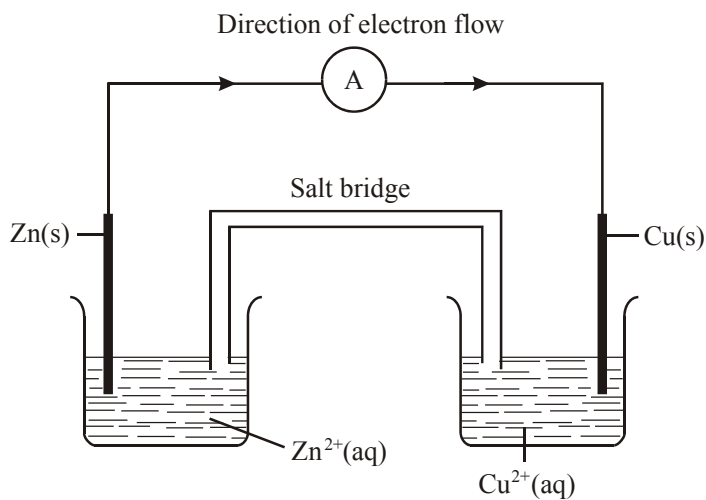
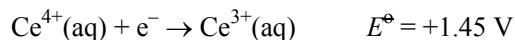
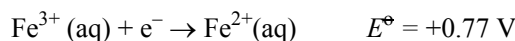
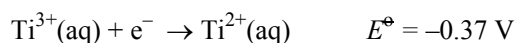


Redox Review – IB Short Questions

Question: 1



- (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.

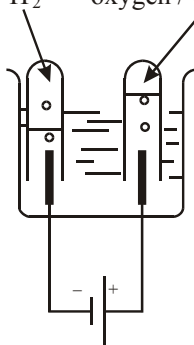


- (i) Using the data above, deduce which species is the best reducing agent, giving a reason in terms of electrons for your answer. 2
- (ii) Write an equation, including state symbols, for the overall reaction with the greatest cell potential. 2

- (iii) State and explain the sign of ΔG^\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

ANSWER: 1

- (a) (i) ionic conductor/allows movement of ions between electrolytes /completes circuit; 1
- (ii) $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$ (state symbols not needed); 1
- (iii) 298 K/25°C, 1 atm/ 1.01×10^5 Pa, 1 mol dm⁻³ solutions; 2
(all 3 for [2], 2 for [1])
- (iv) $0.34 - (-0.76) = 1.10$ V; 2
[1] for finding correct data, [1] for answer with unit (ECF).
- (v) decreases; 2
 Cu^{2+} ions are converted to Cu metal/Cu deposited on electrode;
Allow ECF from (iv).
- (vi) Cu deposited on Zn rod/rod goes pink/brown; 2 max
blue colour of solution → paler;
gets hotter/temperature increase/exothermic;
- (b) (i) Ti^{2+} (no ECF to explanation); 2
 Ti^{2+} has greatest tendency to lose electrons/ Ti^{3+} has least tendency to gain electrons;
- (ii) $\text{Ce}^{4+}(\text{aq}) + \text{Ti}^{2+}(\text{aq}) \rightarrow \text{Ce}^{3+}(\text{aq}) + \text{Ti}^{3+}(\text{aq})$ 2
[1] for equation, [1] for state symbols. If wrong equation is given, award [1] for state symbols.
- (iii) ΔG^\ominus negative; 2
reaction spontaneous/corresponds to positive cell potential;
Positive [0], non-spontaneous [1].
- (c) (i) (aqueous) sodium hydroxide/dilute sulfuric acid/sodium sulfate; 1
Any combination of $\text{K}^+/\text{Na}^+/\text{H}^+$ and $\text{NO}_3^-/\text{SO}_4^{2-}$.
Halides **not** acceptable. ("water" is not a solution)
hydrogen / H_2 oxygen / O_2



(ii)

Or similar suitable diagram.

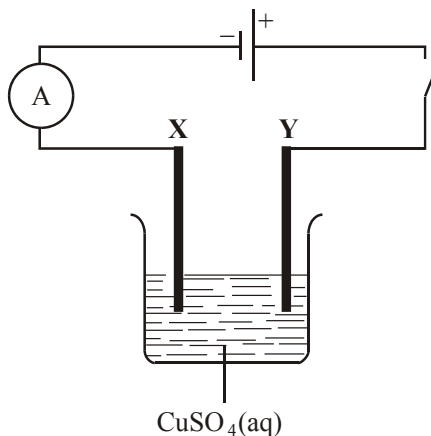
gas collection method;

names of gases correct way round at electrodes;

2:1 volume ratio correct way round;

3

Question: 2



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

Answer: 2 (i) mass increases;

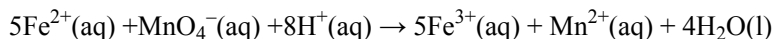
copper deposited;

because X is negative and attracts Cu^{2+} ions/reduction occurs at X/

$\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$; 3

(ii) increase time; 2
increase current;

Question: 3 Consider the following redox equation.



(i) Determine the oxidation numbers for Fe and Mn in the reactants and in the products. 2

(ii) Based on your answer to (i), deduce which substance is oxidized. 1

(iii) The compounds CH_3OH and CH_2O contain carbon atoms with different oxidation numbers. Deduce the oxidation numbers and state the kind of chemical change needed to make CH_2O from CH_3OH . 3

- Answer: 3** (i) Fe reactant +2 AND Fe product +3 AND Mn product +2;
Mn reactant +7; 2
Do not accept Roman numerals.
- (ii) Fe²⁺/iron(ii) ions/ferrous ions; 1
Do not accept "iron".
- (iii) CH₃OH oxidation state -2;
CH₂O oxidation state 0;
(change is) oxidation/dehydrogenation; 3

Question: 4 (a) In one experiment involving the electrolysis of molten sodium chloride, 0.1 mol of chlorine was formed. Deduce, giving a reason, the amount of sodium formed at the same time. 2

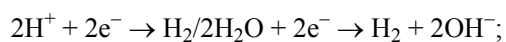
(b) In another experiment involving the electrolysis of molten sodium chloride, the time of the electrolysis was halved and the current increased from 1 amp to 5 amp, compared to the experiment in (a). Deduce the amount of chlorine formed, showing your working. 2

(c) If dilute aqueous sodium chloride is electrolyzed, a different product is obtained at each electrode. Identify the product formed at each electrode and write an equation showing its formation. 4

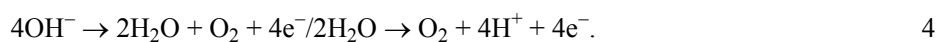
Answer 4. (a) 0.2 mol;
the Na:Cl₂ mol ratio is 2 : 1; 2

(b) $0.1 \times \frac{1}{2} \times 5$;
= 0.25 mol; 2

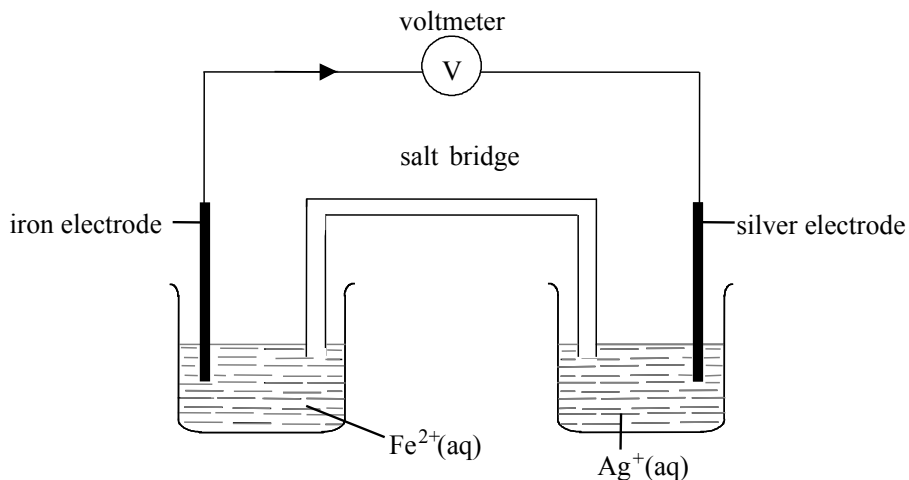
(c) *negative electrode*
hydrogen/H₂;



positive electrode
oxygen/O₂;

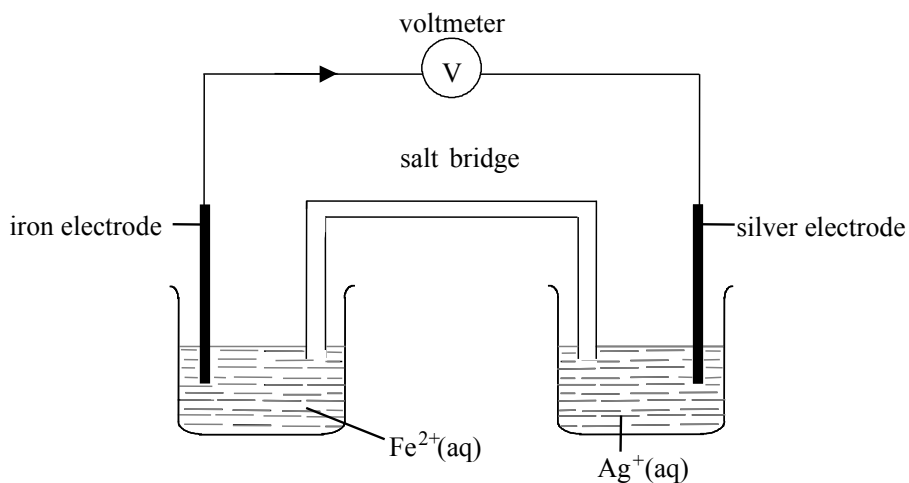


Question : 5. The following diagram shows a voltaic cell.



- (a) State an equation to represent the spontaneous reaction occurring in the cell. 1
- (b) Define the term *standard electrode potential*. 1
- (c) Use Table 15 from the Data Booklet to calculate the standard cell potential for the spontaneous reaction in (a). 1
- (d) Draw arrows on the above diagram to indicate the direction of electron flow. 1

- Answer: 5.** (a) $\text{Fe} + 2\text{Ag}^{+} \rightarrow \text{Fe}^{2+} + 2\text{Ag}$; 1
Ignore state symbols.
Accept $\text{Fe} + 3\text{Ag}^{+} \rightarrow \text{Fe}^{3+} + 3\text{Ag}$
- (b) the potential difference/EMF/Voltage between a standard half-cell and standard hydrogen electrode/*OWTTE*; 1
- (c) (+) 1.24 (V); 1
ECF from (a).
- (d) electron flow indicated on wires; 1
ECF from (a).



[4]

Question: 6. (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

Answer: 6. (a) (i) oxidation half-reaction: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$;
 reduction half-reaction: $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^- / 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ 2
Award [1] only if equations are interchanged.
States not required.

- (ii) Na has high $E^\ominus_{\text{red}} / \text{Na}^+$ not readily reduced (in comparison to H_2O)/if formed, Na would (immediately) react with water to form Na^+ 1

- (b) $\text{H}(\text{g})$ and $\text{O}_2(\text{g})$ /accept names;
 $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4\text{e}^- / 4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-$;
 water is oxidized (instead of the halide);
 since E^\ominus_{OX} for F^- is very negative/ E^\ominus_{red} for F_2 is very high; 4
Accept answer based on oxidizing/reducing strengths.

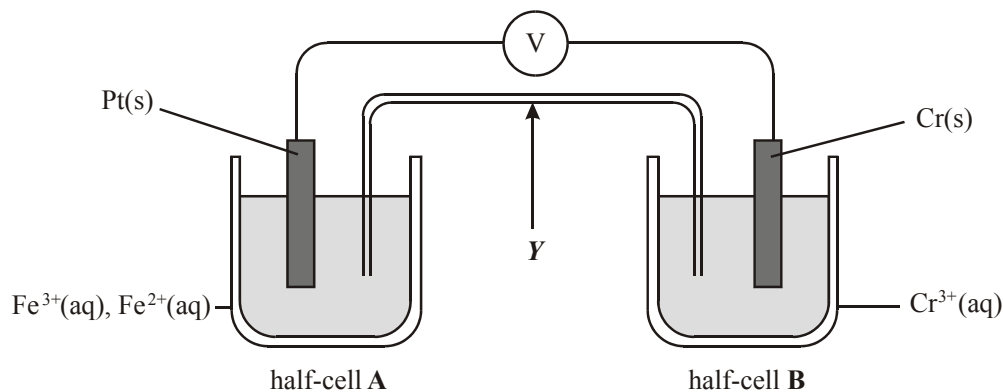
Question : 7. The following are standard electrode potentials.

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

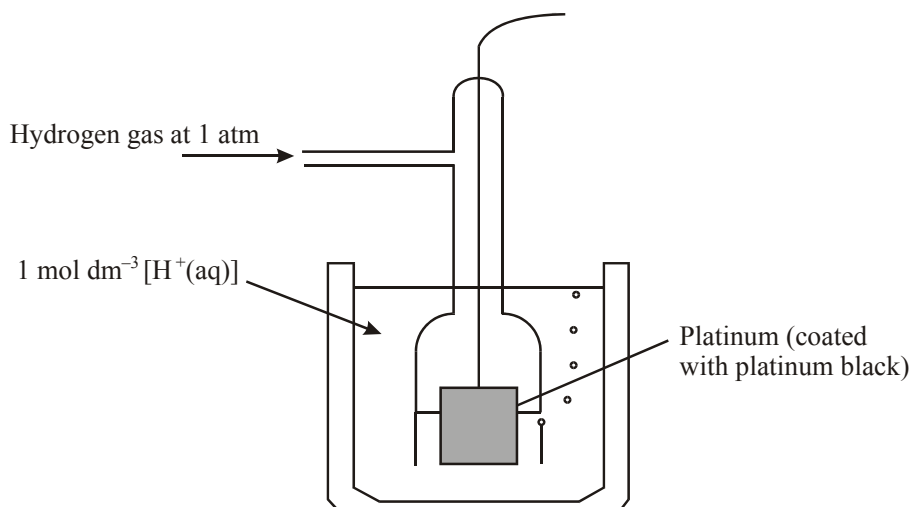
- (b) Define the term *oxidizing agent* in terms of electron transfer and identify the strongest oxidizing agent in the list above. 2

- (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.
- Calculate the cell potential. 1
 - 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.
- State and explain whether zinc or tin would be more effective in preventing iron from rusting under these conditions. 2
 - Electroplating may be used to coat one metal with another metal. Identify the **three** factors affecting the amount of metal discharged during electroplating. 3
 - 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.



- Identify the part of the cell labelled Y and outline its function. 2
- Write an equation for the initial reactions at each electrode and hence write an equation for the cell reaction. 4
- Describe the direction of electron flow in the external circuit. 1
- Calculate the cell potential. 1

Answer: 7. (a)



Accept suitable diagram with the following indicated:

- Pt electrode; $1 \text{ mol dm}^{-3} [\text{H}^+(\text{aq})]$; H_2 gas; at $1 \text{ atm}/1.01 \times 10^5 \text{ Pa}$; $298 \text{ K}/25^\circ\text{C}$; 5
- (b) electron acceptor;
 $\text{Fe}^{3+}(\text{aq})/\text{iron(III) ions}/\text{Fe}^{3+}$; (Do not accept iron/ Fe^{2+} /iron ion.) 2
- (c) (i) (+)1.10; 1
 (ii) $\text{Cu}^{2+}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu}(\text{s})$; 2
Award [1] for correct reactants and products from (c)(i), and [1] for state symbols.
- (d) (i) zinc;
 zinc is more readily oxidised than iron and so protects it by reacting preferentially/*OWTTE* or tin is less readily oxidised than iron and so iron reacts preferentially/*OWTTE*; 2
 (ii) charge on the ion discharged;
 size/magnitude of the current;
 time/duration of the electrolysis; 3
 (iii) positive ions/cations in solution = $\text{H}^+(\text{aq})$, $\text{Zn}^{2+}(\text{aq})$;
 $\text{H}^+(\text{aq})$ discharged preferentially; 2
- (e) (i) salt bridge;
 allows movement of ions between the solutions/to complete the circuit/to maintain electrical neutrality; 2
 (ii) A: $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$;
 B: $\text{Cr}(\text{s}) \rightarrow \text{Cr}^{3+}(\text{aq}) + 3\text{e}^-$;
Allow [2] for correct equation for the cell reaction if equations for A and B are reversed.
 $3 \text{Fe}^{3+}(\text{aq}) + \text{Cr}(\text{s}) \rightarrow 3 \text{Fe}^{2+}(\text{aq}) + \text{Cr}^{3+}(\text{aq})$; 4
Award [1] for correct reactants and products, with state symbols, and [1] for correct balancing.
(iii) from B to A/from Cr to Pt/from right to left; Allow ECF from (ii).
 (iv) (+)1.51; 1
Allow ECF from (ii).

[25