RADLEY COLLEGE
Entrance Scholarships

SCIENCE AND TECHNOLOGY

March 2006

Time allowed: 2 hours

*Answer **all** questions.*

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

Biology **[25 marks]**

Read the following passage:

The hoatzin is a curious heavily built bird, the size of a chicken, which lives in the swamps of Guyana and Venezuela. Its nests are roughly built platforms of twigs, built above water, often in mangroves. When the young first **hatch** they are naked and extremely active. Watching them is not easy. A bump from the **bows** of a canoe against mangrove branches is almost unavoidable, and if the nest shakes the young will scramble feverishly off their twig platform and onto the branches. If they are disturbed any further the chance of seeing them at all is likely to be lost, for they will abruptly launch themselves into the air, dive into the water and swim energetically into the tangle of mangrove roots where you will never be able to follow them. But with luck, you may have seen how they cling so **adhesively** to twigs and clamber from one to another. They have two little claws on the front edge of each wing, relics of the time when their reptilian ancestors had not wings but **forelimbs** with separate **digits**. It is not at all difficult to see in these naked young birds a hint of the way Archaeopteryx moved through the branches of its dinosaur-haunted forests.

When the hoatzin chicks grow up, they lose these **vestigial** claws. The adults are poor flyers, flapping heavily and laboriously along the rivers. They do not seem able to cover more than a hundred metres or so before they have to crash into the vegetation and rest. Nonetheless they are unquestionably very much more accomplished in the air than Archaeopteryx ever was, for they, like all modern birds, have a skeleton that, during the past 140 million years, has become greatly modified for flight.

(Adapted from: *Life on Earth,* David Attenborough)

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) **hatch**
   (ii) **bows**
   (iii) **adhesively**
   (iv) **forelimbs**
   (v) **digits**
   (vi) **vestigial** [6]

2. Give an example from the passage of each of the following
   (i) a producer
   (ii) a consumer [2]

3. To which Phylum and Class do hoatzin belong? [2]

4. To which Kingdom do mangroves belong? [1]

5. Are hoatzin warm or cold-blooded? [1]

6. Give two distinguishing physical features of birds. [2]

7. To which Phylum do reptiles belong? [1]

8. What is the special adaptation of the hoatzin chick's wing and how does it benefit the young? [3]

9. What advantages might a feathered dinosaur have over a non-feathered variety? [2]

10. Archeopteryx is sometimes described as the missing link between dinosaurs and birds. What is the name of the process that is believed to have occurred over millions of years. Suggest how you think it might have happened in this case, and what might be the modifications of a modern bird skeleton. [5]

Chemistry **[25 marks]**

This question is about making salts and how they dissolve.

Potassium chloride is a salt and can be made by reacting an acid and an alkali together. The salt produced is soluble in water.

1. Describe how you could make pure potassium chloride crystals by reacting the acid and alkali. Write the instructions as numbered steps so that another student could follow the experiment and repeat it. [6]

2. How could you tell if the alkali had fully neutralised the acid? [2]

3. Apart from potassium chloride, what else is produced in the reaction? [1]

4. Copper sulphate is also a salt. Give the names of the chemicals that you would use, and the chemicals that you would make in **two** other reactions to produce a salt. [4]

5. When potassium chlorate is a chemical that is not the same as potassium chloride. Potassium chlorate crystals are heated in a test tube, and a gas is given off. It is found to re-light a glowing splint. What is the gas? [1]

The solubility of potassium chloride in water was measured at a number of different temperatures.

Temperature °C	10	20	30	40	50	60	70	80
Solubility (g per 100g of water)	20	28	48	66	87	111	138	170

6. Use these figures to plot a solubility curve, with the temperature on the horizontal axis and solubility on the vertical one. Draw a best fitting line. [5]

7. Describe the shape of the graph. [2]

8. What mass of potassium nitrate dissolves in 100g of water at 60°C? [1]

9. What is the lowest temperature at which 80g of potassium nitrate will dissolve in 100g of water? [1]

10. How much potassium nitrate will crystallize out if a saturated solution of potassium nitrate in 100g of water is cooled from 80°C to 20°C? [2]

Physics **[25 marks]**

The following article appeared in a recent Physics magazine.

Read the text and answer the questions.
WRITE WORDS OF EXPLANATION AS WELL AS YOUR MATHEMATICAL WORKING

Spiders get a grip



Spiders can walk upside-down across almost any type of surface, due to a 'contact force' between them and the surface, according to a team of German and Swiss scientists. The team has also calculated that the 'contact force' is strong enough to allow the animal to carry more than 170 times its own body weight

1. The 'contact force' calculated for by the scientists was 0.025N. **Roughly** what is the spider's bodyweight? [3]

2. Using your answer above, calculate the spider's mass? (g=10 N/kg) [2]

The scientists found that the spider's legs contain a tuft of hairs, and that each individual hair in the tuft is covered by hundreds of thousands of smaller hairs - called setules – each about one hundred nanometres in width. The spider uses these setules to stick to surfaces.

3. 1 nanometer = 10^{-9} metres. How wide is one setule in metres? [2]

4. So how many setules would fill a width of 0.1 mm? [2]

5. So how many setules would you need to cover a square which had sides of 0.1 mm? [3]

6. Imagine that the number of setules you have just calculated is the number that are used by the spider to hang upside-down. Use the information from question 1 to calculate the force produced by each setule. [3]

It has been suggested that the spider would find it easier to hang upside-down above a source of heat, as hot air rises.

7. Why does hot air rise? [2]

8. Do you agree with the above suggestion, that the spider would find it easier? [3]

The results of this research could be exploited to develop new types of adhesives, as the 'contact force' is not affected by the environment and this allows the spiders to walk across wet or slippery surfaces.

9. Suggest a use for a new type of adhesive based on this research. [2]

10. If you scale up a spider by a factor of two in all directions, its mass will increase eight times and its foot size will increase four times. By how much could this spider be scaled up and still be able to hang upside-down? [3]

Design and Technology [25 Marks]

Designing a product to escape from a burning tower block

A company has an idea to develop a system called 'Life Line' to ferry people from one tower block to another. The system will be used when, because of a fire, people are trapped (above the fire) in a tall building (using lifts is dangerous when a building is on fire, and stair ways may also be impossible to use).

Using notes and diagrams, you are asked to help them develop the product.

1 What kind of materials would you choose for the system considering the environment in which it is to be used?

[2]

2 What would be your 'top 8' most important design features when designing a product like this?

[8]

3 How would you attach the system to the body? Sketch **AND** label a diagram, giving the reasons why you have designed the system in this way.

[7]

4 What would control the movement of your system **and** why? Sketch **AND** label a diagram, giving the reasons why you have designed the system in this way.

[8]