RADLEY COLLEGE
Entrance Scholarships

SCIENCE AND TECHNOLOGY II

Wednesday 3rd March 2004

Time allowed: 2 hours

*Answer **all** questions.*

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

Chemistry

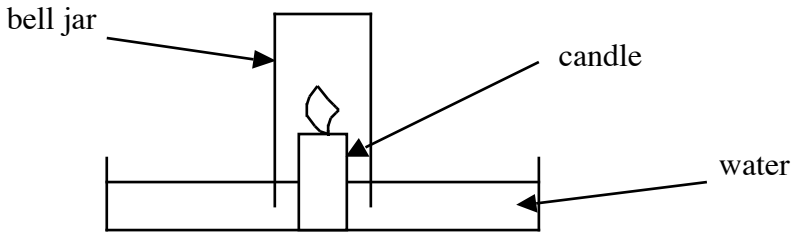
1. Classify each of the following as an element, mixture or compound. [3]

   a) pure orange juice
   b) sea salt
   c) distilled water.

2. What gas or liquid (if any) would you expect to be given off if you heated the following dry solids with a Bunsen burner? [3]

   a) magnesium oxide
   b) hydrated copper sulphate
   c) lead carbonate

3. A Radleian was trying to determine the percentage of oxygen by volume in the atmosphere. He set up an experiment as shown below:

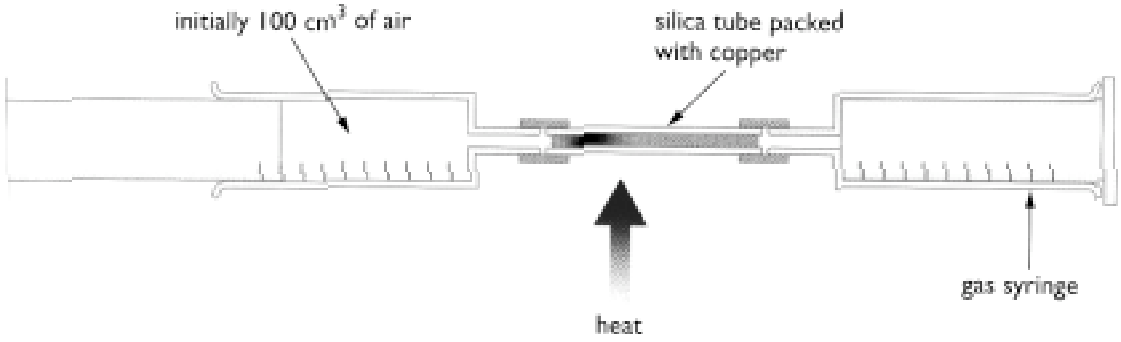


   a) Predict what would happen to the water level in the bell jar when the candle was lit and then the bell jar sealed. [1]

   b) The candle wax was a 'hydrocarbon'. Give two possible products of its combustion. [2]

   c) Give one reason why the results of this experiment might not give an accurate idea of the percentage oxygen by volume in the air. [1]

The apparatus below shows a second experiment that the Radleian performed. Copper metal turnings were heated strongly in a silica tube while air was passed over them in a sealed system. The total initial volume reading in the syringes was 100cm^3.



d) Why do you think a more reactive metal such as sodium was not used? [1]

e) The volume reading 20 seconds after heating started was 107 cm^3.
Why was there an initial increase in the volume? [2]

f) Predict the final volume reading after 10 minutes of strong heating and then cooling to room temperature. [1]

g) A black solid is seen to form in the tube. Write a word equation for the reaction that has happened. [2]

h) Copper has traditionally been used to cover the roofs of some churches. After a period of time a green layer forms on it. Carbon dioxide in the air is blamed for this reaction. What do you think is the name of the green compound formed after prolonged exposure to the air?
[1]

4. Explain the following observations fully:

a) A Bunsen burner can burn with a blue flame or a yellow flame. [2]

b) Heating wine gives off ethanol (alcohol) vapour first. [2]

c) Stainless steel saucepans sometimes have copper bases. [2]

d) A shiny metallic liquid is seen inside many thermometers. [2]

Physics

The wavelength of a musical note can be calculated by using the formula:

$$v = f \times \lambda$$

v is the **velocity** of the wave
f is the **frequency** of the note
λ is the length of each wave (the **wavelength**).

The **frequency** of a note is measured in Hertz.
1 Hertz (Hz) = 1 wobble per second, or 1 oscillation per second

mega = 1 million or 1×10^{6}

nano = 1 billionth or 1×10^{-9}

1 atom ≈ 1×10^{-10} m across.

1 micron = 1×10^{-6} metres

Yamaha FG-310L by Steven W. Allison © 1994 Made with Canvas 3.5

I own a rather smart acoustic guitar. I can play a note which is 300 Hz. The note one octave above this is 600 Hz. One octave higher still is 1200 Hz. One further octave higher is 2400 Hz

1. Using the information above, what is the definition of an "octave". [1]

2. Re-arrange the formula to make λ the subject of the formula. [1]

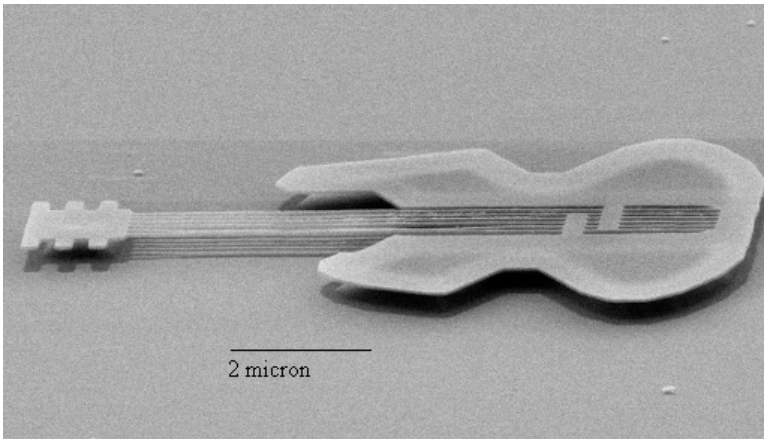
3. If the velocity of the sound wave on the string is 600 metres per second then calculate the wavelength of a 300 Hz note. [2]

4. It turns out that the string of my guitar needs to be half the length of the wave. What will the length of the string be when playing a 300 Hz note? [1]

5. If I place my finger half way down the string I effectively halve the length of the string, and hence halve the wavelength. Using the equation given, calculate the frequency of the new note. [2]

6. How could I produce a note of 1200 Hz? [2]

You may have read about nano-technology. The Cornell University nano-guitar shown below was first built in 1997 but has only recently been played for the first time.



The guitar "strings" (actually slender planks of silicon) are 10 microns long.

7. How long are the guitar strings in millimetres? [2]

8. How many atoms are there along the **length** of each string? [2]

9. Use the photograph and your previous answer to estimate how many atoms **wide** you think each string might be. Show your working! [3]

10. The nano-guitar twangs at a frequency of 40 MegaHertz (MHz). Show that this is some 17 octaves higher than the 300 Hz from my own guitar. [3]

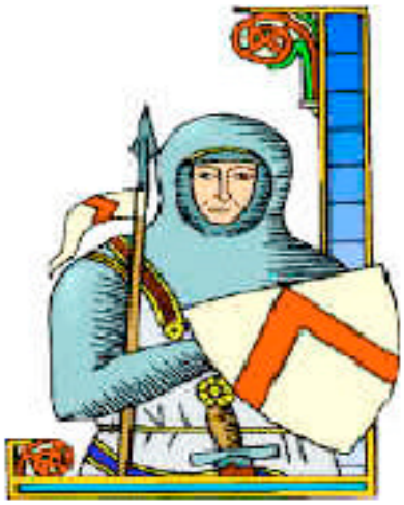
11. This nano-guitar is 100,000 times shorter than my own guitar. Why might it produce a note that is 130,000 times higher? [3]

Researchers at Cornell University used laser light to set the strings of the guitar in motion. The laser light had a wavelength of 500 nanometres (nm). The speed of light waves is 3.0×10^8 m/s

12. Use the wave equation from the previous page to calculate the frequency of the light oscillations. Comment on your answer.

[3]

Design &Technology



Medieval Castle Defences:

1. The drawbridge.

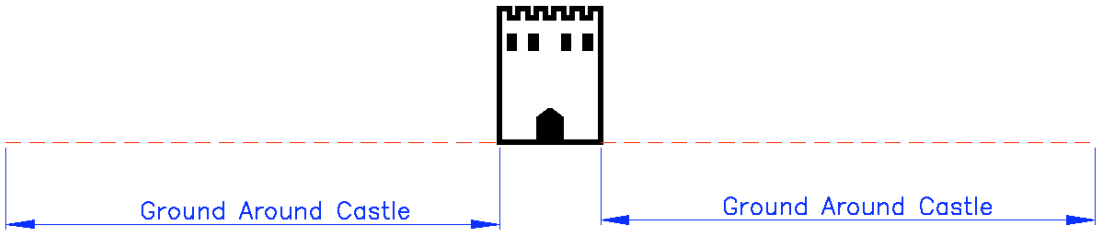
The drawbridge is extremely heavy and the Lord who lives in the castle wants to design a system to pull up the drawbridge as quickly as possible in case of a surprise attack.

Draw a diagram showing a suitable system with notes to explain its use and advantages.

[6 marks : 3 marks for the diagram, 3 for the notes]

2. Designing defences for the ground outside the castle walls.

Look at the below diagram which shows the ground immediately outside the castle.

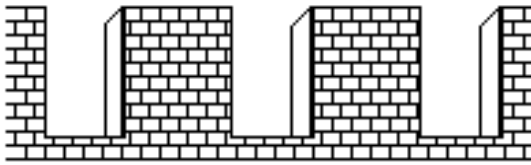


Draw three design features that could be used to protect the castle walls further. Label and briefly explain your additions.

[6 marks: 3 marks for the diagram, 3 for the notes]

3.

In case of castle siege, boiling water can be used to drop on the attackers from the battlements (contrary to popular belief, oil was rarely used as it was expensive to produce).



Design a system to allow water to be loaded quickly, heated and then poured from the edge of the battlements without the castle dwellers being hit by the attackers' arrows.

Drawing **with labels**

[6 marks, 3 marks for the diagram, 3 for the notes]

4.

Using a labelled diagram explain how with the aid of modern materials, power sources, and methods a more effective version of the system in question 3 could be achieved.

[7 marks: 3 marks for the diagram, 4 for the notes]

Biology

What do you understand by the term 'biotechnology'? Discuss the opportunities and threats biotechnology poses. [25]

Credit will be given not only for biological content but also for the breadth of relevant material, and for the organisation and presentation of the essay.