Eton College King's Scholarship Examination 2016

SCIENCE 1

(60 minutes)

Candidate Number:_____

Remember to write your candidate number on every sheet in the space provided.

*You should attempt **ALL** the questions. Write your answers in the spaces provided.*

Allow yourself about 12 minutes for each question.

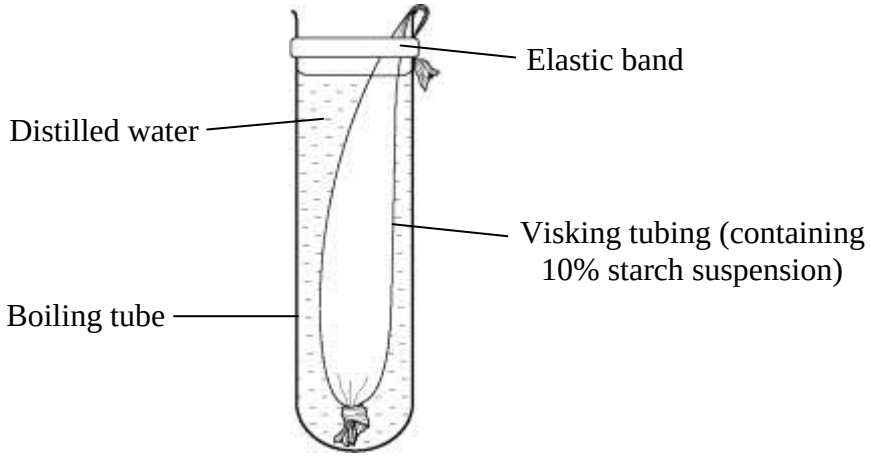
The maximum mark for each question or part of a question is shown in square brackets.

Calculators are allowed. In questions involving calculations, all your working must be shown.

For examiners' use only.

1	2	3	4	5	TOTAL

1. A student set up some apparatus as shown in the diagram below. He lowered some Visking tubing containing a 10% starch suspension into a boiling tube which he then filled with distilled water. Next, he placed the apparatus in a water bath at 30°C, and after waiting for 5 minutes he added a solution of an enzyme which digests starch to the contents of the Visking tubing. He secured the tubing in place with an elastic band and started a stopwatch.



a) Name an enzyme which digests starch. [1]

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b) Describe the test (including the expected result) the student could perform to prove that the contents of the Visking tubing contained starch at the start of the experiment. [2]

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c) Suggest why the student left the apparatus in the water bath for 5 minutes before adding the enzyme. [1]

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Like a cell membrane Visking tubing is semi-permeable, acting as a molecular sieve. This means that the size of a substance determines whether it can pass through or not.

After 20 minutes the student tested the contents of the Visking tubing and the boiling tube for the presence of starch and sugar. The table below shows his findings:

	Starch present?	**Sugar present?**
Contents of Visking tubing	Yes	Yes
Liquid surrounding Visking tubing	No	Yes

d) Explain the results for starch. [2]

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_____

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e) State the source of the sugar and explain why sugar is present in both the Visking tubing and the liquid surrounding it. [3]

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_____

The student then decided to measure the sugar concentration both inside and outside the Visking tubing.

f) Predict the relative concentrations of sugar inside and outside the Visking tubing and explain your reasoning. [3]

_____

_____

_____

_____

He then repeated the experiment at 80°C, keeping all other conditions the same.

g) Predict his findings using the blank table below and explain your reasoning beneath. [2]

	Starch present?	**Sugar present?**
Contents of Visking tubing		
Liquid surrounding Visking tubing		

_____

_____

_____

2. In the process of sexual reproduction in mammals, male and female gametes fuse together to form a zygote. The zygote then develops into a foetus inside the uterus of the female.

a) What is the biological term for fusion of gametes? [1]

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b) Name the male and female gametes produced by mammals, and give two differences between their structures. [3]

_____

_____

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c) A growing foetus requires various substances to develop successfully. Name two of these substances and explain how the foetus obtains them. [4]

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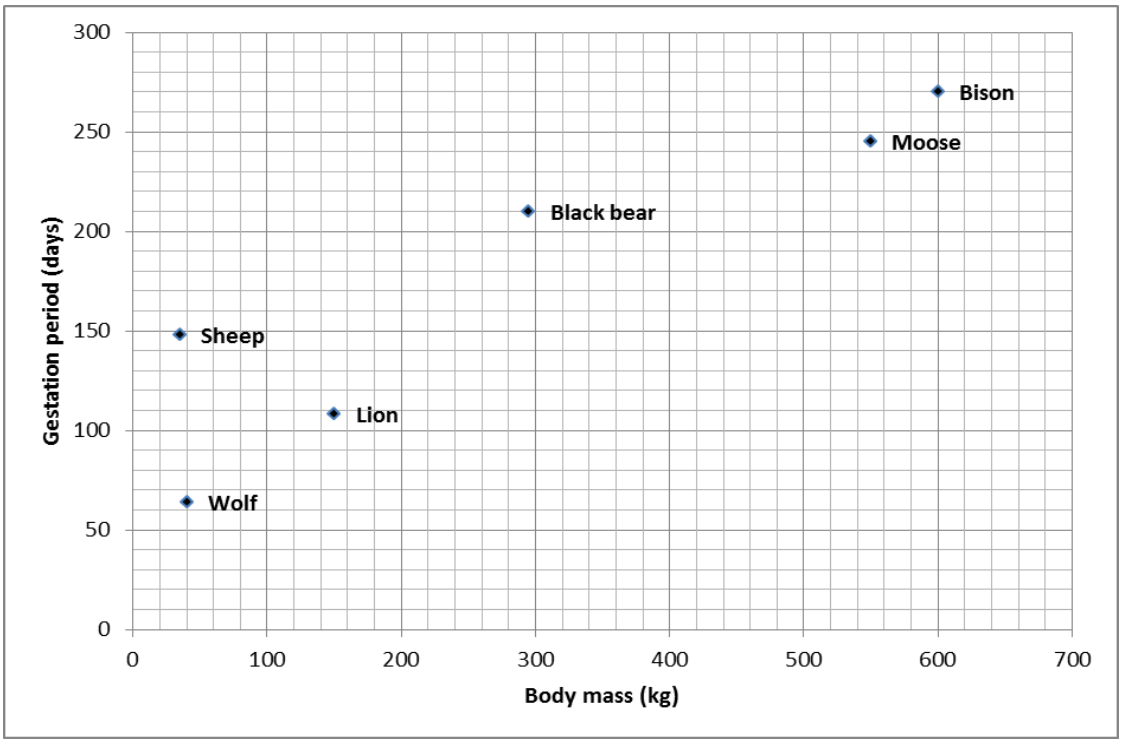
The graph below shows the relationship between body mass and gestation period (pregnancy length) for several species of mammal:



d) Describe the relationship between body mass and gestation period. [2]

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_____

e) Suggest two factors (other than body mass) that might affect the rate at which a mammalian foetus can develop. For each factor, explain how and why you think it might have an effect. [4]

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3. Michael Johnson's world-record time over 400 m is 43.2 s.

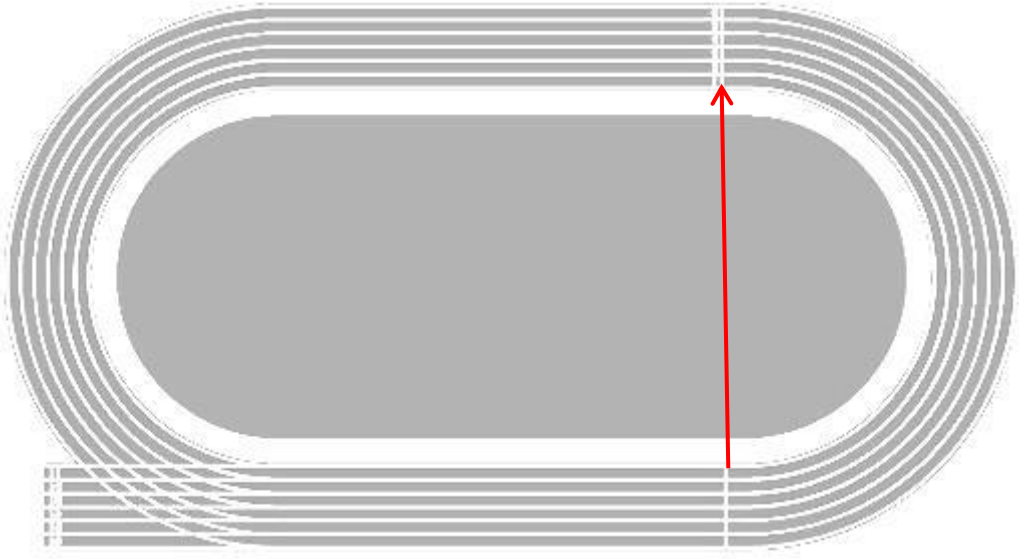
a) What is Michael Johnson's world-record average speed over 400 m? Include the correct unit with your answer. [2]

In physics the displacement of an object is represented by the straight line that joins its starting point to its current position. The size of the displacement is the 'as the crow flies' distance, rather than the actual distance travelled.

Assume that a 400 m run is broken down into four 100 m sections:

- 100 m along the circumference of a semi-circle;
- 100 m straight;
- Another 100 m along the circumference of a semi-circle;
- The final 100 m along a second straight, returning to the start.

Michael Johnson's displacement after running 100 m is represented with an arrow on the diagram below, where we have assumed the innermost lane is used.



b) What is the size of Michael Johnson's displacement after running 100 m? [2]

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c) Draw an arrow on the diagram to represent Michael Johnson's displacement after running 200 m. [1]

d) What is the size of Michael Johnson's displacement after running 200 m? [2]

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e) What is the size of Michael Johnson's displacement after running 400 m? [1]

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Usain Bolt's world-record time over 100 m is approximately 9.6 s.

f) Assuming that Bolt accelerates uniformly from rest over 2.0 s and then completes the rest of the race at a uniform speed, sketch a graph on the axes below to show how Usain Bolt's speed varies with time. Indicate appropriate values on the time axis. [3]

g) Calculate the value of the uniform speed that Usain Bolt reaches after 2.0 s. [3]

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4. The strength of gravity on Earth's surface is 10 N/kg. This means that a mass of 1 kg has a weight of 10 N.

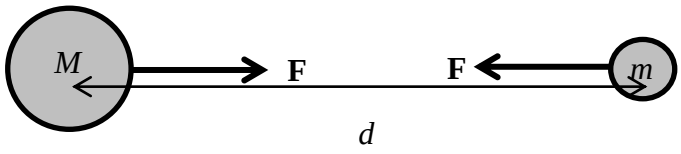
a) An apple has a mass of 0.30 kg. What is its weight? [1]

_____

Newton realised that the weight of an apple and the force on the Moon are two examples of the same universal force: any two masses, *M* and *m*, whose centres are a distance *d* apart, attract each other together with a force *F*, given by:

$$F = \frac{GMm}{d^2}$$

where G is a universal constant which has a value of 6.67×10^{-11} N m^2/kg^2.



b) How could Newton tell that the Moon has a force acting on it?

[2]

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_____

When the apple falls, the force between the apple and Earth causes the apple to accelerate.

c) What happens to Earth at the same time, and why don't we notice it? [2]

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d) Given that the distance from Earth's centre to its surface is 6.4×10^6 m, what value does Newton's equation give for the mass of the Earth? Show all of your working.

[4]

Another planet has the same density as Earth, but twice the radius.

e) What is the mass of the same apple on the surface of this planet?

[1]

f) What would the apple weigh on this planet? Show all of your working.

[4]

5. The table below shows the solubility of various substances in water and can be used to help answer the questions which follow.

Soluble	**Insoluble**
copper chloride	copper oxide
magnesium chloride	carbon
copper nitrate	zinc chloride
silver nitrate	silver chloride
magnesium sulphate	magnesium hydroxide

a) For each of the following mixtures describe how you could separate them in order to obtain a sample of pure gold, explaining in each case how your method works. You may use standard equipment that would be available in a basic school laboratory, as well as any of the following chemicals, if needed: *water; copper sulphate solution; hydrochloric acid; sodium hydroxide solution; zinc sulphate solution; sodium chloride solution.*

[N.B. You should assume that all of the substances in the mixtures have very high melting points and so it would not be possible to melt them using school laboratory equipment.]

i) Gold powder and sodium chloride powder [3]

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ii) Gold powder and charcoal (carbon) powder [3]

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iii) Gold powder and copper oxide powder [3]

b) Describe and explain how you could obtain a sample of pure copper from a mixture of copper powder and gold powder, using basic laboratory equipment and any of the following chemicals: *water; silver nitrate solution; magnesium nitrate solution; magnesium powder; hydrochloric acid.*

[N.B. Copper is too low in the reactivity series to react with dilute acids.]

[5]

[End of paper]