School	*Candidate's Name (PLEASE PRINT)*

WINCHESTER
COLLEGE

Entrance Examination

SCIENCE

Wednesday 8 May 2019

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 The corrosion of metals is estimated to cost the UK economy millions of pounds every year. Rust is mainly comprised of the compound hydrated iron(III) oxide, $Fe_2O_3.xH_2O$, and is formed when iron reacts with oxygen.

(a) In addition to iron and oxygen, which other substance needs to be present in order for rusting to take place?

.....

..... [1]

(b) Explain what the term *compound* means.

.....

.....

.....

..... [2]

(c) Name the class of reaction that applies to this reaction of iron (or indeed any metal) described above.

.....

..... [1]

Metals can also react with acids to produce salts and hydrogen gas.

(d) Describe an experiment, including relevant observations, which would demonstrate that iron reacts with dilute sulfuric acid to produce hydrogen.

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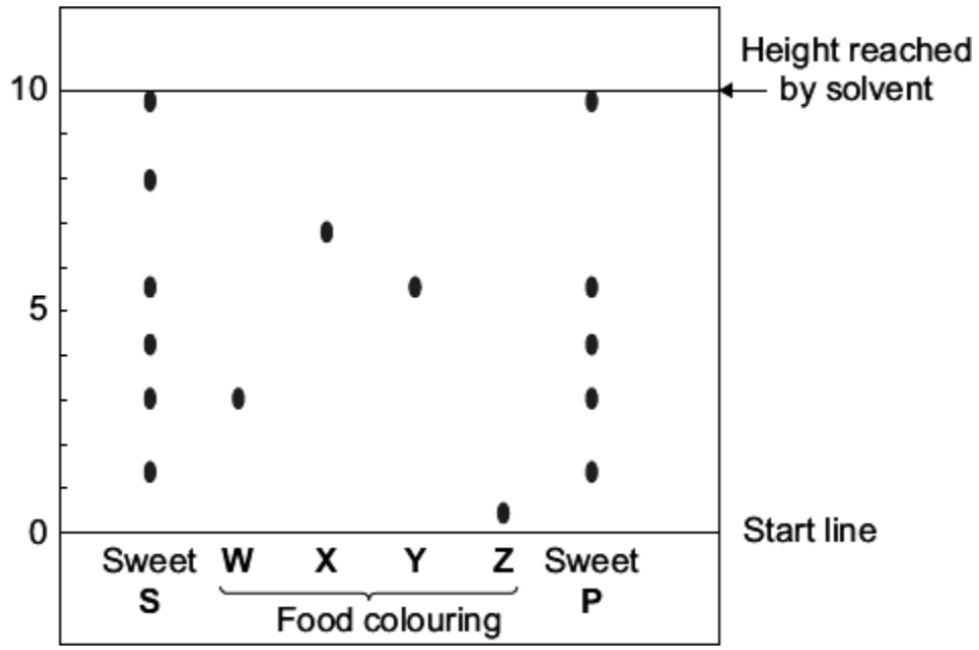
..... [4]

A2 Paper chromatography can be used to separate mixtures of coloured solutes within a solution (inks, food dyes etc.).

In an experiment designed to analyse the composition of Smarties® - two sweets (S and P) were ground up separately using a pestle and mortar. The ground sweets were dissolved in water and any solid residue removed. The solutions were analysed using paper chromatography and the results are shown below:



(a) Name the technique used to remove the solid residue before the analysis by chromatography.

.....

..... [1]

(b) How many food colourings were contained within Sweet S?

..... [1]

(c) Which of the food dyes W, X, Y or Z is the most soluble?

..... [1]

(d) Which of the food dyes W, X, Y and Z are not present in **either** sweet?

.....

..... [2]

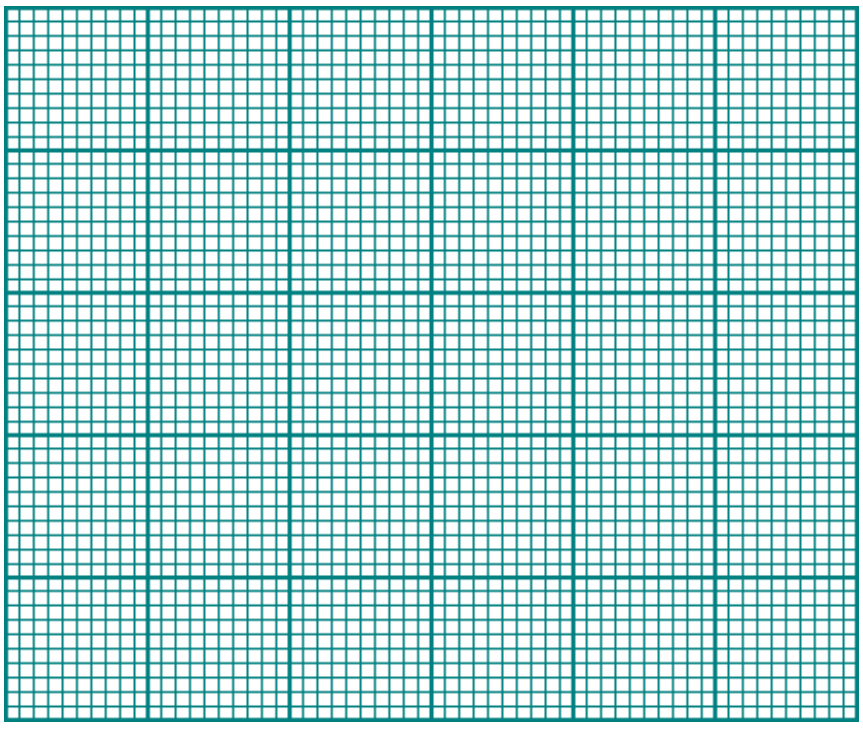
(e) Draw a labelled diagram of the equipment used to conduct paper chromatography. Indicate where the water level should start and how the start line is marked.

[4]

A3 The river Itchen in Winchester is designated as a Site of Special Scientific Interest (SSSI). It is a chalk stream, and chalk (calcium carbonate, $CaCO_3$) has a very low solubility (mass of solute that dissolves in 100 g of water) across a range of temperatures. The table below shows the solubility of $CaCO_3$ over a range of temperatures[1]:

Temperature of water / °C	20	30	40	50	60	70	80	90
Mass / µg dissolved in 100 g of water	600	560	510	460	410	360	315	275

(a) Plot the data on a suitable graph using the grid printed below:



[5]

(b) ***Using your graph***, estimate the solubility of $CaCO_3$ at 47 °C.

.....

.....

..... [2]

(c) What mass of water would be required to ensure that 82 μg of $CaCO_3$ dissolves completely at 60 °C?

.....

..... [1]

End of Section A

1. L. N. Plummer and E. Busenberg, The solubilities of calcite, aragonite and vaterite in CO_2-H_2O solutions between 0 and 90 °C, and an evaluation of the aqueous model for the system $CaCO_3$-CO_2-H_2O, Geochim. Cosmochim. Acta 46 (1982)1011-1040.

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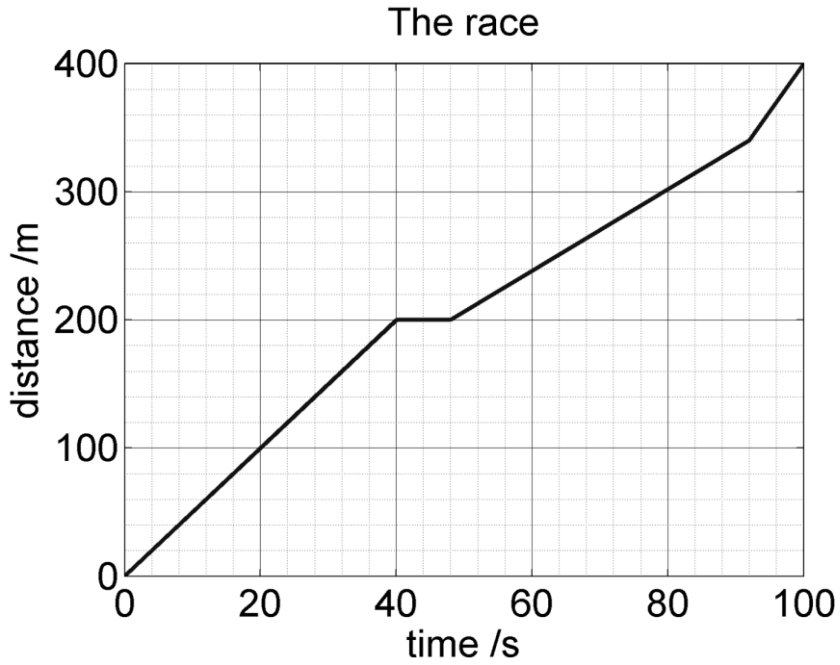
SECTION B – PHYSICS

B1 Alice takes part in a running race during her school sports day. The distance vs time graph for her race is given below:



(a) Calculate her *average speed* in m/s.

.....

.....

Answer:

_____ m/s [2]

(b) At what time during the race did Alice stop to do up her shoelaces?

..... [1]

(c) Showing your working, calculate Alice's speed (in m/s) at:

(i) 20 s

.....

..... [2]

(ii) 96 s

.....

..... [2]

(d) Without doing any calculations, explain how the graph shows that Alice is running *slower* at 60 s than at 99 s.

.....

..... [1]

B2 Jack wins a trip on a research ship investigating the *Marianas Trench*, the deepest part of the Pacific Ocean. In one experiment, Jack drops a solid metal ball of mass 1.23 kg over the side. The ball is attached to a very long wire which is released without tension as the ball sinks. The wire has red marks painted on it every metre.

The strength of gravity g = 9.8 N/kg.

(a) Calculate the *weight* of the ball giving the appropriate standard unit.

..... [2]

(b) After a short time Jack observes that the red marks are now passing at a constant rate. Explain what this implies about the size of the force that the water is exerting on the ball as this happens?

.....

.....

..... [2]

(c) The volume of the ball is 156 cm^3. Calculate its *density* in g/cm^3.

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..... [2]

(d) It takes 49 minutes for the ball to hit the sea floor. Jack counts 370 red marks passing over the side every 100 s. Showing clear workings, use this information to calculate the depth of the water in metres.

.....

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.....

..... [3]

(e) Jack takes a ride in a small submarine to a depth of 456 m. The roof of the submarine has an area of 4.00 m^2. If seawater has a density of 1030 kg/m^3, show that the weight of water directly above the submarine is 18,400,000 N.

.....

..... [3]

(f) If air pressure at sea level is 100,000 N/m^2 calculate the total pressure (in N/m^2) on the roof of the submarine at 456 m depth.

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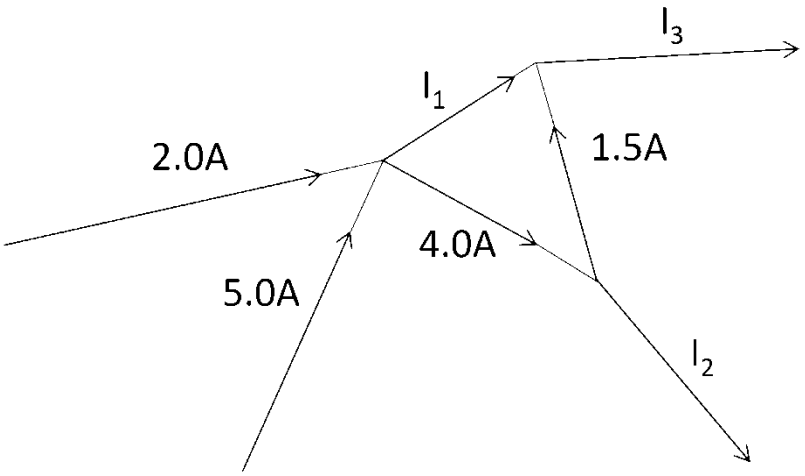
..... [2]

B3 The diagram below is part of an electric circuit. Calculate the currents (in amps) labelled I_1, I_2, I_3.



(a) I_1 = ...

(b) I_2 = ...

(c) I_3 = ... [3]

End of Section B

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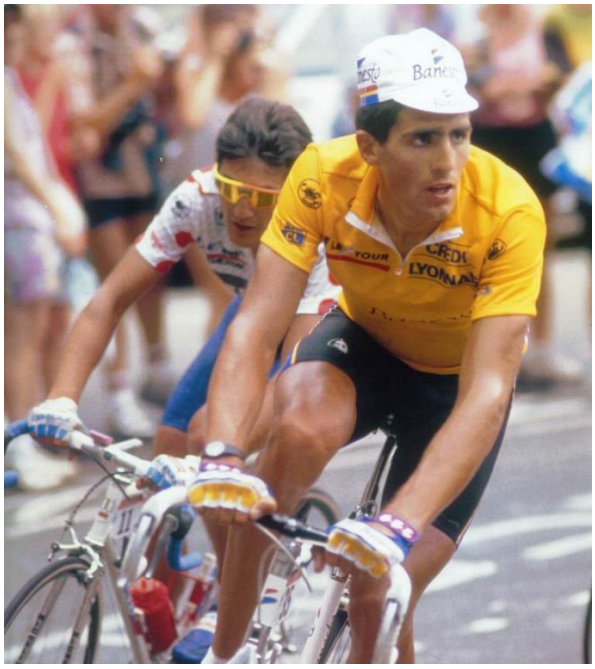
SECTION C – BIOLOGY

C1



(Reference: https://cycling-passion.com)

Miguel Indurain was a Spanish road racing cyclist who won the Tour de France 5 times consecutively from 1991 to 1995. He had a lung capacity of 7.8 litres (compared to 4.8 litres for an average adult male) and a cardiac output (the volume of blood pumped per minute) of 50 litres (compared to 25 litres for a fit male cyclist).

(a) Which characteristic (life process) of all living things would these differences most directly aid?

..... [1]

(b) Explain how a large lung capacity and elevated cardiac output may be an advantage to an endurance athlete like Indurain.

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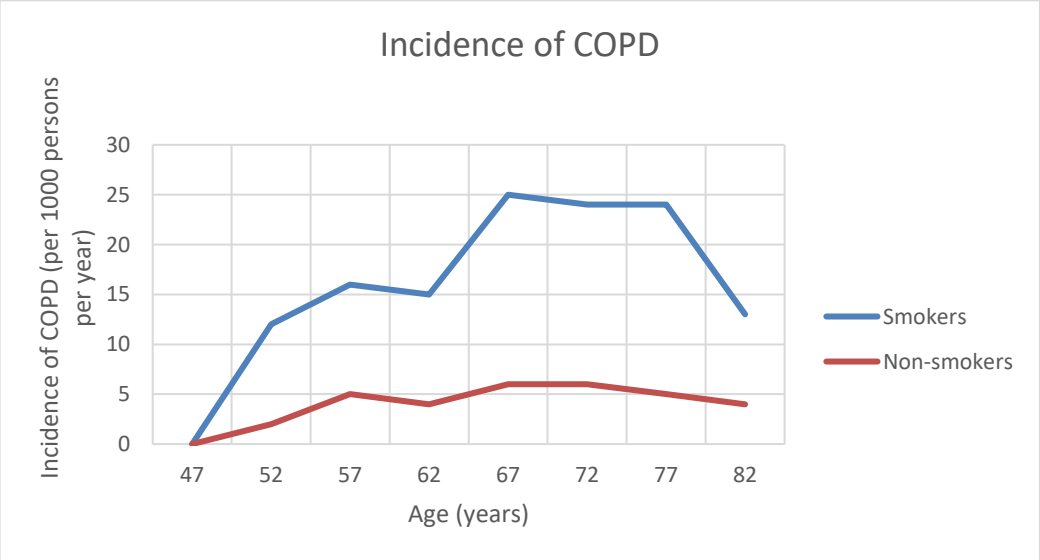
..... [5]

(c) Endurance athletes like Indurain are rarely smokers. Smoking increases the risk of Chronic Obstructive Pulmonary Disease (COPD), a general term for lung diseases which are characterised by breathlessness:



(Reference: "Prevalence and incidence of COPD in smokers and non-smokers: the Rotterdam Study", European Journal of Epidemiology. 2016; 31(8): 785–792)

(d) Describe the detrimental effect tobacco smoke has on the structure of the lungs and bronchi.

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..... [4]

(e) Suggest why the incidence of COPD falls for smokers above the age of 77.

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..... [1]

(f) Single-celled organisms like *Amoeba* do not have lungs or a gut. Describe how they obtain the essential molecules they need to survive.

.....

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..... [2]

(g) Explain why this works for an *Amoeba* but not for a human.

.....

.....

..... [2]

(h) Endurance athletes eat a lot of carbohydrates. This gives them the 'fuel' they need for their sporting exertions. Name and describe the process by which plants obtain the carbohydrates they need to survive.

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..... [5]

(i) Name a specialised organ in most plants where this process takes place.

..... [1]

(j) Explain how the bones in Indurain's body help him to breathe.

.....

.....

..... [2]

(k) Apart from facilitating movement, what other roles do the bones in the human body fulfil?

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..... [2]

End of Section C

SECTION D – GENERAL

Read the following passages and answer the questions that follow

UNESCO has declared that 2019 is the International Year of the Periodic Table of the Chemical Elements, marking its 150th anniversary. The Periodic Table is regarded as the icon of Chemistry. In 1869 Dmitri Mendeleev ordered the known chemical elements by their mass, assembling them in a grid. Today the elements are ordered and understood in terms of subatomic particles, but in 1869 none of these subatomic particles had been discovered. Atoms are now understood to have a nucleus at their centre and to be surrounded by negatively charged orbiting electrons. The subatomic particles of greatest interest to chemists are electrons; being negatively charged they repel each other and are attracted to the nucleus. Electrons in atoms are arranged in shells, the innermost one labelled n=1, the next one out labelled n=2, etc. The number of electrons that can occupy each shell is given by the expression $2n^2$. The element carbon is considered to be the most important of all the elements. Some metallic elements turn out to be very important in Biology.

The Economist predicts that 2019 will be the year of veganism. A vegan diet contains only plant matter: no meat, fish, eggs or dairy products. According to the Vegan Society there are 0.54 million vegans in the UK, up from 150 thousand in 2006. While animal products are a traditional source of proteins and fats, vegans stress that these are available in a vegan diet too. Indeed the cultivation of certain protein sources can give higher returns of protein per unit area of land compared to the farming of livestock. The Eat-Lancet Commission of health experts recommended in January 2019 that meat consumption should be limited to the equivalent of one beef burger per fortnight.

The Department of the Environment has declared that 2019 is the year of green action. Some of the extreme weather events of 2018 raised awareness of the dangers associated with the tremendous energies involved in hurricanes, for example. Indeed, the power outputs associated with major hurricanes dwarf those of the largest power stations.

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D1 Define the word *element* as it relates to the passage.

.....

..... [1]

D2 The text refers to the first Periodic Table ordering elements by their mass. However, the elements had been ordered by their mass before. Suggest what was special about the way Mendeleev had ordered them.

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.....

..... [1]

D3 Define the word *atom*.

.....

.....

..... [1]

D4 The nucleus at the centre of an atom is positively charged. Which statement in the text confirms this fact?

..... [1]

D5 What is the most important force that acts between electrons in an atom? Circle the correct option below.

electric magnetic gravitational frictional [1]

D6 How many electrons can occupy:

(a) the third shell? [1]

(b) the first four shells, altogether? [1]

D7 The element carbon is part of an important cycle in the environment. Outline the key processes in this cycle.

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.....

..... [3]

D8 Which metallic element is important in:

(a) bones and teeth? [1]

(b) chlorophyll? [1]

D9 Work out the percentage increase of vegans in the UK since 2006.

[1]

D10 A common feature of plant and animal cells is that they contain a nucleus. State the function of the nucleus and how it can be made visible on a slide under a microscope.

Function: .....

.....

Made visible by: ..... [3]

D11 Plants and animals are two of the Kingdoms of life. Name two other Kingdoms of life.

.....

..... [2]

D12 The three main food groups are protein, carbohydrate and fat. Give a source of each of these from a vegan diet.

Protein: .....

Carbohydrate: .....

Fat: ..... [3]

D13 The presence of which nutritional substance is tested for by the element iodine?

..... [1]

D14 The concepts of energy and power were mentioned in the text. They are different but related quantities. Give units used to measure each of them.

Energy: ..... Power: ..... [2]

D15 What is, ultimately, the source of energy that drives all weather phenomena?

..... [1]

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?