IB Higher Level Redox Test Mark Scheme

1. Which of the following does **not** contain hydrogen in oxidation state +1?

A. H_2O B. H_2O_2 C. NaOH D. NaH

2. Ethanol can be oxidized to ethanoic acid.

$$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + H^+$$

When this half-equation is balanced using the smallest possible whole numbers

A. the coefficient of H^+ is 2
B. $1e^-$ must be added to the left hand side
C. $4e^-$ must be added to the right hand side
D. $1e^-$ must be added to the right hand side

3. What happens at the positive electrode in a voltaic cell and in an electrolytic cell?

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

4. Some standard electrode potentials are shown below.

$U^{3+}(aq) + 3e^- \rightleftharpoons U(s)$ $E^\ominus = -1.79$ V
$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$ $E^\ominus = -0.74$ V

Which species is the strongest reducing agent?

A. Cr(aq) B. U(s) C. $U^{3+}(aq)$ D. $Cr^{3+}(aq)$

5. In the electrolysis of aqueous sodium sulfate 0.24 dm^3 of oxygen gas was produced. What is the **total** volume of gas produced?

A. 0.24 dm^3 B. 0.36 dm^3 C. 0.48 dm^3 D. 0.72 dm^3

6. Two half equations and standard electrode potentials are shown below.

$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$ $E^\ominus = -0.26$ V
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ $E^\ominus = +0.77$V

The standard cell potential and cell notation are

A. 0.51 V $Ni^{2+}(aq)|Ni(s)||Fe^{3+}(aq)|Fe^{2+}(aq)$
B. 1.03 V $Ni(s)|Ni^{2+}(aq)||Fe^{3+}(aq)|Fe^{2+}(aq)|Pt(s)$
C. 1.80 V $Ni(s)|Ni^{2+}(aq)||Fe^{3+}(aq),Fe^{2+}(aq)|Pt(s)$
D. 1.03 V $Ni(s)|Ni^{2+}(aq)||Fe^{3+}(aq),Fe^{2+}(aq)|Pt(s)$

7. The Winkler method was used to measure the concentration of dissolved oxygen in a sample of water. Manganese(II) sulfate, sulfuric acid and potassium iodide were added to 50.0 cm^3 of the water. The iodine that was formed was titrated against a sodium thiosulfate solution with a concentration of 2.00×10^{-3} mol dm^{-3}. It was found that 10.00 cm^3 of sodium thiosulfate was required for the titration.

The equations for the reactions are:

$2Mn(OH)_2(s) + O_2(aq) \rightarrow 2MnO(OH)_2(s)$

$MnO(OH)_2(s) + 4H^+(aq) \rightarrow Mn^{4+}(aq) + 3H_2O(l)$

$Mn^{4+}(aq) + 2I^-(aq) \rightarrow Mn^{2+}(aq) + I_2(aq)$

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

The concentration of dissolved oxygen in ppm is given by

A. $\dfrac{10.00 \times 32.00 \times 2.00}{4 \times 50.0}$

B. $\dfrac{10.00 \times 32.00 \times 2.00}{50.0}$

C. $\dfrac{10.00 \times 32.00 \times 2.00 \times 10^6}{1000 \times 4 \times 50.0}$

D. $\dfrac{10.00 \times 2.00}{32.00 \times 4 \times 50.0}$

8. Which compound contains nitrogen atoms with different oxidation states?

A NH_4NO_3 B N_2O_4 C $C_6H_4(NO_2)_2$ D Mg_3N_2

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

A. $Zn(NO_3)_{2(aq)} + Mg_{(s)} \rightarrow Mg(NO_3)_{2(aq)} + Zn_{(s)}$

B. $U_{(s)} + 6ClF_{(l)} \rightarrow UF_{6(l)} + 3Cl_{2(g)}$

C. $2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

D. $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

10. Which of the following is ***not*** an observation that could be made when 1 mol dm^{-3} copper(II) sulfate solution is electrolyzed using platinum electrodes.

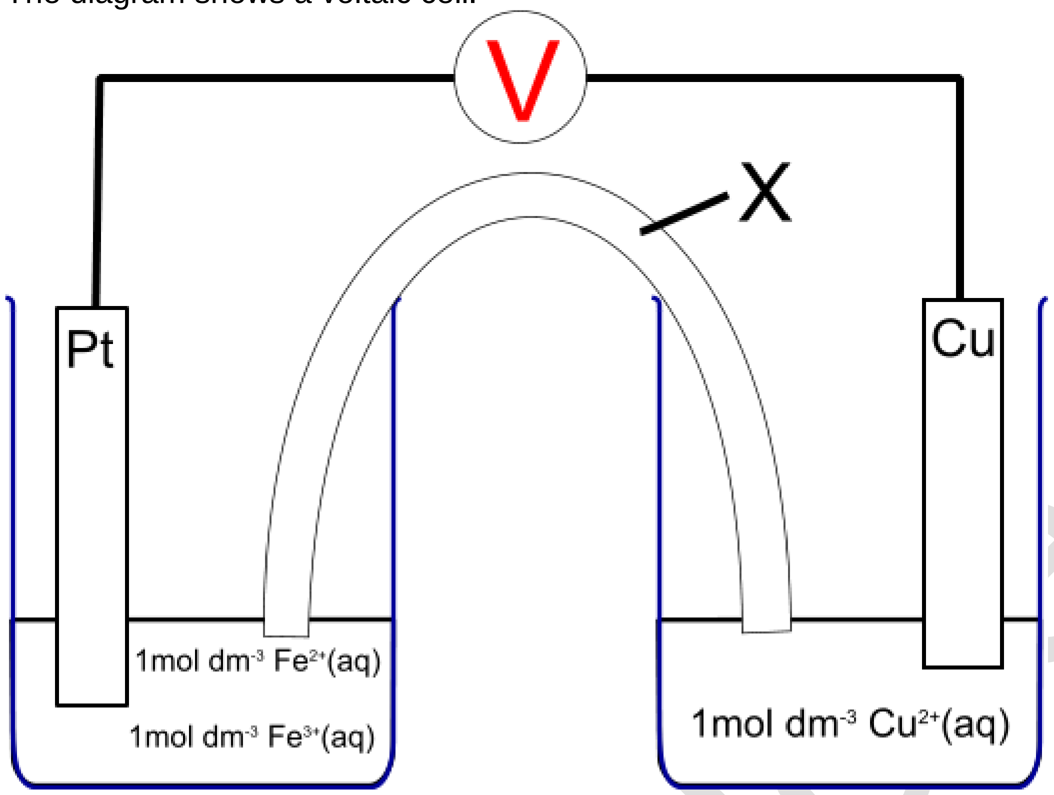
A The cathode becomes coated with a pink-brown metal

B bubbles of gas are given off at the anode

C the pH increases

D the blue colour of the electrolyte fades

11. The diagram shows a voltaic cell.



(a) State the name of the component labelled X and explain what its purpose is. [2]

Salt bridge;
Completes the circuit/allows ions to flow into/out of the half cells

(b) Calculate the cell potential. [1]

(+)0.43 V

(c) On the diagram above, indicate the direction of electron flow in the external circuit and of negative ions through X. [2]

e^- flow from Cu to Pt;
negative ions through slat bridge from Fe^{3+}/Fe^{2+} half cell to Cu^{2+}/Cu half cell;

(d) Write an overall redox equation for the reaction occurring in the above cell when current flows. [2]

$Cu + 2Fe^{3+} \rightarrow Cu^{2+} + 2Fe^{2+}$ [1] for correct species on each side
[1] for balancing

(e) State the cell diagram notation for this cell. [1]

$Cu|Cu^{2+}||Fe^{3+},Fe^{2+}|Pt$ *ignore state symbols*

12. Consider the following half equations and standard electrode potentials

$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	$E^\ominus = -0.26$ V
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	$E^\ominus = +1.36$ V
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	$E^\ominus = +0.77$ V
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$	$E^\ominus = +1.09$ V

(a) Use these equations to identify, giving a reason, the strongest reducing agent. [2]

Ni;
Has greatest tendency to be oxidized/lose electrons; *not just most negative $E^\ominus$ value.*

(b) Discuss whether nickel metal will react with chlorine gas to form nickel(II) chloride [2]

The electrode potentials would suggest that this could be possible as cell potential (for similar reaction) is positive OWTTE;

However, the electrode potentials refer to formation of aqueous solutions/refer to everything under standard conditions/reaction may be very slow/have high activation energy.

Or, we cannot tell because, although the formation of an aqueous solution would be favourable/+ve E_{cell}, the reaction would involve the formation of solid $NiCl_2$ OWTTE for [2]

13 Chlorate(V) ions react with sulfate(IV) ions to form chloride ions and sulfate(VI) ions in aqueous solution.

(a) Write a balanced redox equation for this reaction. [2]

$ClO_3^-(aq) + 3SO_3^{2-}(aq) \rightarrow 3SO_4^{2-}(aq) + Cl^-(aq)$
[1] for all formulae correct
[1] for balance

(b) State which is the oxidizing agent in this reaction. [1]

ClO_3^-/chlorate(V) ion

14 The equation below represents a redox reaction

$$2KMnO_4 + 5Na_2C_2O_4 + 8H_2SO_4 \rightarrow 2MnSO_4 + 10CO_2 + K_2SO_4 + Na_2SO_4 + 8H_2O$$

(a) State the oxidation state of carbon in $Na_2C_2O_4$? +3 *no mark for 3+/3* [1]

(b) 27.60 cm^3 of 0.0200 mol dm^{-3} $KMnO_4(aq)$ reacts with 25.00 cm^3 of $Na_2C_2O_4(aq)$. Calculate the concentration of the $Na_2C_2O_4(aq)$. [2]

Mol $KMnO_4$ = 27.60/1000 x 0.0200 = 5.52×10^{-4} mol
Mol $Na_2C_2O_4$ = 1.38×10^{-3} mol ;

$[Na_2C_2O_4]$ = 0.0552 mol dm^{-3}; *correct final answer scores [2]*

15. The redox equation for the reaction between dichromate(VI) and bromide ions is:

$Cr_2O_7^{2-}(aq) + 14H^+ + 6Br^-(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 3Br_2(l)$

Calculate

(a) the standard cell potential [1]

0.27 V

(b) the value of $\Delta G^{\ominus}$ for this reaction [2]

$\Delta G = -nFE$ $= -6 \times 96500 \times 0.27$; correct number of electrons
ecf from (a)

$-156\ kJ\ mol^{-1}$

Correct final answer scores [2]