Mark Scheme

**Final Assignment**

**Maths problems**

1. [2100/93] ans = 22.58 (rounded to 2dp)

2.

a) [40\*0.5\*150] ans= 3000cm³

b) [3000\*2.53/1000] ans=7.59kg

3. [385000\*2\*π = 2419026.3432641406 **then** 2419026.3432641406/28 = 86393.7979737 **then** 86393.7979737/24 = 3599.74158224 **then** 3599.74158224/60 = 59.9956930373 **then** 59.9956930373/60 = 0.99992821728 **then** 0.99992821728\*1000 (to get metres per second)] ans = 999.93 (rounded to 2dp)

4.

a) [π\*1.13²\*0.32] ans=1.28cm³ (rounded to 2dp)

b) The density of a pound coin can be worked out in the following way:

[9.5/1.28=7.42g/cm³]

This means that a pound coin would float in liquid mercury because liquid mercury is denser (at 13.5g/cm³) than a pound coin.

5.

a) I need the volume first [4.7/10 to get 0.47cm **then** (4/3)\*π\*0.47³ =0.43489]. I then use volume and density to get the mass [0.43489\*11.3] ans = 4.91g (rounded to 2dp)

b) [(4.7\*3)/10 - The /10 to give me a cm value] ans = 1.41cm

**Research Problems**

**If you had a large enough tank of water would the sun float?**

The sun will certainly not float in a tank of water. If you could get a large enough tank of water the sun would evaporate all of the water. In fact dipping the sun in water would make it hotter as the sun heats up the water to such an extent that it breaks apart at the atomic level. The hydrogen and oxygen atoms from the water will be absorbed into the sun.

But even you suspend belief and ignore the suns great heat and you miraculously produce a tank full of water big enough, the sun would still not float in water. Here is how it is proved.

* The suns radius is 696,000km. From that it’s necessary to calculate the volume using the following calculation:

4/3\*π\*696000³

The answer is 1412265429105895845.1420952274395836km³

* The approximate mass of the sun is 1989000000000000000000000000000kg
* The mass divided by the volume gives a density of 1408375478863.94kg/km³
* When this is converted to a g/cm³ figure (divide the kg/km³ by 1,000,000,000,000) the result is 1.41g/cm³ (rounded to 2dp)
* The density of water is 1g/cm³

So sun is clearly denser than water, and if the sun were to be placed in an imaginary super large swimming pool then it would sink as the surrounding water would be less dense.

**Will Vega, Rigel and Sirius A float in water?**

Vega:

* Vega’s radius is 1,961,000,000km. From that it’s necessary to calculate the volume using the following calculation:

4/3\*π\*1961000000³

The answer is 31587946247013819776332970241.1122289470169008km³

* The approximate mass of the Vega is 4246000000000000000000000000000kg
* The mass divided by the volume gives a density of 134.4183622067989765216kg/km³
* When this is converted to a g/cm³ figure (divide the kg/km³ by 1,000,000,000,000) the result is 0.000000000134g/cm³ (rounded to 12dp)

The density of water is 1g/cm³. Therefore (if you suspend belief and ignore all other things) Vega would float as it is far less dense than water:

* Rigel’s radius is 54,290,000,000km. From that it’s necessary to calculate the volume using the following calculation:
* 4/3\*π\*54290000000³

The answer is 670267457528723316301745443424033.3733615883827413km³

* The approximate mass of the Rigel is 35800000000000000000000000000000kg
* The mass divided by the volume gives a density of 0.0534115144602046328kg/km³
* When this is converted to a g/cm³ figure (divide the kg/km³ by 1,000,000,000,000) the result is 0.000000000000053g/cm³ (rounded to 15dp)

The density of water is 1g/cm³. Therefore (if you suspend belief and ignore all other things) Rigel would float as it is far less dense than water.

Sirius A:

* Sirius A’s radius is 1,191,000,000km. From that it’s necessary to calculate the volume using the following calculation:

4/3\*π\*1191000000³

* The answer is 7076587708304445162268113412.1448157387180695km³
* The approximate mass of the Sirius A is 4018000000000000000000000000000kg
* The mass divided by the volume gives a density of 567.787776485104190311kg/km³
* When this is converted to a g/cm³ figure(divide the kg/km³ by 1,000,000,000,000) the result is 0.000000000568g/cm³ (rounded to 12dp)
* The density of water is 1g/cm³

The density of water is 1g/cm³. Therefore (if you suspend belief and ignore all other things) Sirius A would float as it is far less dense than water.

**What differences do you notice between supergiant stars, main sequence stars, and white dwarfs?**

There are different types of stars in the universe. Let’s examine three star types and their attributes:

1. Supergiant stars

These stars are the largest type of stars. They are vast in size and are usually between 8 and 12 times the size of our sun. Supergiant stars are also extremely luminous and are at least 10,000 times more luminous than that of the sun. There are three different types of supergiant, Red, Yellow and Blue. Supergiant stars are older stars and further down the stellar lifecycle than a main sequence star

2. Main Sequence stars

All stars have been a main sequence star at some point in their lifecycle. They fuse Hydrogen to Helium within their core. These stars vary in mass with the smaller ones having one tenth of mass of the sun and the largest having two hundred times more mass. Main sequence stars are relatively young stars. That is stars which haven’t been around long enough to turn into a supergiant. Most stars (about 90%) are main sequence stars, including the sun. If a main sequence star does not explode it will evolve into a supergiant.

3. White Dwarfs

A White dwarf is a remnant of long dead star. The core of a star after it has exhausted its fuel supply and blown its gas and dust into space. They are very dense (in fact one of the densest things ever!) and each one has about the mass of the sun but contained in a much smaller volume. Despite the fact that nuclear fusion no longer takes place, a white Dwarf still has energy. It can emit light and give off heat for billions of years but it will, in theory, eventually burn out becoming a Black Dwarf.

The supergiant, main sequence and white dwarf represent a different stage in the lifecycle of a star.

**What type of star is Betelgeuse? Why?**

Betelgeuse is a Red Supergiant star. This is because of the following:

* Size; Betelgeuse is one of the largest stars known in terms of volume. It’s too big to be a blue supergiant.
* Luminosity; Betelgeuse is 100,000 times brighter than our sun. It is the ninth brightest star in the night sky.
* Colour; The large outer layers of Betelgeuse burn much cooler than the core. This gives Betelgeuse its distinctive red appearance.
* Slow rotation; It’s a fact that red supergiant stars rotate slowly. The rotation period of the sun is 26.24 days. Betelgeuse will take 15 to 30 years to rotate.
* Surface area heat; the other star types (Blue Supergiant stars, main sequence stars etc) are smaller than Red Supergiant stars, the nuclear fusion in their cores heat the surface area more. The suns surface temperature is 5,778k. The surface temperature of Betelgeuse is 3,500k.

**How many mice would you have to fit in a 1 cm³ cube to match the density of Sirius B?**

This will be an approximate calculation because mice come in different sizes and some bits of Sirius B are denser than others. First it is necessary to find the approximate average density of Sirius B. I am working on the assumption that Sirius B is roughly spherical. My research suggests this is the case.

* Sirius B has a radius of 5,900 km. From that it’s necessary to calculate the volume using the following calculation:

4/3\*π\*5900³

* The answer is 860289543468.8241940296256472km³
* The approximate mass of the Sirius B is 1989000000000000000000000000000kg (My research suggests Sirius B is roughly the same mass as our sun)
* The mass divided by the volume gives a density of 2312012292954341652.5860224659415645486kg/km³
* When this is converted to a g/cm³ figure (divide the kg/km³ by 1,000,000,000,000) the result is 2312012.29g/cm³ (rounded to 2dp)

It is now necessary to find the average mass, volume and density of a mouse

* My research revealed average mass of a laboratory mouse is around 35g. This is the mass assumption I will make.
* I will also assume a volume of 2.35cm³ (rounded to 2dp after a conversion from 2.35ml)
* Mass/Volume (35/2.35) gives a density of 14.89g/cm³

To answer the question the following calculation must be done:

2312012.29/14.89

The answer is that you need cram approximately 155,272.82 (rounded to 2dp) mice into a 1 cm³ cube in order to make it match the density of Sirius B

**In 6 billion years, the sun will begin to expand into a Red Giant, if the suns radius increases by 1% every 10 million years, ignoring any mass loss, how long would it take before the sun would float?**

To answer the question it is necessary to make the following calculations:

* The radius of the sun is currently 696,000km. To find 1% of that value divide it by 100. The result is 696km. Every 10 million years (starting in 6 billion years from now) the suns radius will increase by 696km.
* To find out how big the radius needs to be in order for the sun to theoretically float in water I used my knowledge of the suns mass and the calculations applied in the first research question. I initially estimated a radius and calculated the density. The density was quite a lot lower than my target density of 0.99g/cm³ (rounded to 2dp). So I lowered the length of the radius and kept calculating until I got as radius of 780,500km, This is the radius needed for the density to be 0.99g/cm³ (rounded to 2dp), just under the density of 1g/cm³ which would just about enable the sun to float in water.

The difference between 696,000km and 780,500km is 84,500km.

* Divide 84,500km by 696km to find how many times the radius of the sun needs to increase for it to be able to float. The result is 121.41.
* To calculate the time it would take for the suns radius to increase to 780,500km multiply 121.41 by 10,000,000. The result is 1,214,100,000.

The final step is to add 6,000,000,000 to 1,214,100,000. This accounts for the 6 billion years before the suns radius begins to increase. The answer to the question is that it will take 7,214,100,000 years until the sun will be able to float.