MAGDALEN
COLLEGE SCHOOL

Sample Scholarship Examination Paper

SCIENCE

1 hour

Answer one question from each section of the paper.
That is, one question on Biology, one on Chemistry and one on Physics.

Please begin each question on a separate sheet of paper and write your name on each sheet. Calculators are allowed.

You should explain your answers as fully as possible, and show your working when attempting calculations. All questions carry equal weight.

BIOLOGY

Answer Question 1 **or** Question 2 on a SEPARATE SHEET OF PAPER.

Write your name on each page.

Biology - Question 1

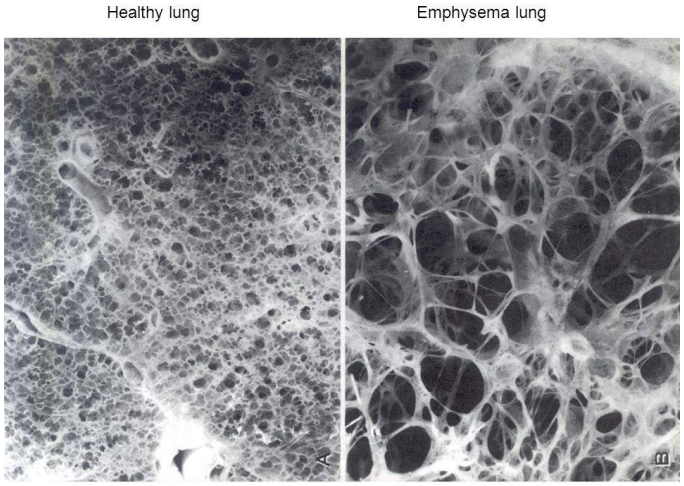
a) All living organisms rely on respiration to release energy. Write the word equation for this process. **(2)**

b) Describe how you would test for the gaseous product of respiration. **(2)**

c) How does oxygen move from the lungs into the bloodstream? Name and describe the process **(2)**

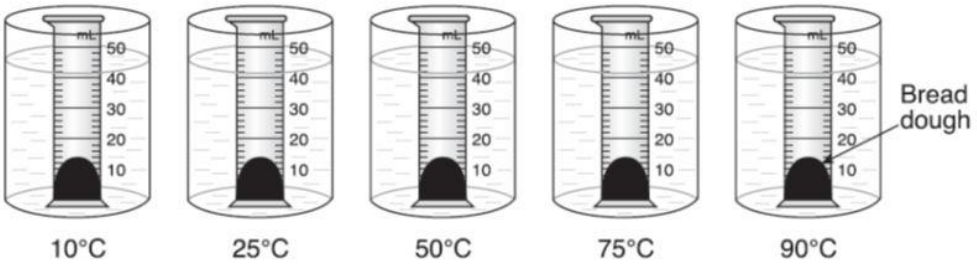
d) Describe and explain two ways that the lungs are adapted to make the process you have described in (c) very efficient. **(4)**

e) Smoking affects the human lungs. One disease it can cause is emphysema. Look at the pictures below. Explain why someone with emphysema will struggle to get enough oxygen to the cells in their body **(2)**



f) Mycobacterium tuberculosis causes tuberculosis, a disease of the respiratory system, in humans. State two features of a bacterial cell that would not be found in an animal cell. **(2)**

g) Yeast is a single-celled fungus. Bread dough is made of yeast, flour, water and a little sugar. A student carried out an experiment to see if temperature affected how much dough rises. An equal volume of dough was placed in the bottom of five measuring cylinders. Each cylinder was then placed in a different temperature water bath for 15 minutes.



The change in the volume of the dough was then recorded:

The Effect of Temperature on Yeast Respiration

Temperature of Water Bath (°C)	**Change in Volume of Bread Dough** (mL)
10	4
25	11
50	20
75	25
90	2

(i) What was the independent variable in this investigation? **(1)**

(ii) Give two variables that should be controlled to ensure a fair test **(1)**

(iii) Describe and explain the results **(4)**

Total: 20 marks

Biology Question 2

a) Which two words complete the following paragraph describing the way in which the bodies of multicellular animals are organised:

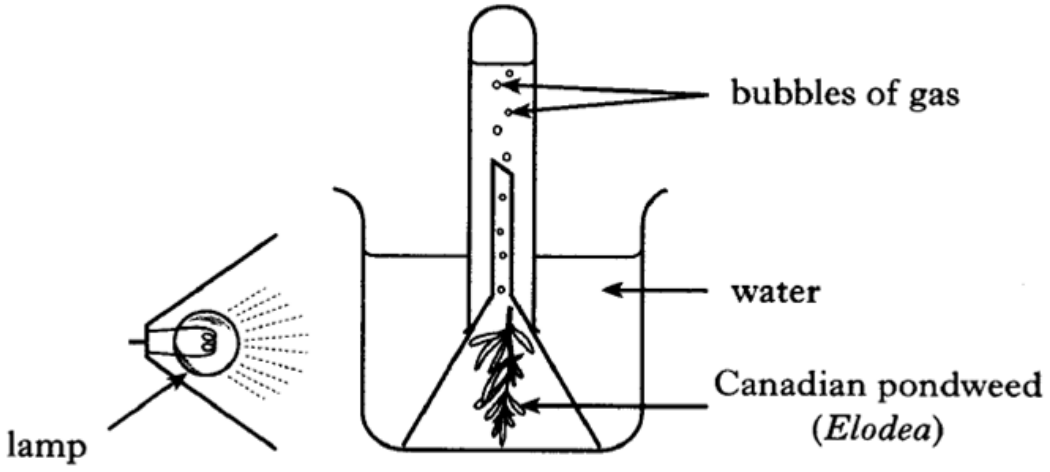
In multi-cellular organisms, cells are massed together to form ……, which can in turn be massed together to form ……. **(2)**

b) Almost all plant and animal cells contain a nucleus, cytoplasm and mitochondria. Briefly outline the function of each of these components. **(3)**

c) In plant cells, which structure carries out the process of photosynthesis? Give the word equation which summarises the process of photosynthesis. **(3)**

d) If plants were left overnight in a sealed greenhouse, what would you expect to happen to the composition of gases in the air inside the greenhouse compared to during the day? Explain your answer **(3)**

e) Laura carried out an investigation into the effect of light intensity on the rate of photosynthesis in a type of pondweed called Elodea. She set up her equipment like this:



She then counted the number of bubbles of gas released by the Elodea in five minutes when the light was at different distances from the beaker. Her results were as follows:

Distance between lamp and beaker (cm)	Number of bubbles released in 5 minutes
5	92
10	85
15	70
20	53
25	40

(i) What was the dependent variable in this investigation? **(1)**

(ii) Give two variables that would need to be controlled to ensure this was a fair test. **(2)**

(iii) How could you show what gas is being given off by the plant? **(1)**

(iv) Describe and explain the results. **(3)**

f) Most plants grow in soil. They have specialised root hair cells. Explain how these cells are adapted to their function. **(2)**

Total: 20 marks

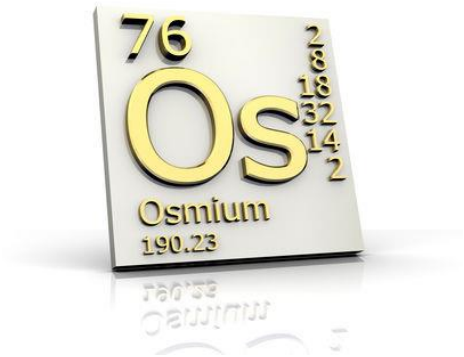
CHEMISTRY

Answer Question 3 **or** Question 4 on a SEPARATE SHEET OF PAPER.

Write your name on each page.

Chemistry - Question 3

The modern periodic table lists over 100 chemical elements. These chemical elements can be divided into metals and non-metals according to their physical and chemical characteristics. This question is about two very dense metallic elements: osmium and iridium.



Element	Density g/cm3
Osmium (Os)	22.59
Iridium (Ir)	22.56
Iron (Fe)	7.87

a) Explain what you understand by the term 'chemical element'. (2)

b)

(i) Osmium has the highest density of all the chemical elements. Using the data in the table above, calculate the mass of a lump of osmium the size of a standard UK house brick (dimensions: 21.5cm x 10.25cm x 6.5cm). **(2)**

(ii) Iridium has the second highest density of the elements in the periodic table. Describe the arrangement and movement of particles in a solid metal such as iridium and suggest why iridium is slightly less dense than osmium at room temperature and pressure. Use a diagram if it helps your answer. **(3)**

(iii) When iridium melts to form a liquid, its density falls to around 19g/cm3. Suggest an explanation for this observation. **(1)**

c) The Ancient Greeks probably knew of six or seven metallic elements. Today we know of many more.

(i) Give two characteristic **physical** properties (other than high density) typical of metallic elements. **(2)**

(ii) Suggest possible reasons why the Ancient Greeks would have known about metals such as silver and gold, but not about metals such as osmium and iridium. **(2)**

d) If exposed to air at room temperature, osmium metal reacts very slowly with oxygen to form the compound osmium tetroxide, OsO_4.

(i) Write a balanced chemical equation for this reaction. Full credit will be awarded for a balanced symbol equation; partial credit can be gained for a correct word equation. **(3)**

(ii) Describe briefly a chemical test to indicate the presence of oxygen gas. **(2)**

(iii) Other than raising the temperature, suggest a way of increasing the speed of the reaction mentioned above. **(1)**

e) Osmium alloys are used as a material for the tips of fountain pen nibs.

(i) What is an 'alloy'? **(1)**

(ii) Why do you think osmium alloys are so suitable for this purpose? **(1)**

Total: 20 marks

Chemistry - Question 4

This question is about compounds found in 'crude oil'. Petroleum or 'crude oil' is a naturally occurring, flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights. Petroleum is usually obtained from geological formations below the earth's surface through drilling. It is refined and separated to produce a large number of consumer products, from petrol and kerosene to asphalt and a wide variety of chemicals used to manufacture plastics and pharmaceuticals.

Some typical hydrocarbon compounds and their molecular formulae are listed in the first table below:

Compound	Chemical Formula
Propane	C_3H_8
Butane	C_4H_{10}
Pentane	C_5H_{12}
Hexane	C_6H_{14}
Heptane	?
??	C_8H_{18}

Element	'Relative Mass' of Atom
Hydrogen (H)	1
Carbon (C)	12
Oxygen (O)	16

a)

(i) Crude oil (pictured above) is a thick, dark liquid at room temperature. Describe the arrangement and motion of the particles in a liquid. Use a diagram if it helps your answer. **(2)**

(ii) What technique would you use in the laboratory to separate a mixture of several liquids, such as crude oil? Explain why this technique works. **(2)**

b) Propane (see table above) is a simple hydrocarbon compound. It has a boiling point of -42.1°C.

(i) Explain what you understand by the term 'compound'. **(2)**

(ii) Explain what the chemical formula of propane tells you about its composition. **(1)**

(iii) What physical state will propane be in at room temperature? **(1)**

(iv) When propane burns completely in oxygen, carbon dioxide and water are produced. Write a chemical equation to illustrate this process. Full

credit will be awarded for a balanced symbol equation; partial credit can be gained for a correct word equation. **(3)**

(v) Describe briefly how you would test the gaseous products formed during the combustion of propane to show the presence of carbon dioxide. **(2)**

c) Using the 'relative mass' values given in the second table above, calculate a value for the 'relative mass' of the following compounds: **(2)**

(i) butane
(ii) water

d)

(i) Work out the formula of the hydrocarbon heptane (marked '?' in the first table above). **(1)**

(ii) Predict the name for the hydrocarbon with formula C8H18 (marked '??' in the first table above). **(1)**

e) Global consumption of fossil fuels such as crude oil continues to rise. Discuss briefly some of the problems associated with this trend. (3)

Total: 20 marks

PHYSICS

Answer Question 5 **or** Question 6 on a SEPARATE SHEET OF PAPER.

Write your name on each page.

Physics - Question 5

A food supply crate is dropped vertically by parachute from an aeroplane. The crate and parachute together weigh 5000 N. The following table shows how the distance they fall and the frictional force of the air upon them vary with the time from release.

Time since release *t* / seconds	**Distance fallen** *d* / metres	**Air Friction** *F* / Newtons
0	0	0
1	10	3160
2	28	3990
3	53	4550
4	85	4800
5	122	4900
6	163	5000
7	210	5000
8	257	5000

a) Draw a labelled diagram of the vertical forces acting on the crate and parachute:
(i) at the instant of their release;
(ii) one second after release;
(iii) seven seconds after release. **(3)**

b) Using the graph paper provided, make a scatter plot of distance fallen *(vertical axis)* against time from release *(horizontal axis)* and draw a smooth curve of best fit. **(5)**

c) By referring to your graph, without calculation, describe how the *speed* of the crate varies:
(i) from release up to 6 seconds;
(ii) after 6 seconds. **(3)**

d) Calculate the average speed of the crate
(i) in the third second (*i.e.* between t = 2 s and t = 3 s)
(ii) in the eighth second (*i.e.* between t = 7 s and t = 8 s) **(3)**

e) Explain why the frictional force of the air on the crate and parachute increases until the sixth second but remains constant after then. **(3)**

f) Briefly outline how to obtain a set of readings for *distance fallen* against *time* for a small falling object in the laboratory. Specify what equipment to use to measure each quantity. **(3)**

Total: 20 marks

Physics - Question 6

This question is about two kinds of wave, light and sound.

a) Draw a labelled diagram to show how a mirror affects the path of a light ray. **(4)**

b) Describe an experiment that you could carry out to verify the relationship between the angle of incidence and the angle of reflection when light hits a plane mirror. Be careful to include all the apparatus needed and details of what measurements to take. **(4)**

c) What precautions would you take to make sure you experiment was as accurate and reliable as possible? **(2)**

Sound waves reflect off hard, flat surfaces in the same way that light reflects off mirrors. Scientists and engineers can use reflected sounds to measure distances.

d) What equation relates speed, distance and time and what units do physicists normally use? **(2)**

e) In an experiment to measure the speed of sound in water, a sound wave was found to travel 50 m in 0.034 s. How fast was the sound travelling? **(2)**

f) A sound wave travelling through air hits a wall at right angles and bounces back. If the speed of sound in air is 340 m/s and the reflection returns 1.2 s after the sound wave was first sent out, how far away is the wall? **(4)**

g) This technique of using sound to measure distances (known as sonar) is commonly used by submarines, but not by aeroplanes. Aeroplanes use radar, which is based on the reflection of radio waves (which are related to light waves). Suggest why submarines use sonar, whereas aircraft use radar. **(2)**

Total: 20 marks

End of paper