following is a redox reaction?

A. $3Mg\ (s) + 2AlCl_3\ (aq) \rightarrow 2Al\ (s) + 3MgCl_2\ (aq)$

B. $SiO_2\ (s) + 2NaOH\ (aq) \rightarrow Na_2SiO_3\ (aq) + H_2O\ (l)$

C. $KCl\ (aq) + AgNO_3\ (aq) \rightarrow AgCl\ (s) + KNO_3\ (aq)$

D. $2NaHCO_3\ (aq) \rightarrow Na_2CO_3\ (aq) + CO_2\ (g) + H_2O\ (l)$

Consider the following reaction:

$$3Sn^{2+}(aq) + Cr_2O_7^{2-}(aq) + 2H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3SnO_2(s) + H_2O(l)$$

Which statement is correct?

A. Sn^{2+} is the oxidizing agent because it undergoes oxidation.

B. Sn^{2+} is the reducing agent because it undergoes oxidation.

C. $Cr_2O_7^{2-}$ is the oxidizing agent because it undergoes oxidation.

D. $Cr_2O_7^{2-}$ is the reducing agent because it undergoes oxidation.

What happens at the negative electrode in a voltaic cell and in an electrolytic cell?

	Voltaic cell	Electrolytic cell
A.	oxidation	reduction
B.	reduction	oxidation
C.	oxidation	oxidation
D.	reduction	reduction

Which statement is correct for a voltaic but **not** for an electrolytic cell?

A. An electrolyte is required.
B. The anode is where oxidation occurs.
C. Ions move in the electrolyte.
D. Electrons flow from the negative electrode to the positive electrode.

Consider the following reactions of three unknown metals X, Y and Z.

$2\mathrm{XNO_3(aq)} + \mathrm{Y(s)} \rightarrow 2\mathrm{X(s)} + \mathrm{Y(NO_3)_2(aq)}$

$\mathrm{Y(NO_3)_2(aq)} + \mathrm{Z(s)} \rightarrow$ No reaction

$2\mathrm{XNO_3(aq)} + \mathrm{Z(s)} \rightarrow 2\mathrm{X(s)} + \mathrm{Z(NO_3)_2(aq)}$

What is the order of **increasing** reactivity of the metals (least reactive first)?

A. $\mathrm{X} < \mathrm{Y} < \mathrm{Z}$

B. $\mathrm{X} < \mathrm{Z} < \mathrm{Y}$

C. $\mathrm{Z} < \mathrm{Y} < \mathrm{X}$

D. $\mathrm{Y} < \mathrm{Z} < \mathrm{X}$

Which is a correct statement for the reaction below?

$$2MnO_4^-(aq) + 6H^+(aq) + 5NO_2^-(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(l)$$

A. MnO_4^- is the reducing agent and the oxidation number of Mn increases.
B. MnO_4^- is the oxidizing agent and the oxidation number of Mn decreases.
C. NO_2^- is the reducing agent and the oxidation number of N decreases.
D. NO_2^- is the oxidizing agent and the oxidation number of N increases.

Which element has the same oxidation number in both species?

A. C in C_2H_4 and CO_2

B. H in H_2O and NaH

C. S in $SO_4^{2-}$and SO_3

D. O in H_2O_2 and H_2O

Consider how current is conducted in an electrolytic cell. Which statement is correct?

A. Electrons move through the electrolyte and the external circuit.

B. Ions move through the electrolyte and the external circuit.

C. Electrons move through the external circuit and ions move through the electrolyte.

D. Electrons move through the electrolyte and ions move through the external circuit.

Which experimental methods could be used to observe the progress of the following reaction?

$$Cr_2O_7^{2-}(aq) + 6I^-(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 7H_2O(l)$$

I. Change in colour
II. Change in mass
III. Change in electrical conductivity

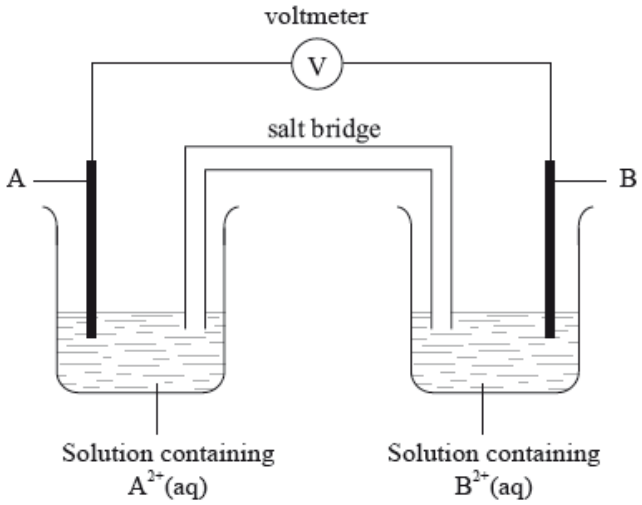
A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Metal A is more reactive than metal B. A standard voltaic cell is made as shown.



Which statement is correct?

A. Electrons flow in the external circuit from A to B.

B. Positive ions flow through the salt bridge from A to B.

C. Positive ions flow in the external circuit from B to A.

D. Electrons flow through the salt bridge from B to A.

Applying IUPAC rules, what is the name of MnO_2?

A. Magnesium(II) oxide

B. Manganese(II) oxide

C. Magnesium(IV) oxide

D. Manganese(IV) oxide

Which statements are correct for a voltaic cell?

I. A spontaneous redox chemical reaction produces electrical energy.
II. Oxidation occurs at the cathode (negative electrode).
III. Electrons flow from anode (negative electrode) to cathode (positive electrode).

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

Which of the following redox reactions take place?

I. $\mathrm{Cl_2(aq) + 2NaI(aq) \rightarrow I_2(aq) + 2NaCl(aq)}$
II. $\mathrm{Br_2(aq) + 2NaI(aq) \rightarrow I_2(aq) + 2NaBr(aq)}$
III. $\mathrm{I_2(aq) + 2NaBr(aq) \rightarrow Br_2(aq) + 2NaI(aq)}$

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

Metal M has only one oxidation number and forms a compound with the formula $\mathrm{MCO_3}$. Which formula is correct?

A. $\mathrm{MNO_3}$
B. $\mathrm{MNH_4}$
C. $\mathrm{MSO_4}$
D. $\mathrm{MPO_4}$

Which are redox reactions?

I. $\mathrm{2FeCl_2 + Cl_2 \rightarrow 2FeCl_3}$
II. $\mathrm{Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2}$
III. $\mathrm{H_2O + SO_3 \rightarrow H_2SO_4}$

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

What is the correct **increasing** order of reactivity of the metals X, Y and Z based on the following information?

$$\mathrm{XCl_2 + Y \rightarrow YCl_2X}$$
$$\mathrm{ZCl_2 + X \rightarrow XCl_2Z}$$
$$\mathrm{YCl_2 + Z \rightarrow \text{no reaction}}$$

A. $\mathrm{Z < X < Y}$

B. $\mathrm{Y < X < Z}$

C. $\mathrm{Z < Y < X}$

D. $\mathrm{X < Z < Y}$

Which statement is correct for the following reaction?

$$\mathrm{2ClO_3^-(aq) + SO_2(aq) + H^+(aq) \rightarrow 2ClO_2(g) + HSO_4^-(aq)}$$

A. $\mathrm{ClO_3^-}$ is the oxidizing agent and it undergoes reduction.

B. $\mathrm{ClO_3^-}$ is the reducing agent and it undergoes oxidation.

C. $\mathrm{SO_2}$ is the oxidizing agent and it undergoes oxidation.

D. $\mathrm{SO_2}$ is the reducing agent and it undergoes reduction.

What are the products of electrolysis when molten calcium bromide is electrolysed using graphite electrodes?

	Product at cathode (negative electrode)	Product at anode (positive electrode)
A.	calcium	bromine
B.	bromine	calcium
C.	calcium ions	bromide ions
D.	bromide ions	calcium ions

Which statement describes a reducing agent?

A. It is reduced and gains electrons.

B. It is reduced and loses electrons.

C. It is oxidized and gains electrons.

D. It is oxidized and loses electrons.

What is the reducing agent in the reaction below?

$$2MnO_4^-(aq) + Br^-(aq) + H_2O(l) \rightarrow 2MnO_2(s) + BrO_3^-(aq) + 2OH^-(aq)$$

A. Br^-

B. BrO_3^-

C. MnO_4^-

D. MnO_2

At which side of the equation are electrons, H^+ ions and H_2O needed to complete the half-equation?

$$MnO_4^-(aq) \rightarrow Mn^{2+}(aq)$$

	Electrons	H^+ ions	H_2O
A.	reactant side	reactant side	product side
B.	reactant side	product side	reactant side
C.	product side	reactant side	product side
D.	product side	product side	reactant side

Which species could be reduced to form NO_2?

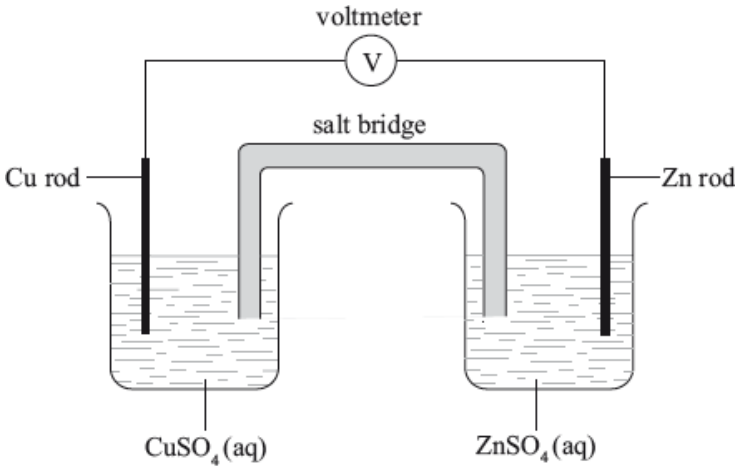
A. N_2O

B. NO_3^-

C. HNO_2

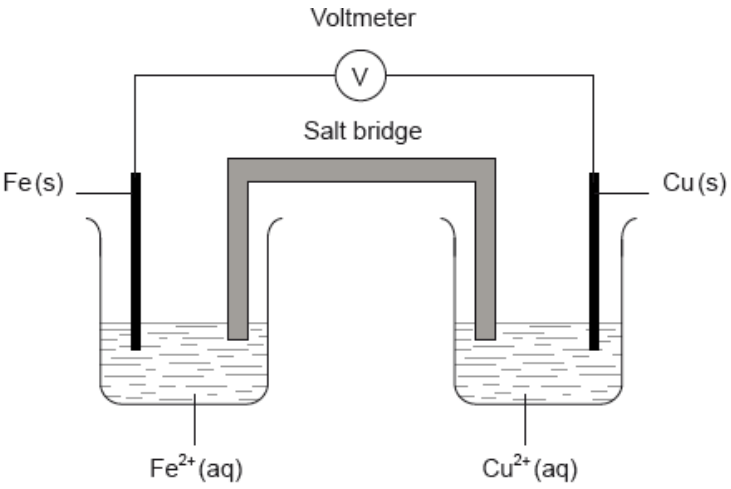
D. NO

Zinc is more reactive than copper. In this voltaic cell, which species is reduced and in which direction do negative ions flow in the salt bridge?



	Species reduced	Direction of negative ion flow in salt bridge
A.	Cu^{2+}	from copper half-cell to zinc half-cell
B.	Cu^{2+}	from zinc half-cell to copper half-cell
C.	Zn^{2+}	from copper half-cell to zinc half-cell
D.	Zn^{2+}	from zinc half-cell to copper half-cell

A voltaic cell is made by connecting a copper half-cell, $\mathrm{Cu(s)}\,|\mathrm{Cu^{2+}(aq)}$, to an iron half-cell $\mathrm{Fe(s)}\,|\mathrm{Fe^{2+}(aq)}$.



Which combination correctly identifies the positive electrode and the species being oxidized?

	Positive electrode	Species oxidized
A.	copper	iron
B.	copper	copper(II) ions
C.	iron	copper
D.	iron	copper(II) ions

Which species is oxidized in the following reaction?

$$2\mathrm{Ag^{+}(aq)} + \mathrm{Cu(s)} \rightarrow 2\mathrm{Ag(s)} + \mathrm{Cu^{2+}(aq)}$$

A. $\mathrm{Ag^{+}}$

B. Cu

C. Ag

D. $\mathrm{Cu^{2+}}$

Which equation shows oxygen undergoing reduction?

A. $2F_2 + O_2 \rightarrow 2F_2O$

B. $Na_2O + H_2O \rightarrow 2NaOH$

C. $H_2O_2 + 2HI \rightarrow 2H_2O + I_2$

D. $2CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$

Which coefficients correctly balance this redox equation?

$$aFe^{2+}(aq) + MnO_4^-(aq) + bH^+(aq) \rightarrow cFe^{3+}(aq) + Mn^{2+}(aq) + dH_2O(l)$$

	a	b	c	d
A.	1	8	1	4
B.	5	4	5	2
C.	3	4	3	2
D.	5	8	5	4

Which process occurs during the electrolysis of molten sodium chloride?

A. Oxidation occurs at the positive electrode (anode).

B. Electrons move through the electrolyte.

C. Sodium ions move through the electrolyte to the positive electrode (anode).

D. Chloride ions move through the electrolyte and are reduced at the negative electrode (cathode).

Which process occurs when a molten salt is electrolysed?

A. The metal ion is oxidized and deposited on the negative electrode (cathode).

B. The metal ion is reduced and deposited on the negative electrode (cathode).

C. The metal ion is oxidized and deposited on the positive electrode (anode).

D. The metal ion is reduced and deposited on the positive electrode (anode).

Which statement is correct for the electrolysis of molten lead iodide, $\mathrm{PbI_2}$?

A. Chemical energy is converted into electrical energy.

B. Pb^{2+} ions are oxidized at the negative electrode (cathode).

C. I_2 is produced at the positive electrode (anode).

D. Ions are produced at both electrodes.

Consider the following reaction.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

Which statement is correct?

A. MnO_4^- is the oxidizing agent and it loses electrons.

B. MnO_4^- is the reducing agent and it loses electrons.

C. MnO_4^- is the oxidizing agent and it gains electrons.

D. MnO_4^- is the reducing agent and it gains electrons.

Which is the oxidizing agent in the following reaction?

$$5SO_2(g) + 2IO_3^-(aq) + 4H_2O(l) \rightarrow 5SO_4^{2-}(aq) + I_2(aq) + 8H^+(aq)$$

A. SO_2

B. IO_3^-

C. H_2O

D. SO_4^{2-}

What are the products of the electrolysis of molten zinc bromide?

	Negative electrode (cathode)	Positive electrode (anode)
A.	zinc	bromine
B.	hydrogen	bromine
C.	bromine	zinc
D.	bromine	hydrogen

Which represents a redox reaction?

A. $NaH(s) + H_2O(l) \rightarrow NaOH(aq) + H_2(g)$

B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

C. $CuCl_2(aq) + K_2S(aq) \rightarrow CuS(s) + 2KCl(aq)$

D. $\mathrm{HCl(aq) + NH_3(aq) \rightarrow NH_4^+CL^-(aq)}$

Which list represents the halogens in **increasing** order of oxidizing strength (weakest oxidizing agent first)?

A. $\mathrm{Cl_2 \quad I_2 \quad Br_2}$

B. $\mathrm{I_2 \quad Br_2 \quad Cl_2}$

C. $\mathrm{I_2 \quad Cl_2 \quad Br_2}$

D. $\mathrm{Cl_2 \quad Br_2 \quad I_2}$

Which statement about the electrolysis of molten sodium chloride is correct?

A. A yellow-green gas would be produced at the negative electrode.

B. A silvery metal is produced at the positive electrode.

C. Chloride ions are attracted to the positive electrode and undergo oxidation.

D. Sodium ions are attracted to the negative electrode and undergo oxidation.

What happens to iodine when iodate ions, $\mathrm{IO_3^-}$, are converted to iodine molecules, $\mathrm{I_2}$?

A. It undergoes reduction and its oxidation number changes from -1 to 0

B. It undergoes oxidation and its oxidation number changes from -1 to 0

C. It undergoes reduction and its oxidation number changes from $+5$ to 0

D. It undergoes oxidation and its oxidation number changes from $+5$ to 0

In which species does sulfur have an oxidation number of 0?

A. $\mathrm{SO_3}$

B. $\mathrm{S_8}$

C. $\mathrm{Na_2SO_4}$

D. $\mathrm{H_2S}$

Which species can oxidize ethanol to ethanoic acid?

A. $\mathrm{I^-}$

B. Fe

C. O^{2-}

D. Acidified $K_2Cr_2O_7$

What are the correct oxidation numbers of chromium in $Cr_2O_7^{2-}$ and manganese in $KMnO_4$?

	Chromium in $Cr_2O_7^{2-}$	Manganese in $KMnO_4$
A.	+7	+7
B.	+6	+7
C.	+6	+4
D.	+7	+4

Two half-cells are connected via a salt bridge to make a voltaic cell. Which statement about this cell is correct?

A. Oxidation occurs at the positive electrode (cathode).

B. It is also known as an electrolytic cell.

C. Ions flow through the salt bridge.

D. It requires a power supply to operate.

What are the correct names for $KMnO_4$ and $K_2Cr_2O_7$, using oxidation numbers?

A. Potassium permanganate and potassium dichromate

B. Potassium manganate(IV) and potassium chromate(VII)

C. Potassium permanganate(IV) and potassium dichromate(VII)

D. Potassium manganate(VII) and potassium dichromate(VI)

What are the oxidation states of each element in K_2CrO_4?

	Potassium	Chromium	Oxygen
A.	+1	+6	−2
B.	−1	+6	−2
C.	+1	−6	+2
D.	−1	−6	+2

Consider the overall reaction taking place in a voltaic cell.

$$Ag_2O(s) + Zn(s) + H_2O(l) \rightarrow 2Ag(s) + Zn(OH)_2(s)$$

What is the role of zinc in the cell?

A. The positive electrode and the oxidizing agent.

B. The positive electrode and the reducing agent.

C. The negative electrode and the oxidizing agent.

D. The negative electrode and the reducing agent.

At which electrodes does oxidation occur in a voltaic cell and in an electrolytic cell?

	Voltaic cell	Electrolytic cell
A.	positive	positive
B.	positive	negative
C.	negative	positive
D.	negative	negative

Which statement is correct about a reducing agent?

A. It is reduced by gaining electrons.

B. It is oxidized by gaining electrons.

C. It is oxidized by losing electrons.

D. It is reduced by losing electrons.

What is the coefficient for I^- when the following equation is balanced using the smallest possible whole numbers?

$$IO_3^-(aq) + \_\_ I^-(aq) + \_\_ H^+(aq) \rightarrow \_\_ I_2(aq) + \_\_ H_2O(l)$$

A. 1

B. 2

C. 3

D. 5

What is the name of $\mathrm{Co_3(PO_4)_2}$?

A. Cobalt(II) phosphite

B. Cobalt(II) phosphate

C. Cobalt(III) phosphite

D. Cobalt(III) phosphate

Consider the following reaction.

$$\mathrm{Sn(s) + 4HNO_3(aq) \rightarrow SnO_2(s) + 4NO_2(g) + 2H_2O(g)}$$

Which statement is correct?

A. $\mathrm{HNO_3}$ is the oxidizing agent because it undergoes oxidation.

B. $\mathrm{HNO_3}$ is the reducing agent because the oxidation number of nitrogen changes from $+5$ to $+4$.

C. Sn is the oxidizing agent because it undergoes reduction.

D. Sn is the reducing agent because the oxidation number of tin changes from 0 to $+4$.

Which species of vanadium has a different oxidation number from the rest?

A. $\mathrm{VO_2^+}$

B. $\mathrm{VO_3^-}$

C. $\mathrm{V_2O_5}$

D. $\mathrm{VO^{2+}}$

What is the correct systematic name of MnO_2?

A. Manganese(II) oxide

B. Manganese(IV) oxide

C. Magnesium(II) oxide

D. Magnesium(IV) oxide

Which statement about an electrolytic cell is correct?

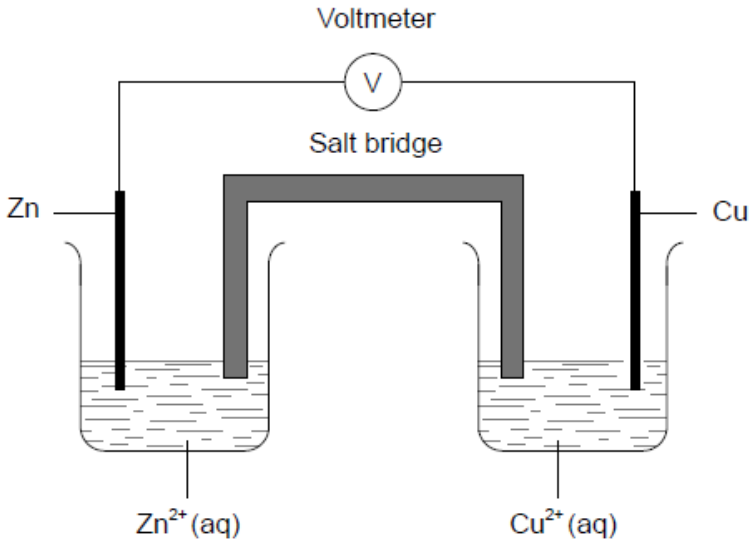
A. Chemical energy is converted to electrical energy.

B. Electrons move through the electrolyte.

C. The cathode is the negative electrode.

D. The negative ions move towards the negative electrode.

A voltaic cell is constructed from zinc and copper half-cells. Zinc is more reactive than copper. Which statement is correct when this cell produces electricity?



A. Electrons flow from the copper half-cell to the zinc half-cell.

B. The concentration of Cu^{2+} (aq) increases.

C. Electrons flow through the salt bridge.

D. Negative ions flow through the salt bridge from the copper half-cell to the zinc half-cell.

A voltaic cell is made by connecting zinc and lead half-cells. The overall equation for the reaction occurring in the cell is shown below.

$$\mathrm{Zn(s) + Pb^{2+}(aq) \rightarrow Pb(s) + Zn^{2+}(aq)}$$

Which statements are correct when the cell produces electricity?

I. The zinc is oxidized.

II. Electrons move from zinc to lead in the external circuit.

III. The mass of the lead electrode increases.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Which statements are correct for the electrolysis of molten lead(II) bromide, $\mathrm{PbBr_2(l)}$?

I. Pb^{2+} is reduced at the negative electrode (cathode).

II. Br^{-} is oxidized at the positive electrode (anode).

III. Bubbles of a brown gas are observed at the negative electrode (cathode).

A. I and II only

B. I and III only

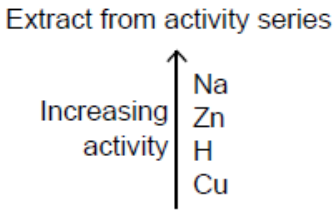
C. II and III only

D. I, II and III

What are the oxidation states of chromium in $(NH_4)_2Cr_2O_7$ (s) and Cr_2O_3 (s)?

	$(NH_4)_2Cr_2O_7$(s)	Cr_2O_3(s)
A.	+7	+3
B.	+6	+3
C.	+6	+6
D.	+7	+6

Which of the following does **not** react with dilute HCl(aq)?



A. Na_2CO_3

B. Cu

C. Zn

D. CuO

What is the reaction type and major product at the **anode** (positive electrode) when molten sodium chloride is electrolysed using platinum electrodes?

	Reaction type	Product
A.	reduction	Cl_2
B.	oxidation	Cl_2
C.	reduction	Na
D.	oxidation	Na