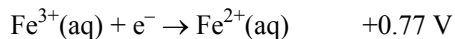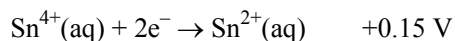# Redox: IB Review Questions

1.   Consider the standard electrode potentials of the following reactions:

$$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq) \qquad +0.15 \text{ V}$$

$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad +0.77 \text{ V}$$
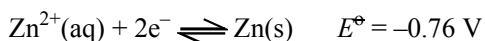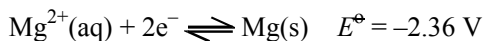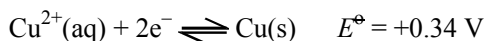
What is the value of the cell potential (in volts) for the spontaneous reaction?

A.   +1.69   B. +1.39   C. +0.92   D. +0.62

2.   Which factors affect the amount of metal formed during electrolysis?

I.   Charge on the metal ion
II.   Current
III.   Time

A.   I and II only   B.   I and III only

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

3.   Consider the following reactions.

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \qquad E^{\ominus} = +0.34 \text{ V}$$

$$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s) \qquad E^{\ominus} = -2.36 \text{ V}$$

$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad E^{\ominus} = -0.76 \text{ V}$$

Which statement is correct?

A. $Cu^{2+}(aq)$ will oxidize both Mg(s) and Zn(s).

B.   Zn(s) will reduce both $Cu^{2+}(aq)$ and $Mg^{2+}(aq)$.

C. $Mg^{2+}(aq)$ will oxidize both Cu(s) and Zn(s).

D.   Cu(s) will reduce both $Mg^{2+}(aq)$ and $Zn^{2+}(aq)$.

4.   Consider the standard electrode potentials of the following reactions.

$$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s) \qquad -0.75 \text{ V}$$

$$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s) \qquad -0.40 \text{ V}$$
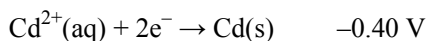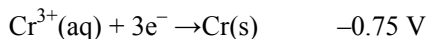
What is the value of the cell potential (in V) for the following reaction?

$$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Cd(s)$$
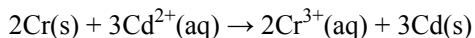
A.   −0.35   B.   −1.15   C.   +0.30   D.   +0.35

5. Aqueous solutions containing different concentrations of NaCl were electrolysed using platinum electrodes. What is the **major** product at the positive electrode in each case?

	0.001 mol dm^{-3} NaCl(aq)	1.0 mol dm^{-3} NaCl(aq)
A.	H_2	Na
B.	H_2	H_2
C.	O_2	Cl_2
D.	Cl_2	O_2

6. The following are standard electrode potentials.

Half-equation	$E^{\ominus}$ / V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	-0.76
$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$	-0.74
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	-0.44
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	-0.14
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	$+0.34$
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	$+0.77$

(a) These values were obtained using a standard hydrogen electrode. Describe the materials and conditions used in the standard hydrogen electrode. (A suitably labelled diagram is acceptable.)   5

(b) Define the term *oxidizing agent* in terms of electron transfer and identify the strongest oxidizing agent in the list above.   2

(c) A cell was set up using zinc in zinc sulfate solution and copper in copper(II) sulfate solution, both solutions being under standard conditions.

   (i)   Calculate the cell potential.   1

   (ii) Write an equation for the spontaneous cell reaction.   2

(d) Both zinc and tin are used to coat iron to prevent it from rusting. Once the surface is scratched, oxygen and water containing dissolved ions come into contact with the iron and the coating metal.

   (i)   State and explain whether zinc or tin would be more effective in preventing iron from rusting under these conditions.   2

(ii)   Electroplating may be used to coat one metal with another metal. Identify the **three** factors affecting the amount of metal discharged during electroplating.   3

(iii)   Explain why electrolysis of aqueous zinc sulfate is not used for coating with zinc metal.   2

(e)   Another cell was set up as shown below.

Pt(s)

Cr(s)

V

Y

$Fe^{3+}(aq)$, $Fe^{2+}(aq)$

$Cr^{3+}(aq)$

half-cell **A**   half-cell **B**
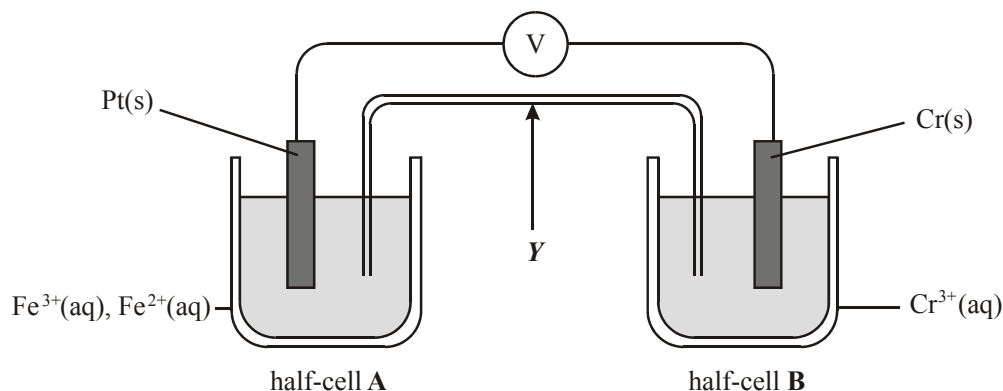
(i)   Identify the part of the cell labelled Y and outline its function.   2

(ii)   Write an equation for the initial reactions at each electrode and hence write an equation for the cell reaction.   4

(iii)   Describe the direction of electron flow in the external circuit.   1

(iv)   Calculate the cell potential.   1
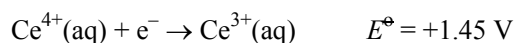
7.

Direction of electron flow

A

Salt bridge

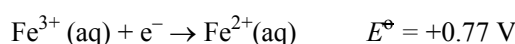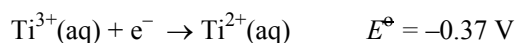Zn(s)

Cu(s)

$Zn^{2+}(aq)$

$Cu^{2+}(aq)$
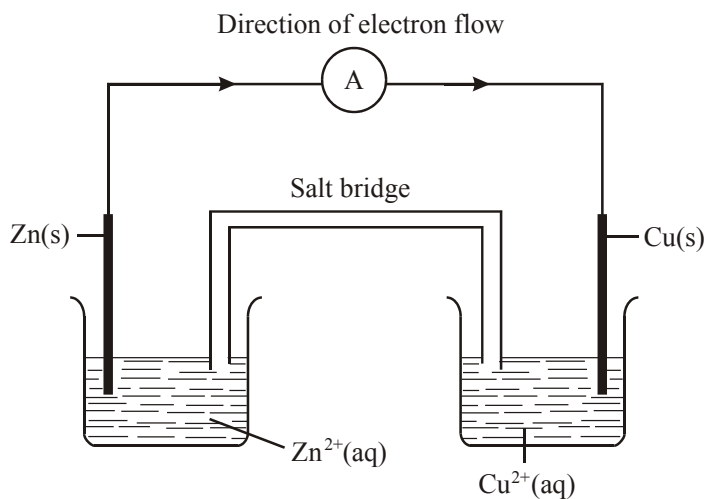
(a)   The apparatus shown above may be used to carry out a redox reaction.

(i)   State the function of the salt bridge.   1

    (ii) Write a half-equation for the oxidation reaction.   1

(iii)   The above reactions are carried out under *standard conditions*.
        State what the standard conditions are for the cell.   2

(iv) Using the Data Booklet, calculate the cell potential for the above cell.   2

(v)   State and explain what happens to the concentration of the copper(II) ions when the
       cell is producing an electric current.   2

(vi) State **two** observations that could be made if the zinc rod were placed in a solution
       of copper(II) ions.   2

(b)   The standard electrode potentials for three electrode systems are given below.

$$Ti^{3+}(aq) + e^- \rightarrow Ti^{2+}(aq) \qquad E^{\ominus} = -0.37 \text{ V}$$

$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad E^{\ominus} = +0.77 \text{ V}$$

$$Ce^{4+}(aq) + e^- \rightarrow Ce^{3+}(aq) \qquad E^{\ominus} = +1.45 \text{ V}$$

(i)   Using the data above, deduce which species is the best reducing agent, giving a
      reason in terms of electrons for your answer.   2

(ii)   Write an equation, including state symbols, for the overall reaction with the
      greatest cell potential.   2

(iii) State and explain the sign of $\Delta G^{\ominus}$ for the reaction in (b) (ii).   2

(c) (i)   State the name of a solution that would produce **only** hydrogen and oxygen when
      electrolyzed using platinum electrodes.   1

(ii)   Draw a diagram of apparatus that would allow the gases produced in the reaction in
      (c) (i) to be collected separately. Annotate your diagram to show the polarity of
      each electrode and the names and relative volumes of each gas.   3

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

$$Ni(s) + Pb^{2+}(aq) \rightarrow Ni^{2+}(aq) + Pb(s)$$
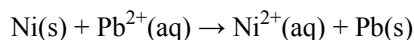
	External circuit	**Ion movement in solution**
A.	electrons move from Ni to Pb	$Pb^{2+}(aq)$ move away from Pb(s)
B.	electrons move from Ni to Pb	$Pb^{2+}(aq)$ move toward Pb(s)
C.	electrons move from Pb to Ni	$Ni^{2+}(aq)$ move away from Ni(s)
D.	electrons move from Pb to Ni	$Ni^{2+}(aq)$ move toward Ni(s)

9.   Which is the strongest reducing agent according to the spontaneous reactions below?

$$2Cr(s) + 3Fe^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Fe(s)$$
$$Fe(s) + Pb^{2+}(aq) \rightarrow Fe^{2+}(aq) + Pb(s)$$
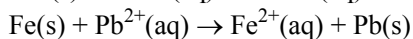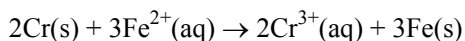
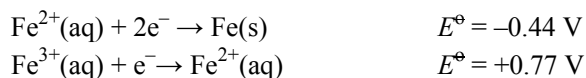A.   Cr(s)   B. $Cr^{3+}(aq)$ C. $Pb^{2+}(aq)$ D.   Pb

10. Aqueous solutions of $AgNO_3$, $Cu(NO_3)_2$ and $Cr(NO_3)_3$ are electrolyzed using the same quantity of electricity. How do the number of moles of metal formed compare?

A. $Ag = Cu = Cr$

B. $Ag > Cu > Cr$

C. $Ag < Cu < Cr$

D. $Cu > Ag > Cr$

11.

$CuSO_4(aq)$
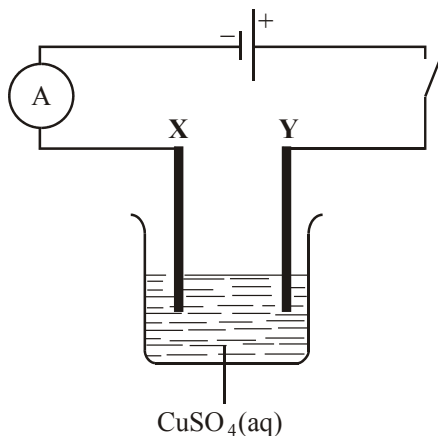
Two copper strips **X** and **Y** are placed in an aqueous solution of copper(II) sulfate and electrolyzed for a certain time. **X** was then dried and weighed.

(i) State and explain what would happen to the mass of **X**. 　　　　　　　　　　　3

(ii) State **two** ways in which the change in the mass of **X** could be increased. 　　　2

12. The standard electrode potentials for two half-cells involving iron are given below.

$$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s) \qquad\qquad E^\ominus = -0.44 \text{ V}$$
$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad\qquad E^\ominus = +0.77 \text{ V}$$

What is the equation and the cell potential for the spontaneous reaction that occurs when the two half-cells are connected?

A. $3Fe^{2+}(aq) \rightarrow Fe(s) + 2Fe^{3+}(aq)$ 　　　　$E^\ominus = +1.21$ V

B. $Fe^{2+}(aq) + Fe^{3+}(aq) \rightarrow 2Fe(s)$ 　　　　$E^\ominus = +0.33$ V

C. $Fe(s) + 2Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq)$ 　　　　$E^\ominus = +0.33$ V

D. $Fe(s) + 2Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq)$ 　　　　$E^\ominus = +1.21$ V

13. (a) When a concentrated aqueous solution of sodium chloride is electrolyzed using inert electrodes, a different gas is produced at each electrode.

(i) Write equations for the oxidation and reduction half-reactions. 　　　　2

Oxidation half-reaction:

Reduction half-reaction:

(ii)   Explain why sodium is not formed during the electrolysis of aqueous NaCl solution.   1

(b)   Deduce the products formed during the electrolysis of an aqueous solution of sodium fluoride. Write an equation for the reaction at the positive electrode (the anode) and give your reasoning.   4

14.   (a)   Some standard electrode potentials are shown in Table 15 of the Data Booklet.

   (i)   State three conditions under which the hydrogen electrode is assigned a potential of zero.   3

   (ii)   Calculate the cell potential of a cell made by connecting standard copper and zinc electrodes. State the direction of electron flow in the external circuit when the cell produces current. Outline the changes occurring at the electrodes and in the solutions during the process.   5

(b)   Using information from Table 15, determine whether or not there is a spontaneous reaction between copper metal and a solution containing hydrogen ions.   2

(c)   Using information from Table 15, identify a substance that will oxidize bromide ions but not chloride ions. Explain your choice, and write an equation for the redox reaction you have chosen.   5

15.   (i)   Solid sodium chloride does not conduct electricity but molten sodium chloride does. Explain this difference, and outline what happens in an electrolytic cell during the electrolysis of molten sodium chloride using carbon electrodes.   4

(ii)   State the products formed and give equations showing the reactions at each electrode. 4

(iii)   State what practical use is made of this process.   1

16.   The following information is given about reactions involving the metals X, Y and Z and solutions of their sulfates.

$$X(s) + YSO_4(aq) \rightarrow \text{no reaction}$$
$$Z(s) + YSO_4(aq) \rightarrow Y(s) + ZSO_4(aq)$$
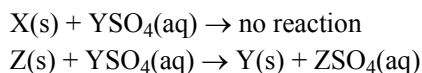
When the metals are listed in decreasing order of reactivity (most reactive first), what is the correct order?

A. $Z > Y > X$ B. $X > Y > Z$ C. $Y > X > Z$ D. $Y > Z > X$

17.   What is the coefficient for H^+ when the equation below is balanced?

$$\_Pb(s) + \_NO_3^-(aq) + \_H^+(aq) \rightarrow \_Pb^{2+}(aq) + \_NO(g) + \_H_2O(l)$$
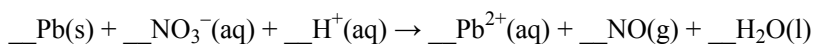
A.   2   B.   4   C.   6   D.   8

18.   A current is passed through molten sodium chloride. Identify the substance formed at each electrode and write an equation to represent the formation of each substance. Determine the mole ratio in which the substances are formed.   5

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

    A.   A colourless gas is produced at the negative electrode.

    B.   The electrolyte does not change colour.

    C.   The negative electrode decreases in mass.

    D.   A colourless gas is produced at the positive elec

20. The **unbalanced** equation for the conversion of sulfur dioxide to sulfuric acid is given below.

$$\_\_\_SO_2 + \_\_\_H_2O \rightarrow \_\_\_H_2SO_4$$
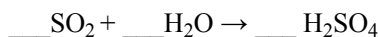
Which other species are used, and on which side of the equation, to balance it?

    A. H^+ and e^- on the left   B. H^+ on the left and e^- on the right

    C. H^+ on the right and e^- on the left   D. H^+ and e^- on the right

21. What happens at the positive 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

22. The cyanide ion, CN^-, can form two complex ions with iron ions. The formulas of these ions are $[Fe(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$. What is the oxidation number of iron in the two complex ions?

	$[Fe(CN)_6]^{4-}$	$[Fe(CN)_6]^{3-}$
A.	–4	–3
B.	+2	+3
C.	+3	+2
D.	–3	–4

23. Electrolysis can be used to obtain chlorine from molten sodium chloride. Write an equation for the reaction occurring at each electrode and describe the two different ways in which electricity is conducted when the cell is in operation.

24. Two reactions occurring in the manufacture of bromine from sea water are

          I $Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(g)$
   II $Br_2(g) + SO_2(g) + 2H_2O(l) \rightarrow 2HBr(g) + H_2SO_4(g)$
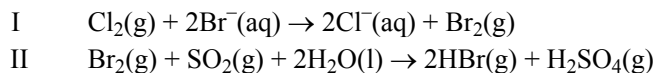
    (i)   Explain, by reference to electrons, why reaction I is referred to as a redox reaction. 2

    (ii)   State and explain whether SO_2 is reduced or oxidized in reaction II by referring to the oxidation numbers of sulfur in this reaction.   3

25. A voltaic cell is made from magnesium and iron half-cells. Magnesium is a more reactive metal than iron. Which statement is correct when the cell produces electricity?

    A.   Electrons are lost from magnesium atoms.

    B.   The concentration of Fe^{2+} ions increases.

    C.   Electrons flow from the iron half-cell to the magnesium half-cell.

    D.   Negative ions flow through the salt bridge from the magnesium half-cell to the iron half-cell.

26. Deduce the **change** in oxidation number of chromium in the below reaction. State with a reason whether the chromium has been oxidized or reduced.   2

$$CrO_7{}^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$
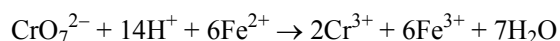
27. A metallic object is electroplated with copper using a solution of copper(II) sulfate. Which statement is correct?

    A.   The positive electrode increases in mass.

    B.   B. The concentration of Cu^{2+} ions in the solution decreases.

    C.   Reduction occurs at the positive electrode.

    D.   The reaction occurring at the negative electrode is $Cu^{2+} + 2e^- \rightarrow Cu$.

28. Which are used for the electroplating of a metal spoon with copper?

    I.   an electrolyte containing aqueous copper(II) ions

    II.   a copper anode (positive electrode)

    III.   a copper cathode (negative electrode)

    A.   I and II only   B.   I and III only

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

29. Iron in food, in the form of Fe^{3+}, reacts with ascorbic acid (vitamin C), $C_6H_8O_6$, to form dehydroascorbic acid, $C_6H_6O_6$.

    (i)   Write an ionic half-equation to show the conversion of ascorbic acid to dehydroascorbic acid in aqueous solution.   1

    (ii)   In the other ionic half-equation Fe^{3+} is converted to Fe^{2+}. Deduce the overall equation for the reaction between $C_6H_8O_6$ and Fe^{3+}.   1

30.   (i)   Draw a diagram of apparatus that could be used to electrolyse molten potassium bromide. Label the diagram to show the polarity of each electrode and the product formed.   3

    (ii)   Describe the **two** different ways in which electricity is conducted in the apparatus.   2

    (iii)   Write an equation to show the formation of the product at each electrode.   2
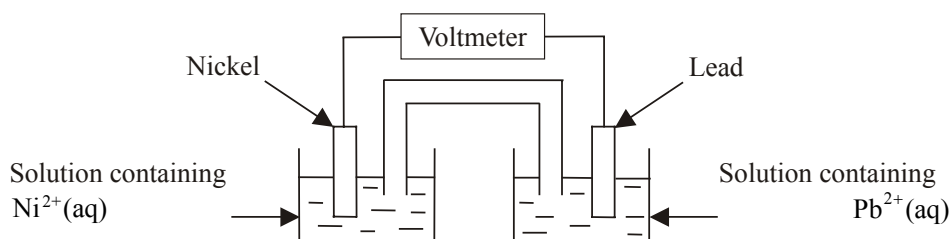
31. Consider these standard electrode potentials.

$$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq) \qquad E^{\ominus} = +0.15 \text{ V}$$

$$Cu^+(aq) + e^- \rightarrow Cu(s) \qquad E^{\ominus} = +0.52 \text{ V}$$
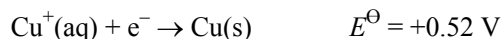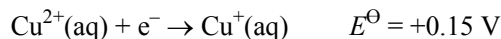
What is the standard cell potential when the two half-cells are connected?

A.   − 0.67 V   B.   − 0.37 V   C.   + 0.37 V   D.   + 0.67 V

32. Use information from Table 15 of the Data Booklet, where relevant, in answering this part.

(i)   The diagram shows the apparatus used in an experiment involving half-cells.

The reading on the voltmeter is 0.10 V. State **two** standard conditions that apply for this
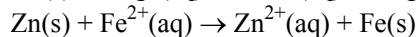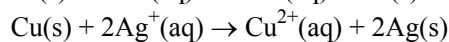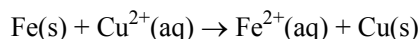reading to be obtained.   2

(ii)   The voltmeter is replaced by a 2 volt power supply, so that non-spontaneous reactions
occur. Deduce the half-equations for these reactions.   2

(iii)   Chlorine gas is formed when potassium manganate(VII) is added to concentrated
hydrochloric acid. Calculate the cell potential for this reaction and deduce the equation
for the reaction.   3

(iv)   Explain why potassium dichromate(VI) does not react with concentrated hydrochloric
acid.   1

33. Consider the following spontaneous reactions.

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

Which is the correct combination of strongest oxidizing agent and strongest reducing agent?

	Strongest oxidizing agent	Strongest reducing agent
A.	$Ag(s)$	$Zn(s)$
B.	$Ag^+(aq)$	$Zn(s)$
C.	$Zn^{2+}(aq)$	$Ag(s)$
D.	$Zn(s)$	$Ag^+(aq)$

34. The compound $[Co(NH_3)_5Br]SO_4$ is isomeric with the compound $[Co(NH_3)_5SO_4]Br$. What is the oxidation state of cobalt in these compounds?

	$[Co(NH_3)_5Br]SO_4$	$[Co(NH_3)_5SO_4]Br$
A.	+3	+3
B.	+2	+1
C.	+3	+2
D.	+2	+3

35. Tin(II) ions can be oxidized to tin(IV) ions by acidified potassium permanganate(VII) solution according to the following unbalanced equation.

$$\underline{\ \ } \ Sn^{2+} + \underline{\ \ } MnO_4^- + \underline{\ \ } H^+ \rightarrow \underline{\ \ } Sn^{4+} + \underline{\ \ } Mn^{2+} + \underline{\ \ } H_2O$$
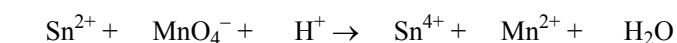
(a)   Identify the oxidizing agent and the reducing agent.

Oxidizing agent:
Reducing agent:

(b)   Balance the equation above.   1

36. Iodide ions, $I^-(aq)$, react with iodate ions, $IO_3^-(aq)$, in an acidic solution to form molecular iodine and water.

(i)   Determine the oxidation number of iodine in each iodine-containing species in the
       reaction.   2

(ii)   Identify, with a reason, the species that undergoes: 2

oxidation

reduction

37. (a)   Iodide ions, $I^-(aq)$, react with iodate ions, $IO_3^-(aq)$, in an acidic solution to form
              molecular iodine and water.

(i)   Determine the oxidation number of iodine in I^- and in IO_3^-.   1

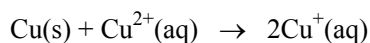(ii)   Identify, with a reason, the species that undergoes

Oxidation
Reduction

(iii)   Write an ionic equation for the reaction of I^- with IO_3^- in an acidic solution.   2

(b)   Use information from Table 15 of the Data Booklet to calculate the cell potential for the
following reaction and state whether or not the reaction is spontaneous.   3

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

38. What process occurs at the cathode in a voltaic cell and at the anode in an electrolytic cell?

	Cathode of voltaic cell	Anode of Electrolytic cell
A.	Oxidation	Reduction
B.	Oxidation	Oxidation
C.	Reduction	Oxidation
D.	Reduction	Reduction

39. Which statement is correct?

A.   Oxidation involves loss of electrons and a decrease in oxidation state.

B.   Oxidation involves gain of electrons and an increase in oxidation state.

C.   Reduction involves loss of electrons and an increase in oxidation state.

D.   Reduction involves gain of electrons and a decrease in oxidation state.