Question 1:

a)

A Segre chart to show the nuclear reactions on the s-process pathway from $^{121}Sb \to ^{121}Xe$

^{127}La	^{128}La	^{129}La	^{130}La	^{131}La	^{132}La	^{133}La	^{134}La	^{135}La	^{136}La	^{137}La	^{138}La	^{139}La
^{126}Ba	^{127}Ba	^{128}Ba	^{129}Ba	^{130}Ba	^{131}Ba	^{132}Ba	^{133}Ba	^{134}Ba	^{135}Ba	^{136}Ba	^{137}Ba	^{138}Ba
^{125}Cs	^{126}Cs	^{127}Cs	^{128}Cs	^{129}Cs	^{130}Cs	^{131}Cs	^{132}Cs	^{133}Cs	^{134}Cs	^{135}Cs	^{136}Cs	^{137}Cs
^{124}Xe	^{125}Xe	^{126}Xe	^{127}Xe	^{128}Xe	^{129}Xe	^{130}Xe	^{131}Xe	^{132}Xe	^{133}Xe	^{134}Xe	^{135}Xe	^{136}Xe
^{123}I	^{124}I	^{125}I	^{126}I	^{127}I	^{128}I	^{129}I	^{130}I	^{131}I	^{132}I	^{133}I	^{134}I	^{135}I
^{122}Te	^{123}Te	^{124}Te	^{125}Te	^{126}Te	^{127}Te	^{128}Te	^{129}Te	^{130}Te	^{131}Te	^{132}Te	^{133}Te	^{134}Te
^{121}Sb	^{122}Sb	^{123}Sb	^{124}Sb	^{125}Sb	^{126}Sb	^{127}Sb	^{128}Sb	^{129}Sb	^{130}Sb	^{131}Sb	^{132}Sb	^{133}Sb
^{120}Sn	^{121}Sn	^{122}Sn	^{123}Sn	^{124}Sn	^{125}Sn	^{126}Sn	^{127}Sn	^{128}Sn	^{129}Sn	^{130}Sn	^{131}Sn	^{132}Sn

You need the atomic number for every nucleus as well - stated in the question

Okay, though you don't need this diagram.

- $^{121}Sb \to ^{122}Sb$ is a neutron capture.
- $^{122}Sb \to ^{122}Te$ undergos beta minus decay.

You also should show the other products here: $\bar{e}$ and $\bar{\nu}_e$

- $^{122}Te \to ^{123}Te \to ^{124}Te \to ^{125}Te \to ^{126}Te$ each of these steps is a neutron capture.
- $^{126}Te \to ^{126}I$ is a beta minus decay. would undergo neutron capture
- $^{126}I \to ^{127}I$ is another neutron capture. would undergo beta decay
- $^{127}I \to ^{127}Xe$ is a beta minus decay. would undergo neutron capture
- and finally $^{127}Xe \to ^{128}Xe$ is a neutron capture. would undergo beta decay

The steps should be shown individually

Well done for attempting this question - please see my comments on your pt3 form about this.

b)

i.

Luminous blue variable stars are massive, evolved stars that show dramatic variations in luminosity. They are thought to be in a transitional phase between the main sequence and Wolf-Rayet stars. They are characterised by their high luminosity, mass loss and spectral variability. They are thought to be the progenitors of supernovae and gamma-ray bursts.

½

For the full mark here, you have to mention they are (a) supergiants, and (b) irregularly pulsating.

ii.

As massive stars evolve off the main sequence and start burning heavier elements in their cores, they expand significantly, becoming cooler and thus shifting horizontally to the right, toward the red supergiant region of the HR diagram.

1

iii.

High mass stars are more luminous and have a higher temperature than low mass stars, this can cause strong stallar winds to form, which can cause the star to lose mass. This mass loss can cause the star to become unstable and eventually explode as a supernova. HIgh mass stars also have more fuel to burn, and can burn heavier elements in their core, which causes the star to have shorter life spans than low mass stars. Higher mass stars can also have transient events which cause them to llose lots of mass very quickly, but the cause for these is not well known.

1

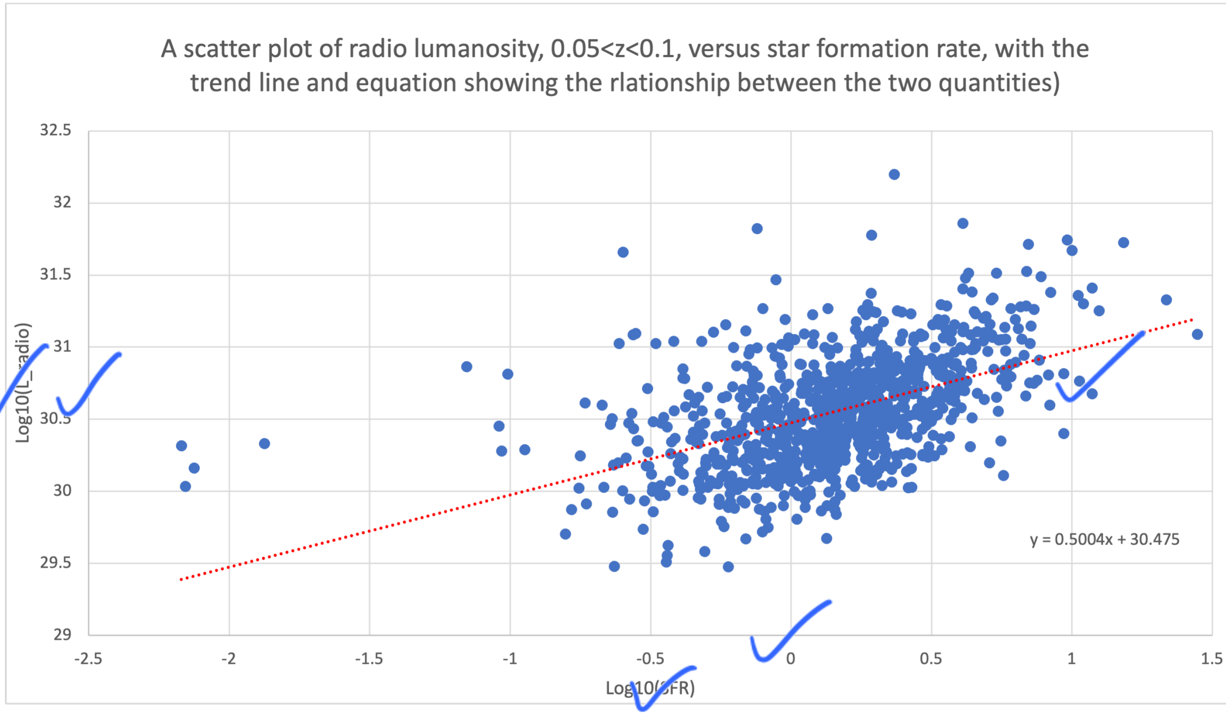
Lower mass stars tend to loose their mass more slowely, mainly through planatary nebulae, and do not have the mass to burn heavier elements in their core. This means that they have longer life spans than high mass stars.

I've given you the mark for this, but much clearer to say mass loss rate in high mass stars is much more extreme

Total for question 1: 2½/8

Question 2:

a)
b)



(b) From the above graph with the redshift $0.05 < z < 0.1$ we obtain the following equation

Excellent, well done.

$$\log_{10}(L_{radio}) = 0.5004\left(\log_{10}(SFR)\right) + 30.475$$

4

4/4

Plotted data 4

Axis ranges 2

Axis labels 2

8/8

c)

Hence for a galaxy with a SFR of 20 $M_\odot$ *yr* within this redshift range

$$\log_{10}(L_{radio}) = 0.5004(\log_{10}(SFR)) + 30.475$$

Substuting in our values

$$\begin{aligned}\log_{10}(L_{radio}) &= 0.5004(\log_{10}(20)) + 30.475\\ L_{radio} = 10^{0.5004(\log_{10}(20))+30.475} &= 10^{0.5004(1.3010)+30.475}\\ &= 10^{0.6510+30.475}\\ &= 10^{31.1260}\\ &= 1.34\times10^{31}\ \text{W} \qquad \textit{To 3 s.f}\end{aligned}$$

2

1½

Good, but give precision to 2sf to match least precise piece of data (3.0 M⊙ century⁻¹)

Considering from the unsorted data we ued the following equation;

$$\log_{10}(L_{radio}) = 0.9628(\log_{10}(SFR)) + 30.368$$

Substuting in our values

$$\begin{aligned}\log_{10}(L_{radio}) &= 0.9628(\log_{10}(20)) + 30.368\\ L_{radio} = 10^{0.9628(\log_{10}(20))+30.368} &= 10^{0.9628(1.3010)+30.368}\\ &= 10^{1.2526+30.368}\\ &= 10^{31.6206}\\ &= 4.17\times10^{31}\ \text{W} \qquad \textit{To 3 s.f}\end{aligned}$$

yes, I agree!

Hence the two values differ by a factor of $\frac{4.17}{1.34} = 3.12$, which is a significant difference. Therefore it is nescesaary to consider the redshift range when calculating the radio luminosity of a galaxy. Because this will remove outliers in the data possibly causing stochastic effects from the small number of galaxies in the sample.

1

1

Well done.

$\frac{5\frac{1}{2}}{6}$

d)
Using

$$R_{SN} = 0.007 \times SFR$$

And looking at a star forming galaxy with a supernova rate of 3 per century, we can calculate the SFR as follows;

$$R_{SN} = 0.007 \times SFR$$

$$SFR = \frac{R_{SN}}{0.007}$$

$$= \frac{0.03}{0.007}$$

$$= 4.29\,\mathrm{M}_{\odot}\,yr$$

Show the calculation you used to get this value, even though it's straightforward

2

to 3 s.f

Hence we can find the L_{radio}

$$\log_{10}(L_{radio}) = 0.5004(\log_{10}(4.29)) + 30.475$$

2

$$L_{radio} = 10^{0.5004(\log_{10}(4.29))+30.475}$$

$$= 10^{0.5004(0.6320)+30.475}$$

$$= 10^{0.3163+30.475}$$

$$= 10^{30.7913}$$

$$= 6.18 \times 10^{30}\,\mathrm{W}$$

1½

to 3 s.f

Well done, though again this should be given to 2sf to match your data.

$\frac{5\frac{1}{2}}{6}$

Total for question 2: 23/24

Grand Total: 26/32