Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Friday 16 June 2023

Morning (Time: 2 hours)

Paper reference **9BN0/02**

Biology A (Salters Nuffield)

Advanced

PAPER 2: Energy, Exercise and Coordination

You must have:
Scientific calculator, pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- In questions marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

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Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 During growth, cells divide by mitosis. Many organisms also carry out meiosis to enable sexual reproduction.

(a) (i) In which stage of cell division do spindle fibres attach to the centromeres?

(1)

☐ **A** anaphase

☐ **B** interphase

☐ **C** metaphase

☐ **D** telophase

(ii) In which stage of the cell division does the nuclear membrane start to break down?

(1)

☐ **A** interphase

☐ **B** metaphase

☐ **C** prophase

☐ **D** telophase

(iii) In which stage of cell division are chromatids first visible when using a light microscope?

(1)

☐ **A** interphase

☐ **B** metaphase

☐ **C** prophase

☐ **D** telophase

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(b) Meiosis is involved in the production of sperm cells.

Crossing over during meiosis can result in genetic variation.

Explain how crossing over can lead to genetic variation.

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(Total for Question 1 = 6 marks)

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2 It has been estimated that up to 90% of the cells present in a human are prokaryotic. This is due to prokaryotes being present on the skin surface and within the human body.

(a) Which one of the following statements comparing prokaryotic DNA with human DNA is correct?

(1)

☒ **A** prokaryotic DNA is linear and human DNA is circular

☒ **B** prokaryotic DNA is located in a membrane-bound nucleus

☒ **C** the base thymine is replaced by uracil in the prokaryotic DNA

☒ **D** the sugar in both eukaryotic and prokaryotic DNA is deoxyribose

(b) The lac operon is found in some prokaryotes.

(i) Describe what is meant by the term **operon**.

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(ii) Describe the effect of lactose on the lac operon.

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(Total for Question 2 = 6 marks)

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3 Damage to the anterior cruciate ligament (ACL) is the most common major knee injury in football.

(a) Which of the following describes the structure and function of a ligament?

(1)

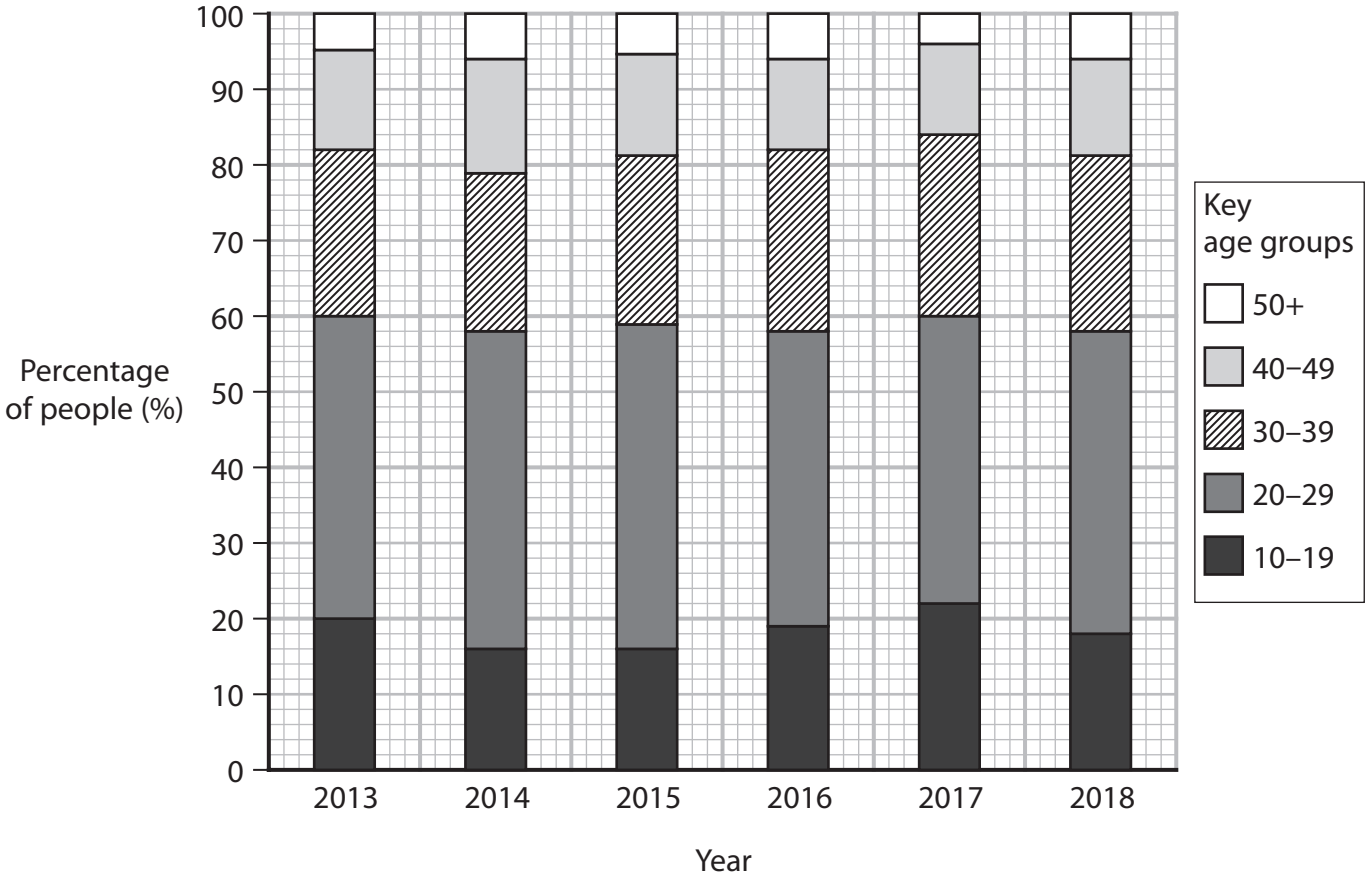
☒ **A** elastic and attaches bone to bone

☒ **B** elastic and attaches muscle to bone

☒ **C** non-elastic and attaches bone to bone

☒ **D** non-elastic and attaches muscle to bone

(b) The graph shows the percentage of people in the UK who had ACL surgery from 2013 to 2018.



Comment on the effect of age on the percentage of people who had ACL surgery from 2013 to 2018.

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(c) Keyhole surgery or open surgery can be used to treat ACL damage.

A study compared wound infections from these two types of surgery.

The table shows the results of this study.

Type of surgery	Number of surgeries	Number of wound infections after surgery	Ratio of wound infections to number of surgeries
Keyhole surgery	2623	2	0.0008 : 1
Open surgery	13 472	68	

(i) Complete the table to show the ratio of wound infections to number of open surgeries.

Give your answer to one significant figure.

(1)

(ii) Explain why there is a greater ratio of wound infections in open surgery compared with keyhole surgery.

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(Total for Question 3 = 7 marks)

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4 There are different types of genetic screening available.

Each year, about 30 000 prenatal genetic screening tests are carried out.

(a) Compare and contrast the use of pre-implantation genetic diagnosis (PGD) and amniocentesis.

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(b) Describe **two** different social issues related to the use of PGD.

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(c) Genetic screening can be used to test for conditions such as cystic fibrosis.

Explain why cystic fibrosis affects digestion.

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(Total for Question 4 = 9 marks)

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5 The bacterium *Escherichia coli* (*E. coli*) makes up about 1% of the human gut flora. Some strains of this bacterium aid our digestion but some strains are pathogenic.

(a) The width of the *E. coli* DNA is 250 times smaller than the width of the bacterium.

An image of *E. coli*, at a magnification of 20 000, had a width of 10 mm.

Calculate the width of its DNA.

Give your answer in micrometres (μm) and in standard form.

(3)

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(b) Meselson and Stahl used *E. coli* to investigate the nature of DNA replication.

They initially grew an *E. coli* population in a medium containing heavy nitrogen (^{15}N) until all the bacteria had DNA containing heavy nitrogen.

They then transferred the bacteria into a medium containing light nitrogen (^{14}N).

The bacteria were sampled after the first replication and after the second replication.

(i) Complete the table to show the expected DNA after *E.coli* had been grown in ^{14}N, for two possible types of DNA replication.

(3)

Type of DNA replication	**DNA before first replication**	**DNA after first replication in ^{14}N**	**DNA after second replication in ^{14}N**
Conservative			
Semi-conservative			

Key

= one strand of DNA containing heavy / ^{15}N

= one strand of DNA containing light / ^{14}N

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(ii) This study enabled Meselson and Stahl to show that DNA replication was semi-conservative rather than conservative.

Explain what is meant by the term **semi-conservative DNA replication**.

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(c) A pathogenic strain of this bacterium, *E. coli*-STEC, produces a toxin that reduces blood platelet concentration.

Explain how an *E.coli*-STEC infection increases the time taken for a blood clot to form.

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(Total for Question 5 = 11 marks)

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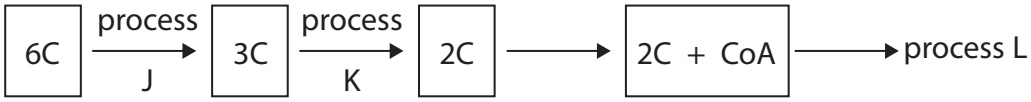
6 Cellular respiration is a metabolic process essential for life.

(a) The diagram represents part of aerobic respiration in a muscle cell.



Key
nC = number of carbons present in the molecule
For example, 6C = a six-carbon molecule

(i) Name two products, other than the three-carbon molecule (3C), that are formed by process J.

(1)

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(ii) Describe what would happen to the three-carbon molecule (3C) if process K stopped.

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(iii) Which one of the following represents process L?

(1)

☒ **A** 6C → 4C → 2C → 0C

☒ **B** 6C → 5C → 4C → 3C

☒ **C** 6C → 4C → 2C

☒ **D** 6C → 5C → 4C

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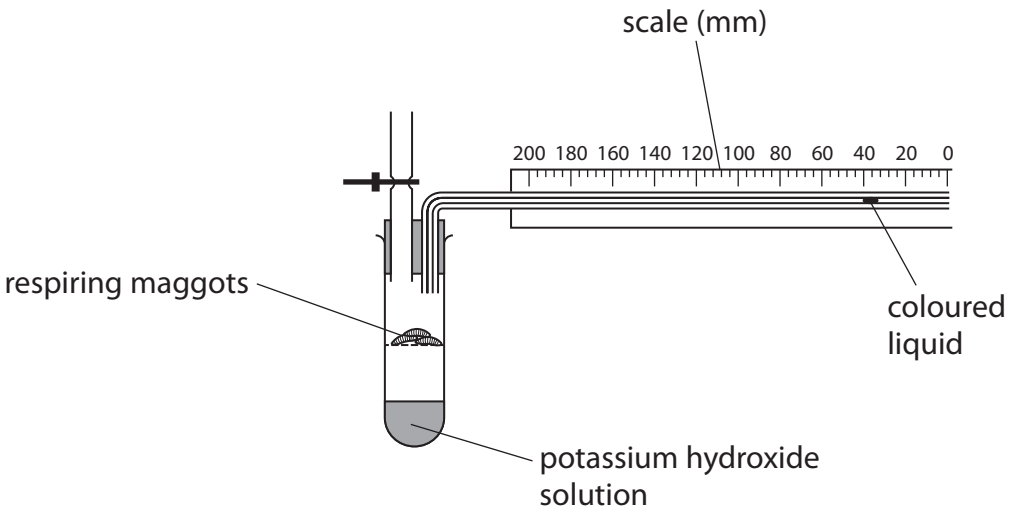
(b) Respiration in maggots is similar to respiration in humans.

In an investigation, three maggots were placed in a respirometer as shown.



The maggots respired aerobically for 20 minutes in this respirometer.

Explain why the coloured liquid moved to the left during the 20 minutes of this investigation.

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(c) Devise an investigation, using a respirometer, to find the optimum temperature for respiration in maggots.

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(Total for Question 6 = 11 marks)

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7 Muscles and eyes are examples of organs found in the human body.

(a) Skeletal muscle tissue contains several types of muscle fibre that have different properties. Two of these are shown in the table.

Properties	Muscle fibre	
	Type I	**Type II**
Speed of contraction	slow	four times the speed of type I
Time taken to fatigue	long	short
Concentration of mitochondria	high	low
Level of anaerobic respiration carried out	low	high

The proportion of type I and type II muscle fibres in the skeletal muscle of long distance runners and sprinters is different.

Explain the advantages for long distance runners of having both type I and type II muscle fibres, but not in equal quantities.

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(b) Some people can have a recessive genetic condition of the eye due to a non-functional gene.

Genetically modified viruses can be used to treat these people by introducing a functional version of the gene into the cells of the eye.

(i) A student made three statements about this treatment:

- ligase would be used to cut open the viral plasmid
- a restriction enzyme would be used to add the functional gene to the genome of a person with the condition
- the functional gene would act as the vector.

How many of these statements are correct?

(1)

☒ **A** none

☒ **B** 1

☒ **C** 2

☒ **D** 3

(ii) EcoR1 is an enzyme that can be used in the process of genetic modification.

This enzyme hydrolyses bonds in DNA producing sticky ends.

The diagram shows a fragment of DNA cut out of a much longer sample of DNA. Not all of the bases in the double-stranded section are shown.

How many phosphodiester bonds were hydrolysed in the production of this fragment of DNA?

(1)

☒ **A** 2

☒ **B** 4

☒ **C** 8

☒ **D** 16

(iii) Explain why a person successfully treated using a genetically modified virus may still have a child with this recessive condition.

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(c) The ability to produce personalised medicines is one outcome of the human genome project (HGP).

Which one of the following allows the development of personalised medicines?

(1)

☒ **A** differences in the genome between people

☒ **B** medicines having the same effects on people

☒ **C** similarities in the genome between people

☒ **D** the genome does not affect the activity of medicines

(Total for Question 7 = 11 marks)

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8 The nervous system contains different types of cell including neurones and Schwann cells.

(a) Mitochondria in the cytoplasm of neurones synthesise adenosine triphosphate (ATP).

Explain the role of ATP in the transmission of impulses along neurones.

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(b) Mitochondria move along the length of the axon in the cytoplasm.

The axon cytoplasm contains actin along its length. There is myosin on the surface of the mitochondria.

(i) Explain how the myosin head could move mitochondria along the axon.

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(ii) In an axon that is 9 cm long, the speed of mitochondrial movement was recorded as 0.5 $\mu m\ s^{-1}$.

Calculate the time it would take a mitochondrion to move the length of this axon. Give your answer in hours.

(2)

..... hours

*(c) The table shows the proportion of two components found in the cell surface membrane of two cells of the nervous system.

Cell of the nervous system	Percentage composition of the cell surface membrane (%)	
	lipid	protein
Motor neurone	50	40
Schwann cell	70	30

Discuss the relative importance of lipids and proteins in the cell surface membranes of motor neurones and Schwann cells.

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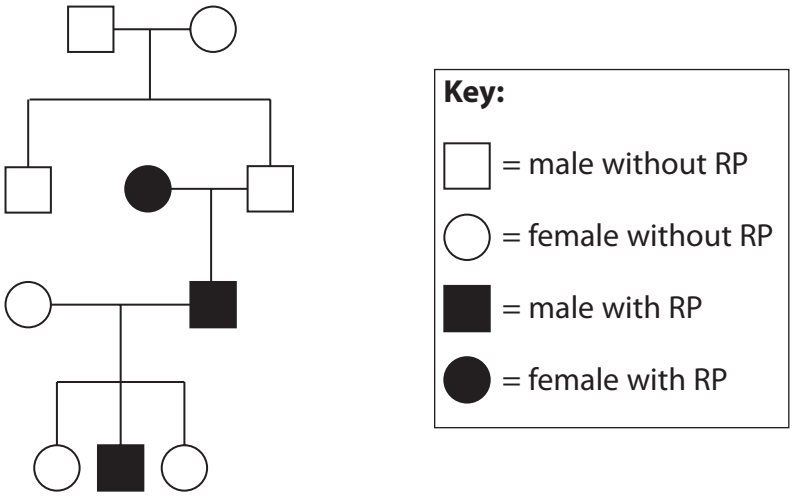
9 Many organisms contain photosensitive pigments. Humans have the photosensitive pigment rhodopsin in the eye. Plants have a photosensitive pigment called phytochrome.

(a) Retinitis pigmentosa (RP) is a genetic condition that can be caused by a dominant allele. It affects the functioning of rhodopsin.

(i) The family pedigree shows the inheritance of this condition in one family.



It is possible to determine genotypes of some individuals from a family pedigree diagram.

How many members of this family can have their genotype for RP determined from this diagram?

(1)

☒ **A** 3

☒ **B** 7

☒ **C** 9

☒ **D** 10

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(ii) Rhodopsin is made of protein and retinal. The structure of rhodopsin can be studied by measuring the ratio of light absorbed at 280 nm and at 500 nm.

The table shows the absorbance ratio of the rhodopsin from two people, one with RP and one without.

Rhodopsin from	Absorbance ratio (280 nm : 500 nm)
person without RP	2.0 : 1
person with RP	5.6 : 1

Explain why a gene mutation causes the difference in the absorbance ratio for a person with RP.

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(b) Rod cells form synapses with bipolar neurones.

Describe how movement of sodium ions in a rod cell affects depolarisation in a bipolar neurone.

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(c) Some plants only flower when the days are long and the nights are short. They are known as long-day plants.

(i) Describe the role of the photosensitive pigment phytochrome in the flowering of long-day plants.

(2)

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(ii) Devise an investigation to find out if a species of plant is a long-day plant or a short-day plant.

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10 Doctors believe that about 28% of the adult population in the UK are obese. This can lead to a number of health-related conditions including coronary heart disease.

(a) Food packaging often contains nutritional information.

The table shows some nutritional information about chocolate biscuits.

Component	Four biscuits contain	Percentage of total recommended daily intake (%)	Recommended daily intake (RI)
Energy content	700 kJ	8	
Fats	7.6 g	11	70 g
of which are saturated	4.7 g	23	20 g
Sugars	20.3 g	23	90 g

(i) Calculate the percentage of fat present in the biscuits that contains carbon to carbon double bonds.

(1)

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(ii) Calculate the number of biscuits needed to exceed the recommended daily intake (RI) for sugar.

(2)

Answer .....

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(iii) The energy content for four biscuits and the percentage of total recommended daily intake can be used to calculate a recommended daily intake.

Calculate the daily recommended intake of energy from the data in the table. Give your answer in joules and in standard form.

(2)

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(b) The Million Women Study was set up in 1996 and considered aspects of the health of UK women.

Using data from this study, scientists investigated the effects of various factors on coronary heart disease (CHD).

The scientists selected one million women who had not had CHD before the study started.

The women provided information on the following:

- BMI
- smoking habits
- alcohol intake
- level of physical activity
- age at the start of the investigation.

The women were monitored for five years and the development of CHD was recorded. The data were used to estimate the likelihood of any woman developing CHD.

The table shows the effect of age and BMI on the development of CHD in women.

Age range / years	**Percentage incidence of CHD over 5 years for different BMI values (%)**			
	BMI 22.5	**BMI 27.5**	**BMI 32.5**	**BMI 37.5**
55–59	1.0	1.5	1.8	2.2
60–64	1.9	2.4	3.0	3.5
65–69	3.0	3.7	4.3	4.8
70–74	4.5	5.1	5.8	7.1

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(i) Describe the effect of age and BMI on the development of CHD in women.

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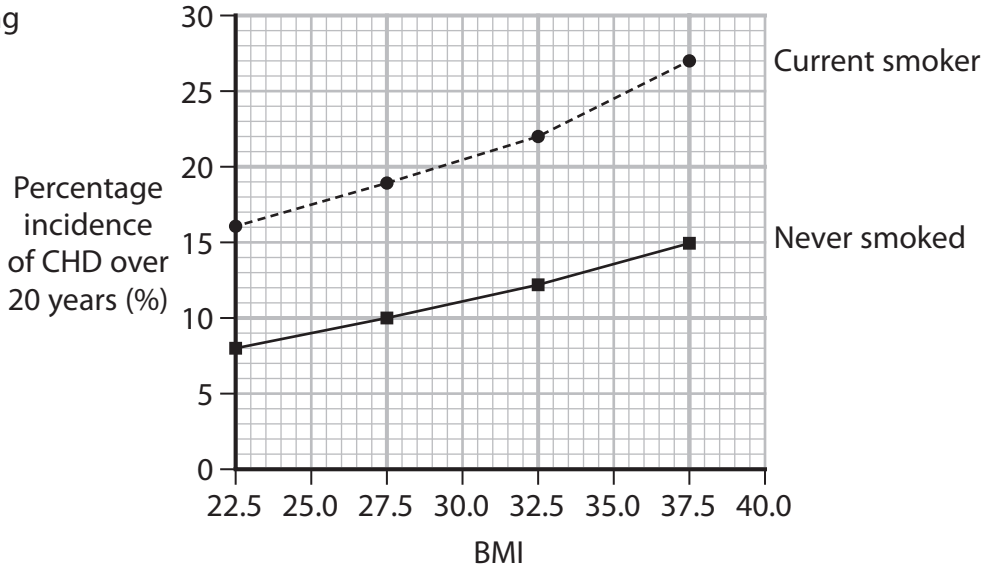
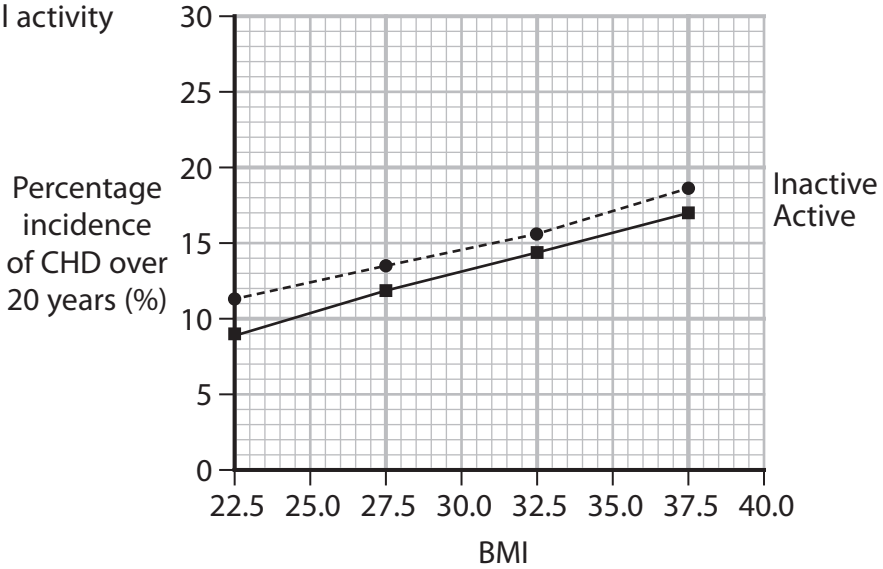
*(ii) The graphs show the effect of three different lifestyle factors on the development of CHD in women.

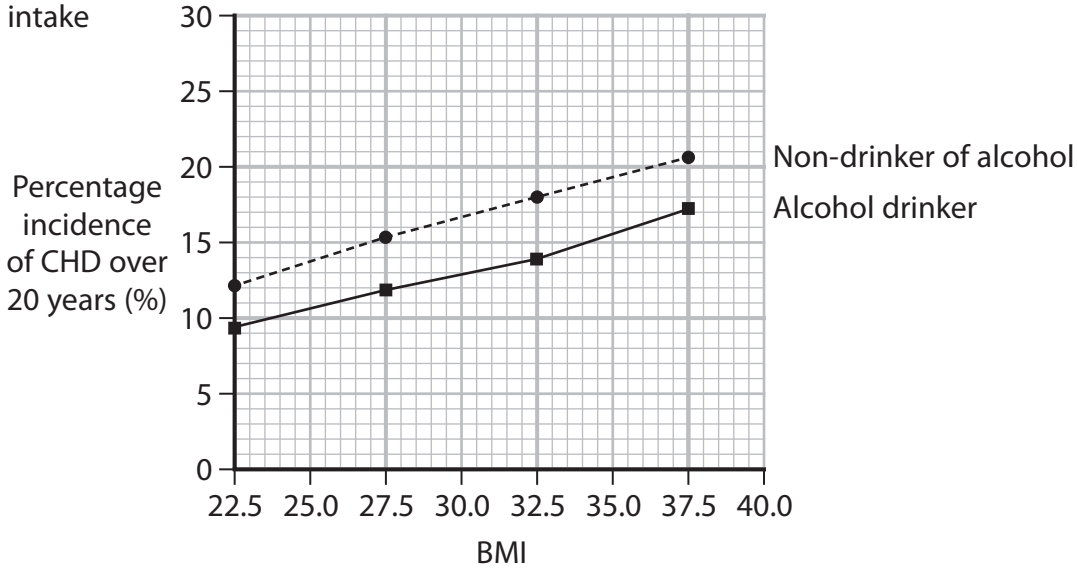
A: By smoking



B: By physical activity



C: By alcohol intake



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Evaluate the information provided in the table and graphs to determine which factors are most likely to increase the risk of CHD in women.

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(Total for Question 10 = 13 marks)

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