Stars and Galaxies

Coursework Sheet 5- Feedback

1.

$$PV = n_{mol}RT$$

$$P = \frac{n_{mol}RT}{V}$$ (1 mark)

Now the total number of particles is related to
the number of moles by $n_{mol}N_A$, where N_A is Avogadro's number.
So the number density of particles is

$$n = \frac{n_{mol}N_A}{V}$$ (1 mark)

and

$$P = \frac{nRT}{N_A}$$

i.e.

$$P \propto nT$$ (1 mark)

(Note that $P = nkT$ where k is the Boltzmann constant.)

The typical density and temperature of H II regions are 10^{10} m^{-3} and 10^4 K.
The typical density and temperature of molecular clouds are 10^{10} m^{-3} and 30 K.
(1 mark)

Hence the pressure of the H II region is about 300 times higher than in the surrounding molecular clouds. Therefore the H II region will expand.
(1 mark)

2.

Using the Doppler shift formula, which you can use in either wavelength or frequency versions such that

$$v = \frac{\Delta\lambda}{\lambda_0} c$$

$$v = \frac{\Delta\nu}{\nu_0} c$$ (1 mark)

where ν is the frequency and ν_0 is the rest frequency.

The central frequency of the emission line is at 1416.2 MHz.

Hence,

$$v = \frac{1420.4 - 1416.2}{1420.4} \times 3 \times 10^8$$

$$= 8.9 \times 10^5 \text{ ms}^{-1}$$

$$= 890 \text{ kms}^{-1}$$ (1 mark)

The radial velocity of the galaxy as a whole (i.e. the centre of mass of the system) is the central velocity of the emission line, i.e. 890 kms^{-1}.

(1 mark)

The rotation of the galaxy is what causes the two components in the line profile due to the fact that one side of the galaxy is rotating towards us (blue shifted relative to the centre of mass) and the other side is rotating away from us (red shifted relative to the centre of mass). The velocities of the two peaks are at 830 (+/- 10) kms^{-1} and 970 (+/- 10) kms^{-1}.

(1 mark)

The rotational velocity is therefore half the difference between these two values, which is 70 kms^{-1}. Alternatively you can take the average of the difference with the centre of mass which is 60 kms^{-1} and 80 kms^{-1} respectively again giving 70 kms^{-1}.

(1 mark)