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AN AUTONOMOUS INSTITUTION



Approved by AICTE, New Delhi and Affiliated to Anna University,
Chennai

23CHT101 – APPLIED CHEMISTRY

2 – MODERN ENERGY STORAGE DEVICES

2.2 – ALKALINE BATTERY

A good battery exhibits several key characteristics that make it efficient, reliable, and suitable for various applications. Here are the primary attributes of a high-quality battery:

1. High Energy Density

- A good battery stores a large amount of energy relative to its weight and size. High energy density is essential for portable devices like smartphones, laptops, and electric vehicles, allowing them to last longer on a single charge.

2. Long Cycle Life

- Cycle life refers to the number of charge-discharge cycles a battery can undergo before its capacity significantly deteriorates. A good battery should have a high cycle life to ensure longevity, especially for applications that require frequent recharging.

3. Fast Charging Capability

- The ability to recharge quickly is crucial, especially for electric vehicles and portable electronics. Good batteries are designed to support fast charging without overheating or degrading quickly.

4. High Power Density

- Power density refers to how much power a battery can deliver over a short period. High power density is necessary for applications that require quick bursts of energy, such as power tools and electric vehicles.

5. Safety and Stability

- Safety is paramount. A good battery is designed with materials and features that prevent overheating, leakage, short circuits, and thermal runaway. Lithium-ion batteries, for instance, are often equipped with safety circuits to prevent overcharging and overheating.

6. Low Self-Discharge Rate

- Self-discharge is the loss of charge over time when the battery is not in use. A good battery has a low self-discharge rate, retaining most of its charge even after extended

periods of inactivity. This is particularly important for backup power and long-term storage applications.

7. Wide Operating Temperature Range

- A good battery should function reliably across a wide temperature range without performance degradation. This is especially important for outdoor and industrial applications, where batteries are exposed to varying temperatures.

8. Environmental Friendliness

- Good batteries are designed with materials that minimize environmental impact. They are either recyclable, made from sustainable materials, or have reduced levels of hazardous substances. This is increasingly important as battery demand grows.

9. High Efficiency

- High efficiency means that a minimal amount of energy is lost during charge and discharge cycles. Efficient batteries convert as much chemical energy into electrical energy as possible, reducing waste and heat generation.

10. Cost-Effectiveness

- Cost is always a factor in battery production. A good battery balances performance with affordability, ensuring it remains accessible for its intended use case while providing good performance for the price.

These characteristics are essential across various battery applications, from consumer electronics to industrial storage and electric vehicles.

Alkaline Battery

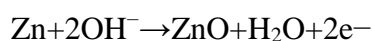
Alkaline batteries are a type of primary (non-rechargeable) battery that operates based on the chemical reaction between zinc and manganese dioxide in an alkaline electrolyte. They are widely used due to their relatively high energy density, long shelf life, and steady voltage output.

Principle

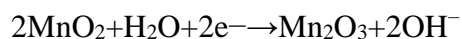
The principle behind an alkaline battery is based on the redox reaction between zinc (Zn) and manganese dioxide (MnO_2) in the presence of an alkaline electrolyte, typically potassium hydroxide (KOH). This electrolyte provides a high ionic conductivity, allowing electrons to flow and generating electrical energy.

Working

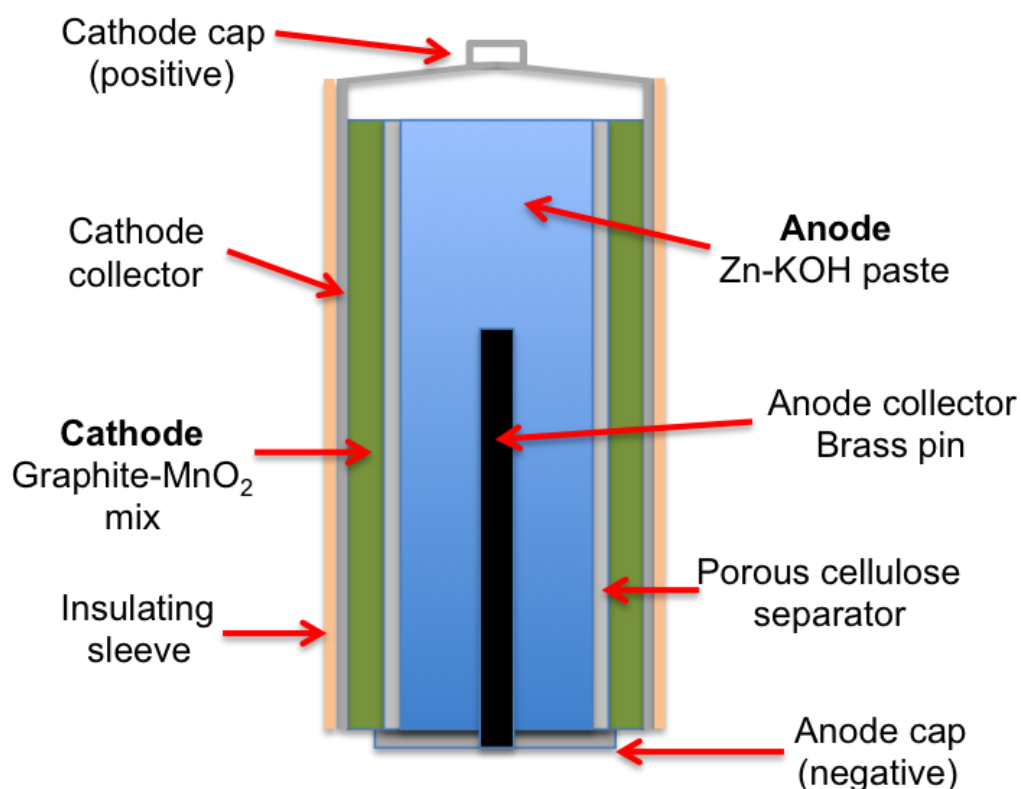
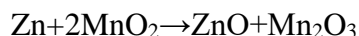
1. Anode Reaction (Oxidation): At the negative electrode (anode), zinc metal is oxidized, releasing electrons:



2. Cathode Reaction (Reduction): At the positive electrode (cathode), manganese dioxide is reduced:



3. Overall Reaction: The combined reactions produce a flow of electrons through an external circuit, powering the connected device:



Applications

Alkaline batteries are commonly used in:

- Household electronics (e.g., remote controls, clocks, flashlights)
- Toys and portable gaming devices
- Small appliances (e.g., radios, cameras)
- Medical devices (e.g., hearing aids and blood pressure monitors)

Advantages

- **High Energy Density:** Provides more energy than zinc-carbon batteries, allowing for longer-lasting power.
- **Long Shelf Life:** Alkaline batteries can last several years without significant loss of charge, making them ideal for infrequent use.
- **Steady Voltage Output:** Delivers a consistent 1.5V output over its lifespan, maintaining device performance.
- **Low Self-Discharge:** Alkaline batteries retain most of their charge when stored, even for extended periods.
- **Environmental Advantage over Older Types:** Alkaline batteries contain no mercury, making them more environmentally friendly than previous battery types like zinc-carbon.

Disadvantages

- **Non-Rechargeable:** Most alkaline batteries are single-use and must be replaced after depletion, leading to higher waste and environmental impact.
- **Waste and Environmental Concerns:** Disposal in landfills can pose environmental issues due to chemicals, though they are generally less toxic than some other types.
- **Size and Power Limitations:** Alkaline batteries are not ideal for high-drain applications, as they can lose power more quickly in such devices compared to rechargeable options.
- **Cost per Use:** Although they are inexpensive upfront, their single-use nature makes them more costly over time for high-use devices.

Alkaline batteries remain popular due to their reliability, long shelf life, and wide availability, but they are best suited for low- to moderate-drain applications where single-use batteries are acceptable.