KNOX
GRAMMAR
SCHOOL

STATE

DA VINCI DECATHLON 2019

CELEBRATING THE ACADEMIC GIFTS OF STUDENTS IN YEARS 9, 10 & 11

SCIENCE

TEAM NUMBER _____

1	2	3	4	Total	Rank
/18	/10	/30	/12	/70	

QUESTION 1: GLACIAL CONCERNS (18 MARKS)

The Thwaites Glacier is one of the largest and fastest retreating glaciers in Antarctica. It covers the area of Great Britain but is so remote very few humans have ever set foot on it. If the Thwaites Glacier melts completely, it holds enough ice to raise the world's ocean around 65 cm. The glacier is also essential to maintain the integrity of the entire West Antarctic Ice Sheet. If this were to collapse, global sea levels would rise over 2.6 metres.

Below is a paragraph that explains the difference between a stable glacier and a retreating glacier:

'A stable Glacier is in equilibrium: snow falling on the glacier replaces the ice flowing into the ocean. Part of the glacier (the ice shelf) floats on the sea and acts like a dam to hold back the ice of the glacier from falling into the sea. The grounding line is the point on the ocean bed at which the ice makes contact with the bed, after which the glacier is no longer floating on water but sitting on the earth's surface. When the equilibrium is lost, the glacier is not stable. Warm currents under the ice increase due to the lack of snow replenishing the melting glacier, which then further increases the rate of melting. This causes breaking of the ice shelf and weakens its damming effect. Slowly the grounding line retreats as water creeps beneath the glacier. The Thwaites Glacier grounding line has retreated 14 km from 1992 2011,'

Your task is to create a visual information guide that can be provided to the general public of Australia, explaining the process that the Thwaites Glacier is currently undergoing along with the risks associated with the glacier melting. An often-important role of the scientist is to translate complex findings into meaningful information for the public; information that the public can relate to. Your guide must include the following:

1. A visual representation of the paragraph above explaining the difference between a stable and retreating glacier (in this case the Thwaites glacier); and

2. Identification of at least **6** consequences resulting from the glacier melting. These need to include issues in the following areas: landscape/geography of Australia, the environment of Australia (emphasising flora and fauna), society (including impacts on humans) and the economy. It is important to be specific, and not general or hyperbolic with your predicted consequences.

You are provided with one A3 page for your guide. No spare paper is permitted as marks will be awarded for conciseness and clarity. You are welcome to use any structure/form for your guide that you deem most appropriate.

ELEMENT	CRITERIA	MARK
Visual representation		
2D scientific diagram (1 mark)	Evident or not	
Accuracy to description (2 marks)	2 marks – completely accurate to scientific description 1 mark – mostly accurate with minor discrepancies	
Labels/annotations (2 marks)	2 marks - clear and organised, concise 1 mark – unorganised but detailed, or only some aspects labelled	
Comparison between stable and unstable glaciers evident (1 mark)	Evident or not	
Style and communication (2 marks)	2 marks – sophisticated style providing clear communication and conveyance of scientific theory 1 mark – a style is chosen but is basic. May be too dense, complex or otherwise hindered in its ability to communicate	
Consequences		
At least 6 consequences must be provided (6 marks)	1 mark per consequence that is specific, and a causal explanation is provided ½ mark – general consequence or no explanation provided Only two categories may have 2 consequences. All other categories must have one consequence. ½ marks are to be awarded to valid consequences that overlap categories beyond these conditions.	
Overall		
Communication (2 marks)	2 marks – excellent communication appropriate to audience (general population) 1 mark – Developing communication or clear but may not be targeted to appropriate audience	
Attention to detail (2 marks)	2 marks – refined guide that is well designed 1 mark – details are considered but sometimes untidy	

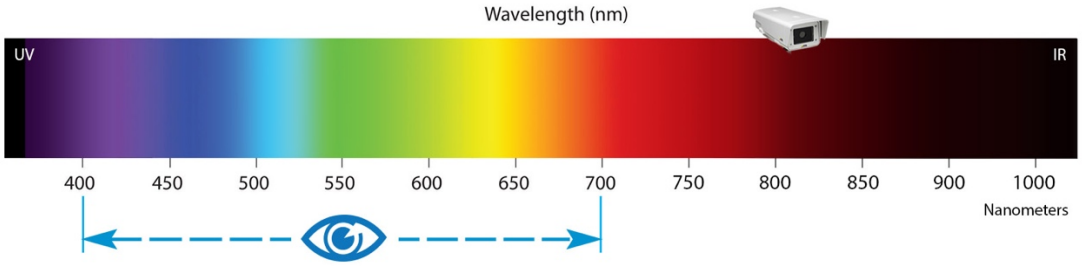
QUESTION 2 – RATIONALISING OUR LANDSCAPE (10 MARKS)

Many things happen around us naturally that we take for granted. Most of these, however, are quite phenomenal. Consider the following scenarios observed and provide a hypothesis, using your general scientific knowledge, as to why they occur.

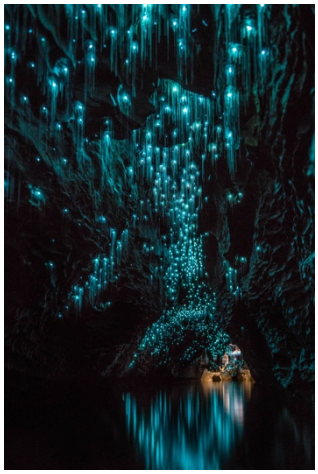
(a) When a balloon is inflated, it grows into a shape similar to a sphere rather than something such as a rectangular prism or cube. Why? (3 marks)

(b) Lemon juice with rind is squeezed from a lemon into a glass of water. The same is done with a lime. The lemon rind remains on the surface of the water while the lime rind settles at the base of the glass. Why? It is known that limes generally have a thicker outer-skin (3 marks).

(c) A red cart is placed next to a blue cart. After 2 months, the red cart's paint had started to fade and decay more than the blue cart. Hypothesise the reason for this observation, using the image below and the fact that energy is inversely proportional to wavelength. (4 marks)



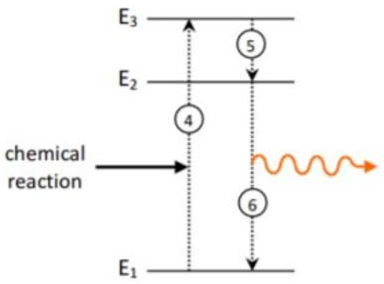
QUESTION 3 – LUMINOUS LANDSCAPES (30 MARKS)



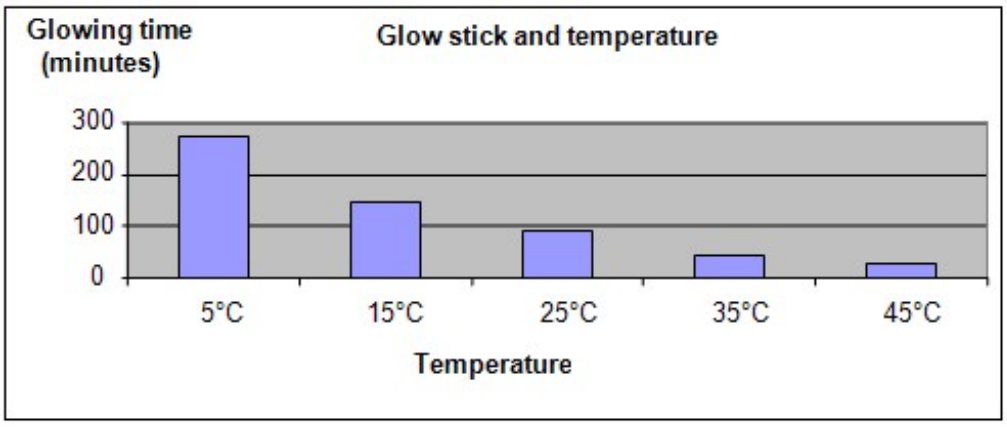
Landscapes are known for their vibrant and diverse colours. Often the most memorable scenes, such as the blossoming of jacaranda trees or the tulip fields in the Netherlands, are characterised by their bright colours.

Landscapes are seldom seen at night. In many forests and seas, particularly those in Central America, however, the night is when landscapes are at their most colourful. For it is at night when fungi, fish and insects glow with bioluminescence.

Bioluminescence was first observed around 350BC by Greek philosopher Aristotle, noting a type of "cold" light as it does not produce heat like most other light. Researchers have since found that this form of chemiluminescence produces blue-green light as a result of the oxidation of a compound called luciferin (the "light-bringer") by an enzyme called luciferase. The oxidation causes an electron to be lost, which excites another electron to a higher state. As the electron relaxes to its 'ground state' (lower energy) it releases the energy as light (see diagram to the right).



(a) Glow sticks use chemiluminescence to produce light. A student undertook an experiment to examine the effect of heat on how the glowstick glowed. The student measured how long the glow stick was glowing for when placed in different temperatures. Her results are below. Reproduce these data in a more appropriate graphical form on page 7 (4 marks)



(b) What trend is observable in the student's results? (1 mark)

(c) By considering the effect of heat on the movement of atoms, along with the process of chemiluminescence, fully explain the trend observed in the data. (4 marks).

(d) Chemiluminescence has had many uses apart from glowsticks. Bioluminescent organisms, for example, aided in the sinking of the last German U-boat during World War One, in November 1918. The submarine is reported to have sailed through a bioluminescent bloom, leaving a glowing wake which was tracked by the allies. Describe two other proactive examples of where humans could/do utilise chemiluminescence and why such a phenomenon is advantageous in that example (3 marks).

(e) It is perhaps the medical applications of bioluminescence that have attracted the most excitement. In 2008, the Nobel Prize in Chemistry was awarded for the discovery and development of green fluorescent protein (GFP). GFP is found naturally in the crystal jellyfish *Aequorea Victoria*, which, unlike the bioluminescence mechanism described so far, is **fluorescent.** It fluoresces with a green light. Fluorescence requires the electrons in the protein to first be excited by blue light. The electron then emits energy as the characteristic green light before relaxing down to the grounds state. Sketch a diagram based on the previous diagram of chemiluminescence to demonstrate fluorescence (2 marks).

(f) A third type of light emission is phosphorescence. In this process, the electron reaches an excited state as in fluorescence by an external light input. However, once at this excited state, the electron relaxes slightly to a *lower* ***excited energy*** *state* through a process called intersystem crossing. This process takes time, after which the electron will decay to the relaxed state in this new system. Amend your diagram for part (e) to also include phosphorescence (2 marks).

(g) Consider a fluorescent molecule that is excited by a photon of green light. By considering the image on page 5, is it possible for this molecule to emit a red photon, or a blue photon, when it fluoresces? Explain (3 marks)

(h) After exciting a molecule with green light, you see a yellow glow followed by a sustained orange glow. Explain these observations using the theory above. (2 marks)

(i) A nightlight in a child's room glows once the room light is turned off, for a round 40 minutes. The room light was yellow, but the nightlight colour is blue. Hypothesise the type of light emission that is occurring (fluorescence or phosphorescence) and why. Is there an inconsistency with the colour of absorption and emission? If so, why might this occur? If not, explain why there is no inconsistency (3 marks).

(j) Since its discovery, GFP has been genetically inserted into various cell types and even animals to shed light on important aspects of cell biology and disease dynamics. There is much contention over whether the human race should engage in gene editing and gene splicing of other animals even if for beneficial purposes such as those described here. Consider the arguments for and against such gene-splicing experimentation and provide an evaluation of whether you think such testing should be permitted, limited in certain ways, or banned entirely, and why. (6 marks)

QUESTION 4 – SOLAR INTERVENTION (12 MARKS)

Many house roofs are now adorned with solar panels. By day, these are mechanical landscapes that produce electricity. In the morning, however, dew often forms on the surface of the cells. These water droplets limit the amount of sun that can reach the cell and, therefore, impacts the efficiency of the solar cell.

You have been considering how to speed up the removal of dew in the morning. One of your friends has suggested that angling the solar cells on a steeper incline might make the droplets drain away faster. You decide to create a small scientific experiment to test this theory. Unfortunately, you don't have a spare solar cell to use, so you need to think of a model system to mimic the solar cells in your experiment.

Design the experiment on page 13, ensuring to include the elements listed in the criteria below.

ELEMENT	CRITERIA – NOT PROVIDED TO STUDENTS	MARK
Title		
Aim		
Hypothesis		
Method (with diagram)		
Description of variables		

END OF PAPER