13+ Scholarship Examinations 2019

SCIENCE

1 hour 10 minutes total

Contained in this package are the Physics, Chemistry and Biology sections.

You are to do THREE questions in total. Each question is worth 20 marks.

You must select one question from EACH section.

Write your name on the front of every section booklet and **circle the question attempted.**

You are advised to spend time at the start of this exam reading through the paper and selecting the questions that you wish to attempt – time has been built in to allow for this.

You will need a calculator and a ruler – ask an invigilator if you do not have one.

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2019

Physics Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Physics – Question 1

You may find the following equations useful for this question

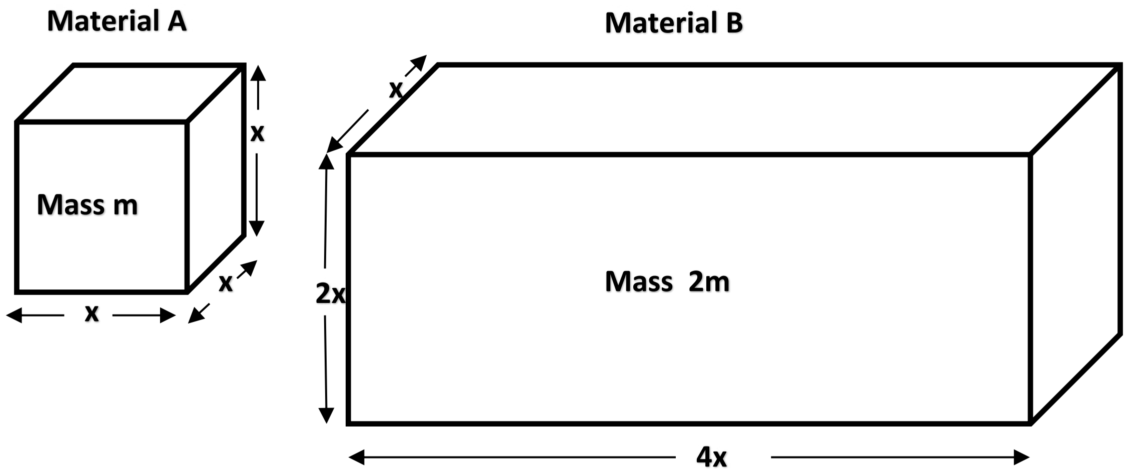
Density = Mass/Volume

Pressure = Force/Area

Area of a circle = πr^2 **where r = radius of the circle**

a) A cube of material A has sides of length x and mass m.

A block of material B has mass 2m and dimensions of x, 2x and 4x as shown below:



Tick the correct answer below and show how you have arrived at your answer.

The density of material B is:

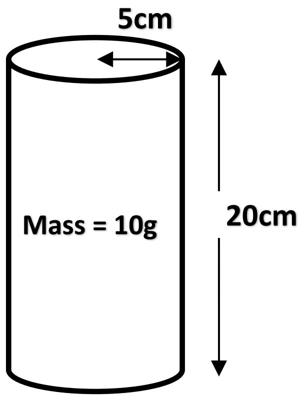
- ☐ Four times that of material A
- ☐ Twice that of material A
- ☐ The same as that of material A
- ☐ Half that of material A
- ☐ A quarter of that of material A

……………………………………………………………………………………………

……………………………………………………………………………………………

………………………………………………………………………………… (2 marks)

b) A cylinder of mass 10g has a radius of 5cm and a length of 20cm.
Calculate the density of the cylinder in g/cm^3.



……………………………………………………………………

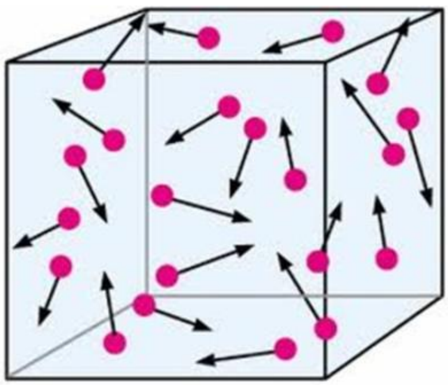
……………………………………………………………………

……………………………………………………………………

……………………………………………………………………

(2 marks)

c) A gas exerts a pressure on its container owing to **collisions** between the gas molecules and the walls of the container. Each collision leads to a force, and the individual forces add up over the surface area of the container to give an average pressure.



How would you expect the pressure of a gas to change if the temperature of the gas were increased? **Explain your answer**.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

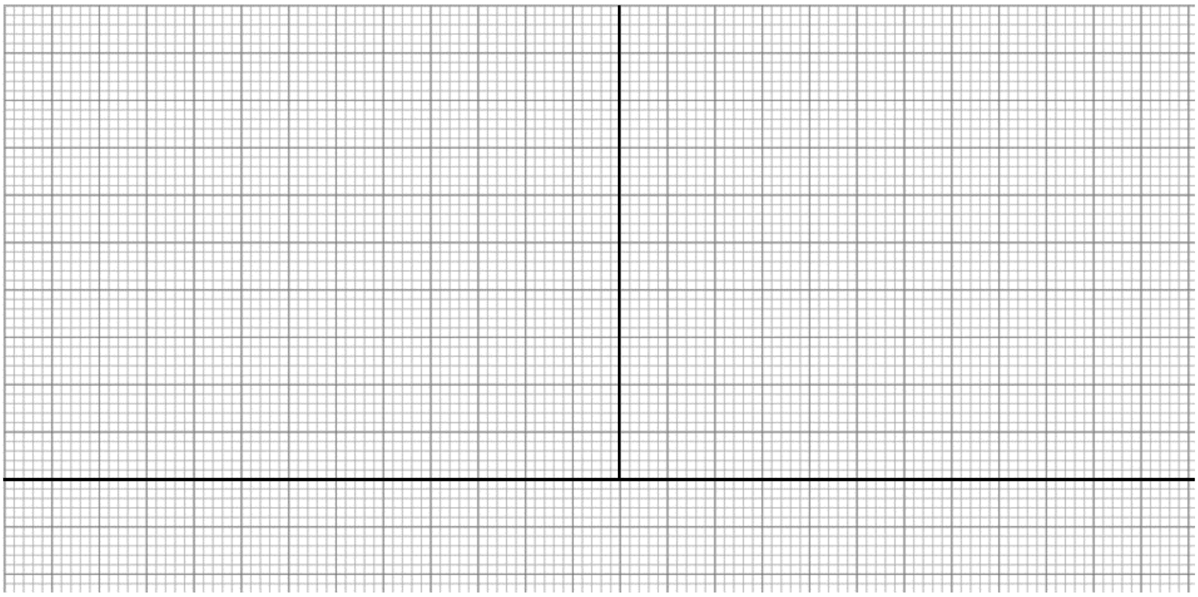
……………………………………………………………………………………

(2 marks)

d) A sealed container contains air. The pressure of the air is measured at different temperatures. The table below shows the results.

Temperature/°C	**Pressure/atmospheres**
-150	0.45
0	1.00
100	1.40
250	1.95

Using the grid below, add a suitable scale and plot a line-graph of pressure on the y-axis and temperature on the x-axis. (3 marks)



e) Use your graph to find the temperature at which the pressure of the air is 0 atm.

....

(1 mark)

This temperature is known as **absolute zero.**

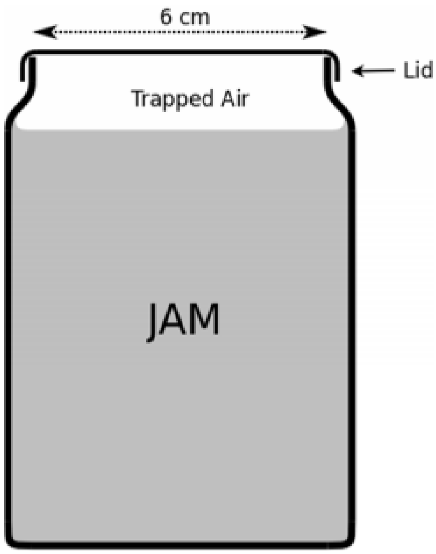
f) Describe the **motion** of the particles if the pressure of a gas is 0 atm..

....

(1 mark)

When jam is made, it is put into a jam jar and the top screwed down while the jam is still hot. The top makes an airtight seal with the jar and the air trapped above the jam cools, so the pressure of the trapped air reduces.

For this question you will need to use a new unit called the **Kelvin** (K). This is a temperature unit based on a scale that starts from absolute zero.



Useful information:

For the air

$$p / T = \text{constant}$$

assuming no air escapes/enters and the volume of the trapped air remains constant

p = pressure of the trapped air
T = Temperature in Kelvin

Atmospheric pressure = 100 kPa
(at room temperature)
Absolute zero = -273 °C

Since absolute zero is at -273°C which is 0 Kelvin, **to convert from °C to K you need to add 273.**

g) Calculate the force due to atmospheric pressure which is acting downwards on the top of the circular lid of the jam jar.

....

....

....

(3 marks)

h) The jam and the trapped air were initially at a temperature of 85°C when the jam was put into the jar and the lid secured. It then cooled to a room temperature of 15°C.

Convert these two temperatures into Kelvin.

85°C = ...K

15°C = ...K

(1 mark)

i) Using the information given next to the diagram on the previous page, show that the pressure of the trapped air, once it has cooled to room temperature inside the jar, is approximately 80kPa (80 000Pa).

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(3 marks)

j) Find the resultant (net) force acting on the lid of the jam jar due to the pressure inside and out.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(2 marks)

End of Physics Question 1

Physics – Question 2

a) A student carried out an experiment to see how the current flowing through a length of wire is related to the potential difference (or voltage) across it. She obtained the following results:

Potential difference/V	Current/A
0	0
0.50	0.14
1.00	0.28
1.50	0.42
2.00	0.56
2.50	0.70

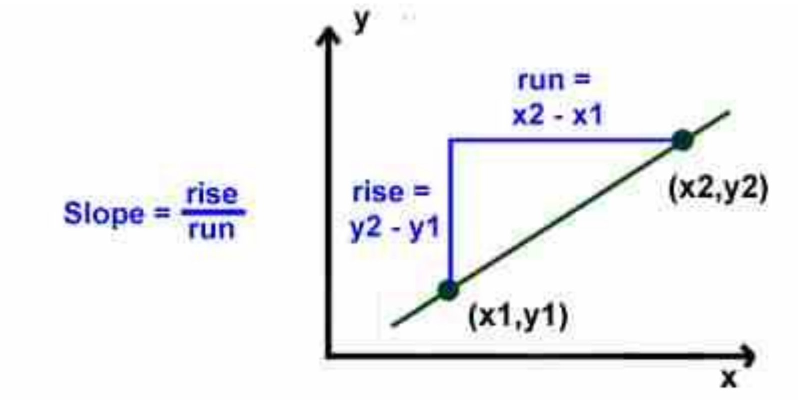
Plot a suitable graph of these results on the graph paper below **with potential difference on the y axis and current on the x axis.** Draw a line of best fit.

(4 marks)

Resistance is a measure of how difficult it is for a current to flow in a circuit. It is given by the following equation:

$$\textbf{Resistance} = \frac{\textbf{Potential difference}}{\textbf{current}}$$

You can find the resistance from your graph by calculating the **gradient** (or slope). A gradient is found by dividing the change in the values on the y axis (called the rise) by the change in the values on the x axis (called the run).



b) Find the gradient of your graph and hence the resistance of the wire.

....

....

Resistance = ...Ω

(1 mark)

c) The student now repeats the experiment with different components connected into her circuit. On the same graph, sketch what the results would look like for:

i) A wire with **twice** the resistance of the first wire.

ii) A lamp whose resistance increases as the potential difference across it increases.

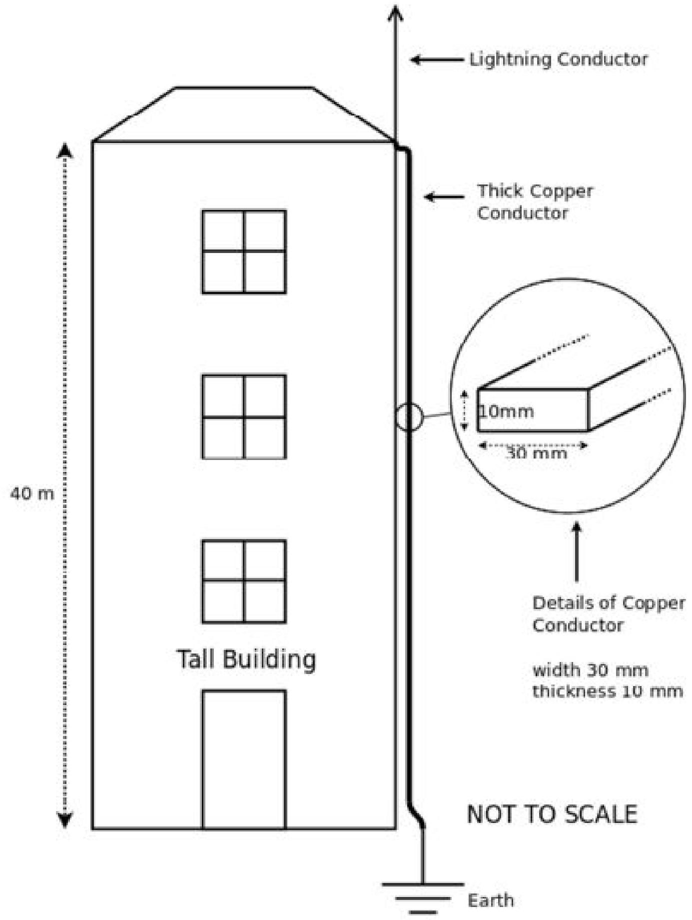
Label your lines (i) and (ii). (3 marks)

BLANK PAGE

Physics Question 2 continues on the next page

This question asks you to use some equations and concepts that you will not have met before. All of the information that you need to solve the problem is given in the question.

A student was interested to work out if the copper cable connecting a lightning conductor to the ground would melt if it was struck by lightning.



The average current flowing through the conductor in a lightning strike = 300 000A

The average time for a lightning strike to fully discharge from the cloud = 0.002s

Density = mass/volume

Heat energy transferred = m c Δ T

where **m** = mass in kg, **c** is a constant called specific heat capacity and Δ **T** is the change in temperature in °C

Useful information about the copper conductor:

- The equation to calculate the resistance of a cable is

$$\mathbf{R = \rho L / A}$$

where **R** is resistance in Ω, **L** is length in m, **A** is cross sectional area in m^2 and ρ is a constant called resistivity

- Resistivity of copper $\rho = 1.7 \times 10^{-8}$ i.e. 0.000000017 Ωm
- Specific heat capacity of copper = 385 J/kg°C (this is the energy needed to raise the temperature of 1 kg of copper by 1°C)
- Density of copper = 8900 kg/m^3
- Melting point of copper = 1085°C

d) Show that the resistance of the conductor is approximately 0.002Ω.

....

....

....

....

(3 marks)

For current flowing through a resistor we can use the equation below to find the power loss.

$$\mathbf{P = I^2R}$$

where P is the power, I is the current and R is the resistance.

The power is the **energy converted per second** and is measured in watts (W) where 1W = 1J/s

e) Calculate the power loss in the conductor and hence show that the energy transferred to the conductor is approximately 400 kJ (400 000J).

....

....

....

....

(3 marks)

f) Calculate the mass of the thick copper conductor.

....

....

....

....

(3 marks)

Question 2 continues on the next page

g) Use the stated specific heat capacity to calculate the temperature rise experienced by the conductor and show that it is unlikely to melt.

……………………………………………………………………………………………..

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

(3 marks)

End of Physics Question 2

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2019

Chemistry Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Name ________________________________

Chemistry – Question 1

This question is about acids, bases, and salts.

Acids, alkalis, and salts are commonly found around the home.

(a) Baking powder contains sodium hydrogencarbonate mixed with an acid.

(i) When water is added, the baking powder releases carbon dioxide. How could you test the gas to show that it is carbon dioxide?

Test……………………………………………………………………………………………(1 mark)

Result…………………………………………………………………………………………(1 mark)

(ii) When sodium hydrogencarbonate reacts with sulfuric acid, three products are formed. Name all three products.

……………………………………………………………………………………………………

……………………………………………………………………………………………(2 marks)

(b) Photographic film often contains the salt silver bromide. Silver bromide is changed by light to form silver which appears as a black solid. This darkens the photographic film.

A photographic film can be made by coating thin transparent plastic with a gel containing silver bromide.

The main steps in making this photographic film are as follows:

Step 1 Gelatine is dissolved in warm water to make a solution.

Step 2 Compound **A**, a soluble compound which contains bromide ions, is dissolved into this solution.

Step 3 The lights are turned out in the darkroom.

Step 4 Compound **B**, a soluble compound which contains silver ions, is dissolved in water.

Step 5 The solution of compound **B** is added to the solution containing compound **A** and gelatine. Solid silver bromide is formed.

Step 6 The warm mixture is poured onto a thin, transparent, plastic film.

Step 7 The mixture sets to form a gel containing solid silver bromide.

The table below gives information about the solubility of some compounds.

SOLUBLE	INSOLUBLE
All sodium and potassium salts	
All nitrates	
Most chlorides, bromides and iodides	Silver and lead chlorides, bromides and iodides
Most sulfates	Lead sulfate and barium sulfate
Sodium, potassium and ammonium carbonates	Most other carbonates

(i) Use the table to help you name suitable compounds for **A** and **B**.

Compound **A**..(1 mark)

Compound **B**..(1 mark)

(ii) Suggest why the lights are turned out at **step 3** in this method of making a photographic film.

....

....(1 mark)

(iii) Suggest what type of chemical reaction takes place when the compounds are mixed in **step 5**.

....

....(1 mark)

Question 1 continues on the next page

(c) Zinc granules react slowly with cold dilute sulfuric acid to give hydrogen gas and a colourless solution of zinc sulfate.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

Small amounts of copper(II) sulfate are often added to the mixture to increase the rate of reaction. The copper(II) sulfate reacts with some of the zinc to produce copper. The copper in contact with the zinc speeds up the reaction.

Design an experiment to find out whether the rate of reaction depends on how much copper (II) sulfate you add. **Full experimental details are not required**.

Your answer should include the following

- A diagram of the apparatus (4 marks)
- Details of what you will measure and how you will use the data generated to compare the rates of reaction in each experiment (3 marks)
- Details of how you are going to make the experiment a fair test (3 marks)

You should take care with your spelling, punctuation and grammar, as well as the clarity of your expression - the quality of your written communication (2 marks).

Diagram

Other details

(12 marks)

End of Chemistry Question 1

Chemistry – Question 2

This question is about acids, bases, salts and indicators.

(a) Indicators are substances that show a different colour when they are in acidic or alkaline solutions. However, indicators change colour at particular pH values, so some indicators, for example, may show their alkaline colour when the solution is in fact acidic.

The table below shows the pH at which some indicators undergo a colour change.

Indicator name	pH of solution at colour change	'Acid' colour	'Alkali' colour
methyl red	5	red	yellow
phenol red	8	yellow	red
thymol blue	2	red	yellow
bromophenol blue	4	yellow	blue
thymolphthalein	10	colourless	blue

(i) What colour would bromophenol blue be in a solution of pH 3?

....(1 mark)

(ii) Which indicator(s), if any, would be red at pH 6?

....(1 mark)

(iii) Which indicator will show a different colour when added separately to dilute ammonia solution (pH 8.5) and to dilute sodium hydroxide solution (pH 12)?

....(1 mark)

(iv) Which is more acidic : a solution of pH 3 or pH 5?

....(1 mark)

(v) Suggest a household substance that would have a pH value of 2-3.

....(1 mark)

(vi) If equal volumes of dilute hydrochloric acid and dilute sodium hydroxide were mixed together, what would the pH of the solution be?

……………………………………………………………………………………………………(1 mark)

(vii) What type of reaction has taken place in part (vi)?

……………………………………………………………………………………………………(1 mark)

(b) Copper sulfate can be made by warming dilute sulfuric acid then adding copper oxide until no more dissolves. The reaction mixture is then filtered and partially evaporated. The solution is then left to cool and crystals of copper sulfate form.

(i) Why is the reaction mixture filtered?

……………………………………………………………………………………………………(1 mark)

(ii) Why is the copper oxide added to the acid until no more dissolves?

……………………………………………………………………………………………………

……………………………………………………………………………………………………(1 mark)

(iii) Why is the solution of copper sulfate only partially evaporated instead of evaporating all the liquid?

……………………………………………………………………………………………………

……………………………………………………………………………………………………(1 mark)

(iv) Draw a series of labelled diagrams to show how you would do this experiment. You should show the reaction, the filtration and the evaporation.

(c) The table below shows the mass of copper sulfate, that is soluble in 100g of water at different temperatures.

Temperature (°C)	10	20	30	40	50	60	70
Solubility (g/100g of water)	27.5	32.0	37.8	44.6	53.2	61.8	72.8

Plot a graph of the results and draw a line of best fit.

(i) Use your graph to estimate the solubility of copper sulfate at 45 °C.

....(1 mark)

(ii) What mass of copper sulfate crystals would form if a solution containing 72.8g of copper sulfate in 100g of water were cooled from 70°C to 30°C?

....(1 mark)

End of Chemistry Question 2

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2019

Biology Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Biology – Question 1

(a) On this diagram, label the embryo, the placenta and the umbilical cord.

(3 marks)

(b) Fertilisation must take place before an embryo is formed. When fertilisation happens, which two types of cells have fused together?

……………………………………………………………………………………………………

(1 mark)

(c) Why is there amniotic fluid surrounding the embryo?

……………………………………………………………………………………………………

(1 mark)

(d) As the embryo grows it respires very rapidly to provide the energy needed for growth. Write the word equation for respiration.

……………………………………………………………………………………………………

(1 mark)

(e) Draw an arrow (→) on the diagram to show where the oxygen and glucose molecules needed for respiration diffuse from the mother's blood into the embryo's blood.

……………………………………………………………………………………………………

(1 mark)

(f) The embryo must absorb other substances from its mother's blood stream. Why does the embryo need to absorb the following?

Protein ……………………………………………………………………………………………

……………………………………………………………………………………………………

Calcium ……………………………………………………………………………………………

……………………………………………………………………………………………………

(2 marks)

The table below gives reproduction details for a range of different mammals.

Mammal	Gestation Time/days (time between fertilisation and giving birth)	Number of young (babies) produced per litter (in one pregnancy)	Number of litters per year (number of times the animal can become pregnant per year)	Mass of adult/kg
Badger	180	3-5	1	15
Cat	60	3-6	2	4
Chimpanzee	270	1	1	75
Elephant	640	1	1 per 2 years	7000
Guinea Pig	60	2-6	2-3	0.8
Hedgehog	60	3-7	1-2	0.8
Horse	335	1-2	1	1300
Mouse	21	4-8	4-6	0.025
Pig	115	6-20	2-3	300
Rabbit	30	4-10	3-4	1.5
Rat	22	5-14	2-7	0.5
Blue Whale	330	1	1 per 2 years	120 000

(g) Using the data in the table above, identify which type of mammal releases the greatest number of eggs from her ovaries in a single ovulation.

……………………………………………………………………………………………………

(1 mark)

(h) Consider the data for guinea pigs and hedgehogs. Which of these mammals **could** produce the greatest number of eggs per year? Show your working.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

(2 marks)

Question 1 continues on the next page

(i) What do you think are the survival advantages and disadvantages of having a long gestation period for an animal?

………………………………………………………………………………………………..

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(1 mark)

(j) Birds lay fertilised eggs and incubate them in a nest.

A bird embryo develops inside each egg. When the embryo is fully developed it will hatch. Name an environmental factor that directly affects the rate of egg development.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

(1 mark)

(k) The cuckoo is a brood parasite. It lays an egg in the nest of another bird species and then flies away. The young cuckoo hatches and is fed by the parent birds of the new nest, not its own parents. To be successful the cuckoo must hatch before the other eggs in the nest.

Put a cross on the egg which is most likely to be the cuckoo egg in this nest.

(1 mark)

(l) Parasites live on their hosts without killing them whereas predators hunt, kill and eat their prey. Identify the parasite and the predator in this scenario :

The hedgehog was moving through the leaf litter beneath the trees, eating earthworms, beetles and spiders. Every so often its rear leg would scratch vigorously at its side because of the large number of fleas on its body.

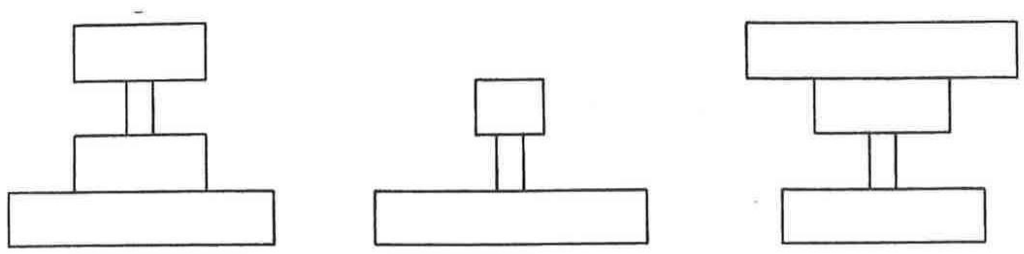
………………………………………………………………………………………………

(1 mark)

(m) Draw a food web that includes all the living things mentioned in the above scenario.

(3 marks)

(n) Which of the following pyramids of number best represents the food chain you have drawn?



(1 mark)

End of Biology Question 1

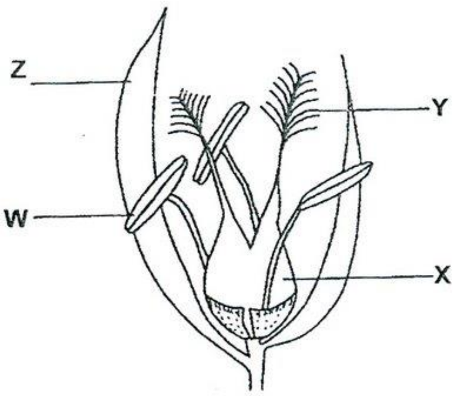
Question 2 starts on the next page

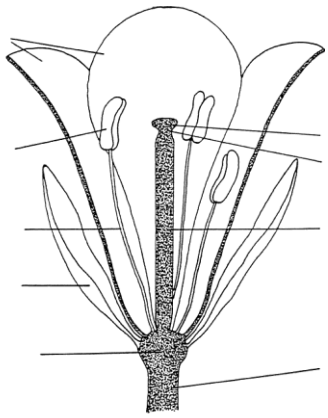
Biology – Question 2

Flowers enable sexual reproduction in plants. The diagrams below show an insect-pollinated and a wind-pollinated plant.

(a) Identify which of the flowers is wind-pollinated and which is insect-pollinated

(1 mark)





This flower is pollinated by…………………… This flower is pollinated by…………………

(b) Anthers produce pollen. Label the anthers on both plants. (1 mark)

(c) Pollen is deposited on the stigma, the female part of the flower. Give one reason why the stigma of the wind-pollinated flower is different from that of the insect-pollinated one.

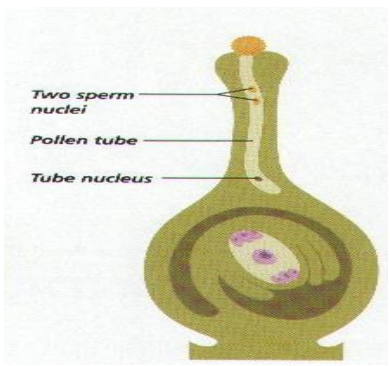
…………………………………………………………………………………………………

…………………………………………………………………………………………………

(1 mark)

(d) Once deposited on the stigma, the pollen tube grows down through the stigma and style until it reaches the ovary so that fertilisation can take place. The speed at which the pollen tubes grow is an important factor in successful fertilisation.

What is produced by the plant once fertilisation has taken place?



…………………………………………………………………………………………………

(1 mark)

Question 2 continues on the next page

Pollen tube treatment		Plant species tested				
		Lillium auratum	Lillium platyphylia	Lillium longiflorum	Camellia assanque	Impatiens balsamina
		Average pollen tube length /mm after 24 hours at 28^0C				
Pollen soaked in solution before growth was measured	Fresh unsoaked pollen	11.6	14.2	10.4	2.1	2.1
	Acetone	14.4	21.6	16.4	6.8	2.2
	Benzene	15.2	16.1	12.4	6.1	2.3
	Ethanol	4.0	1.9	5.9	4.2	0.1
	Methanol	0.6	0.7	0.3	0.7	0.1

(e) Which type of untreated pollen grew the fastest?

....

(1 mark)

(f) Describe the effect of Acetone and Benzene on pollen tube growth.

....

(1 mark)

(g) Which solution had the greatest effect on pollen tube growth?

....

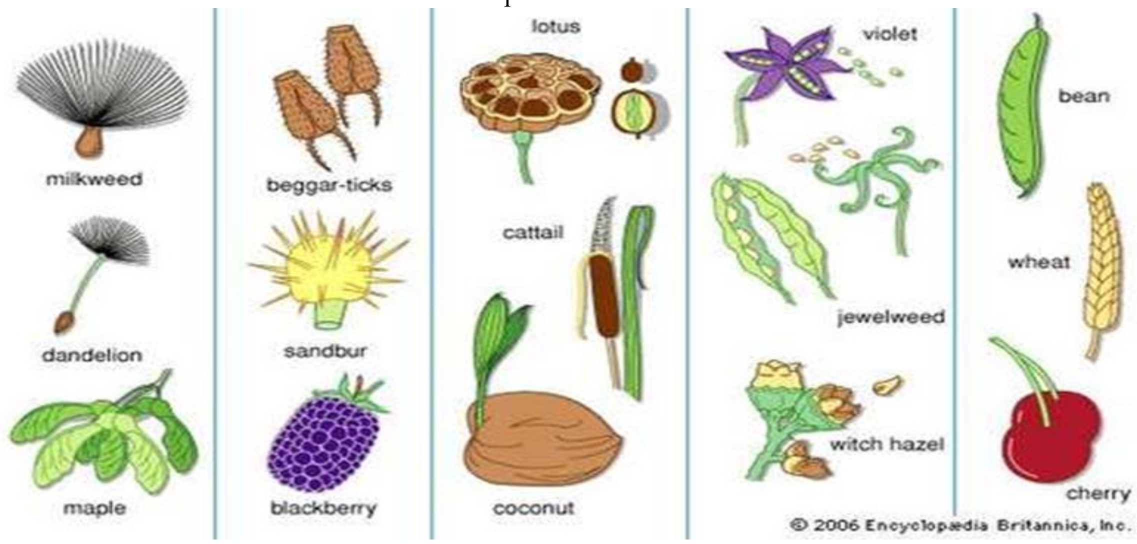
(1 mark)

(h) Name two factors that the investigators should have controlled when soaking the pollen in different solutions?

....

(1 mark)

(i) Identify which of the seeds in the following table are adapted for distribution by wind. Explain how the structure of one of these seeds is adapted to successful wind distribution.



…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

(2 marks)

(j) Which seed-distribution strategy would be the most reliable? Explain why you made your decision.

………………………………………………………………………………………………

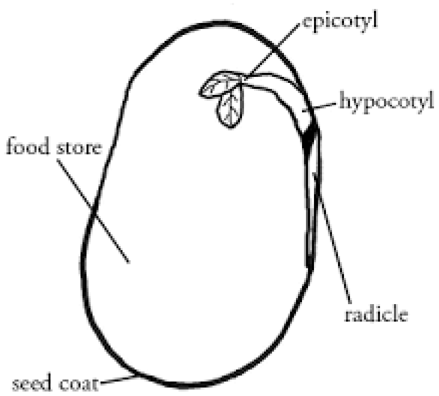
………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

(3 marks)

(k) Seeds contain a food store.



Seed food reserves contain a lot of starch. Name two other types of food molecules that will be present in this seed's food store.

1. ……………………………………

2. ……………………………………

(2 marks)

(l) Gardeners and farmers have to collect the seeds from their plants at the right time for maximum success when planting their seeds the following year. Look at this table of data:

Date of Collection		Seed weight (g)	Moisture (%)	Germination (%)
1st	15th July	7.50	76.69	0
2nd	1st August	8.72	74.42	0
3rd	15th August	12.98	72.03	0
4th	1st September	18.46	71.23	0
5th	15th September	25.93	67.73	0
6th	1st October	32.22	66.76	0
7th	15th October	39.30	64.09	24
8th	1st November	44.98	60.84	50
9th	15th November	52.03	58.37	80
10th	1st December	52.03	58.37	80

(m) What is the minimum seed weight needed for successful germination?

....

(1 mark)

(n) How do you think the plant makes the seed weight increase?

....

(1 mark)

(o) Why do you think that the seed weight does not increase after 15th November?

....

(1 mark)

(p) Once produced, seeds can remain dormant for many years. What advantages does this give to the plant species that produced the seeds?

....

....

....

(2 marks)

End of Biology Question 2

Name ________________________________

The King's School Canterbury

Science Scholarship Paper 2019

<u>Data Analysis</u>

You should complete <u>all</u> of the questions in this section.

You are advised to spend approximately 20 minutes on this section.

Mark /20	

Q1. You have just carried out an experiment to look at the relationship between the rate of reaction between reactants A and T and the percentage concentration of reactant T. The table below shows a **different** set of data for the same reaction.

We can calculate the **rate of reaction** using the equation below.

Rate of reaction = 100/t where t = time to the end-point

a) In the table below, complete the column to show the rates of reaction. **State your values to 2 significant figures.** (4 marks)

Experiment number	Percentage concentration of T	Time to end-point/s	Rate of reaction
1	100	6	
2	80	8	
3	60	13	
4	40	16	
5	20	36	

b) Plot a graph of these results with percentage concentration of T the x-axis and rate of reaction on the y-axis. Choose a suitable scale and label your axes clearly. (5 marks)

c) Draw a line of best fit on your graph. (1 mark)

d) One of the results is an anomaly. Circle the anomaly on your graph and suggest what might have caused it.

……………………………………………………………………………………………

……………………………………………………………………………………………

(2 marks)

e) Suggest two ways that you could improve your experiment if you were to do it again.

……………………………………………………………………………………………

……………………………………………………………………………………………

(2 marks)

f) Use your graph to estimate a rate value for a 50% concentration of T. Show your working on the graph.

……………………………………………………………………………………………

(2 marks)

g) Another factor that affects the rate of a chemical reaction is temperature. Give a brief outline of how you might use the same experiment to **investigate the effect of temperature on a chemical reaction.** Your answer should include:

- What you will measure
- What you will control
- How you will make it a fair test
- Any safety issues to consider (4 marks)

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

....

....

....

....

....

....

....

....

....

....

....

....

END OF DATA ANALYSIS

13+ Scholarship Examinations

SCIENCE
May 2021

1 hour 30 minutes total

Contained in this package are the Physics, Chemistry, Biology and General Science sections.

You should attempt four questions in total. Each question is worth 20 marks.

You must select one question from each of the Biology, Chemistry and Physics sections.

You must then complete the General Science section.

Write your name on the front of every section booklet and **circle the question attempted.**

You are advised to spend a short time at the start of this exam looking through the paper and selecting the questions that you wish to attempt – time has been built in to allow for this.

Calculators may be used – ask an invigilator if you do not have one.

Total number of marks: 80

BLANK PAGE

Name ________________________________

School ________________________________

The King's School, Canterbury

Science Scholarship Paper 2021

Biology Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Biology – Question 1

Here is a key to the common groups of invertebrates (animals without backbones) found in UK gardens.

1	Animals without legs	go to 2
	Animals with legs	go to 5
2	Animals divided into rings or segments	go to 3
	Animals not divided into rings or segments	go to 4
3	Tapered body	Fly larvae
	Cylindrical body	Worms
4	Coiled shell	Snails
	No shell	Slugs
5	Three pairs of legs	Insects
	More than three pairs of legs	go to 6
6	Four pairs of legs	go to 7
	More than four pairs of legs	go to 9
7	Body divided into two distinct parts	Spiders
	Body not clearly divided into two distinct parts	go to 8
8	Legs much longer than body	Harvestmen
	Legs much shorter than body	Mites
9	Seven pairs of legs	Woodlice
	More than seven pairs of legs	go to 10
10	All legs alike	go to 11
	Front pairs of legs jointed, back pairs of legs very short	Caterpillars
11	One pair of legs per body segment	Centipedes
	Two pairs of legs per body segment	Millipedes

Use the key to answer the following questions:

a) Identify this animal. Its body is divided into twelve segments, there are jointed legs on the front three segments and short legs on five of the back segments.

……….. (1 mark)

b) Identify three groups of animals mentioned in the key that have eight legs or more.

i. ……………………………………………………………………………………........... (1 mark)

ii. ……………………………………………………………………………………………….. (1 mark)

iii. ……………………………………………………………………………………………….. (1 mark)

c) State one similarity and one difference between slugs and snails.

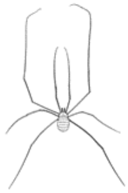
i. Similarity

…….

ii. Difference

…….(2 marks)

d) Circle the larger of the two animals shown below.

 Magnification x 0.5	 Magnification x 10

(1 mark)

e) Predict which one of these animals hunts, kills and eats its prey. Give a reason for your choice.

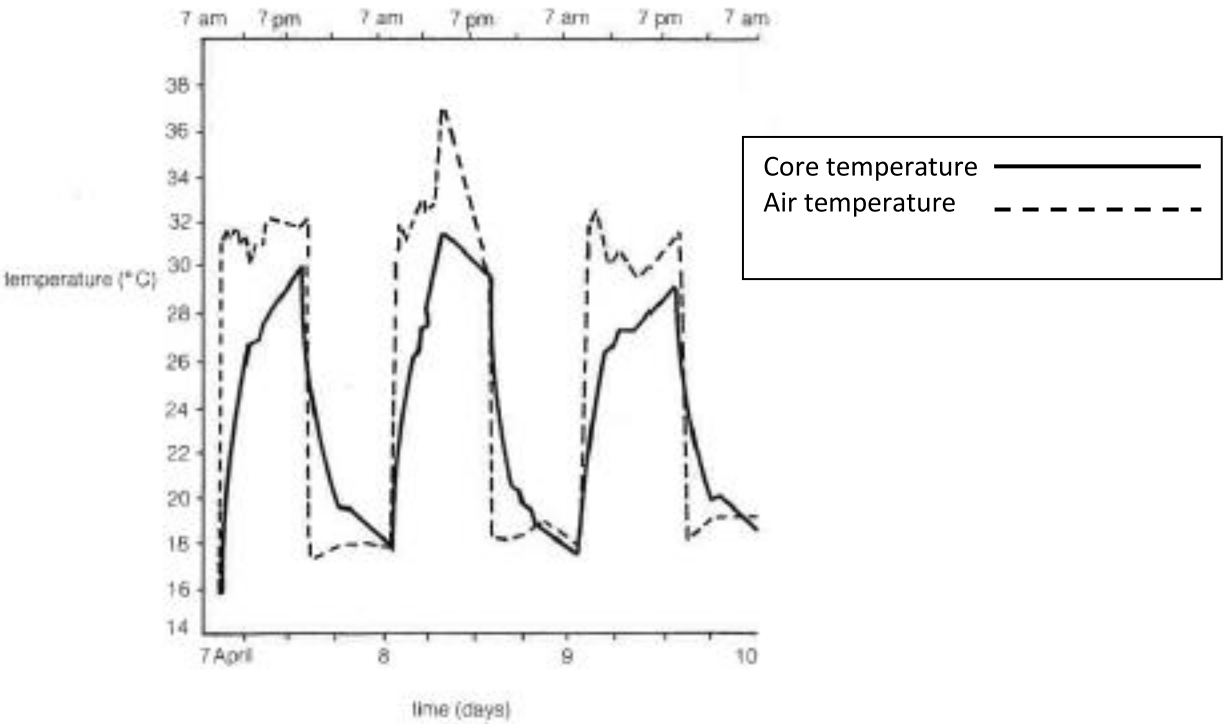
………

………

……..

(2 marks)

A Californian scientist kept a python snake in a large cage in a garden. At regular intervals over a period of three days he measured the python's core temperature and the temperature of the air in the cage. The readings are shown on the graph below.



f) Do you think the python controls its internal body temperature? Give reasons for your answer.

……

……

……

……

(2 marks)

g) What could the python do to increase the rate at which it warmed up in the morning?

……

……

(1 mark)

h) What was the maximum body temperature reached by the python over the three day experiment?

……

(1 mark)

i) Give three different reasons why the python's body temperature might have been slightly lower on day three of the experiment.

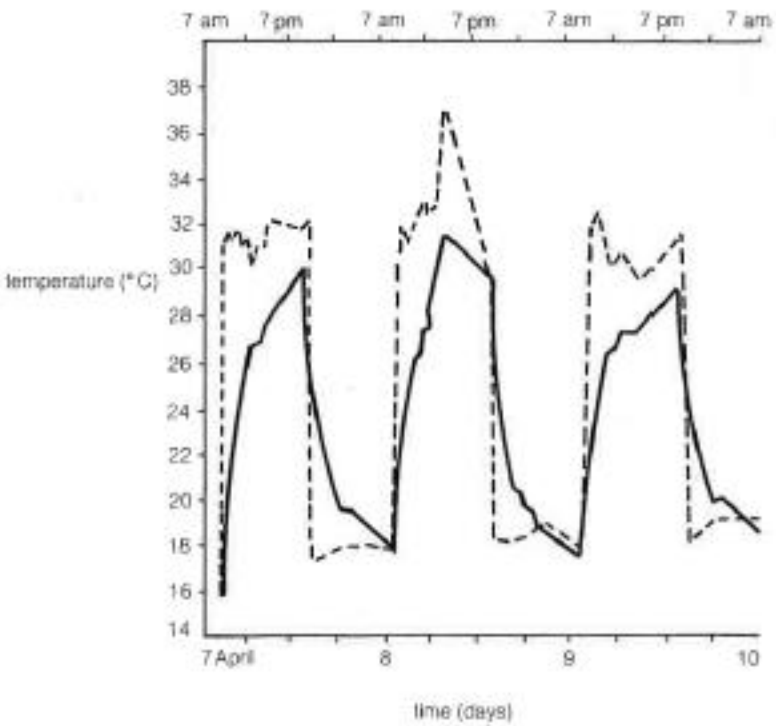
i. ……

ii. ……

iii. ……

(3 marks)

j) If the scientist had performed the same experiment with a cat, kept in the same conditions, sketch how the cat's core body temperature would change on the graph below.



(1 mark)

Question 1 continues on the next page

k) Monkeys control their core body temperature at 38^{o}C. Monkeys that live in very hot climates have adaptations to help them lose body heat. Describe three adaptations you might see on monkeys that are adapted to live in very hot climates. Give reasons for each answer.

i. ……

……

ii. ……

……..

iii. ……

……

(3 marks)

End of Question 1

Biology Question 2

a) Study the illustrations of birds' feet below and match each with one of the following descriptions of the bird. **Write the letter i – v next to the matching foot shape.**

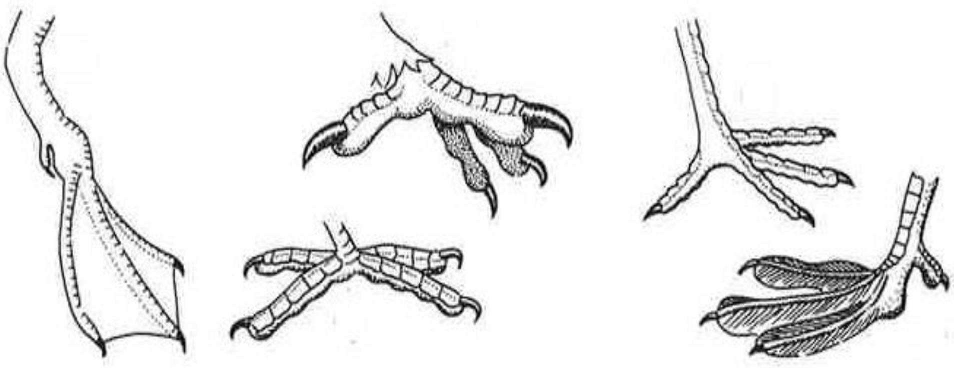
i. Carnivorous bird that catches rabbits and other small animals as prey.

ii. Herbivorous bird that sits on the surface of a lake or river and paddles along on water

iii. Carnivorous bird that walks across soft mud looking for worms.

iv. Carnivorous bird that spends many hours standing on tree branches, it has to hold on securely

v. Omnivorous bird that hops along solid ground looking for worms, seeds or breadcrumbs.



(3 marks)

b) A ground squirrel, a salmon and a Jay all have a mass of 200g.

		
Ground squirrel 200g	Salmon 200g	Jay 200g

The ground squirrel runs along the ground at 3km/hr, using 4kJ (i.e. 4000J) of energy to run 1km. A salmon swims at 3km/hr using 0.3kJ to swim 1km. A jay uses 1.5kJ to fly 1km at a speed which is about 20 times faster than the squirrel runs or the salmon swims.

Which method of movement - running, swimming or flying - uses the least energy per km?

………. (1 mark)

c) Describe two adaptations that help a salmon move quickly through water. Give reasons for each answer.

i. ……

……

ii. ……

……

(2 marks)

d) Suggest why the ground squirrel has to use so much energy for running. In your answer include details of how energy might be wasted in moving over land.

……

……

……

(2 marks)

e) How much energy would the salmon use if it swam for 1 hour? Show your workings.

……

……

……

(2 marks)

f) 1g of fat provides 36kJ of energy. How far could the jay fly on a store of 1g of fat? Show your workings.

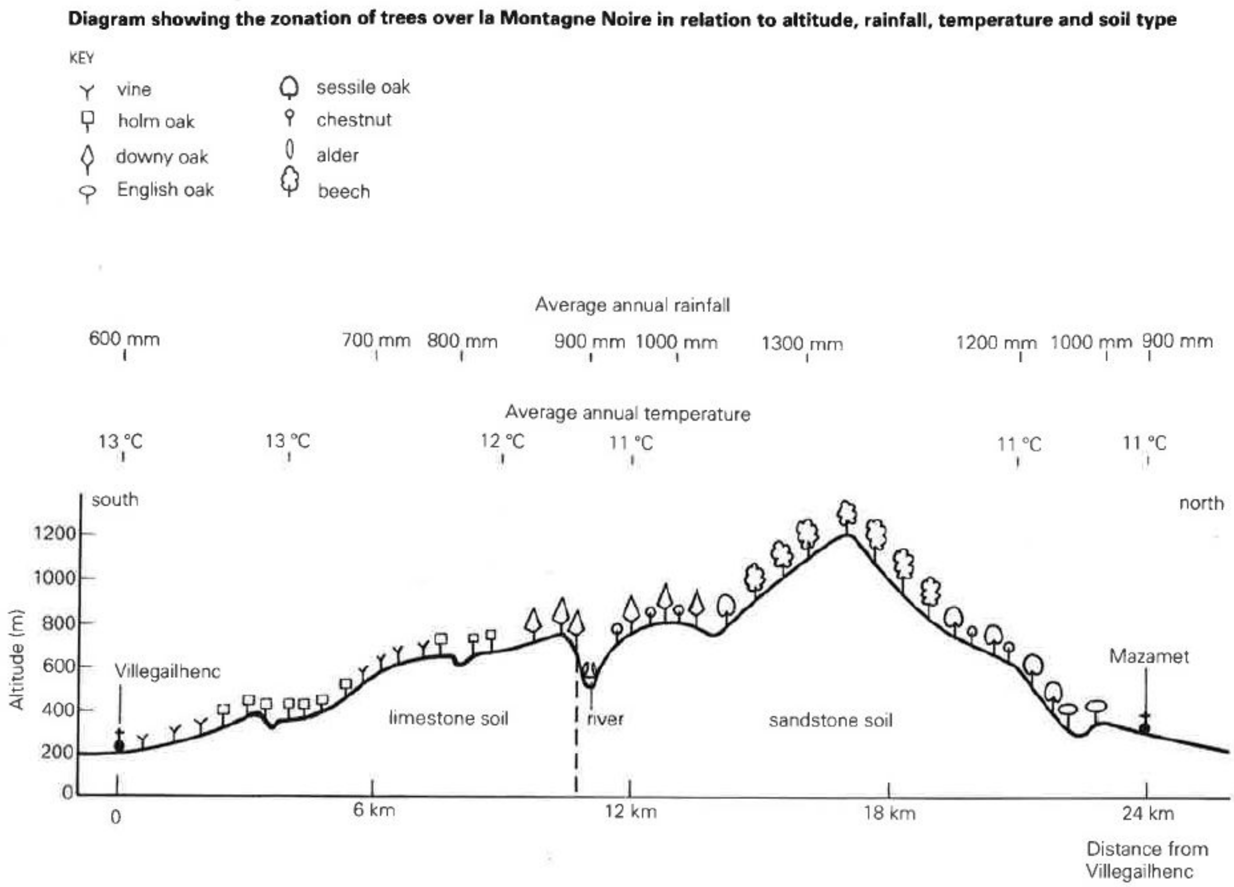
……

……

……

(2 marks)

The diagram below shows the distribution of different types of trees on the Montagne Noire in relation to altitude (height above sea level), rainfall, temperature and soil type.



g) Which type of tree is found on the summit of la Montagne Noire?

………

(1 mark)

h) Which type of tree is only ever found growing with another to form a mixed woodland?

………

(1 mark)

i) Which type of tree is able to grow on both limestone soil and sandstone soil?

………

(1 mark)

j) Using the evidence from the diagram, compare Holm Oak growth and English Oak growth under three different conditions.

i) Altitude :………

………

ii) Average rainfall :………

………

iii) Average annual temperature :………………………………………………………………………………………………

………

(3 marks)

k) As global temperatures rise, how might the distribution of trees on Montagne Noire change over the next 100 years?

………

………

………

(2 marks)

End of question 2

Name ________________________________

School ________________________________

The King's School, Canterbury
Science Scholarship Paper 2021

Chemistry Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

<u>Chemistry Question 1</u>

Metallic iron can be produced by heating iron oxide powder with aluminium powder.
The word equation for the reaction is shown below:

aluminium + iron oxide → iron + aluminium oxide

a) What does the reaction tell you about the position of iron and aluminium in the reactivity series of metals?

………

(1 mark)

b) Which substance is being reduced during the reaction?

………

(1 mark)

c) Explain why the two starting materials should both be powdered?

………

………

(2 marks)

d) Would you expect the mass of iron produced to be more, or less than the mass of iron oxide which reacted with the aluminium? Explain your answer.

………

………

(2 marks)

The equation below shows the balanced chemical equation for the same reaction. It shows the ratio in which the chemicals are needed for the reaction.

$$\mathbf{2\,Al + 1\,Fe_2O_3 \rightarrow 2\,Fe + 1\,Al_2O_3}$$

e) Masses of atoms are measured in atomic mass units (amu). Each atom of aluminium has an atomic mass of 27 amu and each atom of iron has an atomic mass of 56 amu. Using this information, calculate the mass of iron which would be produced if 1.8g of aluminium reacted with iron oxide. Show your working.

…….

…….

…….

…….

(3 marks)

f) A student performed the reaction with 1.8g of aluminium. Using the atomic masses, he correctly calculated the mass of iron he would expect. However, after the experiment he found that he obtained less than this amount. Other than human error, suggest two possible scientific explanations for this.

…….

…….

…….

…….

(2 marks)

g) Although this reaction produces a lot of heat, it will not start until the powered iron oxide and aluminium are at a high temperature. Suggest a reason for this.

…….

……

(1 mark)

h) The energy produced by a reaction can be calculated using the equation shown below.

$$Q = m\ c\ \Delta T$$

Q= energy in joules (J)
m = mass in grams (g)
c = specific heat capacity of the mixture (in J/°C/g)
ΔT = temperature change (in °C)

Find the amount of energy released when a substance of mass 0.225kg and specific heat capacity 0.670 J/°C/g rises in temperature from 20^{o}C to 2120^{o}C.

…….

…….

…….

(3 marks)

i) This reaction is an example of an exothermic reaction, where heat energy is produced. Considering the information in the previous question, what state of matter will the iron be in once this reaction is complete?

…….

(1 mark)

j) In a separate reaction, 510g of a different mixture was reacted which produced a temperature change of 2215°C. This resulted in 420 kilojoules (kJ) of energy being released.

Calculate the specific heat capacity for the reaction mixture.

Give your answer to an appropriate number of significant figures.

…….

…….

……… J/°C/g

(4 marks)

End of Question 1

Chemistry Question 2

A student made some crystals of copper sulfate by following these instructions:

Warm some dilute sulphuric acid and add solid copper carbonate until no more will react. Evaporate water from the filtrate until you have a saturated solution, then leave to cool.

a) Write a word equation for the reaction of dilute sulphuric acid with copper carbonate.

…….

…….

(2 marks)

b) How would the student know when he had added enough copper carbonate?

…….

…….

(2 marks)

c) What is meant by a 'saturated solution'?

…….

…….

(2 marks)

d) When the saturated solution was cooled, blue crystals of copper sulfate appeared. What does this tell you about the solubility of copper sulfate in water?

…….

…….

(2 marks)

e) A student became distracted during the practical and did not watch the evaporation. She only returned to her experiment after all the water had disappeared. She did not see any blue crystals. What would she have seen instead? Explain your answer.

……….

……….

……….

(2 marks)

f) In a subsequent lesson, the copper carbonate ran out. A student suggested that it might still be possible to produce copper sulfate by doing the same experiment, but using pieces of copper metal instead of copper carbonate. What do you think would happen if this was done? Explain your answer.

……….

……….

……….

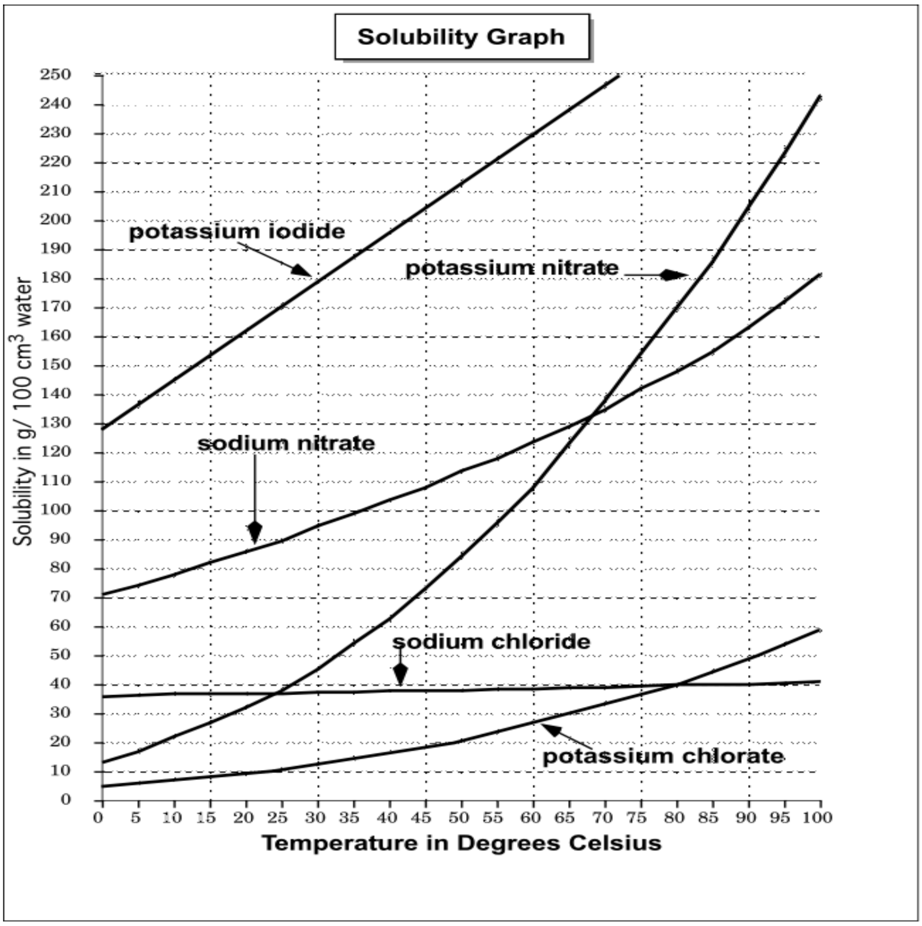
(2 marks)

Turn over

BLANK PAGE

Question 2 continues on the next page

The solubility of a substance at varying temperatures can be determined by experiment. Typical solubility curves can be seen in the graph below.



g) What is the maximum amount of potassium iodide that can dissolve in 100g of water at 50^{o}C?

……….

(1 mark)

h) At what temperature are the solubilities of sodium nitrate and potassium nitrate the same?

……….

(1 mark)

i) What is the maximum amount of sodium chlorate that can dissolve in 45g of water at 90^{o}C?

…….

…….

(2 marks)

j) A Saturated solution of potassium nitrate in 100g of water is made at 60^{o}C and then cooled to 30^{o}C. Use the graph to determine the mass of potassium nitrate crystals that would form.

…….

…….

…….

(2 marks)

k) It is not just solids that dissolve in water - gases dissolve in water too. The solubility of oxygen in water at 25^{o}C and atmospheric pressure is 40 milligrams (mg) per litre. Oxygen makes up approximately 21% of the composition of air at atmospheric pressure. Using the information given in the question, calculate the amount of oxygen that will dissolve in water at 25^{o}C. Show all of your workings.

…….

…….

…….

…….

(2 marks)

End of Question 2

BLANK PAGE

Name ________________________________

School ________________________________

The King’s School, Canterbury

Science Scholarship Paper 2021

Physics Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Physics Question 1

You may find the following equation helpful for this question

$$\textbf{Average speed (in m/s)} = \frac{\textbf{distance (in m)}}{\textbf{time (in s)}}$$

This question is about maintaining a safe braking distance whilst driving.

It is not possible to stop a car immediately as there is a time delay caused by both the reaction time of the driver and by the fact that it takes time to physically stop the car.
The total distance travelled by a stopping car can be calculated using the following equation:

Total stopping distance = thinking distance + braking distance

…where the thinking distance is the distance travelled whilst the driver reacts to a situation and the braking distance is the distance travelled once the brakes are applied.

a) A typical reaction time for a human is 0.25s.

i) If a car was moving at 30m/s, how far would it travel during this reaction time?

……

(1 mark)

ii) State one factor that might affect a human's reaction time and hence the thinking distance.

……..

(1 mark)

b) The braking distance depends on how much kinetic energy the car has before the brakes are applied.

The kinetic energy of an object can be found using the following equation:

kinetic energy = ½ x mass x speed squared

or in symbols

$KE = \frac{1}{2} m v^2$ (v stands for speed in this case)

Where mass is in kg, speed is in m/s and kinetic energy is in J

Calculate the kinetic energy of a car of mass 1500kg travelling at 30m/s.

………

……… KE = …………………….....J

(2 marks)

To stop the car this kinetic energy must be converted into other forms such as thermal energy in the brakes and tyres.

The following table shows the typical stopping distances given in the Highway Code, a document that explains the safety rules of the road.

Speed in m/s	Thinking distance in m	Braking distance in m	Total stopping distance in m
10	7	8	15
20	14	32	46
30	21	72	93

c) We would say that the thinking distance is **directly proportional** to the speed of the car. This means that if you multiply the speed by a particular factor, the thinking distance is multiplied by the same factor (e.g. if you double one, the other doubles as well).

What would you expect the thinking distance to be if the car was travelling at 25m/s?

……

(1 mark)

d) The braking distance is **not** directly proportional to speed – in fact it is proportional to **speed squared**.

i) Check this by showing what happens to the braking distance when you double the speed.

……

……

(2 marks)

ii) *Why* do you think the braking distance depends on speed squared?

……..

……..

(1 mark)

iii) What would the braking distance be for a speed of 25m/s?

……..

……..

……..

(2 marks)

iv) What is the **total** stopping distance for a car travelling at 25m/s according to the Highway Code?

……

(1 mark)

e) The Highway Code was written in the 1930s. Suggest a reason why the stopping distances given in the Highway Code may be over-estimates when it comes to modern motoring.

…….

…….

…….

…….

(1 mark)

f) The deceleration of a car (i.e. the rate at which it is slowing down) can be calculated using the following equation:

$$\textbf{Deceleration} = \frac{\textbf{change in speed}}{\textbf{time}}$$

Where change in speed is equal to (initial speed – final speed) in m/s,
time is in s and deceleration has the unit m/s^2.

Calculate the time to for a car to stop if it slows from a speed of 30m/s to rest with a deceleration of $3m/s^2$.

……

……

……

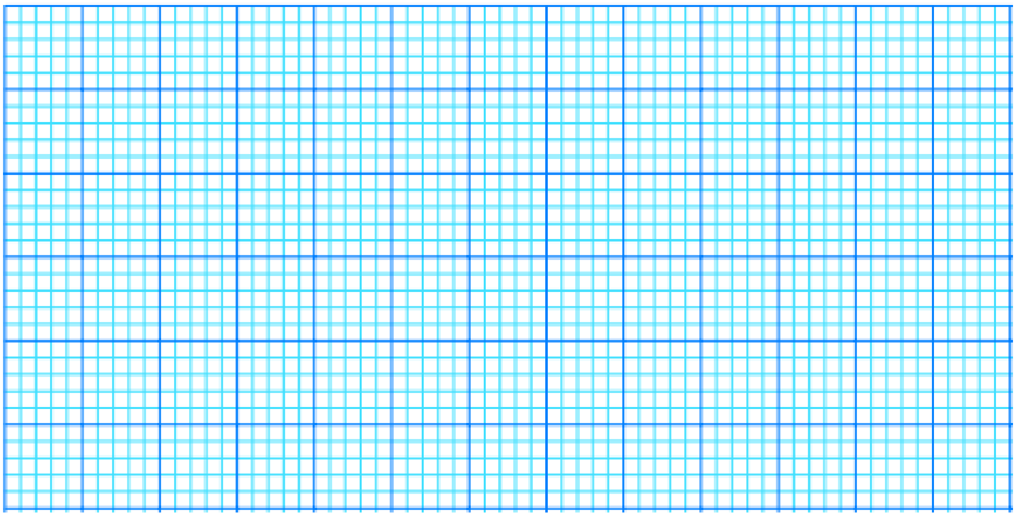
(2 marks)

g) A driver is travelling at 20m/s along a main road. He sees an obstruction in the road ahead and puts his foot on the brakes, decelerating at a constant rate of $10m/s^2$. If his reaction time is 0.5s, sketch a speed-time graph on the grid below for the period of time between when he first sees the obstruction and when the car stops. (3 marks)

Space for calculations if needed.

……

……



Total distance travelled can be calculated from the **area** under the line on a speed-time graph.

h) The obstruction was 28m ahead of him. **Use the graph** to calculate whether or not he hit the obstruction.

……

……

……

……

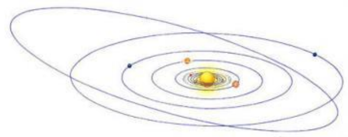
(3 marks)

End of Question 1

Physics Question 2

You may find the following information useful for this question:

1 million = 1000 000 or 1 x 10^6



a) A science fiction author wrote about an imaginary Solar System in a book. The information used in the book is shown below.

The planets orbit around a star called Dumbledore.

NOTE: The data given for the time of rotation, diameter and gravitational field strength (a measure of the strength of gravity) is **relative** to the Earth.

Planet	Distance from Dumbledore (millions of km)	Time of rotation of the planet on its axis (Earth = 1)	Diameter (Earth = 1)	Gravitational Field Strength (Earth = 1g)	Surface temperature (^{0}C)
Gryffindor	10	1.2	0.4	0.3	500
Ravenclaw	40	1.4	1.5	2.0	300
Slytherin	200	0.75	0.7	1.5	25
Hufflepuff	360	2.5	3.0	13.0	-50

i) Which of the planets in the table might humans be able to successfully inhabit?

………

Explain your choice of planet.

………

………

(2 marks)

The ***actual*** diameter of the Earth is 12 800km

ii) Calculate the ***actual*** diameter of Hufflepuff.

……… km

(1 mark)

iii) Calculate the ***actual*** time for one complete rotation of Ravenclaw on its axis.

……

………hours

(2 marks)

iv) Give two reasons why Gryffindor is unlikely to have an atmosphere.

……

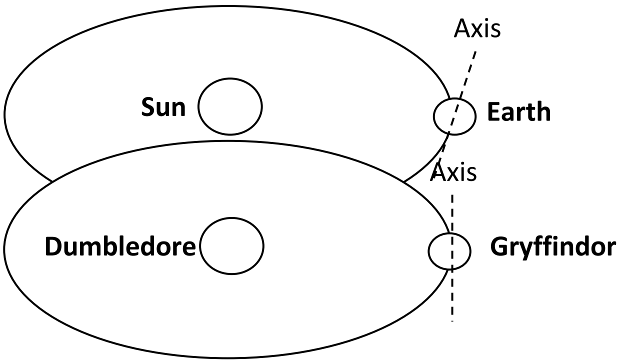
……

……

……

(2 marks)

The diagram below shows the orbit of planet Gryffindor and planet Earth.



v) Describe the differences in day-length and the seasons between planet Gryffindor and planet Earth.

……

……

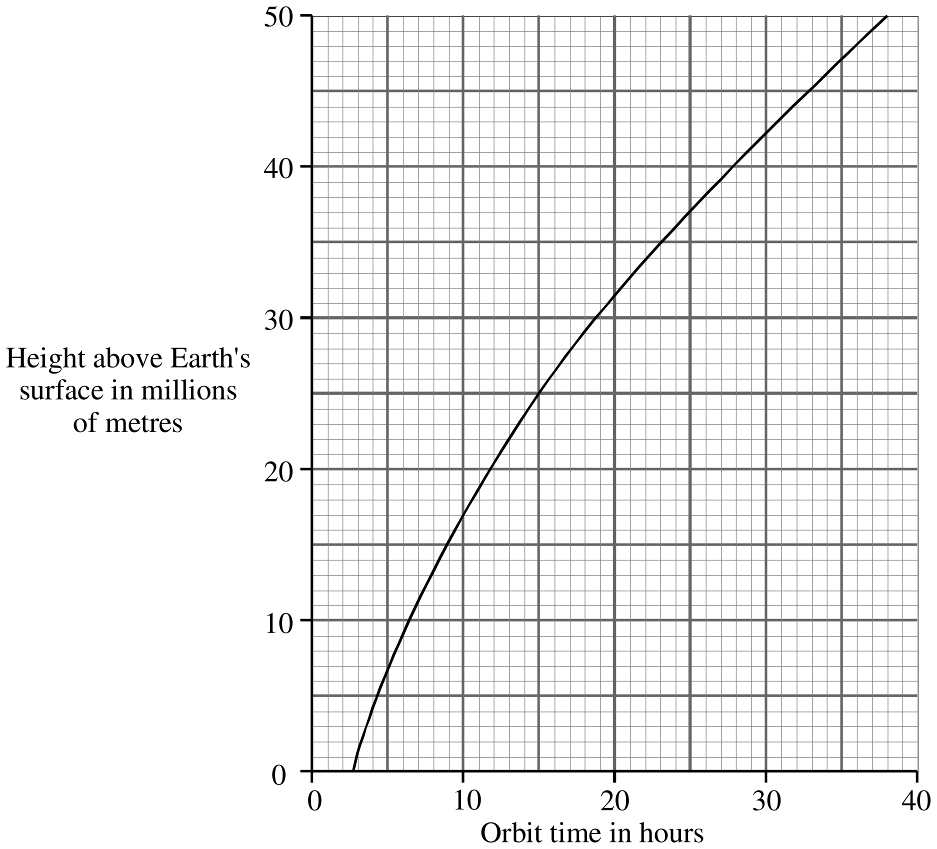
……

……

(2 marks)

The second part of this question is about artificial satellites.

b) The graph below shows how the orbit time of an artificial satellite depends on its height above the Earth's surface.



i) What is the relationship between the orbit time and the height above the Earth's surface?

....

....

(1 mark)

ii) Suggest a reason **why** the orbit time varies with height in this way.

....

....

....

(1 mark)

The table below gives some information about three satellites.

satellite name	purpose	orbit height above Earth's surface	approximate orbit time
Hubble space telescope	to observe the stars	612 km	1.5 h
NOAA-17	to monitor the Earth's atmosphere and oceans	833 km	1.7 h
Intelsat-906	geostationary communications satellite		24 h

c) Intelsat-906 is an example of a satellite in **geostationary orbit**. These satellites have an orbital time of 24 hours which mean that they remain above the same point on the Earth's surface.

Using the graph from earlier in this question, complete the table to show the orbital height of Intelsat-906. (1 mark)

d) NOAA-17 is in a polar orbit. This means that it travels around the earth from pole to pole as shown below.

i) Approximately how many orbits does NOAA-17 make in one day?

....

(1 mark)

ii) Explain how this type of orbit allows NOAA-17 to monitor all of the Earth's oceans.

....

....

....

(1 mark)

e) The orbital speed (or velocity) of a satellite can be calculated using the following equation

$$v = \frac{2\pi r}{T}$$

where v = orbital speed in m/s

r = radius of orbit in m (measured from the **centre** of the planet to the satellite)

T = time for one complete orbit in s (also called time period)

A satellite is in a geostationary orbit 36 000km above the Earth's surface. The radius of the Earth is 6400km.
Show that the orbital speed of this satellite is approximately 2150m/s.

....

....

....

....

(3 marks)

f) The speed of radio waves is 3.0×10^8 m/s (i.e. 300 000 000 m/s)

The geostationary satellite in part e) is used for telephone communications.

Estimate the time delay between a voice message being sent and received via this satellite.

....

....

....

(3 marks)

End of Question 2

BLANK PAGE

Name ________________________________

School ________________________________

The King’s School, Canterbury

Science Scholarship Paper 2021

General Science Section

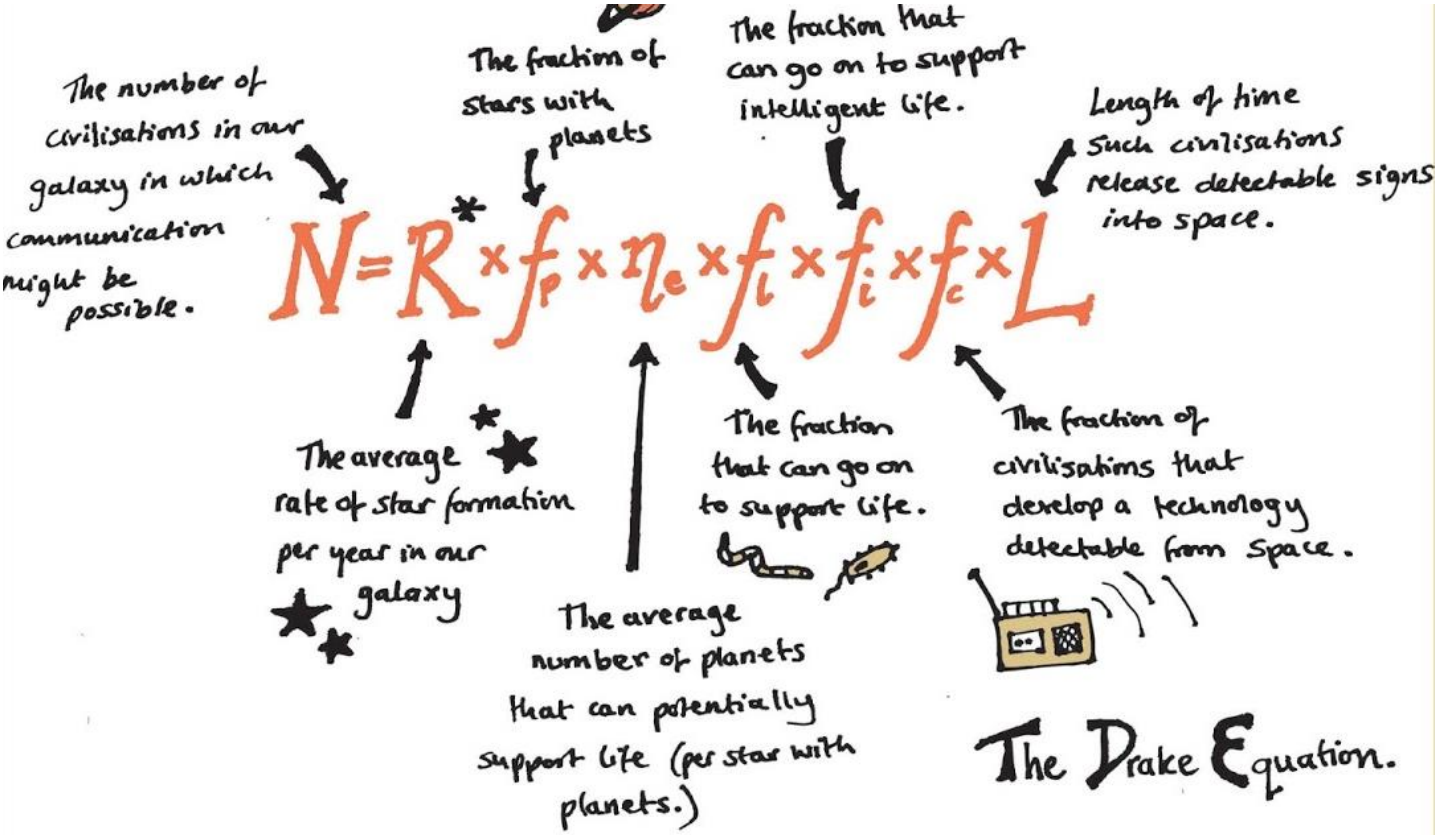
You must complete all questions in this section.

20 marks total.

	Mark

The Drake Equation, created in 1961 by American astrophysicist Professor Frank Drake (born in 1930), is an attempt to answer the question, “How many intelligent civilisations are there in our galaxy (with whom we might be able to communicate)?”.

The Drake Equation



a) What units of time must L be measured in for the equation to be consistent?

……….

(1 mark)

b) Calculate N from the following estimated values, rounding to the nearest whole number:

$R = 3.5$
$f_p = 0.45$
$n_e = 0.50$
$f_l = 0.20$

$f_i = 0.05$
$f_c = 0.50$
$L = 500$

………

………

(2 marks)

c) What in your view is the value of n_e for our own solar system? Justify your answer.

……

……

……

(2 marks)

d) What kinds of "communication" do you think are relevant to this question?

……

……

……

……

(2 marks)

e) Energy consumption & transformation via respiration is one characteristic shared by all life-forms on Earth. Give three other characteristics.

……

……

……

……

(3 marks)

f) What constitutes "intelligent life" in your view? Give some characteristics of a life-form that could make it "intelligent".

……

……

……

……

……

(3 marks)

g) Place the following events in the Earth's history in chronological order and by doing so match them with the dateline by writing the correct letters on the dotted lines (.....).

(5 marks)

A	Dinosaurs became extinct	.... 4.6 billion years ago
B	Modern humans started to evolve	.... 3.8 billion years ago
C	The ozone layer formed, allowing life to colonise land.	.... 3.6 billion years ago
D	The iron age	.... 600 million years ago
E	The Sun formed from the collapse of a large cloud of matter	.... 65 million years ago
F	Humans walked on the moon	.... 14 million years ago
G	The first great apes appeared	.... 200,000 years ago
H	The surface of Earth changed from molten to solid rock	.... 5,500 years ago
I	The invention of the wheel	.... 3,300 years ago
J	Single-cell life appeared	.... 50 years ago

h) The 'stone age' then the 'bronze age', the 'iron age', the 'dark ages', the 'middle ages', the 'industrial age'… what age do you think we are now in? Give a name for it and justify your answer.

....

....

....

....

(2 marks)

END OF GENERAL SCIENCE QUESTION

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2021

<u>Physics Section</u>

You should complete <u>one</u> of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Physics Question 1

You may find the following equation helpful for this question

$$\textbf{Average speed (in m/s)} = \frac{\textbf{distance (in m)}}{\textbf{time (in s)}}$$

This question is about maintaining a safe braking distance whilst driving.

It is not possible to stop a car immediately as there is a time delay caused by both the reaction time of the driver and by the fact that it takes time to physically stop the car.

The total distance travelled by a stopping car can be calculated using the following equation:

Total stopping distance = thinking distance + braking distance

…where the thinking distance is the distance travelled whilst the driver reacts to a situation and the braking distance is the distance travelled once the brakes are applied.

a) A typical reaction time for a human is 0.25s.

i) If a car was moving at 30m/s, how far would it travel during this reaction time?

………

(1 mark)

ii) State one factor that might affect a human's reaction time and hence the thinking distance.

………..

(1 mark)

b) The braking distance depends on how much kinetic energy the car has before the brakes are applied.

The kinetic energy of an object can be found using the following equation:

kinetic energy = ½ x mass x speed squared

or in symbols

$$KE = \frac{1}{2} m v^2$$ (v stands for speed in this case)

Where mass is in kg, speed is in m/s and kinetic energy is in J

Calculate the kinetic energy of a car of mass 1500kg travelling at 30m/s.

……

…………………………………………………………………………………………………… KE = ……………………......J

(2 marks)

To stop the car this kinetic energy must be converted into other forms such as thermal energy in the brakes and tyres.

The following table shows the typical stopping distances given in the Highway Code, a document that explains the safety rules of the road.

Speed in m/s	Thinking distance in m	Braking distance in m	Total stopping distance in m
10	7	8	15
20	14	32	46
30	21	72	93

c) We would say that the thinking distance is **directly proportional** to the speed of the car. This means that if you multiply the speed by a particular factor, the thinking distance is multiplied by the same factor (e.g. if you double one, the other doubles as well).

What would you expect the thinking distance to be if the car was travelling at 25m/s?

…….

(1 mark)

d) The braking distance is **not** directly proportional to speed – in fact it is proportional to **speed squared**.

i) Check this by showing what happens to the braking distance when you double the speed.

……

……

(2 marks)

ii) *Why* do you think the braking distance depends on speed squared?

……..

……..

(1 mark)

iii) What would the braking distance be for a speed of 25m/s?

……..

……..

……..

(2 marks)

iv) What is the **total** stopping distance for a car travelling at 25m/s according to the Highway Code?

……

(1 mark)

e) The Highway Code was written in the 1930s. Suggest a reason why the stopping distances given in the Highway Code may be over-estimates when it comes to modern motoring.

……….

……….

……….

……….

(1 mark)

Turn over

BLANK PAGE

Question 1 continues on the next page

f) The deceleration of a car (i.e. the rate at which it is slowing down) can be calculated using the following equation:

$$\textbf{Deceleration} = \frac{\textbf{change in speed}}{\textbf{time}}$$

Where change in speed is equal to (initial speed – final speed) in m/s,

time is in s and deceleration has the unit m/s^2.

Calculate the time to for a car to stop if it slows from a speed of 30m/s to rest with a deceleration of $3m/s^2$.

……

……

……

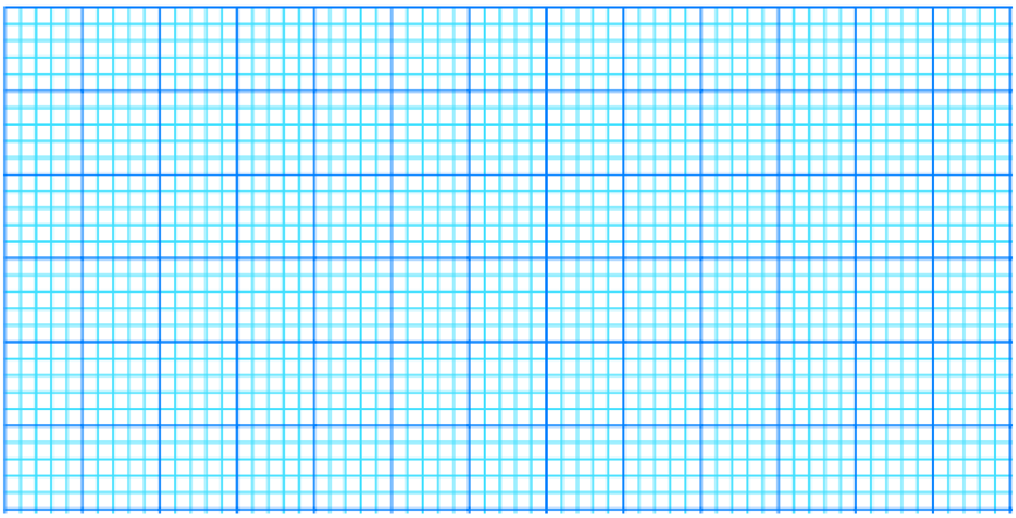
(2 marks)

g) A driver is travelling at 20m/s along a main road. He sees an obstruction in the road ahead and puts his foot on the brakes, decelerating at a constant rate of $10m/s^2$. If his reaction time is 0.5s, sketch a speed-time graph on the grid below for the period of time between when he first sees the obstruction and when the car stops. (3 marks)

Space for calculations if needed.

……

……



Total distance travelled can be calculated from the **area** under the line on a speed-time graph.

h) The obstruction was 28m ahead of him. **Use the graph** to calculate whether or not he hit the obstruction.

………

………

………

………

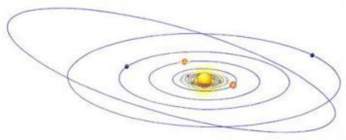
(3 marks)

End of Question 1

Physics Question 2

You may find the following information useful for this question:

1 million = 1000 000 or 1 x 10^6



a) A science fiction author wrote about an imaginary Solar System in a book. The information used in the book is shown below.

The planets orbit around a star called Dumbledore.

NOTE: The data given for the time of rotation, diameter and gravitational field strength (a measure of the strength of gravity) is **relative** to the Earth.

Planet	Distance from Dumbledore (millions of km)	Time of rotation of the planet on its axis (Earth = 1)	Diameter (Earth = 1)	Gravitational Field Strength (Earth = 1g)	Surface temperature (^{0}C)
Gryffindor	10	1.2	0.4	0.3	500
Ravenclaw	40	1.4	1.5	2.0	300
Slytherin	200	0.75	0.7	1.5	25
Hufflepuff	360	2.5	3.0	13.0	-50

i) Which of the planets in the table might humans be able to successfully inhabit?

………

Explain your choice of planet.

………

………

(2 marks)

The ***actual*** diameter of the Earth is 12 800km

ii) Calculate the ***actual*** diameter of Hufflepuff.

…… km

(1 mark)

iii) Calculate the ***actual*** time for one complete rotation of Ravenclaw on its axis.

………

………hours

(2 marks)

iv) Give two reasons why Gryffindor is unlikely to have an atmosphere.

………

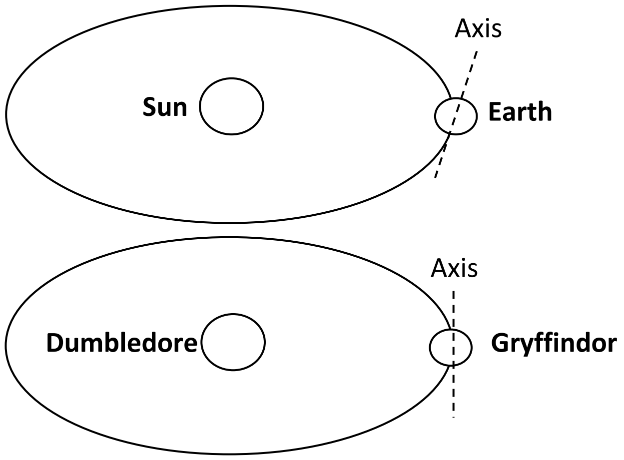
………

………

………

(2 marks)

The diagram below shows the orbit of planet Gryffindor and planet Earth.



v) Describe the differences in day-length and the seasons between planet Gryffindor and planet Earth.

………

………

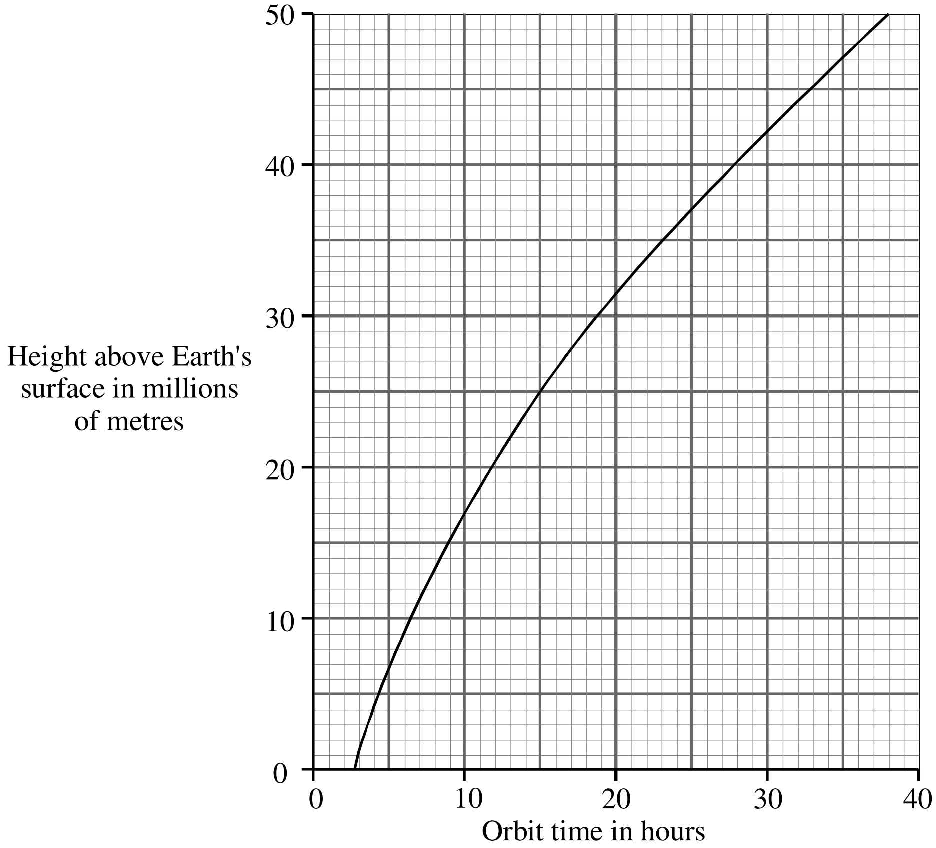
………

………

(2 marks)

The second part of this question is about artificial satellites.

b) The graph below shows how the orbit time of an artificial satellite depends on its height above the Earth's surface.



i) What is the relationship between the orbit time and the height above the Earth's surface?

....

....

(1 mark)

ii) Suggest a reason **why** the orbit time varies with height in this way.

....

....

....

(1 mark)

The table below gives some information about three satellites.

satellite name	purpose	orbit height above Earth's surface	approximate orbit time
Hubble space telescope	to observe the stars	612 km	1.5 h
NOAA-17	to monitor the Earth's atmosphere and oceans	833 km	1.7 h
Intelsat-906	geostationary communications satellite		24 h

c) Intelsat-906 is an example of a satellite in **geostationary orbit**. These satellites have an orbital time of 24 hours which mean that they remain above the same point on the Earth's surface.

Using the graph from earlier in this question, complete the table to show the orbital height of Intelsat-906. (1 mark)

d) NOAA-17 is in a polar orbit. This means that it travels around the earth from pole to pole as shown below.

i) Approximately how many orbits does NOAA-17 make in one day?

....

(1 mark)

ii) Explain how this type of orbit allows NOAA-17 to monitor all of the Earth's oceans.

....

....

....

(1 mark)

Question 2 continues on the next page

e) The orbital speed (or velocity) of a satellite can be calculated using the following equation

$$v = \frac{2\pi r}{T}$$

where v = orbital speed in m/s

r = radius of orbit in m (measured from the **centre** of the planet to the satellite)

T = time for one complete orbit in s (also called time period)

A satellite is in a geostationary orbit 36 000km above the Earth's surface. The radius of the Earth is 6400km.
Show that the orbital speed of this satellite is approximately 2150m/s.

....

....

....

....

(3 marks)

f) The speed of radio waves is 3.0×10^8 m/s (i.e. 300 000 000 m/s)

The geostationary satellite in part e) is used for telephone communications.

Estimate the time delay between a voice message being sent and received via this satellite.

....

....

....

(3 marks)

End of Question 2

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2021

<u>Chemistry Section</u>

You should complete <u>one</u> of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Chemistry Question 1

Metallic iron can be produced by heating iron oxide powder with aluminium powder.

The word equation for the reaction is shown below:

aluminium + iron oxide → iron + aluminium oxide

a) What does the reaction tell you about the position of iron and aluminium in the reactivity series of metals?

……

(1 mark)

b) Which substance is being reduced during the reaction?

……..

(1 mark)

c) Explain why the two starting materials should both be powdered?

……..

……..

(2 marks)

d) Would you expect the mass of iron produced to be more, or less than the mass of iron oxide which reacted with the aluminium? Explain your answer.

……..

……..

(2 marks)

The equation below shows the balanced chemical equation for the same reaction. It shows the ratio in which the chemicals are needed for the reaction.

$$\mathbf{2\,Al + 1\,Fe_2O_3 \rightarrow 2\,Fe + 1\,Al_2O_3}$$

e) Masses of atoms are measured in atomic mass units (amu). Each atom of aluminium has an atomic mass of 27 amu and each atom of iron has an atomic mass of 56 amu. Using this information, calculate the mass of iron which would be produced if 1.8g of aluminium reacted with iron oxide. Show your working.

……..

……..

……..

……..

(3 marks)

f) A student performed the reaction with 1.8g of aluminium. Using the atomic masses, he correctly calculated the mass of iron he would expect. However, after the experiment he found that he obtained less than this amount. Other than human error, suggest two possible scientific explanations for this.

……..

……..

……..

……..

(2 marks)

g) Although this reaction produces a lot of heat, it will not start until the powered iron oxide and aluminium are at a high temperature. Suggest a reason for this.

……..

……

(1 mark)

h) The energy produced by a reaction can be calculated using the equation shown below.

$$Q = m\ c\ \Delta T$$

Q= energy in joules (J)	m = mass in grams (g)
c = specific heat capacity of the mixture (in J/°C/g)	ΔT = temperature change (in °C)

Find the amount of energy released when a substance of mass 0.225kg and specific heat capacity 0.670 J/°C/g rises in temperature from 20°C to 2120°C.

………

………

………

(3 marks)

i) This reaction is an example of an exothermic reaction, where heat energy is produced. Considering the information in the previous question, what state of matter will the iron be in once this reaction is complete?

………

(1 mark)

j) In a separate reaction, 510g of a different mixture was reacted which produced a temperature change of 2215°C. This resulted in 420 kilojoules (kJ) of energy being released.

Calculate the specific heat capacity for the reaction mixture.

Give your answer to an appropriate number of significant figures.

………

………

…… J/°C/g

(4 marks)

End of Question 1

Chemistry Question 2

A student made some crystals of copper sulfate by following these instructions:

Warm some dilute sulphuric acid and add solid copper carbonate until no more will react. Evaporate water from the filtrate until you have a saturated solution, then leave to cool.

a) Write a word equation for the reaction of dilute sulphuric acid with copper carbonate.

……….

……….

(2 marks)

b) How would the student know when he had added enough copper carbonate?

……….

……….

(2 marks)

c) What is meant by a 'saturated solution'?

……….

……….

(2 marks)

d) When the saturated solution was cooled, blue crystals of copper sulfate appeared. What does this tell you about the solubility of copper sulfate in water?

……….

……….

(2 marks)

e) A student got distracted during the practical and did not watch the evaporation. She only returned to her experiment after all the water had disappeared. She did not see any blue crystals. What would she have seen instead? Explain your answer.

……….

……….

……….

(2 marks)

f) In a subsequent lesson, the copper carbonate ran out. A student suggested that it might still be possible to produce copper sulfate by doing the same experiment, but using pieces of copper metal instead of copper carbonate. What do you think would happen if this was done? Explain your answer.

……….

……….

……….

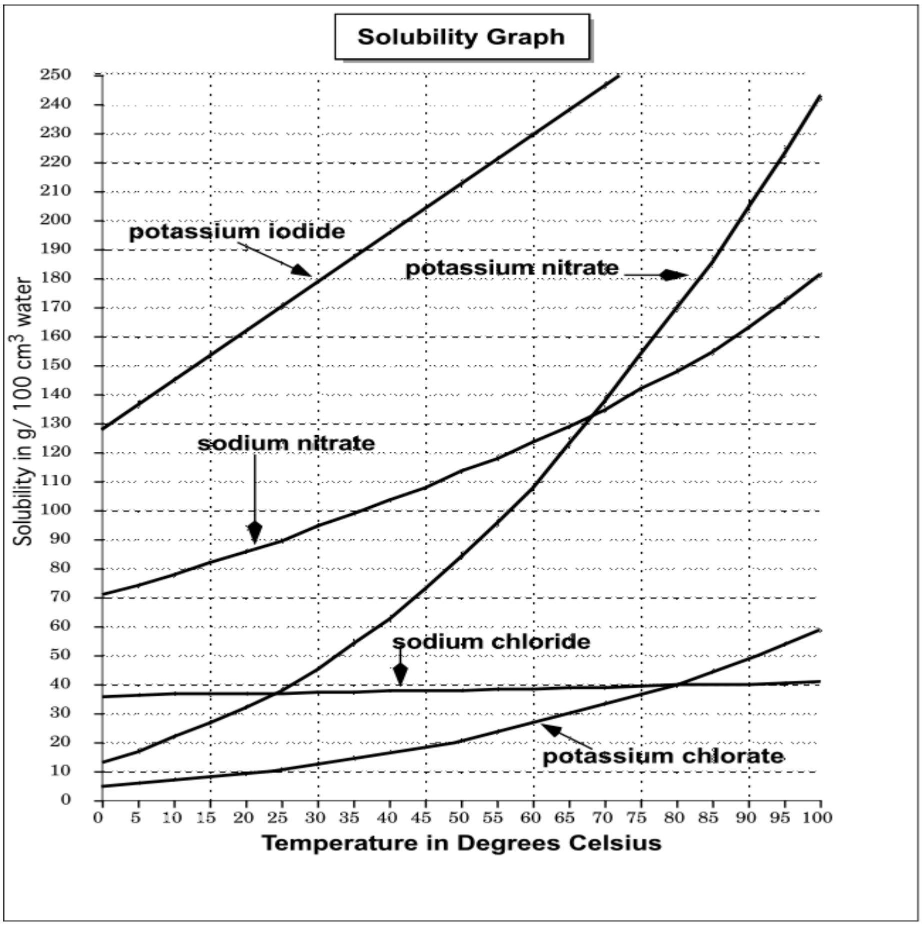
(2 marks)

Turn over

BLANK PAGE

Question 2 continues on the next page

The solubility of a substance at varying temperatures can be determined by experiment. Typical solubility curves can be seen in the graph below.



g) What is the maximum amount of potassium iodide that can dissolve in 100g of water at 50°C?

……

(1 mark)

h) At what temperature are the solubilities of sodium nitrate and potassium nitrate the same?

……

(1 mark)

i) What is the maximum amount of sodium chlorate that can dissolve in 45g of water at 90^{o}C?

……….

……….

(2 marks)

j) A Saturated solution of potassium nitrate in 100g of water is made at 60^{o}C and then cooled to 30^{o}C. Use the graph to determine the mass of potassium nitrate crystals that would form.

……….

……….

……….

(2 marks)

k) It is not just solids that dissolve in water - gases dissolve in water too. The solubility of oxygen in water at 25^{o}C and atmospheric pressure is 40 milligrams (mg) per litre. Oxygen makes up approximately 21% of the composition of air at atmospheric pressure. Using the information given in the question, calculate the amount of oxygen that will dissolve in water at 25^{o}C. Show all of your workings.

……….

……….

……….

……….

(2 marks)

End of Question 2

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2021

Biology Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Biology – Question 1

Here is a key to the common groups of invertebrates (animals without backbones) found in UK gardens.

1	Animals without legs	go to 2
	Animals with legs	go to 5
2	Animals divided into rings or segments	go to 3
	Animals not divided into rings or segments	go to 4
3	Tapered body	Fly larvae
	Cylindrical body	Worms
4	Coiled shell	Snails
	No shell	Slugs
5	Three pairs of legs	Insects
	More than three pairs of legs	go to 6
6	Four pairs of legs	go to 7
	More than four pairs of legs	go to 9
7	Body divided into two distinct parts	Spiders
	Body not clearly divided into two distinct parts	go to 8
8	Legs much longer than body	Harvestmen
	Legs much shorter than body	Mites
9	Seven pairs of legs	Woodlice
	More than seven pairs of legs	go to 10
10	All legs alike	go to 11
	Front pairs of legs jointed, back pairs of legs very short	Caterpillars
11	One pair of legs per body segment	Centipedes
	Two pairs of legs per body segment	Millipedes

Use the key to answer the following questions:

a) Identify this animal. Its body is divided into twelve segments, there are jointed legs on the front three segments and short legs on five of the back segments.

…….. (1 mark)

b) Identify three groups of animals mentioned in the key that have eight legs or more.

i. ……………………………………………………………………………………………........... (1 mark)

ii. …………………………………………………………………………………………………….. (1 mark)

iii. …………………………………………………………………………………………………….. (1 mark)

c) State one similarity and one difference between slugs and snails.

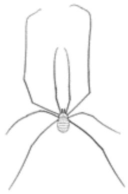
i. Similarity

……..

ii. Difference

………(2 marks)

d) Circle the larger of the two animals shown below.

 Magnification x 0.5	 Magnification x 10

(1 mark)

e) Predict which one of these animals hunts, kills and eats its prey. Give a reason for your choice.

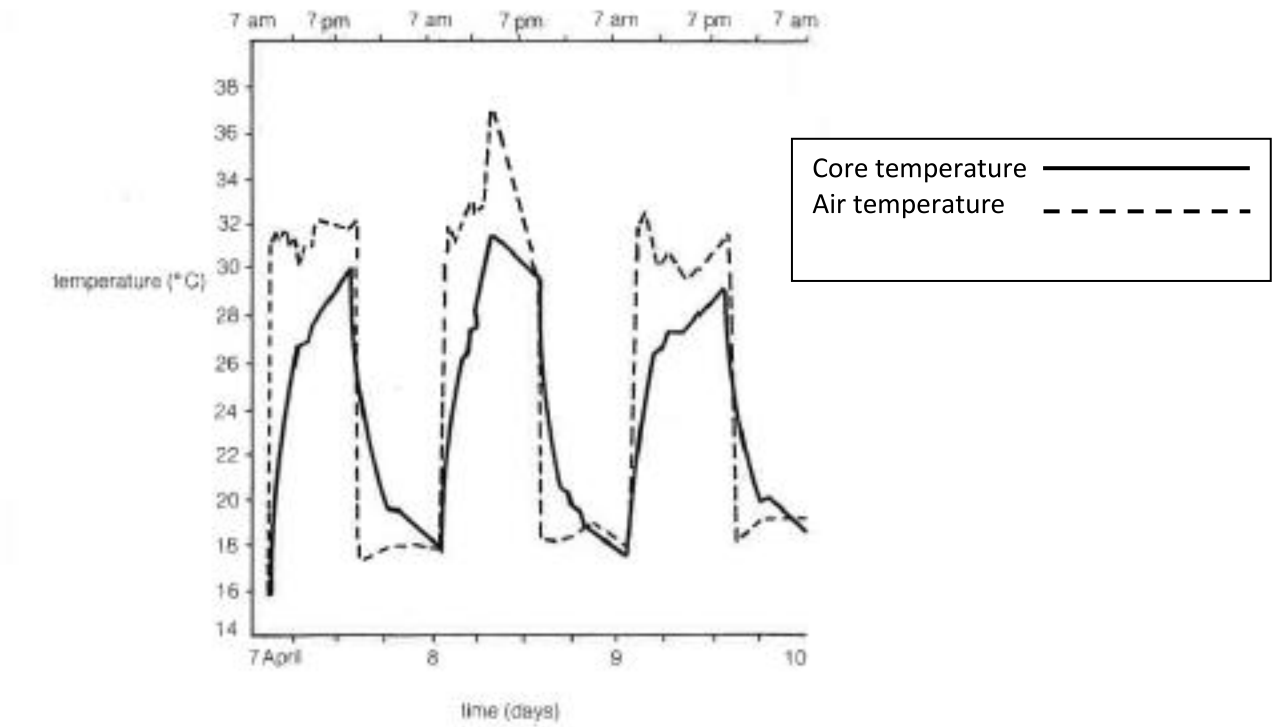
……

……

………..

(2 marks)

A Californian scientist kept a python snake in a large cage in a garden. At regular intervals over a period of three days he measured the python's core temperature and the temperature of the air in the cage. The readings are shown on the graph below.



f) Do you think the python controls its internal body temperature? Give reasons for your answer.

……

……

……

……

(2 marks)

g) What could the python do to increase the rate at which it warmed up in the morning?

……

……

(1 mark)

h) What was the maximum body temperature reached by the python over the three day experiment?

……

(1 mark)

i) Give three different reasons why the python's body temperature might have been slightly lower on day three of the experiment.

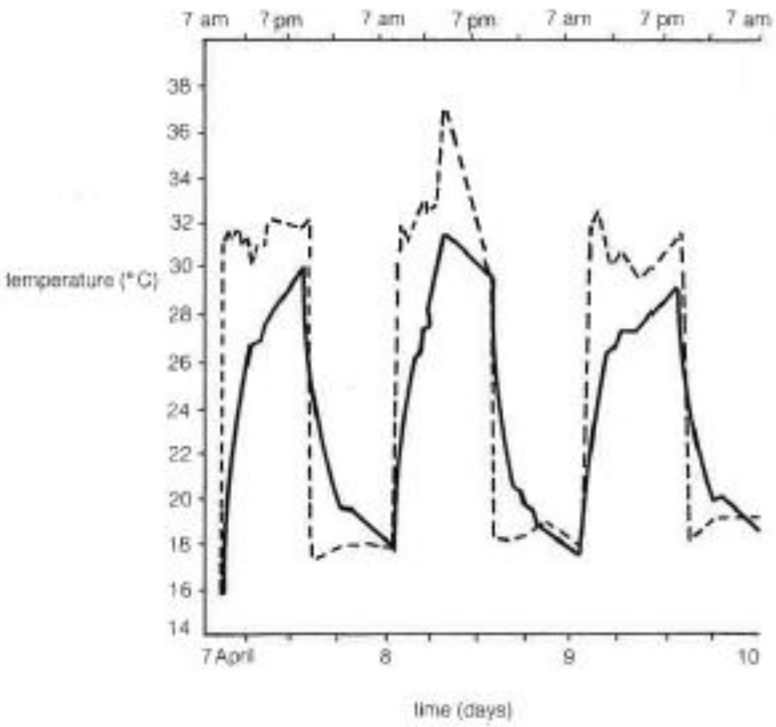
i. ……

ii. ……

iii. ……

(3 marks)

j) If the scientist had performed the same experiment with a cat, kept in the same conditions, sketch how the cat's core body temperature would change on the graph below.



(1 mark)

Question 1 continues on the next page

k) Monkeys control their core body temperature at 38°C. Monkeys that live in very hot climates have adaptations to help them lose body heat. Describe three adaptations you might see on monkeys that are adapted to live in very hot climates. Give reasons for each answer.

i. ……

……

ii. ……

……

iii. ……

……

(3 marks)

End of Question 1

Biology Question 2

a) Study the illustrations of birds' feet below and match each with one of the following descriptions of the bird. **Write the letter i – v next to the matching foot shape.**

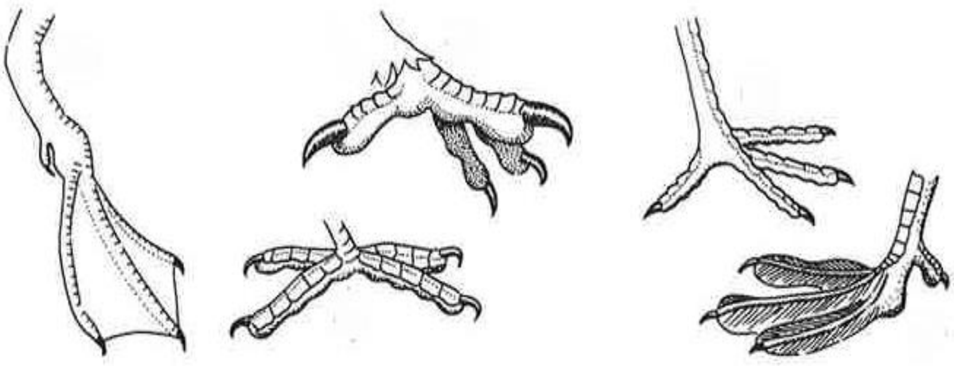
i. Carnivorous bird that catches rabbits and other small animals as prey.

ii. Herbivorous bird that sits on the surface of a lake or river and paddles along on water

iii. Carnivorous bird that walks across soft mud looking for worms.

iv. Carnivorous bird that spends many hours standing on tree branches, it has to hold on securely

v. Omnivorous bird that hops along solid ground looking for worms, seeds or breadcrumbs.



(3 marks)

b) A ground squirrel, a salmon and a Jay all have a mass of 200g.

		
Ground squirrel 200g	Salmon 200g	Jay 200g

The ground squirrel runs along the ground at 3km/hr, using 4kJ (i.e. 4000J) of energy to run 1km. A salmon swims at 3km/hr using 0.3kJ to swim 1km. A jay uses 1.5kJ to fly 1km at a speed which is about 20 times faster than the squirrel runs or the salmon swims.

Which method of movement - running, swimming or flying - uses the least energy per km?

.... (1 mark)

c) Describe two adaptations that help a salmon move quickly through water. Give reasons for each answer.

i. ……

……

ii. ……

……

(2 marks)

d) Suggest why the ground squirrel has to use so much energy for running. In your answer include details of how energy might be wasted in moving over land.

……

……

……

(2 marks)

e) How much energy would the salmon use if it swam for 1 hour? Show your workings.

……

……

……

(2 marks)

f) 1g of fat provides 36kJ of energy. How far could the jay fly on a store of 1g of fat? Show your workings.

……

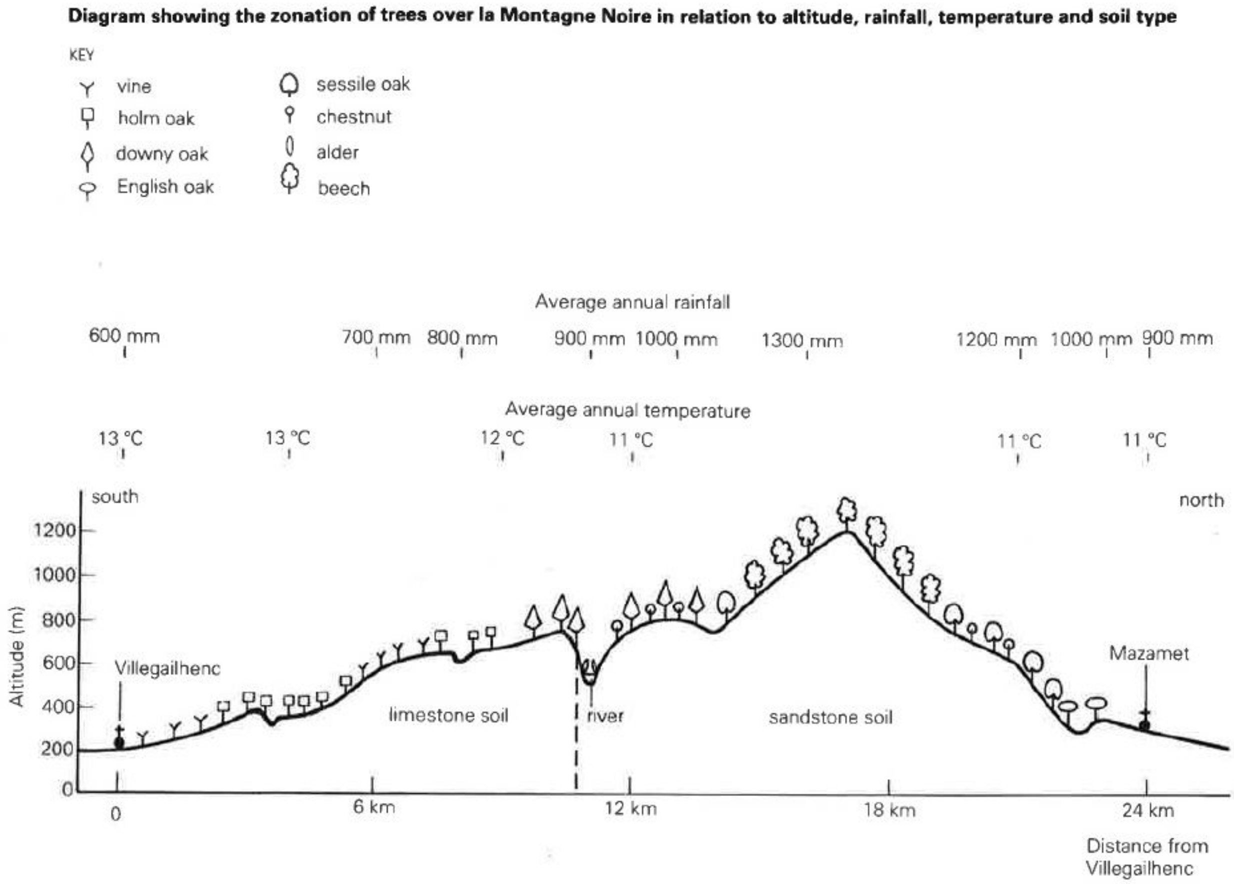
……

……

(2 marks)

Question 2 continues on the next page

The diagram below shows the distribution of different types of trees on the Montagne Noire in relation to altitude (height above sea level), rainfall, temperature and soil type.



g) Which type of tree is found on the summit of la Montagne Noire?

………

(1 mark)

h) Which type of tree is only ever found growing with another to form a mixed woodland?

………

(1 mark)

i) Which type of tree is able to grow on both limestone soil and sandstone soil?

………

(1 mark)

j) Using the evidence from the diagram, compare Holm Oak growth and English Oak growth under three different conditions.

i) Altitude :………

………

ii) Average rainfall :………

………

iii) Average annual temperature :……………………………………………………………………………………………

………

(3 marks)

k) As global temperatures rise, how might the distribution of trees on Montagne Noire change over the next 100 years?

………

………

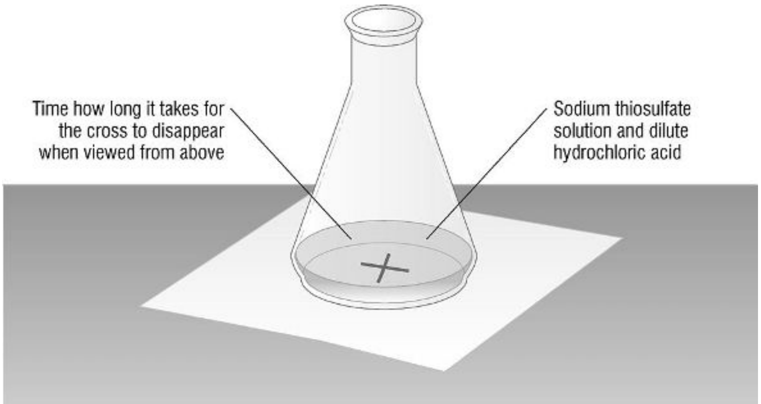
………

(2 marks)

End of question 2

Experiment to investigate the effect of changing the concentration of reactant T in a reaction between reactants T and A

T + A → precipitate (enough to block out the cross under the conical flask). We will call this the **end-point** of the reaction



Method

1. Measure 10 cm^3 of A and 10 cm^3 of T in separate clean measuring cylinders labelled A and T. The latter will be your maximum concentration of T (100%).
2. Add T to the conical flask and place on top of the cross (see diagram).
3. Now add A to the conical flask and start the stop-clock.
4. Stop the stop-clock when you can no longer see the cross from above. We will call this the **end-point** of the reaction.
5. Next you will be repeating the experiment using a weaker concentration of T. Combine 8cm^3 of T with 2cm^3 of distilled water in the same test tube. This will give you an 80% concentration. Measure out another 10cm^3 of A in another test tube, as before.
6. Add the diluted mixture of T to a **clean** conical flask placed on top of the cross. Add A, start the stop-clock and record the end-point as before.
7. Repeat the experiment with a 60% concentration of T. To achieve this you will need 6cm^3 of T and 4 cm^3 of distilled water.
8. Repeat for the final time with a 40% concentration of T: calculate the volumes needed. The combined volume of T and distilled water must be 10cm^3.

Results

Complete the table with the values you have chosen to achieve 40% concentration and the time taken to the end-point for each of the four experiments. (3 marks)

Experiment	1	2	3	4
Volume of A/cm^3	10	10	10	10
Volume of T/cm^3	10	8	6	
Volume of distilled water/cm^3	0	2	4	
Percentage concentration of T/%	100	80	60	40
Time taken for cross to disappear (the end point)/s				

State one thing that you did during your experiment to make this a fair test.

……

(1 mark)

What is the relationship between the concentration of T and the time taken to the end-point?

……

……

(1 mark)

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2022

Physics Section

You should complete one of the questions in this section.

Circle the question you have attempted.

Question	Mark
1	
2	

Physics Question 1

In this question you will be using some equations that you may not be familiar with. All of the information that you need will be given so read this carefully before attempting the questions.

Equation 1

Electrical power = current x voltage or in symbols $P = I \times V$

Power is measured in Watts (W), current in Amps (A) and voltage in Volts (V)

A milliamp (mA) is equal to 0.001A (or 10^{-3}A)

Equation 2

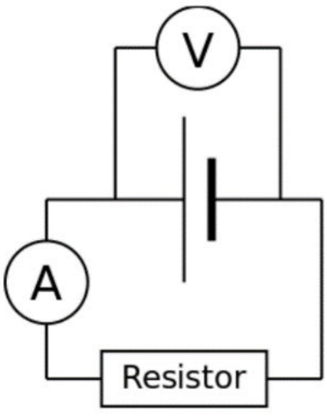
Energy = Power x time or in symbols $E = P \times t$

Energy is measured in Joules (J), power is measured in W and time is measured in seconds (s).

This question is about energy in a chemical cell and whether or not other technology could easily replace the chemical cell.

The most common chemical cell is probably the 'AA battery'.

One of these cells is connected to a resistor in a circuit as shown below.



The voltage across the cell and the current in the circuit were measured at intervals throughout the day.

The results are shown in the table.

Elapsed time /hours	Voltage /V	Current /mA
0	1.6	200
1	1.6	200
3	1.4	175
6	1.2	150
7	1.1	140
8	0.2	25

a) Why do you think the results are changing in this way throughout the course of the day?

……

……

(1 mark)

b) Convert the initial current in the cell to Amps (A).

……

(1 mark)

c) Using one of the provided equations, show that the power delivered by the cell when timing started was about 0.3W

……

……

(2 marks)

d) Using one of the provided equations, show that the energy delivered by the cell in the first hour of the experiment was approximately 1150J.

……

……

(2 marks)

e)

i) If the cell remained at the initial voltage and current for the full 8 hours of the experiment, what would be the total energy delivered by the cell?

………

………

(1 mark)

ii) In fact the total energy delivered by the cell is 6370J. Suggest why this value is different to the one that you calculated. You should use the data in the table to support your answer.

……

……

(1 mark)

An alternative technology uses a component called a supercapacitor to store charge.

The capacitance (C) of the supercapacitor is measured in Farads (F).

For a supercapacitor, the energy stored is given by $\mathbf{E = \frac{1}{2} C V^2}$ where V is the voltage across the capacitor when it is charged.

f) Consider a supercapacitor with a capacitance of 15F that is charged so that it has a voltage of 2.8V across the terminals.

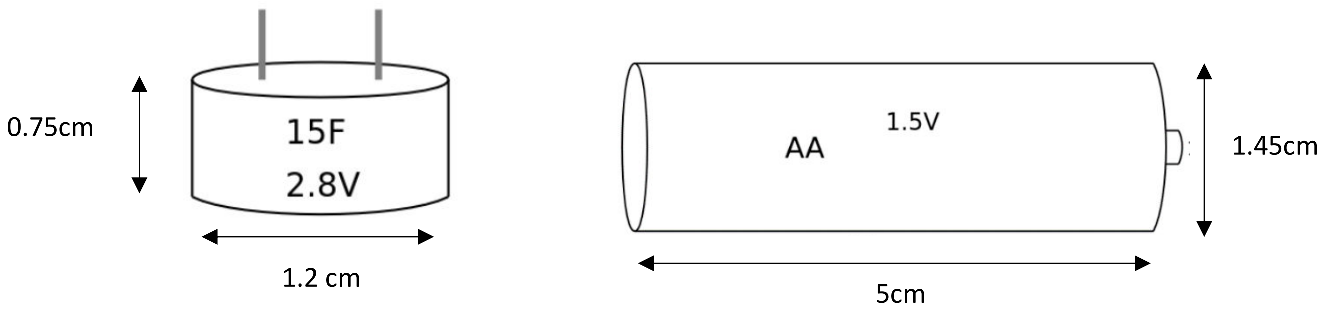
Show that the energy stored in this case is approximately 60J.

……

……

(2 marks)

The dimensions of the supercapacitor and the AA cell are shown below



The volume of a cylinder is given by the following equation

$$\mathbf{V = \pi\, r^2 \times l}$$

Where r = radius of cylinder, l = length of cylinder and π is a constant (3.14).

g) Calculate the volume of both the supercapacitor and the AA cell.

Volume of supercapacitor:

………

……… cm^3

Volume of cell:

………

……… cm^3

(3 marks)

Question 1 continues on the next page

Energy density can be used to compare the two sources of power.

Energy density is defined as the **energy stored per cm^3.**

h) From earlier in the question we saw that the energy stored by the supercapacitor is 60 J and the energy stored by the AA cell is 6370 J. Calculate the energy density for each.

Energy density of supercapacitor:

…….

…… J/ cm^3

Energy density of cell:

…….

…… J/ cm^3

(3 marks)

i) By considering the volumes, calculate how many supercapacitors would fit into an object the size of an AA cell?

…….

…….

…….

(1 mark)

j) Using your calculations above, discuss whether or not it is likely that we will replace AA cells with equivalent devices made from supercapacitors.

…….

…….

…….

…….

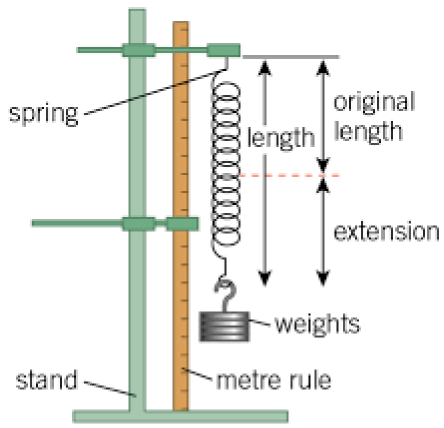
…….

(3 marks)

End of Question 1

Physics Question 2

Jo carried out an experiment looking at how a spring behaves when various weights are hung from it.



She obtained the following results:

Weight/N	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Length of spring /cm	6.5	7.0	7.5	8.0	8.5	9.0	11.0	14.5

a)

i) What was the original length of the spring?

....

(1 mark)

ii) Describe one technique that Jo might have used to make her experiment more accurate.

....

....

(1 mark)

b) If the spring is overloaded it will be over-stretched – we say that it has gone past its **elastic limit.**

i) Has the spring in Jo's experiment gone past its elastic limit? Explain your answer.

....

....

(1 mark)

ii) The **extension** of a spring is the amount that it has stretched **from its original length.** Complete the following table to show how the extension of the spring changed during Jo's experiment:

Weight/N	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Extension of spring /cm								

(2 marks)

Jo noticed that as long as the spring did not go past its elastic limit, when she doubled the weight, the extension doubled and when she tripled the weight, the extension tripled. She found that this worked for any multiplying factor.

Her teacher told her that this is known as a **directly proportional relationship.**

c) Using this idea, what would the **extension** be if she added the following weights to the spring?

0.45N ………

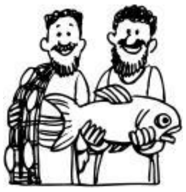
0.01N ………

0.34N ………

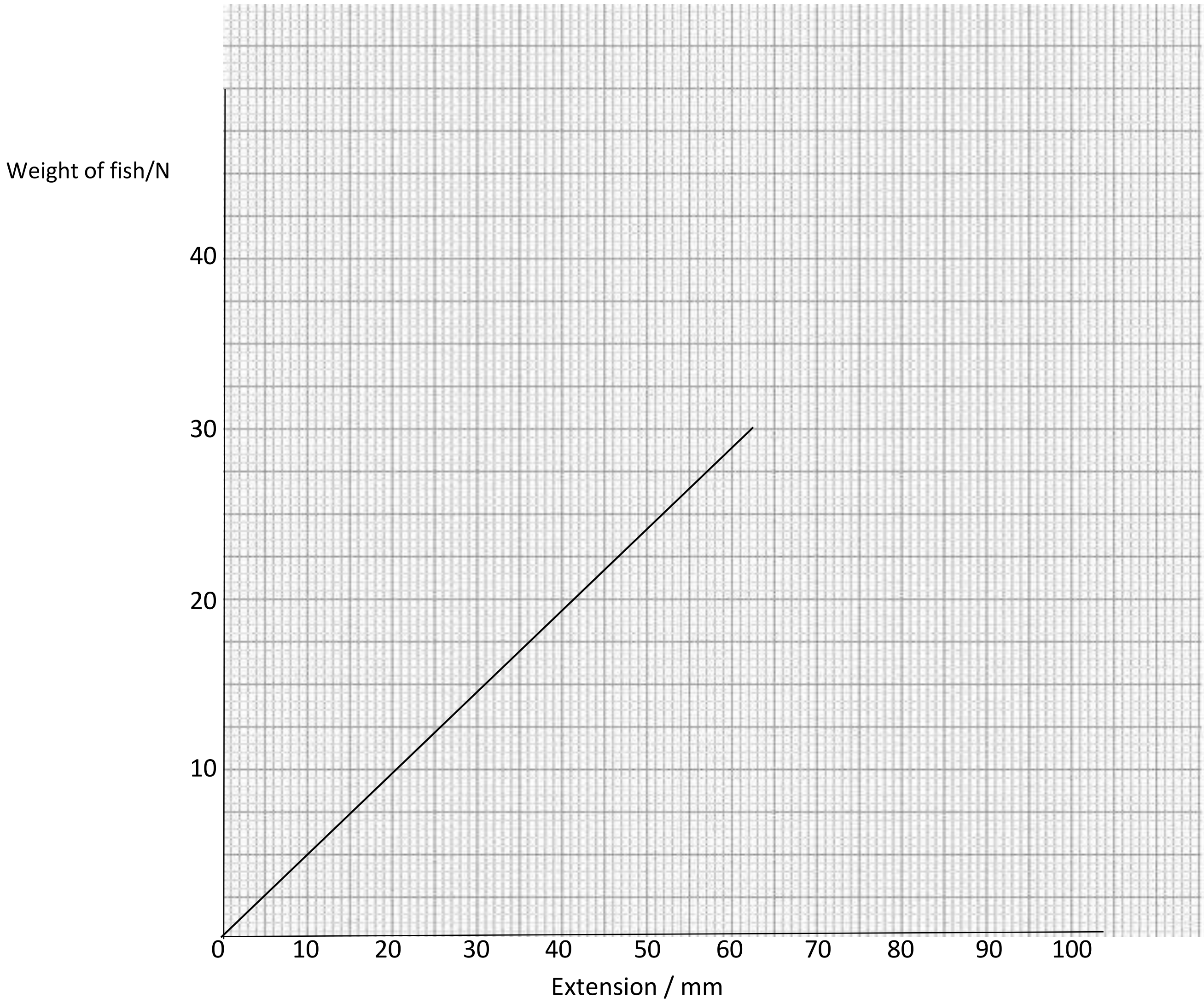
(3 marks)

Question 1 continues on the next page

James and Mark went fishing. They each weighed the fish that they caught on their own Newton balances. The extension of the spring inside each balance was also measured.



James' results are shown on the graph below



d) If James caught another fish which gave an extension of 5cm, what would be the weight of the new fish?

……….

(1 mark)

The weights and extensions of Mark's fish are shown in the table below.

Weight of fish /N	5.0	9.0	16.0	20.0	20.5
Extension / mm	20	36	64	88	100

e)

i) Plot these points on the same axes. Draw in a line or curve of best fit.

(3 marks)

ii) Using the information on the graph, explain why Mark's Newton balance is unsuitable for weighing fish.

………

………

(1 mark)

The stiffness of a spring is a measure of how easily it deforms (i.e. changes shape) when a force is applied.

f) Which of the two fishermen's Newton balances had a stiffer spring? Explain how you know this from the graph.

………

………

(1 mark)

Question 2 continues on the next page

We can calculate a value for the stiffness by using the following equation:

$$\textbf{Stiffness (in N/m)} = \frac{\textbf{Force (in N)}}{\textbf{extension (in m)}}$$

g) Calculate the stiffness of both springs **in N/m** when there is a load of 15N hanging on them.

Stiffness of James' spring: ………………………………………………………………………N/m

Stiffness of Mark's spring: ……………………………………………………………………… N/m

(3 marks)

h) James has a very successful day and catches a 65N fish. Calculate the extension that you would expect to get on his spring. Comment on whether or not you think your answer is reliable.

……

……

……

……

(3 marks)

End of Question 2

Name ________________________________

The King’s School, Canterbury

Science Scholarship Paper 2022

Chemistry Section

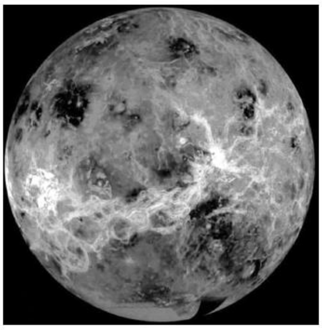
You should complete at least one of the questions in this section.

Circle the question(s) you have attempted.

Question	Mark
1	
2	

Chemistry Question 1

The photograph shows the planet Venus.



Although Venus is similar in size to the Earth, it is very different in other ways.

The temperature at the surface of Venus is about 470 °C. The atmospheric pressure is 90 times that of the Earth.

The clouds in the atmosphere of Venus are made up of droplets of sulfuric acid.

The table lists some properties of metals that could be used to make a space probe to land on Venus.

Metal	Melting point in °C	Relative density	Reaction with sulfuric acid
copper	1083	8.9	no reaction
lead	328	11.3	no reaction
magnesium	650	1.7	fizzes vigorously
nickel	1453	8.9	fizzes slowly
titanium	1675	4.5	no reaction
zinc	420	7.1	fizzes quite vigorously

The probe needs to be launched with enough energy to escape the Earth's gravity. To make this easier, the mass of the probe needs to be as low as possible. The probe also needs to withstand the conditions on the surface of Venus.

Use the information above to help you answer parts (a) to (e).

a)

i) Which metal in the table could be used to make a probe with the lowest density?

....

(1 mark)

ii) Why would this metal be unsuitable for making a probe to land on Venus?

……

……

(1 mark)

b) Very small amounts of lead can be used in electrical circuits.
Why would lead **not** be suitable for use in the electrical circuits of a probe to land on Venus?

……

……

(1 mark)

c) Choose a metal from the table that would be the **most** suitable for making a probe to land on Venus. Give **two** reasons for your choice.

Metal

……

Reasons

1 ……

……

2 ……

……

(3 marks)

d)

i) Place the three most reactive metals, from the six metals in the table, in order of reactivity, starting with the most reactive.

……

(1 mark)

ii) Why is it not possible to order the reactivity of the other three metals in the table, based on the information given?

……

……

(1 mark)

iii) Give brief details of an experiment you could carry out which would enable you to place these other three metals in an order of reactivity.

....

....

....

....

....

....

....

....

(3 marks)

e)

i) Use the boxes below to show how the arrangement of the water particles would change from when they were on Earth to when they were on the surface of Venus. Draw your water particles like this: ○

Arrangement on Earth | Arrangement on Venus

(4 marks)

ii) What assumption, if any, have you made in your right hand diagram about the effect that the very high pressure on Venus' surface has on water's boiling point?

....

....

(1 mark)

iii) Explain why water's boiling point at the top of Mount Everest is $68^{o}C$, rather than $100\,^{o}C$.

....

....

....

(2 marks)

iv) Describe how the movement of the water particles changes when water is cooled below its melting point?

....

....

....

(2 marks)

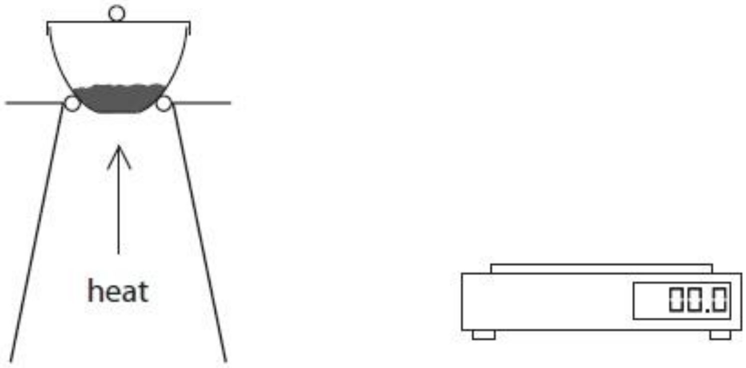
End of Question 1

Chemistry Question 2

The equation for the thermal decomposition of copper(II) carbonate is

copper(II) carbonate $\longrightarrow$ **copper(II) oxide + carbon dioxide**

A student investigates the decomposition of copper(II) carbonate using this apparatus.



She uses this method:

- weigh the crucible, lid and copper(II) carbonate
- heat the crucible, lid and contents for 2 minutes
- allow to cool and then reweigh
- heat for a second period of 2 minutes
- allow to cool and then reweigh
- heat for a third period of 2 minutes
- allow to cool and then reweigh

The table shows the student's results.

	Mass of crucible, lid and contents in grams			
Experiment	**before heating**	**after heating for 2 minutes**	**after heating for 4 minutes**	**after heating for 6 minutes**
1	26.3	23.0	21.9	21.4
2	25.8	22.7	21.5	21.5
3	26.0	23.0	21.2	21.2
4	26.1	23.2	21.8	21.8

a) Give the states of matter at room temperature of the chemicals in the equation:

copper(II) carbonate ....

copper (II) oxide ....

carbon dioxide ....

(1 mark)

b) Why does the mass decrease during heating?

....

....

(1 mark)

c)

i) In which experiment might the decomposition **not** be complete?

....

(1 mark)

ii) Give a reason for your choice.

....

....

(1 mark)

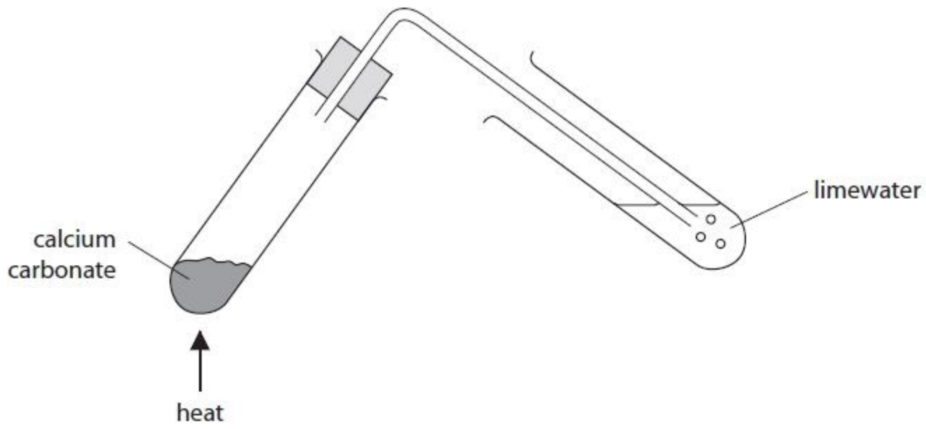
iii) Which statement could explain why the decomposition might not be complete?

☐ **A** The student used a higher temperature than in the other experiments.
☐ **B** The student used less copper(II) carbonate than in the other experiments.
☐ **C** The student heated the crucible without a lid on.
☐ **D** The student opened the Bunsen burner's air hole less fully than in the other experiments.

(1 mark)

d) Calcium carbonate reacts similarly to copper(II) carbonate when heated.

Some powdered calcium carbonate was heated strongly in a test tube.
The gas given off was bubbled through limewater.



i) What type of chemical reaction is taking place when calcium carbonate is heated?

- ☐ **A** displacement
- ☐ **B** oxidation
- ☐ **C** neutralisation
- ☐ **D** thermal decomposition

(1 mark)

ii) For **two** of the three answers which you think are **incorrect** in (d) (i), give an example of that type of reaction, naming the type of chemical reaction, and the reactants and products that you would use in your example.

Name of type of reaction ………………………………………….

Reactant(s) ………………………………………………………………………………

Product(s) ………………………………………………………………………………

Name of type of reaction ………………………………………….

Reactant(s) ………………………………………………………………………………

Product(s) ………………………………………………………………………………

(4 marks)

iii) State the appearance of the limewater before and after the gas was bubbled through it.

appearance before

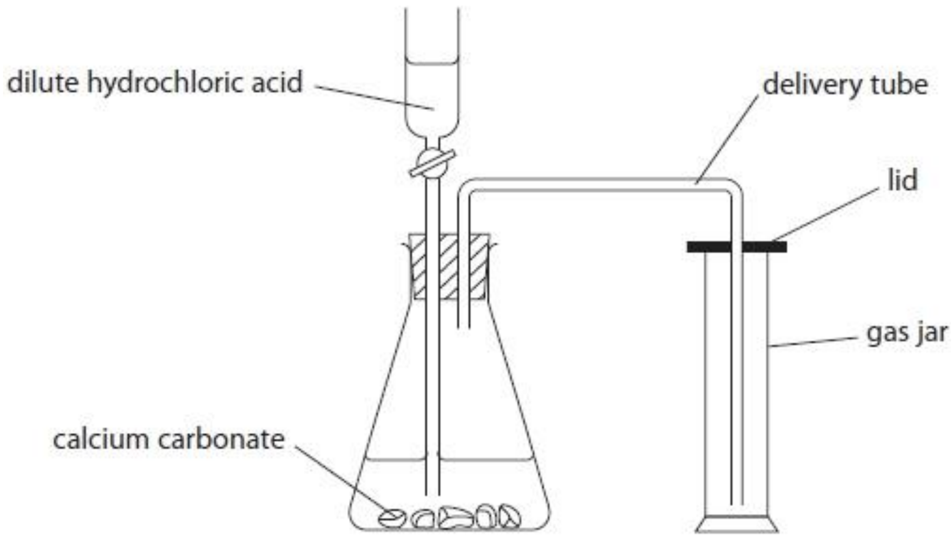
....

appearance after

....

(2 marks)

b) The diagram shows the apparatus used to prepare carbon dioxide in the laboratory.



i) Which of these is a true statement about carbon dioxide?

- ☐ **A** it turns red litmus blue
- ☐ **B** it turns limewater milky
- ☐ **C** it relights a glowing spill
- ☐ **D** it burns with a squeaky pop

(1 mark)

ii) Name the two products, other than carbon dioxide, that are formed in this reaction.

Product 1 ………………………………………………………………………………

Product 2 ………………………………………………………………………………

(2 marks)

Question 2 continues on the next page

iii) When carbon dioxide dissolves in water, a weakly acidic solution forms.

Suggest a pH value for this solution.

....

(1 mark)

iv) Suggest a pH value for a strongly alkaline solution.

....

(1 mark)

e) The Taj Mahal is a famous building in India. It is made out of a form of calcium carbonate called marble.

The appearance of the marble has changed gradually over the years because of the effects of sulfur dioxide in the atmosphere.
Describe how sulfur dioxide has caused this change in appearance.

....

....

....

....

....

....

....

(3 marks)

End of Question 2

Name ________________________________

The King's School, Canterbury

Science Scholarship Paper 2022

<u>Biology Section</u>

You should complete at least one of the questions in this section.

Circle the question(s) you have attempted.

Question	Mark
1	
2	

<u>Biology – Question 1</u>

This question is about sheep and Vitamin D.

The table below shows the amount of Vitamin D present in the blood of two groups of sheep during different months of the year. The Group A sheep were allowed to let their wool grow during the investigation. The Group B sheep had their wool clipped every week during the investigation.

Group A

Group B

Amount of Vitamin D (International units)		
Month	**Group A Sheep**	**Group B Sheep**
May	10	30
June	20	65
July	25	78
August	30	90
September	25	67
October	19	40
November	11	25
December	9	19
January	8	18

a) Describe the pattern of vitamin D content in both groups of sheep from May to January.

………

………

………

(1 mark)

b) Sheep get some of their vitamin D from the plants they eat. Suggest two reasons for the changes in sheep vitamin D levels from May to August.

……

……

………..

(1 mark)

c) Group B sheep contain more vitamin D than Group A sheep. Suggest why this might be, giving a reason for your answer.

……

……

………..

(2 marks)

d) Some sheep are farmed to produce meat rather than wool. What advice would you give to these farmers?

……

……

……

……

(1 mark)

e) What problems might be created by the strategy you have suggested in d) ?

……

……

……

……

……

(2 marks)

Question 1 continues on the next page

The experiment to test vitamin D levels was extended using sheep with different colour wool.

Sheep C

Sheep D

f) Suggest the two most important things that should be kept the same when testing vitamin D content in type C and D sheep. Give reasons for your choices.

i. ……

……

ii. ……

……

(2 marks)

g) Which of these two types of sheep will contain the least vitamin D? Give a reason for your answer.

……

……

……

(1 marks)

h) During the construction of the new science buildings at The King's School, a new species of animal was discovered living in the disused pipes underneath the ancient buildings. The animal has been officially named *Winrowus campbellis*. Consider how *Winrowus campbellis* - commonly known as the 'pipette'- is adapted to live in its pipe habitat. What features do you think this new species will have?

(10 marks)

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

More space on the next page if needed

End of Question 1

Biology Question 2

The stomach temperature of a Mako shark was measured as it swam through water over a period of several days. The water temperature around the shark was also measured by attaching a temperature probe to the shark's skin.

Time / hours	Stomach temperature / ^0C	Water temperature / ^0C
0	24	20
4	25	20
8	25	14
12	23	15
16	22	14
20	23	21
24	24	19
28	25	21
32	27	15
36	26	18
40	26	19
44	26	20
48	26	20
52	28	21
56	27	20
60	26	17
64	26	17
68	27	20
72	28	20

a) Fish are often said to be 'cold blooded'. Sharks are types of fish. From the information in the table, would you agree with this statement? Give reasons for your answer.

……

……

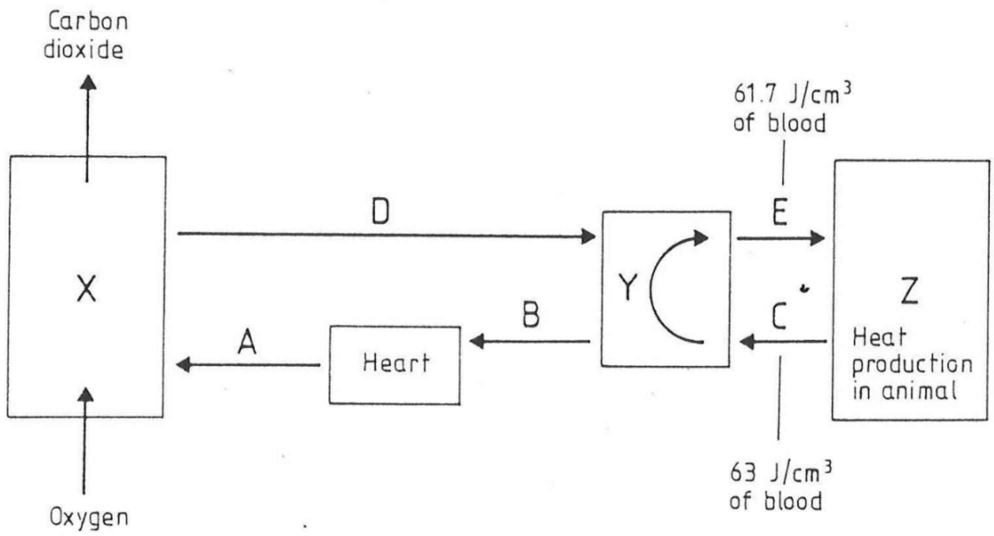
……

……

(2 marks)

Question 2 continues on the next page

Study this diagram of a Mako shark's circulation before answering the following questions.



b) Which of the letters A,B,C,D or E indicates the blood vessel with the highest

i) Concentration of oxygen?.. (1mark)

ii) Blood pressure? ………………………………………………………………………………… (1mark)

c) Which of the letters X, Y, or Z represents

i) The shark's gills?……………………………………………………………………………....... (1 mark)

ii) The shark's heat exchange system ?……………………………………………….…….. (1 mark)

iii) Blood Pressure ?…………………………………………………………………………………. (1 mark)

d) Was measuring the temperature of its stomach the best way to monitoring its body temperature? Describe how would you improve this method and explain the reasons for your choices.

……

……

………

……

……

……

(2 marks)

e) How much energy is transferred per cm^3 of blood to the heat exchange system?

………

………

………

(1 mark)

f) During the construction of the new science buildings at The King's School, a new species of animal was discovered living in the disused pipes underneath the ancient buildings. The animal has been officially named *Winrowus campbellis*. Consider how *Winrowus campbellis* commonly known as 'the pipette' is adapted to live in its pipe habitat. What features do you think this new species will have?

(10 marks)

………

………

………

………

………

………

………

………

………

………

………

………

………

………

………

More space on the next page if needed

End of question 2