# 5.3 Cardiac and ventilation control

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

**KEY WORDS** myogenic • sino-atrial node • Purkyne fibres • medulla oblongata • minute ventilation

## Objective

Practise statements 7.12-7.13 and 7.15 with Core Practical 17: the myogenic heart and its conducting system, cardiac output calculations, the medulla's control centres, and spirometer-trace analysis.

## 1 Key knowledge and worked examples

### ■ The heart sets its own pace

Cardiac muscle is **myogenic** : contraction starts at the **sino-atrial node** without nerve input. The excitation spreads across the atria (atria contract), reaches the **atrio-ventricular node**, and runs along Purkyne fibres to the ventricle walls – delaying ventricular contraction until the atria have emptied.

### ■ Control on demand

The cardiovascular control centre and ventilation centre sit in the **medulla oblongata** . They read chemoreceptors (CO2, pH) and baroreceptors, then adjust heart rate and depth and rate of breathing via the autonomic nervous system (sympathetic speeds, parasympathetic slows).

### ■ Two formulas

$$\text{cardiac output} = \text{stroke volume} \times \text{heart rate}$$

$$\text{minute ventilation} = \text{tidal volume} \times \text{breathing rate}$$

### ■ Worked example: reading a spirometer trace

At rest the trace oscillates 0.5 dm3 about a baseline, 15 times a minute: tidal volume 0.5 dm3, minute ventilation 7.5 dm3 min-1. During exercise the oscillations grow to 2.2 dm3 and the frequency to 30 min-1: minute ventilation 66 dm3 min-1 – nearly tenfold. Oxygen consumption rises with it, measured as the slope of the falling trace volume.

## 2 Practice

**2.1** State what is meant by a myogenic muscle. [1]

**2.2** Name the structure where the heartbeat is initiated. [1]

**2.3** Calculate cardiac output for stroke volume 95 cm3 at 130 beats per minute, in dm3 min-1. [2]

## 3 Exam-style questions

**3.1** Describe how the heartbeat is initiated and coordinated through the chambers of the heart, naming the structures in order. [5]

**3.2** During exercise a runner's cardiac output rises from 5.6 to 17.5 dm3 min-1 while heart rate rises from 70 to 140 beats min-1. Calculate both stroke volumes and explain which factor - heart rate or stroke volume - has contributed more to the rise in cardiac output. [5]

**3.3** Explain why the ventilation rate increases when blood carbon dioxide concentration rises, naming the receptors, the control centre and the effector. [5]

## Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

**2.1** A muscle whose contraction is initiated within the muscle itself, not by nerve impulses.

**2.2** The sino-atrial node.

**2.3** $95 \times 130 = 12\,350\ \text{cm}^3\text{min}^{-1} = 12.35\ \text{dm}^3\text{min}^{-1}$.

**3.1** The sino-atrial node fires and the wave spreads across both atria, causing atrial systole; the impulse reaches the atrio-ventricular node, delayed briefly to let the atria empty; it travels down the Purkyne fibres to the ventricle walls, causing ventricular systole from the apex upward.

**3.2** Rest: $5\,600/70 = 80\ \text{cm}^3$; exercise: $17\,500/140 = 125\ \text{cm}^3$. Heart rate doubled (x2) while stroke volume rose by factor 1.56; both contribute, heart rate slightly more.

**3.3** Chemoreceptors in the medulla and arteries detect rising CO2 (as carbonic acid, lowering pH); the ventilation centre in the medulla sends more frequent impulses; to the intercostal muscles and diaphragm; deeper and faster breathing expels CO2 faster, restoring pH.