Gateways School

**Electrode potentials & Redox**

**Revision PPQ**

43 marks

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_**

**Q1.**

This table shows some standard electrode potential data.

|  |  |
| --- | --- |
| **Electrode half-equation** | **Eϴ / V** |
| Au+(aq) + e−  Au(s) | +1.68 |
| ½ O2(g) + 2H+(aq) + 2e−  H2O(l) | +1.23 |
| Ag+(aq) + e−  Ag(s) | +0.80 |
| Fe3+(aq) + e−  Fe2+(aq) | +0.77 |
| Cu2+(aq) + 2e−  Cu(s) | +0.34 |
| Fe2+(aq) + 2e−  Fe(s) | −0.44 |

(a)     Draw a labelled diagram of the apparatus that could be connected to a standard hydrogen electrode in order to measure the standard electrode potential of the Fe3+ / Fe2+ electrode.

In your diagram, show how this electrode is connected to the standard hydrogen electrode and to a voltmeter. Do **not** draw the standard hydrogen electrode.

State the conditions under which this cell should be operated in order to measure the standard electrode potential.

Conditions \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(5)**

(b)     Use data from the table to deduce the equation for the overall cell reaction of a cell that has an e.m.f. of 0.78 V.
Give the conventional cell representation for this cell.
Identify the positive electrode.

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**(4)**

(c)     Use data from the table to explain why Au+ ions are **not** normally found in aqueous solution.
Write an equation to show how Au+ ions would react with water.

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**(3)**

(d)     Use data from the table to predict and explain the redox reactions that occur when iron powder is added to an excess of aqueous silver nitrate.

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**(3)**

**(Total 15 marks)**

**Q2.**

(a)     Lithium ion cells are used to power cameras and mobile phones.
A simplified representation of a cell is shown below.

Li | Li+ || Li+, CoO2 | LiCoO2 | Pt

The reagents in the cell are absorbed onto powdered graphite that acts as a support medium. The support medium allows the ions to react in the absence of a solvent such as water.

The half-equation for the reaction at the positive electrode can be represented as follows.

Li+ + CoO2 + e–  Li+[CoO2]–

(i)      Identify the element that undergoes a change in oxidation state at the positive electrode and deduce these oxidation states of the element.

Element \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Oxidation state 1 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Oxidation state 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

(ii)     Write a half-equation for the reaction at the negative electrode during operation of the lithium ion cell.

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**(1)**

(iii)     Suggest two properties of platinum that make it suitable for use as an external electrical contact in the cell.

Property 1 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Property 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(iv)    Suggest **one** reason why water is **not** used as a solvent in this cell.

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**(1)**

(b)     The half-equations for two electrodes used to make an electrochemical cell are shown below.

ClO3–(aq) + 6H+(aq) + 6e–  Cl–(aq) + 3H2O(I)        *E*~~ο~~ = +1.45 V

SO42–(aq) + 2H+(aq) + 2e–  SO32–(aq) + H2O(I)       *E*~~ο~~ = +0.17 V

(i)      Write the conventional representation for the cell using platinum contacts.

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**(2)**

(ii)     Write an overall equation for the cell reaction and identify the oxidising and reducing agents.

Overall equation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Oxidising agent \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Reducing agent \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(3)**

**(Total 12 marks)**

**Q3.**

Where appropriate, use the standard electrode potential data in the table below to answer the questions which follow.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|   |   |   |   |   |   |   | *E*~~O~~/V |
| Zn2+(aq) | + | 2e– | → | Zn(s) |   |   | –0.76  |
| V3+(aq) | + | e– | → | V2+(aq) |   |   | –0.26 |
| + 2H+(aq) | + | 2e- | → |  | + | H2O(l)  | +0.17  |
| VO2+(aq) +2H+(aq) | + | e– | → | V3+(aq) | + | H2O(l) | +0.34 |
| Fe3+(aq) | + | e– | → | Fe2+(aq) |   |   | +0.77 |
| + 2H+(aq) | + | e– | → | VO2+(aq) | + | H2O(l) | +1.00 |
| Cl2(aq) | + | 2e– | → | 2Cl–(aq) |   |   | +1.36  |

(a)     From the table above select the species which is the most powerful reducing agent.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     From the table above select

(i)      a species which, in acidic solution, will reduce  to VO2+(aq) but will **not** reduce VO2+(aq) to V3+(aq),

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(ii)     a species which, in acidic solution, will oxidise VO2+(aq) to .

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     The cell represented below was set up under standard conditions.

Pt|Fe2+(aq), Fe3+(aq)||Tl3+(aq),Tl+(aq)|Pt                             Cell e.m.f. = + 0.48 V

(i)      Deduce the standard electrode potential for the following half-reaction.

Tl3+(aq) + 2e– → Tl+(aq)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

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**(3)**

(d)     After acidification, 25.0 cm3 of a solution of hydrogen peroxide reacted exactly with
16.2 cm3 of a 0.0200 mol dm–3 solution of potassium manganate(VII). The overall equation for the reaction is given below.

 + 6H+ + 5H2O2 → 2Mn2+ + 8H2O + 5O2

(i)      Use the equation for this reaction to determine the concentration, in g dm–3, of the hydrogen peroxide solution.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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(ii)     Calculate the maximum volume of oxygen, measured at a pressure of 98 kPa and a temperature of 298 K, which would be evolved in this reaction.

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**(8)**

**(Total 14 marks)**

**Q4.**

Use the data in the table below to answer this question.

|  |  |
| --- | --- |
|  | *E* / V |
| MnO (aq) + 8H+(aq) + 5e− → Mn2+(aq) + 4H2O(l) | + 1.52 |
| Cr2O(aq) + 14H+(aq) + 6e− → 2Cr3+(aq) + 7H2O(l) | + 1.33 |
| Fe3+(aq) + e− → Fe2+(aq) | + 0.77 |
| Cr3+(aq) + e− → Cr2+(aq) | − 0.41 |
| Zn2+(aq) + 2e− → Zn(s) | − 0.76 |

The most powerful oxidising agent in the table is

**A**       Mn2+(aq)

**B**       Zn(s)

**C**       MnO(aq)

**D**       Zn2+(aq)

**(Total 1 mark)**

**Q5.**

Use the data in the table below to answer this question.

|  |  |
| --- | --- |
|  | *E* / V |
| MnO (aq) + 8H+(aq) + 5e− → Mn2+(aq) + 4H2O(l) | + 1.52 |
| Cr2O(aq) + 14H+(aq) + 6e− → 2Cr3+(aq) + 7H2O(l) | + 1.33 |
| Fe3+(aq) + e− → Fe2+(aq) | + 0.77 |
| Cr3+(aq) + e− → Cr2+(aq) | − 0.41 |
| Zn2+(aq) + 2e− → Zn(s) | − 0.76 |

Which one of the following statements is **not** correct?

**A**       Fe2+(aq) can reduce acidified MnO(aq) to Mn2+(aq)

**B**       CrO(aq) can oxidise acidified Fe2+(aq) to Fe3+(aq)

**C**       Zn(s) can reduce acidified Cr2O(aq) to Cr2+(aq)

**D**       Fe2+(aq) can reduce acidified Cr3+(aq) to Cr2+(aq)

**(Total 1 mark)**