A-LEVEL PHYSICS • EXERCISE SHEET

21.2 Rectification and smoothing

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS rectification 整流 • bridge rectifier 桥式整流器 • diode 二极管 • smoothing 平滑 • half-wave rectificat

Objective

Build the skills to answer exam questions on **rectification** and **smoothing**.

You must be able to:

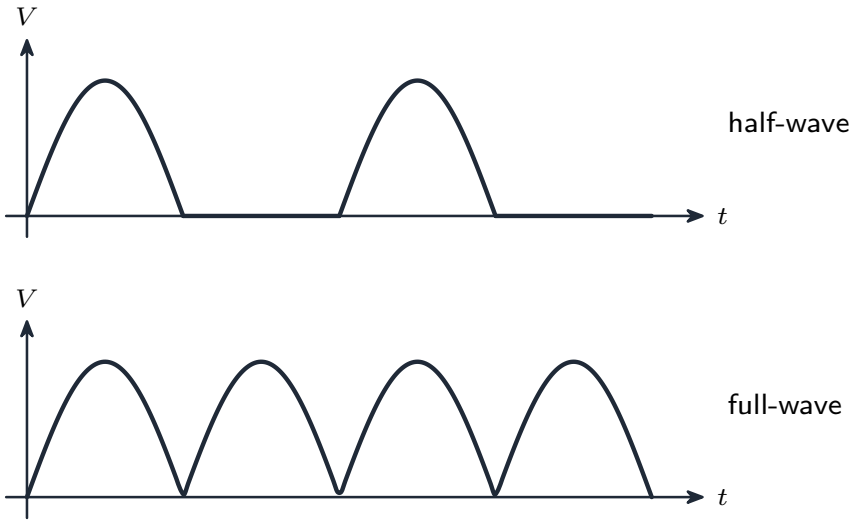
- distinguish **half-wave** and **full-wave** rectification
- explain the **single diode** and the **bridge rectifier**
- explain capacitor **smoothing**

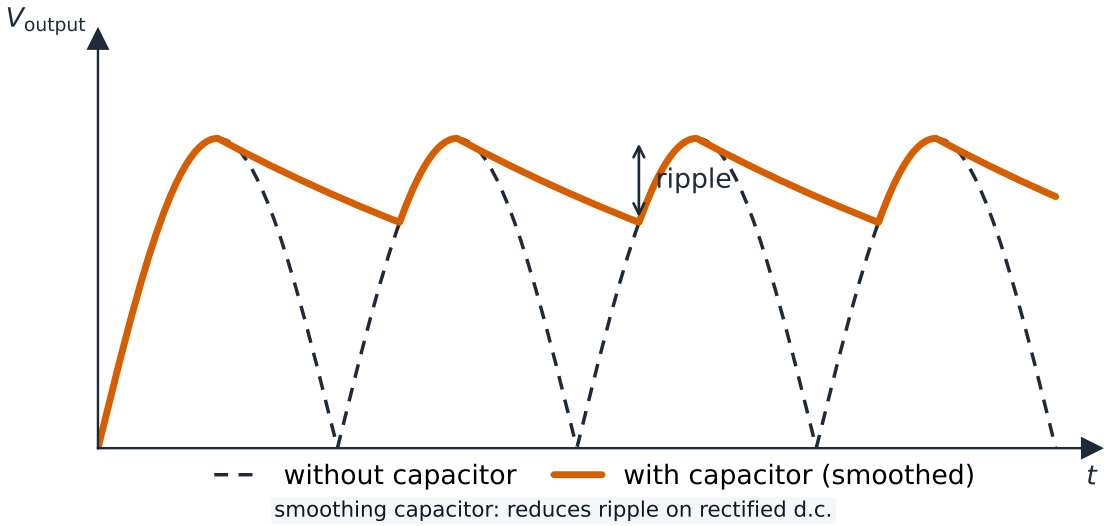
1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Rectification

Rectification turns a.c. into one-direction (d.c.-like) voltage using **diodes**:





A smoothing capacitor after rectification

- **half-wave** (single diode): passes only positive half-cycles — half the input wasted;
- **full-wave** (4-diode **bridge rectifier**): uses every half-cycle, giving continuous humps at **twice** the frequency.

Smoothing

A **capacitor** across the load charges on each peak and discharges through the load in the gaps, reducing the **ripple**. A **larger** capacitance (or larger load resistance) gives **smoother** output (larger time constant RC).

2 Practice

Now apply the methods above.

2.1 State what **rectification** does. [1]

2.2 State how many **diodes** a bridge rectifier uses. [1]

2.3 State the difference between **half-wave** and **full-wave** output. [2]

2.4 State the purpose of a **smoothing capacitor**. [1]

3 Exam-style questions

3.1 A **single diode** in series with a load produces: [1]

- **A** full-wave rectification
- **B** half-wave rectification
- **C** smoothed d.c.
- **D** alternating current

3.2 Explain how a single diode produces **half-wave** rectification. [2]

3.3 Describe how a **bridge rectifier** (four diodes) achieves **full-wave** rectification. [3]

3.4 Explain how a **capacitor** smooths the output, and what happens to the smoothing if the **capacitance is increased**. [3]

3.5 A bridge rectifier is built from four diodes and supplied with a sinusoidal input of peak voltage 12 V. The input completes 8 cycles in 2.8 s.

(a) **State** what is meant by **rectification**, and name the type produced by a bridge rectifier. [2]

(b) **Show that** the period of the input is 0.35 s. [1]

(c) **Calculate** the root-mean-square input voltage. [2]

(d) In the space below, **sketch** the output voltage V_{OUT} across the load against time, from $t = 0$ to $t = 0.35$ s. **Label** both axes with values. [3]

(e) A large capacitor is now connected **across the load**. On the same sketch, **draw** the new output and **explain** its shape. [3]

(f) **State and explain** the effect on the smoothed output of (i) using a larger capacitance, and (ii) connecting a smaller load resistance. [2]

Solutions

2.1 Turns an **alternating** voltage/current into a **one-direction** (d.c.-like) one.

2.2 Four.

2.3 Half-wave keeps **only the positive half-cycles** (with gaps); full-wave **inverts the negative half-cycles** too, giving a continuous run of positive humps at twice the frequency.

2.4 To **smooth** the output — reduce the ripple, giving a steadier d.c..

3.1 B — half-wave rectification.

3.2 The diode conducts only when **forward-biased** (positive half-cycle); on the negative half-cycle it is **reverse-biased** and blocks the current, so only positive humps pass.

3.3 Four diodes are arranged so that on **each** half-cycle a **different pair** conducts; whichever a.c. terminal is positive, the current through the load flows the **same way**; so every half-cycle is used, giving full-wave output.

3.4 The capacitor **charges** to the peak and **discharges** slowly through the load during the dips, filling the gaps and reducing the ripple; a **larger** capacitance increases the time constant RC, so it discharges more slowly and the output is **smoother** (smaller ripple).

3.5 (a) Rectification is the conversion of **alternating** current into **direct** (one-directional) current; a bridge rectifier gives **full-wave** rectification.
(b) $T = \dfrac{2.8}{8} = 0.35$ s.
(c) $V_{\text{r.m.s.}} = \dfrac{V_0}{\sqrt{2}} = \dfrac{12}{\sqrt{2}} = 8.5$ V.
(d) All humps **above** the axis — the negative half-cycles are flipped up; **two** humps in 0.35 s, so the output period is 0.175 s; peak value 12 V, axes labelled.
(e) The output becomes a **smoothed** line that rises with each hump to 12 V and then decays gently until the next hump catches it. The capacitor **charges** to the peak, then **discharges** through the load while the rectified voltage falls, so the output never drops to zero and the remaining variation is the **ripple**.
(f) (i) A larger capacitance stores more charge and discharges more slowly ($\tau = RC$ is longer), so the ripple is **smaller**. (ii) A smaller load resistance draws more current and shortens τ, so the capacitor discharges further between humps and the ripple is **larger**.