1 Ice at 0 °C melts into water at 0 °C.

Which row of the table gives the changes in mean molecular kinetic energy and mean molecular potential energy as the ice melts?

	Mean molecular kinetic energy	Mean molecular potential energy
☒ **A**	no change	no change
☒ **B**	no change	increases
☒ **C**	increases	no change
☒ **D**	increases	increases

(Total for Question 1 = 1 mark)

9 Two gas cylinders have the same volume. One cylinder contains nitrogen gas. The other cylinder contains oxygen gas.

Both gases are at the same temperature and pressure.

Which of the following statements is **not** correct?

☒ **A** Each cylinder contains the same number of molecules.

☒ **B** The average molecular kinetic energy is the same for each gas.

☒ **C** The density of gas is the same in each cylinder.

☒ **D** The internal energy is the same for each gas.

(Total for Question 9 = 1 mark)

8 A mixture of helium gas and hydrogen gas is kept at room temperature.

Which of the following is correct?

☒ **A** The mean kinetic energy of the helium molecules is greater than the mean kinetic energy of the hydrogen molecules.

☒ **B** The mean kinetic energy of the helium molecules is less than the mean kinetic energy of the hydrogen molecules.

☒ **C** The mean square velocity of the helium molecules is greater than the mean square velocity of the hydrogen molecules.

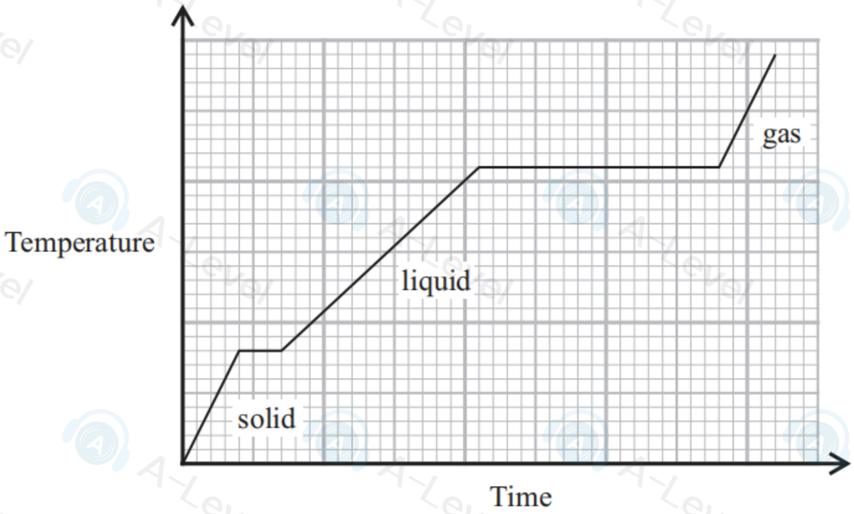
☒ **D** The mean square velocity of the helium molecules is less than the mean square velocity of the hydrogen molecules.

(Total for Question 8 = 1 mark)

10 Energy is supplied at a constant rate to a material. The material is initially solid.

As energy is supplied, the solid melts to form a liquid and finally the liquid turns into a gas. The mass remains constant during the heating process.

The graph shows how the temperature changed with time.



Which of the following is correct?

☒ **A** specific heat capacity of solid > specific heat capacity of liquid

☒ **B** specific heat capacity of solid > specific heat capacity of gas

☒ **C** specific heat capacity of solid = specific heat capacity of liquid

☒ **D** specific heat capacity of solid = specific heat capacity of gas

(Total for Question 10 = 1 mark)

17: The Gaia globe is a three-dimensional model of the Earth, as shown. The inflated globe is suspended from above and is able to rotate.

The globe is filled with nitrogen gas. When fully inflated the globe has a radius of 3.50 m.

(a) Calculate the mass of nitrogen gas needed to exert a pressure of 1.12×10^5 Pa inside the globe, at a temperature of 22.0 °C.

mass of a nitrogen molecule = 4.67×10^{-26} kg

(5)

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Mass of nitrogen gas = ...

(b) The globe rotates with an angular velocity of $2.76 \times 10^{-2}\,\mathrm{rad\,s^{-1}}$.

Calculate the time taken for the globe to make one complete rotation.

(2)

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Time taken for one rotation = ...

(c) A solid sphere has the same diameter as the Gaia globe.

Calculate the mass of the sphere that would give a value of g, at its surface, of $9.8\,\mathrm{N\,kg^{-1}}$.

(2)

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Mass of sphere = ...

(Total for Question 17 = 9 marks)

19 A filament bulb contains argon gas to extend the lifetime of the filament.

(Source: © mauritius images GmbH / Alamy Stock Photo)

While the bulb is off, the argon gas inside the bulb is at a temperature of 290 K. The pressure of the argon gas inside the bulb is 75% of atmospheric pressure.

volume of bulb = $1.25 \times 10^{-4}\,m^3$
atmospheric pressure = $1.03 \times 10^5\,Pa$

(a) Calculate the number of argon atoms in the bulb.

(3)

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Number of argon atoms = ...

(b) While the bulb is on, the pressure of the argon gas is 83% of atmospheric pressure.

The manufacturer states that the temperature of the gas inside the bulb is about 60°C while the bulb is on.

Assess whether this statement is accurate.

(3)

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(c) (i) While the bulb is on, radiation is emitted by the filament. This radiation has a peak power output at a wavelength, λ_{max}, of 1100 nm.

Calculate the power output of the bulb.

surface area of filament = $1.55 \times 10^{-5}\ m^2$

(3)

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Power output of bulb = ...

(c) (i) While the bulb is on, radiation is emitted by the filament. This radiation has a peak power output at a wavelength, λ_{max}, of 1100 nm.

Calculate the power output of the bulb.

surface area of filament = $1.55 \times 10^{-5}\,m^2$

(3)

Power output of bulb = ...

(ii) Suggest why the actual power output of the bulb may be lower than the value calculated.

(1)

(Total for Question 19 = 10 marks)

15 The photograph shows a large area of ice floating in the sea. This is called an ice floe.

(Source: © elmvilla/Getty Images)

Energy from the Sun melts the ice floe.

(a) An ice floe has a mass of 3.53×10^5 kg.

Show that the energy required to melt this ice floe is about 1.3×10^{11} J.

initial temperature of ice = –18.0 °C
final temperature of ice = 0.0 °C
specific heat capacity of ice = $2.09 \times 10^3\,\mathrm{J\,kg^{-1}\,K^{-1}}$
specific latent heat of ice = $3.36 \times 10^5\,\mathrm{J\,kg^{-1}}$

(3)

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) At the top of the atmosphere, the intensity of radiation from the Sun is $1370\,\text{W}\,\text{m}^{-2}$. As radiation passes through the atmosphere, 44% is absorbed or reflected by the atmosphere.

A scientist claims that, even with continuous sunshine, the time taken for the ice floe to melt completely would be greater than 7 days.

Deduce whether this claim is correct.

average thickness of ice floe = $0.85\,\text{m}$
volume of ice floe = $385\,\text{m}^3$
1 day = $8.64 \times 10^4\,\text{s}$

(6)

(Total for Question 15 = 9 marks)

16 An electric kettle contains $4.25 \times 10^{-4}\,m^3$ of water. The temperature of the water is 22°C.

The kettle is switched on. The water takes 85 s to reach a temperature of 100°C.

(a) Show that the power of the kettle is about 1600 W.

specific heat capacity of water = $4190\,J\,kg^{-1}\,K^{-1}$
density of water = $998\,kg\,m^{-3}$

(4)

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(b) The water boils at 100°C.

Calculate the time now taken for 75% of the water to boil away.

specific latent heat of vaporisation of water = $2.26 \times 10^6\,J\,kg^{-1}$

(3)

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Time taken = ...

(Total for Question 16 = 7 marks)

15 A teacher used liquid nitrogen to demonstrate low temperature physics.

The teacher dropped a peeled banana at room temperature into a flask of liquid nitrogen.

(a) Explain why the liquid nitrogen boiled when the banana was submerged in the liquid nitrogen.

(2)

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(b) During the demonstration, the liquid nitrogen remained at its boiling point in a large flask. The teacher estimated that at least 0.5 kg of liquid nitrogen was needed to cool the banana from room temperature to the temperature of the liquid nitrogen.

Assess the accuracy of the teacher's estimate.

latent heat of vaporisation of nitrogen = $1.98 \times 10^5\,\mathrm{J\,kg^{-1}}$
boiling point of liquid nitrogen = 77.4 K
specific heat capacity of banana = $1.76 \times 10^3\,\mathrm{J\,kg^{-1}\,K^{-1}}$
mass of banana = 0.118 kg
room temperature = 292 K

(3)

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(Total for Question 15 = 5 marks)