

Eton College King's Scholarship Examination 2019

SCIENCE 1 (Theory)

(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.

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

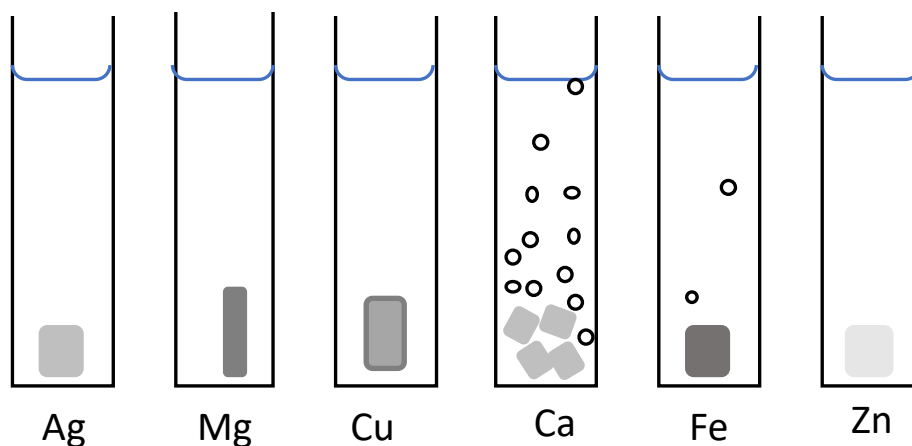
Calculators are allowed. In questions involving calculations, all your working must be shown.

For examiners' use only.

1	2	3	4	5	6	TOTAL [70]

Do not turn over until told to do so.

1. Samples of various metals were placed into the same volume (20 cm^3) of hydrochloric acid which had a concentration of 0.05 mol dm^{-3} . The diagram below was used to represent the difference in reactivity of the metals by showing the number of bubbles of hydrogen that were observed during the reaction. No bubbles were seen in the copper (Cu) or silver (Ag) tubes.



- (a) Complete the diagram to show the approximate number of bubbles you would expect to see in the magnesium (Mg) and Zinc (Zn) tubes. [1]

- (b) Write the word equation for the reaction of calcium (Ca) and hydrochloric acid. [1]

- (c) Describe a chemical test for the gaseous product from this reaction. [2]

- (d) Eventually, bubbles stopped being produced from the reaction between zinc and hydrochloric acid and some of the zinc remained in the test tube. Explain why the reaction stopped. [1]

(e) The same volume and concentration of acid was used in each tube, and the same amount of each metal. However, in the test tube containing calcium and hydrochloric acid, bubbles continued to be produced for much longer and a white solid appeared in the flask. Suggest a reason for this.

[1]

(f) It is not possible to determine which is more reactive out of copper and silver using this experiment as neither react with the acid. How could you determine which is more reactive using the following chemicals; silver, copper, silver nitrate solution and copper(II) nitrate solution.

[2]

2. There are many different types of fire extinguisher; some contain water, some contain powder and some contain carbon dioxide. It can be dangerous if you choose the wrong type of extinguisher for a particular fire. For example, you should never use a water-containing fire extinguisher on an electrical fire.

(a) Carbon dioxide is denser than air. Explain how this property enables carbon dioxide to be used to extinguish fires.

[1]

(b) Magnesium is a reactive metal and burns in air with a brilliant, bright white light. Explain what would happen if you used a carbon dioxide fire extinguisher in this instance.

[2]

The halogens are the elements in group 7 of the periodic table.

F Fluorine
Cl Chlorine
Br Bromine
I Iodine
At Astatine

Some of them can be dissolved in water to form aqueous solutions, depending on their reactivity; the more reactive halogens will react with water, and so it is difficult to make an aqueous solution.

When bromine solution is added to a solution of potassium iodide, a displacement reaction occurs and a colour change from orange to brown is observed.

(c) Write the word equation for the reaction that is occurring.

[1]

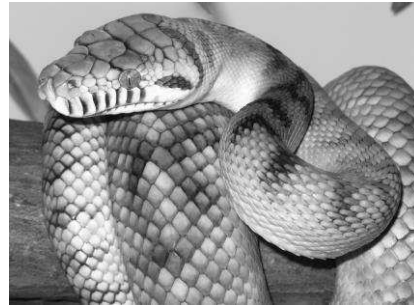
(d) Explain why this reaction occurs.

[1]

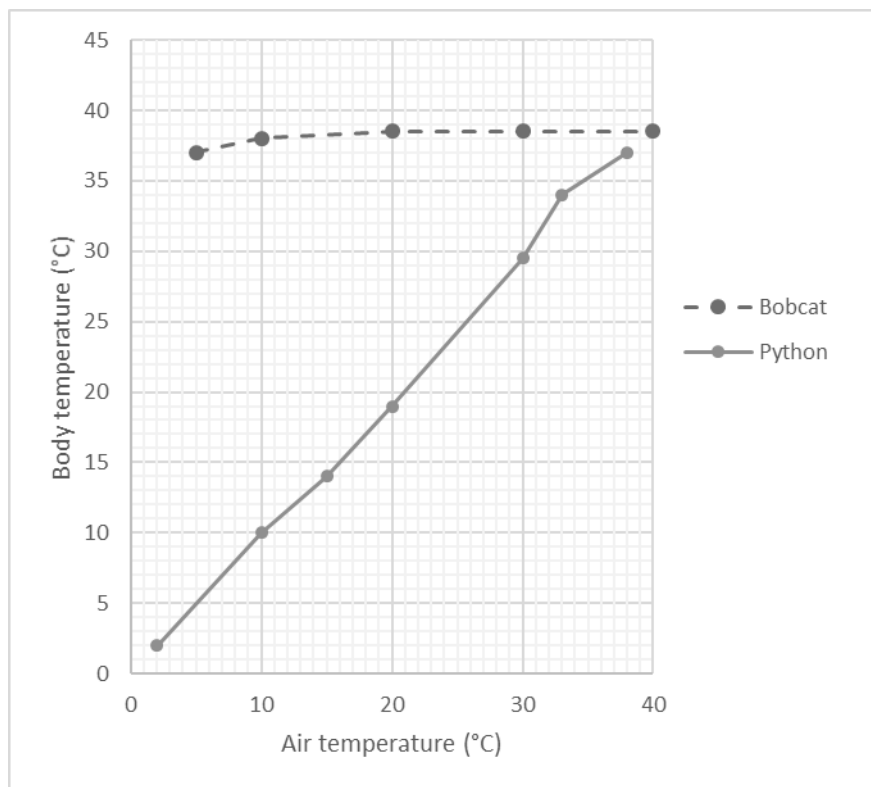
(e) Explain if it would be possible to make an aqueous solution of fluorine.

[1]

3. The photographs below show two animals, a bobcat (left image) and a python (right image). Both have a body mass of 10kg.



The graph below shows the body temperatures of these animals over a range of different air temperatures.



- (a) Describe what the graphs show you about the effect of air temperature on the body temperature of the two animals.

(b) The graph only shows how body temperature changes over a limited range of air temperatures. Suggest why scientists did not investigate air temperatures up to 60°C.

[1]

(c) The bobcat and the python look very different, but in terms of classification they belong to the same kingdom. Name the kingdom.

[1]

(d) The bobcat is classified as a mammal, and the python as a reptile. Compare and contrast three features of these groups in the table below.

[3]

Mammals	Reptiles

(e) The bobcat consumes far greater quantities of food than the python during the course of a year. With reference to the graph, and using your own knowledge, explain why this is so.

[3]

(f) Bobcats are found in the wild over a much wider range of habitats and climates than pythons. One reason for this is their ability to tolerate a broad range of temperatures. Discuss other possible reasons for this difference in distribution.

[4]

4. Digestive enzymes in the gut break down (digest) food into soluble substances. One of these is a protease enzyme called pepsin. Pepsin acts in the stomach to break down protein in the diet into soluble amino acids, which can then be absorbed into the bloodstream.

(a) Why are proteins required in the diet?

_____ [1]

(b) Suggest what happens to the amino acids once they have been absorbed into the bloodstream.

_____ [2]

(c) As well as containing pepsin, the stomach also contains hydrochloric acid. This creates an acidic environment (pH 3). Suggest possible benefits of this.

_____ [2]

(d) When egg white, which consists of protein, is added to a solution of pepsin it slowly disappears. What causes the egg white to disappear?

_____ [2]

You are required to plan an investigation into the effect of different temperatures on the rate at which pepsin can digest egg white. Spend a few minutes thinking carefully about how you would like to carry out this investigation and what you need to do to produce accurate and reliable results, then complete the questions below.

(e) List the apparatus you require.

_____ [2]

(b) Explain why the mass moves to the right.

[2]

(c) Explain why the mass doesn't stop at the lowest point of the swing.

[1]

(d) We will define one swing as the mass starting from the highest point on the left and returning to the highest point on the left. A student wants to measure the time it takes for one swing. They measure 40 swings in a time of 50s.

i. Explain why the student didn't measure just one swing.

[1]

ii. Calculate the time it takes for one swing.

[1]

(e) The teacher explains that the time taken, T , for one swing is proportional to the square root of the length of the string as shown in the equation below, where c is a constant.

$$T = c\sqrt{L}$$

What length of string would give a time period twice as long?

[2]

- (f) The teacher demonstrates another example of periodic motion using an old record player. The same mass is placed 15 cm from the centre of the rotating plate, as shown in Figure 2, and moves along a circular path without slipping on the rotating plate.

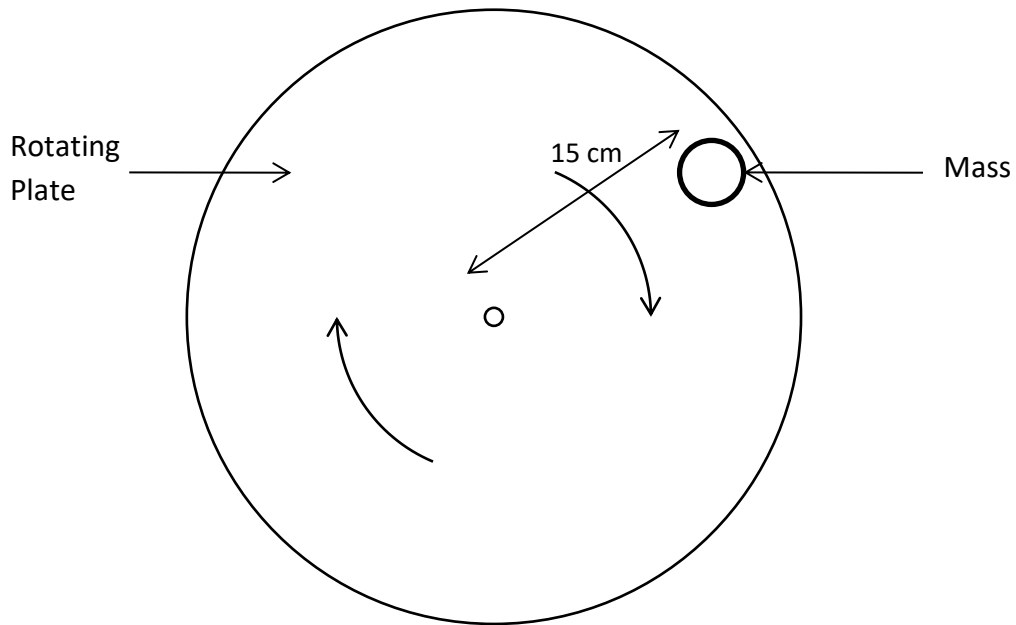


Figure 2: A record player with the plate rotating clockwise and a mass placed on it and moving with the plate.

- i. Draw an arrow on the diagram showing the direction of the resultant force acting on the mass and label it F . [1]
- ii. The plate rotates 78 times per minute. Calculate the time it takes to do one rotation in seconds.

[2]

- iii. Calculate the speed of the mass on the rotating plate in metres per second (m/s).

[2]

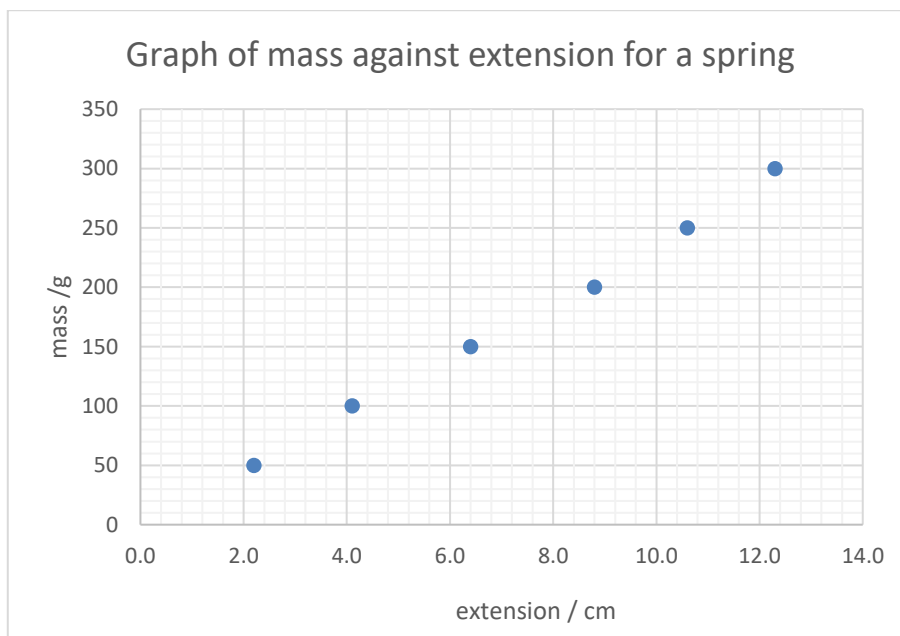
- iv. The rotating plate suddenly stops and the mass rolls off the plate. On the diagram draw a line showing the direction the mass rolls and label it v . [1]

6. Hooke's Law states that the extension of a spring is directly proportional to the force applied, provided the elastic limit has not been exceeded. The equation for Hooke's Law can be set out as $F = kx$, where F is the force applied to the spring, k is the spring constant and x is the extension.

(a) A student hung a mass of 0.3 kg on a spring with a spring constant 10 N/cm. Assuming the spring has an elastic limit of 5 N, by how much would the spring extend on Earth, where the gravitational field strength is 10N/kg?

[2]

The student then wanted to find out if a second spring was more or less stiff than the first. He hung a number of different masses from the second spring and measured the respective extensions. His results are displayed in the graph below.

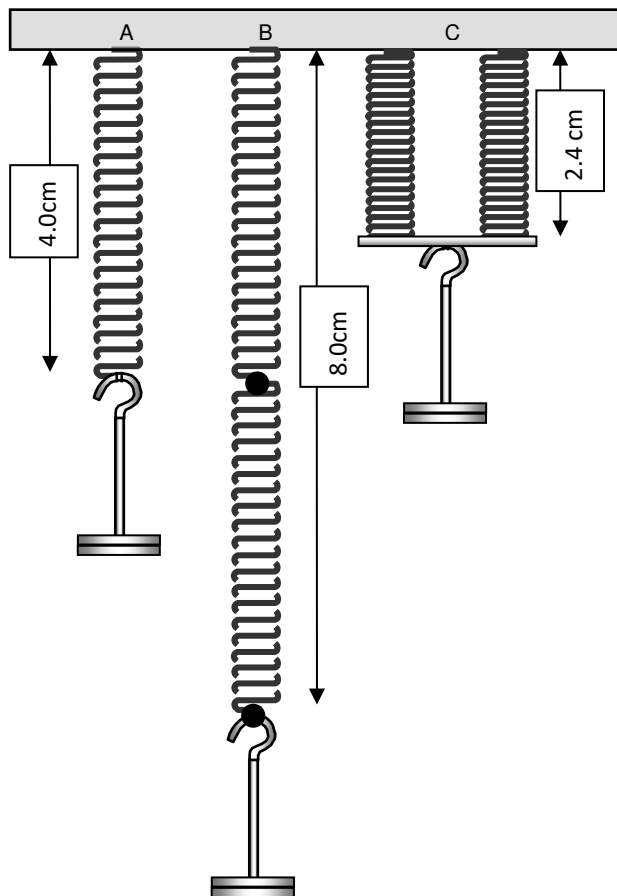


(b) Plot a line of best fit, calculate the gradient of the line using a triangle and then calculate the spring constant of this second spring in N/cm. Make sure you show all your working clearly.

[4]

(c) State whether the second spring is more or less stiff than the first.

[1]



The diagram to the left shows five identical springs arranged in three combinations:

A: a single spring

B: two springs hung end to end (in series)

C: two springs hung side by side (in parallel)

The mass on each combination is the same and the overall length of the stretched springs is marked on the diagram.

Diagram modified from: www.iop.org

(d) Explain why two springs in parallel have a smaller extension than a single spring.

[2]

(e) Using the information provided, calculate the length of the individual spring when it has no weight hanging on it. Remember that all five springs are identical! Show your working clearly.

[4]

(f) State any assumptions you have made in arriving at your answer to part (e).

[1]

[End of paper]