Q1.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒). If you change your mind about an answer, put a line through the box and then mark your new answer with a cross (☒).

Which of the following statements about the absolute zero of temperature is correct?

☐ **A** It is the temperature of deep space.

☐ **B** It is the temperature at which nitrogen gas liquefies.

☐ **C** It is the lowest temperature reached so far in an experiment.

☐ **D** It is the temperature at which the internal energy of an ideal gas is a minimum.

(Total for question = 1 mark)

Q2.

Basketballs are usually made from a leather composite and are filled with air. A standard basketball has a total mass of 0.620 kg and a volume of 8.18×10^{-3} m^3.

(a) A basketball is filled with air at a pressure of 1.55×10^5 Pa and at a temperature of 20°C.

Calculate the number of air molecules inside the basketball.

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Number of air molecules = ...

(b) A standard basketball rebounds to a height of between 1.40 m and 1.60 m when dropped onto a hard surface from a height of 1.80 m.

(i) Show that the maximum allowable decrease in kinetic energy during the bounce is about 2.4 J.

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(ii) The specific heat capacity of the basketball can be taken to be 1170 J kg^{-1} K^{-1}.

Calculate the number of times a standard basketball must be dropped from 1.80 m to increase the temperature of the basketball and the air inside by 0.5°C.

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Number of times basketball must be dropped = ...

(iii) State one assumption that you had to make to calculate the number of times that the basketball had to be dropped.

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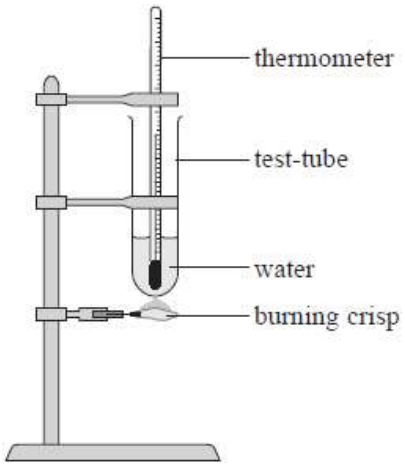
(Total for question = 10 marks)

Q3.

A student carried out an experiment to investigate the amount of energy stored in potato crisps. He placed 22.5 cm^3 of water into a test-tube and recorded the temperature. He then placed a crisp of mass 1 gram in a holder and set light to the crisp and placed it under the test-tube.



Once the crisp had finished burning, the student recorded the final temperature of the water. The experiment was carried out three times using a crisp of the same mass.

Initial water temperature / °C	Final water temperature / °C
21.5	52.1
21.5	52.8
21.5	52.6

(a) Use the student's data to show that the energy released by burning a crisp is about 2900 J.

density of water = 1.00 g cm^{-3}

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

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(b) Explain one precaution that the student should take when carrying out the experiment to make the energy calculated as accurate as possible.

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(c) It states on the crisp packet that the energy per gram for the crisps is 21.9 kJ.

Compare this value with the value calculated from the student's data and suggest a reason for the difference.

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(Total for question = 7 marks)

Q4.

The average molecular kinetic energy of a sample of nitrogen gas is E_k. The gas is heated and its temperature changes from 200 K to 400 K.

Which of the following is the new average molecular kinetic energy?

☐ **A** $\frac{E_k}{4}$

☐ **B** $\frac{E_k}{2}$

☐ **C** $2E_k$

☐ **D** $4E_k$

(Total for question = 1 mark)

Q5.

The maximum recommended temperature at which meat should be maintained when it is being transported is 4°C.

275 kg of meat is being transported to a supermarket. The meat is cooled from 18.5°C to 1.5°C before it is loaded onto the van ready for transportation.

Specific heat capacity of the meat = 3.59×10^3 J kg^{-1} K^{-1}

(a) Calculate the amount of thermal energy that has been removed from the meat.

(2)

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Thermal energy removed = ...

(b) When the meat is unpacked at the supermarket it is initially left in a warm environment. The meat warms up uniformly from 1.5°C as energy is transferred to the meat from the surroundings at a rate of 720 W.

Show that there may be a risk in eating the meat if it is left out for longer than an hour.

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(Total for question = 5 marks)

Q6.

Party balloons are often filled with helium so that they float in the air. The helium is supplied from a small, metal canister containing helium gas under pressure.

The canister contains enough helium to inflate 50 balloons, each to a volume of 8.2×10^{-3} m^3. When inflated each balloon contains 2.2×10^{23} atoms of helium.

(a) Show that at a temperature of 293 K the pressure exerted by the gas in a balloon is about 1×10^5 Pa.

(2)

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(b) At a temperature of 293 K the pressure in the canister when full of helium is 2.3×10^6 Pa.

Calculate the volume of the canister.

(2)

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Volume = ...

(c) The pressure in the canister decreases as helium is used to fill the balloons. Explain why this is the case, including ideas of momentum in your answer.

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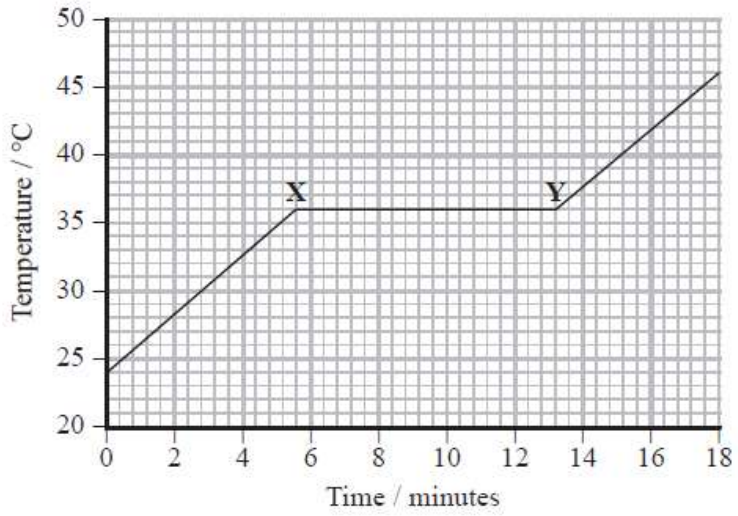
(Total for question = 7 marks)

Q7.

A piece of chocolate is heated at a constant rate.

The graph shows how the temperature of the chocolate varies with time.



Select the correct statement for the time between X and Y.

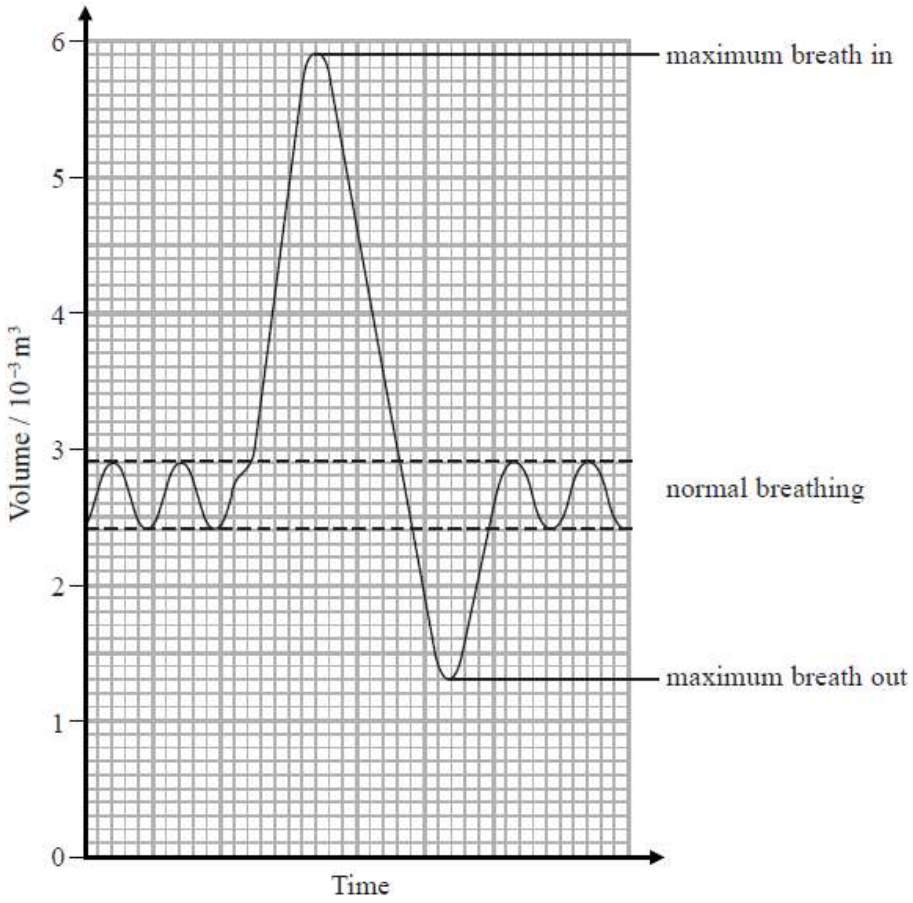
- ☒ **A** The internal energy of the chocolate increases.
- ☒ **B** The internal energy of the chocolate stays constant.
- ☒ **C** The kinetic energy of the molecules in the chocolate increases.
- ☒ **D** The potential energy between the molecules in the chocolate stays constant.

(Total for question = 1 mark)

Q8.

A spirometer is a device used in medical tests to investigate breathing. The spirometer measures the volume of air entering and leaving the lungs.

A patient is asked to breathe normally, take a maximum breath in and a maximum breath out, then breathe normally again. The results are shown on the graph.



(a) Whilst in the lungs the air was at a temperature of 37.0 °C and a pressure of 1.02×10^5 Pa.

(i) Show that the number of air molecules expelled from the lungs between the maximum breath in and the maximum breath out is about 1×10^{23}.

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(ii) Calculate the total kinetic energy of the air molecules expelled from the lungs between the maximum breath in and the maximum breath out.

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Total kinetic energy of air molecules = ...

(iii) Explain why the internal energy of the air can be taken as the total kinetic energy of the molecules of the air.

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(b) Air is a mixture of mainly nitrogen and oxygen. Oxygen molecules are more massive than nitrogen molecules. Nitrogen accounts for about 80% of the molecules in a given sample of air.

(i) Compare the mean square speed of the oxygen molecules to the mean square speed of the nitrogen molecules in a sample of air.

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*(ii) The pressure exerted by the air in a sample is partly due to the oxygen molecules and partly due to the nitrogen molecules.

Explain why the nitrogen molecules would account for 80% of the pressure exerted by the air.

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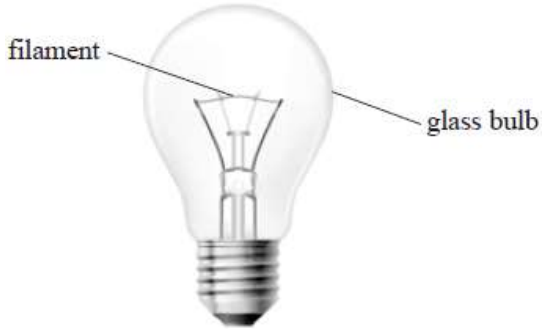
(Total for question = 12 marks)

Q9.

Some light bulbs consist of a metal filament inside a glass bulb. The bulb may be filled with a mixture of gases to reduce vaporisation of the filament.



(a) The glass bulb contains a mixture of krypton gas and xenon gas at room temperature. The mean squared speed of the krypton molecules is 8.72×10^4 m^2 s^{-2}.

Calculate the mean squared speed of the xenon molecules.

mass of 1 molecule of krypton = 1.39×10^{-25} kg
mass of 1 molecule of xenon = 2.18×10^{-25} kg

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Mean squared speed = ... $m^2\ s^{-2}$

* (b) When a current flows through the filament, the gas in the bulb heats up and the pressure exerted by the gas increases.

Explain, including ideas of momentum, why the pressure exerted by the gas increases.

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(Total for question = 6 marks)

Q10.

The air in a train carriage heats up due to the people inside the carriage.

On one journey there are 44 people in the carriage. The temperature of the air in the carriage is initially 16 °C, and rises to 28 °C.

(a) The doors and windows in the carriage are closed.
Calculate the time taken for the temperature of the air in the carriage to rise to 28 °C due to the people in the carriage.

average rate at which one person heats the air = 85 W
mass of air in the carriage = 110 kg
specific heat capacity of air = 720 J kg^{-1} K^{-1}

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Time taken = ...

(b) Suggest why the actual time taken for the temperature to rise to 28 °C will be greater than the time you have calculated.

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(Total for question = 4 marks)

Q11.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A mixture of helium He and hydrogen H_2 gases is maintained at a temperature of 300 K. The average kinetic energy of the He molecules is E_k and their average speed is v.

Which of the following is a correct statement?

☒ **A** The average kinetic energy of the H_2 molecules is less than E_k.

☐ **B** The average kinetic energy of the H_2 molecules is the same as E_k.

☐ **C** The average speed of the H_2 molecules is less than v.

☐ **D** The average speed of the H_2 molecules is the same as v.

(Total for question = 1 mark)

Q12.

An ideal gas is maintained at a constant temperature in a sealed container and the volume of the container is varied.

Which of the following is the correct statement about the pressure exerted by the gas?

☒ **A** The pressure is directly proportional to the volume.

☐ **B** The pressure is independent of the volume.

☐ **C** The pressure is inversely proportional to the volume.

☐ **D** The pressure is proportional to the square of the volume.

(Total for question = 1 mark)