RADLEY

2021 Academic Scholarship Examination Paper

STAGE TWO

Physics

23 – 25 February 2021

Time allowed: 30 minutes

Total marks: 33

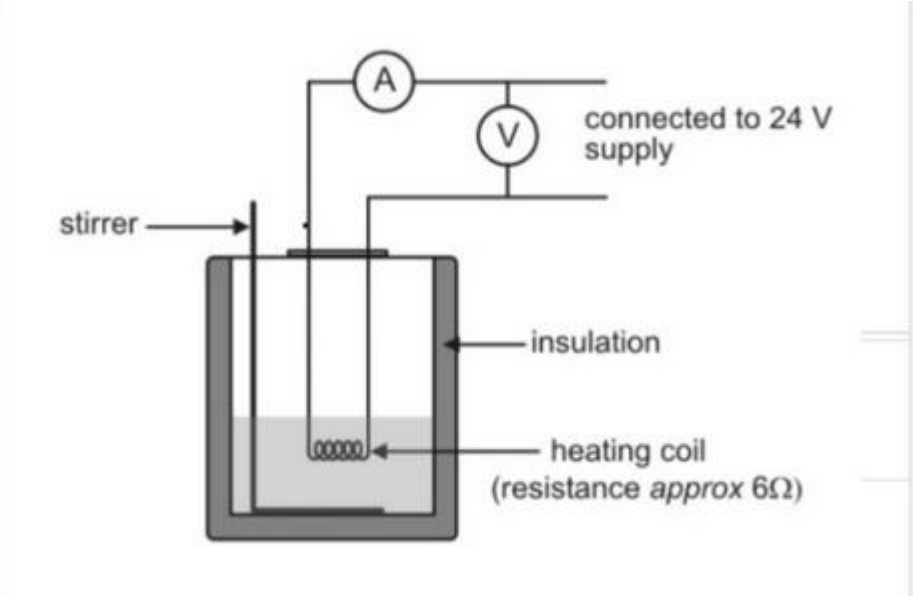
PLEASE WRITE IN BLACK INK

Calculators are not to be used

- Please write your answers on separate sheets of paper.
- Most of the marks are for **showing clear thinking**.
- Your final answers are less important than demonstrating a logical and systematic approach.
- **Use bullet points.**
- **Show your working** out at all stages. State any assumptions that you make.
- Where you can, use powers of ten to show very big or very small numbers.
  For example, "1,000,000" can be written: 1.0×10^6

Question 1

Tell me as much as you can about what you can see in this diagram:



(5 marks)

Question 2

Work out :

(a) $2.8 \times 10^{387} + 1.9 \times 10^{389}$

(b) $2.8 \times 10^{387} - 1.9 \times 10^{389}$

Show your working.

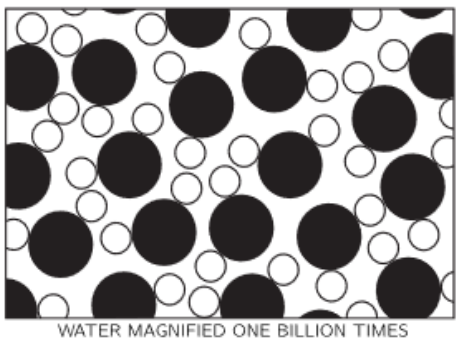
Hint: think about more familiar examples

(6 marks)

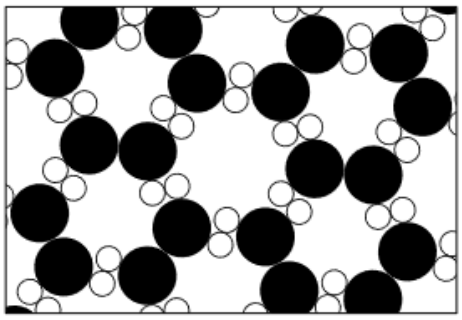
Question 3

All things are made of atoms—little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another. In that one sentence, you will see, there is an *enormous* amount of information about the world, if just a little imagination and thinking are applied.

This is a picture of water magnified a billion times. If we decrease the temperature of our drop of water, the molecules lock into a new pattern which is *ice.* The interesting point is that the material has a *definite place for every atom.*



WATER MAGNIFIED ONE BILLION TIMES



ICE

Figure 1.1

Figure 1.2

Figure 1.1 shows a photograph of the ice in a birdbath made of stone. Figure 1.2 shows a detailed picture of the pillar of ice shown in Figure1.1. The birdbath was in the open air and no water fell from above. **Suggest an explanation.**

(6 marks)

Question 4

You may have heard the phrase "worth its weight in gold".

If all of the books in Radley College library were suddenly turned into gold, **estimate** how much they would be worth.

Show your thinking clearly – it *may* help to draw a diagram.

(6 marks)

Question 5

For lots of relationships in Physics, one thing is proportional to another. For example, if the density of an object (of a certain shape and size) doubles, its mass will double.

$$density \propto mass$$

Other relationships are more complicated.

In 1619, Johannes Kepler found that the square of the time taken for a planet to go around the sun (time for one orbit) is proportional to the cube of the size of the orbit.

$$Orbit\ time^{2} \propto orbit\ size^{3}$$

For example:

Mercury has an orbit time of 88 (Earth) days. Mars has an orbit which takes 8 times longer, 680 Earth days. That means that its (orbit time)^2 is $8^2 = 64$ times longer.

Mercury is 58 million km from the Sun. Mars is four times further away: 232 million km from the Sun. Mars' (orbit size)^3 is $4^3 = 64$ times bigger.

(a) A satellite in a geosynchronous orbit goes around the earth once every 24 hours, and orbits at a distance of 42000 km from the centre of the Earth. How far from the centre of the Earth would a satellite orbit which took 8 hours be?

[*Hint – if a number is nearly right, approximate! e.g.* $3^3 \approx 5^2$ *(27≈25). And* ***show your working***.]

(5 marks)

(b) Ole Rømer used Kepler's work to time eclipses of Io, a moon of Jupiter. He found that sometimes the moons were sometimes ahead of where they should be, and sometimes behind! This was very confusing, until he realized that the light was taking time to reach us.

Rømer calculated that the light was taking about 22 minutes to travel a distance equal to the diameter of Earth's orbit around the Sun. What **estimate** the speed of light that Rømer calculated (this was the first time anyone calculated this!)

(5 marks)