Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1661/01

APPLIED SCIENCE
UNIT 1

P.M. THURSDAY, 12 January 2012

1½ hours

For Examiner's use only			
	Question	**Max. Mark**	**Mark Awarded**
Section A	**1-16**	**31**	
Section B	**17**	**6**	
	18	**12**	
	19	**11**	
	20	**10**	
	21	**10**	
Total		**80**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

A data page can be found on page 23.

INFORMATION FOR CANDIDATES

Section A is based on the pre-release article (included).

The number of marks is given in brackets at the end of each question or part-question.

You are reminded that assessment will take into account the quality of written communication used in your answers.

Blood doping is rife in cycling, claims Bernhard Kohl

Bernhard Kohl, the Austrian cyclist who finished third in the 2008 Tour de France before testing positive for a previously undetectable form of performance enhancing drug, EPO (Erythropoietin), has revealed the extent of his doping practices, and claimed the much-vaunted biological passport programme of the Union Cycliste Internationale (UCI) is ineffective in catching cheats.

A biological passport is an individual, electronic record for each rider, in which the results of all doping tests over a period of time are collated. The passport for each rider contains:

- Results of individual urine tests
- Results of individual blood tests
- A haematological profile
- A steroid profile.

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In an interview with French newspaper L'Equipe, Kohl admitted that, as well as taking EPO, he performed illegal blood transfusions during last year's Tour, in which he was crowned King of the Mountains. He also claimed a culture of doping is still prevalent in the sport, and that, in his opinion, any rider who finished in the top 10 of last year's race was likely to have doped.

On the biological passports, Kohl said: "The top riders are so professional in their doping that they know very well they have to keep their blood values stable [so as] not to be detected. The UCI sent us the values resulting from the controls: we thus referred to those to mark the next ones. In a way, the passport almost helped us."

Kohl said that his manager, Stefan Matschiner, flew to France three times during last year's Tour, providing half-litre bags of the cyclist's blood, which had been withdrawn prior to the race. "By re-injecting half a litre of blood the blood parameters are not subject to suspect variation." He added: "I did not cheat anyone in the peloton, be sure of that – there is like a social organisation [of doping] within the peloton, these things are accepted."

The UCI, which launched the passport in 2008, claiming that it represented a new frontier in the fight against doping, has come under fire for a perceived lack of progress. So far, despite huge investment, it has failed to produce a single positive case.

Among Kohl's claims were that "micro-dosing" of EPO was undetectable, even by the passports. The Austrian said tiny doses of EPO added to his own blood – before it was re-transfused – meant that illegal blood transfusions could not be detected. Michael Ashenden, one of the UCI's panel of experts countered Kohl's claims. "I can understand the rationale behind that but it would then make the athlete prone to being caught for EPO, which we can detect. There's a trade-off: you can transfuse blood and risk being caught by the passport, or use EPO and risk being caught for that."

"Of course it's possible that riders could find a way around the passport. It would be naive to sit back and think they're not going to try to find a way around it. They've tried to do that every time we've brought in a new test in the past and I expect they'll do that every time we bring in a new test in future. But the passport is the best strategy we have; it's not perfect, but it's the best we've got."

What is blood doping?

Blood doping is the practice of boosting the number of red blood cells (RBCs) in the bloodstream in order to enhance athletic performance. Because they carry oxygen from the lungs to the muscles, more RBCs in the blood can improve an athlete's aerobic capacity (VO_2 max) and endurance.

The term blood doping originally meant doping with blood, i.e. the transfusion of RBCs. RBCs are uniquely suited to this process because they can be concentrated, frozen and later thawed with little loss of viability or activity. There are two possible types of transfusion: homologous and autologous. In a homologous transfusion, RBCs from a compatible donor are harvested, concentrated and then transfused into the athlete's circulation prior to endurance competitions. In an autologous transfusion, the athlete's own RBCs are harvested well in advance of competition and then re-introduced before a critical event. For some time after the harvesting the athlete may be anaemic.

Both types of transfusion can be dangerous because of the risk of infection and the potential toxicity of improperly stored blood. Homologous transfusions present the additional risks of communication of infectious diseases and the possibility of a transfusion reaction. From a logistical standpoint, either type of transfusion requires the athlete to surreptitiously transport frozen RBCs, thaw and re-infuse them in a non-clinical setting and then dispose of the medical paraphernalia.

In the late 1980s, an advance in medicine led to an entirely new form of blood doping involving the hormone erythropoietin (EPO). EPO is a naturally-occurring hormone growth factor that stimulates the formation of RBCs. Recombinant DNA technology made it possible to produce EPO economically on a large scale and it was approved in the US and Europe as a pharmaceutical product for the treatment of anaemia resulting from renal failure or cancer chemotherapy. Easily injected under the skin, pharmaceutical EPO can boost hematocrit for six to twenty four weeks, or longer. The use of EPO is now believed by many to be widespread in endurance sports.

EPO is not free of health hazards: Excessive use of the hormone can raise hematocrit above 70% which can cause polycythemia, a condition wherein the level of RBCs in the blood is abnormally high. This causes the blood to be more viscous than normal, a condition that strains the heart. Some elite athletes who died of heart failure — usually during sleep, when heart rate is naturally low—were found to have unnaturally high RBC concentrations in their blood. Other serious health risks associated with use of EPO include:

- Increased risk of blood clots, stroke and heart attacks
- Increased risk of contracting infectious diseases such as hepatitis and HIV/AIDS
- Risk of developing an autoimmune reaction

Red blood cell count (hematocrit) goes down with age and EPO also has health benefits, especially after age 50 to prevent senility and in general a loss of neurons.

Detection of blood doping

A time-honored approach to the detection of doping is the random and often-repeated search of athletes' homes and team facilities for evidence of a banned substance or practice. Professional cyclists customarily submit to random drug testing and searches of their homes as an obligation of team membership and participation in the UCI ProTour.

In 2004, British cyclist David Millar was stripped of his world time-trial championship after pharmaceutical EPO was found in his possession. Because athletes sometimes inject or infuse non-banned substances such as vitamin B or electrolytes, the possession of syringes or other medical equipment is not necessarily evidence of doping.

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A more modern approach, which has been applied to blood doping with mixed success, is to test the blood or urine of an athlete for evidence of a banned substance, usually EPO. This approach requires a well-documented chain of custody of the sample and a standard procedure that can be relied upon to be accurate and reproducible. Athletes have, in many cases, claimed that the sample taken from them was misidentified, improperly stored or inadequately tested.

Yet another detection strategy has been to regard any apparently unnatural population of RBCs in the blood as evidence of blood doping. RBC population in the blood is usually reported as hematocrit (HCT) or as the concentration of haemoglobin (Hb). HCT is the fraction of blood by volume occupied by red blood cells. A normal HCT is 41-50% in adult men and 36-44% in adult women.

Haemoglobin (Hb) is the iron-containing protein that binds oxygen in RBCs. Normal Hb levels are 140-180 g/dm^3 of blood in men and 115-160 g/dm^3 in women.

HCT and Hb measurements can suggest that the blood sample has been taken from a doping athlete. The Union Cycliste Internationale (UCI), for example, imposes a 15-day suspension from racing on any male athlete found to have an HCT above 50% and hemoglobin concentration above 180 g/dm^3. A few athletes naturally have high RBC concentrations (polycythemia), which they must demonstrate through a series of consistently high hematocrit and haemoglobin results over an extended period of time.

Why use EPO?

Professional cycling is a fiercely contested sport which pushes its competitors to their physical limits. In a race some racers heart rates have been recorded at 201 beats per minute. On an average stage of the Tour de France a rider's heart rate will stay over 120 bpm for large lengths of time and higher numbers of RBC's will deliver more oxygen to the muscles during this period of strenuous exercise. There is huge pressure on riders to perform. The very survival of a pro-cycling team can depend on it achieving sponsorship through race victories. This means some cyclists will do anything, even if this means resorting to drugs, to win races.

Figure 1 shows a rider's heart rate on a stage of the Tour De France

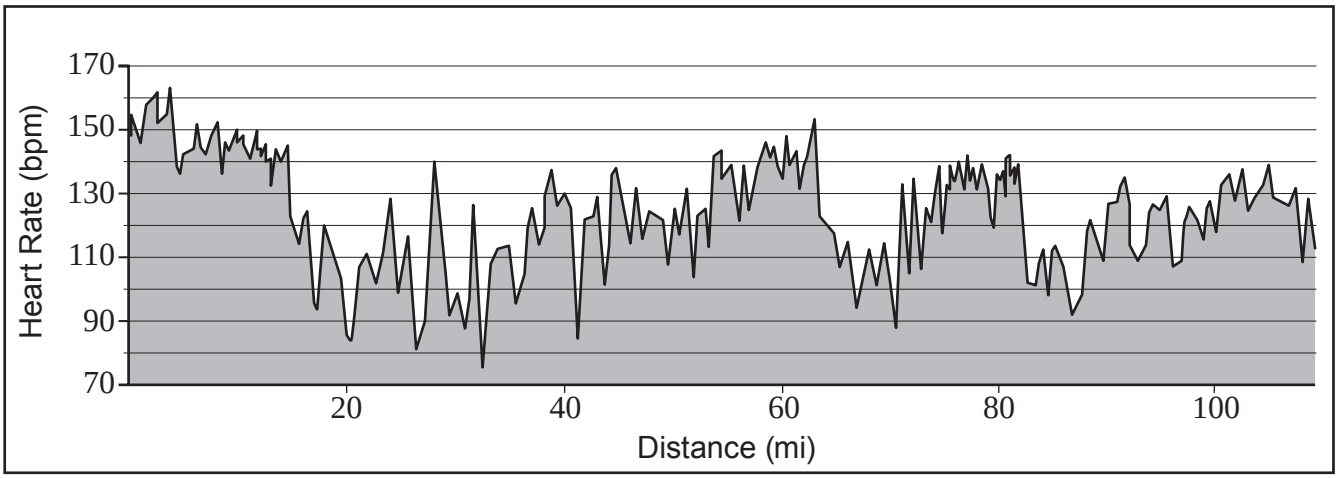
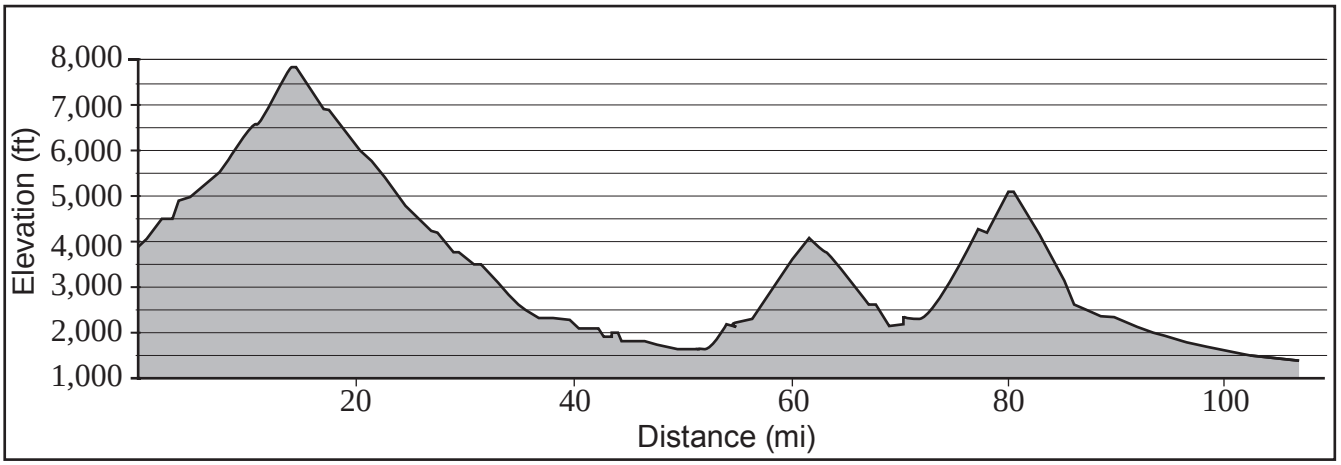


Figure 2 shows the gradient profile for the same stage



Adapted from UCI Anti-Doping Procedural Guideline 6.0
Conducting a blood sample collection session

Purpose

The purpose of this procedure is to describe the process for ensuring that a blood sample collection session is conducted in accordance with UCI Anti-Doping Rules and the World Anti-Doping Program.

Standard Procedure

1. Ensure the availability of adequate Blood Collection Officials (BCO) for the procedure and Chaperones for the purpose of notifying and escorting selected riders.

2. In conjunction with the Blood Collection Official, the Doping Control Officer (DCO) shall ensure that the sample collection site and the equipment supplies are adequate for the testing session.

3. If located in a public space, the minimum requirements for the blood sample collection site are privacy, sole-use and cleanliness. If located in the rider's hotel room or home, the BCO should be satisfied that the conditions will not adversely affect the health of the rider.

4. The type of equipment may vary but, as a guideline, will include:

    - Sterile needles
    - Butterfly needles
    - Disposable plastic syringes
    - Vacutainer collection tubes to draw a predetermined volume of blood
    - Sterile disinfectant pads
    - Gloves providing barrier protection
    - Tourniquets
    - A disposal container for bio-hazardous waste (including a sharps box)
    - A bio-hazard spill kit
    - Adhesive bandage and gauze
    - An ice-pack container/cold box
    - Berlinger kits
    - All doping control documentation, including doping control forms.

Figure 3 A butterfly needle

5. The Rider shall be provided with the opportunity to hydrate.

6. The Rider must be under observation at all times until sample collection begins.

7. In order to ensure the same conditions for all, the Rider shall remain seated and relaxed for 10 minutes before undergoing Venipuncture.

8. As a minimum, the DCO shall ensure the Rider is informed of his/her rights and responsibilities.

9. After the required rest period of at least 10 minutes, and the DCO/BCO explanation of procedure, the DCO shall direct the Rider to choose a Blood Sample collection kit.

10. The Rider must be able to choose between at least 3 Blood Sample collection kits.

11. The Rider and DCO shall check that the equipment is clean and intact. If either the Rider or DCO is not satisfied with the equipment, the Rider shall make another selection.

12. If the Rider is not satisfied with any of the equipment, and the DCO does not agree with the Rider's opinion that all of the available equipment is unsatisfactory, the DCO shall instruct the Rider to proceed with the sample collection session and the Rider's views must be recorded on the doping control documentation by the DCO.

13. If both the DCO and the Rider agree that none of the equipment is satisfactory, the DCO shall terminate sample collection, and record the reasons.

14. The BCO shall assemble the equipment in sight of the Rider.

15. If the BCO believes that a butterfly needle is required for Venipuncture, the Rider shall be asked to select a butterfly needle from a selection of sealed needles.

16. If necessary, the BCO shall apply a tourniquet to the Rider's upper arm. If the Rider has a skin problem, the tourniquet shall be applied over thin clothing or a paper tissue so that the skin is not pinched.

17. The skin at the puncture site shall be cleaned with a sterile disinfectant wipe or swab. The needle shall be inspected visually before insertion.

18. The BCO shall collect the amount of blood advised by the UCI for the type of sample analysis to be conducted. The collection vessel (s) shall always be kept in full view of the Rider.

19. No more than three attempts to insert a needle into the Rider's body shall be made. The DCO shall record the reasons for terminating the collection attempt.

20. Blood collection equipment must be disposed of in accordance with the required standards for handling blood.

Figure 4 Sharps bin

21. After withdrawing the needle from the Rider's arm, the BCO shall place a pad over the puncture site and instruct the Rider to press firmly on the pad.

22. The BCO or the DCO shall advise the Rider not to undertake any strenuous exercise using the arm for at least 30 minutes. This minimizes any potential bruising.

23. The BCO shall be prepared to conduct first-aid if necessary.

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Examiner only

SECTION A

Answer **all** *questions.*

1. State what is meant by the term *'blood doping'*. [1]

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2. State **two** of the pieces of information contained on a rider's biological passport. [2]

1. .....

2. .....

3. Describe the difference between **homologous** and **autologous** transfusion. [2]

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4. Why is homologous transfusion regarded as more dangerous than autologous transfusion? [1]

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5. How does EPO (Erythropoietin) improve the performance of endurance athletes? [1]

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6. Anaemia is a decrease in number of red blood cells (RBCs) in a person's blood. Suggest **two** symptoms a person suffering from anaemia would display. [2]

1. .....

2. .....

7. Red blood cells carry oxygen around the body. State **two** structural adaptations red blood cells have to allow them to carry the maximum volume of oxygen. [2]

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8. Complete the table below, stating the functions of the other components of the blood. [3]

Component	*Function*
Thrombocytes	.....
Leucocytes	.....
Plasma	.....

9. What piece of equipment would a Blood Collection Official use to measure the number of red blood cells in the blood? [1]

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10. After a race a male rider is randomly tested. He produces a hematocrit score of 51% and a haemoglobin concentration of 170 g/dm^3. Do you think the rider should receive a ban for this result? Explain your reasoning. (Lines 94-106) [2]

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11. When conducting a blood sample collection, explain why the rider is "kept under observation until sample collection begins". (Line 148) [1]

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Examiner only

12. State how needles should be disposed of after the sample collection. [1]

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13. Why does the Blood Collection Official need to wear gloves when carrying out the procedure? [1]

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14. On several occasions the rider is involved in selecting equipment for the sample collection. (Lines 152-154, 164-165). Give **two** reasons why this is the case. [2]

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15. Since 2006 there have been 136 positive drug tests in professional cycling. 40 of these have been for EPO related violations. Calculate the percentage of all drug offences that were EPO related. [2]

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16. *(a)* Look at **figures 1** and **2** (page 5) and state what is causing the rider's heart rate to increase between 70 and 80 miles. [1]

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(b) Explain why the rider's heart rate is increasing. [2]

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Examiner only

(c) The rider's heart rate increases again towards the end of the race. Suggest why this might be the case. [1]

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(d) Other than strenuous exercise what **three** factors could cause a rise in heart rate? [3]

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Examiner only

SECTION B

Answer **all** *questions.*

17. *(a)* A medical examination is required for a life insurance policy. What piece of equipment would the nurse use to test the following measurements? [4]

Test	*Equipment*
(i) Tidal volume	
(ii) Blood pressure	
(iii) Peak respiratory flow	
(iv) Pulse rate	

(b) Before testing, medical professionals often have to carry out risk assessments. Explain the difference between the terms *hazard* and *risk*. [2]

Hazard .....

.....

Risk .....

.....

.....

18. Collette has trouble with her breathing. She goes to a doctor who diagnoses her as having asthma.

(a) Explain how asthma makes breathing difficult. [2]

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(b) State **two** possible triggers of asthma attacks. [2]

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(c) Collette is prescribed a relief inhaler. Explain how this relieves the symptoms of an asthma attack. [3]

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(d) (i) The number of people admitted to hospital for emergency treatment relating to asthma varies across Wales. Use the table below to draw a chart to best display the information. [4]

Selected counties	*Emergency hospital admissions for asthma attacks in 2008 (all ages)*
Blaenau Gwent	167
Cardiff	78
Denbighshire	92
Flintshire	83
Gwynedd	92
Monmouthshire	87
Newport	135
Pembrokeshire	106
Vale of Glamorgan	114

(ii) Cardiff has the highest population of any county within Wales and yet has the lowest emergency hospital admissions for asthma. Suggest **one** reason why this might be the case. [1]

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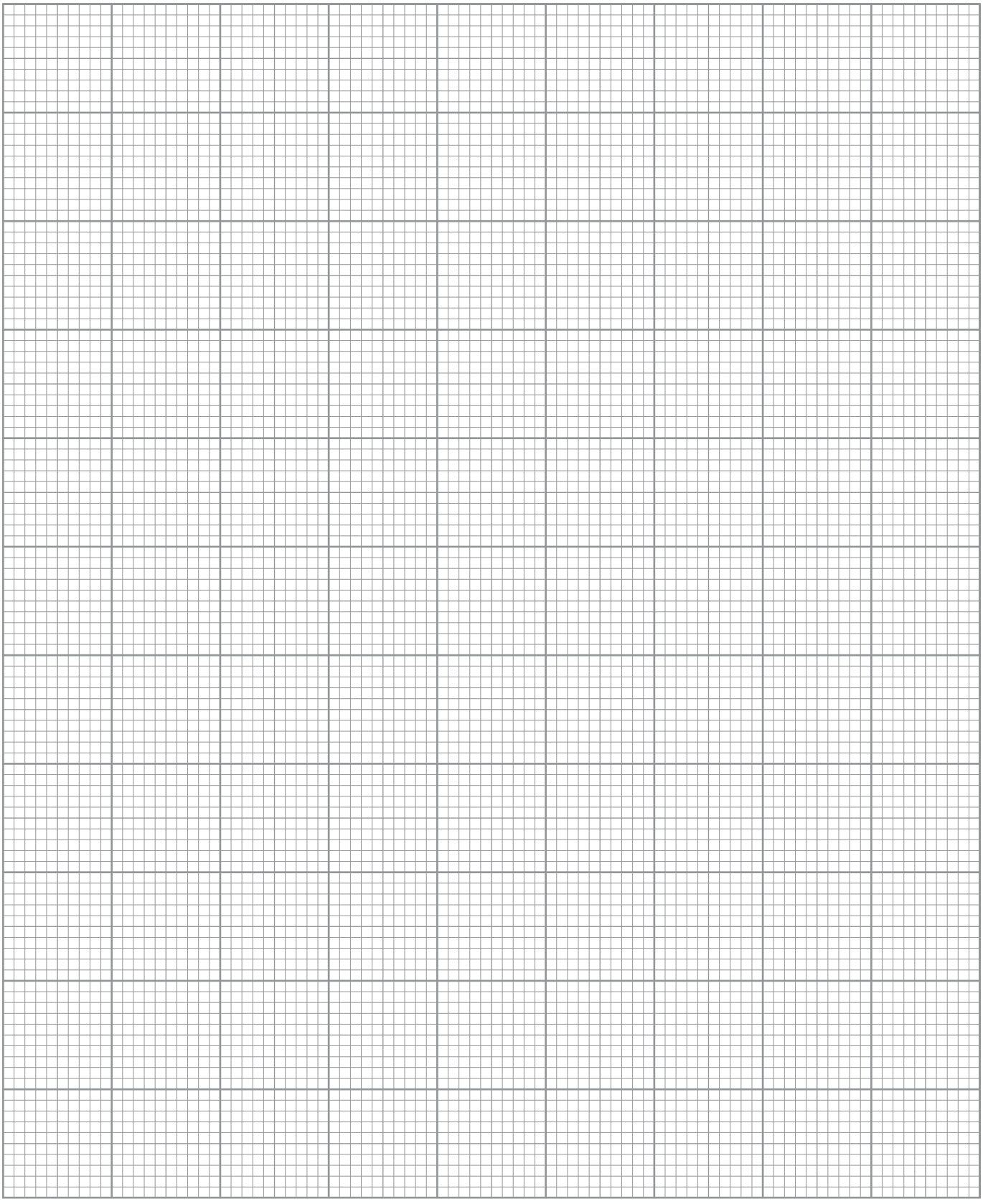

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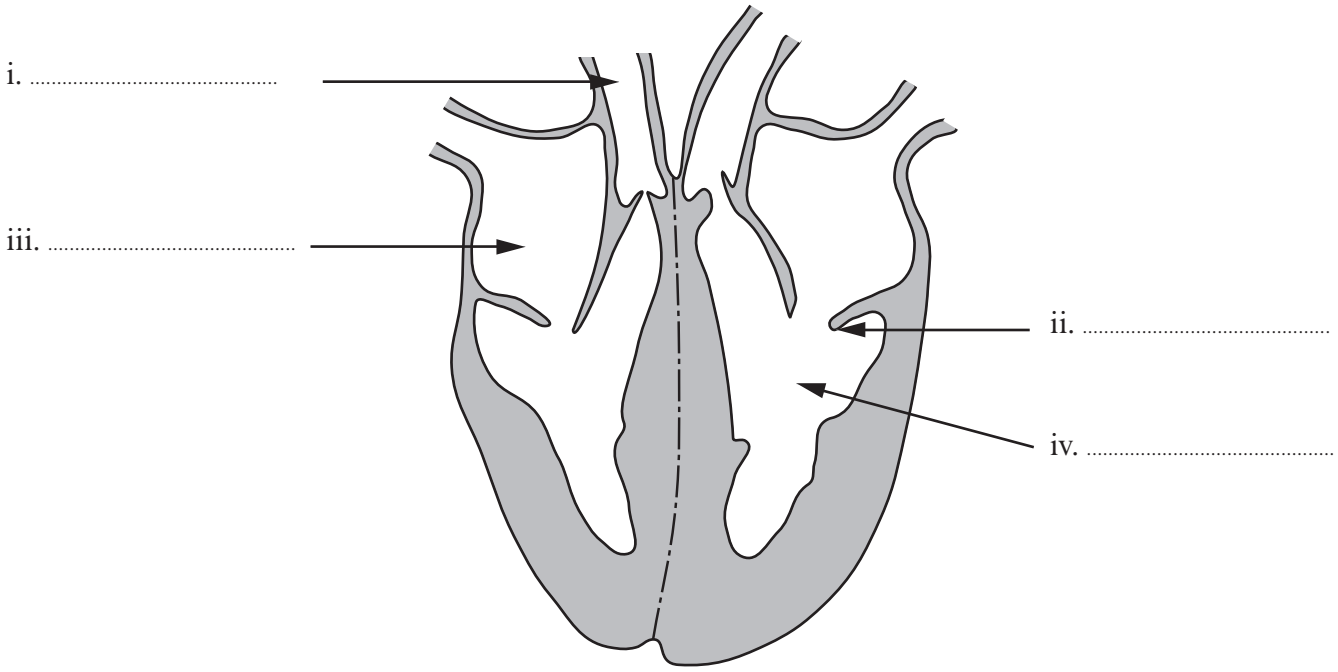
Examiner only

19. Below is a diagram of the heart.



(a) Label the **four** structures on the diagram above. [4]

(b) Explain why one side of the heart is thicker than the other. [2]

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(c) The heart muscle is myogenic. Explain what this means. [1]

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(d) Describe the function of the following structures

(i) The bundle of His .....

(ii) Sinoatrial node .....

(iii) Pulmonary vein .....

(iv) Atrio ventricular node .....

[4]

20. A doctor is carrying out a routine medical examination on four members of a running club before they embark on a training schedule. He conducts various physiological tests on four of the runners. The results of the tests are displayed below.

Runner	*Age*	*Blood pressure (mmHg)*	*Vital capacity (dm^3)*	*Resting pulse rate (bpm)*	*Tidal volume (cm^3)*	*Red blood cell count (dm^3)*
Christopher	24	125/80	4.9	62	432	5.0×10^{12}
Sally	42	133/85	4.0	45	510	6.1×10^{12}
Jonathon	30	146/93	4.9	63	450	5.2×10^{12}
Sophia	21	123/80	2.9	92	399	4.0×10^{12}

(a) One of the runners has only just finished training for another event. State which runner you think this is and give **two** pieces of evidence to support your decision.

Name ..... [1]

1. ..... [1]

2. ..... [1]

(b) (i) Explain what the terms *diastolic* and *systolic* mean. [2]

(a) Diastolic

.....

(b) Systolic

.....

(ii) One of the runners has high blood pressure. State the name of the runner. [1]

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(iii) State **two** factors that could have caused this runner's high blood pressure. [2]

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(c) One of the runners has just recovered from an illness which means they have **not** been able to do any exercise. Suggest who this is and explain your answer. [2]

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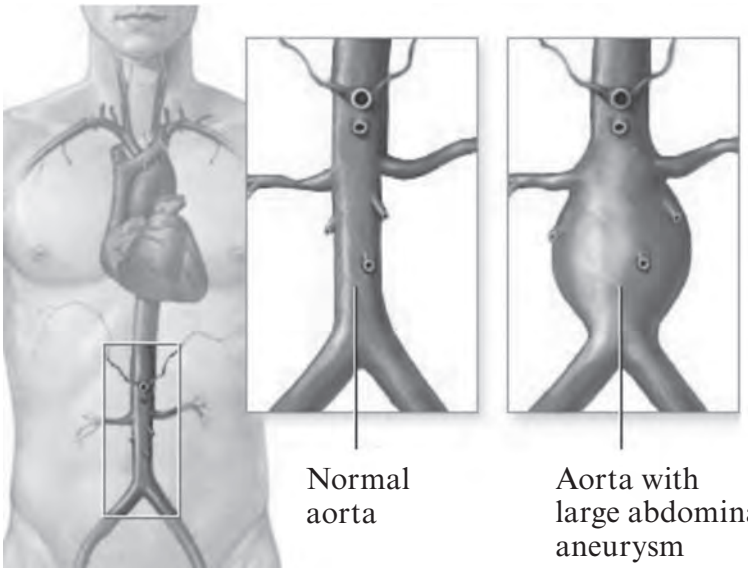
21. Radioactive tracers are used in medicine to detect aneurysms in blood vessels.



(a) Describe the procedure by which a radioactive trace allows a medical professional to detect abnormalities in blood vessel walls. [3]

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(b) Circle which of the following is **not** a medical use of radioactive tracers. [1]

Detecting tumors

Killing cancerous cells

Imaging the bowel and large intestine

Measuring thyroid gland activity

(c) An aneurysm is a bulge in a blood vessel that is caused by a weakness in the blood vessel wall. The pressure of the blood causes it to bulge outwards like a balloon. If the aneurysm grows too big, there is a danger that it will rupture which can cause potentially fatal internal bleeding.

(i) Arteries carry blood under high pressure. Explain how they are able to transport blood at high pressure. [2]

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(ii) The mean pressure of the blood in the arteries in one individual is 103 mmHg. By the time the blood has reached the capillaries it has dropped to 19 mmHg.

Explain the change in blood pressure between the arteries and capillaries. [2]

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(d) In March 2009, the NHS launched a pilot screening service in the south of England, designed to check men who are 65 years of age or over for aortic aneurysms. Suggest **two** reasons why the NHS **might not** extend this scheme across the whole of the UK. [2]

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Data Sheet

Table 1 Normal values for some physiological indicators

Indicator	Adult Male	Adult Female
Pulse Rate	60 – 80 beats per minute	60 – 80 beats per minute
BREATHING		
Rate	12 – 15 breaths per minute	12 – 15 breaths per minute
Tidal volume	400 – 500 cm^3	400 – 500 cm^3
Vital Capacity	4.8 dm^3	3.1 dm^3
Peak Flow	400 – 600 $dm^3\ min^{-1}$	400 – 600 $dm^3\ min^{-1}$
BLOOD PRESSURE		
20 years old	125/80 mmHg	123/80 mmHg
40 years old	135/85 mmHg	133/85 mmHg

Table 2 Reference ranges for some common blood tests

Test	Adult Male	Adult Female
Glucose (Fasting)	4.5 – 6.1 mmol dm^{-3}	4.5 – 6.1 mmol dm^{-3}
Sodium ions	133 – 147 mmol dm^{-3}	133 – 147 mmol dm^{-3}
Potassium ions	3.5 – 5.0 mmol dm^{-3}	3.5 – 5.0 mmol dm^{-3}
Calcium ions	1.15 – 1.29 mmol dm^{-3}	1.15 – 1.29 mmol dm^{-3}
Zinc ions	10 – 17 μmol dm^{-3}	10 – 17 μmol dm^{-3}
RED BLOOD CELLS		
Haemoglobin	140 – 180 g dm^{-3}	115 – 160 g dm^{-3}
Red Cell count	4.5 – 6.5 × 10^{12} dm^{-3}	3.8 – 5.8 × 10^{12} dm^{-3}
WHITE BLOOD CELL COUNT	4 – 11 × 10^9 dm^{-3}	4 – 11 × 10^9 dm^{-3}
PLATELET COUNT	150 – 400 × 10^9 dm^{-3}	150 – 400 × 10^9 dm^{-3}