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, what other substance needs to be present in order for rusting to take place?

Water/H_2O (accept moisture)

[1]

.....

.....

(b) Explain what the term compound means.

Two or more elements chemically combined (1) in a fixed ratio (1)

.....

.....

.....

[2]

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

Oxidation/Redox

.....

[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 sulphuric acid to produce hydrogen.

Addition of solid to sulphuric acid within an appropriate piece of glassware (1)

Effervescence/bubbling observed (1)

Solid appears to disappear/reacts and forms a solution (1)

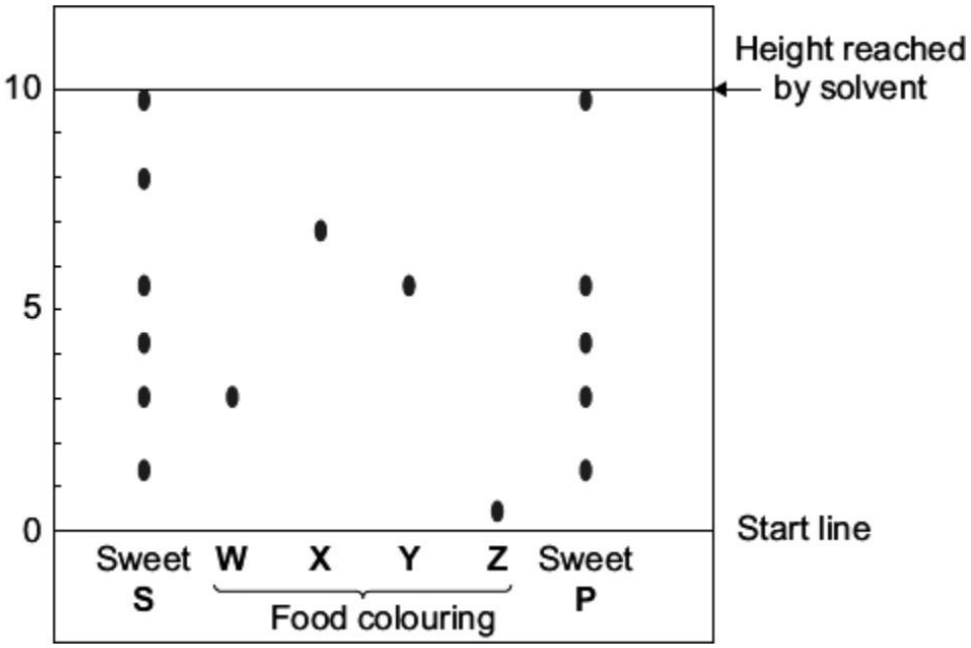
Appropriate method (linked to point 1) for collection of H_2 AND testing of H_2 (mention of squeaky pop test) (1)

.....

..... [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 chromatography and the results are shown below:



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

Filtering/Filtration

.....

[1]

.....

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

6

[1]

.....

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

X

.....

[1]

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

X and Z (1 mark for each)

.....

..... [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.

Any four from:

Chromatography 'tank'/beaker (1)

Water level below start line (1)

Chromatography paper labelled (1)

Pencil start line (1)

Any other sensible point (1)

[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

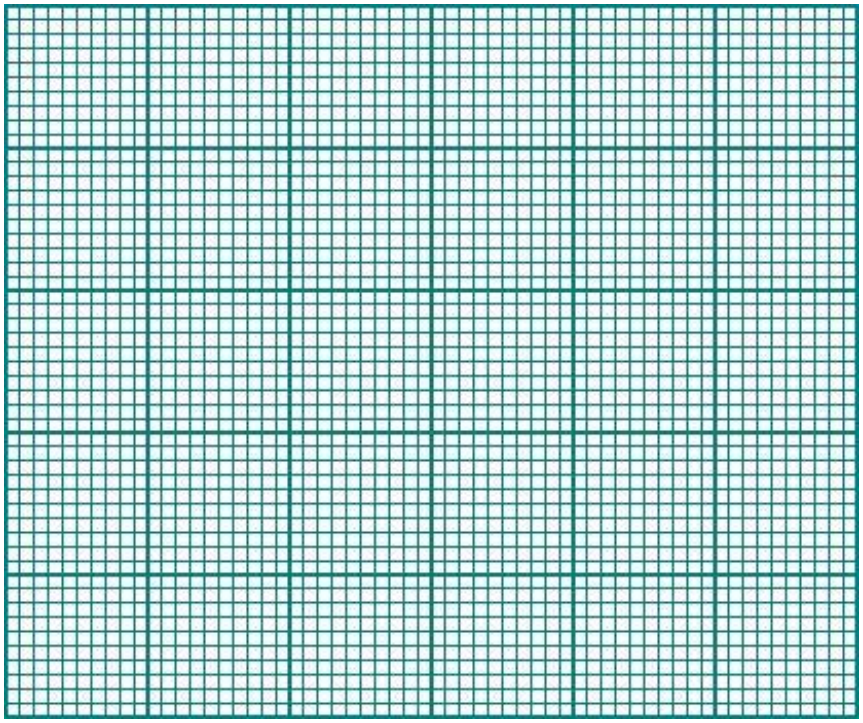
(a) Plot the data on a suitable graph using the grid printed below:

1 mark for suitable scale

1 mark for labelled axes

2 marks for all points plotted correctly/1 mark if any error present/0 marks where there is more than one error

1 mark for line of best fit/appropriate straight line (not a curve)



[5]

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

470µg/100g water (accept 475-465) (1 mark)

Evidence of using the graph to estimate the value (construction lines) (1 mark)

.....

.....

[2]

.....

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

20g (1 mark)

.....

[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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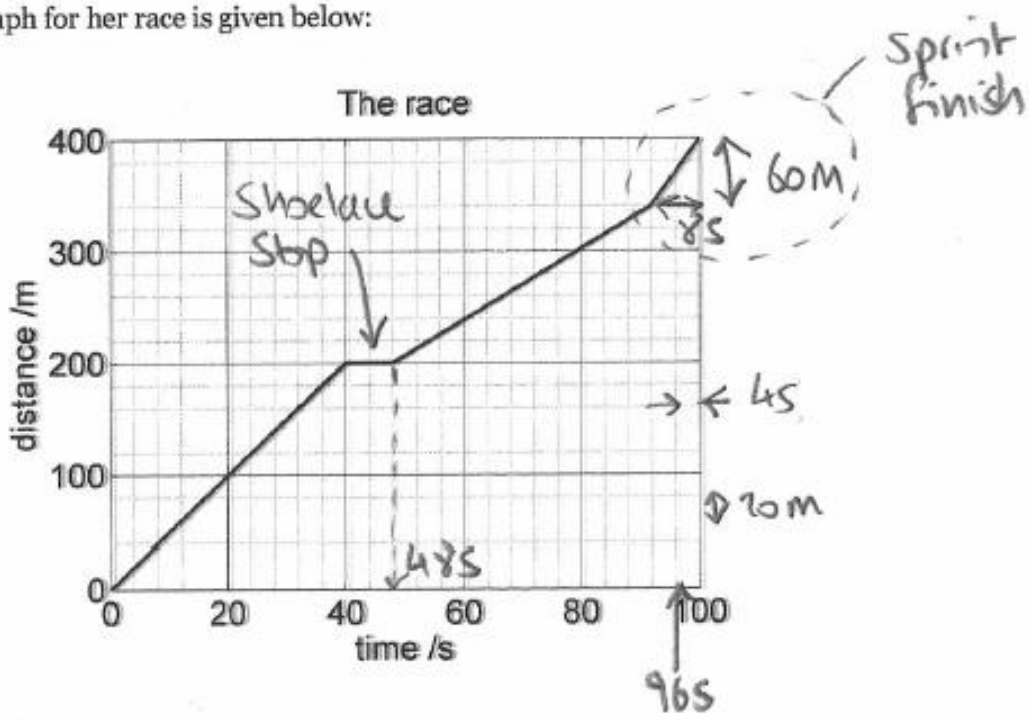
SECTION B – PHYSICS

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.

Average speed = total distance travelled / total time taken

Answer: $= \frac{400M}{100S} = 4.0\ M/S$ m/s [2]

[✓ Coherent workings ✓ correct answer]

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

Stops at 20m from 40s to 48s [1]

[Note 4s is time interval for minor grid]

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

(i) 20 s $v = \frac{200m}{40s} = 5.0 m/s$ [2]

(ii) 96 s $v = 60m/8s = 7.5 m/s$ [2]

[For both ✓ Coherent working ✓ correct answer]

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

Speed is the gradient of the distance vs time graph, and graph line is steeper at 99s [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.

so weight = mass x strength of gravity

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

Weight = 1.23 kg x 9.8 N/kg = 12.1 N [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?

If moving at constant speed, no net force. Hence upthrust = weight i.e. 12.1 N [2]

[✓ "Same as above i.e. weight", ✓ Explanation] ideally

B3

(c) The volume of the ball is 156 cm³. Calculate its *density* in g/cm³.

Density = mass / volume = 1230g / 156 cm³

= 7.88 g/cm³ [2]

[✓ correct use of formula, ✓ for 1.23 kg → 1230g and hopefully correct answer!]

(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.

✓ speed = 370 M / 100S = 3.7 M/S

✓ Distance = speed × time = 3.7 M/S × 49 × 60 S

= 10,900 M ✓

[✓ mark if sensible but unit conversion incorrect] [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 m². If seawater has a density of 1030 kg/m³, show that the weight of water directly above the submarine is 18,400,000 N.

Weight = Mass of water × strength of gravity ✓

= Volume × density × 9.8 N/kg ✓ [3]

= 456 M × 4.00 M² × 1030 kg/m³ × 9.8 N/kg = 18,400,000 N ✓

(f) If air pressure at sea level is 100,000 N/m² calculate the total pressure (in

N/m²) on the roof of the submarine at 456 m depth.

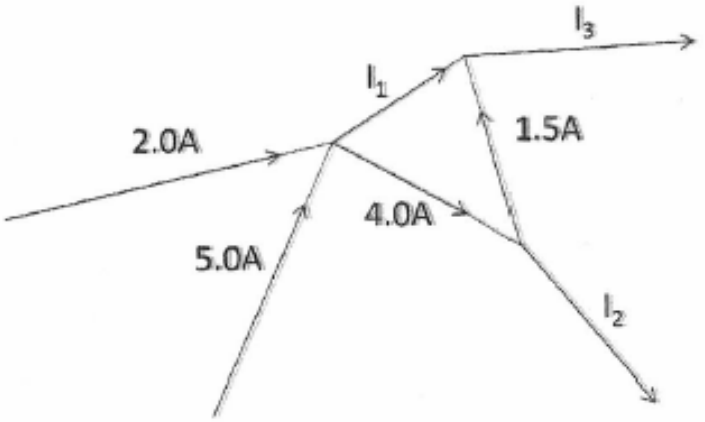
Pressure = weight of water / area + atmospheric pressure [2]

$= \frac{18,400,000\ N}{4.00\ m^2} + 100,000\ N/m^2$

$= 4,700,000\ N/m^2$

(1 atm ≈ 47 atm)

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



1.5 charge flowing/s

(a) I_1 = 3.0A

(b) I_2 = 2.5A

(c) I_3 = 4.5A [3]

[Kirchoff I: Current going into a "vertex" = total current leaving]

End of Section B

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	MARK SCHEME

SECTION C - BIOLOGY

C1

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

Respiration; [1]

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

Lung capacity → oxygenation of blood;

→ removal of carbon dioxide;

cardiac capacity → ↑ blood flow;

↑ supply of glucose + oxygen to tissues;

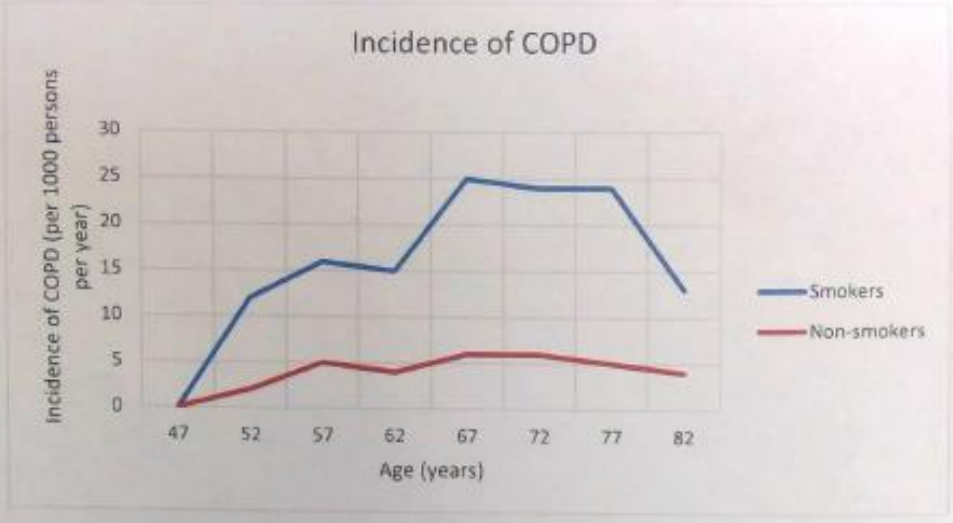
& transport of carbon dioxide to lungs;

allowing aerobic respiration;

release of ATP / energy;

max [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:



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

Constrict bronchi;
kill cilia;
↑risk of lung cancer;
emphysema / breakdown of alveoli;
reduced surface area for gas exchange;
↑ bronchitis;

max [4]

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

dying of other causes [1]

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

Diffusion;

Across CSM;

correct ref. to concentration gradients;

max [2]

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

SA:V ratio okay for unicellular not multicellular;

Aquatic environment vs terrestrial;

Difference in metabolic requirements;

Ref to Diffusion distances;
(R) size alone if unqualified)

max [2]

(h) Endurance athletes eat a lot of carbohydrates. This gives them the 'fuel' they need for their sporting exertions. How do plants obtain the carbohydrates they need to survive?

Photosynthesis;

correct reference to chlorophyll;

Use light energy;

CO_2 from air & H_2O;

create glucose / sugars;

max [4]

(i) Name the specialised organ plants have to facilitate this process.

leaf (② chloroplast) [1]

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

Ribs;

By raising ribcage; (allow ribs once only)

Cause drop in pressure in lungs/thorax;

Air "sucked" into lungs; max [3]

(or vice versa for exhalation)

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

Protection;

Support;

~~Production of blood cells;~~

max [2]

2019 Entrance General Section

Mark Scheme

D1 An element is a pure substance that cannot be chemically separated into simpler substances.

D2 The elements in the Periodic Table are also ordered by their chemical properties in columns.

D3 An atom is the smallest particle of an element that shows the element's properties.

D4 Negatively charged electrons are attracted to the nucleus.

D5 Electric

D6 (a) 18

(b) 2+8+18+32=60

D7 Brief descriptions of photosynthesis, respiration, combustion & decay

D8 (a) Calcium

(b) Magnesium

D9 (540 – 150)/150 x 100% = 260%

D10 The nucleus contains all the genetic information in the cell

The nucleus controls the production of protein in the cell

The nucleus determines an organism's characteristics

It is made visible by using methylene blue (or other stain)

D11 Bacteria / blue-green algae / prokaryotes

Fungi

Protists / archaea

D12 Protein: soy / tofu / nuts / lentils / chickpeas

Carbohydrates: rice / oats / pasta / bread / potatoes

Fat: nuts / avocado / vegetable oil

D13 Starch

D14 Energy: joules / calories Power: watts

D15 The Sun