Remember to write your candidate number on every sheet in the space provided.

You should attempt ALL the questions. Write your answers in the spaces provided.

Allow yourself about 12 minutes for each question.

The maximum mark for each question or part of a question is shown in square brackets.

Calculators are allowed. In questions involving calculations, all your working must be shown.

For examiners’ use only.

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Do not turn over until told to do so.
1. Felicity carried out an experiment to investigate the reaction of solid copper carbonate powder with dilute sulfuric acid. She did the experiment at room temperature, and used an excess of copper carbonate. The equation for the reaction is:

\[
\text{copper carbonate}^{(s)} + \text{sulfuric acid}^{(aq)} \rightarrow \text{copper sulfate}^{(aq)} + \text{carbon dioxide}^{(g)} + \text{water}^{(l)}
\]

She measured the volume of carbon dioxide gas produced at suitable time intervals. Her results are shown on the sketch graph below.

(a) Alice repeated Felicity’s experiment, but used half the amount of copper carbonate. This was still sufficient to react with all the acid. Using the axes above, sketch a graph of the results she would obtain and label this graph “A”.

Beatrice did the same experiment as Felicity, but instead of measuring the volume of gas produced, she put the flask containing the reaction mixture on a balance and measured the mass shown by the balance at suitable time intervals.
(b) Use the axes below to sketch the results she would obtain. The flask and its contents had a mass of 100 grams at the start of the experiment.

(c) After the reaction was over, Felicity wanted to obtain some pure, blue copper sulfate crystals from her mixture. Her teacher gave her two pieces of advice:

- copper sulfate is much more soluble in hot water than in cold water;
- blue copper sulfate crystals will decompose if strongly heated.

Describe clearly what Felicity should do to obtain some pure, blue copper sulfate crystals?

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(d) What would be seen if the blue copper sulfate crystals were heated strongly? Explain your answer.

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(e) Some of the carbon dioxide gas from the experiments was bubbled into a test tube containing water and a little Universal Indicator. Describe and explain the colour change which would be seen.

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(f) The test tube from part (e) was then heated, but not enough to boil the water. Bubbles of gas were seen escaping from the liquid. What will happen to the colour of the Universal Indicator? Explain your answer.

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__________________________________________________________________________________________________________________________________________ [2]
2. Gertrude prepared some copper by heating copper oxide in a stream of hydrogen. She used the apparatus shown below. “Cobalt chloride paper” is filter paper which has been soaked in cobalt chloride solution and then thoroughly dried.

The equation for the reaction is: \( \text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O} \)

(a) Which of the reactants is being **reduced** during the reaction? Explain your answer.

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(b) Would you expect a similar reaction to occur if magnesium oxide was used in place of copper oxide? Explain your answer.

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(c) Gertrude’s teacher told her to burn the excess hydrogen as it emerged from the apparatus, rather than just letting it escape into the air. Why did the teacher do this?

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(d) Although the hydrogen flowed into the apparatus at a constant rate, Gertrude noticed that the size of the hydrogen flame was not constant during the experiment. How, and why, would you expect the flame size to vary?

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(f) Gertrude observed that the piece of cobalt chloride paper furthest from the heated copper oxide changed colour, but the piece nearest to the heated copper oxide did not. Explain these observations.

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(g) After the reaction had finished, Gertrude’s teacher told her to let the experiment cool before turning off the hydrogen supply. However, Gertrude was impatient and dismantled the apparatus while it was still hot. She noticed that her solid copper started to change colour, and when she weighed it she found that the mass of the solid was greater than expected. Suggest an explanation for these observations.

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(e) On the scale of atomic masses, a copper atom has a mass of 64 and an oxygen atom has a mass of 16. Calculate the mass of copper which would be formed from 40 grams of copper oxide, CuO.

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[Page 6 of 12]
3. The adult cod population off the coast of Canada has dropped over time as a result of overfishing. Adult cod feed on various small prey known collectively as forage fish. Forage fish eat tiny animals known as zooplankton, which include the eggs of cod themselves.

(a) Using this information, suggest why some small cod populations cannot recover even when fishermen stop removing adult cod from the ocean.

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For the population to increase, new fish must successfully hatch from eggs and survive. This is often referred to as the birth rate. The population may decrease due to death of existing fish, which itself could be due to several reasons, including fishing. This is referred to as death rate.

(b) Define the term population.

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The graph below shows how birth and death rates (R) are affected by population size (N):

(c) Suggest why the death rate increases as population size increases.

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(d) Birth rate is lower for both small and large populations. Suggest why this might be.

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(e) On the graph, indicate with an ‘X’ the population size at which the population is growing at the greatest rate. Explain why you have chosen this value.

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(f) Some ecologists want to know how many cod they need to introduce into an area of ocean to start a successful new population. Of the five population sizes indicated on the graph (A, B, C, D and E), which would be most appropriate? Explain your answer fully.

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4. The diagram below shows a cross-section of a typical flower.

(a) What is the term used to describe the transfer of pollen to the stigma in a flower. 
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(b) Pollen grains and ovules contain the male and female gametes respectively. Describe what you understand by the term gamete.  
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(c) In order for fertilisation to occur, the pollen tube has to germinate and then grow down to the ovules in the ovary so that the gametes can fuse (as shown in the diagram above). Successful fertilisation leads to fruit formation. Suggest how the pollen tube grows down through the tissue of the style.  
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Apple growers often plant two different varieties of apple tree in an orchard in order to improve the success rate of pollination and so produce more fruit. The table below sets out information about four apple varieties: Bramley, Discovery, Early Windsor and Royal Gala. Bramley is the first of these to flower, followed a week later by Early Windsor and Royal Gala. Discovery flowers about 18 days after Bramley and each variety acts as a good pollinator for about 5 days. The table also gives information about the germination rate (%) of Royal Gala pollen in a range of sucrose concentrations (M) to which stigma extract from the four varieties had been added.

<table>
<thead>
<tr>
<th>Source of stigma extract</th>
<th>0M</th>
<th>1M</th>
<th>2M</th>
<th>3M</th>
<th>4M</th>
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<tbody>
<tr>
<td>Bramley</td>
<td>0</td>
<td>45</td>
<td>95</td>
<td>25</td>
<td>0</td>
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<tr>
<td>Discovery</td>
<td>0</td>
<td>55</td>
<td>85</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>Early Windsor</td>
<td>0</td>
<td>25</td>
<td>65</td>
<td>30</td>
<td>0</td>
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<tr>
<td>Royal Gala</td>
<td>0</td>
<td>15</td>
<td>35</td>
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(d) Suggest reasons why Royal Gala pollen grains failed to germinate in both the 0M and 4M sucrose solutions.

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A keen gardener has a single Royal Gala apple tree. She would like to plant another apple tree to obtain more fruit.

(e) Using all the information provided, explain, with reasons, which of the four apple varieties she should plant in order to produce the most fruit.

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[Page 10 of 12]
(f) Describe and explain what environmental factors might affect the average mass of apples produced in her garden.

5. (a) Explain the scientific meaning of the term density.

(b) Density may be expressed in g/cm³ or kg/m³. What is the value of 1 kg/m³ expressed in g/cm³? Show all of your working.

(c) A spherical raindrop of water, illustrated below, has mass $4.2 \times 10^{-6}$ kg. To one significant figure, what is the density of water? (This is a value you should use for the rest of the question).

![Diagram of a sphere with diameter 2 mm and volume of sphere formula $\frac{4}{3}\pi r^3$]
Pressure increases with depth underwater due to the total weight of the water above pressing down on an object. 1 kg of matter weighs 10 N on Earth and you may assume that the density of water remains constant at all depths.

(d) A sealed treasure chest with a flat top of area $A$ is resting on the seabed. A pressure increase due to the water of more than 500 000 N/m$^2$ will cause the chest to break open. What is the maximum depth the chest could withstand without breaking open?

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(e) If the chest were to be submerged in liquid mercury, it would break open at a depth of 3.5 m. What is the density of liquid mercury?

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(f) Explain, using ideas about pressure, why an object submerged in water experiences an upwards buoyancy force. A diagram may aid your explanation.

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