REDOX Core (SL & HL)

1. Consider the overall redox reaction:

$$CrO_4^{2-}(aq) + 3Fe(OH)_2(s) + 4H_2O(l) \rightarrow Cr(OH)_3(s) + 3Fe(OH)_3(s) + 2OH^-(aq)$$

(a) Determine the oxidation state for chromium (Cr) and iron (Fe) in the reactants and the products.

[2]

Chromium +6 → +3 ✓

Iron +2 → +3 ✓

CrO_4^{2-} -8 / $+6$ / -2

+6 $-2\times4=-8$

$Cr(OH)_3$ OH^-

+3

(b) State what is oxidised and what is reduced.

[1]

(OILRIG) Iron is oxidised & chromium is reduced. ✓

(c) Deduce, from the overall equation, the half equation for iron.

[1]

$Fe^{2+} \rightarrow Fe^{3+} + e^-$ ✓

- or with equilibrium (⇌) sign, in either direction.
- multiples ok.

2. Calcium chloride can be electrolysed. It is heated to a temperature of over 850°C. The melting point of calcium chloride is 772°C.

(a) Explain why the calcium chloride is heated to a molten state.

[1]

To allow the conduction of electricity / allow ions to move (to carry charge) ✓

(b) Deduce the half-equations for the reactions at each electrode, showing the state symbols of the products. The melting point of calcium is 842°C.

(i) Anode (positive electrode):

[1]

$2Cl^-_{(l)} \rightarrow Cl_{2(g)} + 2e^-$

state symbol of product!

(ii) Cathode (negative electrode):

[1]

$Ca^{2+}_{(l)} + 2e^- \rightarrow Ca_{(l)}$

state symbols

(c) Write an equation for the overall cell reaction.

[1]

$CaCl_{2(l)} \rightarrow Ca_{(l)} + Cl_{2(g)}$

state symbols not required.

3. A student places pieces of copper metal in separate solutions of silver nitrate and lead (II) nitrate.

(a) Using **section 25** of the data booklet, state for each solution whether it will undergo a reaction.

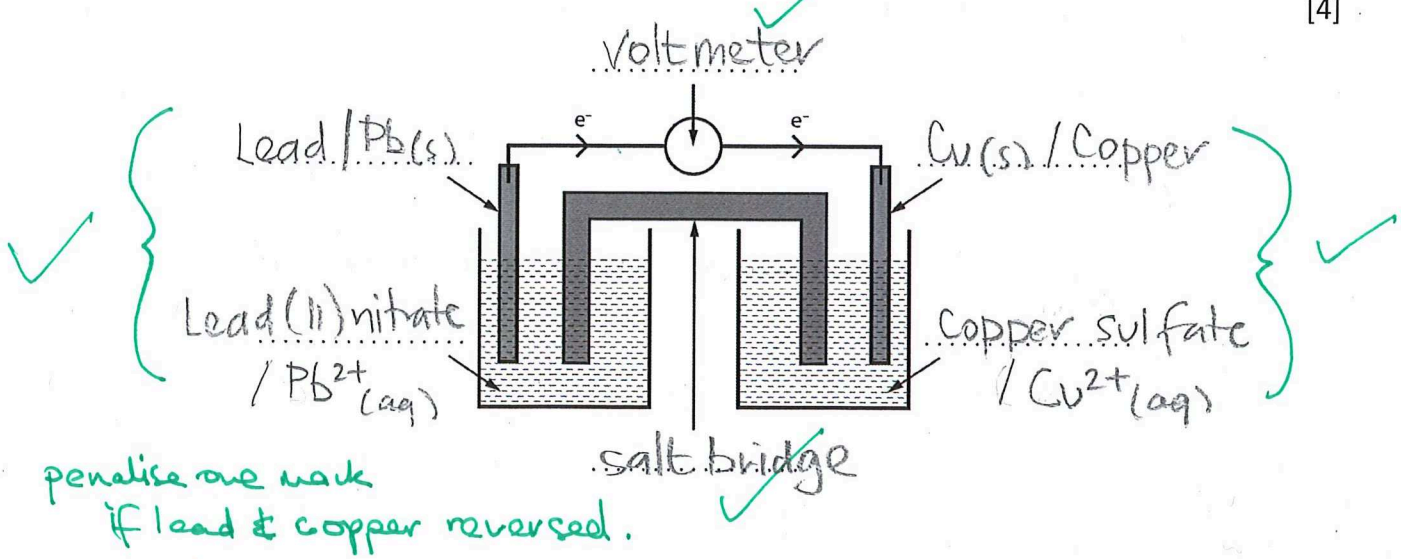
[1]

copper + silver nitrate will react

copper + lead (II) nitrate will not react.

(b) The student decides to build a voltaic cell consisting of a copper electrode, a lead electrode, and solutions of copper sulfate and lead (II) nitrate, and measure the voltage of the cell. Label the diagram below, using **section 25** of the data booklet.

[4]



penalise one mark if lead & copper reversed.

(c) Write an **ionic** equation for the expected overall cell reaction.

[1]

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

State symbols not required.

4. (a) Tin ions will react with manganate (VII) ions in acid solution according to the follow equation:

$$\_\_\_ Sn^{2+} + \_\_\_ MnO_4^- + \_\_\_ H^+ \rightarrow \_\_\_ Sn^{4+} + \_\_\_ Mn^{2+} + \_\_\_ H_2O$$

(+7) $+5e^-$ $-2e^-$

(i) Rewrite and balance the equation above.

[1]

$5Sn^{2+} + 2MnO_4^- + 16H^+ \rightarrow 5Sn^{4+} + 2Mn^{2+} + 8H_2O$ ✓

(ii) Identify the oxidising agent and the reducing agent in this reaction.

[1]

MnO_4^- is the oxidising agent ✓

Sn^{2+} is the reducing agent

(b) Bromine can form the bromate (V) ion, BrO_3^-.

(i) Bromate (V) ions act as oxidising agents in acidic conditions to form bromide ions. Deduce the half-equation for this reduction reaction.

[2]

$BrO_3^- + 6H^+ + 6e^- \rightarrow Br^- + 3H_2O$

(+5)

✓ Species correct (ignore electrons)

✓ balanced (including electrons)

(ii) Bromate(V) ions oxidise silver to silver ions, Ag^+. Deduce the equation for this redox reaction.

[1]

$BrO_3^- + 6H^+ + 6Ag \rightarrow 6Ag^+ + Br^- + 3H_2O$ ✓

$(Ag \rightarrow Ag^+ + e^-)$

5. Ethane-1,2-diol, CH_2OHCH_2OH, is used as anti-freeze.

(a) Deduce the oxidation state of carbon in ethane-1,2-diol.

[1]

$C_2H_6O_2$ −1

−2 +6 −4

(b) Ethane-1,2-diol can be oxidised to ethandioic acid, CO_2HCO_2H. Deduce the oxidation state of carbon in ethandioic acid.

[1]

$C_2H_2O_4$ +3

+6 +2 −8

(c) Other than a change in oxidation state, describe another way in which ethane-1,2-diol can be said to have been oxidised to ethandioic acid.

[1]

Loss of hydrogen or gain of oxygen (either)

(d) Construct a balanced chemical equation to show oxidation of ethane-1,2-diol to ethandioic acid. Use [O] to represent oxygen.

[1]

$C_2H_6O_2 + 4[O] \longrightarrow C_2H_2O_4 + 2H_2O$

or structural formulae.

(e) Using the half equation below, state how many moles of dichromate ions ($Cr_2O_7^{2-}$) would be needed to oxidise three moles of ethane-1,2-diol.

[1]

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

oxidation state change for carbon (−1 → +3) x2 C atoms.

so '8e⁻' vs '6e⁻' for dichromate

So FOUR moles of dichromate ions needed

Total Marks 24 (36 minutes)