

5.1.4 Select half-cell apparatus and write conventional diagrams

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS evidence • conditions

Objective

Select half-cell apparatus and write conventional diagrams. All questions and marking guidance are original.

1 Key knowledge and worked examples

A metal/metal-ion couple uses the metal as electrode. A gas/ion or all-solution ion/ion pair needs an inert conducting electrode, commonly platinum. The standard hydrogen electrode uses Pt/H₂/H⁺. A single vertical line marks a phase boundary; a comma separates different ions in one solution. The double line marks the salt bridge.

■ Worked method

An Fe²⁺/Fe³⁺ oxidation half-cell connected to Cu²⁺/Cu reduction is represented as Pt(s) | Fe²⁺(aq), Fe³⁺(aq) || Cu²⁺(aq) | Cu(s). This is a representation exercise, not a claim of spontaneous direction without potential data. State the concentrations alongside the diagram. Use a high-resistance voltmeter to measure emf with little current.

2 Practice

2.1 Select the conducting electrode for a Cu²⁺/Cu half-cell and for an Fe³⁺/Fe²⁺ half-cell. Explain the difference. [3]

2.2 For a theoretical chlorine/chloride gas half-cell under an approved supervised procedure, identify the electrode, gas condition and ion concentration for a standard measurement. [3]

2.3 Write a conventional diagram with zinc oxidation on the left and Fe³⁺ reduction to Fe²⁺ on the right. Include physical states. [3]

3 Exam-style questions

3.1 Write a cell diagram with hydrogen oxidation on the left and Cu²⁺ reduction on the right. State all three standard measurement conditions. [5]

3.2 An Fe³⁺/Fe²⁺ electrode is positive relative to hydrogen. Describe how to measure that potential and explain why the reference is necessary. [4]

3.3 A cell voltage is initially below the standard prediction. Give three measurement checks and distinguish a concentration effect from random reading scatter. [4]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 Copper metal for Cu^{2+}/Cu ; inert platinum for $\text{Fe}^{3+}/\text{Fe}^{2+}$, because both members of the iron pair are dissolved and need a separate electron contact.

2.2 Inert platinum electrode, chlorine at 100 kPa, chloride at 1.00 mol dm^{-3} , with temperature 298 K. This is apparatus interpretation, not a student instruction to generate chlorine.

2.3 $\text{Zn(s)} \mid \text{Zn}^{2+}(\text{aq}) \parallel \text{Fe}^{3+}(\text{aq}), \text{Fe}^{2+}(\text{aq}) \mid \text{Pt(s)}$. Correct metal half-cell, solution pair/platinum, boundaries and states.

3.1 $\text{Pt(s)} \mid \text{H}_2(\text{g}) \mid \text{H}^+(\text{aq}) \parallel \text{Cu}^{2+}(\text{aq}) \mid \text{Cu(s)}$. 298 K, hydrogen 100 kPa, ions at 1.00 mol dm^{-3} .

3.2 Connect the iron solution/platinum half-cell to the standard hydrogen electrode with salt bridge and external high-resistance voltmeter. Keep standard conditions. Only a potential difference can be measured, so the defined-zero reference establishes the comparison.

3.3 Check actual ion concentrations, temperature/gas pressure as applicable, clean electrodes/good contacts or bridge continuity. A persistent non-standard concentration shift changes the electrode equilibrium rather than being removed simply by repeating the meter reading.