

**RADLEY COLLEGE**  
**Entrance Scholarships**



**SCIENCE AND TECHNOLOGY I**

Wednesday 12th February 2003

Time allowed - 2 hours

*Answer **all** 4 sections.*

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

*Each section carries the same number of marks.*

*You may use a calculator, but remember to show all working.*

*Illustrate your answers with diagrams  
or sketches where appropriate.*

## Biology

### Read the following passage:

Passage through an animal's gut is essential for some seeds. The species of acacia whose umbrella shape is so typical of the plains of East Africa encloses its seeds in small twisted pods. These are very rich in protein and many of the plant-eating animals on the plains relish them. Those seeds that remain uneaten on the ground seldom if ever **germinate**, whereas those that are swallowed with the pods and then pass through an animal's digestive system nearly always do. It used to be thought that this was because stewing in digestive juices weakened the covering of the seeds and made it possible for the infant plant within to break out. The truth, however, is somewhat different. Within a few hours of the acacia tree shedding its **Pods**, large numbers of a particular kind of small beetle fly in, pierce the pods with their sharp **ovipositors** and lay their eggs within. The eggs hatch rapidly and the tiny **grubs** then proceed to feed on the acacia's seeds. Unless, that is, the pods are eaten by an animal such as an elephant. Although the elephant grinds up the pods with its teeth, many of the seeds remain unharmed and are swallowed with the **mash**. In the stomach all the beetle eggs are killed stone dead by the digestive juices. So when the seeds finally return to the outside world with the animal's droppings, they have been freed from their pests by the elephant, just as effectively as seeds of wheat that have been treated by a farmer with pesticide.

Some animals drop their dung on special **middens**. That is likely to be a disadvantage for a seed, which would be better served by a more widespread distribution. But this is not necessarily the case. The great Indian rhinoceros is a creature of regular habits. Each evening it visits one of its regular sites along a river for a wallow. After it has spent some time standing in the cooling water, it emerges on to a mud-bank, where there is plenty of open space around and little danger of it being ambushed by a tiger. And there it defecates.

(Adapted from: *The Private Life of Plants*. 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:
  - (a) germinate
  - (b) pods
  - (c) ovipositor
  - (d) grubs
  - (e) mash
  - (f) midden[6]
2. Give an example from the passage of each of the following
  - (a) a producer
  - (b) a primary consumer
  - (c) a secondary consumer
  - (d) an invertebrate[2]
3. Why are acacia seeds so important in many animals' diets [2]
4. Are rhinoceroses herbivores, carnivores or omnivores? [1]
5. To which Kingdom does acacia belong? [1]
6. To which Phylum do elephants belong? [1]
7. Give two distinguishing features of mammals [2]
8. To which Phylum do beetles belong? [1]
9. Give three distinguishing features of insects [3]
10. How does the behaviour of the elephants help the acacia [3]
11. Draw a food web using organisms **named** in the passage [3]

## Chemistry

### *Chemical Reactions*

Identify the names of the substances represented by the letters (A- K) in the following reaction schemes. [11]

1.

A is a white solid that when heated produces a colourless gas B and a white solid C.

Gas B forms a milky suspension A when bubbled through limewater.

When solid C is added to dilute hydrochloric acid, a new metal-containing compound D is formed.

When a solution of D is electrolysed, two colourless gases E and F are formed at the anode and cathode respectively.

2.

G is a blue crystalline solid that, when heated, produces a white solid H and a colourless gas that condenses to form a liquid I that boils at 100 C (at 1 atmosphere pressure).

When solid H is heated further, a black solid J and a gas K that fumes in moist air are produced.

When solid J is added to dilute sulphuric acid and warmed, a blue solution is formed that, when allowed to crystallise, produces solid G.

Gas K when bubbled through water, reacts violently to form sulphuric acid.

*Solubility of Gases*

The following table shows how various gases dissolve in water at different temperatures. The solubility of the gas is measured as the mass of gas (in grams) that dissolves in 1.00 g of water at a particular temperature.

Gas	Temperature / Celsius		
	0	20	40
<b>Ammonia</b>	0.895	0.531	0.307
<b>Carbon dioxide</b>	$3.35 \times 10^{-3}$	$1.69 \times 10^{-3}$	$9.73 \times 10^{-4}$
<b>Oxygen</b>	$6.94 \times 10^{-5}$	$4.34 \times 10^{-5}$	$3.08 \times 10^{-5}$
<b>Hydrogen</b>	$1.92 \times 10^{-6}$	$1.60 \times 10^{-6}$	$1.38 \times 10^{-6}$
<b>Hydrogen chloride</b>	0.823	0.721	0.633

3. Which gas is the
- (a) most soluble at 40 °C? [1]
- (b) least soluble at 40 °C? [1]
4. What is the **trend** in solubility on **increasing** the temperature of the water? [1]
5. Calculate the mass of ammonia expected to dissolve in 100 g of water at 20 °C? [2]
6. A 500 cm<sup>3</sup> sample of water at 0 °C is **saturated** with oxygen gas.
- (a) Calculate the maximum mass of oxygen gas that should be able to dissolve in this volume of water at 0 °C. [2]
- (b) The same solution is heated to 40 °C. Calculate the mass of oxygen released from the solution when the solution reaches 40 °C. [3]
7. It is known that 14.0 g of ammonia gas will occupy a volume of approximately 24 000 cm<sup>3</sup> and this volume of gas contains  $6 \times 10^{23}$  molecules.
- (a) Calculate the mass of one ammonia molecule. [2]
- (b) Calculate the average volume of space occupied by one ammonia molecule. [2]

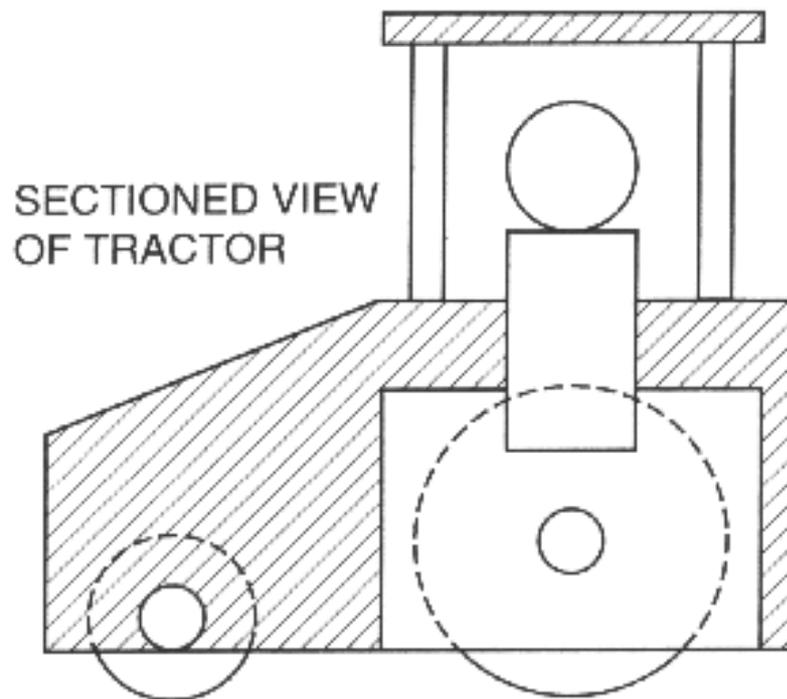
## Design & Technology

1. 'Toys in Wood' are a manufacturer of wooden toys for young children. They wish to introduce a new range of hand-powered toys in time for Christmas. The company intends to use home-grown hardwoods for all of their components.

(a) There are two basic types of wood, hardwood is one, what is the other? [1]

(b) Name an appropriate hardwood and explain why its properties would be suitable. [3]

2. Draw a suitable mechanism to create an **up and down** movement for the driver in the wooden toy shown below. [3]



3. Draw an appropriate mechanism to create a **rotating** movement of the driver as the train goes along (so the driver looks like he is looking around in circles as the train goes along). **All parts should be clearly drawn and named.** [3]

4. Each new toy in the range will possess some kind of movement, when pulled along. Choose one of your mechanisms and design a **wooden pull along toy** based on a Christmas theme.

Your design should **clearly** show the mechanism in use.

Your design will be judged on:

The range of ideas [5]  
The suitability of the solution [5]  
Quality of presentation [5]

## Physics

Along with Father Christmas, the Tooth Fairy bases her operations up in the North Pole. Young children have 20 “milk” teeth which they generally lose at the age of 7. These are then replaced by 32 “adult” teeth.

The approximate population of the World is 6 billion ( $6 \times 10^9$ ) of whom half are children **under** the age of 15.

1. How many children in the world are aged 7? [2]
2. How many teeth are lost each year? [2]
3. Show that roughly 10 million teeth must be collected each evening. [2]

Unfortunately the Tooth fairy can only carry one one coin at a time and so must do a complete journey from the North Pole and back for each and every tooth. [2]

4. If the Tooth Fairy works for 24 hours each day then how long does she have to complete each journey? Your answer should be less than 1/100th of a second. [2]
5. The World has a radius of 6,400 km. Show that the distance from the North Pole to the Equator is about 10,000 km. [2]
6. Assume that a typical 7 year old is 10,000km from the North Pole. How fast must the Tooth Fairy travel to complete each journey in the time available? Give your answer in m/s [2]
7. Is this faster or slower than the speed of Light ( $3 \times 10^8$  m/s)? [2]
8. Assume that each tooth has a mass of 10 grams (much of which is Calcium). What is the total mass of teeth lost each year, in kilograms? [2]
9. Assume that the Tooth Fairy delivers coins with a mass of 20 grams. What mass of coins will the Tooth Fairy have to move each evening? [2]
10. The kinetic energy required for each journey can be calculated using the formula  $\frac{1}{2} \times m \times v^2$  where  $m$  is mass in kg and  $v$  is speed in m/s. What is the kinetic energy required to carry each coin? [2]

Einstein's equation  $E = m \times c^2$  suggests that Mass can be converted into energy where  $E$  is energy,  $m$  mass and  $c$  is the speed of Light ( $3 \times 10^8$  m/s).

11. How much energy could (theoretically) be acquired from each tooth? [2]
12. Is this enough to deliver a 20 gram coin? Can you suggest an alternative? [3]