Entrance Scholarships

SCIENCE AND TECHNOLOGY II

Wednesday 5th March 2003

Time allowed - 2 hours

Answer all 4 sections.

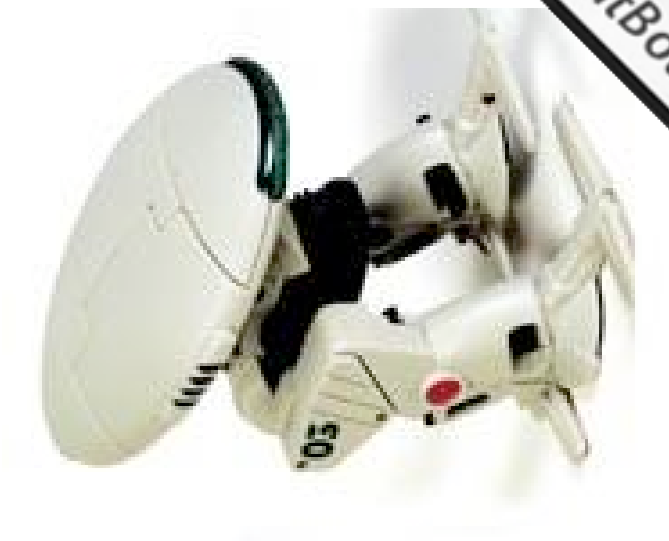
Each section carries the same number of marks.

Illustrate your answers with sketches where necessary.

Write the answers to each section

on a separate sheet of paper.

You may use a calculator



The picture shows a toy robot, called a Climbatron that uses suction pads to climb up smooth surfaces. It is claimed that it can even walk upside down on a smooth ceiling.

A Physicist wants to do some calculations on the Climbatron. To simplify his calculations, he assumes that it is solid plastic and is made up of three cylinders. The 'head' has a radius of 3cm, and a height of 2cm. The two 'legs' have a radius of 1cm and a height of 8cm.

You may find the following information useful:

Area of a circle= πr^2

Volume of a cylinder = area of base circle x height.

Density of plastic = 1200 kg/m^3

Atmospheric Pressure = $1x10^5$ Pa (1Pa=$1N/m^2$)

Gravitational force constant, g = 10 N/kg

Answer the following questions, drawing diagrams where appropriate.

1. a. What is the volume of the head in cm^3?

   b. What is the volume of **each** leg in cm^3? [2]

   c. Show that the volume of the whole Climbatron is about 1×10^{-4} $\mathbf{m^3}$ [1]

   d. So what is the mass of the Climbatron? [2]

   e. So what is the weight of the Climbatron? [1]

2. Each Climbatron sucker is a circle of **radius** 1.5 cm

   a. What is the area of the sucker **in** $\mathbf{m^2}$? [3]

   b. What is the force on the sucker from the atmosphere, if it has a vacuum underneath it? [2]

3. Do your answers in questions 1 and 2 suggest that the Climbatron can really walk upside down (justify your answer)? [3]

4. How does the atmosphere exert the force on the sucker? [3]

5. a. Draw a simplified diagram to show the Climbatron climbing a vertical surface.

   b.Draw arrows to show its weight and the pressure on the sucker. [2]

   c. The bottom of the sucker acts as a pivot point. If the manufacturers made the legs of the Climbatron **longer**, would it climb walls as easily? [4]

[25 Marks total]

1. List **eight** important Design considerations when designing and ma tree house. [4]

2. There is to be an emergency escape device to get down from the tree house.

Suggest **four** ways (**apart from a fireman's pole and a rope ladder**) in which this could be done. [4]

3. Describe **two** of these ideas and sketch them out using notes and diagrams to explain your design. [8]

4. Suggest **one advantage** and **one disadvantage** of using aluminium for the rungs of the rope ladder. [2]

using a square wooden frame on each side. Suggest some structural improvements that could be made to the sides of the tree house in order to improve stability and strength.

Draw 3 different solutions in boxes on your answer sheet

Label your sketches 5a, 5b and 5c (example shown below).

5a 5b 5c

[3]

6. To ensure that the children who play in the tree house can see on a dark Winter's night, the designer has decided to include a simple light inside.

Name one disadvantage of using main's electricity? [1]

7. Draw a simple circuit diagram **NOT** using main's electricity for the night light. [3]

[25 Marks total]

When a series of metals were added to acids, the following observations w made.

When dilute hydrochloric acid was added to a piece of magnesium ribbon, the magnesium fizzed and a gas, A, was given off which gave a squeaky pop on contact with a lighted splint. When the reaction had finished, a colourless solution, B, resulted.

When dilute hydrochloric acid is reacted with copper, no reaction takes place and even when concentrated hydrochloric acid is added to copper, there is no reaction. However, when concentrated nitric acid is added, a brown gas, C is given off, and a blue solution results, D. The brown gas when added to water reconstituted the original acid.

1. What is gas A? [1]

2. From which substance did gas A originate: the hydrochloric acid or the magnesium? [1]

3. Where has the magnesium gone at the end of the reaction? [1]

4. What is the colourless solution B? [2]

5. Why doesn't copper react with dilute HCl whereas Mg does? [2]

6. If concentrated nitric acid, HNO_3 reacts with copper, but concentrated hydrochloric acid, HCl, does not, then which part of the acid is it that is reacting with the copper? Explain your answer. [2]

7. Identify the two elements that are bonded together to make up the compound that is gas C. [2]

8. What is D? [2]

In another series of experiments aqueous metal compounds were reacted with other metals.

Reaction 1: An excess of zinc was added to 100 cm^3 of a solution of aqueous copper sulphate and the temperature rose by 5 °C.

Reaction 2: An excess of Magnesium was added to 100 cm^3 of a similar solution of aqueous copper sulphate and the temperature rose by 10 °C.

Reaction 3: A piece of potassium was reacted with 100 cm^3 of a similar solution of aqueous copper sulphate and a violent reaction occurred and a purple flame was seen above the potassium. The total temperature rise was 14 °C and a pale blue precipitate was seen at the end.

9. How can you tell that in each of the experiments above that a reaction had occurred? [1]

10. What other observation could be made in the first two reactions that would show that a reaction had occurred? [2]

11. Which reaction gave off the most heat energy? [1]

12. Reactions 1 and 2 are often called displacement reactions. Explain why this is by using equations for the reactions to illustrate your answer. [4]

13. What does the potassium react with in Reaction 3? [1]

14. In Reaction 3 a purple flame was seen above the potassium. What substance is burning? [1]

15. Using your answers to questions 13 and 14, or from your knowledge of chemistry, predict the name of the blue precipitate. [2]

[25 Marks total]

"Why study Biology?"

Write an essay outlining how the study of Biology has been useful in the past, and may help humans, other organisms and the environment in the future.

Do NOT spend more than 30 minutes on this Section. [25]

[25 Marks total]