RADLEY COLLEGE
Entrance Scholarships

SCIENCE AND TECHNOLOGY

March 2008

Time allowed: 2 hours

*Answer **all** questions.*

Write the answers to each section on a separate sheet of paper.

Biology **[25 marks]**

For wildlife, life in the tropics is comparatively easy. There are none of the seasonal extremes of climate experienced as you approach the poles, and with no changing seasons to disturb their **life-cycles**, insects in particular have proliferated. This has driven further **diversity** among the plants on which so many of them feed. As plants have evolved various defences, so the insects have changed their methods of attack, and the resulting **arms** races have further fuelled diversity. Similar arms races between predators and their **prey** have encouraged enormous proliferation among the animals themselves. And with a relatively stable supply of suitable food, most species can develop and specialize further and further.

But cooperation, too, has driven the diversification of species. The first **canopy** is so thick that little wind is available to pollinate flowers or spread seeds. So plants have developed intimate relationships with animals, bring them with nectar to carry pollen from flower to flower and fruit to disperse the resulting seeds. Such **mutually beneficial relationships** are particularly common and complex in rainforests.

(Adapted from: Planet Earth, Alastair Fothergill)

Using information in the passage and your own knowledge, answer the following questions.

1. What is meant in the passage by the words indicated in bold as follows:

(i) **life-cycle(s)**
(ii) **diversity**
(iii) **arms**
(iv) **prey**
(v) **canopy**
(vi) **mutually beneficial relationship(s)** [6]

2. To which phylum do the insects belong? [1]

3. Why is there a relatively stable food supply in the tropics? [1]

4. Explain the mutually beneficial relationship between the plants and insects. [2]

5. How might the seed-eating birds of the rain forest benefit the plants? [1]

6. Describe a similar mutualistic relationship example from this country, including the benefits to each organism [2]

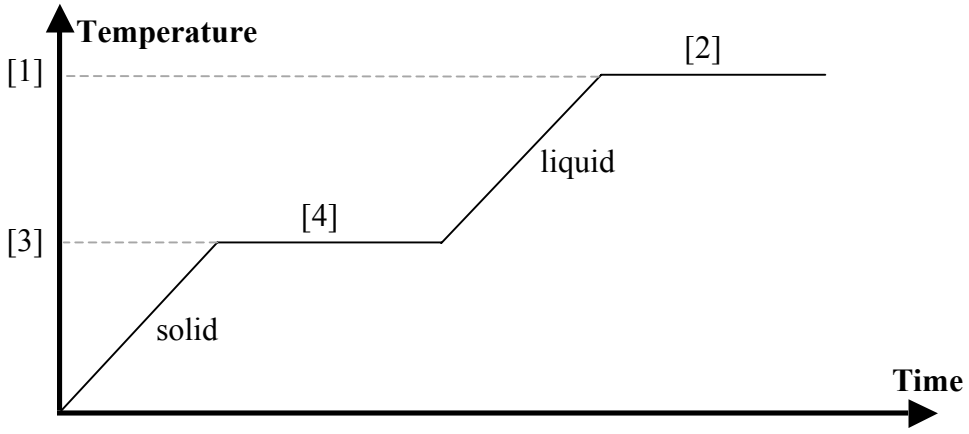
7. How might a wind-pollinated plant differ from one that is insect-pollinated? [4]

8. How else (apart from pollination) would the 'thick canopy' affect the flora and fauna on the floor of the forest? [3]

9. Using named examples, explain how the 'arms race between predators and their prey' has caused each species to evolve due to each others' influence. [5]

Chemistry **[25 marks]**

1. Using a Bunsen burner, a student heated a beaker of ice and monitored the temperature as a function of time. He recorded the temperature of the beaker contents every 2 minutes. Below is the graph of his data.



(a) On the graph above, which number represents the melting point of the ice? [1]

(b) Which number represents the time when the ice was melting? [1]

(c) During the transition from (solid) ice to (liquid) water the temperature remains the same even though the substance is being heated. Explain this in terms of the bonds between the molecules. [3]

(d) At sea level the boiling point of water is 100 ^{o}C, however, at temperatures below 100 ^{o}C it is still possible for water molecules to escape and enter the gas phase. Explain this phenomenon in terms of the energy of the water molecules. [2]

(e) Using the idea of pressure, explain why the boiling point of water will NOT be 100 ^{o}C at the top of Mount Everest. You MUST mention whether it will be higher or lower than 100 ^{o}C. [3]

2. The elements in Group VII of the Periodic Table are called the halogens. The word halogen comes from the Greek word meaning "salt-producing".
In the same way that a more reactive metal can displace a less reactive metal from solution, a more reactive halogen can displace a less reactive halogen from a salt solution. One such example is fluorine displacing iodide ions from a solution of potassium iodide.

(a) Write a word equation for this reaction. [2]

(b) A student followed the reaction by determining the amount of iodine formed as a function of time. The data is given below:

Time (s)	Concentration of iodine (mol dm^{-3})
0	0
60	0.2
120	0.4
180	0.6
240	0.7
300	0.75
360	0.75
420	0.75

(i) Plot a graph of this data, labelling both axes. Draw a trendline to fit the data. [5]

(ii) Using your graph, determine the concentration of iodine after 4 minutes 30 seconds. [1]

(iii) Explain what happens to the rate of the reaction as time proceeds. [1]

3. Universal indicator was used to measure the pH of several different substances:

Substance A	Indicator went blue-green
Substance B	Indicator went orange
Substance C	Indicator went red
Substance D	Indicator went indigo

(a) (i) Which substance is a weak acid? [1]

(ii) Which substance is ammonia? [1]

(iii) Substance C is naturally present in the body. Suggest what substance C might be? [1]

(iv) Which substances could be used to increase the pH of acidic soil? [1]

(b) The soil in Mr Parson's garden has a pH of 4.9. What ionic compound could he add to the soil to make it neutral? [1]

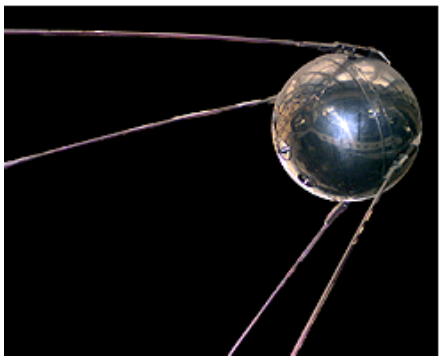
Physics **[25 marks]**

This question is about Rocket Science.

Sputnik, the first man made satellite first orbited the earth just over fifty years ago on the 4th October 1957. Read the short passage below and then answer the questions. Excerpts from the passage are included next to the questions to help you.

The number of marks for each question are shown in [ ] after the question

CALCULATORS ARE NOT ALLOWED AND SO YOU MUST SHOW ALL YOUR WORKING TO GET AS MANY MARKS AS POSSIBLE



1. Sputnik consisted of a spherical metal shell (pictured above), which contained a radio transmitter and some scientific instruments. Also clearly visible in the picture are four radio antennae, which were attached to the satellite.

   a) Sputnik had a radius of 30 cm and a mass of approximately 90 kg. Calculate the volume of the sphere in cm^3. Give your answer to 1 significant figure. [2]

   Volume of a sphere = $\frac{4}{3}\pi r^3$

   Assume that $\pi = 3$ to make the calculation easier.

   b) Use your answer to part a) to calculate the average density of sputnik in g/ cm^3. [3]

2. Sputnik took approximately 100 minutes to complete 1 orbit of the earth. We will assume that orbit was circular and that it had a radius of 7000 km measured from the centre of the earth.

a) Calculate the time **in seconds** for Sputnik to complete one orbit. [1]

b) Calculate the distance **in metres** travelled by Sputnik in completing one orbit. Write your answer in standard form. [3]

Circumference of a circle = $2\pi r$
Assume that $\pi = 3$ to make the calculation easier.

c) Calculate the average speed in m/s of Sputnik in orbit. Write your answer in standard form [4]

d) Convert your answer in part c) above into miles per hour. Make sure you show all your working. [4]

1 mile = 1600m

e) Sputnik stayed in orbit for 93 days. Calculate approximately how many complete orbits of the earth it would have made in this time. Remember that 1 orbit takes 100 minutes. [5]

Number of minutes in one day = 1440 minutes

3. After 93 days, Sputnik 'burnt up' in the earth's atmosphere as it fell back to earth. Discuss the energy changes which took place as this happened. [3]

Design and Technology **[25 Marks]**

You have been asked to answer a large number of questions below. The best way to gain the most marks is by **first answering the questions you can, subsequently returning to any you find more difficult**. Leave at least 10 lines space for each diagram. Questions that require a diagram (and at least 10 lines of space) are underlined.

Question A

Designing a product to get down a hill fast!

1. What **2 different** systems could you design to give a smoother ride for the user? [2]

2. If you chose to use wheels, **what size wheels** would you choose for bumpy terrain **and why?** [2]

3. If you were trying to make the product seem very scary for the user what **2 things** could you alter to achieve this (please keep your answers directed to the product, not things like putting it on a very steep / bumpy hill / altering the course etc.) [2]

Question B

You have been asked to make a secret switch that will turn on when you press your toe down. It will be hidden in your shoe and could be used to turn on small light bulbs, LED's, LCD screens or some other device of your choice.

4. Use step-by-step drawings to show how you would make a light-up badge that is comfortable and works. [4]

5. Make a drawing of yourself to show where you would position the wires, battery / solar panel and other parts. [2]

Question C

A group of Biologists needs to trap and tag field mice as part of a study on the feeding habits of Barn Owls. The information will be used to find out where owls feed and how often they catch their food. You have been asked to design a device for trapping the field mice so the scientists can tag them before they are returned into the wild.

6. Before designing your trap, you need to investigate the problem in order to gather useful information. Make a list of the **4 things** you would need to find out before you started designing. [2]

7. **List 4** design specifications (qualities of the Design) for a suitable mouse trap. [2]

8. Sketch a design for a trap, which would meet the criteria, you have listed in the last question. Use **notes and diagrams** to explain how the trap would work. [6]

9. Suggest **3 different** materials from which the trap could be made and explain why you think they would be suitable. [3]