



OUNDLE
School

EXAMINATION PAPER
13+ Academic Scholarship 2023

Science (Paper 2)

Time allowed: 1 hour

Name: _____

Instructions

- Write your name clearly in the space above.
- Answer in this paper.
- Calculators are allowed.
- Answer ALL the questions in all sections. Each section carries the same number of marks.
- You are expected to write clearly and accurately throughout each of your answers. You should leave some time towards the end of the examination to check your work carefully.
- The maximum number of marks for this paper is 60.

SECTION ONE: BIOLOGY [19 Marks]

Comprehension Exercise

1. The following question is about inheritance. You may not know the answers but you will be able to interpret the information and offer sensible responses.

Mammals inherit their characteristics from their parents. Characteristics are controlled by genes. Genes are encoded (carried) in the DNA of the nucleus. Every cell of an individual contains the same set of genes. A single set of genes is inherited from each parent. This means that mammals contain two copies of each gene in their nuclei. The way these genes interact generates an individual's unique characteristics. For example, we may be able to roll our tongue because we have inherited the gene for 'tongue-rolling' from both our parents. Some genes come in different versions. Just like a shirt can be long-sleeved or short-sleeved, the gene for chin shape may be 'dimpled' or 'not-dimpled'. One version of the gene is said to be **dominant** if it hides the other version of the gene; the hidden version is called **recessive**. Eye lash length is a gene that comes in two forms: **long** is dominant over **short**. Biologists use letters to represent a gene. A capital letter represents the dominant version.

Two parents with long eye-lashes produce four children.

- a. Complete the table – one has been done for you.

Parents	Long Eye Lash	Long Eye Lash
Genes	Ll	Ll
Gametes	L and l	L and l

Gametes	L	l
L	1 =	2 = Ll
l	3 =	4 =

[2 marks]

- b. What type of eye lash do the four off-spring have? Complete the table.

	Type of eyelash length
Children 1	
Children 2	
Children 3	
Children 4	

[4 marks]

- c. Child **number 2 (L1)** went on to have children with a person with **short** eye lashes. Use the table below to calculate the probability of their children have **SHORT** eye lashes. (Table 2)

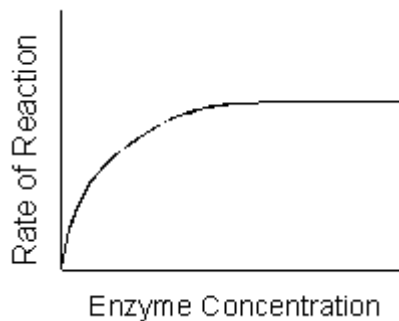
	Parent number 2 gametes	
Short eye lash parent gametes		

Answer – the probability of having short eye lashes is:.....

[2 marks]

2. Enzymes are molecules found in all cells. They speed up chemical reactions but are left unaffected by the reaction – they are sometimes known as *biological catalysts*. In order to work, they must collide with their target molecule or molecules as well as have a specific shape so all the molecules fit together. All molecules have energy which allows them to move by diffusion. As they get warmer, they gain more energy and move more quickly. As molecules move more quickly, they are more likely to collide. As they get warmer, enzymes also move more quickly but at very high temperatures they lose their shape and stop working.

Look at the graphs and answer the questions.



Graph 1

- a. Describe the shape of the curve in graph 1.

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.....

[2 marks]

b. Suggest an explanation for the first part of the line.

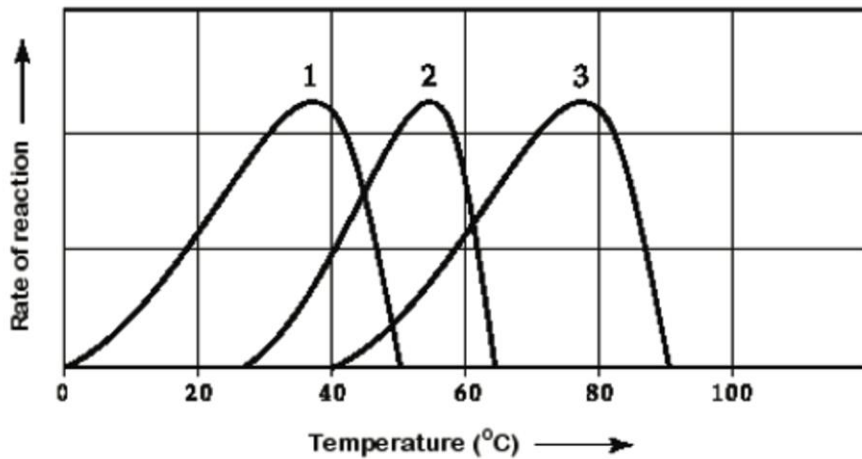
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[2 marks]



Graph 2

c. Looking at Graph 2 describe the shape of **line 1**.

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.....

.....

[2 marks]

d. Looking at graph 2 suggest an explanation for the shape of **line 1**.

.....

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.....

.....

[2 marks]

e. Looking at graph 2 which line (1, 2 or 3) is likely to be a mammalian enzyme?

.....
.....

[1 mark]

i. Why do you think this?

.....
.....

[1 mark]

f. Looking at graph 2 which line (1, 2 or 3) is likely to be found in an organism living in a hot spring?

.....
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[1 mark]

i. Why do you think this?

.....
.....

[1 mark]

SECTION TWO: CHEMISTRY [20 Marks]

There are many different types of fuels but currently, the most common are fossil fuels, made from the anaerobic decay of plant and animals over millions of years. Many of these fossil fuels are hydrocarbons. This means they are compounds made from only hydrogen and carbon atoms.

- a. Methane, ethane and propane are the three smallest hydrocarbons and these gases are generally used in gas ovens and camping stoves.

We can represent hydrocarbon compounds using different formulae:

Molecular formulae show the total number of atoms of each element in the compound

Structural formulae show the groups of atoms around each carbon atom in the compound

Displayed formulae show the atoms **and** chemical bonds between the atoms in the compound

- i. Use the information above to complete the table below:

Name	Molecular formula	Structural formula	Displayed formula
methane	CH ₄		$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$
ethane		CH ₃ CH ₃	
propane			$\begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{H} & -\text{C} & - & \text{C} & - & \text{C} & -\text{H} \\ & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & \end{array}$

[5 Marks]

- ii. There is one other type of formula called a skeletal formula. In these formulae, the carbon atoms are not drawn but are represented by the 'ends and the bends' of lines, all hydrogen atoms are assumed and not written either.

Example:

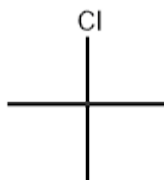
Propane can be represented by: 

Suggest **skeletal** formulae for the following compounds:

Compound	Structural formula	Skeletal formula
Butane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	
2-methylpropane	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$	

[4 Marks]

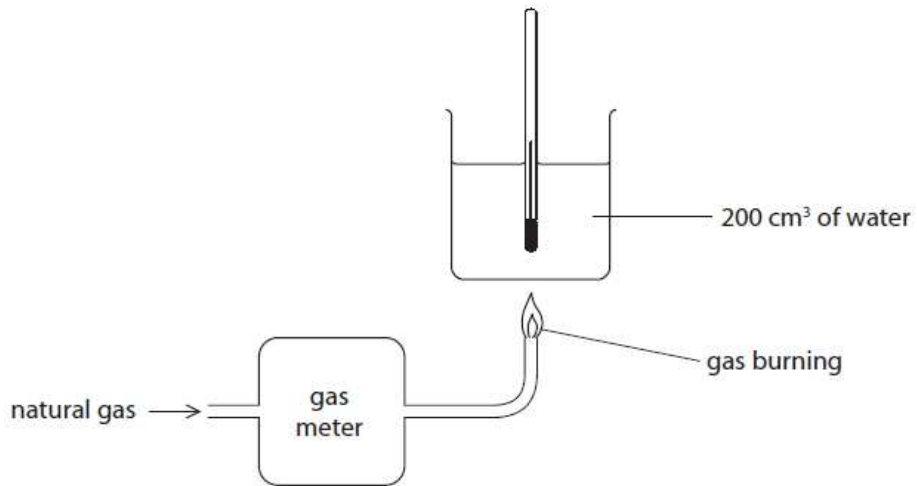
- iii. Based on the definitions for the types of formulae above, write the **molecular** formulae for:



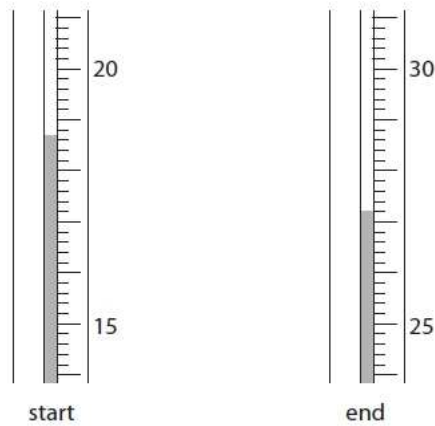
.....

[1 Mark]

- b. A student does some experiments to find the heat energy released when natural gas, methane burns. She uses this apparatus.



- i. The diagram shows the thermometer readings in one of her experiments.



Use these readings to complete the table, entering all values to the nearest 0.1 °C.

temperature of water at start in °C	
temperature of water at end in °C	
temperature change in °C	

[3 Marks]

- ii. Calculate the energy released by burning the methane gas in this experiment using the equation:

$$\text{Energy} = \text{mass of water (g)} \times \text{specific heat capacity of water (J/g/}^\circ\text{C)} \times \text{temperature change (}^\circ\text{C)}$$

where specific heat capacity of water = 4.2 J/g/°C

heat energy change = J

[3 Marks]

- iii. The energy released when a range of other fuels were burned was used to raise the temperature of 100 g of water. For each fuel, the student recorded the mass of fuel burned and the increase in temperature of the water.

Her results are shown in the table:

Fuel	Average relative formula mass	Mass of fuel burned in g	Amount of fuel burned in mol	Increase in temperature in °C
diesel	170	4	0.024	15
ethanol	46	3	0.065	10
methanol	32	2	0.063	5
petrol	114	1	0.009	4

The best fuel is the one that releases the most energy.

Look at the information given in the table and state which fuel is the best fuel per gram.

Justify your answer.

Best fuel per gram is

.....

.....

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[2 Marks]

- c. All of the fuels in this question are made or separated from crude oil, a fossil fuel.
Explain why it is important for us to look for new sources of power rather than
continue to burn fossil fuels.

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[2 Marks]

SECTION THREE: PHYSICS [20 Marks]

1. On the 12th July 2022 stunning images peering deep into space were released of a by NASA and ESA using the James Webb Space Telescope (JWST).



Figure 1: The Carina Nebula, as seen by Hubble (top) and James Webb (bottom). Credit NASA

This unprecedented resolution, shown in the bottom image, is owed to the fact that JWST is about 100 times more sensitive than Hubble thanks to its much larger light-collecting mirror shown below.

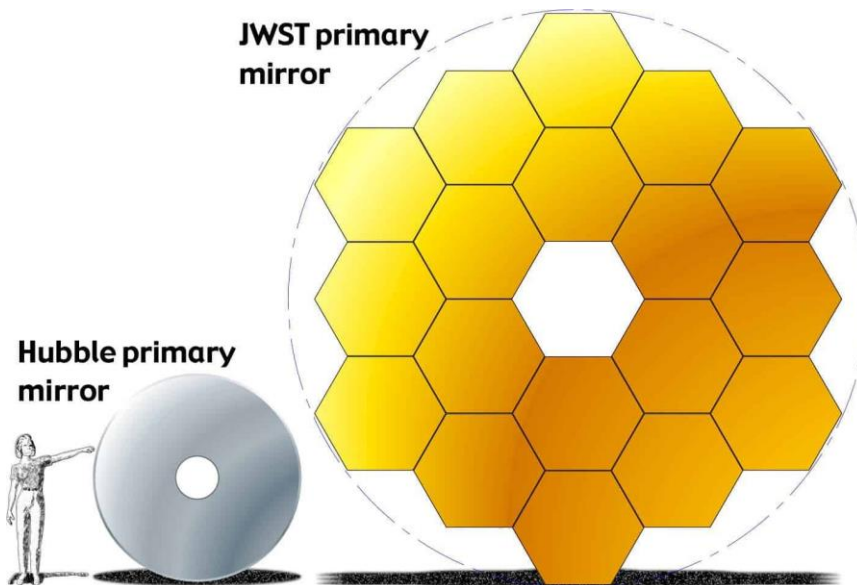


Figure 2: Webb's primary mirror has a diameter of 6.5 meters, compared to Hubble's much smaller 2.4 meters in diameter. Credit: NASA.

Unlike the famous Hubble Space Telescope, JWST is orbiting the sun approximately 1.5 million kilometres away from the Earth. It took JWST approximately 30 days to reach this point in space.

- a. Calculate the average speed of JWST in kilometres per hour

Answer: _____ km/hour
[2 Marks]

- b. Calculate the average speed of JWST in meters per second

Answer: _____ m/s
[2 Marks]

Frequency, wavelength and speed are three important properties of the electromagnetic waves that JWST uses to communicate (send back picture and data) with us back on Earth . They are related by the following equation:

$$\text{Wave Speed (in metres per second)} = \text{Frequency (in Hertz)} \times \text{Wavelength (in metres)}$$

Signals from Earth to JWST are broadcast at a frequency of 2.0×10^9 Hertz. Electromagnetic waves travel at 3.0×10^8 m/s.

- c. Calculate the wavelength of the radio wave signals that travel from Earth to the JWST - express your answer in metres.

Answer: _____ m
[2 Marks]

The amount of light collected by a telescope depends on the **area** of the telescope's mirror.

$$Area = \pi \times (radius^2)$$

Calculate the area of both the Hubble's mirror and the JWST mirror (please consider the JWST mirror as a circle).

- d. Calculate the area of the Hubble's mirror (give your answer to 2 significant figures)

Area: _____ m²
[2 Marks]

- e. Calculate the area of JWST mirror (consider the JWST mirror as a circle).

Area: _____ m²
[1 Mark]

- f. If the Hubble space telescope collects light from a distant galaxy, 36 photons are collected in the telescopes mirror per second. How many photons per second would the JWST mirror collect per second?

photons per second = _____
[2 Marks]

[Total 11 marks]

2. Whilst watching the commonwealth games Alice wanted to know how **long** (time) a high diver has to perform all their flips and spins before hitting the water when competing in the 10 meter high dive competition.

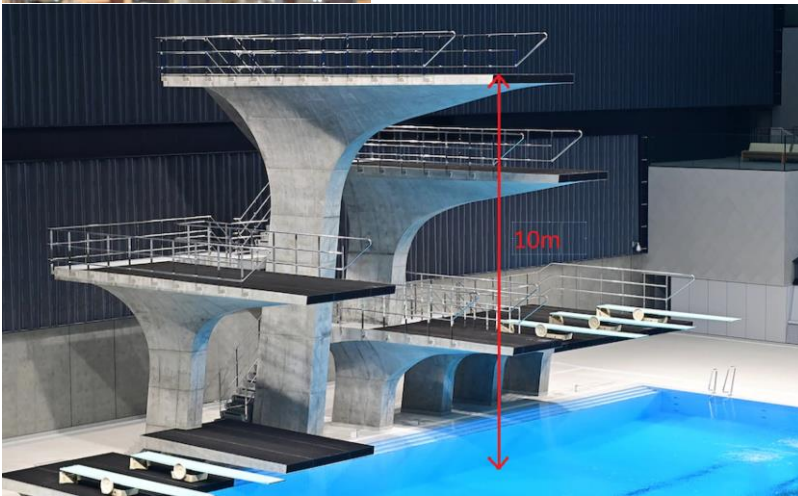


Figure 3: Divers competing in the 10 meter platform diving competition.

a. Describe the motion of the divers after they leave the diving platform in as much detail as possible.

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.....
.....

[2 marks]

b. Describe the forces acting on them as they fall. Consider the size, direction and type of forces acting.

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.....
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[2 marks]

c. Describe the energy changes that take place as they fall towards the water.

.....
.....

[1 mark]

- d. Alice takes her question to school and asks her physics teacher for help with the calculation. Mr Roberts gives her the following formula to calculate the time to divers will be in the air before hitting the water.

$$H = \frac{1}{2} \times g \times (t^2)$$

where:

H is the hight from which they are falling

g is the acceleration due to gravity on Earth = 10m/s^2

t is the time it takes for the diver to hit the water

Using the information in the images in figure 3 calculate the time the divers have before hitting the water. Explain any assumptions you have made and show all your working below – there are many ways to get full marks in this question.

time = _____ s

[4 Marks]

[Total 9 marks]