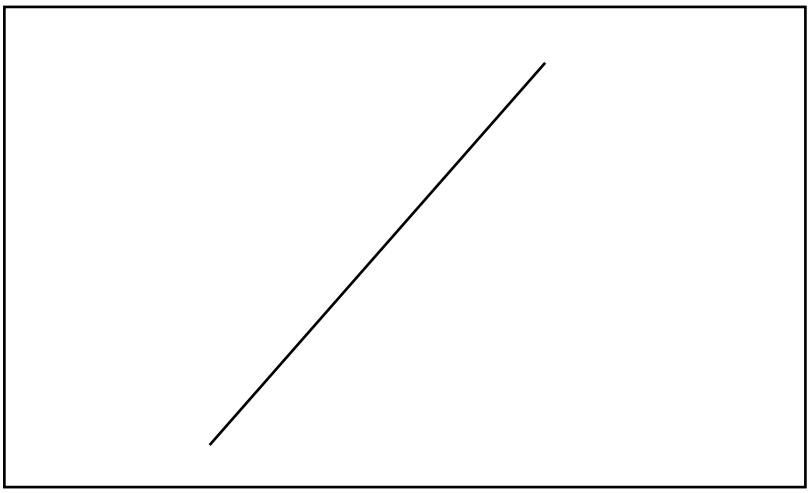
SECTION A: (90 MARKS)

Question 1: Brittle deformation. (14 marks)
Consider a normal fault as drawn in the cross-section view below.



Draw in the box above the geometries of the following features consistent with a normal fault:

1.1. En-échelon tension gashes (2 marks)
1.2. Riedel shear (2 marks)
1.3. wing cracks (2 marks)
1.4. deflection of passive markers (such as bedding planes) (2 marks)
1.5. and arrows representing the orientation of sigma 1 (σ_1) and sigma 3 (σ_3). (4 marks)
1.6. What is the typical dip angle of a normal fault according to Anderson's theory of faulting? (2 marks)

Question 2: Stress. (12 marks)

2.1. Draw a generalized schematic of the Mohr diagram. (3 marks)
2.2. Label the axes of the diagram. (2 marks)
2.3. Draw an example Mohr circle on the diagram, labelling the points at σ_1 and σ_3 (depict σ_3 as negative and σ_1 as positive). (3 marks)
2.4. Based on your diagram, answer the following:
2.4.1. Is σ_1 compressional or tensional? (1 mark)
2.4.2. Is σ_3 tensional or compressional? (1 mark)
2.5. By definition, what is the value of shear stress at σ_1 and σ_3 on the Mohr circle? (2 marks)

Question 3: Strain. (12 marks)

3.1. Define homogeneous strain and provide an example. (6 marks)

3.2. With drawings, differentiate between the stress ellipse and the strain ellipse. How are the two interrelated? (6 marks)

Question 4: Folding and fabrics. (21 marks)

4.1. Draw a 2-D diagram of an upright, isoclinal, chevron, asymmetric, class 1B, non-plunging synformal structure with several layers. (6 marks)
4.2. With a colored pencil, draw a series of lines throughout the folded layers depicting the likely orientation of axial plane cleavage, if developed. (2 marks)
4.3. Explain by means of annotated sketches what a disharmonic fold is. (5 marks)
4.4. Which type of fold will you expect if the mean competence of the multilayer and the competence contrast are both high? (4 marks)
4.5. Explain what the differences are between class 1B and class 2 folds using annotated sketches. (4 marks)

Question 5 : Rheology. (14 marks)

Are these statements true or false?
If the statement is false, give the right answer and explain why it is the right answer. Marks are allocated for giving the right answer, and the reason why it is the right answer.
5.1. Pore fluid pressure promotes fracturing.
5.2. Brittle failure is common in the lower crust.
5.3. Marbles are commonly less competent than quartzites.
5.4. The crust is the strongest at the brittle-ductile transition.
5.5. Rheological importance of mechanical anisotropy is higher in the lower crust than in the upper crust.

Question 6: Primary and non-primary structures. (8 marks)

6.1. Explain how to differentiate a magmatic foliation from a metamorphic foliation. (5 marks)
6.2. Name three types of structures linked to meteorite impacts. (3 marks)

Question 7 : Ductile deformation. (9 marks)

7.1. What is a mylonite? How is it different from a slaty cleavage? (4 marks)

7.2. Which kind of structure is shown by the two arrows in the photo below? (3 marks)

7.3. What kind of kinematic information can be retrieved from the photo, provided that the photo is in the right plane of finite strain. (2 marks)

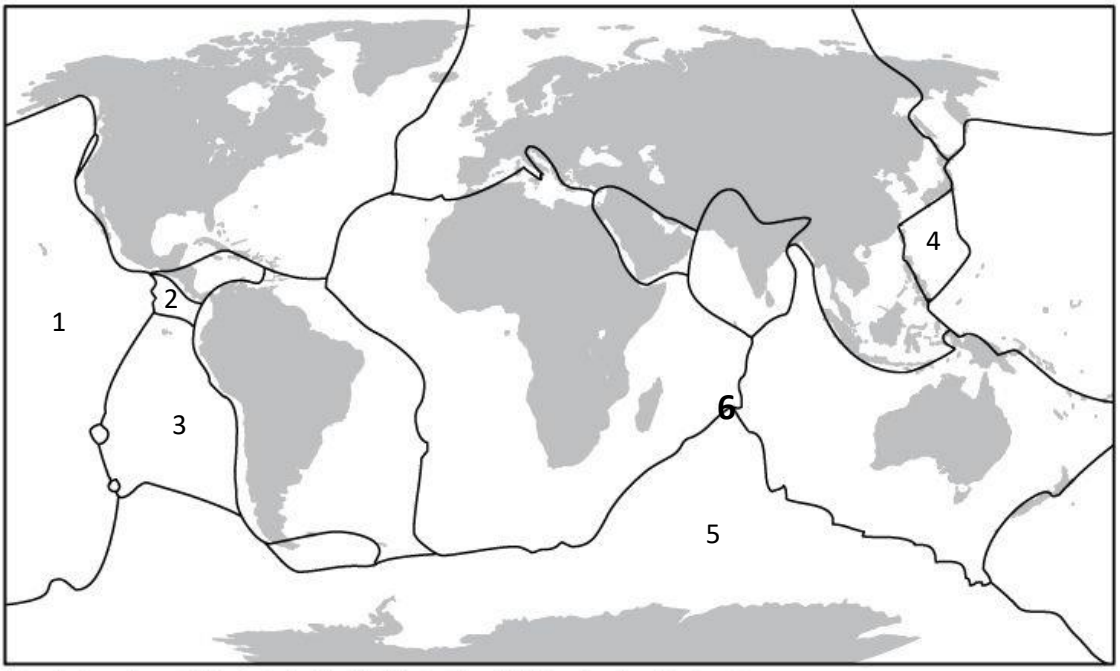
SECTION B: (90 MARKS)

Question 8: Contrast the plate tectonic setting of north-south trending a narrow active continental rift and a north-south trending ensimatic with an overiding plate to the west. (50 marks)

Your answer should be in essay form (like summarized study notes) and should be structured under the following headings:

- Lithospheric structure (30 marks)
    - Provide a lithospheric cross section of each of the systems and indicate the following:
        - Thickness, its variation and nature (continental vs oceanic) of crust
        - Thickness and its varaiation of the mantle lithosphere
        - Label the astenosphere
        - Dominant structures and their nature (i.e., normal, reverse, or transform; ductile or brittle)
        - Locality and depth distribution of earthquakes
        - Locality of volcanism on the surface
- Seismicity (10 marks)
    - Provide typical focal mechanism solutions for earthquakes that characterize the systems
- Magmatism (10 marks)
    - Typical expected magmatic rocks/compositions
    - Change in composition through space and time

Question 9: Tectonic plates (20 marks)



9.1. Label the numbered plates 1 to 5 (5 marks)

9.2. What physically are the plates that are referred to in plate tectonics? (3 marks)

9.3. A triple junction is formed by three spreading ridges at point 6. Explain why such a triple junction would ideally be dynamically stable? Why would a triple junction formed by three transform faults always be dynamically unstable? Illustrate your answer. (8 marks)

9.4. The plate boundary between plate 1 and plate 3 is also known as the East Pacific Rise. Briefly describe the nature of this plate boundary (4 marks)

Question 10: Supercontinent cycle (20 marks)

10.1. When did the listed supercontinents exist in Earth history? (8 marks)

- Rodinia
- Columbia
- Gondwana
- Kenorland

10.2. Name and describe three geological observations/datasets that can be used to highlight the supercontinent cycle. Illustrate how each reveals the supercontinent cycle (12 marks)