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Physics
Standard level
Paper 2

3 May 2023

Zone A morning | **Zone B** afternoon | **Zone C** morning

Candidate session number

1 hour 15 minutes

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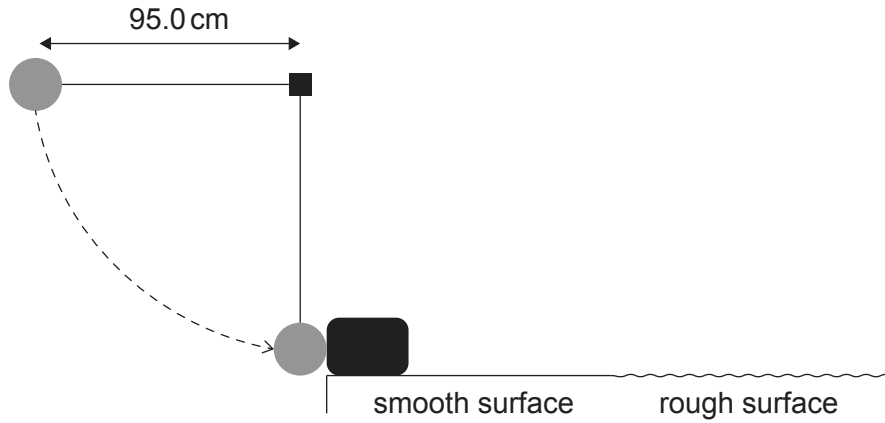
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



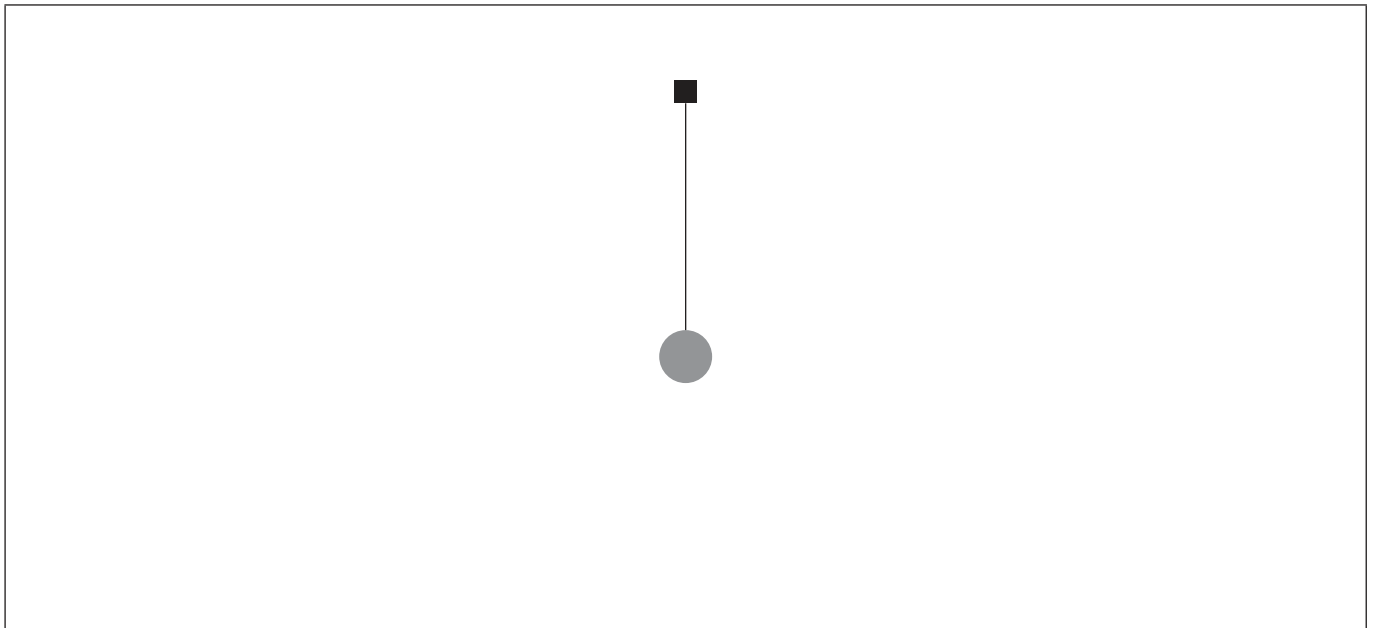
Answer **all** questions. Answers must be written within the answer boxes provided.

1. A ball of mass 0.800 kg is attached to a string. The distance to the centre of the mass of the ball from the point of support is 95.0 cm . The ball is released from rest when the string is horizontal. When the string becomes vertical the ball collides with a block of mass 2.40 kg that is at rest on a horizontal surface.



- (a) Just before the collision of the ball with the block,
(i) draw a free-body diagram for the ball.

[2]



(This question continues on the following page)



(Question 1 continued)

(ii) show that the speed of the ball is about 4.3 ms^{-1} . [1]

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(iii) determine the tension in the string. [2]

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20EP04

(Question 1 continued)

(b) After the collision, the ball rebounds and the block moves with speed 2.16 m s^{-1} .

(i) Show that the collision is elastic. [4]

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(ii) Calculate the maximum height risen by the centre of the ball. [2]

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(c) The coefficient of dynamic friction between the block and the rough surface is 0.400.

Estimate the distance travelled by the block on the rough surface until it stops. [3]

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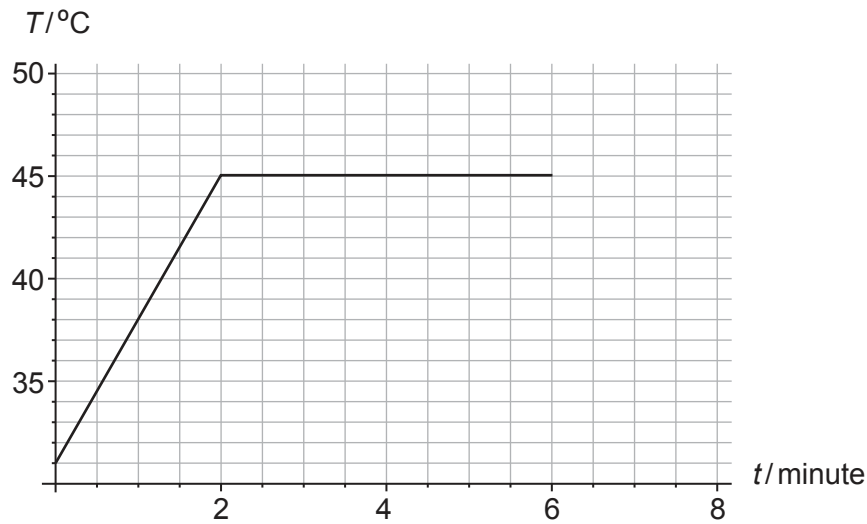
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2. A solid piece of chocolate of mass 82 g is placed in a pan over fire. Thermal energy is transferred to the chocolate at a constant rate. The graph shows the variation with time t , of the temperature T of the chocolate. At 6.0 minutes all the chocolate has melted.



The specific heat capacity of solid chocolate is $1.6 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$.

- (a) Show that the average rate at which thermal energy is transferred into the chocolate is about 15W. [3]

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- (b) Estimate the specific latent heat of fusion of chocolate. [2]

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(This question continues on the following page)



(Question 2 continued)

(c) Compare the internal energy of the chocolate at $t = 2$ minutes with that at $t = 6$ minutes. [2]

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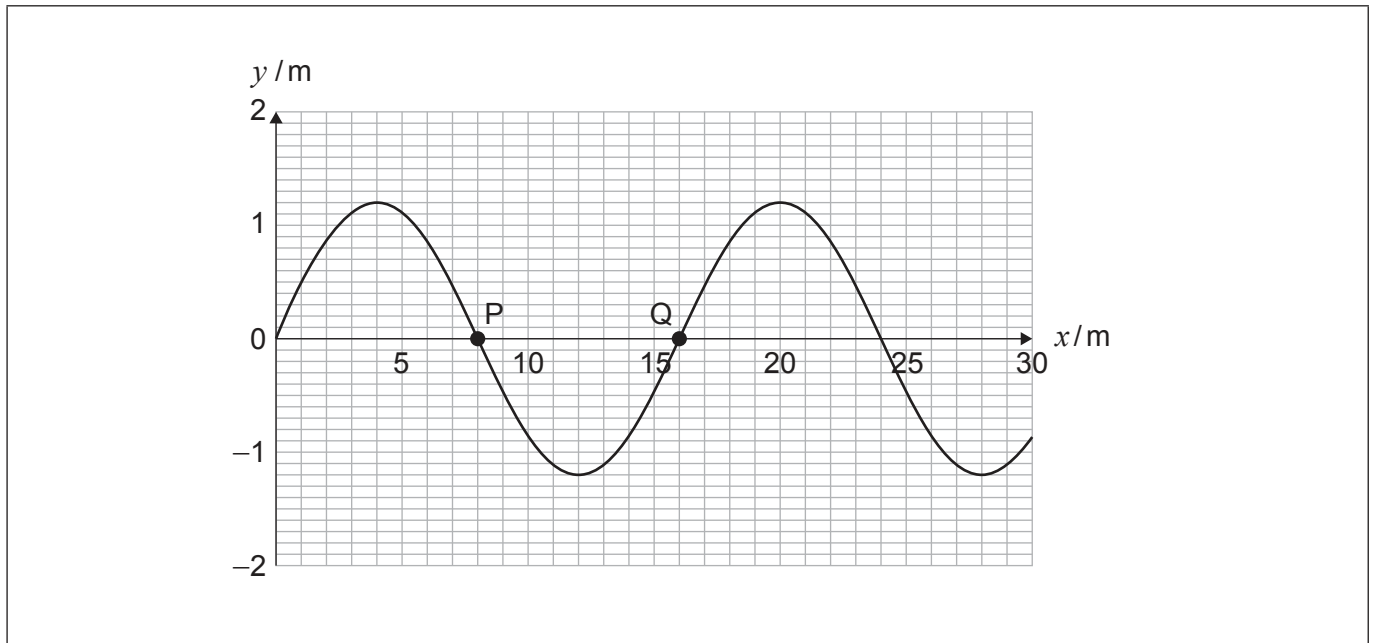
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20EP07

Turn over

3. (a) A transverse water wave travels to the right. The diagram shows the shape of the surface of the water at time $t = 0$. P and Q show two corks floating on the surface.



- (i) State what is meant by a transverse wave. [1]

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- (ii) The frequency of the wave is 0.50 Hz. Calculate the speed of the wave. [1]

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- (iii) Plot on the diagram the position of P at time $t = 0.50$ s. [1]

- (iv) Show that the phase difference between the oscillations of the two corks is π radians. [1]

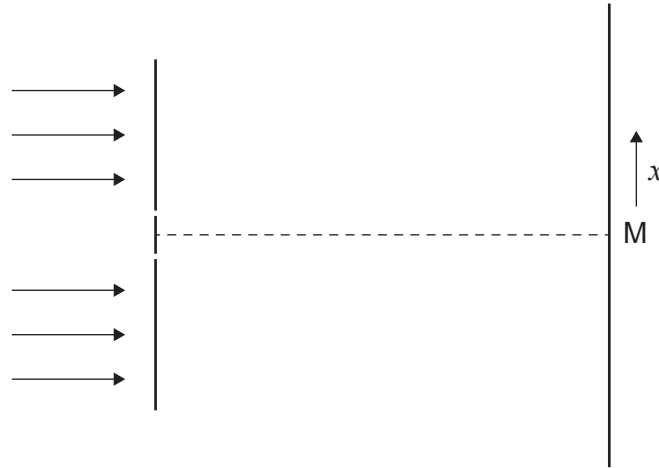
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(Question 3 continued)

- (b) Monochromatic light is incident on two very narrow slits. The light that passes through the slits is observed on a screen. M is directly opposite the midpoint of the slits. x represents the displacement from M in the direction shown.



A student argues that what will be observed on the screen will be a total of two bright spots opposite the slits. Explain why the student's argument is incorrect.

[2]

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20EP09

Turn over

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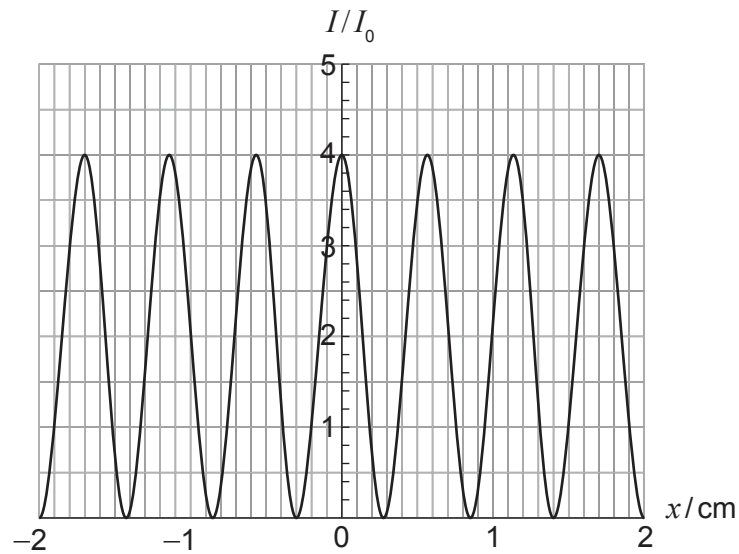
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20EP10

(Question 3 continued)

- (c) The graph shows the actual variation with displacement x from M of the intensity of the light on the screen. I_0 is the intensity of light at the screen from one slit only.



The slits are separated by a distance of 0.18 mm and the distance to the screen is 2.2 m. Determine, in m, the wavelength of light.

[2]

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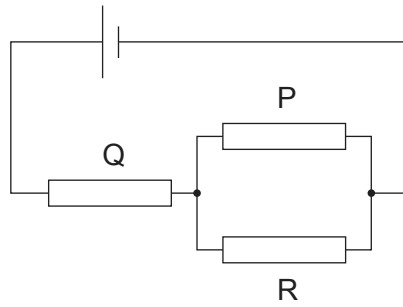
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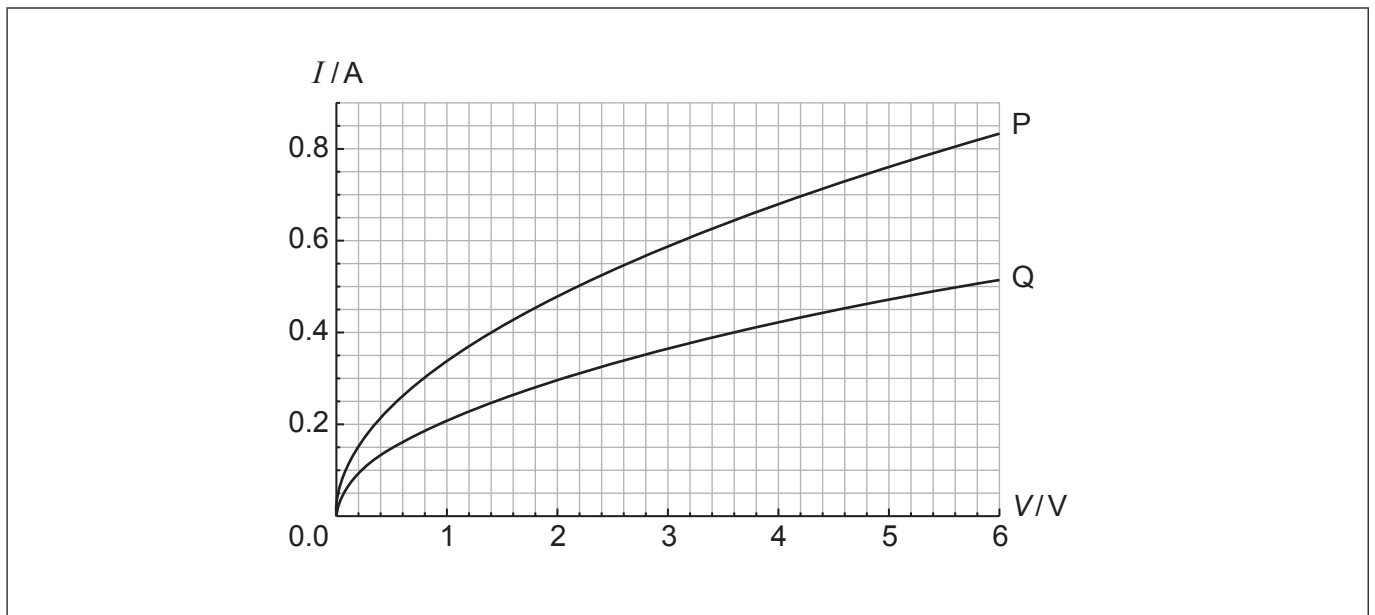
20EP11

Turn over

4. (a) A cell of negligible internal resistance and electromotive force (emf) 6.0V is connected to three resistors R, P and Q.



R is an ohmic resistor. The I - V characteristics of P and Q are shown in the graph.



The current in P is 0.40A.

- (i) Show that the current in Q is 0.45A.

[3]

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(This question continues on the following page)



(Question 4 continued)

(ii) Calculate the resistance of R.

[2]

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(iii) Calculate the total power dissipated in the circuit.

[1]

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(b) Resistor P is removed. Suggest, without any calculations, the effect of this on the resistance of Q.

[2]

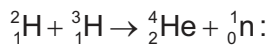
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5. (a) Identify with ticks [✓] in the table, the forces that can act on electrons and the forces that can act on quarks. [2]

	Weak nuclear	Strong nuclear
Electrons		
Quarks		

- (b) The following data is available for atomic masses for the fusion reaction



${}^2_1\text{H}$	2.0141 u
${}^3_1\text{H}$	3.0160 u
${}^4_2\text{He}$	4.0026 u

- (i) Show that the energy released is about 18 MeV. [2]

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- (ii) Estimate the specific energy of hydrogen by finding the energy produced when 0.4 kg of ${}^2_1\text{H}$ and 0.6 kg of ${}^3_1\text{H}$ undergo fusion. [2]

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(This question continues on the following page)



(Question 5 continued)

(c) It is hoped that nuclear fusion can be used for commercial production of energy.

Outline

(i) **two** difficulties of energy production by nuclear fusion. [2]

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(ii) **one** advantage of energy production by nuclear fusion compared to nuclear fission. [1]

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20EP16

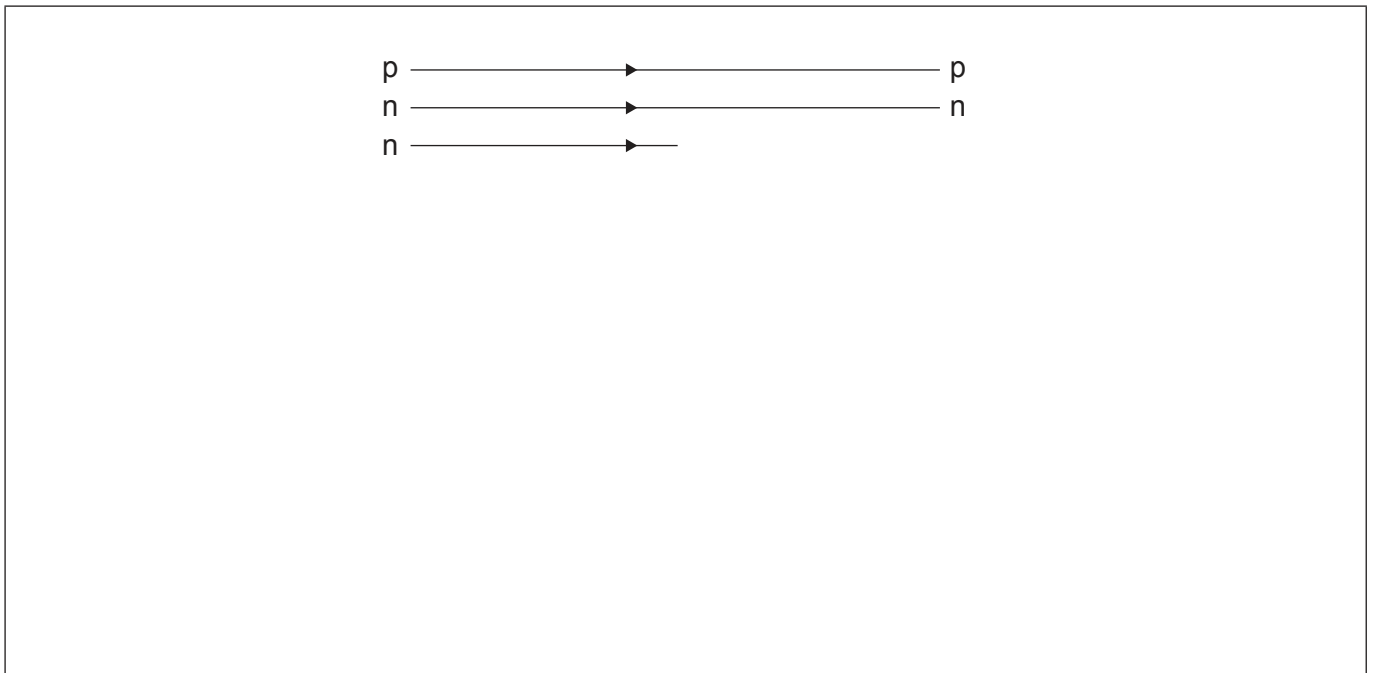
(Question 5 continued)

(d) Tritium (${}^3_1\text{H}$) is unstable and decays into an isotope of helium (He) by beta minus decay with a half-life of 12.3 years.

(i) State the nucleon number of the He isotope that ${}^3_1\text{H}$ decays into. [1]

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(ii) The following diagram is an incomplete Feynman diagram describing the beta minus decay of ${}^3_1\text{H}$ into He. Complete the diagram and label all the missing particles. [3]



References:

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20EP18

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20EP19

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20EP20