LUI | | | | | | | | | | | School code | | | | |

School name

Given name/s

Family name

Attach your barcode ID label here

Book of books used

External assessment 2021

Question and response book

Engineering

Time allowed

- Perusal time — 10 minutes
- Working time — 120 minutes

General instructions

- Answer all questions in this question and response book.
- QCAA-approved calculator permitted.
- Protractor and ruler required.
- QCAA formula and data book provided.
- Planning paper will not be marked.

Section 1 (10 marks)

- 10 multiple choice questions

Section 2 (36 marks)

- 7 short response questions

Section 3 (39 marks)

- 6 short response questions

Clear zone — margin trimmed off after completion of assessment

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

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Section 1

Instructions

- Choose the best answer for Questions 1–10.
- This section has 10 questions and is worth 10 marks.
- Use a 2B pencil to fill in the A, B, C or D answer bubble completely.
- If you change your mind or make a mistake, use an eraser to remove your response and fill in the new answer bubble completely.

	A	B	C	D
Example:	●	○	○	○

	A	B	C	D
1.	○	○	○	○
2.	○	○	○	○
3.	○	○	○	○
4.	○	○	○	○
5.	○	○	○	○
6.	○	○	○	○
7.	○	○	○	○
8.	○	○	○	○
9.	○	○	○	○
10.	○	○	○	○

Do not write outside this box.

Section 2

Instructions

- Write using black or blue pen.
- Respond in paragraphs consisting of full sentences.
- If you need more space for a response, use the additional pages at the back of this book.
  - On the additional pages, write the question number you are responding to.
  - Cancel any incorrect response by ruling a single diagonal line through your work.
  - Write the page number of your alternative/additional response, i.e. See page …
  - If you do not do this, your original response will be marked.
- This section has seven questions and is worth 36 marks.

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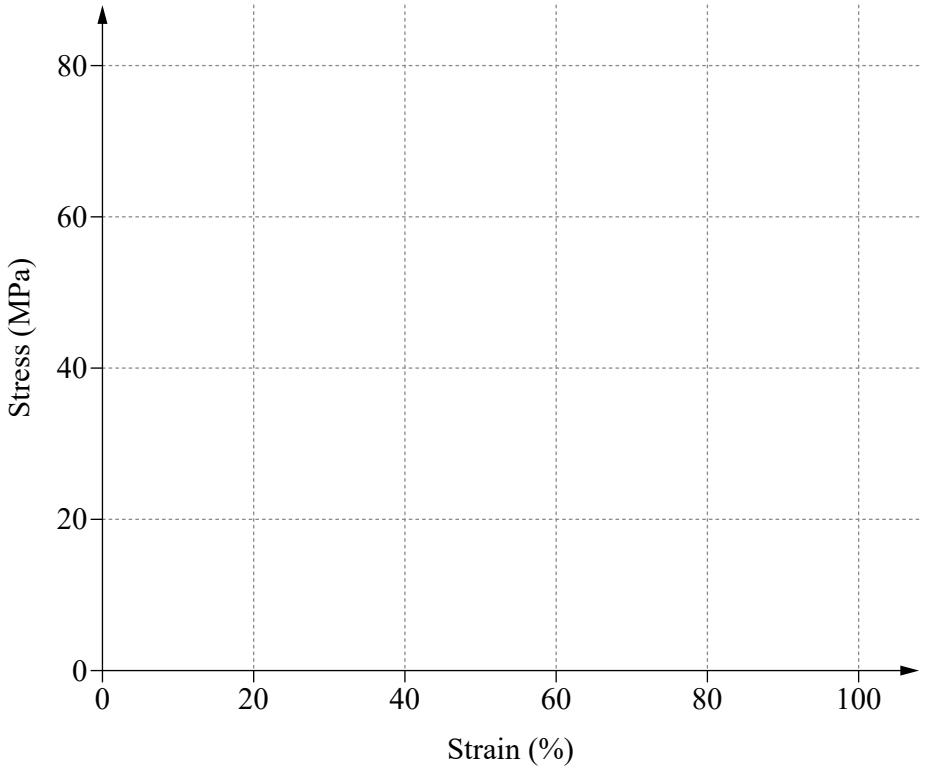
QUESTION 11 (4 marks)

Sketch the stress–strain curve for nylon on the graph. Clearly label the features that indicate the material's ability to absorb and store energy and to withstand elastic deformation within the material's proportional limit.



Note: If you make a mistake in the graph, cancel it by ruling a single diagonal line through your work and use the additional response space on page 27 of this question and response book.

QUESTION 12 (4 marks)

State four fields of knowledge used by a biomedical engineer to perform their role.

1. _____

2. _____

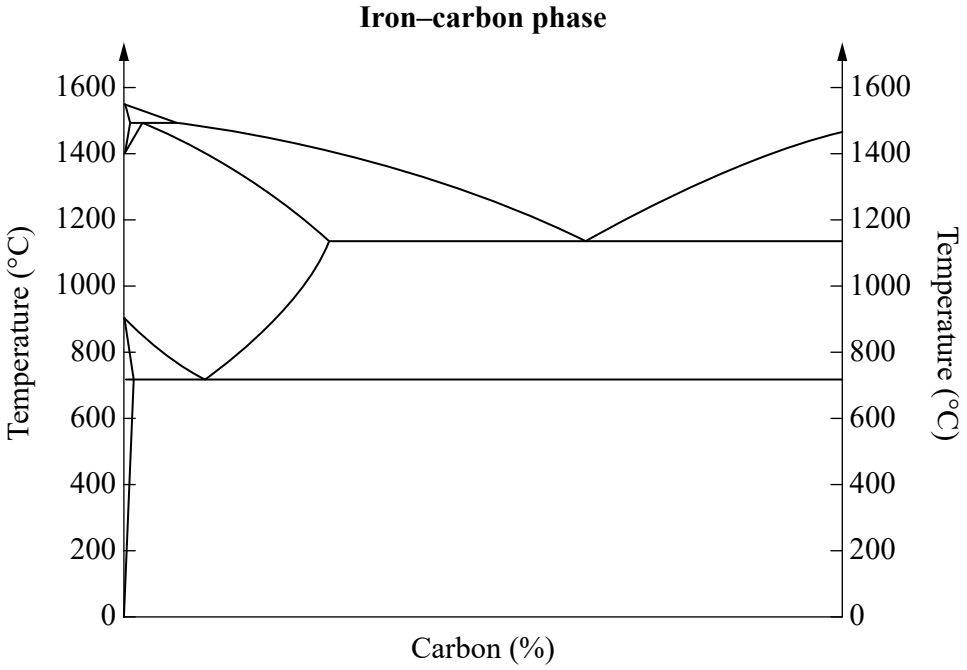
3. _____

4. _____

Do not write outside this box.

QUESTION 13 (5 marks)

Explain how the microstructure of a 3% carbon cast iron changes during cooling between the eutectic and eutectoid temperatures. Annotate the diagram to identify the material's approximate location and the eutectic and eutectoid temperatures to support your explanation.



Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space on page 28 of this question and response book.

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QUESTION 14 (6 marks)

Explain how the tensile test for a low-carbon steel material can be used to determine the ductility of the material. Sketch and annotate a stress–strain diagram to support your explanation.

Note: If you make a mistake in the sketch, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

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QUESTION 15 (6 marks)

An automated machine fabricates a metal component using a punching tool. The machine includes sensors that allow it to operate only when the punching tool is detected as correctly inserted with the safety guard in the punching position, and when either a component is detected as correctly positioned or with the manual shut-down switch not activated. All sensors send a 1 input for a yes/activated condition and a 0 input for a no/not activated condition.

Develop a logic gate circuit to control the given function of the automated punching machine to produce a 1 output from the circuit.

Clearly annotate all logic gate inputs and outputs, and label all sensors.

Sensor description	Label
Punching tool detection	P
Component detection	C
Safety guard	S
Manual shut-down switch	M

Note: If you make a mistake in the sketch, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

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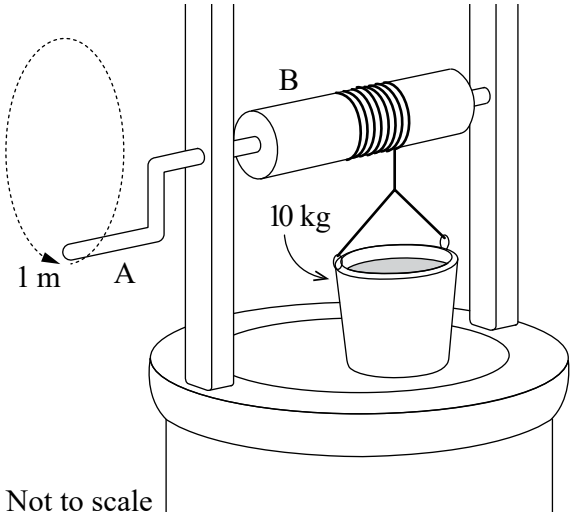
QUESTION 16 (5 marks)

This simple machine is used by turning handle A to raise a 10 kg bucket of water from a 10 m deep well. The hand-operated handle A has a turning circle of 1 m and the lifting arm B has a diameter of 250 mm. The machine takes 30 seconds to raise the water. Explain the work done by the machine and the power used to lift one bucket of water. Use mathematical reasoning to support your explanation.



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QUESTION 17 (6 marks)

Describe a community problem related to a sustainability issue. Explain how engineers have used their knowledge to develop a solution for this problem and how the solution has reduced the environmental impact to provide two benefits for the community involved.

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Section 3

Instructions

- Respond showing full working for calculations.
- This section has six questions and is worth 39 marks.

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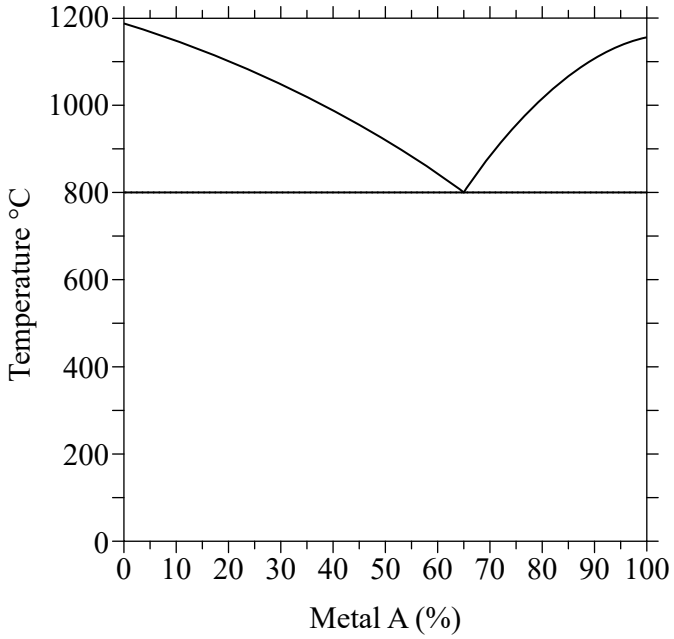
QUESTION 18 (5 marks)

Use and annotate the binary equilibrium diagram for an alloy of metals A and B to calculate the percentage of solid and liquid material present for an alloy of 20% Metal A and 80% Metal B at 900 °C. Answer to the nearest whole unit.



Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space on page 29 of this question and response book.

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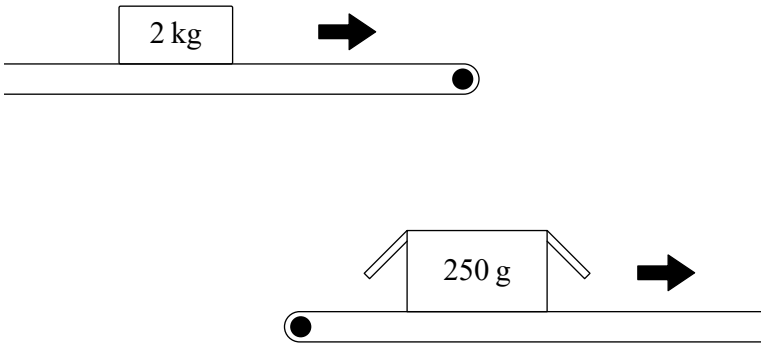
QUESTION 19 (8 marks)

A 2 kg package is moving at 5 m/s in the direction of the arrow, as shown. The package drops into a 250 g carton moving in the same direction at 2 m/s on a second conveyor.



a) Calculate the force exerted by the package if it just causes the carton to begin sliding on the conveyor surface. The coefficient of static friction between the carton and the conveyor surface is 0.4. Answer to the nearest whole unit. Include a free-body diagram with your working. *[3 marks]*

Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

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b) If the coefficient of kinetic friction is 0.3, determine the distance the carton slides along the conveyor surface after the package lands in it. Answer to the nearest whole unit (mm). Include a free-body diagram with your working. *[5 marks]*

Note: If you make a mistake in the diagram, cancel it by ruling a single diagonal line through your work and use the additional response space at the back of this question and response book.

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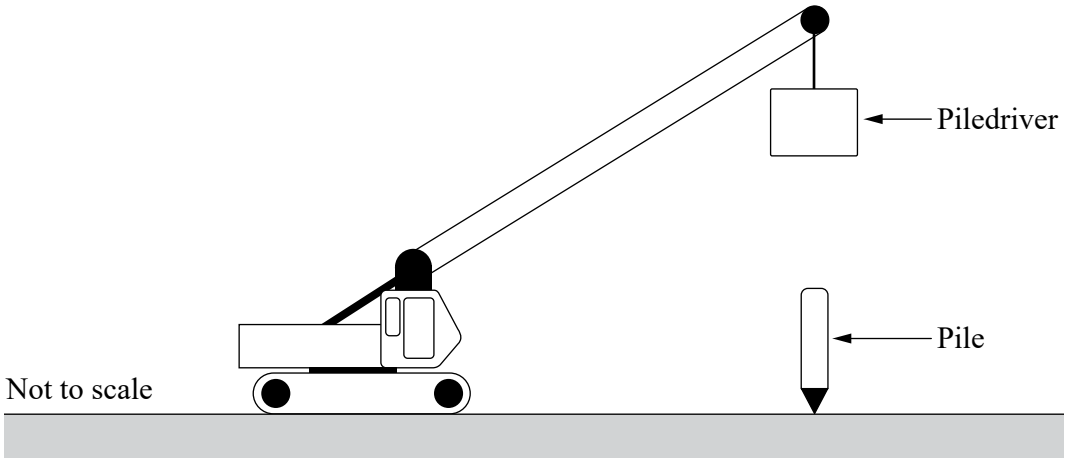
QUESTION 20 (5 marks)

A 500 kg piledriver is used to drive a 200 kg pile into the soil as shown. The piledriver falls freely through a distance of 4 m before impacting the pile with 19.6 kJ of energy. At the moment of impact, energy is lost as heat and sound.



a) If 5.4 kJ of energy is lost during the impact between piledriver and pile, determine the velocity of the piledriver just after impact. Answer to two decimal places. *[3 marks]*

b) If the pile and piledriver decelerate at a constant rate of 30 m/s^2 after impact due to the resistance of the soil, determine the distance the pile is driven into the ground. Answer to the nearest whole unit (mm). *[2 marks]*

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QUESTION 21 (5 marks)

A bucket is used to carry iron ore vertically up a mine shaft from its base. The bucket is raised from rest at the base of the shaft and accelerates constantly upwards at a rate of 0.75 m/s^2 for 4 s. It then travels at a constant velocity before decelerating constantly to stop at the top of the shaft.

a) Determine the maximum velocity of the bucket to the nearest whole unit. *[3 marks]*

b) From rest, the bucket is lowered from the top of the shaft with a constant acceleration. Determine the bucket's acceleration if the bucket has been lowered 25 m after 10 s. Answer to one decimal place. *[2 marks]*

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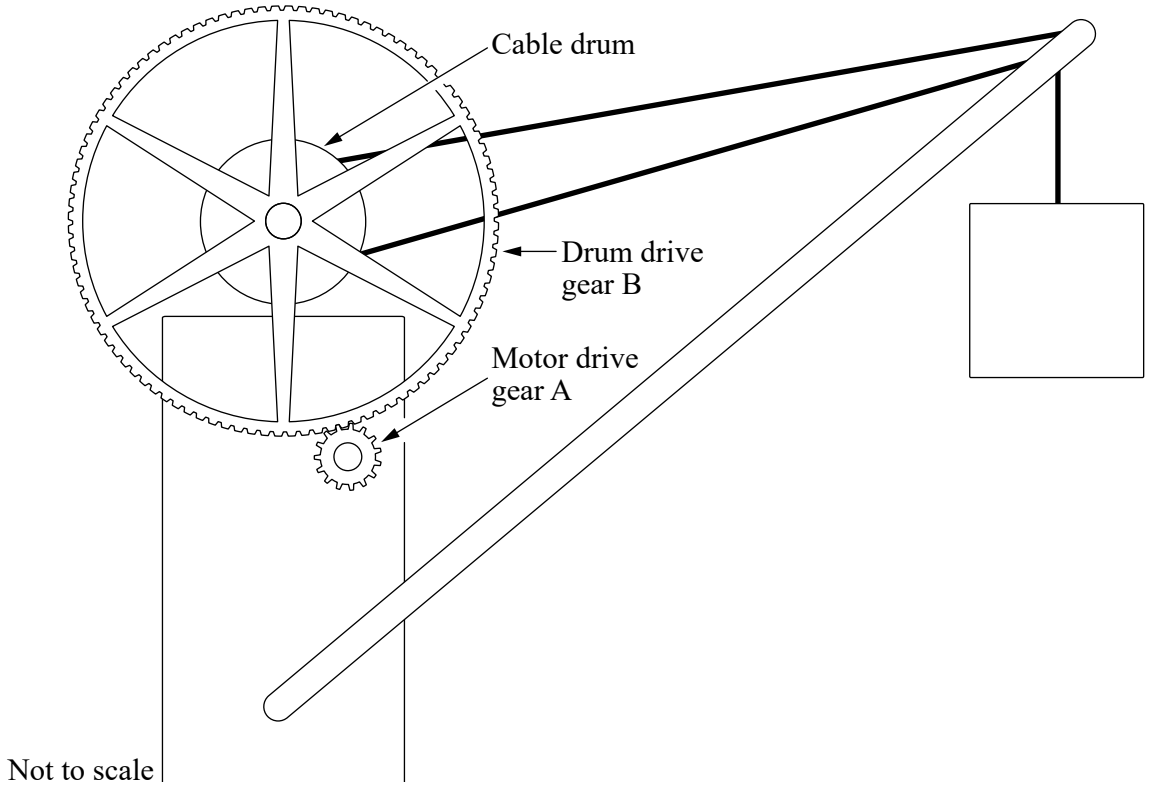
QUESTION 22 (6 marks)

This winch crane is driven by an electric motor. The motor drive shaft is fitted to a 15-tooth gear A, which drives a 100-tooth gear B attached to a cable drum. The 500 mm diameter cable drum houses a steel cable that is used to vertically raise 20 kg hay bales 2 m from the ground to be loaded onto trucks.



a) Calculate the output power of the crane if it takes 30 seconds to raise two hay bales. Answer to two decimal places. *[2 marks]*

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b) Determine the number of motor revolutions required to produce the 2 m lift.
Answer to one decimal place. *[4 marks]*

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QUESTION 23 (10 marks)

A conveyor transfers a 2 kg component between two assembly points during a product manufacturing process. Initially stationary at assembly point 1, the component moves 10 m with a uniform acceleration of 2 m/s^2, just without slipping on the conveyor, to assembly point 2, where it stops.

Determine the coefficient of static friction required between the conveyor and the component if the transfer time between the two assembly points is reduced by 20%. Answer to two decimal places.

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ADDITIONAL PAGE FOR STUDENT RESPONSES

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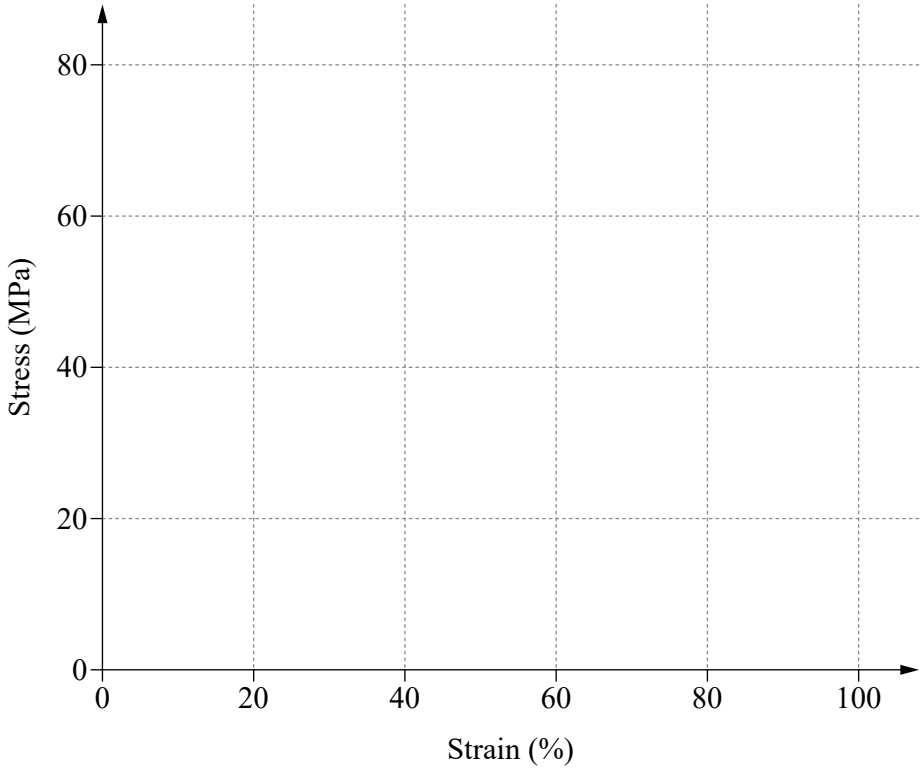
ADDITIONAL RESPONSE SPACE FOR QUESTION 11

If you want this graph to be marked, rule a single diagonal line through the graph on page 3.



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ADDITIONAL RESPONSE SPACE FOR QUESTION 13

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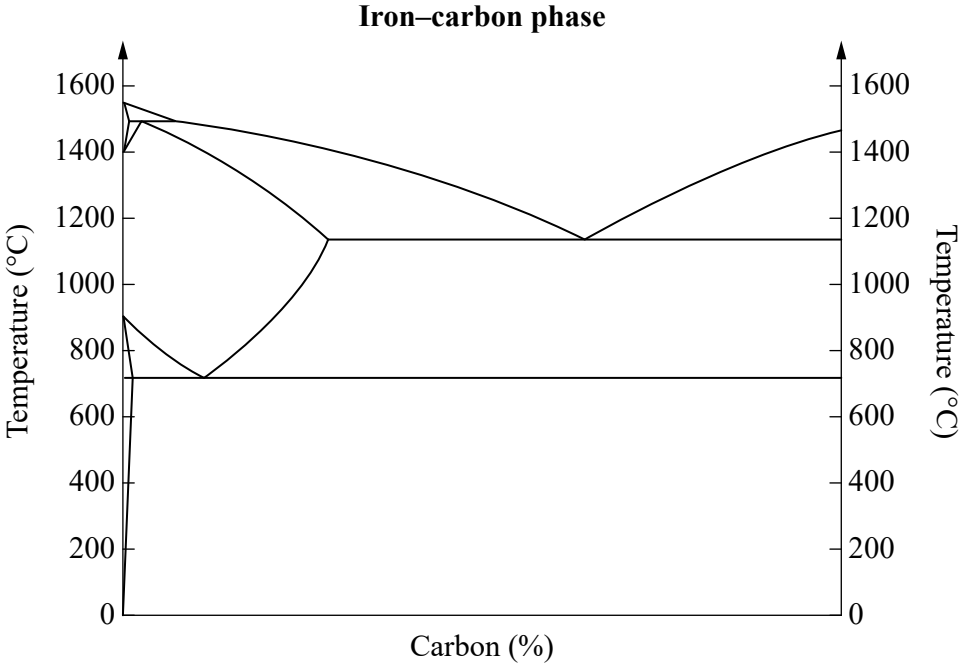

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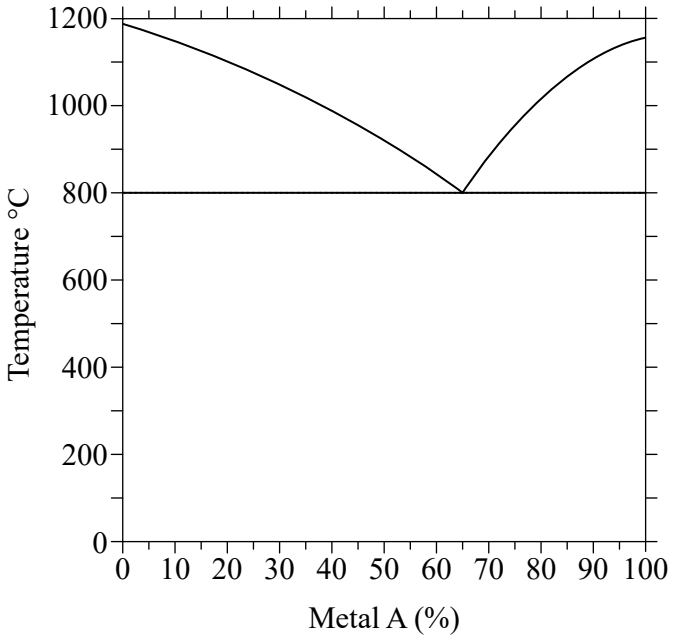
ADDITIONAL RESPONSE SPACE FOR QUESTION 18

If you want this diagram to be marked, rule a single diagonal line through the diagram on page 10.



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References

Question 13

2016, *Brosen ironcarbon.svg*, https://commons.wikimedia.org/wiki/File:Brosen_ironcarbon.svg#metadata.

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