OUNDLE
School

EXAMINATION PAPER
Academic Scholarship 2021

Science (Paper 2)

Time allowed: 1 hour

Name: _____

Instructions

- Write your name clearly in the space above.
- Write your answer on the question paper.
- Calculators are allowed.
- Answer ALL the questions in all sections. Each section carries the same number of marks.
- You are expected to write clearly and accurately throughout each of your answers. You should leave some time towards the end of the examination to check your work carefully.
- The maximum number of marks for this paper is 59.

SECTION ONE: BIOLOGY [19 Marks]

Comprehension Exercise

Read the following passage then answer the questions. You may not have met this material or the concepts before: your answers will reflect your level of engagement with the material, not your recall.

There are three significant ways in which molecules travel across the membranes of living cells. Membranes found around cells (cell membranes) and the those inside (plasma membranes) are generally impermeable and most larger molecules cannot cross this barrier. Very small molecules such as gases, water and soluble salts can cross the membranes quite freely. Larger molecules, such as sugars and proteins can only cross through special channels, called pores. Membranes have these pores for specific molecules according to tissue function.

Most particles move because they have kinetic energy. This allows them to travel from an area of high concentration to an area of lower concentration – down their concentration gradient. This is known as **diffusion**. This happens when sugar dissolves in a cup of tea – the dissolved sugar molecules spread out in the drink until they are evenly distributed. When the sugar is dissolved it is called a **solute**; the water is the **solvent**; the mixture is a **solution**.

Water moves in a similar fashion but from a low solute concentration to a high solute concentration, down the water concentration gradient. Membranes of living cells cannot control water movement so it is important that the concentration of water and solute is the same on either side of a membrane, otherwise water will move down its own gradient. When this happens, plant cells can become turgid or flaccid; animal cells collapse or burst. The movement of water across a membrane like this is called **osmosis**.

The third way particles move is against their concentration gradient. This requires energy because the particles are moving across a membrane from a low concentration to a higher concentration. This is called **active transport** because it requires energy. Diffusion and osmosis do not require energy and are considered **passive.**

1. Komodo dragons have chemical receptors on their tongues that allow them to taste the air. When hunting, their tongue flicks in and out. This helps them find their prey, often large mammals such as buffalo.

   Suggest how they can use their tongue to find their food.

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   [2 marks]

2. Predatory fish, such as shark and piranha, are thought to swim towards an injured mammal following the blood. Suggest why they do this.

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[2 marks]

3. Gardeners will get rid of soft-bodied organisms like slugs using two types of traps:

   - Sweet smelling water – beer sometimes – is placed in a bowl. The slugs get into the water and then expand before dying. Suggest why.
   - Salt traps are used. These are baited traps that contain dry salt. Suggest how this may kill the slugs

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[4 marks]

4. Honey is well known as an antibacterial agent. It also has a very long shelf-life. Suggest why it may kill microbes.

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[2 marks]

5. Many seabirds have glands by their eyes that excrete salt droplets. Suggest why.

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…….

[2 marks]

6. Very few aquatic creatures can live in salt water and in fresh water. Suggest why.

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[3 marks]

7. Plants need minerals from the soil, dissolved in soil water, to make a large number of different molecules.
    a. Suggest what process allows plants to absorb minerals.

    …….

    [1 mark]

    b. After prolonged heavy rain or flooding, oxygen concentrations in the soil become reduced. Newly sprouting crops can suffer from mineral deficiencies. Suggest why.

    …….

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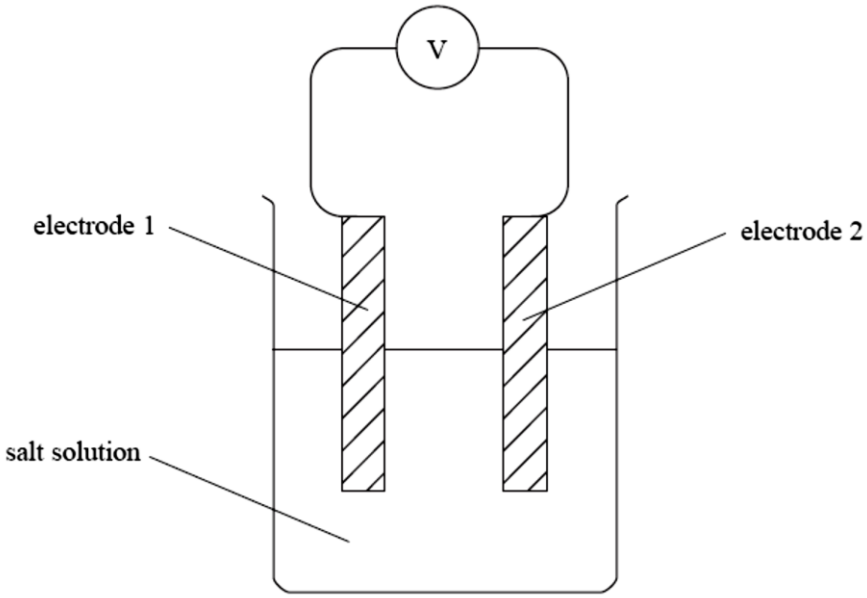
    …….

    [3 marks]

SECTION TWO: CHEMISTRY [20 Marks]

The relative reactivity of metals can be compared using the apparatus shown below.



- Electrode 1 and electrode 2 are made from two different metals.
- The greater the value of the voltmeter reading (ignoring the sign), the bigger the difference in reactivity between the two metals.
- If the reading on the voltmeter is negative, the metal used for electrode 1 is more reactive than the metal used for electrode 2.
- If the reading on the voltmeter is positive, the metal used for electrode 1 is less reactive than the metal used for electrode 2.

A pupil used the apparatus shown to investigate four metals, **P**, **Q**, **R** and **S**. The table below shows the voltmeter readings that she took using the metals as electrodes 1 and 2.

		metal used for electrode 1		
		P	**Q**	**R**
metal used for electrode 2	**Q**	+1.6 V		
	R	–1.1 V	–2.7 V	
	S	–0.9 V	–2.5 V	+0.2 V

a) Use the data in the table to answer the questions below.

i. Which metal is the **most** reactive? .....

[1 mark]

ii. Which **two** metals are most similar in reactivity? .....

[1 mark]

b) Suggest what the reading on the voltmeter would be when the same metal is used for both electrode 1 and electrode 2.

Explain your answer.

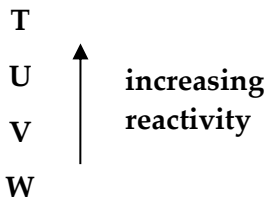
reading = ...V

explanation.....

.....

[2 marks]

A pupil investigated four other metals, **T**, **U**, **V** and **W**.
The order of reactivity of these metals is:



c) When metal **S** is used as electrode 1 and metal **T** is used as electrode 2, the voltmeter reading is –0.8 V.

Calculate the voltmeter reading when metals **P** and **T** are used as electrode 1 and electrode 2 respectively. Explain your answer and show your working.

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[2 marks]

d) The pupil continued her investigation into reactivity and found that when metal **T** is added to a solution of the sulfate of metal **U**, a displacement reaction occurs.

Experiment ①	Metal **S** is added to a solution of the sulfate of metal **R**.
Experiment ②	Metal **V** is added to a solution of the sulfate of metal **U**.
Experiment ③	Metal **T** is added to a solution of the sulfate of metal **W**.
Experiment ④	Metal **T** is added to a solution of the sulfate of metal **R**.

Use the information given to you earlier in this question to decide in which of the following experiments a displacement reaction will also occur.

Explain your answer.

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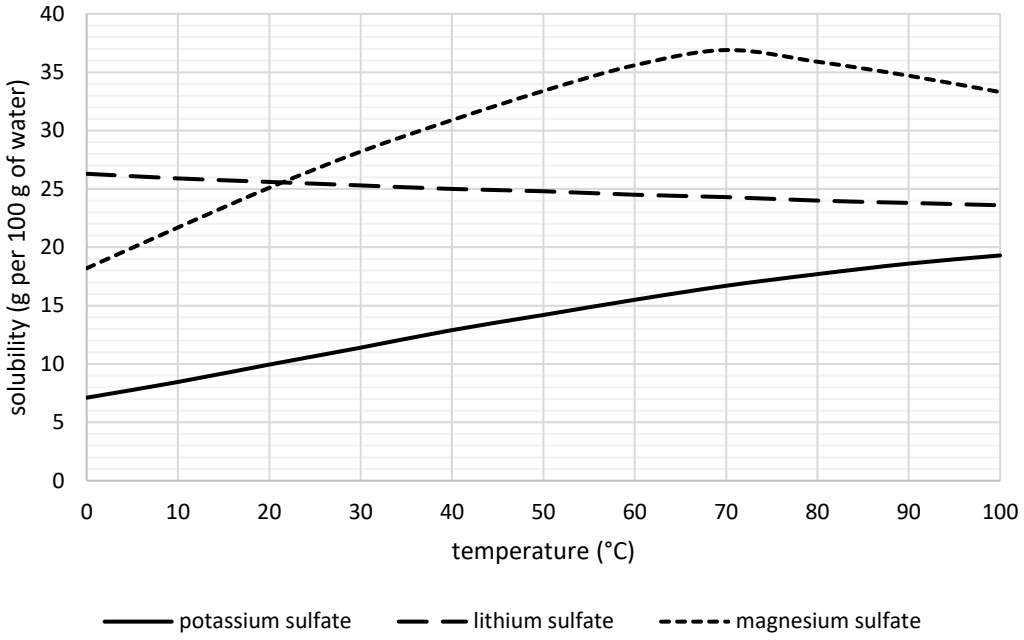
[2 marks]

The graph below shows how temperature affects the solubilities of three sulfate salts of reactive metals. Use the graph to help you answer the following questions.



e) The pupil had a beaker containing 18 g of potassium sulfate dissolved in 100 cm^3 of water at 90°C. She cooled the solution to 20°C and then filtered the contents of the beaker.

State and explain all the observations the pupil made in this experiment. Be as precise as you can in your answer.

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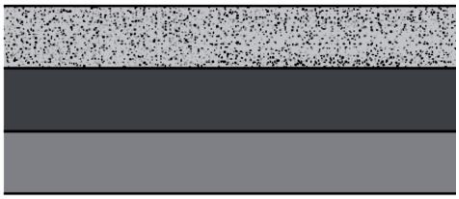
[3 marks]

f) After her experiments, the pupil poured the three solutions of lithium sulfate, magnesium sulfate and potassium sulfate into the same waste beaker. The pupil left the beaker in the laboratory over the weekend. When she returned to the laboratory, she discovered that the water had evaporated from the beaker, leaving layers of the sulfate salts deposited in the order shown below.



magnesium sulfate

lithium sulfate

potassium sulfate

Look at the graph on the previous page.
Suggest what was the temperature of the laboratory over the weekend.
Explain your answer.

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[2 marks]

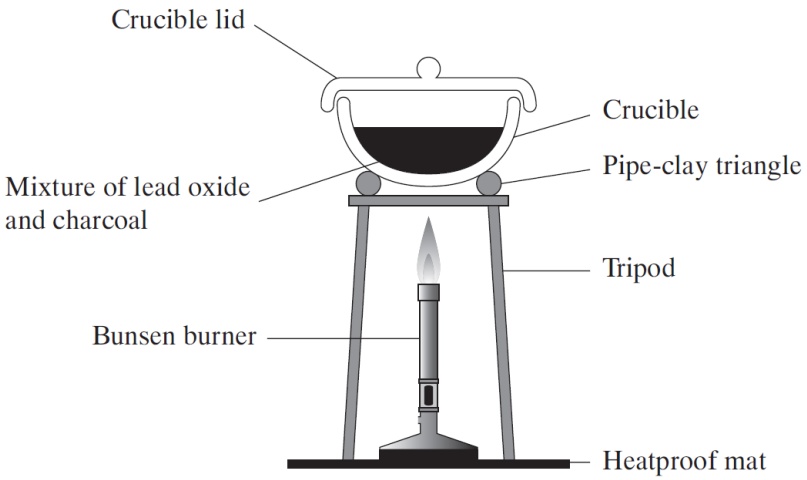
g) The solubility of sulfate at different temperatures is given in the table below.

temperature (°C)	0	10	20	30	40	50	60	70	80	90	100
solubility (g per 100 g of water)	12	14	16	19	22	25	28	32	36	40	45

Plot these data on the graph on the previous page.

Draw a smooth line through the points. *[3 marks]*

Lead is a relatively unreactive metal, used in the construction and electronics industries.
Lead metal can be extracted from lead oxide (PbO) in the laboratory.



The mixture of lead oxide and charcoal is heated in a crucible.

h) The crucible is made from a ceramic material.

Suggest the property of a ceramic that makes it a good choice for making the crucible.

.....

[1 mark]

i) Charcoal (carbon) acts as a reducing agent in this reaction.

$$\text{lead oxide} + \text{carbon} \rightarrow \text{lead} + \text{carbon dioxide}$$

How does the charcoal reduce the lead oxide?

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[1 mark]

j) After heating, the crucible lid is kept on the crucible until the apparatus has cooled to room temperature.

Suggest why this is the case.

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[2 marks]

SECTION THREE: PHYSICS [20 Marks]

A cable that hangs vertically has a maximum possible length beyond which it can no longer support its own weight.

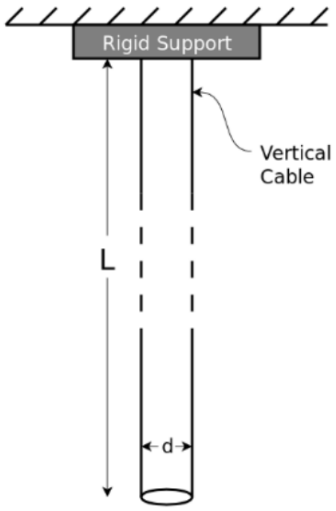


Figure 1

(a) For a steel cable with a diameter of 4 cm and a length of 1 m, calculate that the mass of the cable.

diameter = 4 cm

Length = 1 m

density of steel = 8000 kg / m^3

[2 marks]

(b) What is the weight force on this 1 m cable if it hangs downwards W = m g, where m is the mass and g = 10 N/kg?

[1 mark]

(c) Stress (σ) is defined as Force ÷ Cross sectional Area and the unit is Pascal (Pa).

$$\text{Stress} = F / A$$
$$1 \text{ Pa} = 1 \text{ N/m}^2$$

Calculate the stress at the top of the 1 m cable (Figure 1) where it is joined to the rigid support.

[2 marks]

(d) The maximum stress that a steel cable under tension can withstand, before it breaks, is 400 000 000 Pa. This is often referred to as the ultimate tensile strength of the material.

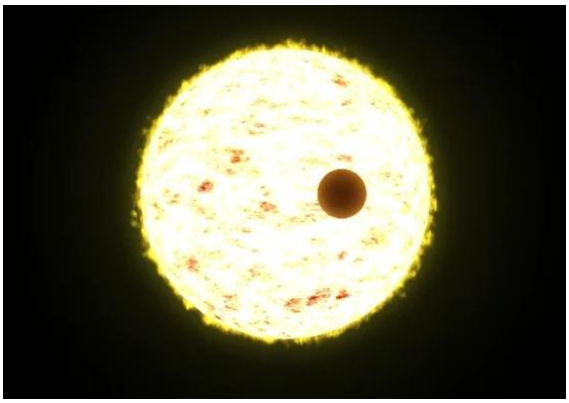
Calculate the maximum length of a steel cable with a diameter of 4 cm that can be hung vertically from a suitable rigid support such that it can support its own weight.

maximum length = _____

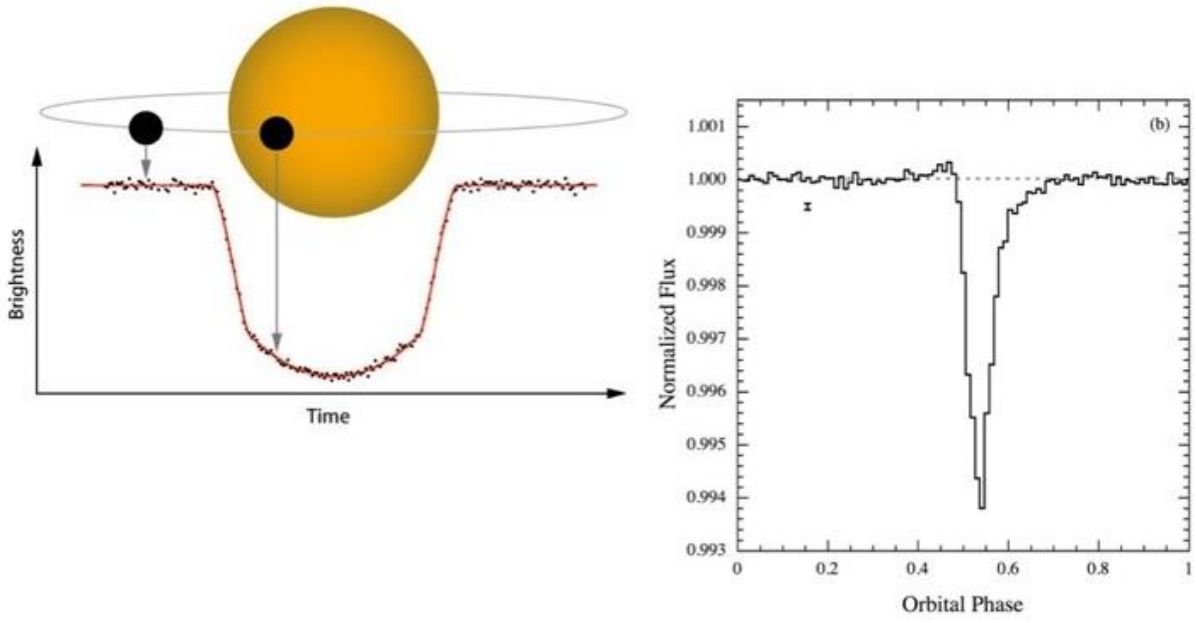
[2 marks]

Exoplanets

2. Exoplanets are planets that orbit a star other than our sun. Most known exoplanets have been discovered using the transit method. A transit occurs when a planet passes between a star and its observer. Transits within our solar system can be observed from Earth when Venus or Mercury travel between us and the Sun.

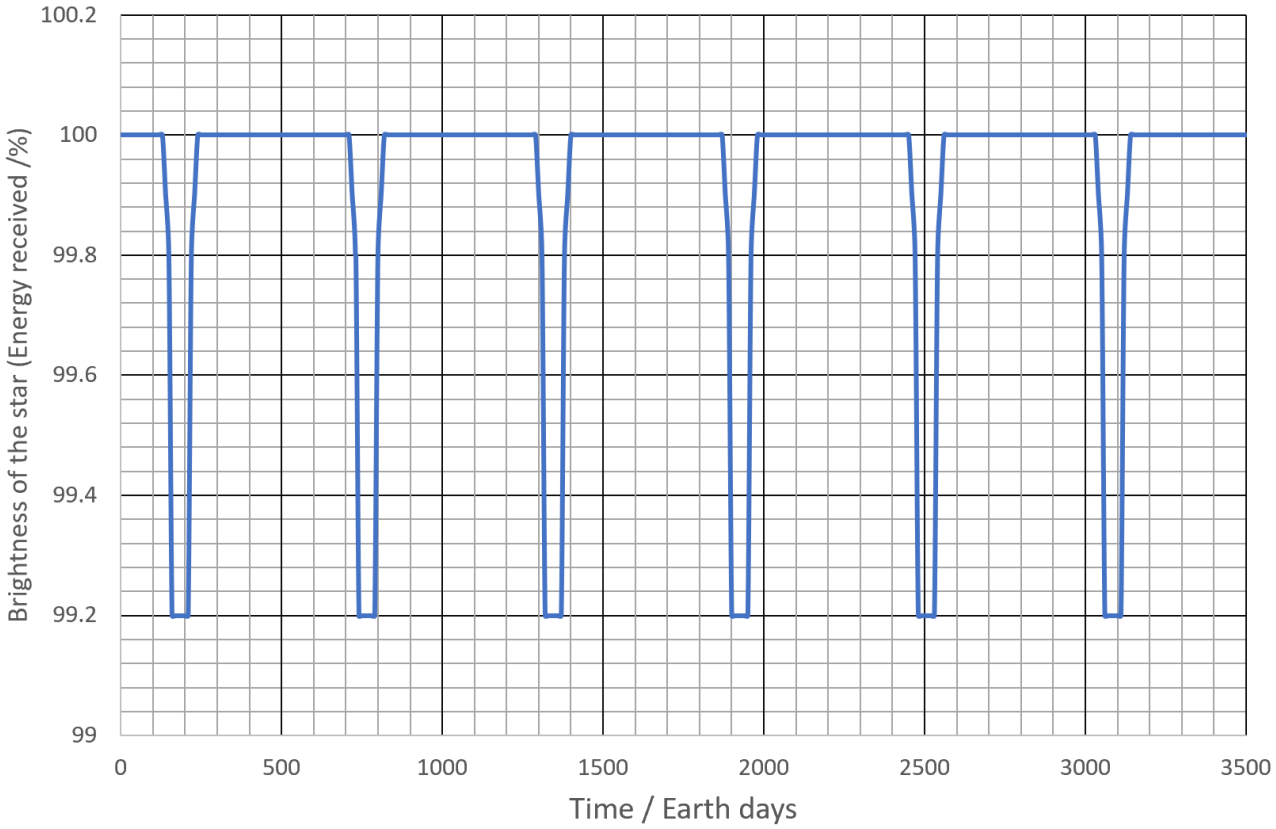


Transits reveal an exoplanet not because we directly see it from many light-years away, but because the planet passing in front of its star ever so slightly dims its light. This dimming can be seen in light curves – graphs showing light received over a period of time. When the exoplanet passes in front of the star, the light curve will show a dip in brightness.



This data is part of why transits are so useful: Transits can help determine a variety of different exoplanet characteristics. The size of the exoplanet's orbit can be calculated from how long it takes to orbit once (the period), and the size of the planet itself can be calculated based on how much the star's brightness lowered.

a) The graph below is a light curve for star P625, with the dips in brightness being seen as sharp downward spikes due to an exoplanet.



Using the graph above:

(i) How long does it take for the exoplanet to complete 5 orbits of the star?

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[2 marks]

(ii) Calculate the time for one orbit (using your answer from part a).

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[1 mark]

(iii) Do you think that the planet in this question is closer to its star than the Earth is to the sun, or further away from its star than the Earth is to the sun? Explain your answer

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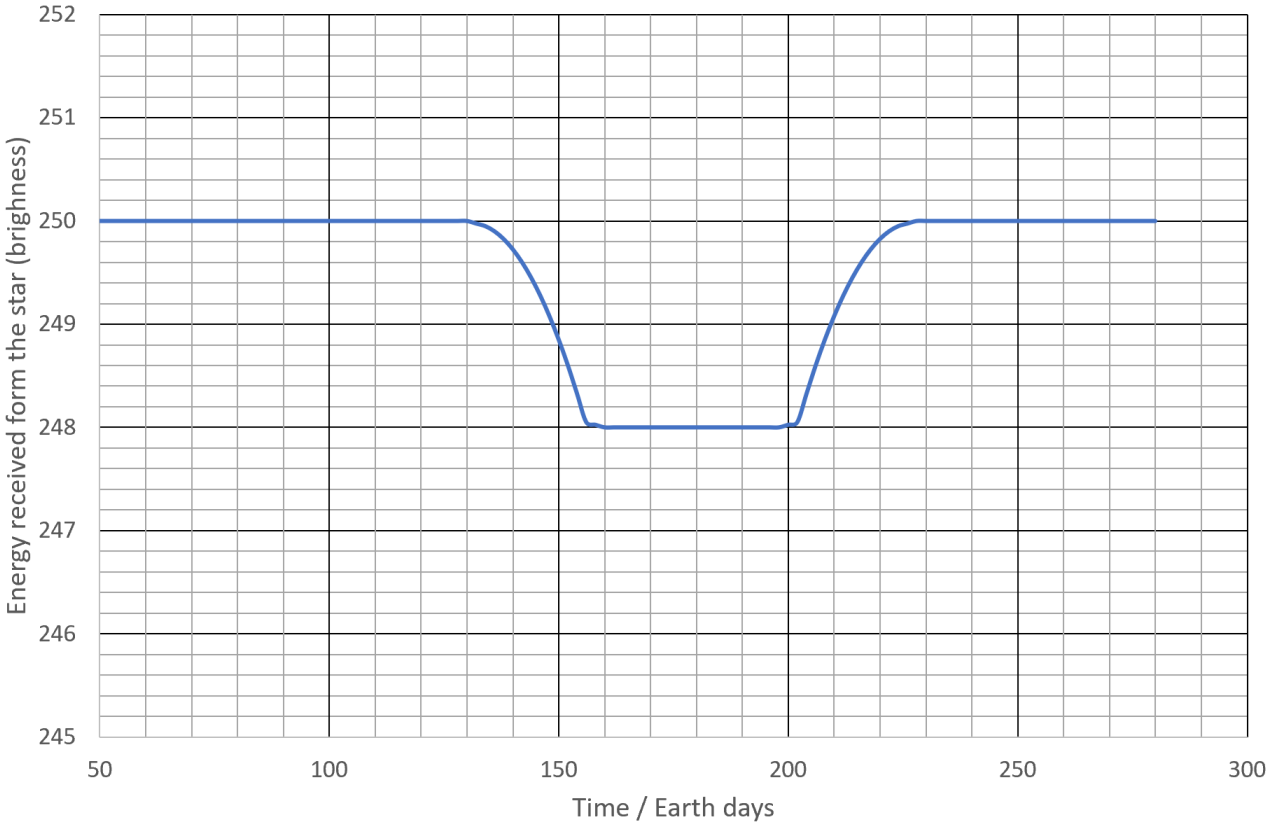
[2 marks]

b) The graph below is a light curve for star GR142, with the single dips in brightness due to the transit of the planet Dagobah.



(i) On the graph above please sketch an approximate light curve if Dagobah had a significantly larger diameter. Please label this line A and explain why you have drawn your curve like this below.

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[2 marks]

(ii) On the graph above please sketch an approximate light curve if Dagobah was the same size but orbited the star at twice the distance. Please label this line B and explain why you have drawn your curve like this below.

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[3 marks]

c) The Milky Way has approximately 100,000 million stars. Therefore, measuring the light from each one to see if there are planets orbiting takes a long time. If we could check five hundred stars per month, how long would it take to check every star in the Milky Way?

Most of the marks awarded for this question are for showing your working. Please make it as clear as possible.

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Time taken = ... years

[3 marks]