RADLEY COLLEGE
Entrance Scholarships

SCIENCE AND TECHNOLOGY I

Wednesday 11th February 2004

Time allowed: 2 hours

*Answer **all** questions.*

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

Biology

Read the following passage:

In the Galapagos, finches attend to giant tortoises as they graze on Opuntia. They **alight** in front of one of them and hop up and down in an exaggerated fashion. If the tortoise feels the need to be cleaned, it signals its acceptance by **craning** its neck upwards and stiffening its legs so that its huge shell is lifted clear from the ground. In this position, all the more intimate parts of its skin where something unpleasant and irritating may have lodged are as fully exposed as they can be. Immediately, the finch flies on to the tortoise, inspecting its neck and climbing up its thighs while the tortoise stands quite motionless with that air of frozen patience adopted by a man having his hair cut.

The same sort of services are also available in the sea. Huge sunfish come to the surface of the water and float on their sides so that gulls can come down and remove fish-lice from their flanks. Phalaropes have been seen doing the same thing for grey whales that **strain** algae, zooplankton and amphipods through their baleen combs. On coral reefs there are special places that are recognised by fish as cleaning stations. Here a resident staff of small wrasse and shrimps is always on hand. When a big grouper or a parrot fish cruises in, a cleaner wrasse, a slim little fish wearing a vivid uniform of blue and white stripes, dances in front of the new arrival with a bobbing motion.

The grouper now hangs in the water, holding open its gill covers and mouth, often with its body tipped more vertically than horizontally, sometimes head-up, sometimes head-down, in a posture that signals its willingness to have its toilet attended to. The little wrasse swims in and fusses all over its client, trimming off pieces of dead skin, snipping away **infestations** of fungus, boldly venturing right into the huge jaws and coming out through the **gaping** gill covers. Many fish return to these stations every few days for servicing and even though the cleaners can deal with as many as three hundred customers in six hours, there may still be queues awaiting their turn.

The organisms removed by these cleaners are mostly fish-lice, specialised crustaceans that spend all their adult lives on the bodies of fish. Some feed by scraping tissue from the surface of the skin. Some suck blood and some burrow so deep into the fish's body that only their tails show to the outside world. These creatures are not **innocuous** passengers like the mouse's beetles or the sloth's moths. They do not provide a service of any kind whatsoever. They feed on the flesh of their hosts and give nothing in return.

(Adapted from: *The Trials of Life*. 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) **alight**
   (ii) **craning**
   (iii) **strain**
   (iv) **infestations**
   (v) **gaping**
   (vi) **innocuous** [6]

2. Give an example from the passage of each of the following

   (i) a producer
   (ii) a primary consumer
   (iii) a secondary consumer
   (iv) a parasite [2]

3. Why does a grouper hang with its body tipped more vertically than horizontally? [2]

4. Are wrasses herbivores, carnivores or omnivores? [1]

5. To which Kingdom do algae belong? [1]

6. To which Phylum do finches belong? [1]

7. Give two distinguishing features of reptiles. [2]

8. To which Phylum do tortoises belong? [1]

9 Give three distinguishing features of crustaceans. [3]

10. How does the behaviour of the finches help the tortoise? [3]

11. Draw a food web using some of the organisms **named** in the passage. [3]

Chemistry

Magnesium is reacted with some sulphuric acid. The magnesium is placed in a conical flask, the acid added and a bung with a rubber tube linked to a gas syringe is fitted immediately. A gas is given off and the volume of gas is measured every five seconds for one minute and recorded (see first table). The gas is tested and found to ignite with a squeaky pop. A colourless solution is left.

Reaction A results:

Time (in seconds)	0	5	10	15	20	25	30	35	40	45	50	55	60
Volume of gas (in cm^3)	0	30		64	78	82	94	96	97	97	97	97	97

The reaction was performed again in exactly the same way as with the first experiment, but with a different concentration of sulphuric acid. The results were as follows:

Reaction B results:

Time (in seconds)	0	5	10	15	20	25	30	35	40	45	50	55	60
Volume of gas (in cm^3)	0	6	14	25		55	79	90	94	96	97	97	97

1. What is the gas that is given off in this reaction? [1]

2. What is the chemical formula for the gas given off? [1]

3. What is the chemical formula of sulphuric acid? [1]

4. Describe what you would see during the reaction. [2]

5. Try to write a balanced chemical equation for the reaction that has occurred. [1]

6. On a piece of squared paper plot the results from the two experiments, with volume of gas on the y-axis against time on the x-axis. Mark the first concentration of hydrochloric acid "A" and the second concentration "B". [5]

7. Use your graph to predict values for the missing values in the table. In reaction A at t = 10 seconds and in reaction B, at t = 20 seconds. [2]

8. At what time is reaction A going the fastest? Mark this point on your graph. [2]

9. At what time was reaction B going the fastest? Mark this point on your graph. [2]

10. Calculate the rate of reaction in cm^3 per second at the fastest point in reaction B. [2]

11. One of the reactants was in excess in both reactions. Which reactant was it, and how do you know? [2]

12. In which reaction, A or B, was the hydrochloric acid the most concentrated? Explain your answer. [2]

13. The experiments were repeated but this time the magnesium was replaced by a) zinc and b) copper. In each case, a) and b), predict how the shape of the graph would differ from that with magnesium. [2]

Physics

This question is about some physics that you might see in a bath.

You may find the following information useful. PLEASE SHOW FULL WORKING.

Area of a circle = π $\mathbf{r^2}$, where r = radius of circle

Density of water = 1000 kg/m^3
1 kg weighs 10 N on Earth

Suppose that the bath has a rectangular base with vertical sides. The base measures 70 cm by 180 cm. The bath water is filled to a depth of 35 cm.

1 a. What is the **volume** of water in **cm^3**? [1]

b. What is the **volume** of water in **m^3**? [2]

c. What is the **mass** of water in **kg**? [2]

d. What is the **weight** of water in **N**? [2]

e. What **pressure** does the water exert on the floor of the bath? [2]

f. The answer to e. above is the same for **any** bath size if the water is filled to a depth of 35 cm. Looking back at your calculations, **try to explain why**. [3]

2 a. The plughole in a different bath has a radius of 2cm. What is its **area** in **cm^2**? [1]

b. What is its **area** in **m^2**? [2]

c. This time the bath is filled so that the water exerts a pressure of 3 000 N/m^2 on the base of the bath. What is the **force** on the plug due to the water? [2]

An inventor has come up with a method that will allow someone to turn on the taps and leave the bath to fill without it overflowing. A balloon is attached to the plug with a chain. The idea is that the balloon floats and pulls out the plug when the chain goes tight, so that excess water drains away.

3 a. The bath is filled from separate hot and cold taps. When the inventor experiments, he discovers that the water flowing out of the plughole is **colder** than the average temperature of the bath water. **Why**? [2]

b. What is the **upwards force** needed to pull out the plug in question 2? [1]

c. Unfortunately, the invention would need a huge balloon to be able to lift the plug. The inventor wonders whether he should use a helium-filled balloon instead. **Draw a diagram** of his device and **label the forces** on it. **Do you think that he should use helium?** [3]

d. An alternative idea might be to redesign the plug and plughole. How should he change them so that less force is needed to lift the plug? [2]

Design & Technology

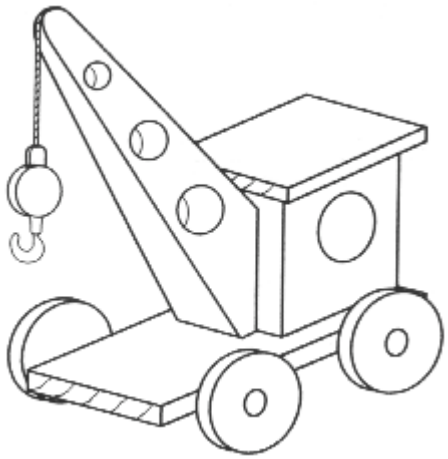
1. Study the table below that shows a list of mechanical properties.

1	Density	
2	Tensile Strength	
3	Compressive Strength	
4	Torsional Strength	
5	Shear Strength	
6	Bending Strength	
7	Elasticity	**ANSWER = H**
8	Ductility	**ANSWER = J**
9	Malleability	**ANSWER = E**
10	Hardness	
11	Brittleness	
12	Toughness	**ANSWER = A**
13	Conductivity	
14	Expansion	

Match the physical property above with its definition in the table below. Four have already been done for you. [5]

A	the opposite of brittleness
B	(strength when it is cut)
C	(strength when it is squashed)
D	how well it transmits heat or electricity along it (or insulates)
E	how easily it can be shaped by hammering
F	resistance to scratching or denting
G	(strength when it is twisted)
H	does it return to its original size and shape?
I	(strength when it is bent)
J	how easily it can be stretched
K	lightness or heaviness
L	(strength when it is stretched)
M	how much it grows in length when heated
N	how easily it cracks when hit or dropped

2. The diagram below shows a child's toy.



State **three** design features that could be added to make this toy more interesting for children to play with.

[3]

3. Give **three** important design requirements, apart from cost, for the following. In each case, briefly explain why the requirement you have suggested is important.

a) A surgeon's blade.

[2]

b) Bouncy castle fabric.

[2]

c) A bullet for a gun.

[2]

d) A police riot shield.

[2]

4. Your school has asked you to design a bird table to be placed in a prominent position in the school grounds.

a) Draw a suitable bird table. [3]

b) Explain the following choices of materials.

i) The materials which you chose, and why they were chosen. [2]

ii) How the surfaces of the bird table are to be finished and why. [2]

iii) Two suitable reasons why you have designed the bird table to look the way it does. [2]