

RADLEY COLLEGE
Entrance Scholarships



SCIENCE AND TECHNOLOGY II

Wednesday 7th March 2001

Time allowed - 2 hours

Answer all questions.

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.***

Physics

1. In 1989, an American hairdresser, Phillip McCrory, discovered that pillows full of human hair could be used to mop up oil spills from shipwrecked tankers.

A typical man has his hair cut once every month. About 9mm is cut off each hair.

- a. What is the length of hair cut off in metres? (1)
- b. Show that there about 2.6×10^6 seconds in a 30 day month. (2)
- c. So how fast is a man's hair growing in m/s? (2)

2. The average head has about 100,000 hairs on it.

A piece of hair 12cm long has a volume of $1 \times 10^{-3} \text{ cm}^3$

- a. What is the volume of a piece 9mm long? (1)
- b. So what is the volume of hair cut from the average head? (2)
- c. The density of hair is approximately 1.2 g/cm^3 . What is the mass of hair cut off the average head? (2)
- d. If a barber can cut one person's hair in 15 minutes, what mass of hair will he cut off in a 7 hour working day? (2)

3. The hairdresser Phillip McCrory thought that about 0.6 million kg of hair could have soaked up the $42,000 \text{ m}^3$ of oil leaked by a ship called the Exxon Valdez.

a. Suppose the density of crude oil is 700 kg/m^3 . So what was the mass of oil leaked? (2)

b. 0.3 kg of oil contains very roughly 10^{24} molecules. How many molecules were spilt? (3)

4. 0.6 million kg of hair is equivalent to one strand of hair $60,000 \text{ m}$ long.

a. How many molecules of oil are trapped by each mm of hair? (3)

b. How many barbers would it take to produce 0.6 million kg of hair in a day? (3)

c. Comment on this answer. (2)

(Total 25 Marks)

Chemistry

1. When concentrated sulphuric acid is added to rock salt, a colourless gas is produced that we shall call 'salt gas'.

When this gas is passed over heated iron, a chemical reaction occurs and a new gas is produced that gives a squeaky pop when exposed to a lighted splint.

- a. What is the name of the gas that produces a squeaky pop? (1)
- b. What does the result from this experiment tell us about the elemental composition of salt gas? (1)

2. A solution of salt gas in water is now prepared. A small amount of potassium permanganate (KMnO_4) is added to the salt gas solution and chlorine gas is produced.

- a. What does this reaction indicate about another element that must be present in salt gas? (1)
- b. Is salt gas a compound, a mixture or an element? **Give evidence for your answer.** (3)
- c. A friend suggests that the chlorine gas produced in this second experiment may not have come from the salt gas. What is your response? (1)
- d. What do the results of the experiments show about the number of elements present in salt gas? (2)

3. Describe an experiment that you could carry out that proves, beyond any reasonable doubt, that salt gas is made up of only 2 elements?

(3)

4. This question is about an investigation into calcium carbonate.

- Calcium carbonate is strongly heated in a Bunsen burner.
- A colourless gas, X, is produced.
- When this gas is passed through lime water, a white suspension is produced; this is carefully removed.
- When dilute hydrochloric acid is added to the white suspension, the same colourless gas, X, is formed.

a. What is the name of gas X? (1)

b. What is the name of the white suspension produced when gas X is passed through lime water? (1)

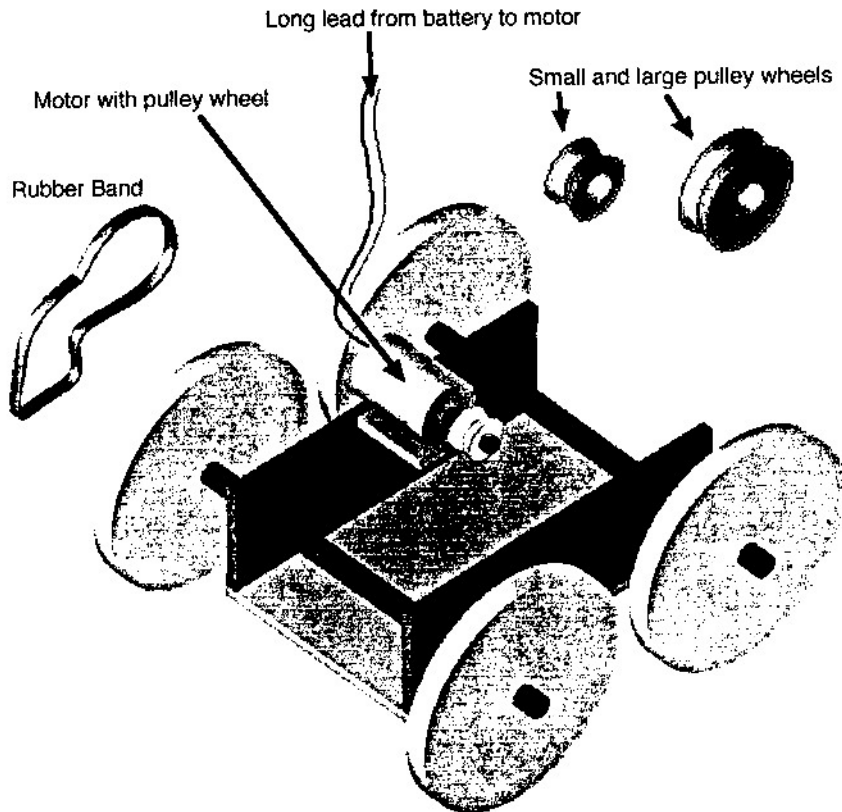
c. Describe, **with the aid of a carefully labelled diagram**, how the white suspension is removed from the solution. (4)

d. Using the information above, describe an experiment that you could carry out to separate a mixture of hydrogen and carbon dioxide gases. At the end of your suggested experiment, each gas must be chemically intact. (4)

5. Gas X from question 4 has many implications for environmental issues such as pollution. Discuss. (3)

(Total 25 Marks)

Design & Technology



A pupil has made a small battery powered model car. An elastic band will transmit the power from the pulley wheel on the motor, to a pulley wheel on the axle of the model.

- 1 If he wants the car to go as fast as it can, which of the two spare pulley wheels will he use on the axle of the model?
(1 mark)
 - 2 If he wants the vehicle to be able to climb steep slopes, which of the two spare pulley wheels will he use?
(1 mark)
 - 3 The vehicle when tested kept slipping. State two different design changes the pupil could make to improve the situation?
(2 marks)
 - 4 The pupil tries putting the battery on the car so that it will be carried by the car.
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- (a) State two **negative** effects on the car's performance.
(b) State two **positive** effects on the car's performance. (4 marks)

5

The pupil is given a set of tires for the wheels. This increases the wheel's diameter.

- (a) Will the vehicle have a faster top speed?
(b) What effect will the new tyre have on the acceleration of the vehicle? (2 marks)

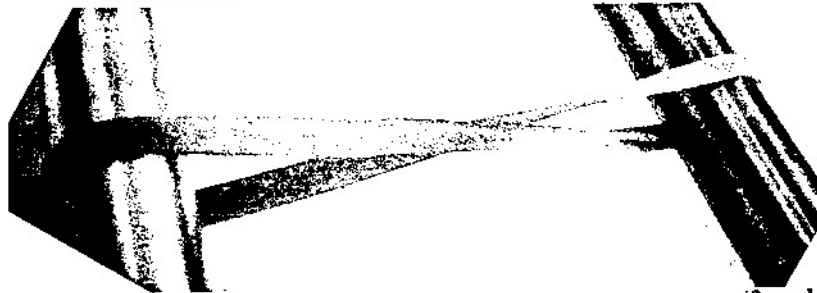
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When tested, the vehicle's metal axles rub inside the holes making the sides of the car hot and stopped the motion of the vehicle being smooth.

- (a) What is this kind of energy loss called?
(b) Name **two** design changes the pupil could make to reduce the problem. (3 marks)

7

The rubber band was found to be too loose on the pulley wheels and the pupil finds that the elastic band is slipping. He puts one twist in the rubber band which tightens the rubber band (as in the diagram below). What effect does this have on the direction of the car?



(2 marks)

8

The pupil also tries an **extremely tight** elastic band which he only just manages to get on the pulley wheels. He then finds the car will not move. Why? (2 marks)

9

The car is to be given to the pupil's 3 year old brother as a Christmas present. State **two** design safety changes the pupil would need to make first. (2 marks)

10

Name one design change **not mentioned already** which could make the car go faster. (1 mark)

11

The pupil wants the car to appeal to his 3 year old brother. List **three** design considerations the pupil might think about. (3 marks)

12

Suggest **two** materials that might be suitable for the body shell giving reasons for your selection. (2 marks)

Total 25 marks

Biology

Describe, in as much scientific detail as you can, the journey a **carbon atom** makes from being part of a carbon dioxide molecule in the air above a wheat field, until it becomes part of a carbon dioxide molecule breathed out by you during a rugby game.

Try to structure your answer as much as possible.

(Total 25 Marks)