Question 2
part a, 8%
part b, 4%

(*a*) (i) Sketch a Hertzsprung–Russell diagram with the following features:

- correctly labelled axes, with a *rough* indication of the range of values on each axis
- the *approximate* evolutionary track of a star like the Sun, from where it leaves the main sequence to when it is a cool white dwarf.

(ii) Outline, with the aid of a sketch, how you would use a star's spectral absorption lines to determine its photospheric temperature.

(*b*) Describe whether, over any portion of the track you have drawn in part *a*,

(i) the star becomes variable (and name any type of variable star it becomes)

(ii) the star looks, from its external appearance, like a massive, upper main sequence star.

Question 3
part a, 4%
part b, 8%

(*a*) Outline why a supergiant becomes a Type II supernova.

(*b*) A typical Type II supernova releases about 10^{46} J of energy into the interstellar medium, of which about 1% is in the kinetic energy of the ejected shell of gas, about 0.01% is in the form of electromagnetic radiation, and the rest is in the form of neutrinos. A diffuse cloud of 10 solar masses, consisting almost entirely of hydrogen atoms, lies some way from the supernova, and absorbs a fraction 5×10^{-6} of the electromagnetic radiation, and a fraction 5×10^{-5} of the kinetic energy of the shell. Calculate the rise in the temperature of the diffuse cloud.

$E = 10^{46} \times 10^{-4} \times 5E{-6} + 10^{46} \times 10^{-2} \times 5E{-5}$
$= 5E36 + 5E39 = 5E36 + 5000E36 = 5005E36$

$N_H = \frac{19.9E30}{1.673E{-27}} \approx 12E57$

$\frac{E}{N_H} = \frac{5005E36}{12E57} = 4.17{-19}J = \frac{3}{2} kT$

$T = \frac{4.17E{-19}}{2.07E{-23}} = 2E4K$