5.2 Chemical cells and fuel cells

Name: _____ Class: _____ Date: _____ **Total: 36 marks**

KEY WORDS fuel cell • electrode • potential difference

Objective

Explain cells, batteries and hydrogen fuel cells, with (HT) half-equations. Chemistry only. Original questions for spec statement 4.5.2.

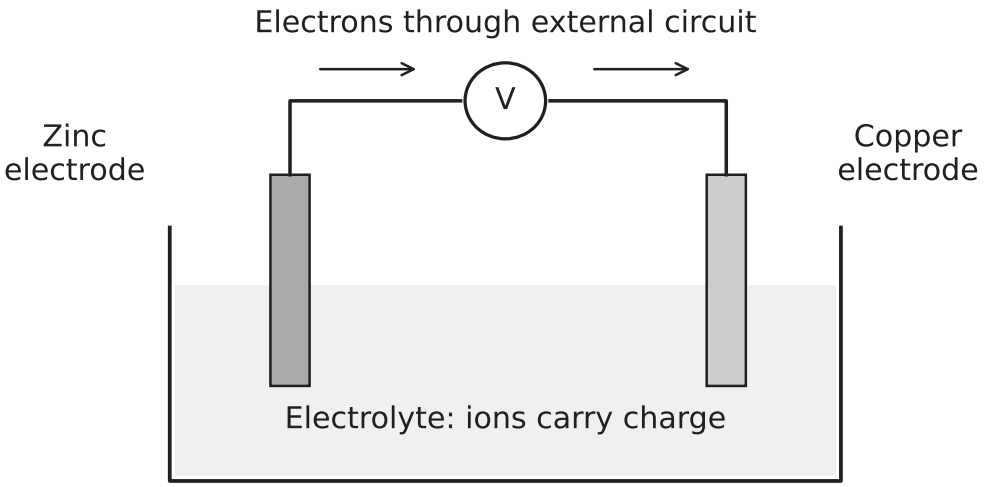
1 Key knowledge and worked examples

Cells contain chemicals that react to produce **electricity**; the voltage depends on the **electrode metal** and the **electrolyte**. Simple cell = **two different metals** in an electrolyte; use supplied readings under comparable conditions to compare voltages. **Batteries** = two or more cells **in series**.

- **Non-rechargeable** (alkaline): reactions stop when a reactant is used up.
- **Rechargeable**: an external current **reverses** the reactions.

Hydrogen fuel cell: hydrogen + oxygen supplied continuously; hydrogen is **oxidised electrochemically** to water, giving a potential difference. Water is the direct reaction product; both fuel cells and rechargeable batteries can have no polluting exhaust at a vehicle. Compare fuel production, storage, infrastructure and cost using given information.

(HT) Half-equations: negative electrode $2\ H_2 \rightarrow 4\ H^+ + 4e^-$; positive electrode $O_2 + 4\ H^+ + 4e^- \rightarrow 2\ H_2O$; overall $2\ H_2 + O_2 \rightarrow 2\ H_2O$.



Illustrative Zn/Cu cell; voltage depends on electrolyte and conditions

Worked example (3 marks). With copper and the electrolyte unchanged, a supplied table gives Zn/Cu = 1.10 V and Fe/Cu = 0.78 V. Which has the greater voltage, and by how much?

Zn/Cu gives the greater voltage under these conditions (1); difference = 1.10 − 0.78 = 0.32 V (1). The metal changed while the other electrode/electrolyte were controlled; this does not fix the voltage with every electrolyte (1).

2 Practice

2.1 What two factors does a cell's voltage depend on? [2]

2.2 Why can rechargeable cells be reused? [1]

2.3 What is the only product of a hydrogen fuel cell? [1]

3 Exam-style questions

3.1 Describe how a simple cell is made and how to compare the voltages when one metal is swapped fairly. [4]

3.2 A hydrogen fuel-cell car and a rechargeable-battery car both have no polluting exhaust at the vehicle. Explain why this does not prove zero lifetime environmental impact. Identify one further data item needed for each car and explain why it matters. [4]

3.3 *(HT)* Write the half-equations and the overall equation for a hydrogen fuel cell. [4]

3.4 In the same electrolyte, cell A (Zn/Cu) gives 1.10 V and cell B (Fe/Cu) gives 0.78 V. Cell C (Zn/Cu) uses a different electrolyte and gives 0.94 V. Calculate A − B. Which comparison isolates changing a metal, and which isolates electrolyte choice? Why cannot A − C be explained only by metal reactivity? [4]

3.5 Three identical 1.2 V rechargeable cells are connected in series with the same orientation. Calculate the total voltage. Explain why a non-rechargeable cell stops and how recharging differs from adding fresh fuel to a fuel cell. [5]

3.6 A delivery vehicle must operate for 8 hours with one stop of at most 10 minutes. Supplied data: battery option runs for 4 hours and takes 90 minutes to recharge; hydrogen option runs for 4 hours per tank and refuels in 5 minutes, but hydrogen is not available at every depot. Recommend an option for a depot with hydrogen, explain the infrastructure limit and give two other data items needed for a wider evaluation. [6]

3.7 *(HT)* A student mixes these half equations for an acidic hydrogen fuel cell:

$$H_2 \rightarrow 2H^+ + e^-$$

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

Correct the hydrogen equation, write a consistent acidic oxygen equation and combine them. Identify the negative electrode and direction of electron flow through the wire. [5]