STATE DA VINCI DECATHLON 2017

CELEBRATING THE ACADEMIC GIFTS OF STUDENTS IN YEARS 5 & 6

SCIENCE

TEAM NUMBER _____

POWER

Power is essential for living things. For organisms and wildlife, power is needed to move and for bodily functions to operate. As humans have advanced, we also rely on power for our daily lives, with most of our machinery requiring electricity. For millions of years, the natural world operates to minimise energy loss and maximise the productivity of available power. In fact, the world as a whole prefers to remain in a state that requires the least amount of energy whenever possible. In this paper, you will traverse the world around us to inquire how nature uses power, minimises power and makes the most of what is available. We will finish with the future and what might sources might be available to power us for millennia to come.

QUESTION 1: RANDOM WORLD (13 MARKS)

The more disordered or random a particular system is in the world, the less energy it requires. For example, when one thing becomes three, the state of being in three things is preferred. Alternatively, if you force 10 bouncy balls into a tight bag, they will naturally want to burst out and roll all over the room. To measure this degree of randomness we have a term called entropy. Entropy follows the law that the universe tends towards the highest entropy (**i.e. the most random state**) that is possible during spontaneous changes.

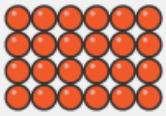
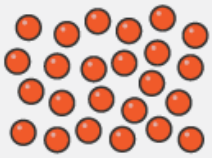
a) A marble is placed in a small box and another marble is placed in a large box. Compare the entropy of each marble (3 marks)

b) A box contains 10 white marbles aligned in two columns. Next to these columns are two columns of 10 black marbles. The box is closed and shaken up. Predict the arrangement of the coloured marbles after the shaking using the principle of entropy. (2 marks)

c) Explain why ice melting is an example of increasing entropy. (2 marks).

d) Identify 2 other processes in your kitchen that increase entropy when they occur (2 marks).

e) Below are models to describe the state of particles in a solid, liquid and gas. Compare the entropy of the three states and use this to explain how boiling water satisfies the rule of entropy (4 marks).

State	Solid	Liquid	Gas
Diagram			
Arrangement of particles	Regular arrangement	Randomly arranged	Randomly arranged
Movement of particles	Vibrate about a fixed position	Move around each other	Move quickly in all directions
Closeness of particles	Very close	Close	Far apart

QUESTION 2: LOCOMOTION (12 MARKS)

Below are various animals and their method of moving around. Using the glossary above the table, assign **three** design features of each animal that assist with their movement.

Design Features: smooth scales; rudders to steer direction; Muscles along the body that constrict to shorten skin segments and pull trailing body parts forward; Large surface area exposed above water; Strong outer shell; Light body; Microscopic hairs that trap air bubbles; Large surface area exposed above water; Circular muscles along the body that constrict to elongate skin segments and move forward; Flexible spine; Bristles to anchor body and prevent backwards sliding; Hydrophobic (water-detracting) material coating feet

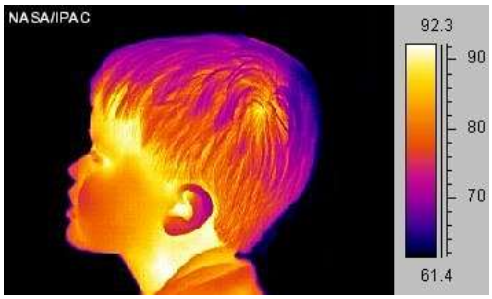
Animal	Method of Locomotion	Design Features
 Armadillo	rolling using gravity	
 Water Striding Insect	Floats and jumps on the surface of water	
 Valella	Sails in the wind	
 Worms	slides along the ground	

QUESTION 3: FRIENDLY BLOOD? (10 MARKS)

Read the passage below about warm and cold blooded animals. Use this passage to construct a table that compares the advantages and disadvantages of being cold and warm blooded. You must include comparisons of: where these animals can live, how much energy they use, **their resilience to bacteria (knowing that bacteria prefers to grow in warm places!),** along with any other interesting points you can think of. Think about how you can present this information so it can be easily read. Remember to include titles!

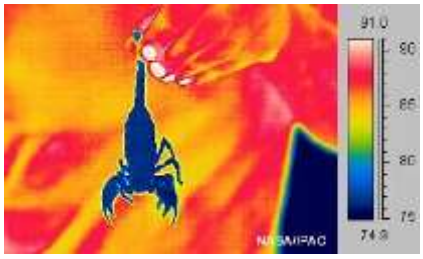
Warm-Blooded vs. Cold-Blooded

Warm-blooded creatures, like mammals and birds, try to keep the inside of their bodies at a constant temperature. They do this by generating their own heat when they are in a cooler environment, and by cooling themselves when they are in a hotter environment. To generate heat, warm-blooded animals convert the food that they eat into energy. They have to eat a lot of food, compared with cold-blooded animals, to maintain a constant body temperature. Only a small amount of the food that a warm-blooded animal eats is converted into body mass. The rest is used to fuel a constant body temperature.



The thermal infrared image to the left of warm-blooded animals, show how birds and mammals maintain body temperatures well above the surrounding, cooler air temperature.

Cold-blooded creatures take on the temperature of their surroundings. They are hot when their environment is hot and cold when their environment is cold. In hot environments, cold-blooded animals can have blood that is much warmer than warm-blooded animals. Cold-blooded animals are much more active in warm environments and are very sluggish in cold environments. This is because their muscle activity depends on chemical reactions which run quickly when it is hot and slowly when it is cold. A cold-blooded animal can convert much more of its food into body mass compared with a warm-blooded animal.

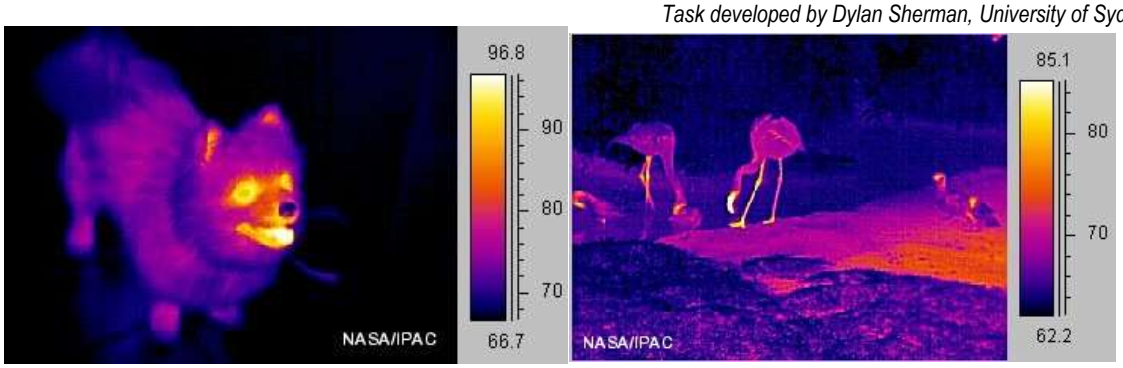


The infrared image to the left show how cold-blooded animals take on the temperature of their surroundings. Both the gecko and the scorpion are at the same temperature as the air surrounding them. Notice the difference between these cold-blooded creatures and the warm-blooded humans holding them.

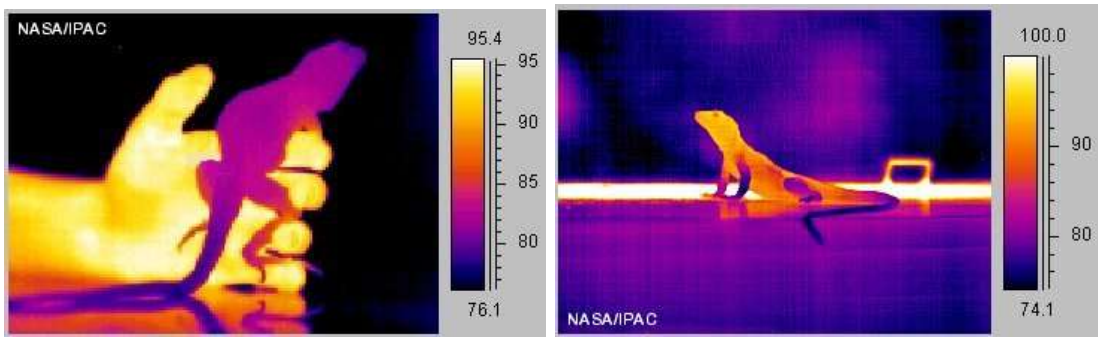
Staying Cool and Keeping Warm

To stay cool, warm-blooded animals sweat or pant to lose heat by water evaporation. They can also cool off by moving into a shaded area or by getting wet. Only mammals can sweat. Primates, such as humans, apes and monkey, have sweat glands all over their bodies. Dogs and cats have sweat glands only on their feet. Whales are mammals who have no sweat glands, but then since they live in the water, they don't really need them. Large mammals can have difficulty cooling down if they get overheated. This is why elephants, for example, have large, thin ears which lose heat quickly. Mammals have hair, fur or blubber, and birds have feathers to help keep them warm. Many mammals have thick coats of fur which keep them warm in winter. They shed much of this fur in the summer to help them cool off and maintain their body temperature. Warm-blooded animals can also shiver to generate more heat when they get too cold. Some warm-blooded animals, especially birds, migrate from colder to warmer regions in the winter.

The below infrared images show some ways in which warm-blooded animals try to maintain a constant temperature. The dog in the left image pants when he is too warm. Notice the extra heat radiating from the dog's mouth as he pants. The flamingos in the right image are covered with feathers which help keep these birds warm when it is cool outside.



Cold-blooded animals often like to bask in the sun to warm up and increase their metabolism. While basking, reptiles will lie perpendicular to the direction of the sun to maximize the amount of sunlight falling on their skin. They will also expand their rib cage to increase their surface area and will darken their skin to absorb more heat. When a reptile is too hot, it will lie parallel to the sun's rays, go into a shady area, open its mouth wide, lighten its skin colour or burrow into cool soil. Some cold-blooded animals, such as bees or dragonflies, shiver to stay warm when in a cold environment. Fish who live in areas where the winters are cold move to deeper waters during the colder months or migrate to warmer waters. Some fish have a special protein in their blood which acts like anti-freeze to help them survive very cold water temperatures. Snakes, lizards, toads, frogs, salamanders and most turtles will hibernate during cool winters. Some insects die when it gets too cold, however others survive by migrating to warmer areas or moving underground. Honeybees stay warm by crowding together and moving their wings to generate heat.



These thermal infrared images of a collard lizard show a cold-blooded animal's body temperature in a cooler and warmer environment. In the image to the left, the lizard is just above room temperature, being warmed by the human hand holding it. To warm up lizards will seek a sunny area and bask in warm sunlight, as in the image to the right.

Question 3: Answer

Please note: Think about how you can present this information so it can be easily read. Remember to include titles!

QUESTION 4: SAVING POWER (20 MARKS)

a) As electricity is more expensive every year, Mona wants to find ways to reduce her power. There are four items in her house she believes are using the most power per day – the air conditioner, the plasma TV, her stereo-system and the clothes dryer. **She wants to design an experiment that would allow her to order these four items in terms of power usage per day so that she can remove the most power consuming device**. During the experiment she will be using the devices as she normally would during the day. Mona also wants to know exactly how much power is used by each item. Mona has a device that can determine how much power her whole uses during one day.

Design Mona's experiment, including an aim and method. Make sure you describe **three types of variables** in your experiment – **an independent variable** (the thing that you are changing), **the dependent variable** (the thing that you are measuring) and **control variables** (things that remain the same). Also consider how her experiment can be reliable. Reliability increases when there is **repetition** of data collection. (10 marks)

b) Mona collected the following data of the amount of energy used by each device. Graph the information in the space below in the most appropriate way to make it easy to understand. Remember to include a title and units for the axis. (5 marks)

Item	Power used per day (Watts)
Plasma TV	200
Air Conditioner	2500
Clothes dryer	1800
Stereo-system	700

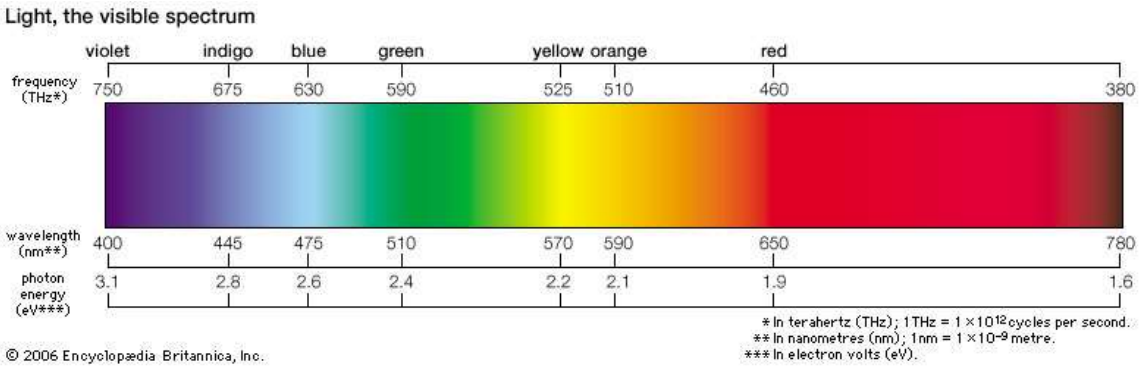
c) Write a conclusion for Mona's experiment. (2 marks)

d) Describe **3 changes** Mona could make to reduce her power usage at home. (3 marks)

QUESTION 5: POWER COLOURS (7 MARKS)

Cars very quickly heat up by absorbing energy from our sun. Once hot, they require a large amount of power to cool down using the air conditioner. In order to reduce the temperature a car heats up we can reduce the amount of heat the car absorbs. This can be done by altering the colour of the car!

Light is actually a wave that travels through space. Depending on the wavelength of that wave, the light changes colour. Below is a diagram that shows the colour spectrum of light, with corresponding wavelengths for different colour:



If we see an object as a certain colour, it is because that object **reflects** that particular wavelength of colour. All other wavelengths are absorbed. For our question today, you also need to know that longer wavelength colours have lower energy than higher wavelength colours.

a) White is the reflectance of all light, while black is the absorption of all light. Which colour is better to paint your car to ensure your car stays cooler? (2 marks)

b) Using the information above, determine whether a car will stay cooler if it is painted blue or red. Explain your reasoning. (5 marks)

QUESTION 6: THE CYCLE OF BIOFUEL (10 MARKS)

Biofuel has been claimed to be the future of our oil crisis. Instead of relying on petrol found in fossil fuels and oils, which are refined at factories (producing a lot of pollution), we can generate oil for our car engines from plants. Through photosynthesis, plants collect carbon dioxide gas that is released by cars when the cars are running and consuming fuel. Photosynthesis allows the plants to grow. Farmers then collect the seeds from these plants, by harvesting their crops such as sunflowers or corn crops. The seeds are used to extract crude vegetable oil. This oil is then refined by distillation. After refining, a 'transesterification' process occurs, that includes the addition of alcohol, to produce the biodiesel. This is then used in cars as petrol.

a) Using the information above, design a life cycle of the production of biofuel. Include the major products/steps along with the processes involved in reaching each step. (6 marks)

b) When used in cars, biofuel produces less pollution than normal petrol. Being derived from plants, it is also cleaner than collecting oil and other fossil fuels. Many therefore claim that it is greener than normal fuel. By considering the process above and the energy required at each step, evaluate this claim and justify whether using biofuel is in fact greener than normal petrol. (4 marks)

STATE DA VINCI DECATHLON 2017

CELEBRATING THE ACADEMIC GIFTS OF STUDENTS IN YEARS 5 & 6

SCIENCE SOLUTIONS

TEAM NUMBER _____

Q1	Q2	Q3	Q4	Q5	Q6	Total
/13	/12	/10	/20	/7	/10	/72

POWER

Power is essential for living things. For organisms and wildlife, power is needed to move and for bodily functions to operate. As humans have advanced, we also rely on power for our daily lives, with most of our machinery requiring electricity. For millions of years, the natural world operates to minimise energy loss and maximise the productivity of available power. In fact, the world as a whole prefers to remain in a state that requires the least amount of energy whenever possible. In this paper, you will traverse the world around us to inquire how nature uses power, minimises power and makes the most of what is available. We will finish with the future and what might sources might be available to power us for millennia to come.

QUESTION 1: RANDOM WORLD (13 MARKS)

The more disordered or random a particular system is in the world, the less energy it requires. For example, when one thing becomes three, the state of being in three things is preferred. Alternatively, if you force 10 bouncy balls into a tight bag, they will naturally want to burst out and roll all over the room. To measure this degree of randomness we have a term called entropy. Entropy follows the law that the universe tends towards the highest entropy (i.e. the most random state) that is possible during spontaneous changes.

a) A marble is placed in a small box and another marble is placed in a large box. Compare the entropy of each marble (3 marks)

Small box = low entropy; large box = high entropy (2 marks). 1 mark to compare – marble in large box will have greater entropy than small box marble.

b) A box contains 10 white marbles aligned in two columns. Next to these columns are two columns of 10 black marbles. The box is closed and shaken up. Predict the arrangement of the coloured marbles after the shaking using the principle of entropy. (2 marks)

Random (1 mark) this has the lowest entropy (1 mark)

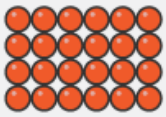
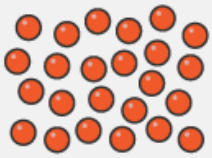
c) Explain why ice melting is an example of increasing entropy. (2 marks).

More space is taken up by liquid water than solid water (1 mark). This is more random, that is higher entropy (1 mark).

d) Identify 2 other processes in your kitchen that increase entropy when they occur (2 marks).

Boiling water, dissolving sugar etc…

e) Below are models to describe the state of particles in a solid, liquid and gas. Compare the entropy of the three states and use this to explain how boiling water satisfies the rule of entropy (4 marks).

State	Solid	Liquid	Gas
Diagram			
Arrangement of particles	Regular arrangement	Randomly arranged	Randomly arranged
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Low to high entropy: solid – liquid to gas (2 marks for correct order). 2 marks explaining that water is liquid, then becomes gas when it boils (1 mark) so entropy increases, therefore, law is satisfied (1 mark).

QUESTION 2: LOCOMOTION (12 MARKS)

Below are various animals and their method of moving around. Using the glossary above the table, assign **three** design features of each animal that assist with their movement.

Design Features: smooth scales; rudders to steer direction; Muscles along the body that constrict to shorten skin segments and pull trailing body parts forward; Large surface area exposed above water; Strong outer shell; Light body; Microscopic hairs that trap air bubbles; Large surface area exposed above water; Circular muscles along the body that constrict to elongate skin segments and move forward; Flexible spine; Bristles to anchor body and prevent backwards sliding; Hydrophobic (water-detracting) material coating feet

Animal	Method of Locomotion	Design Features
 Armadillo	rolling using gravity	Smooth scales Flexible spine Strong outer shell
 Water Striding Insect	Floats and jumps on the surface of water	Microscopic hairs that trap air bubbles Light body Hydrophobic (water-detracting) material coating feet
 Valella	Sails in the wind	Light and flexible skin Large surface area exposed above water Rudders to steer direction
 Worms	slides along the ground	Bristles to anchor body and prevent backwards sliding Circular muscles along the body that constrict to elongate skin segments and move forward Muscles along the body that constrict to shorten skin segments and pull trailing body parts forward

QUESTION 3: FRIENDLY BLOOD? (10 MARKS)

Read the passage below about warm and cold blooded animals. Use this passage to construct a table that compares the advantages and disadvantages of being cold and warm blooded. Think of consequences such as where these animals can live, how much energy they use comparatively, what they can or can't do and their resilience to bacteria (knowing that bacteria prefers to grow in warm places!). Think about how you can present this information so it can be easily read.

Warm-Blooded vs. Cold-Blooded

Warm-blooded creatures, like mammals and birds, try to keep the inside of their bodies at a constant temperature. They do this by generating their own heat when they are in a cooler environment, and by cooling themselves when they are in a hotter environment. To generate heat, warm-blooded animals convert the food that they eat into energy. They have to eat a lot of food, compared with cold-blooded animals, to maintain a constant body temperature. Only a small amount of the food that a warm-blooded animal eats is converted into body mass. The rest is used to fuel a constant body temperature.

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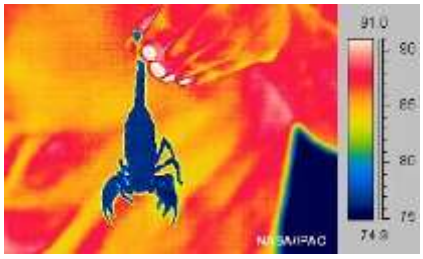

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Staying Cool and Keeping Warm

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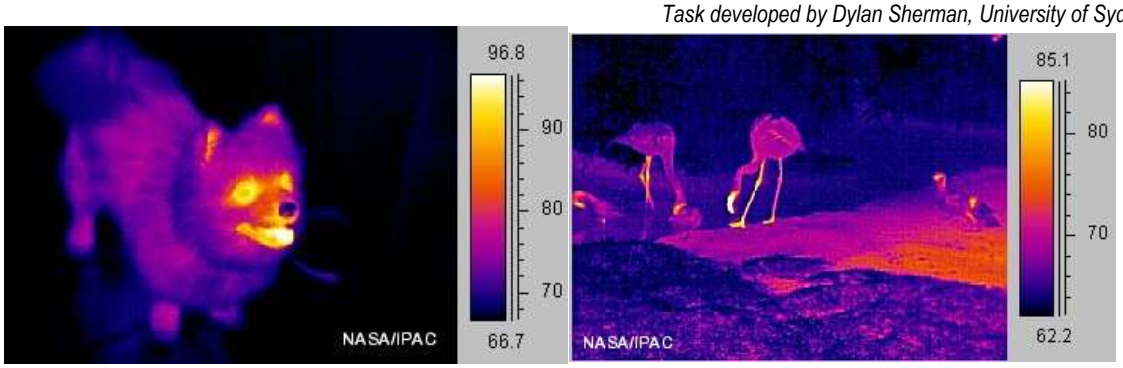
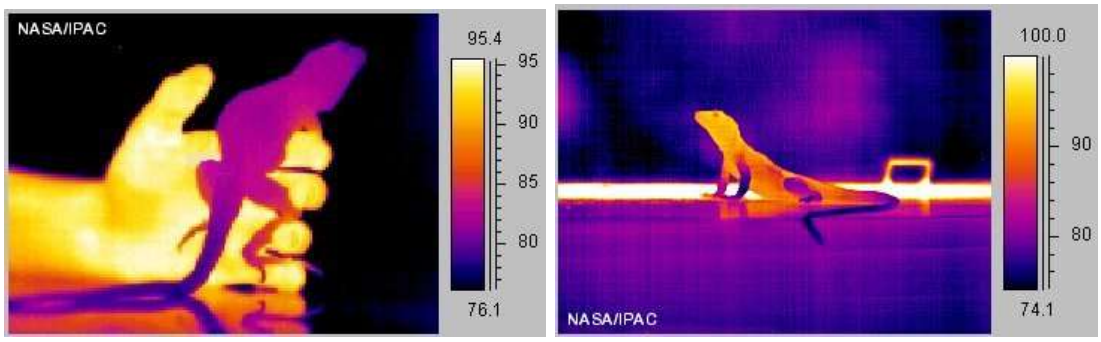


Cold-blooded animals often like to bask in the sun to warm up and increase their metabolism. While basking, reptiles will lie perpendicular to the direction of the sun to maximize the amount of sunlight falling on their skin. They will also expand their rib cage to increase their surface area and will darken their skin to absorb more heat. When a reptile is too hot, it will lie parallel to the sun's rays, go into a shady area, open its mouth wide, lighten its skin colour or burrow into cool soil. Some cold-blooded animals, such as bees or dragonflies, shiver to stay warm when in a cold environment. Fish who live in areas where the winters are cold move to deeper waters during the colder months or migrate to warmer waters. Some fish have a special protein in their blood which acts like anti-freeze to help them survive very cold water temperatures. Snakes, lizards, toads, frogs, salamanders and most turtles will hibernate during cool winters. Some insects die when it gets too cold, however others survive by migrating to warmer areas or moving underground. Honeybees stay warm by crowding together and moving their wings to generate heat.



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Marks

6 marks	**Awarded for valid comparison points:** If they structure by advantages/disadvantages then 6 points must be made. If they structure by characteristic and then warm/cold blooded then 3 characteristics must be identified
2 marks	Awarded exclusively for mentioning resilience to bacteria for cold blooded animals but not warm blooded animals.
2 marks	Use of a table and presentation
1 mark	For headings

Answers may include:

Advantages of cold blooded:
Blend into their surrounds – harder for predators to find.
More active in warm environments
Food can become body mass more easily
Less energy required to survive.
Can lower temperatures to protect themselves from bacteria

Advantages of warm blooded:
Can generate their own heat thus live in either hot or cold environments.
Allows for migration and adaptability
Can remain active in cold environments.

Disadvantages of cold blooded:
Unable to function in cold – muscles less active.
Unable to defend themselves or find food when weather is too cold.
Cannot live in all locations.

Disadvantages of warm blooded:
Requires energy to convert food to energy. This uses more energy than cold blooded animals. This means they must eat more often and find food.
Because of this energy requirement, little amounts of food end up becoming body mass
Constant body temperature must be kept otherwise they can become sick
Overheating

QUESTION 4: SAVING POWER (20 MARKS)

a) As electricity is more expensive every year, Mona wants to find ways to reduce her power. There are four items in her house she believes are using the most power per day – the air conditioner, the plasma TV, her stereo-system and the clothes dryer. She wants to design an experiment that would allow her to order these four items in terms of power usage per day so that she can remove the most power consuming device. During the experiment she will be using the devices as she normally would during the day. Mona also wants to know exactly how much power is used by each item. Mona has a device that can determine how much power her whole uses during one day. Design Mona's experiment, including an aim and method. Make sure you describe three types of variables in your experiment – an independent variable (the thing that you are changing), the dependent variable (the thing that you are measuring) and control variables (things that remain the same). Also consider how her experiment can be reliable. Reliability increases when there is repetition of data collection. (10 marks)

1 mark. ½ off if not worded correctly, or partly incorrect.	**Aim** To determine the order of Mona's 4 items in terms of power used per day (or something similar)
• 1 mark • 1 mark • 2 marks • 1 mark • 1 mark • I mark • 2 marks	**Method** • Formatting – numbered sequentially • Reliability addressed (repeated at least 3 times) • Logical flow of steps taken • IV identified (item) • DV identified (the total amount of power used by the house that day) • To work out the exact power Mona will need to also take a reading on a day with NO item being used then subtract this from the amount used on the day with the item. • Controlled variables addressed such as using the same general household items each day such as lights, washing machine etc…, trying to do the tests on days with similar temperatures…

b) Mona collected the following data of the amount of energy used by each device.

Graph the information in the most appropriate way to make it easy to understand. Remember to include a title and units for the axis, with an appropriate scale for the power used axis (5 marks).

Item	Power used per day (watts)
Plasma TV	200
Air Conditioner	2500
Clothes dryer	1800
Stereo-system	700

Column graph (1 mark). Title (1 mark). X axis = item (1 mark), power with units that has an appropriate scale (Y axis) (1 mark), 1 mark for overall tidiness.

c) Write a conclusion for Mona's experiment (2 marks – ½ mark each for the correct order))

Order of items by power used is: TV, Stereo, Clothes Dryer and AC.

d) Describe 3 changes Mona could make to reduce her power usage at home. (3 marks)

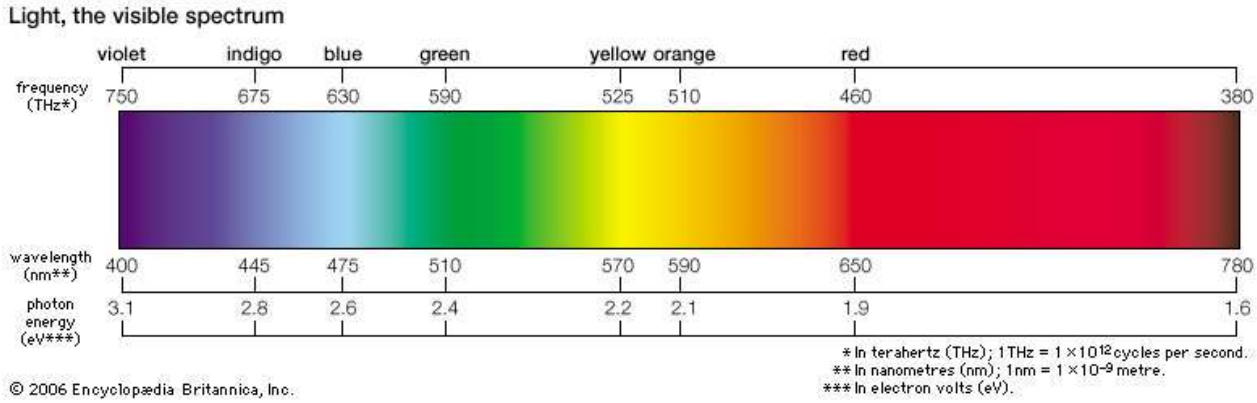
1 mark for each valid suggestion:

- dry clothes outside
- use fans or open windows to let fresh air through
- close blinds to reduce heat entering the house
- make sure the TV and Stereo are off when not being used etc…

QUESTION 5: POWER COLOURS (7 MARKS)

Cars very quickly heat up by absorbing energy from our sun. Once hot, they require a large amount of power to cool down using the air conditioner. In order to reduce the temperature a car heats up we can reduce the amount of heat the car absorbs. This can be done by altering the colour of the car!

Light is actually a wave that travels through space. Depending on the wavelength of that wave, the light changes colour. Below is a diagram that shows the colour spectrum of light, with corresponding wavelengths for different colour:



If we see an object as a certain colour, it is because that object reflects that particular wavelength of colour. All other wavelengths are absorbed. For our question today, you also need to know that longer wavelength colours have lower energy than higher wavelength colours.

a) White is the reflectance of all light, while black is the absorption of all light. Which colour is better to paint your car to ensure your car stays cooler? (2 marks)

White (1 mark) - no energy absorbed (1 mark)

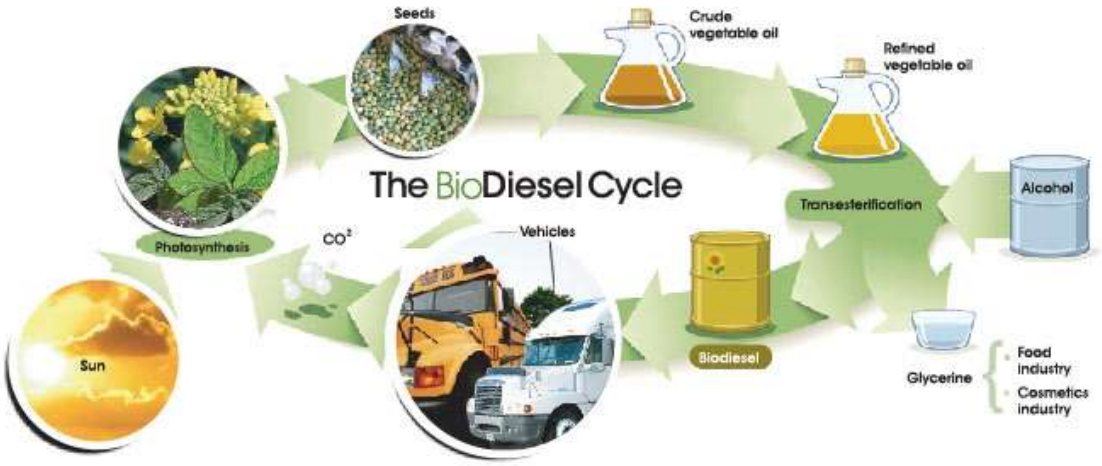
b) Using the information above, determine whether a car will stay cooler if it is painted blue or red. Explain your reasoning. (5 marks).

Red colour means blue is being absorbed (1 mark).
Blue has lower wavelength and therefore higher energy (1 mark).
Blue colour means red is being absorbed (1 mark).
Red has higher wavelength and lower energy (1 mark).
Therefore, a Blue car would therefore absorb less energy so remain cooler (1 mark)

QUESTION 6: THE CYCLE OF BIOFUEL (10 MARKS)

Biofuel has been claimed to be the future of our oil crisis. Instead of relying on petrol found in fossil fuels and oils, which are refined at factories (producing a lot of pollution), we can generate oil for our car engines from plants. Through photosynthesis, plants collect carbon dioxide gas that is released by cars when the cars are running and consuming fuel. Photosynthesis allows the plants to grow. Farmers then collect the seeds from these plants, by harvesting their crops such as sunflowers or corn crops. The seeds are used to extract crude vegetable oil. This oil is then refined by distillation. After refining, a 'transesterification' process occurs, that includes the addition of alcohol, to produce the biodiesel. This is then used in cars as petrol.

a) Using the information above, design a life cycle of the production of biofuel. Include the major products/steps along with the processes involved in reaching each step (6 marks)



3 marks for correct steps (plants, seeds, crude oil, refined oil, biofuel and cars)
3 marks for processes (photosynthesis, harvesting, collect oil, refine oil, transesterification, release of CO2 by cars)

b) When used in Cars, biofuel produces less pollution than normal petrol. Being derived from plants, it is also cleaner than collecting oil and other fossil fuels. Many therefore claim that it is greener than normal fuel. By considering the process above and the energy required at each step, evaluate this claim and justify whether using biofuel is in fact greener than normal petrol (4 marks).

1 mark for a judgment and 3 marks for scientific justification. E.g. We believe that biodiesel is not greener normal fuel. This is because the steps taken to produce it end up producing more pollution and require more energy than petrol. For example, the harvesting will require tractors with fuel (1 mark), refining the oil will require factories (1 mark), transporting of products to these locations will require petrol and energy (1 mark) and the transesterification process will also require energy to occur. Added together, these steps will end up releasing just as much pollution as petrol. May also include ideas such as the land mass required to harvest plants would be very large, this will affect the environment and provide less food for populations.