TMA 05

General instructions

Covering: Topic 5 (Evolution and death), and the activity related to this topic. All references to exercises, figures or tables relate to Topic 5, unless stated otherwise in the question.

Make sure you know when and how to complete and submit your TMA: detailed instructions are given in the Assessment section of *What is S284, and how to study it*, and in the OU's Assessment Handbook (which can be found from the Student policies and regulations website).

It is important to answer questions in your own words, rather than copy text from other sources. Your TMA submission will be passed through automatic plagiarism detection software and you risk losing marks, or incurring more serious penalties, if you are found to have plagiarised others.

Your solutions should be your own work and should not therefore contain downloaded text or diagrams from the internet or material copied from paper sources, unless you are directed to do so in the question. Where you do include such material, be certain to reference it clearly and appropriately (see the Plagiarism and referencing section of *What is S284, and how to study it*.)

All questions are linked to specific learning outcomes as identified in the rubric for each question. Please refer to the Learning outcomes section of *What is S284, and how to study it* for an explanation of the abbreviations (such as KU1) that are used for the learning outcomes.

In all calculations:

- show all details of your working (unless the question specifies that you may do otherwise)
- include units with all physical quantities
- work to an appropriate number of significant figures
- include numbers and captions for any figures or tables you create
- make sure any images are legible at the size presented.

The overall mark you obtain for TMA 05 will contribute a maximum of 8% towards the marks required to pass this module. See the Your module result section of *What is S284, and how to study it* for details of how the module is assessed.

Question 1 (*8 marks*)

This question relates specifically to the following module learning outcomes: KU1, CS2, KS1 and KS3

Figure 1 shows the chart of nuclides for elements between $Z = 50$ (Sn, tin) and $Z = 57$ (La, lanthanum). Stable isotopes are shown in black and unstable isotopes are shown in white. You may assume that each of the unstable isotopes have **half-lives** which are short enough such that they cannot capture **neutrons** in the **s-process**.

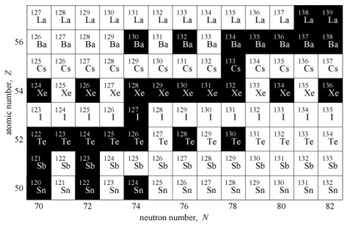


Figure 1 Segrè plot showing some **stable nuclei** (in black) and **unstable nuclei** (in white).

Maximise

Show description

a. Write down the sequence of 10 nuclear reactions that occur on the s-process pathway starting from $^{121}\mathrm{Sb}$ and ending at $^{128}\mathrm{Xe}$.

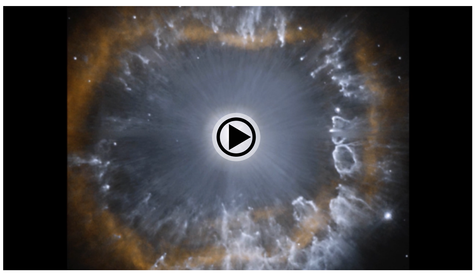
Label each isotope with its correct **mass number**, atomic number and symbol. Indicate all the other reactants/products involved in each step, and label each step as either **neutron** capture *or* **beta-minus decay**.

(**5 marks**)

b. Video 2.3 discussed the late stages of evolution for massive **stars**; it is repeated below for convenience. Watch the video again and answer the questions that follow.

i. What are luminous blue variable stars?
ii. In what direction do **supergiant** stars move on the HR diagram in their final stages of life?
iii. What is the main difference in mass loss behaviour for low- and high-mass stars?

(**3 marks**)



Repeat of Video 2.3 The role of mass loss and pulsations in the end stages of life for massive stars

Question 2 (*24 marks*)

This question relates specifically to the following module learning outcomes: KU1, CS1–CS3, KS2, KS3, PPS1 and PPS3.

In the Topic 5 activity you investigated the relationship between **radio luminosity** and **star** formation rate (SFR) using a spreadsheet. Open the spreadsheet you used in completing the Topic 5 activity and follow the instructions below.

a. Make an appropriate plot to show the relationship between radio luminosity and SFR that includes *only* those **galaxies** in the **redshift** range $0.05 < z < 0.1$. Ensure that this plot is well presented, with axes formatted to **avoid** unnecessary white space, and legible labels on the *x*- and *y*-axes. Copy an image of your plot into your TMA submission.

Hint: there are several ways you could select these galaxies. You can sort the galaxies in order of redshift (as in Task 1 of the Topic 5 activity, taking care to select *all* columns before sorting) and then scroll to the correct range and copy and paste the sub-sample you want into another sheet in the spreadsheet. Alternatively, Microsoft Excel provides an option to filter your data based on column values.

(**8 marks**)

b. Fit a trend line relating radio luminosity and SFR for the **galaxy** sub-sample selected in part (a). Write an equation for the relationship you find between these two quantities, substituting *x* and *y* with the appropriate terms.

(**4 marks**)

c. Use the trend line from part (b) to calculate the predicted radio luminosity of a galaxy that has a star formation rate of $20\ M_\odot\ \mathrm{y}^{-1}$. Comment on whether there is any difference between this luminosity and the luminosity you calculated in Task 4 of the activity, where you were using the trend line for the full data set. Do your results suggest it is necessary to take redshift into account when using radio luminosity to investigate star formation?

(**6 marks**)

d. The rate of core-collapse (Type II) **supernovae** is closely related to the star formation rate. The relationship can be written as $R_{\mathrm{SN}} = 0.007 \times \mathrm{SFR}$, where R_{SN} is the **supernova** rate in units of $\mathrm{SN\ y}^{-1}$, the SFR is in units of $M_\odot\ \mathrm{y}^{-1}$ and 0.007 should be treated as an exact number that does not affect the precision of the answer.

Based on your results from part (b), what radio luminosity would you predict for a star-forming galaxy with a supernova rate of 3.0 per century?

(**6 marks**)