ST EDWARD'S
OXFORD

13+ SCHOLARSHIP EXAMINATION
2014

SCIENCE

Candidate Name

1 Hour

INSTRUCTIONS TO CANDIDATES

Write your name in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
The marks allocated and the spaces provided for your answers are a good indication of the length of answers required.
A calculator may be used.

Biology	Chemistry	Physics

Total /60

%

Grade

CHEMISTRY

1. (a) The table below shows the melting points and boiling points of four elements.

element	melting point (°C)	boiling point (°C)
aluminium	660	2520
iron	1540	2760
magnesium	650	1100
mercury	−39	357

When answering the questions below, you may give the name of an element more than once.

Which element in the table is:

(i) a liquid at 0°C?

.....

1 mark

(ii) a solid at 1500°C?

.....

1 mark

(iii) a gas at 500°C?

.....

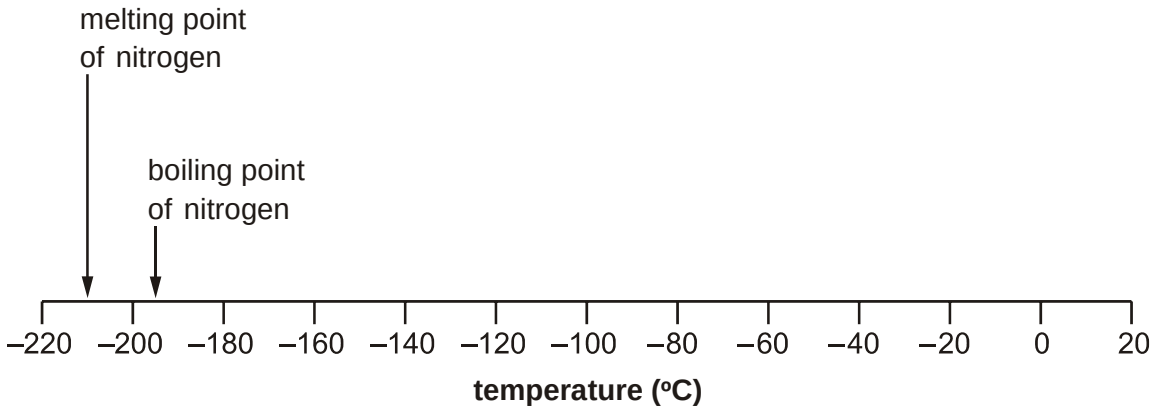
1 mark

(iv) a liquid over the biggest temperature range?

.....

1 mark

(b) The melting point and boiling point of nitrogen are marked on the scale below.



(i) **Draw an arrow** on the scale above to show the temperature at which water freezes.

1 mark

(ii) When water is a liquid, what is the physical state of nitrogen?
Tick the correct box.

solid ☐ liquid ☐ gas ☐

1 mark

(iii) What is the physical state of nitrogen at −200°C?
Tick the correct box.

solid ☐ liquid ☐ gas ☐

1 mark

(Total 7 Marks)

2. (a) Write the word equation for the symbol equation below.

……

(1)

$$H_2 + O_2 \rightarrow H_2O$$

(b) Balance the above equation. (2)

(c) What atoms does each molecule of H_2O contain?

.....

(2)

(Total 5 marks)

3. The table below gives information about some hydrocarbons.

HYDROCARBON	MOLAR MASS (Mr)	BOILING POINT (ºC)
Butane C_4H_{10}	58	0
Pentane C_5H_{12}	72	36
Hexane C_6H_{14}	86	69
Heptane C_7H_{16}		99
Octane C_8H_{18}	104	126
Nonane C_9H_{20}	128	

(a) Heptane has the formula C_7H_{16}.

Calculate the molar mass of heptane and insert the value in the table above.

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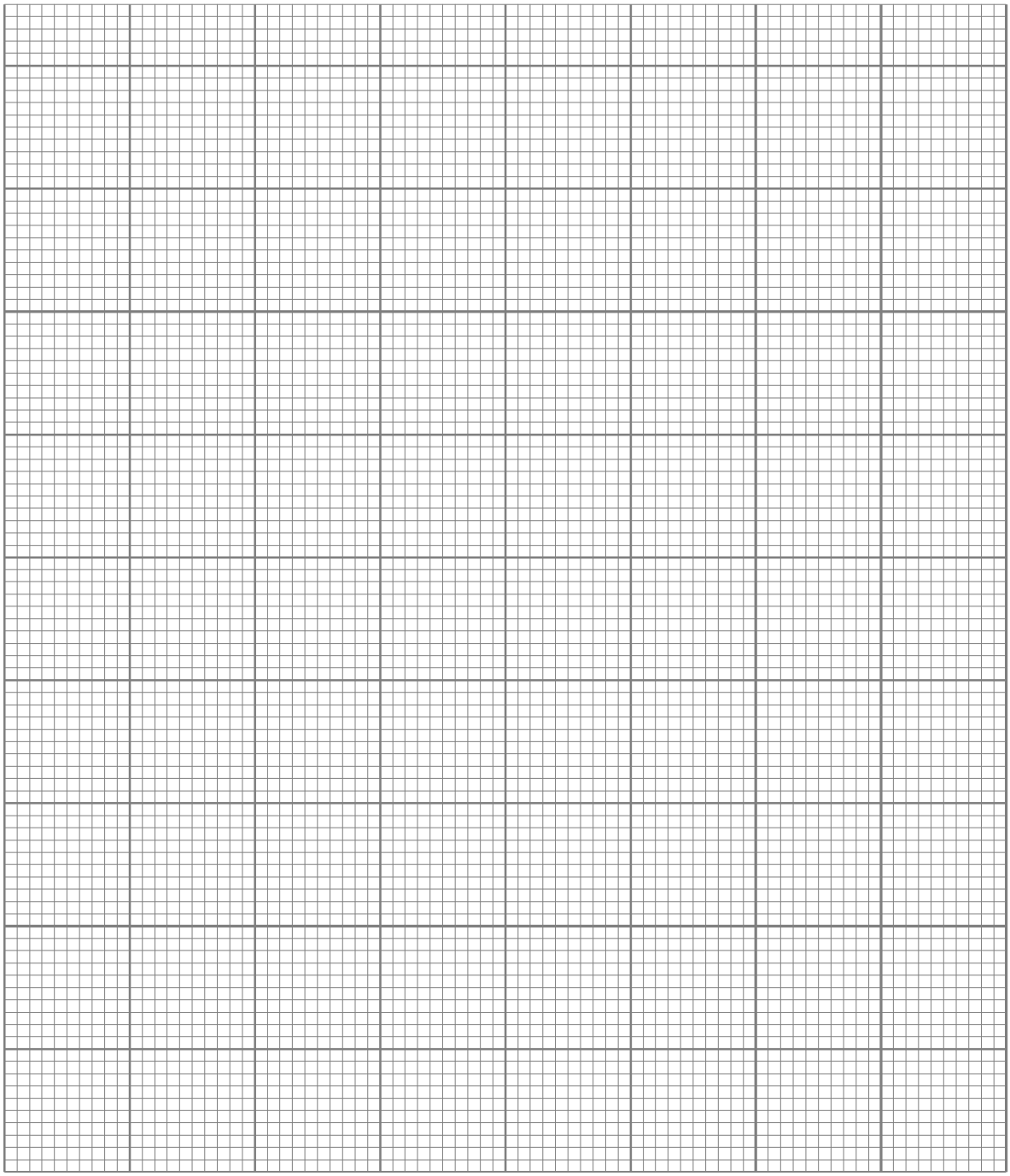
(1)

(b) Draw a suitable graph to enable you to estimate the boiling point of the hydrocarbon called nonane which has a molar mass of 128.



Boiling point of nonane = ... °C

(7)

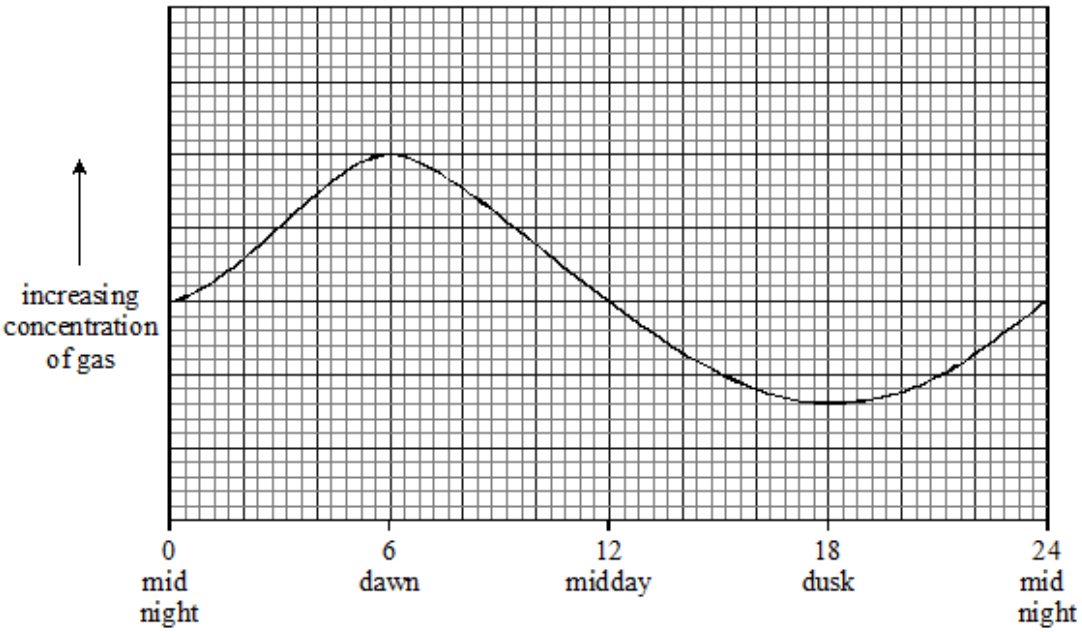
(Total 8 marks)

BIOLOGY

1. Plants carry out the process of photosynthesis.
   Write a **word equation** for this process in the space below: [4]

   ……

2. The graph below shows the change in concentration of **carbon dioxide** in a glasshouse full of plants over a period of 24 hours.



   (a) Explain the shape of the curve as fully as you can. [4]

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(b) Draw a line on the graph to show how the concentration of **oxygen** would change over the same time period. [2]

3. The diagrams below show the shapes of the **same species** of tree grown on their own and inside a wood.

Tree on its own

Trees inside a wood

Describe and **explain** the differences you can see between the tree on its own and the trees inside the wood. [5]

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4. The animal shown in the photograph below is called a limpet.

Limpets are molluscs (similar to garden snails) and are found on rocky shores between the high tide and low tide marks. When the tide is out they remain fixed to the rock surface.

(a) Describe how you could use a **quadrat** to estimate the number of limpets in a given area on the shore. [3]

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(b) Name **two** factors that could affect the size of the limpet population. [2]

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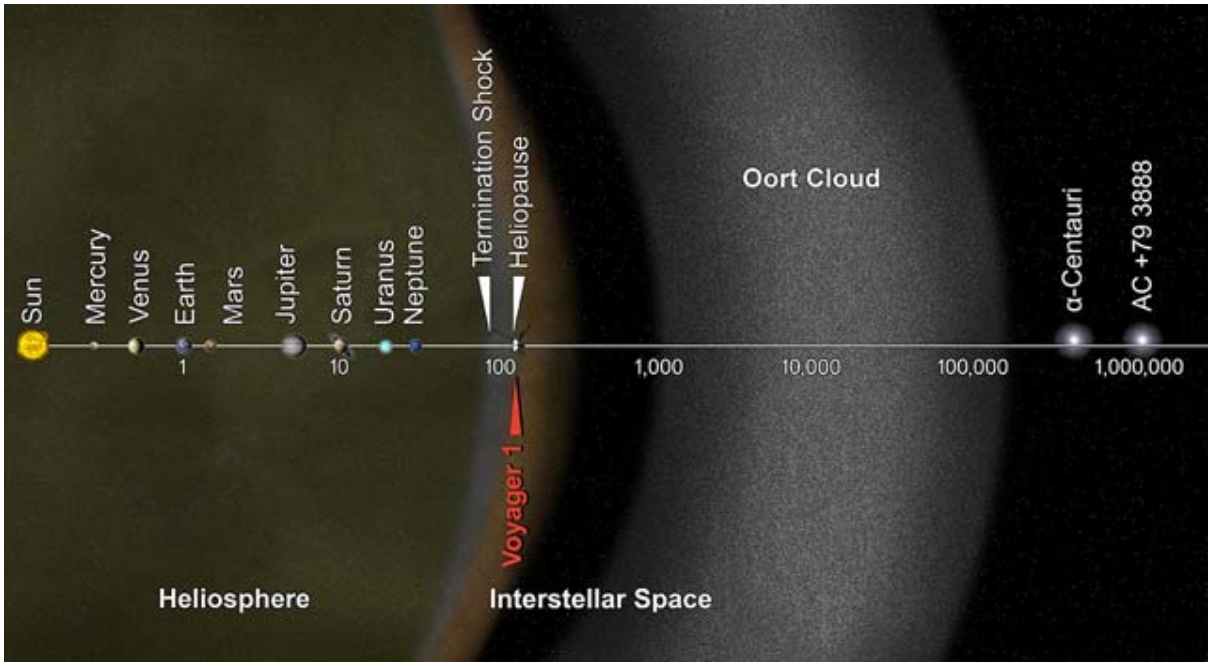
PHYSICS

THE VOYAGER 1 SPACE PROBE

Read the articles on Voyager 1 and then answer the questions.

Article 1 - How Do We Know When Voyager Reaches Interstellar Space?



You Are Here, Voyager: This artist's concept puts huge solar system distances in perspective. The scale bar is measured in astronomical units (AU), with each set distance beyond 1 AU representing 10 times the previous distance. Each AU is equal to the distance from the sun to the Earth. It took from 1977 to 2013 for Voyager 1 to reach the edge of interstellar space

September 12, 2013

Whether and when NASA's Voyager 1 spacecraft, humankind's most distant object, broke through to interstellar space, the space between stars, has been a thorny issue. For the last year, claims have surfaced every few months that Voyager 1 has "left our solar system." Why has the Voyager team held off from saying the craft reached interstellar space until now?

"We have been cautious because we're dealing with one of the most important milestones in the history of exploration," said Voyager Project Scientist Ed Stone of the California Institute of Technology in Pasadena. "Only now do we have the data -- and the analysis -- we needed."

Basically, the team needed more data on plasma, which is ionized gas, the densest and slowest moving of charged particles in space. (The glow of neon in a storefront sign is an example of plasma.) Plasma is the most important marker that distinguishes whether Voyager 1 is inside the solar bubble, known as the heliosphere, which is inflated by plasma that streams outward from our sun, or in interstellar space and surrounded by material ejected by the explosion of nearby giant stars millions of years ago. Adding to the challenge: they didn't know how they'd be able to detect it.

"We looked for the signs predicted by the models that use the best available data, but until now we had no measurements of the plasma from Voyager 1," said Stone…….

"In the end, there was general agreement that Voyager 1 was indeed outside in interstellar space," Stone said. "But that location comes with some disclaimers - we're in a mixed, transitional region of interstellar

space. We don't know when we'll reach interstellar space free from the influence of our solar bubble."

So, would the team say Voyager 1 has left the solar system? Not exactly - and that's part of the confusion. Since the 1960s, most scientists have defined our solar system as going out to the Oort Cloud, where the comets that swing by our sun on long timescales originate. That area is where the gravity of other stars begins to dominate that of the sun. It will take about 300 years for Voyager 1 to reach the inner edge of the Oort Cloud and possibly about 30,000 years to fly beyond it. Informally, of course, "solar system" typically means the planetary neighbourhood around our sun. Because of this ambiguity, the Voyager team has lately favoured talking about interstellar space, which is specifically the space between each star's realm of plasma influence.

"What we can say is Voyager 1 is bathed in matter from other stars," Stone said. "What we can't say is what exact discoveries await Voyager's continued journey. No one was able to predict all of the details that Voyager 1 has seen. So we expect more surprises."

Voyager 1, which is working with a finite power supply, has enough electrical power to keep operating the fields and particles science instruments through at least 2020, which will mark 43 years of continual operation. At that point, mission managers will have to start turning off these instruments one by one to conserve power, with the last one turning off around…..

The two Voyager spacecraft were launched in 1977 and, between them, had visited Jupiter, Saturn, Uranus and Neptune by 1989. Voyager 1's plasma instrument, which measures the density, temperature and speed of plasma, stopped working in 1980, right after its last planetary flyby. When Voyager 1 detected the pressure of interstellar space on our heliosphere in 2004, the science team didn't have the instrument that would provide the most direct measurements of plasma. Instead, they focused on the direction of the magnetic field as a proxy for source of the plasma. Since solar plasma carries the magnetic field lines emanating from the sun and interstellar plasma carries interstellar magnetic field lines, the directions of the solar and interstellar magnetic fields were expected to differ.

Voyager 1 will continue sending engineering data for a few more years after the last science instrument is turned off, but after that it will be sailing on as a silent ambassador. In about 40,000 years, it will be closer to the star AC +79 3888 than our own sun. (AC +79 3888 is traveling toward us faster than we are traveling towards it, so while Alpha Centauri is the next closest star now, it won't be in 40,000 years.) And for the rest of time, Voyager 1 will continue orbiting around the heart of the Milky Way galaxy, with our sun but a tiny point of light among many.

Article 2 – NASA's Voyager 1 Spacecraft, Launched in 1977, Continues Explorations

What's also amazing is that the equipment aboard the probe was powerful when it was launched, but in comparison with today's technology, it is incredibly outdated.

There are three computers on board, along with three duplicate back-up computers, for a total of six. Those six machines have a total of 68KB of memory, compared with a typical 16GB smartphone in 2013 that contains about 235,000 times more memory, according to Medina.
One of the computers is used for telemetry data, while another sends and receives sequences detailing what NASA wants to do on the craft. The remaining computer system is the attitude and articulation control system (ACS), which Medina calls "my baby." That computer controls the actual movement of Voyager 1 and keeps it pointed toward the Earth.
"I deal with it, I program it, and when there are problems, I reprogram it. We're here every day and we get data on the Voyagers on the average of six to eight hours a day from each one," he said, adding that Voyager 2 is also still in space, on a trajectory that will have it reaching interstellar space in the next two to three years.

Five of the original 11 experiments built into Voyager 1 are still operational, 36 years after the mission began, said Medina. A camera was shut off in 1990 when it was no longer needed in a power-saving move. The spacecraft, which is powered by nuclear fuel, plutonium 238, only has enough fuel to operate the remaining experiments through 2020. At that point, scientists will have to shut down more experiments. By 2025, only enough fuel will remain to simply fly the probe, without any operating experiments, he said.

"At that time, we either go and engineer a monitoring mission with no data or we shut it off," said Medina.
"This is just another phase," Medina said of the craft's travels through interstellar space. "This is not the end of the mission, by no stretch of the imagination. We're trail-blazing unknown territory."

1. The scale of the graph is logarithmic. Describe the pattern shown and state why the pattern is unusual.

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   .....

   (2)

2. The scale of the graph is in AU, astronomical units. What does one AU represent?

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   (1)

3. According to the graph, approximately how many AU is it from Voyager to Earth?

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   (1)

4. If one astronomical unit is 150 000 000 kilometres, show that Voyager is approximately 15 000 000 000 kilometres away from Earth?

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   (1)

5. How many hours in one year?

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(2)

6. Show that Voyager has been travelling approximately 316 000 hours.

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(2)

7. What speed is Voyager travelling in kilometres per hour?

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(2)

8. What planets have the Voyager spacecraft visited on their journey to the outside of the solar system?

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(2)

9. When will Voyager's instruments stop working?

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(1)

10. How many years until Voyager is closer to the star Alpha Centauri than the Sun?

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(1)

11. How many experiments were built into Voyager 1 spacecraft?

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(1)

12. How many of the experiments built into Voyager still work?

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(1)

13. What provides power to the Voyager spacecraft sensors and instruments?

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(1)

14. Why could Voyager not use solar cells?

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(2)