

<i>School</i>	<i>Candidate's Name (PLEASE PRINT)</i>
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WINCHESTER  
COLLEGE

## Entrance Examination

### SCIENCE

Wednesday 2 May 2018

Total time allowed: 1 hour 30 minutes

This paper is divided into **FOUR** sections.

- Section A    Chemistry
- Section B    Physics
- Section C    Biology
- Section D    General

Each section carries equal marks.

The mark for each question is given in brackets [ ].

All sections are composed of a number of short answer questions.

Candidates should attempt **ALL** the questions in these sections, answering in the spaces provided on the question paper. Calculators may be used.

**Candidates will be penalized for giving answers to too many significant figures.**

## SECTION A – CHEMISTRY

A1 Limestone is made mainly of calcium carbonate,  $\text{CaCO}_3$ , a chalky white solid. Calcium carbonate is formed as a solid when solutions containing calcium ions and carbonate ions are mixed together. Calcium carbonate is also formed when calcium oxide reacts with carbon dioxide.

- (a) In addition to the identities of the elements comprising calcium carbonate, give another piece of information that the chemical formula,  $\text{CaCO}_3$ , conveys.

.....  
..... [1]

- (b) Explain what is meant by a *solution* in this context.

.....  
.....  
..... [1]

- (c) Name the process of forming a solid from a solution by mixing, as described above.

..... [1]



A2 Hot, dry regions are susceptible to forest fires. Fire is a sign of chemical reactions taking place and releasing heat. On a small scale, fire can be useful in the home and in the laboratory.

(a) In addition to heat, give the two requirements necessary to maintain a fire.

..... [1]

(b) Some fires may be extinguished using water. State which of the three requirements for fire is removed by the water.

..... [1]

(c) Forest fires are typically contained by the use of fire breaks. These are strips of land cleared of trees and wood. Explain how fire breaks work.

.....  
.....  
..... [1]

(d) Explain why high winds increase the severity of forest fires.

.....  
..... [1]

(e) Draw a labelled diagram of a Bunsen burner in use, adjusted for strong heating. Indicate the materials it uses and where they are supplied to the burner.

[4]

(f) If a flammable liquid catches fire in the laboratory, a fire blanket is placed over its container until the fire goes out. Explain how the fire blanket puts out the fire.

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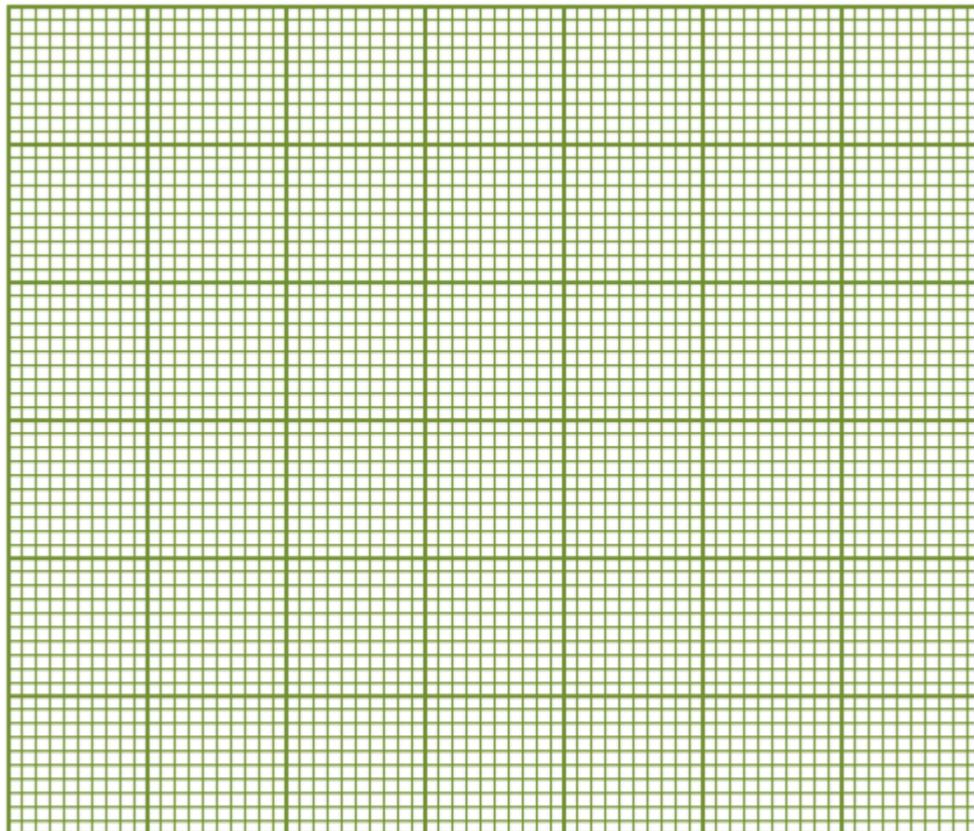
[1]

A3 When fossil fuels containing sulfur are burnt, they release sulfur dioxide,  $\text{SO}_2$ , which causes acid rain. Sulfur dioxide is soluble in water. The table below shows how the pH of  $1.0\text{m}^3$  of water depends on the mass of dissolved sulfur dioxide:

Mass of $\text{SO}_2$ per $\text{m}^3$ of water / kg	0.000	0.010	0.040	0.10	0.40	0.65
pH of resulting solution		2.8	2.5	2.3	2.0	1.9

(a) Fill in the missing pH value in the table. [1]

(b) Plot the data on a suitable graph using the graph printed below.



[5]

(c) Estimate the mass of sulfur dioxide required to make  $2000\text{cm}^3$  ( $0.002\text{m}^3$ ) of an acidic solution with a pH of 2.6.

.....

.....

[2]

**End of Section A**

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**SECTION B - PHYSICS**

B1 (a) The density of water can be calculated using a measuring cylinder, a mass balance and a supply of water. Explain what you would need to do with this equipment to obtain the measurements that you need.

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.....  
.....  
.....  
.....  
.....

[2]

(b) State the calculation you would now perform in order to obtain the density.

.....  
.....

[1]

B2 (a) Write down an equation relating pressure, force and area.

.....  
.....

[1]

(b) Underline any of the following units which could be used for pressure:

N/cm<sup>2</sup>

kg/m<sup>2</sup>

N<sup>2</sup>/m

N.m

[1]

B3 A boy wishes to make an electromagnet. He has been to the workshops and collected a nail, some insulated wire, a switch, a variable resistor and a 2 volt cell.

(a) Draw a labelled diagram in the space below to show how he should assemble this apparatus to make an electromagnet. He should be able to switch the electromagnet off and on, and also vary its strength. You may use standard symbols where appropriate.

[3]

(b) Suggest how, using the same apparatus, he could adjust his design to increase the maximum strength of the electromagnet.

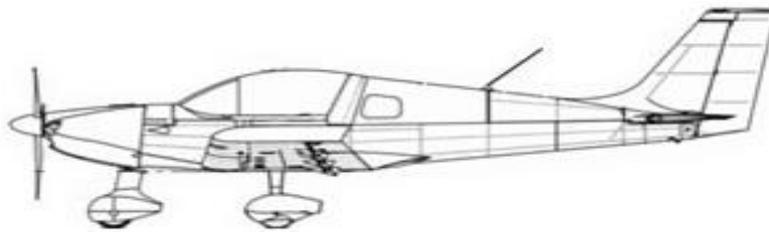
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.....

[1]

B4 An aeroplane is cruising at altitude at a steady 525 miles per hour in straight, horizontal flight. The four forces acting on the aeroplane are air resistance, lift, weight and thrust.

(a) On the diagram below, indicate with arrows each of these four forces acting on the plane:



[2]

(b) State which forces must balance each other, and explain how you know this.

.....  
.....  
.....  
.....

[2]

B5 (a) Sound is a type of wave. State how the sound wave associated with a loud sound differs from that of a quiet sound of the same pitch.

.....

[1]

b) Billy Wykeham is watching a storm. He sees a lightning flash – there is a gap of several seconds before he hears the thunder. “This is evidence,” says Billy, “that light travels very fast. In fact, it shows that light travels almost instantly from the flash to my eye.” Explain carefully how far you agree with Billy.

.....  
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.....

[2]

c) Light in fact travels at 300,000 km/s and takes roughly 8 minutes to travel from the Sun to the Earth. Use this information to calculate how far the Sun is from the Earth. Be sure to show your working.

.....  
.....  
.....

[2]

B6 This question is about energy changing from one form into another. For example, a solar panel converts **light energy** from the Sun into **electrical energy** as electrical current is produced, with some being wasted as **heat energy** as the panel heats up.

Describe in as much detail as you can the energy changes involved when a firework rocket travels up into the air and then explodes in a colourful display.

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[4]

B7 Estimate the volume of your thumb, by first considering the dimensions of it. Show your working. State the units of your answer.

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[3]

**End of Section B**

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**SECTION C – BIOLOGY**

C1 *Saccharomyces cerevisiae*, a species of yeast, is a single-celled organism in the Fungi kingdom. Structurally, the cells are similar to animal cells, but also have a cell wall.

(a) Draw a diagram of *Saccharomyces cerevisiae* and label as many features as you can.

[4]

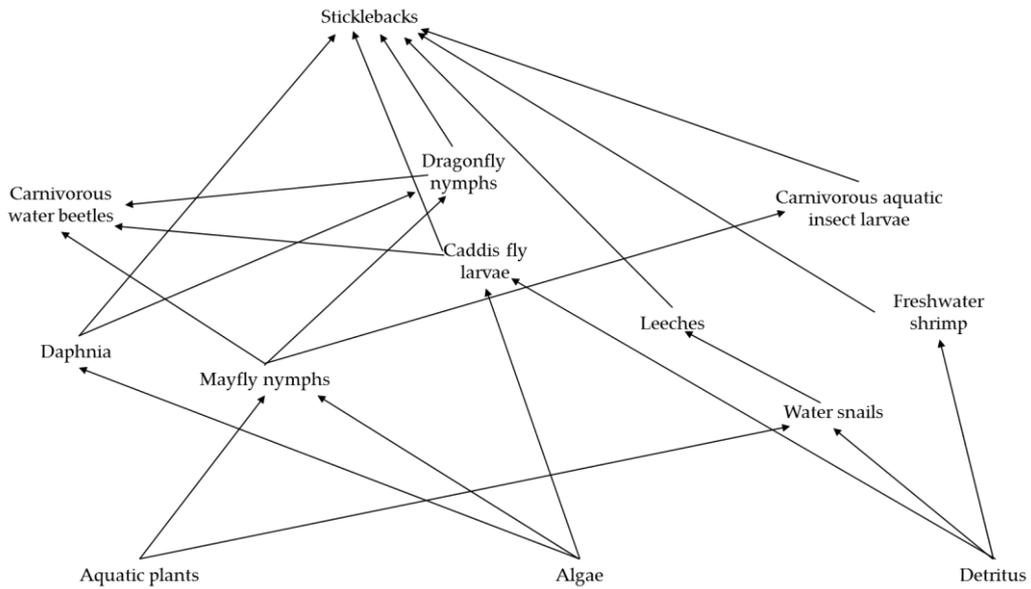
(b) Name two features that are present in a plant cell, but which are not present in *Saccharomyces cerevisiae*.

.....

.....

[2]

C2 The River Itchen runs through Winchester and supports a wide variety of life. Below is a food web showing how the various organisms depend on each other.



(a) (i) State and explain at least one factor that could affect the number of dragonfly nymphs in this ecosystem.

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.....

[2]

(ii) Suggest and explain what may happen if caddis fly larvae were wiped out by a disease.

.....

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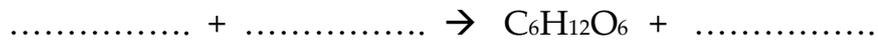
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[3]

- (b) The organisms at the bottom of the food web photosynthesise, providing raw materials for the ecosystem.

Complete the following symbol equation for photosynthesis, and state two requirements needed for the process.



Requirement 1.....

Requirement 2..... [3]

- (c) Some students designed an experiment to test how the rate of photosynthesis is affected by light intensity. Their method is described below:

1. Obtain a cutting of the pondweed *Elodea* and place it in a boiling tube, with enough water to cover the plant.
2. Check for bubbles of gas coming from the cut end of the stem.
3. Place a lamp 30 cm away from the boiling tube and switch it on. This should be the only source of light.
4. Count the number of bubbles of gas coming from the stem in one minute.
5. Record this result.
6. Repeat steps 3 – 5 above four more times, with the same cutting, moving the lamp 5 cm closer each time.

- (i) State the independent and dependent variables for this experiment.

Independent: .....

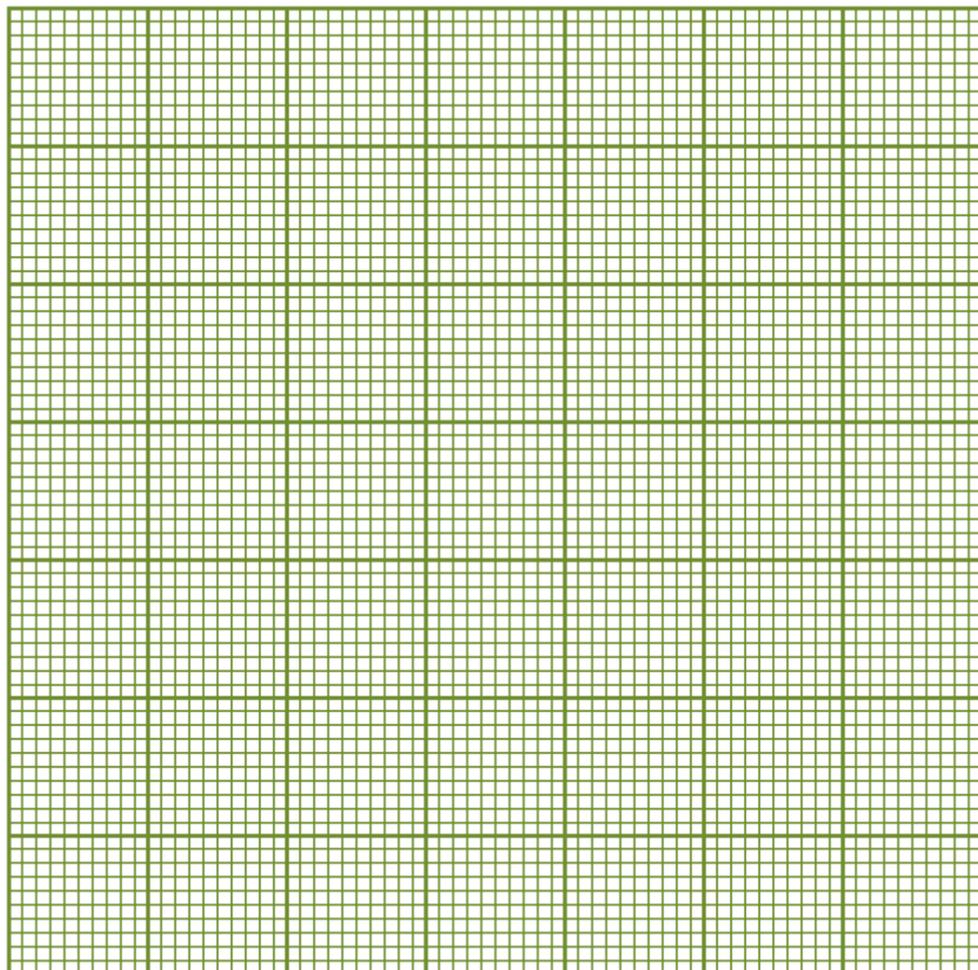
Dependent: .....

[1]

The table below shows the results they obtained:

Distance of the light from the boiling tube (cm)	Number of bubbles produced in one minute
30	30
25	55
20	85
15	121
10	118

(ii) Plot a graph using these results.



(iii) Describe the trend in the students' results and explain the data using your understanding of photosynthesis.

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.....  
.....  
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.....

[4]

(d) Suggest two ways in which the experiment could be improved.

.....  
.....  
.....

[2]

**End of Section C**

## SECTION D – GENERAL

**Read the following passages and answer the questions that follow**

### **The Most Powerful Rocket in the World**

A major science news story in 2018 was the launch of the Falcon Heavy rocket on February 6<sup>th</sup>. It is the most powerful rocket in the world by a factor of 2, restoring the possibility of flying missions with crews to the Moon or Mars. It was reported to produce a thrust of “5 million pounds-force”.

While American space exploration always used to be associated with a large state-funded body, the Falcon Heavy was the first privately-funded rocket to lift a payload beyond Earth orbit. The rocket was designed and built by SpaceX, founded by American entrepreneur Elon Musk. Both stages of the Falcon Heavy rocket are powered by kerosene and liquid oxygen.

The dramatic footage of the launch in February is believed to have generated greater public fascination with space. Many believe that the breakthroughs in space exploration with Sputnik 1 in 1957 and Apollo 11 in 1969 inspired the interest of a generation in science and technology.

### **Micro-organism Discovery in Antarctica**

The discovery within the last year of micro-organisms in some of the most inhospitable parts of Antarctica has given scientists ideas about how life might look on other planets with atmospheres and conditions very different from those on Earth.

A surprisingly rich diversity of microbial communities was found surviving with very little liquid water or carbon in the soil, little sunlight during the winter and, of course, very low temperatures. The micro-organisms were able to extract trace gases from the air, including hydrogen.

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D1 There are 2.2 pounds in a kilogram. On the surface of the Earth, a mass of 1 kilogram has a weight-force of 9.8 newtons. Calculate the thrust of the Falcon Heavy in newtons.

..... [1]

D2 Multiple forces act on the rocket; taken together, their resultant is the net force. The acceleration of the rocket is not constant. It is given by the equation:

$$\text{acceleration} = \text{net force} \div \text{mass}$$

If we assume the rocket moves vertically upwards, the net force on the rocket is given by the equation:

$$\text{net force} = \text{thrust} - \text{weight} - \text{air resistance}$$

From the moment the rocket's engines are started, the rocket's mass decreases as it consumes the kerosene and oxygen and releases the products as gases.

(a) Suggest what effect the changing mass has on the net force on the rocket and its acceleration. Explain your reasoning.

.....  
 .....  
 ..... [2]

(b) In the upper atmosphere the air is thinner. Suggest what effect this has on the air resistance, the net force on the rocket, and its acceleration as the rocket moves higher into the atmosphere.

.....  
.....  
.....

[2]

D3 It is costly to liquefy oxygen gas, and the use of such a cold liquid creates engineering problems. Suggest why the oxygen in the Falcon Heavy is liquefied.

.....  
.....

[1]

D4 Jet aircraft also use kerosene fuel, but do not carry oxygen. Suggest why jet aircraft don't need to carry oxygen but the Falcon Heavy does.

.....  
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[1]

D5 Kerosene contains molecules that are made from carbon and hydrogen atoms only. Suggest the products that are formed when it reacts completely with oxygen.

.....

[2]

D6 What is the name of the American state-funded organisation that has been associated with US space exploration since the 1960s?

..... [1]

D7 Sputnik 1 is said to have started the 'space race'. What was Sputnik 1 and which country was responsible for it.

Sputnik 1 was .....

Country responsible ..... [2]

D8 Which feat was achieved by the Apollo 11 mission in 1969?

.....

..... [1]

D9 What are the two most abundant gases in the Earth's atmosphere?

Most abundant .....

2<sup>nd</sup> most abundant ..... [2]

D10 The micro-organisms obtain their carbon from a rare gas in the atmosphere that is not carbon dioxide. Suggest the identity of the gas.

..... [1]

D11 Hydrogen, being the first element in the Periodic Table, is the most abundant element in the universe, but it is a rare gas on Earth. Suggest why the abundance of hydrogen gas on Earth isn't higher.

.....  
..... [1]

D12 What is the name of the process through which micro-organisms obtain gases from the air?

..... [1]

D13 Biologists are interested in how the micro-organisms evolved their ability to make use of these rare atmospheric gases. Suggest which molecules in the micro-organisms are being investigated to answer this question.

..... [1]

D14 Give two ways in which micro-organisms can be harmful to us and one way in which they can be beneficial.

Harmful 1. ....

Harmful 2. ....

Beneficial ..... [3]

D15 Yeast is an example of a micro-organism. Write the word equation for the anaerobic respiration of yeast.

..... [1]

D16 Despite the extreme conditions in the Arctic and Antarctic, animals have evolved to live there. Suggest two adaptations that could confer an evolutionary advantage to animals in these regions.

.....  
.....  
..... [2]

**End of Section D**

**Have you written your School and Name in the boxes provided at the top of Sections A, B, C and D?**