A closed box of fixed volume 0.15 m$^3$ contains 3.0 mol of an ideal monatomic gas. The temperature of the gas is 290 K.

1a. Calculate the pressure of the gas. [1 mark]

When the gas is supplied with 0.86 kJ of energy, its temperature increases by 23 K. The specific heat capacity of the gas is 3.1 kJ kg$^{-1}$ K$^{-1}$.

1b. Calculate, in kg, the mass of the gas. [1 mark]

1c. Calculate the average kinetic energy of the particles of the gas. [1 mark]
1d. Explain, with reference to the kinetic model of an ideal gas, how an increase in temperature of the gas leads to an increase in pressure.

An ideal monatomic gas is kept in a container of volume $2.1 \times 10^{-4} \text{ m}^3$, temperature $310 \text{ K}$ and pressure $5.3 \times 10^5 \text{ Pa}$.

2a. State what is meant by an ideal gas.

2b. Calculate the number of atoms in the gas.

2c. Calculate, in J, the internal energy of the gas.
The volume of the gas in (a) is increased to $6.8 \times 10^{-4} \text{ m}^3$ at constant temperature.

2d. Calculate, in Pa, the new pressure of the gas.  \[1 \text{ mark}\]

2e. Explain, in terms of molecular motion, this change in pressure.  \[2 \text{ marks}\]
A large cube is formed from ice. A light ray is incident from a vacuum at an angle of 46˚ to the normal on one surface of the cube. The light ray is parallel to the plane of one of the sides of the cube. The angle of refraction inside the cube is 33˚.

3a. Calculate the speed of light inside the ice cube. [2 marks]

3b. Show that no light emerges from side AB. [3 marks]

3c. Sketch, on the diagram, the subsequent path of the light ray. [2 marks]
Each side of the ice cube is 0.75 m in length. The initial temperature of the ice cube is –20 °C.

3d. Determine the energy required to melt all of the ice from –20 °C to water at a temperature of 0 °C. [4 marks]

Specific latent heat of fusion of ice = 330 kJ kg\(^{-1}\)
Specific heat capacity of ice = 2.1 kJ kg\(^{-1}\) k\(^{-1}\)
Density of ice = 920 kg m\(^{-3}\)

3e. Outline the difference between the molecular structure of a solid and a liquid. [1 mark]

4a. Define internal energy. [2 marks]
4b. 0.46 mole of an ideal monatomic gas is trapped in a cylinder. The gas has a volume of 21 m$^3$ and a pressure of 1.4 Pa.

(i) State how the internal energy of an ideal gas differs from that of a real gas.

(ii) Determine, in kelvin, the temperature of the gas in the cylinder.

(iii) The kinetic theory of ideal gases is one example of a scientific model. Identify one reason why scientists find such models useful.
In an experiment to determine the specific latent heat of fusion of ice, an ice cube is dropped into water that is contained in a well-insulated calorimeter of negligible specific heat capacity. The following data are available.

Mass of ice cube = 25g  
Mass of water = 350g  
Initial temperature of ice cube = 0˚C  
Initial temperature of water = 18˚C  
Final temperature of water = 12˚C  
Specific heat capacity of water = 4200Jkg⁻¹K⁻¹

5a. Using the data, estimate the specific latent heat of fusion of ice. [4 marks]

5b. The experiment is repeated using the same mass of crushed ice. [2 marks]

Suggest the effect, if any, of crushing the ice on
(i) the final temperature of the water.
(ii) the time it takes the water to reach its final temperature.