

**T Level Technical Qualification in Healthcare Science
(603/7083/X)**

Core knowledge and understanding Paper B Elements 11–12

Paper number: **P001963**Time allowed: **2 hours 30 minutes**Assessment date: **Wednesday 21 June 2023**Time: **9:00am – 11:30am****Student instructions**

- Use black or blue ink.
- Fill in the boxes at the bottom of this page.
- Answer **all** questions.
- Read each question carefully.
- You **must** write your responses in the spaces provided.
There may be more space than you need.
- You may do rough work in this answer book. Cross through any work you do not wish to be marked.

Student information

- The marks available for each question are shown in brackets. This is to help you decide how long to spend on each question.
- The maximum mark for this paper is 112.
- In questions **7, 14, 18** and **19** you will be assessed on your quality of written communication (QWC) and use of specialist terminology. Specifically, your ability to:
 - use good English
 - express and organise ideas clearly and logically
 - use appropriate technical terms.
- In questions **3, 9, 12, 16** and **17** you will be assessed on your mathematical ability.
- You may use a calculator.

Do not turn over until the invigilator tells you to do so.**Please complete / check your details below**

Student Name:

Provider Name:

Student Number:

Provider Number:



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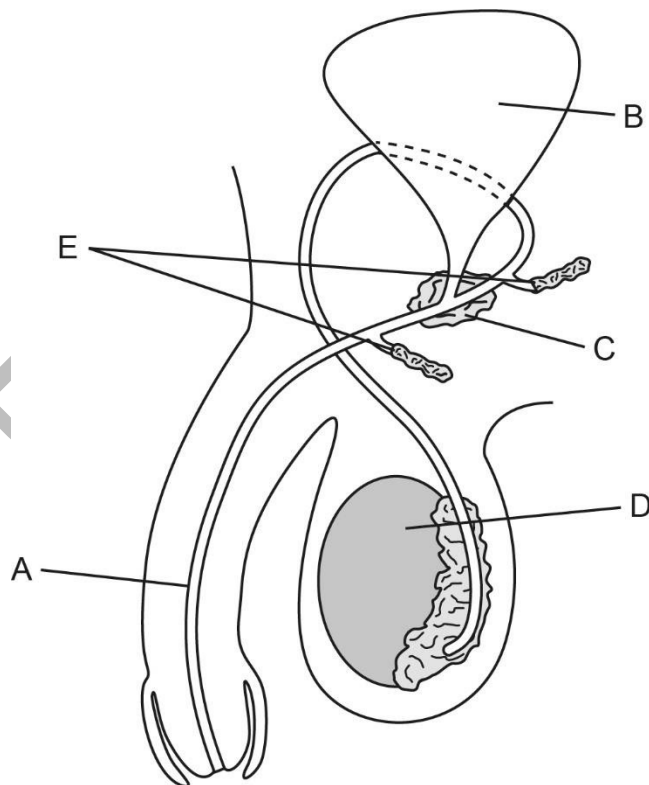
P001963

Section A: Biology

This section is worth 45 marks, plus 3 marks for quality of written communication (QWC) and use of specialist terminology.

Answer **all** questions in the spaces provided.

- 1 **Figure 1:** diagram of the human male reproductive organs



- (a) Identify structures A, C and E shown in **Figure 1**.

[3 marks]



- (b) Drinking alcohol reduces production of antidiuretic hormone (ADH). Name the structure **labelled B** in **Figure 1** and describe what effect a reduction in ADH would have on this structure.

[2 marks]

- (c) **Structure D** needs to be at a temperature slightly below body temperature to function.

Explain **one** possible consequence if the temperature of **structure D** was maintained at body temperature.

[2 marks]

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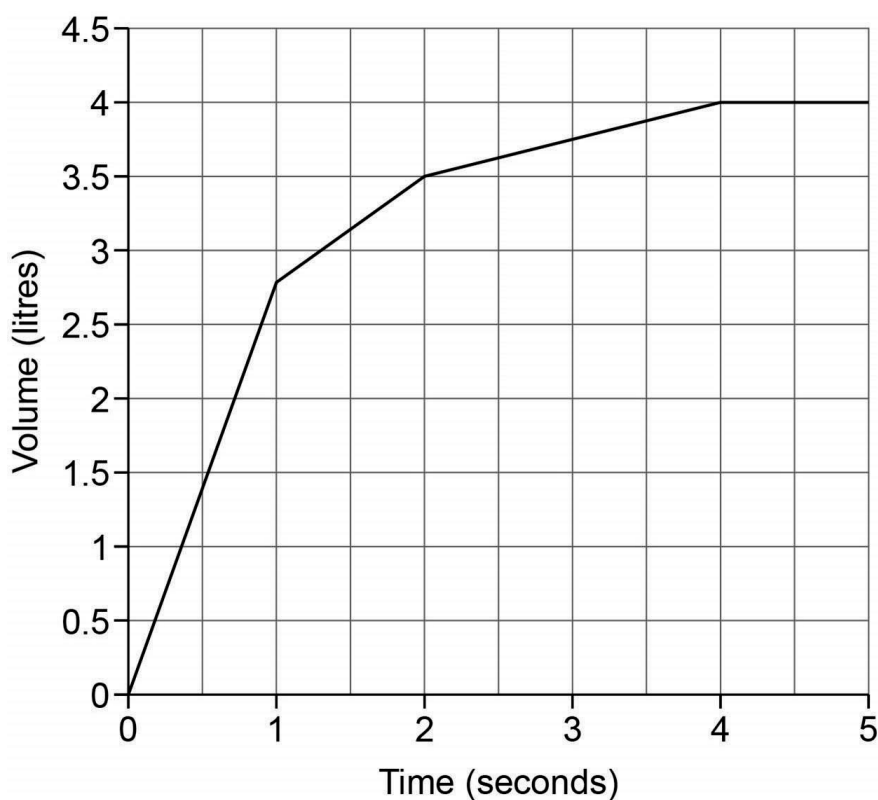
2 Figure 2: volume of expired air against time

Figure 2 represents a spirometer reading from an adult, who has exhaled fully after taking a maximum breath.

- (a)** Give the period of time in which exhalation rate was maximum.

[1 mark]

- (b)** Describe **two** differences you would expect to see for a plot line in **2(a)** if the same adult developed Chronic Obstructive Pulmonary Disease (COPD).

[2 marks]



- (c) A student stated that 'the plot shown in **Figure 2** must represent a female as the plot for a male would have a higher final volume'.

Evaluate the validity of the student's statement, providing conclusions.

[3 marks]

- 3 The average maximum heart rate for a healthy 20 year old male is 200 beats per minute (bpm).

The average maximum heart rate for a healthy 30 year old male is 190 bpm, a reduction of 10 bpm.

Using the information above, calculate the percentage reduction in average maximum heart rate from the age of 20 to the age of 30.

Show your working.

[2 marks]



4 Virus X is a newly emerging pathogen (disease causing organism), **three** of its features are described below:

- found in significant quantities in the blood and sexual fluids of infected individuals
- degrades rapidly when outside the body, if not in blood or sexual fluids
- degrades rapidly when exposed to the secretions of the digestive system.

(i) Give **three** ways in which it may be transmitted from person to person.

(ii) Justify your choices with reference to the features described.

[6 marks]

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5 **Table 1:** information about various diseases

Disease	Causative organism(s)	Inadequate sanitary condition associated with disease	Annual cases
Cholera	<i>Vibrio cholerae</i>	Contaminated food and water	1.3 – 4 million
Diarrhoea	Numerous species of bacteria and viruses	Contaminated food and water	1.7 billion
Typhoid	<i>Salmonella typhi</i>	Contaminated food and water	11 – 21 million
Malaria	<i>Plasmodium</i> species via Anopholes mosquito bite	Stagnant standing water acts as a breeding ground for mosquitos	229 million

Table 1 gives some details of the main cause of spread of **four** diseases in populations, the causative organism(s) and the approximate annual number of cases worldwide.

The vast majority of cases for each of these diseases are in the developing world.

Inadequate sanitary conditions are examples of factors which can contribute to disease spreading in a population.

(a) Identify **three** other factors.

[3 marks]



- (b) Define the term epidemiology.

[1 mark]

- (c) Name **one** influencing factor in the epidemiology of disease.

[1 mark]

- (d) Availability of toilets and safe disposal of sewage is often very low in countries with poor access to modern healthcare, unlike the UK.

Using the table in 5(a), to what extent would providing access to toilets with safe sewage disposal for all, significantly reduce incidence of these diseases.

[4 marks]



6 Investigations have shown that smoking can significantly reduce the effectiveness of mucociliary transport.

A student states that 'smokers are more likely to suffer from respiratory problems than non-smokers, as a result of this reduction in effectiveness'.

Using your knowledge of the mechanism and function of mucociliary transport, evaluate this statement.

Your response should include reasoned judgements and/or conclusions.

[6 marks]

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7 **Table 2** shows the maximum resolution of **three** different types of microscopes.

Type of microscope	Maximum resolution (nanometre (nm))
Light microscope	200
Scanning electron microscope (SEM)	1-20
Transmission electron microscope (TEM)	< 1

Resolution is the smallest distance between two points that can be seen as separate.

A virologist wishes to examine the detailed surface structure of a particular virus species, the average diameter of this virus is 220 nm; however, it can range from 150 nm to 250 nm.

Using your knowledge and understanding of the properties of different types of microscopes, and the information provided, discuss which type of microscope would be most suitable in this scenario.

Your response should include reasoned judgements and / or conclusions.

[9 marks, plus 3 marks for QWC]

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Section B: Physics

This section is worth 26 marks, plus 3 marks for quality of written communication (QWC) and use of specialist terminology.

Answer **all** questions in the spaces provided.

- 8** State the direction in which a transverse wave oscillates in relation to its direction of travel.

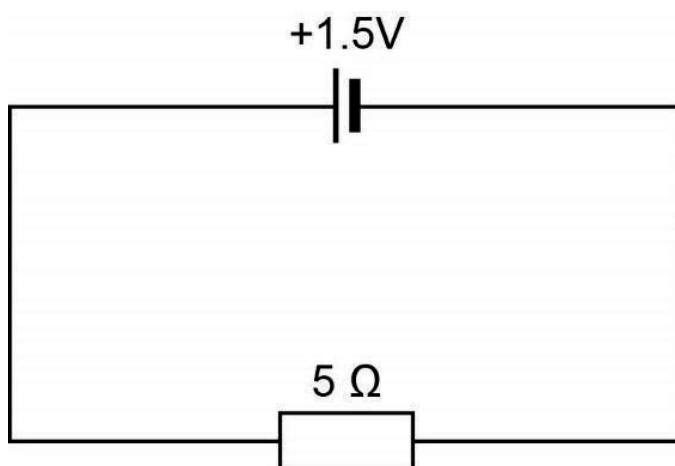
[1 mark]

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9 **Figure 3:** a series circuit

Study **Figure 3**. Calculate the charge that passes through the resistor over a 30 second period.

The following equations will help you:

$$I = V / R$$

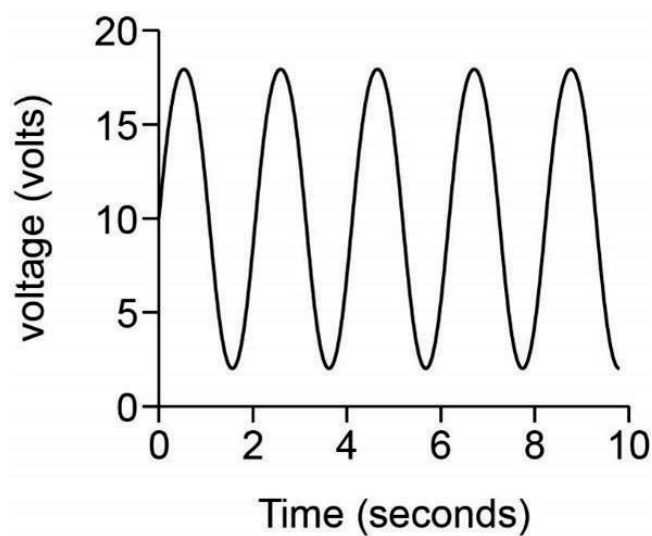
$$Q = It$$

Show your working and give units in your answer.

[4 marks]



10 **Figure 4:** voltage readings from a power source over a 10 second period



A scientist is investigating a power source, which is to be connected to an electric motor.

The voltage across the power source is recorded over a 10 second period and shown in **Figure 4**.

The scientist concludes that the power source will cause the motor to spin continuously and at a uniform speed. Therefore, it is an appropriate selection.

Using your knowledge of voltage, current and the motor effect, discuss this conclusion.

[3 marks]



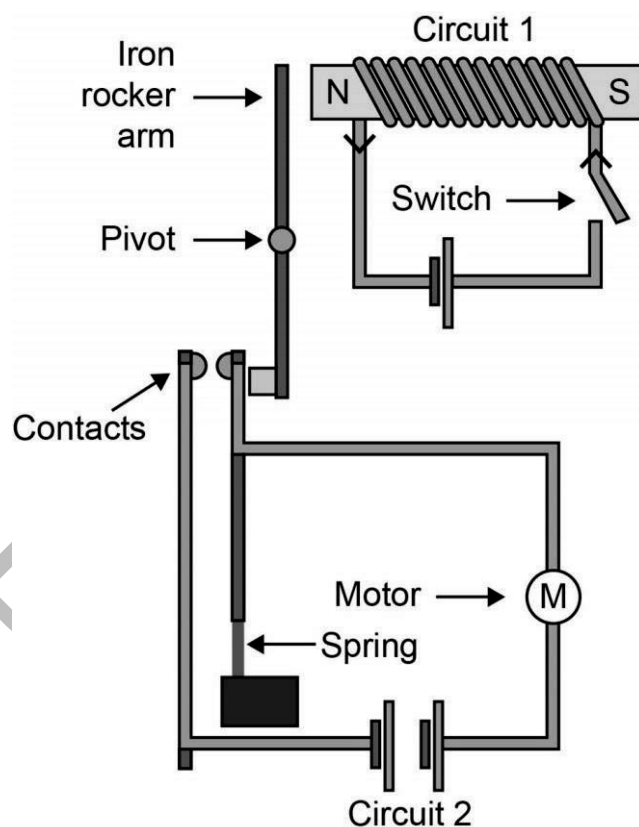
11(a) Name the areas of a bar magnet where the magnetic forces are strongest.

[1 mark]

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11(b) Figure 5: diagram showing an electrical relay in a circuit that drives a motor



Relays are small circuits containing electromagnets that are used to activate mechanical switches controlling larger circuits. A small circuit activates an electromagnet, which closes the switches (or contacts) to complete another larger circuit.

An example of a relay might be automatically switching a powerful fan off and on to keep a room at a constant temperature in a laboratory.

An electrician has been tasked with replacing the core in the electromagnet, the instructions say to use iron. This is because steel remains magnetic for a long period of time when the current is switched off whereas iron does not

- (i) Describe how wrapping an iron core in a coil of wire produces an electromagnet.

[1 mark]

- (ii) Explain why iron is more suitable than steel as a core in a relay.

[2 marks]



- 12 A gamma ray travels with a frequency of 6×10^{19} Hz.

The speed of light is $c = 3 \times 10^8$ m/s.

The equation for calculating wavelength is $v = f\lambda$.

Calculate the wavelength of this wave.

Show your working.

[2 marks]



- 13 A scientist is investigating the decay of Fermium-252 (^{252}Fm). 100 g of ^{252}Fm is placed on a weighing scale. The mass of the sample is recorded every 12 hours.

The radioactivity of the sample (in counts / minute) is also measured.

Figure 6: a graph to show radioactivity over a period of 96 hours

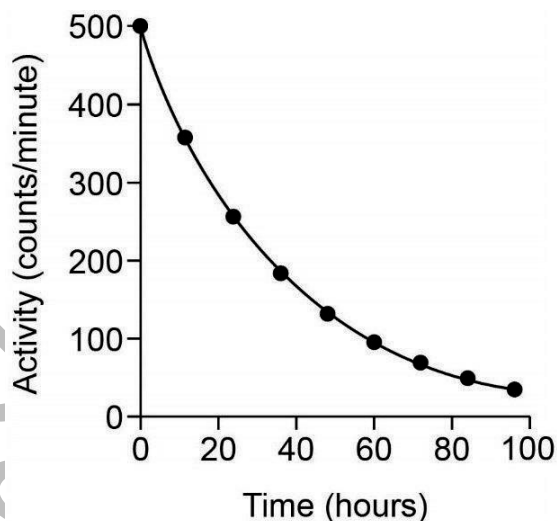


Table 3: a table to show changes in mass of a radioactive sample over a period of 96 hours

Time (hours)	0	12	24	36	48	60	72	84	96
Mass (g)	100	99.5	99.2	99.0	98.8	98.7	98.6	98.6	98.5

Based upon these observations (shown in **Figure 6**), the scientist concludes that ^{252}Fm decays via alpha emission, with a half-life of 24 hours.

Evaluate the accuracy of the scientist's conclusion.

[3 marks]



- 14 An engineer is designing a radio system for the emergency services in a major city.

Table 4 shows the radio wave frequencies that are available for this system.

The engineer recommends using high frequency (HF) waves, as they all travel at the same speed and the lower power is safer for the people that will be using the system.

Table 4: properties of different bands of radio waves that can be used in communication

Name Band	Power (W)	Wavelength Range (m)	Frequency Range (MHz)	Flat Open Terrain (miles)	Suburban Locations (miles)	Urban Areas (miles)	Inside Buildings (floors)
High Frequency (HF)	4	10 to 100	3 to 30	5 - 6	2½ - 4½	1 - 3	10 - 15
Very High Frequency (VHF)	5	1 to 10	30 to 300	4½ - 6	2 - 4	1½ - 2	10 - 15
Ultra High Frequency (UHF)	6	0.1 to 1	300 to 3000	4 - 6	2½ - 4½	1½ - 3	25 - 30

Using your knowledge of waves in communication, and the information above, evaluate the validity of this recommendation.

[9 marks, plus 3 marks for QWC]



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Section C: Chemistry

This section is worth 17 marks, plus 3 marks for quality of written communication (QWC) and use of specialist terminology.

Answer **all** questions in the spaces provided.

15 Polyethylene is a polymer, often used in pharmaceutical packaging.

(a) State **one** property of polyethylene which makes it a good packaging material. [1 mark]

(b) A team of scientists are developing a new material to transport sensitive pharmaceuticals. They are testing **three** different polymers. Their results are shown below:

Table 5: scientists' initial study on three potential materials

Polymer	Melting point (°C)	Density (grams per cubic centimetre (gcm ⁻³))
Polyethylene	115	0.88
Polyvinyl chloride	110	1.33
Polypropylene	130	0.95

The scientists are looking for a strong lightweight material to use.

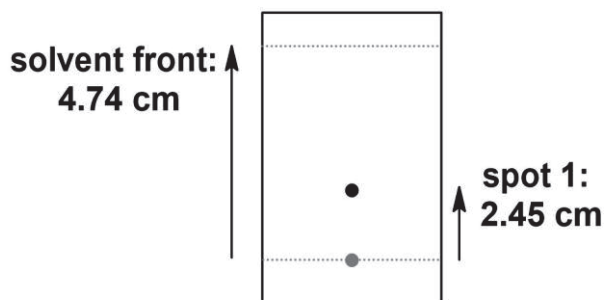
Based on this initial data, assess which polymer would be the most suitable to investigate further.

[3 marks]



- 16 A scientist is testing the purity of a pharmaceutical solution in the laboratory. After a TLC analysis they obtain the following chromatogram:

Figure 7: chromatogram of pharmaceutical solution



To identify specific compounds, scientists use R_f values which are calculated using the following equation:

$$R_f = \frac{\text{Distance travelled by spot}}{\text{Distance of solvent front}}$$

Calculate the R_f value associated with spot 1 in **Figure 7**. Give your answer to **two** decimal places.

Show your working.

[2 marks]



- 17 Yield is the percentage mass of a product produced in a reaction. It is calculated using the equation below:

$$\text{Percentage Yield (\%)} = \frac{\text{Amount synthesised}}{\text{Amount expected}} \times 100$$

Scientists are producing ibuprofen and have synthesised 2.76g from a reaction. The amount that the scientists expected to produce was 4.13g

Using this equation above, calculate the percentage yield.

Give your answer to **three** significant figures and show your working.

[2 marks]

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- 18** Scientists are developing a new pharmaceutical compound (R). As part of this development, they modify the pharmaceutical compound with **three** different chemical groups that vary in acidity (pH) and record the rate of reaction (k). Their results are displayed in the table below.

Table 6: pH and reaction rate data from the scientist's initial laboratory studies

Group (X)	pH	Reaction rate (<i>k</i>)
OH	11	0.67
SO ₄ H	2.75	1.67
SH	4.97	1.51

From these observations in **Table 6**, the scientists conclude that the pH of the group does not play a significant role in this reaction, as the rates between SO_4H and SH are similar compared to that of OH .

Using your knowledge of the pH scale and acidity, evaluate the scientists' conclusions.

Your answer should include reasoned judgements and / or conclusions.

[9 marks, plus 3 marks for QWC]

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Section D: Biology, Chemistry and Physics

This section is worth 12 marks, plus 3 marks for quality of written communication (QWC) and use of specialist terminology.

Answer **all** questions in the spaces provided.

- 19** A patient with a family history of bowel cancer is admitted to hospital with sudden onset bowel pains. An ultrasound scan shows a possible 'mass' in the large intestine.

Based on family history, a practitioner observing the scan states:

‘The mass is likely to be a cancerous tumour and therefore the next step should be to use radioactive tracers. During this process the most important factors to consider are:

- the radioactive tracers have a short half-life
- the radioactive tracers emit gamma radiation, rather than alpha or beta, as gamma radiation is low ionising
- the radioactive tracers should easily be taken up by the tumour cells'.

Evaluate the practitioner's statement, including reasoned judgements and conclusions.

[12 marks, plus 3 marks for QWC]

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To be completed by the examiner			
Question	Mark	Question	Mark
1 (a)		8	
1 (b)		9	
1 (c)		10	
2(a)		11 (a)	
2 (b)		11 (b)	
2 (c)		12	
3		13	
4		14	
5 (a)		15 (a)	
5 (b)		15 (b)	
5 (c)		16	
5 (d)		17	
6		18	
7		19	
		TOTAL MARK	

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