3 Planet Z is spherical and has a uniform density. It has only argon in its atmosphere.

(a) The escape velocity is the minimum velocity required to escape the gravitational pull of a celestial body.

Show that the escape velocity v of Planet Z is given by

$$v = \sqrt{\frac{8}{3} G \pi \rho r^2}$$

where r is the radius, and ρ is the density of Planet Z.

[2]

(b) Given that Planet Z has a mean density of 5500 kg m^{-3} and radius of 413 km, calculate the escape velocity of the argon gas molecules at its surface.

v = ... m s^{-1} [1]

(c) Argon gas behaves as an ideal monatomic gas on Planet *Z*, and it has a molar mass of 40 g mol^{-1}.

Assume that the root-mean-square speed of the argon molecules is equal to the escape velocity.

Using Kinetic Theory, determine the absolute temperature of the atmosphere on Planet *Z*.

absolute temperature = …… K [3]

(d) Suppose the atmosphere of Planet Z is 100 K lower than the temperature calculated in **(c)**. Suggest a reason whether argon gas molecules would be able to escape from the atmosphere of Planet Z.

……

……

…… [2]

[Total: 8 marks]