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 14 June 2024

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 question(s) 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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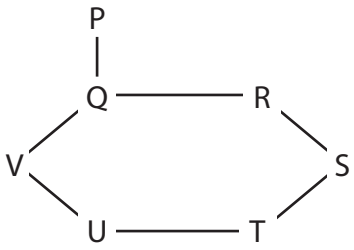
Answer ALL questions. Write your answers in the spaces provided.

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 Cells in the human brain use glucose as a respiratory substrate.

(a) The diagram represents a glucose molecule.

The letters P–V represent atoms or groups in the glucose molecule used as a respiratory substrate.



(i) Which atom does R represent?

(1)

☒ **A** carbon

☒ **B** hydrogen

☒ **C** nitrogen

☒ **D** oxygen

(ii) Which group does P represent?

(1)

☒ **A** CH_2OH

☒ **B** CH_3

☒ **C** COOH

☒ **D** OH

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(b) PET, MRI and fMRI are methods for scanning the brain.

PET uses labelled glucose. This glucose can be detected so that PET can be used to identify brain tumours.

(i) Describe the advantages of using PET and fMRI rather than MRI scans to investigate a possible tumour in the brain.

(2)

(ii) The images show brain scans produced from two imaging techniques other than PET.



Image 1

(Source: ZEPHYR/SCIENCE PHOTO LIBRARY)

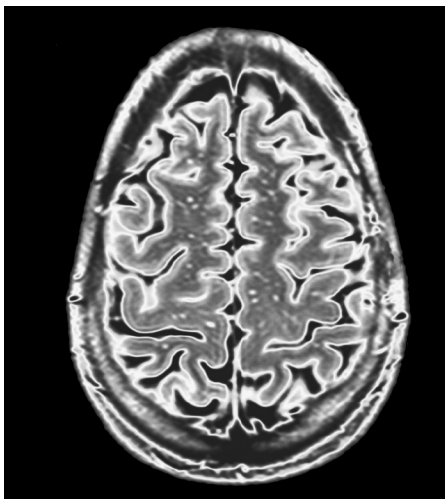


Image 2

(Source: ALFRED PASIEKA/SCIENCE PHOTO LIBRARY)

State how image 1 can be identified as being produced by CT and image 2 by MRI.

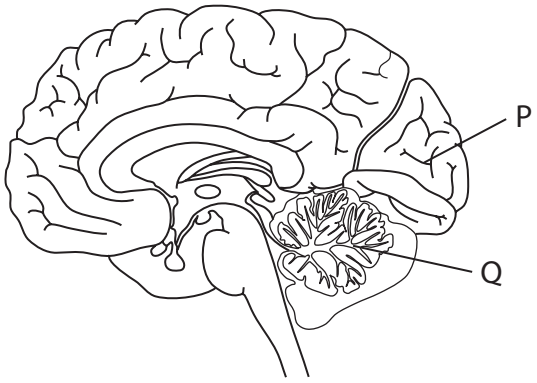
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(c) The diagram shows a human brain.



Brain tumours can change brain function.
Describe the possible effects of brain tumours in parts P and Q.

(2)

P .....

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Q .....

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(Total for Question 1 = 7 marks)

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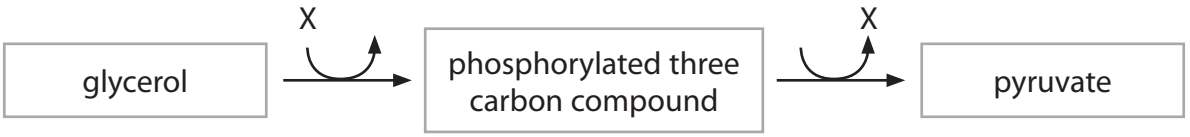
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2 A range of organic molecules can be synthesised in metabolic reactions in mammals. These organic molecules include pyruvate, lactate and vitamin C.

(a) In human liver cells, glycerol can be converted to pyruvate. This conversion involves glycolysis as shown in the diagram.



Which of the following is molecule X?

(1)

- ☒ **A** adenosine diphosphate (ADP)
- ☒ **B** adenosine triphosphate (ATP)
- ☒ **C** nicotinamide adenine dinucleotide (NAD)
- ☒ **D** reduced nicotinamide adenine dinucleotide (NADH + H^+)

(b) Explain why human muscle cells sometimes convert pyruvate to lactate.

(4)

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(c) Many mammals such as cows can synthesise vitamin C from glucose in the liver.

Vitamin C solutions can be prepared from fresh or frozen cow liver.

Devise an investigation to compare the vitamin C content of these solutions.

(4)

(Total for Question 2 = 9 marks)

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3 In 2021, there was an accident at a nuclear power station in Spain. There was no radiation leak but carbon dioxide was released.

Some people were taken to hospital showing symptoms of carbon dioxide poisoning after inhaling carbon dioxide.

Their symptoms included rapid breathing and an increased heart rate.

(a) (i) Explain why rapid breathing is a symptom of carbon dioxide poisoning.

(4)

(ii) A person's breathing rate can be calculated from a spirometer trace.

Which of the following calculations would give the rate of breathing as breaths per minute?

(1)

☒ **A** number of peaks on the trace in 10 seconds divided by 60

☒ **B** number of troughs on the trace in 15 seconds divided by 0.25

☒ **C** tidal volume multiplied by 60

☒ **D** tidal volume multiplied by number of peaks per second

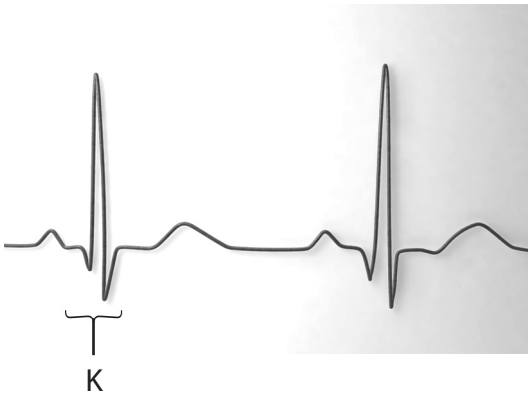
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(b) Electrocardiograms (ECGs) were also recorded for the people with carbon dioxide poisoning.

The diagram shows part of an ECG.



(Source: KATERYNA KON/SCIENCE PHOTO LIBRARY)

Explain the role of the atrioventricular node (AVN) in the events happening at K on the ECG.

(3)

(c) Radiation has leaked from accidents at other nuclear power stations. This has led to mutations in the developing embryos of pregnant women.

Prenatal genetic screening can be offered to check for certain mutations.

Give a reason why some pregnant women may choose chorionic villus sampling rather than amniocentesis.

(1)

(Total for Question 3 = 9 marks)

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4 Mutations are rare changes in the sequence of bases in DNA.

(a) Each body cell contains 6 billion base pairs.

The mutation rate for human cells has been estimated to be 2.5×10^{-8} mutations per base pair per cell cycle.

Calculate how many mutations could happen per body cell in one cell cycle.

(1)

Answer .....

(b) Some mutations affect the phenotype of the organism.

(i) The DNA template strand is involved in the synthesis of mRNA.

The anticodons of the first four tRNA molecules that carry amino acids into a ribosome are shown.

UAC GGA UCG AAC

Determine why the sequence of bases in these anticodons is 83% the same as the sequence of bases on the DNA template strand.

(2)

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(ii) Explain why a change in the DNA sequence can change the phenotype of an organism.

(3)

(c) Mutations can affect the metabolism of glycogen in fast twitch muscle fibres.

Explain why fast twitch muscle fibres contain more glycogen than slow twitch muscle fibres.

(3)

(Total for Question 4 = 9 marks)

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5 The resting heart rate varies between individuals for a variety of reasons.

(a) An adult male had a resting heart rate of 90 beats per minute. The systole stage was found to be 30% of his cardiac cycle.

Calculate the length of time for a single systole stage for this person.

(2)

..... seconds

(b) Some people with high blood pressure have a 100% increased risk of developing CVD.

(i) State what is meant by a 100% increased risk.

(1)

.....

.....

(ii) This person could be treated with antihypertensives.

Give **two** risks of this treatment.

(2)

1 .....

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2 .....

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(iii) Explain how antihypertensives can reduce the risk of developing CVD.

(4)

(Total for Question 5 = 9 marks)

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6 In 2018, there were 7340 non-identical twins born in the UK. Each set of twins was the outcome of two egg cells each fertilised by a different sperm cell.

(a) Which of the following shows the probability of a pair of non-identical twins being the same sex?

(1)

- ☒ **A** 0.00
- ☒ **B** 0.25
- ☒ **C** 0.50
- ☒ **D** 1.00

(b) Explain how a sperm cell is adapted for its role in fertilisation.

(3)

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(c) At fertilisation, a zygote is formed. The zygote is a totipotent cell. The zygote then divides repeatedly to form an embryo. There are pluripotent cells in a five-day-old embryo.

(i) Describe the differences between pluripotent stem cells and totipotent stem cells.

(3)

(ii) Stem cells divide by mitosis.

Describe the role of centromeres in mitosis.

(3)

(Total for Question 6 = 10 marks)

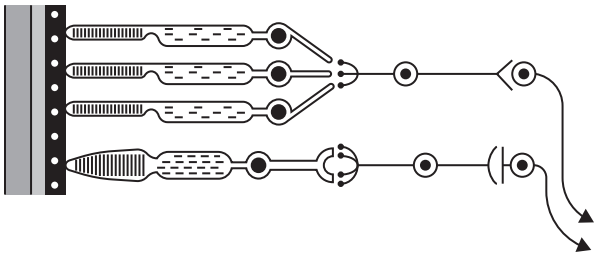
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7 The human retina contains rod cells and three types of colour sensitive cell. This allows full colour vision. However, there are many inherited conditions that can affect these cells.

(a) The diagram shows a section through a typical human retina.



State why the retina can be described as a tissue.

(2)

.....

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(b) One recessive genetic condition affecting the eye is fundus albipunctatus.

In this condition the speed of rhodopsin formation in rod cells is reduced after exposure to bright light.

(i) Describe the process of rhodopsin formation in rod cells after exposure to bright light.

(2)

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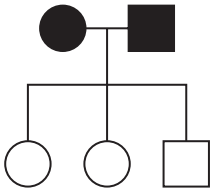
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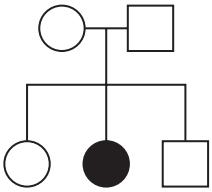
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(ii) The diagram shows three family pedigrees. Each pedigree shows the inheritance of a different genetic condition. Only one of the pedigree diagrams definitely shows that fundus albipunctatus is inherited as a recessive condition.

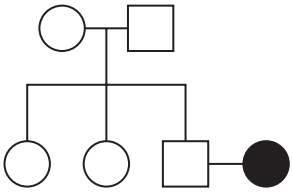
Pedigree 1



Pedigree 2



Pedigree 3



Key
a shaded shape shows the person has the condition

Explain which family pedigree shows the inheritance of fundus albipunctatus.

(2)

(c) Each type of colour sensitive cell in the retina contains a different pigment. One pigment is sensitive to blue light, one to green light and one to red light.

The gene for blue pigment is on chromosome 7. The genes for red and green pigment are located on the X chromosome.

(i) Give a reason why the genes for red and green pigment are not present on the Y chromosome.

(1)

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(ii) Some people do not have full colour vision and are described as being colour blind. Colour blindness is a recessive condition.

An investigation was carried out to discover the number of male and female people who are colour blind, in a sample of the UK population.

It was found that 4.5% of the sample were colour blind as shown in the table.

Type of colour blindness	Number of females	Number of males
Blue	1	2
Green	10	91
Red	2	25

The percentage of males in the whole sample was 55%.

Calculate the number of males in the whole sample who have full colour vision.

(3)

Answer .....

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(iii) Deduce how colour blindness is inherited.

(4)

(Total for Question 7 = 14 marks)

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8 Phytochromes are photosensitive pigments in plants that absorb light.

(a) A phytochrome consists of a protein bonded to a non-protein molecule.

(i) Which of the following is the location for the synthesis of protein in a cell?

(1)

☒ **A** centrioles

☒ **B** Golgi apparatus

☒ **C** lysosomes

☒ **D** rough endoplasmic reticulum

(ii) Which of the following is the location where carbohydrate can be added to a protein molecule in a eukaryotic cell?

(1)

☒ **A** cytoplasm

☒ **B** Golgi apparatus

☒ **C** lysosome

☒ **D** smooth endoplasmic reticulum

(iii) Which of the following describes a peptide bond?

(1)

☒ **A** bond between a carbon atom on one amino acid and a carbon atom on another amino acid

☒ **B** bond between a nitrogen atom on one amino acid and a carbon atom on another amino acid

☒ **C** bond between a nitrogen atom on one amino acid and an oxygen atom on another amino acid

☒ **D** bond between an oxygen atom on one amino acid and a carbon atom on another amino acid

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(b) The non-protein part of phytochrome is a light absorbing pigment.

Light of a suitable wavelength and duration can stimulate plant growth.

(i) What happens to phytochrome in the dark?

(1)

		Converted	To phytochrome
☒	**A**	Rapidly	far red
☒	**B**	Rapidly	red
☒	**C**	Slowly	far red
☒	**D**	Slowly	red

(ii) Explain how the response of phytochrome to a light stimulus can cause an increase in plant growth.

(3)

(Total for Question 8 = 7 marks)

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9 Many organisms that live in the sea produce poisonous chemicals called neurotoxins.

(a) Pufferfish produce a neurotoxin called tetrodotoxin (TTX). This is believed to be a defence against predators.

An investigation studied TTX from five individuals of the same species of pufferfish.

(i) The investigation showed that the distribution of TTX within the pufferfish varies, as shown in the table.

Tissue	Mean concentration of TTX / mass per gram of tissue
Liver	0.046 mg
Muscle	2.000 µg
Gonad (ovary/testis)	0.365 mg
Skin	25.000 µg

Calculate the percentage difference in mean concentration of TTX in pufferfish liver tissue compared with skin tissue.

(2)

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(ii) The investigation also tested the toxicity of the different tissues from each of the five pufferfish.

The level of toxicity was tested in mice, and the results are shown in the table.

	Level of toxicity per gram of pufferfish tissue / arbitrary units			
Sex of fish	**Liver**	**Muscle**	**Gonad**	**Skin**
Female	126	4	398	18
Female	239	6	485	17
Female	112	4	350	16
Male	4	3	3	15
Male	4	3	4	17

Some humans eat pufferfish.

Describe why mice were used to determine the level of toxicity.

(3)

(iii) Deduce the effect of the sex of the pufferfish on the level of toxicity for different pufferfish tissues.

(2)

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*(b) *Conus* is a predatory marine snail. It uses a neurotoxin, conotoxin, to paralyse the muscles of its prey.

The neurotoxins conotoxin and TTX work in different ways:

- Conotoxin inhibits calcium ion movement across the cell surface membrane
- TTX inhibits sodium ion movement across the cell surface membranes

Discuss how the investigations support the potential use of neurotoxins as painkillers and treatments for uncontrolled muscle movement in humans.

(6)

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(Total for Question 9 = 13 marks)

10 Environmental conditions such as temperature can affect the performance of athletes. Some countries are concerned about the impact of this in major competitions.

An investigation studied the effect of temperature on athletes before the Tokyo Olympics in the summer of 2021.

The athletes were grouped based upon the type of sport they competed in. Various details were collected as shown in the table.

Group based on type of sport	Total number of athletes	Number of male athletes	Mean age / years
Endurance (e.g. cycling)	27	12	25
Mix-trained (e.g. hockey)	31	22	27

(a) Which of the following shows the ratio, in its simplest form, of female to male athletes in this investigation?

(1)

☒ **A** 0.7 : 1

☒ **B** 1 : $1\frac{2}{5}$

☒ **C** 1.4 : 1

☒ **D** 12 : 17

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(b) At the start of the investigation, each athlete swallowed a small digital thermometer so their core body temperature could be measured. A mean core temperature was calculated.

The athletes carried out warm-up activities for 20 minutes in a chamber set at 16 °C.

After warming up, each athlete exercised. The intensity of the exercise was increased at three-minute intervals. Each athlete exercised until they were unable to continue.

The change in body mass of each athlete during the warm-up activities and the exercise was recorded. The mean change in mass was calculated and used as a measure of the sweat produced.

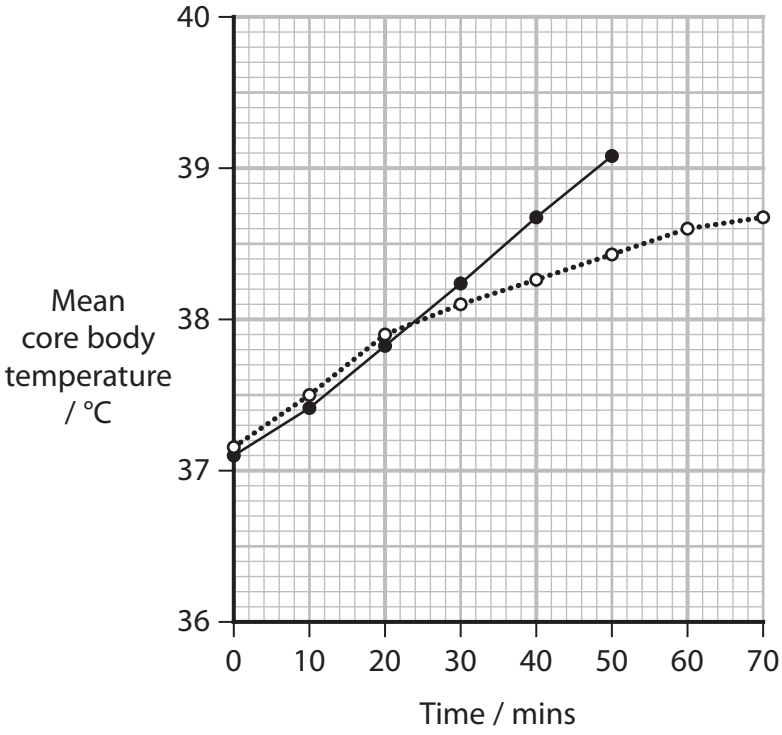
The warm-up and exercise were repeated at a temperature of 32 °C.

(i) Explain why the athletes were not allowed to eat or drink during this investigation.

(3)

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(ii) The graph shows the effect of the warm-up activities (from 0–20 minutes) and exercise (from 20 minutes) on mean core body temperature.



Explain the effect of environmental temperature on core body temperature during warm-up activities followed by exercise.

(3)

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*(iii) The mean performance of the athletes was measured during the exercise as:

- mean length of time of exercise
- mean maximum power output
- mean rate of sweating.

The table shows the mean performance for the two types of sport.

	Mean length of exercise / min		Mean maximum power output / a.u.		Mean rate of sweating / kg hour^{-1}	
Type of sport	**at 16 °C**	**at 32 °C**	**at 16 °C**	**at 32 °C**	**at 16 °C**	**at 32 °C**
Endurance	64	47	4.4	3.7	0.9	1.6
Mix-trained	57	40	3.0	2.5	0.9	1.7

The results of this investigation were used to suggest that training programmes should take into account different environmental conditions.

Evaluate the evidence to suggest that this would benefit the performance of athletes when competing in different environmental conditions.

(6)

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