Name: …….. School: ……

TONBRIDGE SCHOOL

Scholarship Examination Sample Paper

Science I

Time allowed: 45 minutes

Answer all the Questions

You may use a calculator

The entire paper is worth 40 marks and the number of marks for each question is shown in brackets.

1. On 13 October 2024, a rocket designed by SpaceX called Starship completed a world first after its main booster was successfully captured on its return to the launch pad.

The Starship rocket is a two-stage rocket, which means at liftoff the main booster, called the Super Heavy booster is fired to launch the vehicle. When the rocket is 40 miles (65 km) above the Earth, the booster separates from the Starship. The Starship rocket engines then fire and continue to push the rocket into space.

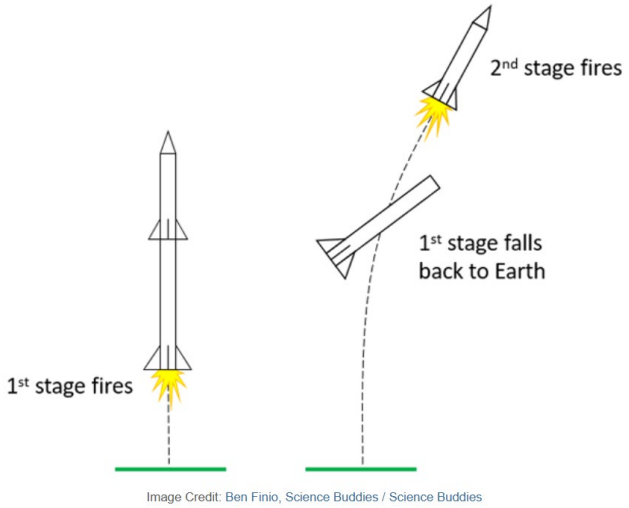

Image Credit: Ben Finio, Science Buddies / Science Buddies

a. What is the advantage of using a two-stage rocket rather than a single rocket to launch Starship into space? (2)

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In the past, the main booster would fall back to Earth and land in the sea. However, SpaceX achieved a huge milestone in the history of space exploration by guiding the Super Heavy booster gently back to the launchpad to catch it in a pair of giant mechanical arms. This achievement brings SpaceX's ambition to develop a fully reusable and rapidly deployable rocket a big step closer.

b. Explain why catching the Super Heavy booster means that it will be reusable **and** rapidly deployable. (2)

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After the rocket is launched, the Starship and the Super Heavy booster separate two and three-quarter minutes after leaving the ground.

c. Calculate the average speed of the Starship rocket during its ascent to this point of separation. Give your answer in metres per second. (2)

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If we assume the acceleration is constant, the final speed of Super Heavy booster at the point of separation will be twice the speed you calculated in part c.

d. Calculate the final speed of the Super Heavy booster and explain whether you think the assumption of a constant acceleration during its ascent is reasonable. (3)

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As the Super Heavy booster fell back to Earth it slowed down from speeds more than a few thousand miles per hour. When it approached the landing tower the booster engines worked to control its landing. It seemed to almost float, orange flames engulfed the booster as it deftly slotted into the giant mechanical arms.

e. Convert a speed of one thousand miles per hour into metres per second. (1 mile is approximately 1600 metres.) (2)

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f. Why is the speed reached by the booster as it falls to Earth much greater than the speed it reached at the point of separation? (2)

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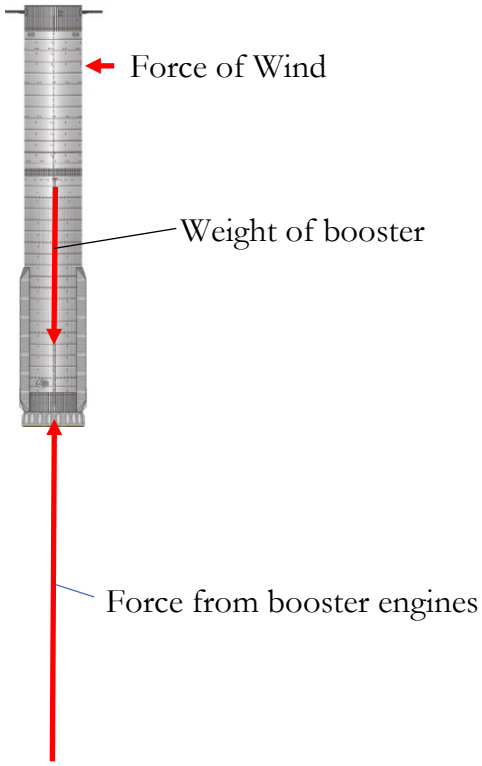
The wind speed at the launch pad can produce gusts of nearly 30 mph, creating a force equivalent to the force of a single large diesel locomotive pressing against the side of the booster. The diagram below shows this force acting towards the top of the booster while the booster engines are firing as it falls towards the launchpad. (The lengths of the arrows represent the relative sizes of the forces.)



g. Describe carefully the motion of the Super Heavy booster if these are the only forces acting during its descent. (2)

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h. Describe how the force from the booster engines would need to change if the Super Heavy booster is to hover **in the vertical position** when it has slowed to a stop (so it can then be grabbed by the giant mechanical arms). (2)

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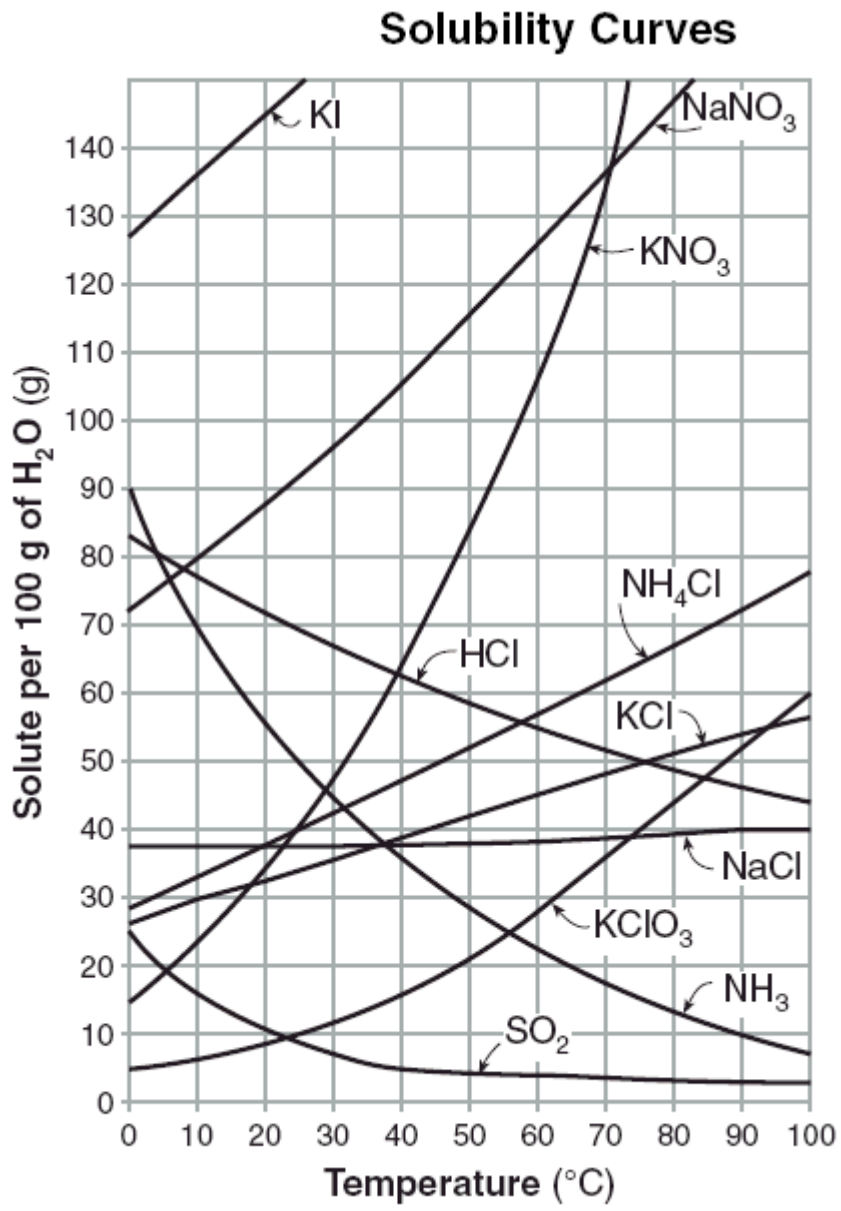
Question / 17

2. The graph below shows solubility curves for different substances. They show the mass of the substances that will saturate 100 g (100 ml) of water at different temperatures.



A solute is a substance that dissolves in some other substance – known as a solvent – to form a solution. Although a solute is generally thought of as being solid, a solute can be either solid, liquid, or gas.

a. Define the meaning of a saturated solution. (1)

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b. Find the temperature that sodium chloride and ammonia have the same solubility in water. (1)

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c. Use the graph to calculate the mass of potassium chloride solid, KCl, that will form when a saturated solution of potassium chloride, containing 200 ml of water is cooled from 75 ^{0}C to 10 ^{0}C. (3)

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d. If 5 g of extra solute is added to this mixture at 10 ^{0}C, to what minimum temperature would the mixture then need to be raised to dissolve all the solid? (2)

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e. The solubility curve for carbon dioxide is like the curve shown in the graph for sulphur dioxide, SO_2. Explain why a fizzy drink like Coca-Cola, stays fizzy when enjoyed at a ski resort compared to a glass served on a tropical beach in Hawaii. (2)

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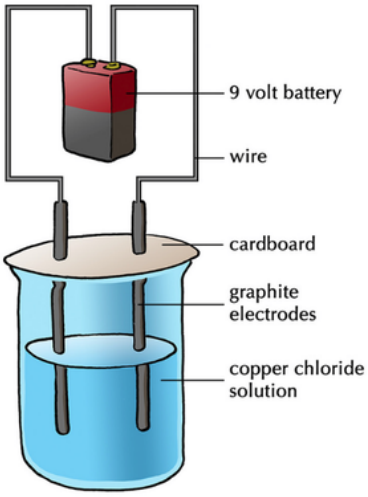
Question / 9

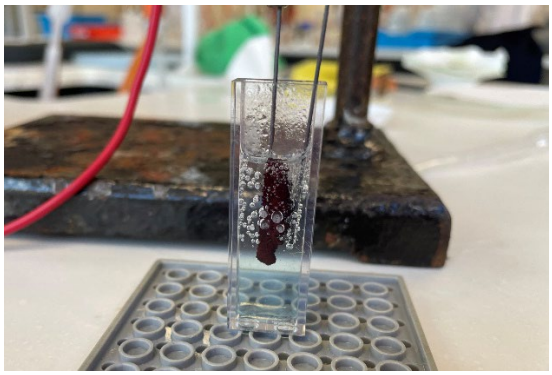
3. A Sixth Form student recently investigated the electrolysis of copper chloride solution. He wanted to find out if using small plastic Lego pieces would be as effective as using traditional equipment, such as larger beakers and test tubes made of glass.



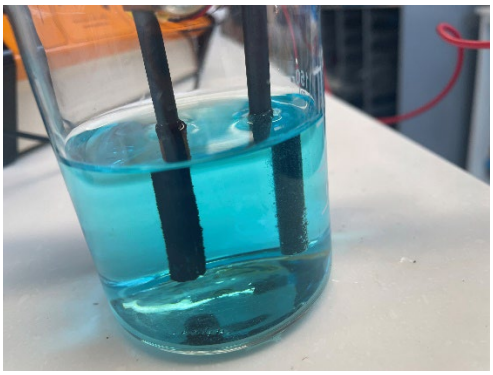
When electricity passes through the copper chloride solution, copper is formed on one of the graphite electrodes and chlorine gas is given off at the other electrode.

Using Lego and then using glassware, he measured the **mass of copper metal** deposited on the electrode.

<u>Electrolysis using Lego</u>



<u>Electrolysis using a glass beaker</u>



He wrote down the readings on his computer as follows:

<u>Glass</u>	<u>Lego</u>
Mass of electrode before, 24 g	(1) 3.01, (2) 3.01 (3) 3.011
Mass electrode after (1), 24.442 g	electrode, 3.002
Mass electrode after (2), 24.469 g	
Mass (3), 24.453,	
Average, 0.455	

a. Organise these results into a suitable table. (3)

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b. Using the photographs suggest why the mass of copper metal deposited on the electrode was lower when using the Lego apparatus. (1)

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c. What measuring instrument would you use to measure the mass of the copper metal and explain whether the result for the mass of copper formed using Lego is as accurate as the result using the glass beaker. (2)

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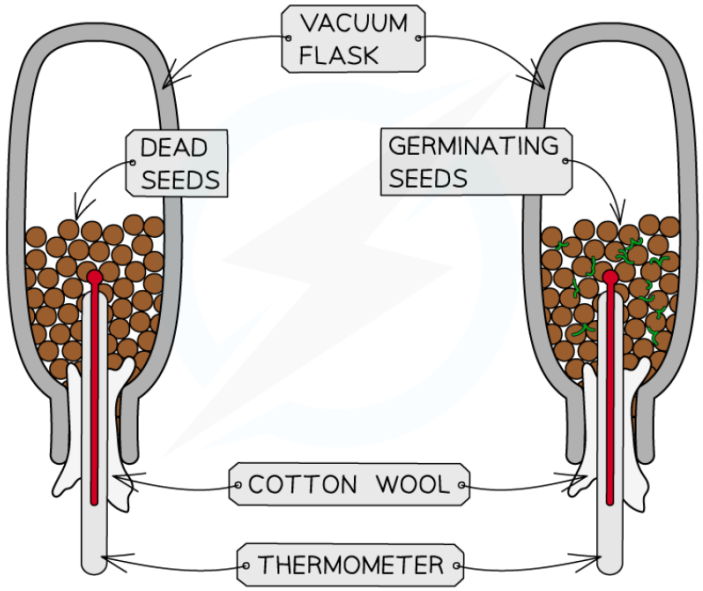
Question / 6

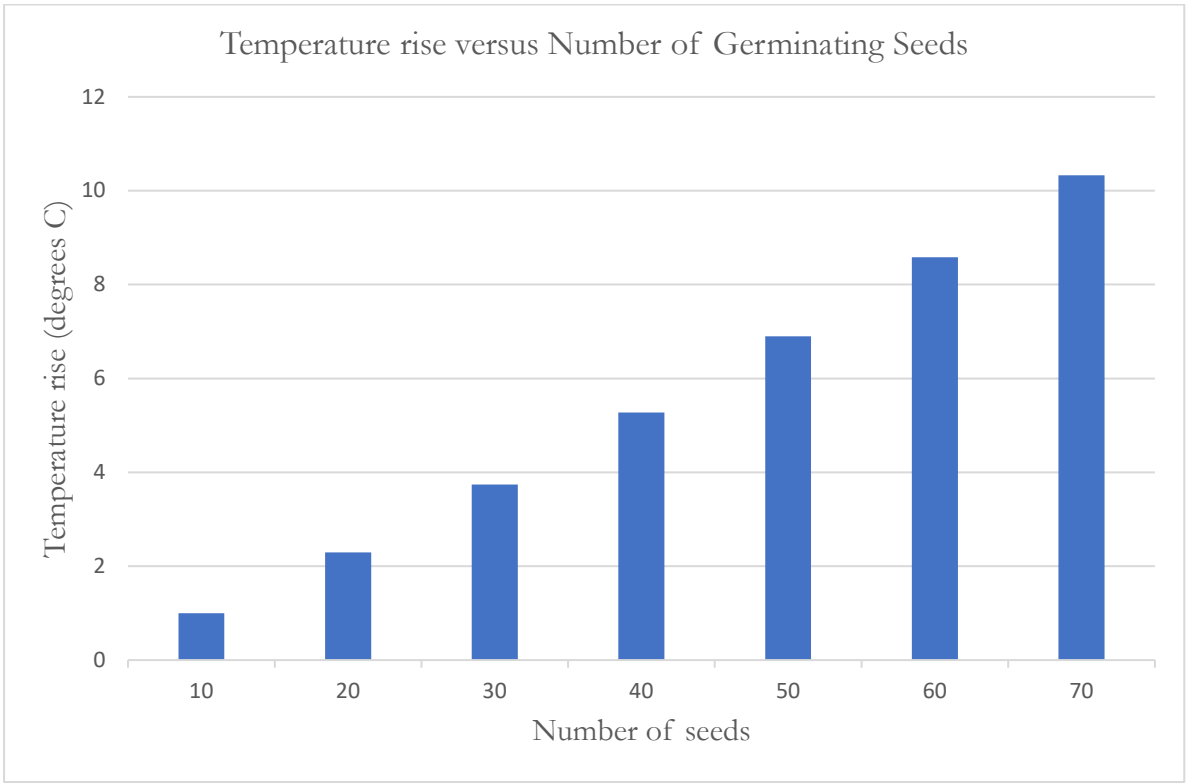
4. Another student investigates the heat energy produced in respiration.



He sets up the apparatus shown above and records the temperature readings at the beginning of the experiment and after 4 hours.

He repeats the experiment using different numbers of seeds. He finds there is no temperature rise for the dead seeds no matter how many seeds are used.

His results are shown in the graph below:



a. Why has he plotted his results using a bar chart? (1)

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b. Describe the trend shown in the results. (2)

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c. Why did he use dead seeds as well as germinating seeds in his experiment? (1)

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d. One student suggests he should also use glass beads as a further comparison. What do you think to this suggestion? (1)

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e. What other features of the experiment should the student keep the same? (2)

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f. Why is it important to keep these features of the experiment the same? (1)

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Question / 8

END OF PAPER