# Cells and batteries

4.5.2.1 · Energy changes · revision notes

Chemistry only (not in Combined Science). A cell uses chemical reactions to produce electricity. You need to know how simple cells and batteries are made, the difference between rechargeable and non-rechargeable cells, and how to use voltage data to compare the reactivity of metals and to evaluate the use of cells.

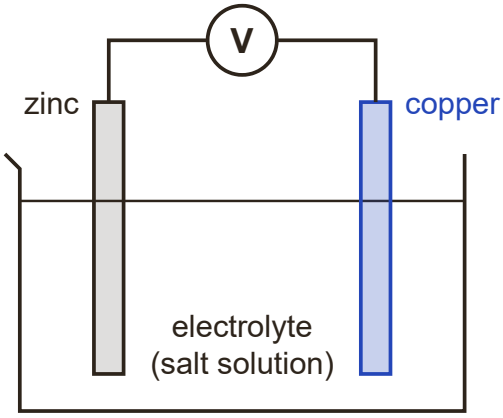
## Key facts

- Cell: contains chemicals that react to produce electricity
- Voltage depends on the type of electrodes and the electrolyte
- Battery: two or more cells in series; the voltages add
- Rechargeable: reactions reversed when an external electrical current is supplied
- Simple cell: two different metals in contact with an electrolyte
- Bigger difference in reactivity = bigger voltage; same metal on both sides = 0 V
- Non-rechargeable (e.g. alkaline): stops when a reactant is used up
- Grade 7+ only The more reactive metal is the negative electrode

## Notes

### Simple cells

- A **cell** contains chemicals that react to produce electricity.
- You can make a simple cell by connecting two **different metals** in contact with an **electrolyte** (a solution containing ions, such as salt solution).




**two different metals + an electrolyte**

The bigger the difference in reactivity between the two metals, the bigger the voltmeter reading.

- The voltage of a cell depends on several factors, including the type of electrodes (which metals) and the electrolyte.
- The **bigger the difference in reactivity** between the two metals, the **bigger the voltage**.
- If both electrodes are the same metal, the voltage is zero.
- The more reactive metal is the negative electrode: it loses electrons more easily, and these electrons flow from it through the external circuit. Grade 7+ only
- If the two metals are swapped over at the voltmeter, the reading has the same size but the opposite sign. Grade 7+ only

### Investigating the voltage of a cell

- Clean two metal strips with emery paper and dip them into a beaker of electrolyte without letting them touch. Connect them to a voltmeter and record the voltage.
- To compare metals, keep one metal the same and change the other. To test the electrolyte, change its concentration and keep both metals the same.
- Keep the same: the volume and type of electrolyte, the size of the strips, how deep they dip and the distance between them. Repeat and calculate a mean.

### Batteries

- A **battery** is two or more cells connected together **in series** to give a bigger voltage.
- The voltages of cells in series add up, e.g. three 1.5 V cells give 4.5 V.
- Number of cells needed = battery voltage ÷ voltage of one cell, e.g. 14.4 V ÷ 3.6 V = 4 cells.

## Non-rechargeable and rechargeable

- In **non-rechargeable** cells and batteries, the chemical reactions stop when one of the reactants has been used up. Alkaline batteries are non-rechargeable.
- **Rechargeable** cells and batteries can be recharged because the chemical reactions are **reversed** when an external electrical current is supplied.
- Rechargeable cells cost more to buy, but they can be reused many times, so they are cheaper over time and fewer are thrown away. They need a charger, and recharging takes time.
- Non-rechargeable cells are cheap and ready to use, but they are thrown away after one use, which wastes resources and adds to landfill unless they are recycled.

## How to answer each type of question

**Recall: simple cells and batteries** 1 to 2 marks **Grade 4**

1. Simple cell: two different metals and an electrolyte.
2. Battery: cells joined in series, so add the voltages.
3. Why a cell stops: one of the reactants has been used up.

**Example.** (a) Give the **two** things needed to make a simple cell. (2)
(b) A battery is made from three cells in series. Each cell has a voltage of 2.0 V. What is the voltage of the battery? (1)
(c) Explain why a non-rechargeable cell eventually stops producing electricity. (1)

---

**Model answer.**

(a) two different metals (1); an electrolyte (1)
(b) 3 × 2.0 = 6.0 V (1)
(c) one of the reactants has been used up, so the chemical reactions stop (1)

## Use voltage data to compare the reactivity of metals

2 to 4 marks | **Grade 5**

1. Bigger voltage = bigger difference in reactivity between the two metals.
2. If every cell shares one metal, the metal giving the biggest voltage with it is the one furthest from it in reactivity.
3. Two electrodes of the same metal give 0 V.
4. To estimate the voltage of a new pair, subtract their voltages measured against the same metal.

**Example.** A student made cells using a silver electrode and a second metal, in the same electrolyte. Silver is the least reactive metal used.

| Second metal | Voltage in V |
|---|---|
| magnesium | 2.6 |
| metal X | 1.9 |
| zinc | 1.4 |
| iron | 1.0 |
| lead | 0.8 |
| copper | 0.4 |

(a) Put all seven metals, including silver, in order of reactivity. Start with the most reactive. (2)
(b) Explain how the results show this order. (1)
(c) Estimate the voltage of a cell made from magnesium and zinc. (1)

---

**Model answer.**

(a) magnesium, X, zinc, iron, lead, copper, silver: X placed between magnesium and zinc (1); the other metals in the correct order, with silver last (1)

(b) the bigger the voltage, the bigger the difference in reactivity from silver, so the more reactive the metal (1)

(c) 2.6 − 1.4 = 1.2 V (1)

## Explain how rechargeable cells can be recharged

2 to 3 marks | **Grade 5**

1. For a non-rechargeable cell: the reactions stop when a reactant is used up.
2. For a rechargeable cell: an external electrical current is supplied (from a charger).
3. This reverses the chemical reactions, so the cell can be used again.

**Example.** Explain why a rechargeable battery can be used again after it has gone flat, but an alkaline battery cannot. (3)

---

**Model answer.** In the alkaline battery the chemical reactions stop when one of the reactants has been used up (1). An external electrical current can be supplied to the rechargeable battery (1), which reverses the chemical reactions (1).

**Evaluate the use of rechargeable and non-rechargeable cells** 3 to 4 marks **Grade 5**

1. Pick out the useful data: cost, voltage, how long each lasts, number of recharges.
2. Make a fair comparison, e.g. cost per hour of use.
3. Give points for both types, including waste and convenience.
4. Finish with a conclusion that follows from your points.

**Example.** A family buys AA cells for a child's remote-control car.

| | Alkaline cell | Rechargeable cell |
|---|---|---|
| Cost of one cell | 50p | £2.50 |
| Voltage | 1.5 V | 1.2 V |
| Time it runs the car | 4 hours | 3 hours per charge |
| Can it be recharged? | no | yes, 400 times |
| Needs a charger? | no | yes |

Evaluate the use of the two types of cell in the car. (4)

---

**Model answer.** The alkaline cell costs 50 ÷ 4 = 12.5p per hour, but the rechargeable cell costs about 250 ÷ (400 × 3) = 0.2p per hour, plus the charger and electricity (1). The rechargeable cell produces much less waste, because it is not thrown away after one use (1). The alkaline cell has a higher voltage, runs the car for longer each time and needs no charger or waiting time (1). The rechargeable cell is the better choice because it is far cheaper over time and less wasteful if the car is used often (1).

## Don’t lose marks

- Saying a cell 'runs out of electricity' or 'runs out of energy'. Say one of the reactants is used up, so the reactions stop.
- Saying a rechargeable cell is recharged by 'adding more chemicals'. An external electrical current reverses the reactions.
- Saying the cells in a battery are joined in parallel. They are joined in series.
- Expecting a voltage from two electrodes made of the same metal.
- In 'evaluate' questions, only giving points for one type of cell, or giving no conclusion.
- Drawing a wire joining the two electrodes directly, or leaving out the electrolyte, in a cell diagram. Both metals must dip into a labelled electrolyte, with the lamp or voltmeter in the external circuit.

## More tips

### Memory tricks

- 'Bigger gap, bigger voltage': the further apart two metals are in the reactivity series, the bigger the voltage.
- Same metal on both sides: no difference in reactivity, so 0 V.
- Cells in series: just add the voltages.
- REcharge = REverse: recharging reverses the chemical reactions.
- The more reactive metal gives away electrons, so it is the negative electrode.

### Exam technique

- In data questions, quote numbers: 'magnesium gave the highest voltage, 2.6 V, so it is the most reactive'.
- Learn the key wording: 'the chemical reactions are reversed when an external electrical current is supplied'.
- For 'evaluate', give at least one point for each type of cell, use the data (a cost per hour is a strong point), and end with a justified conclusion.
- When asked to predict a voltage, check your answer fits the pattern: tested against the same metal, a metal between two others in reactivity should give a voltage between theirs.

## What each grade needs

What you need to be able to do, from the first marks up to the top grade.

**Grade 3** — **State what a cell does**
A cell contains chemicals that react to produce electricity.

**Grade 4** — **Describe how to make a simple cell**
Put two different metals in contact with an electrolyte and connect them with wires, e.g. to a voltmeter.

**Grade 4** — **Explain how a battery gives a bigger voltage**
A battery is two or more cells connected in series, so their voltages add together.

**Grade 4** — **Explain how rechargeable cells are recharged**
When an external electrical current is supplied, the chemical reactions are reversed.

**Grade 5** — **Explain why non-rechargeable cells stop working**
The chemical reactions stop when one of the reactants has been used up.

**Grade 5** — **Use voltage data to order metals by reactivity**
The bigger the difference in reactivity between the two metals, the bigger the voltage of the cell.

**Grade 5** — **Evaluate rechargeable and non-rechargeable cells**
Compare cost, lifetime, voltage, waste and convenience using given data, and reach a justified conclusion.

**Grade 8** — **Estimate voltages for new pairs of metals**
If two metals were each tested against the same third metal, the difference between their voltages estimates the voltage of a cell made from the two.

Free notes, Full packs, practice papers and mock exams at chhetriacademy.com. Written for this site; not taken from past papers. Stuck? 1-to-1 tutoring with a free 30-minute trial lesson.