GEOLOGY
A2 Level

Interpreting the Geological Record

Topic G3: Past Life and Past Climates

Name .....

Question no.	Mark
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1 **Figure 2a** illustrates four fossil trilobites (**A-D**). **Figure 2b** and **Table 2** describe the origin and diversity of the group during Palaeozoic times.

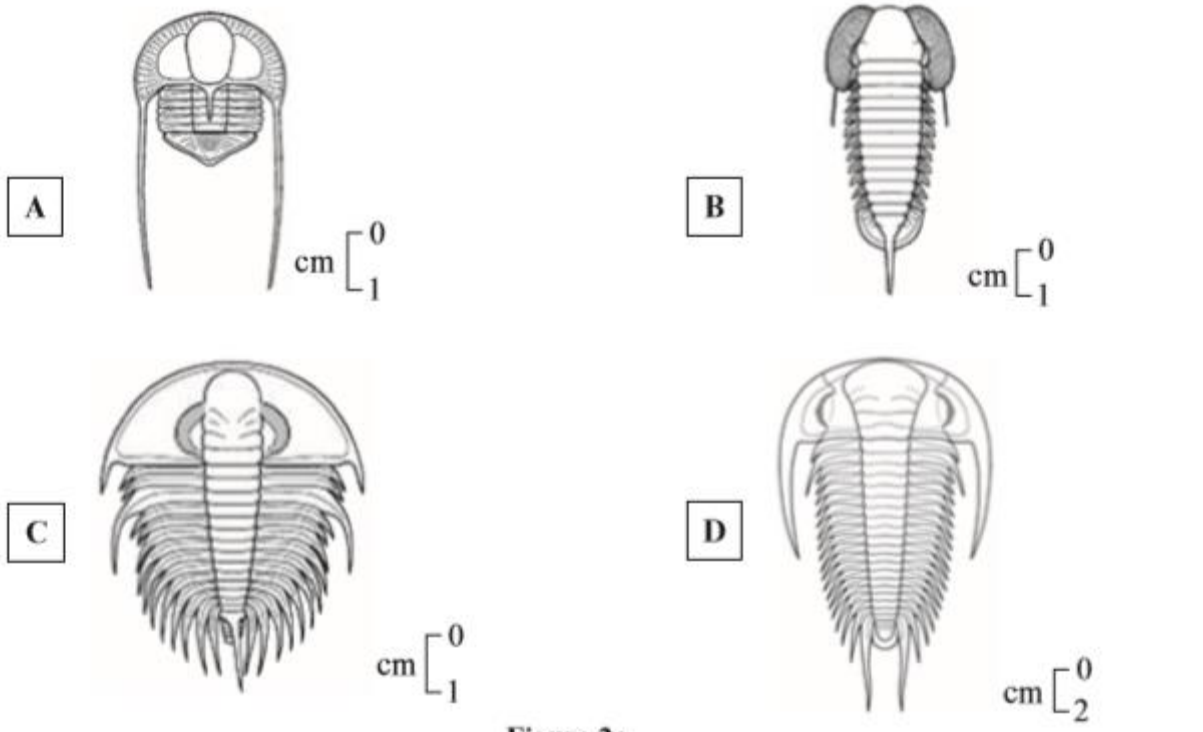

Figure 2a

Source – www.trilobites.info

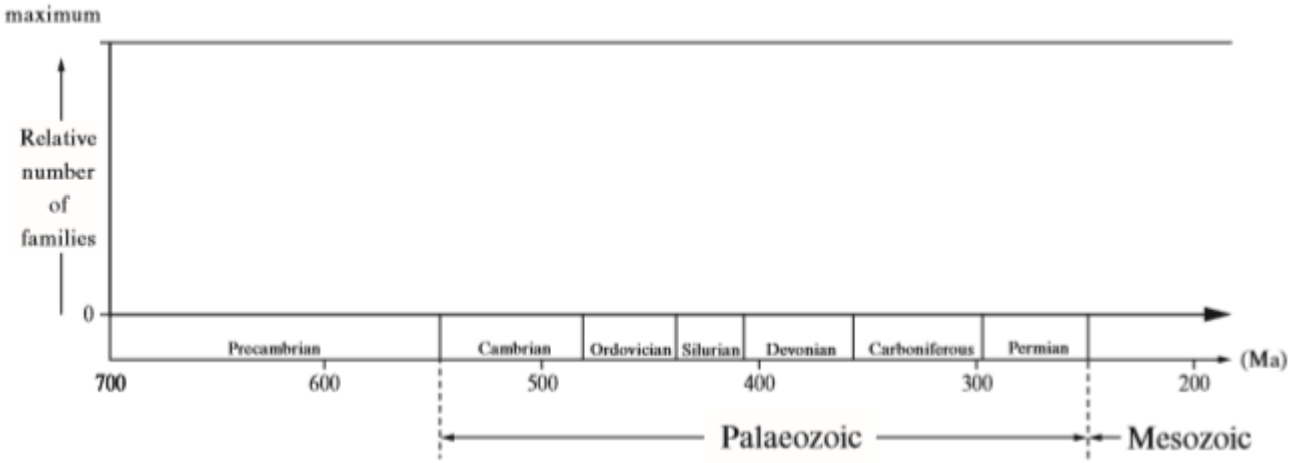

Figure 2b

Table 2

Trilobites suddenly appear in considerable numbers in the early Cambrian rocks. Their numbers had reached a maximum by the early Ordovician and gradually declined during the Silurian and Devonian. They were uncommon in the Carboniferous and finally became extinct in the Permian.

The genus *Olenellus* is an early trilobite with two large crescent-shaped eyes that are joined to the glabella. The thorax has many spines and the pygidium is relatively small.

Paradoxides has a large semi-circular cephalon, long genal spines and narrow crescent-shaped eyes. The thorax shows 16-21 segments each ending in a spine.

(a) With reference to **Table 2**, draw a graph on **Figure 2b** to illustrate the diversity (relative numbers) of trilobites during the Palaeozoic. [3]

(b) (i) In the appropriate box below, state which of the trilobites (**A-D**) in **Figure 2a** represent the genera *Olenellus* and *Paradoxides*, outlined in **Table 2**. [2]

Olenellus = (**A, B, C** or **D**) ☐ *Paradoxides* = (**A, B, C** or **D**) ☐

(ii) State **two** morphological differences between trilobite **A** and the other trilobites (**B, C** and **D**) shown in **Figure 2a**. [2]

1. .....

2. .....

(c) Suggest a possible mode of life for EITHER trilobite **A** OR trilobite **B**.
Explain **two** pieces of evidence from the morphology of the fossil. [3]

Chosen trilobite (**A** or **B**) ☐

Mode of Life .....

Evidence .....

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Evidence .....

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(d) "The *Ediacaran fauna* represent the oldest, most diverse set of multicellular, soft-bodied organisms with a possible link to the early appearance of trilobites as a complex and diversified group."

(i) Explain why the fossil record does not contain evidence of trilobites before the Cambrian. [2]

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(ii) On **Figure 2b** on page **1**, clearly mark with an arrow (labelled **E**) a geological time when the *Ediacaran fauna* flourished. [1]

(iii) Suggest a possible reason for the sudden development and diversification of the *Ediacaran fauna* during this time. [2]

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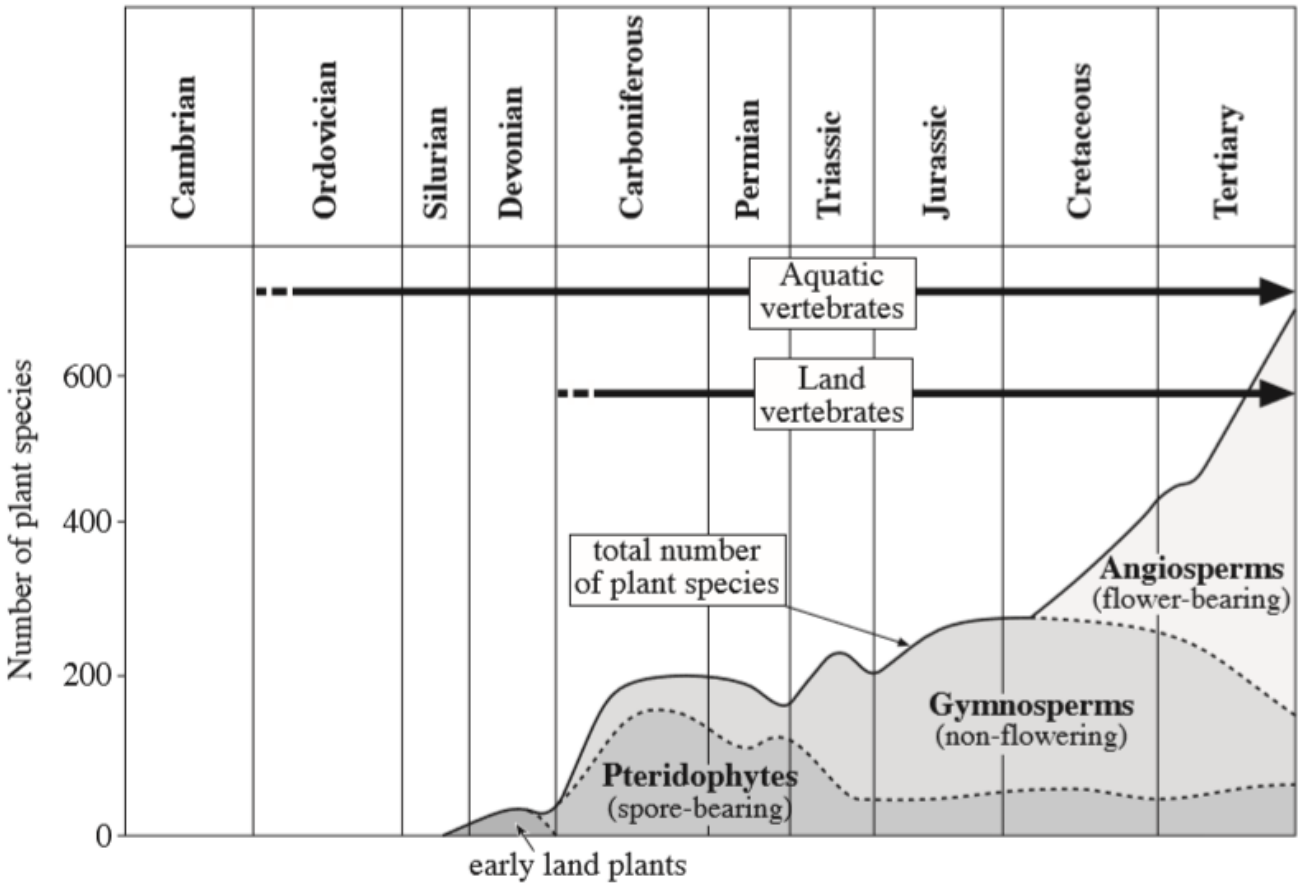
2 **Figure 3a** shows changes in the diversity of fossil land plants and vertebrate development through time.



Source: Adapted from *The Elements Of Palaeontology* - Black. (second edition - 1990)

Figure 3a

(a) With reference to **Figure 3a**, state the geological period during which

(i) plants first began to colonise the land, ... [1]

(ii) land vertebrates first appeared. ..... [1]

(b) Describe the changes in the total number of plant species in **Figure 3a** and account for the anomalies at the end of the Permian and Triassic periods. [4]

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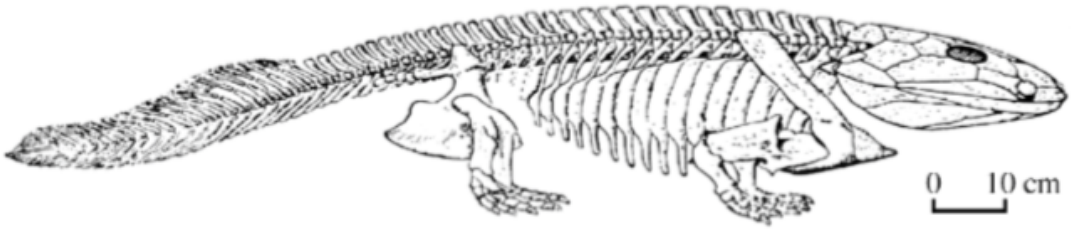
(c) **Figure 3b** shows the skeleton of a late Devonian amphibian *(Ichthyostega)*, thought to represent a transitional form between fish and land vertebrates.



Source: *www.mathsaharry.com/dino/oscar/rommy.htm*

Figure 3b

State **one** morphological adaptation that would suggest that *Ichthyostega* was

1. partly adapted to life in water,
2. partly adapted to life on land.

Explain your reasoning in each case. [4]

1. *Adaptation to life in water* .....

Explanation .....

.....

2. *Adaptation to life on land* .....

Explanation .....

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(d) There is little evidence in the fossil record of the gradual evolution of fish into land vertebrates. Explain how such evidence may be distorted or destroyed in the fossil record. [3]

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(e) With reference to **Figure 3a**, explain a possible link between the development of land plants and the evolution of land vertebrates. [2]

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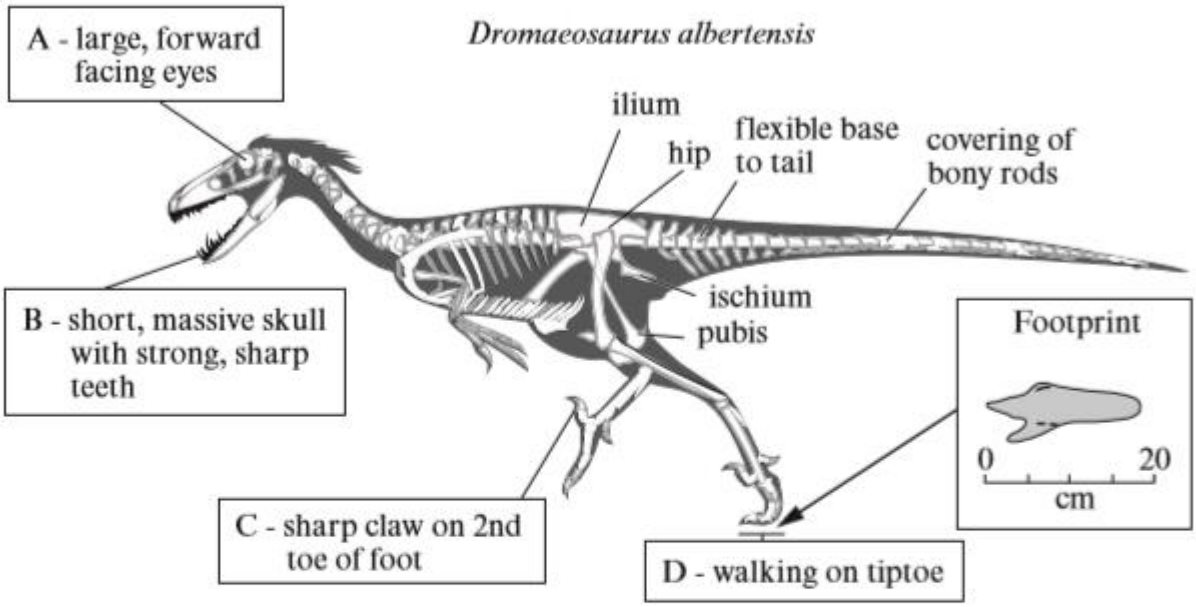
Total 15 marks

3 **Figure 1a** shows the morphology of the dinosaur, *Dromaeosaurus albertensis*, and information on how dinosaurs are classified.



Source: http://the_dinosauria.tripod.com/dromaeosaurus.html

Classification of Dinosaurs

Dinosaurs are sub-divided into two Orders – **Saurischian** or **Ornithischian** - based on the structure of the pelvis. In Saurischian dinosaurs, the pubis bone is at an angle to the ischium bone, whereas in Ornithischian dinosaurs these bones are parallel, nearly touching along their whole length. Ornithiscian dinosaurs were plant-eaters.

Figure 1a

Refer to **Figure 1a**.

(a) Using the data in **Figure 1a**

(i) complete the classification of *Dromaeosaurus albertensis*, [2]

Classification	
Class	Reptile
Order	•
Genus	•
Species	•

(ii) complete the estimates of the size of *Dromaeosaurus*. [2]

Size	
Footprint length	•
Approximate hip height (4 times footprint length)	•
Approximate body length (10 times footprint length)	1.8 m

(b) (i) Choose **two** of the characteristic features (labelled **A-D**) and explain how they support the conclusion that *Dromaeosaurus* was a carnivorous, predatory dinosaur. [4]

Chosen characteristic feature **(A-D)** ☐

Explanation .....

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Chosen characteristic feature **(A-D)** ☐

Explanation .....

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(ii) Fossil evidence suggests that *Dromaeosaurus* could run with its tail carried sharply erect (upturned). Explain the morphological evidence from **Figure 1a** to support this conclusion and explain how this might be of benefit to a predatory dinosaur. [3]

Explanation .....

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Advantage .....

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(c) **Figure 1b** shows dinosaur trackways on a bedding surface.

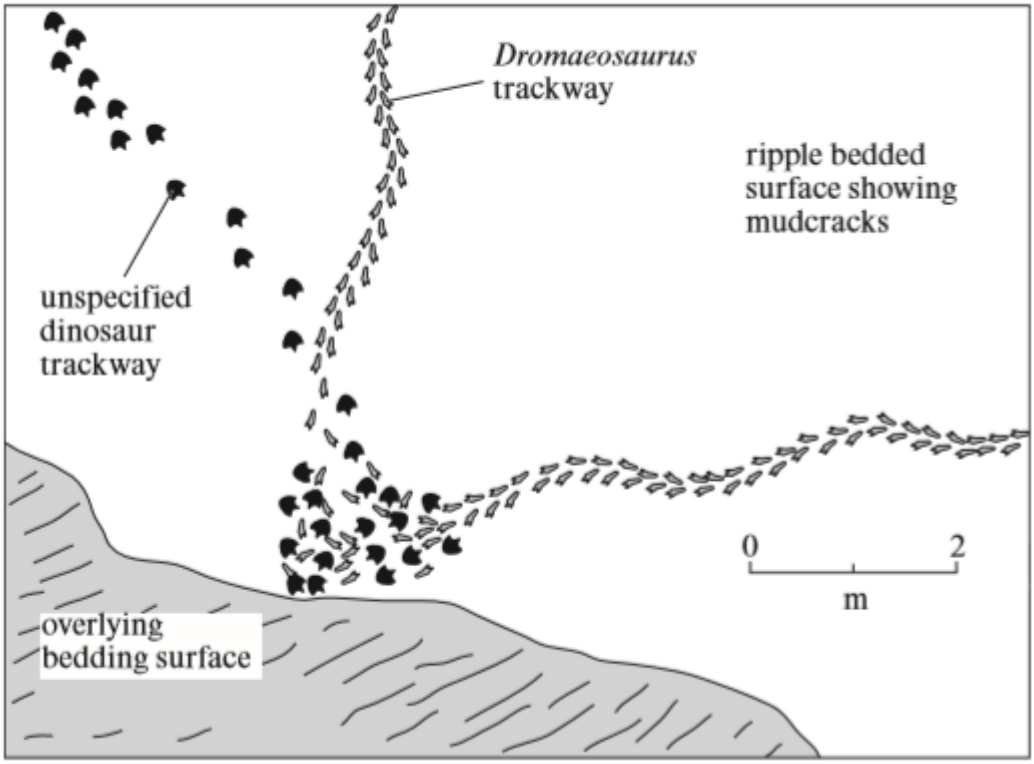

Figure 1b

A student concluded that the tracks provide evidence that, despite its small size, *Dromaeosaurus* was able to prey on larger dinosaurs.

(i) With reference to **Figure 1b**, analyse the **evidence** that might support this conclusion. [3]

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(ii) Suggest likely alternative explanations for the events leading to the formation of these tracks that do not necessarily involve *Dromaeosaurus* actively hunting. [2]

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Total 16 marks

4 **Figure 2a** shows a skeleton of the bird-hipped dinosaur, *Stegosaurus*. **Figure 2b** shows details of the skull of *Stegosaurus*.

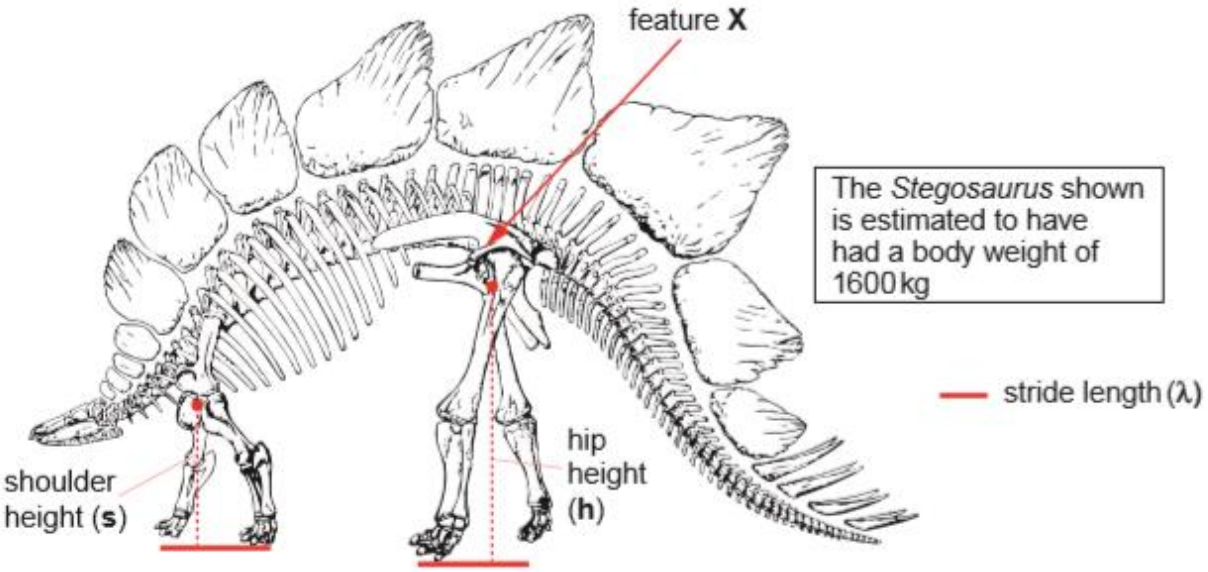

Figure 2a

Figure 2b

(a) Complete **Table 2a** by stating the level of classification (order, phylum or species) represented by the term *ornithischian*. [1]

Classification level	Classification
Class	Reptile
	ORNITHISCHIAN (bird-hipped)
Family	Stegosaurid
Genus	*Stegosaurus*

Table 2a

(b) Refer to **Figure 2a** and **Figure 2b**.

(i) Name the morphological feature **X** and suggest its function. [2]

feature **X** .....

function .....

(ii) Explain how the morphological features of the *Stegosaurus* skeleton suggests it was **unlikely** to have been a carnivorous predator. [4]

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(c) **Figure 2c** shows how the stride length and **relative** stride length of the forelimbs and hindlimbs of *Stegosaurus* (**Figure 2a**) can be used to determine the dinosaur's gait (i.e. whether it walked, trotted or ran).

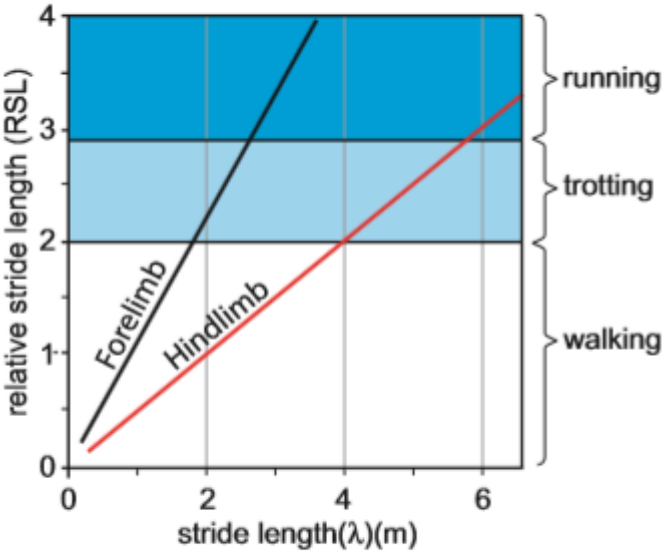

Figure 2c

Stride length (λ) = the distance travelled by a forelimb or hindlimb during each stride.

Relative stride length (RSL) = the stride length (λ) relative to the shoulder or hip height ($\frac{\lambda}{s}$ or $\frac{\lambda}{h}$).

Running involves all 4 limbs being in the air at the same time.

Refer to **Figure 2a** and **Figure 2c**.

(i) Using **Figure 2c**, complete **Table 2b** by inserting the appropriate relative stride length and gaits. [3]

Stride length (λ) of forelimb and hindlimb (m)	Relative stride length of limbs (RSL)		gait (walking, trotting or running)
	forelimb ($\frac{\lambda}{s}$)	hindlimb ($\frac{\lambda}{h}$)	
1	1.1		walking
		•	walking
2	2.2		•
		1.0	walking
3	3.3		•
		1.5	walking

Table 2b

(ii) Using the data in **Table 2b**, complete **Table 2c** below by calculating the shoulder height (**s**) for *Stegosaurus* from the formula;

[Relative stride length (RSL) = $\frac{\lambda}{\mathbf{s}}$]

Show your working. [2]

shoulder height (**s**)	Working: ..... m

Table 2c

(iii) Explain why the data (**Figure 2a**, **Figure 2c** and **Table 2b**) might suggest that *Stegosaurus* was unable to run fast. [3]

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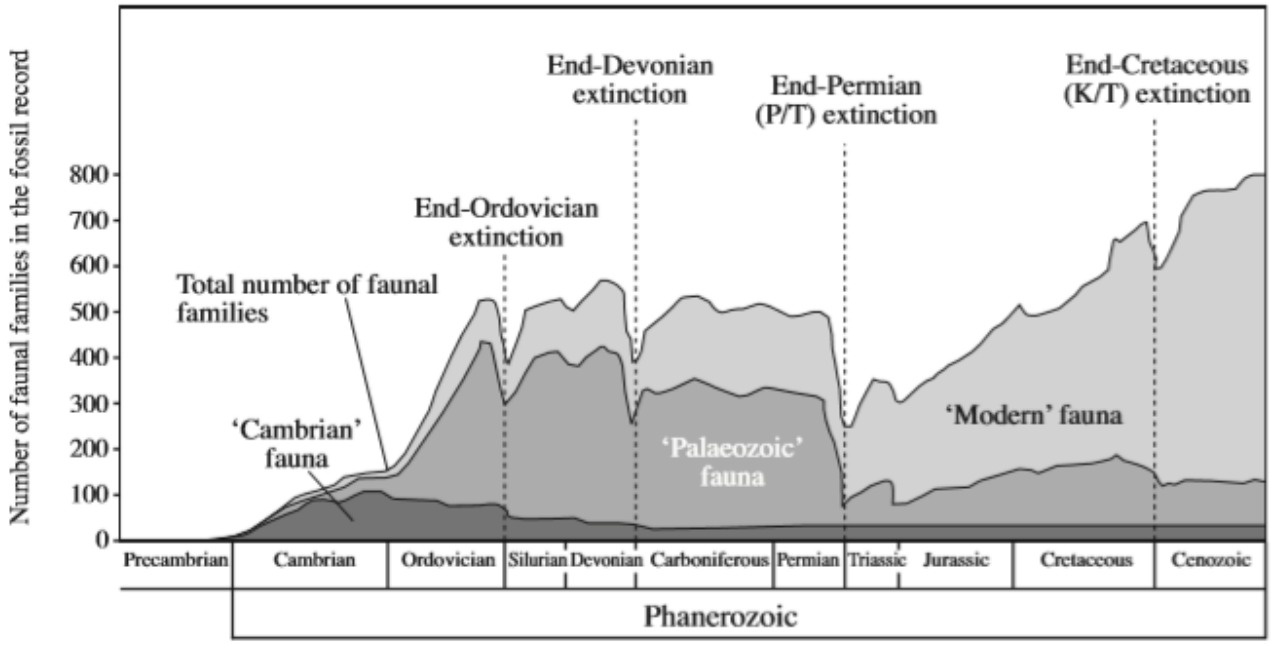
5 **Figure 2a** shows the changes in diversity of fauna (Sepkoski's curves) during the Phanerozoic.



Source: Milsom & Rigby – "Fossils at a Glance" (2009)

Figure 2a

Refer to **Figure 2a**.

(a) (i) State the total number of faunal families at the end of the Cambrian. [1]

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(ii) State the most abundant Phanerozoic fauna ('Cambrian', 'Palaeozoic' or 'Modern' fauna) that existed during the Devonian. [1]

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(iii) Describe the changes in relative abundance of Phanerozoic faunas between the end-Devonian and end-Cretaceous (K/T) mass extinction events. [3]

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(b) (i) Using **Figure 2a**, calculate the percentage of faunal families that became extinct during the end-Permian mass extinction (P/T). Show your working. [2]

Percentage of families extinct .....%

(ii) From your knowledge, describe **one** possible mechanism for the end-Permian (P/T) mass extinction. [3]

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(c) **Figure 2b** and **Figure 2c** show sketches of the diversity within typical 'Cambrian' and 'Modern' faunas (in **Figure 2a**) based on fossil evidence.

'Cambrian' fauna

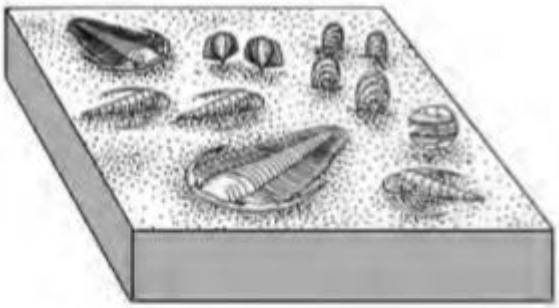

Figure 2b

'Modern' fauna

Figure 2c

Source: Milsom & Rigby – "Fossils at a Glance" (2009)

(i) With reference to **Figure 2b** and **Figure 2c**, describe **two** differences in the modes of life of 'Cambrian' and 'Modern' fauna which help explain the greater diversity during the Phanerozoic. [2]

1. .....

2. .....

(ii) Some Cambrian fossil formations (e.g. Burgess Shale) have recorded higher diversity of faunas than in **Figure 2b**. Explain the factors that may lead to an underestimation of the true diversity of fauna in the Cambrian. [3]

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Total 15 marks

6 **Figure 4** shows the changes in diversity of marine fauna (Sepkoski's curves) during the Phanerozoic along with the arrangement of continents over the same time.

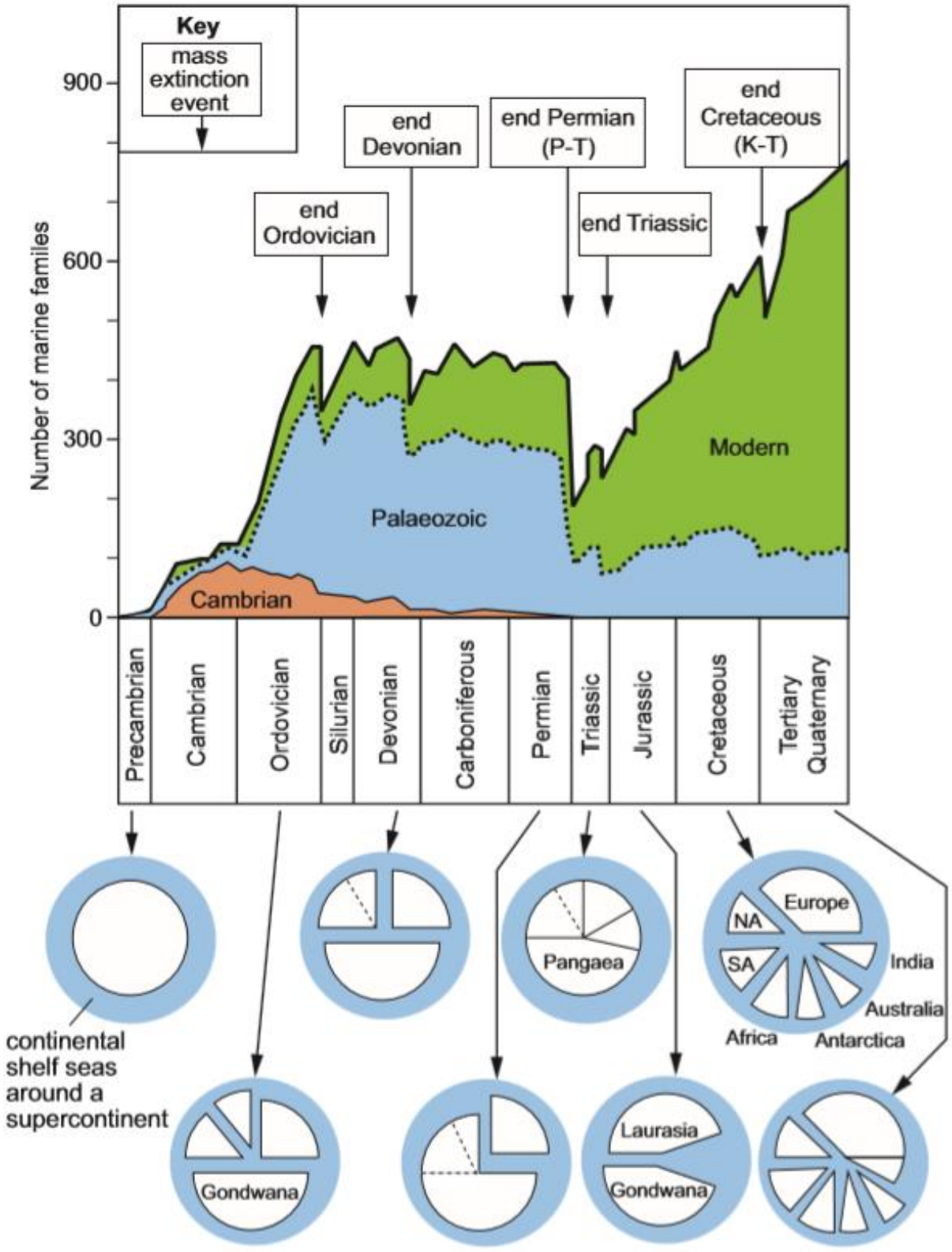

Figure 4

Refer to **Figure 4**.

(a) (i) Name the most abundant Phanerozoic fauna (*Cambrian, Palaeozoic* **or** *Modern*) that existed during the Mesozoic era. [1]

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(ii) Complete **Table 4** below with the following.

1. The percentage of marine families that became extinct during the end Cretaceous (K-T) extinction. Show your working in the space provided.

2. The name of the mass extinction at which approximately 51 % of marine families became extinct. [3]

Extinction events	Percentage of marine families extinct
end Cretaceous (K-T)	Working • *Answer* = ... %
•	51 %

Table 4

(b) Explain why the small number of families recorded in the late Precambrian may not necessarily reflect the abundance of life at that time. [3]

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(c) (i) Describe the relative change in the area of continental shelf seas in **Figure 4** between the Precambrian and the end of the Carboniferous. [2]

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(ii) **Describe** the correlation between changes in the diversity of marine organisms and the breakup of the continents following the end Permian (P-T) mass extinction. [2]

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(iii) *"Changes in the proportion of continental shelf seas were responsible for the diversity of marine fauna through geological time."*

Critically evaluate this statement. [4]

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7 **Figure 4a** illustrates three fossil trilobites (**A-C**) interpreted as having different modes of life based on their external skeleton. Two reconstructions of possible modes of life are shown for trilobites **B** and **C**.

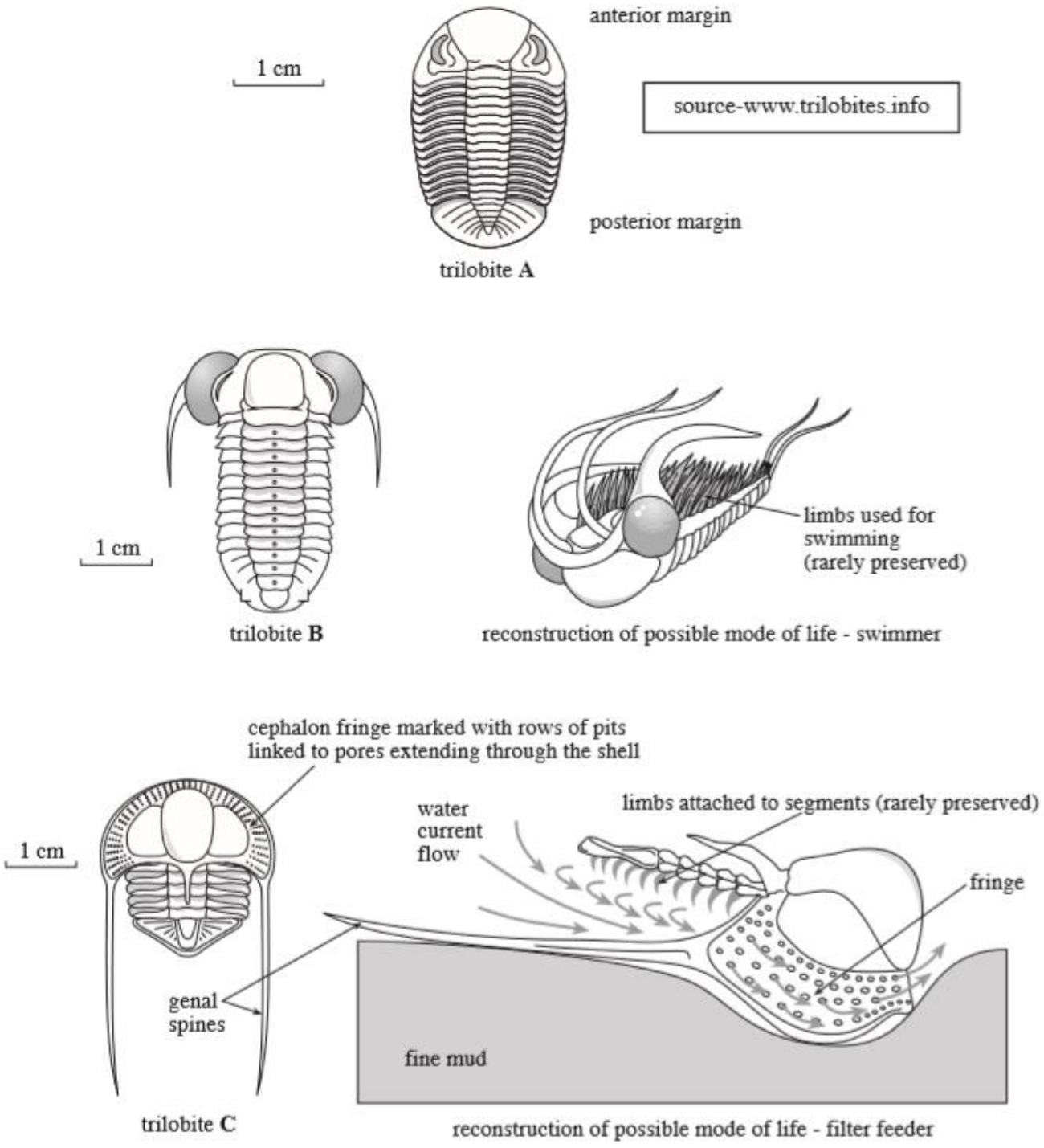

Figure 4a

Refer to **Figure 4a**

(a) Evaluate the following student's description of trilobite **A**.

"……the semi-circular cephalon shows a glabella which is wider at the anterior margin, kidney-shaped eyes and no genal spines. The thorax contains 14 segments and the pygidium is larger than the cephalon." [2]

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(b) (i) **Explain** how the morphological features of trilobite **B** suggest that it was an active swimmer. [2]

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(ii) With reference to trilobite **C**, suggest a possible function of the morphological features shown in **this** proposed reconstruction of the animal in filter-feeding mode. [3]

Morphological feature	Possible function
Genal spines	•
Limbs	•
Fringe on the cephalon	•

(c) Explain the problems of relating morphology to function and mode of life in extinct groups like the trilobites and why these problems may be minimised in areas of exceptional preservation. [3]

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(d) **Figure 4b** illustrates selected data from a sample of Welsh trilobites showing how the average number of segments on the pygidia of one trilobite group changes with time.

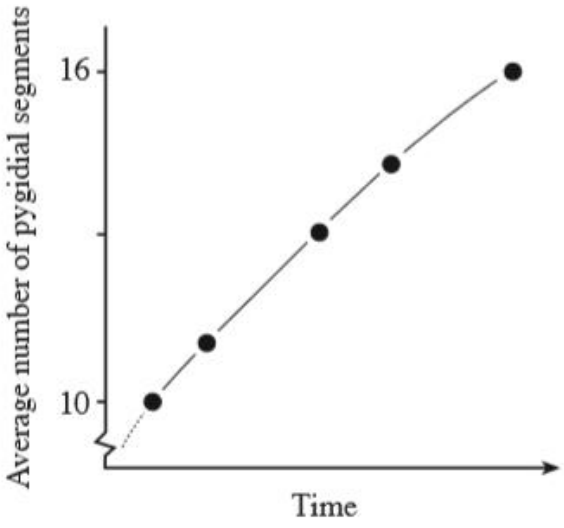

Figure 4b

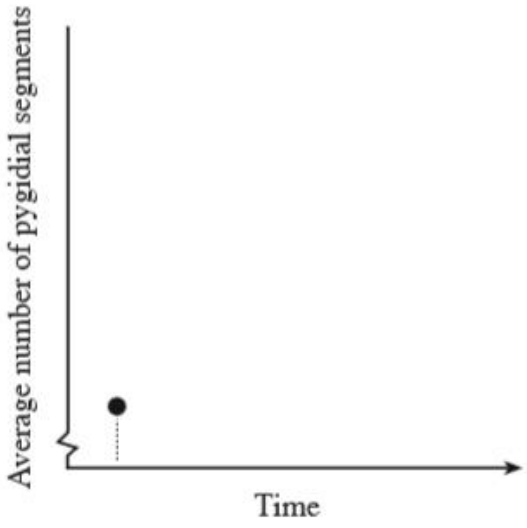

Figure 4c

Trilobites have been shown to demonstrate a gradual pattern of evolutionary change in the fossil record *(gradualism)* rather than an alternative pattern with periods of stability *(stasis)* interrupted by sudden change *(punctuated equilibrium)*.

(i) Explain why the evolutionary pattern in **Figure 4b** is interpreted as showing *gradualism* rather than *punctuated equilibrium.* [2]

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(ii) Complete **Figure 4c** by sketching a graph that might be expected if the pattern of pygidial segments in trilobites showed *punctuated equilibrium.* Clearly label (with an **S** ➔) a period of '**stasis**'. [2]

(e) Using your knowledge, evaluate how reliable the fossil record is in interpreting evolutionary patterns. [3]

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Total 17 marks

8 **Figure 2a** and **Figure 2b** show two species of marine molluscs. **Figure 2a** are fossils representative of a sample from a single bedding plane **(species A)** while **Figure 2b** represents shells collected from a modern beach **(species B)**.

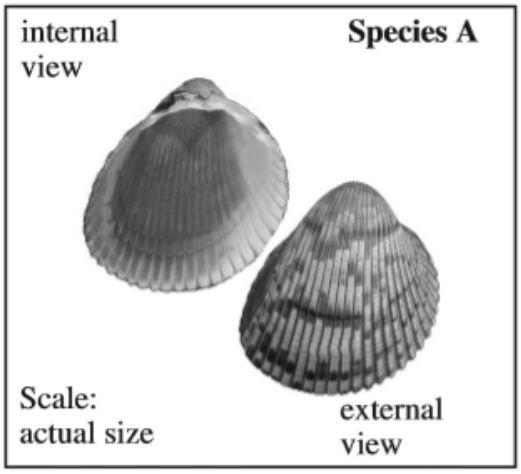

Figure 2a

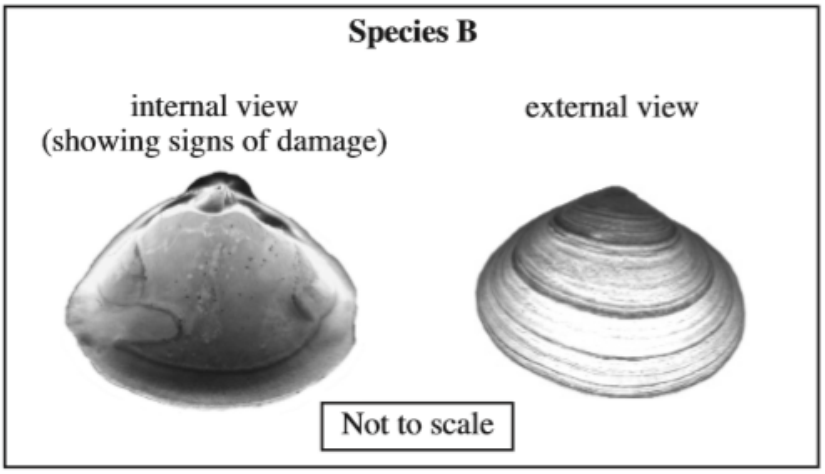

Figure 2b

Refer to **Figures 2a** and **2b**.

(a) (i) State the type of marine mollusc represented by species **A** and **B**. [1]

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(ii) Describe **two** morphological differences between species **A** and **B**. [2]

Difference .....

Difference .....

(iii) Explaining **one** piece of evidence, contrast the former modes of life of both species **A** and **B**. [4]

Species A *Mode of life* .....

Explanation of the evidence .....

.....

Species B *Mode of life* .....

Explanation of the evidence .....

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(b) **Figure 2c** is a scatter graph of the size variation of **species A** on the bedding surface compared with the beach assemblage of **species B**.

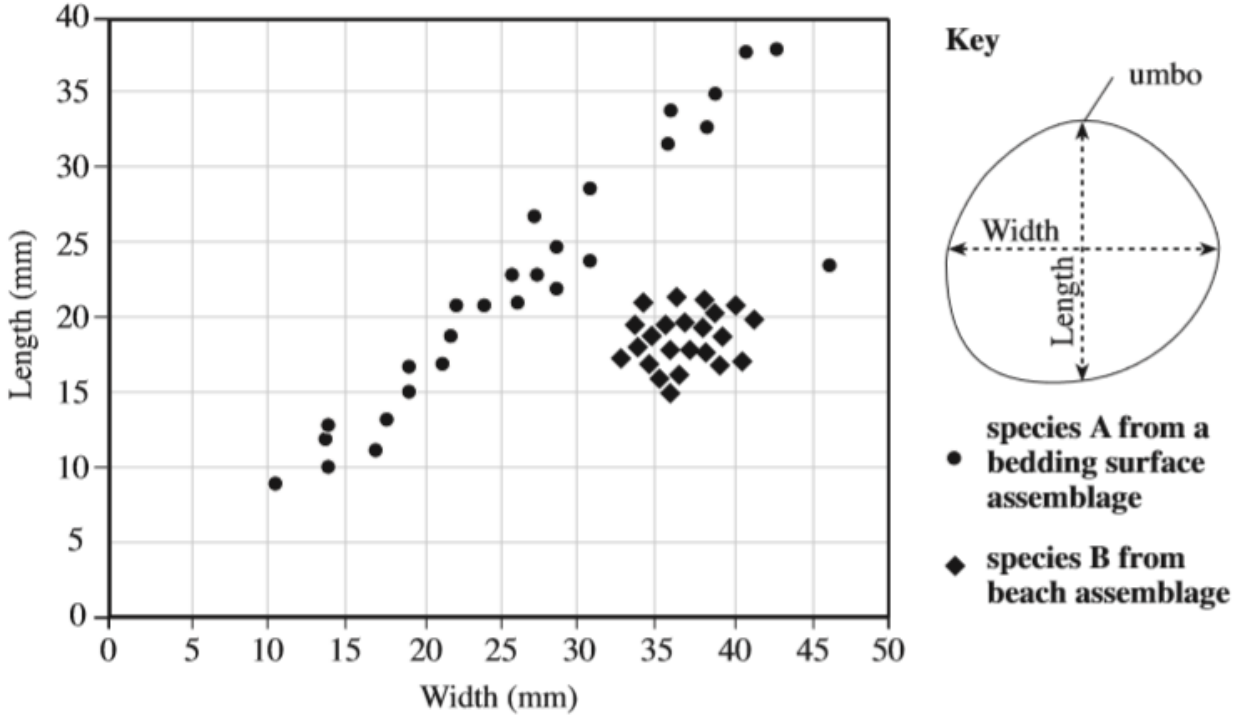

Figure 2c

(i) Measure the length and width of **one** valve from **species A** in **Figure 2a** and plot the position of the valve on **Figure 2c**. [2]

(ii) Describe and explain the distribution of the data for **species A** on **Figure 2c**. [3]

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(iii) A student concluded from the data that the beach assemblage **(species B)** represented a death (transported) assemblage.
Evaluate this statement with reference to the evidence. [3]

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Total 15 marks

9 The question refers to an area of NE Africa which is believed to be an example of part of the J. Tuzo Wilson cycle.

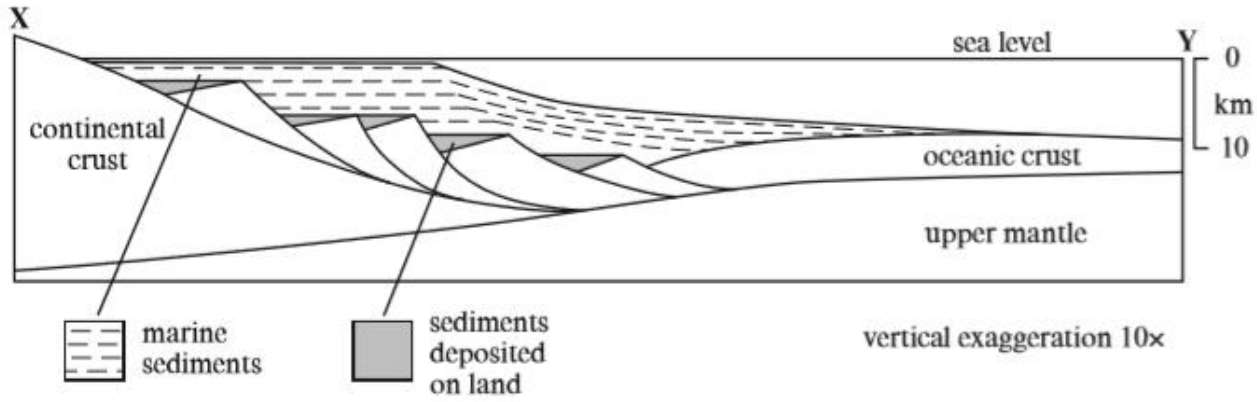

Figure 1a

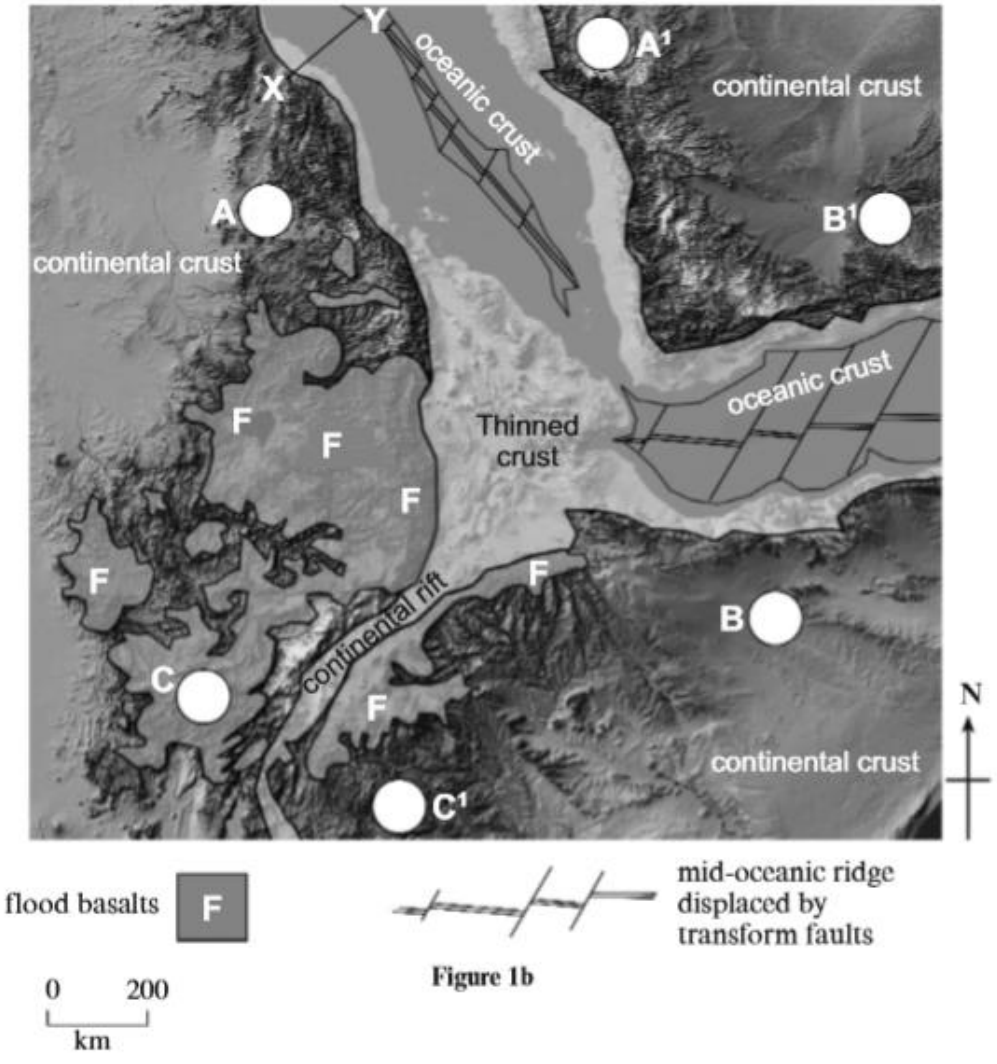

Figure 1b

Figure 1a is a section **X-Y** of continental margin (as shown in **Figure 1b**) which is believed to have formed due to rifting at a constructive plate boundary. Using **Figure 1a**.

(a) State and explain **one** piece of evidence which indicates that the area formed in a region that has experienced tensional stresses. [2]

Evidence .....

Explanation .....

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Figure 1b shows an annotated aerial view of part of NE Africa.
Three areas of continental crust are marked, as are areas covered with flood basalts.
The positions of the oceanic ridges are shown in the oceanic crustal areas together with some of the transform faulting.

(b) (i) In each of the pairs of circles (**A-A^1**; **B-B^1** and **C-C^1**) draw arrows to show the relative directions of movement of the plate at those localities. [3]

(ii) Give reasons for your choice of directions in circles **A** and **A^1**. [2]

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(c) (i) Describe the distribution of the flood basalts. [2]

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(ii) State what this distribution indicates about the **viscosity** of the flood basalts. [1]

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(d) Earthquakes in this region usually register less than 5 on the Richter Scale and occur at shallow depths (10 km or less).
With reference to **Figure 1a** and **Figure 1b** suggest why the earthquakes are usually shallow and of low magnitude. [3]

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(e) Assuming that this area is one stage of a Wilson cycle, with reference to **Figure 1b** suggest how the region might be expected to evolve into the next stage. [2]

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Total 15 marks

10 **Figure 4a** is a model of the long-term carbon cycle in which plate tectonics and chemical weathering are the main controls of atmospheric carbon dioxide (CO_2).

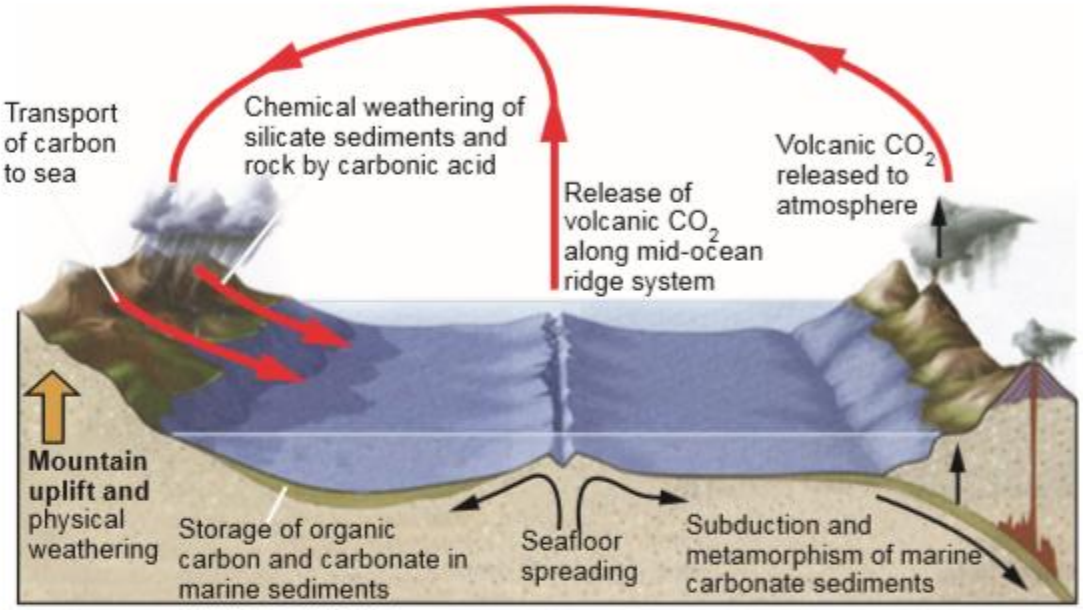

Figure 4a

(a) Refer to **Figure 4a**.

(i) Describe how carbon is transferred from marine sediments to the atmosphere at plate boundaries. [2]

(ii) Describe how carbon is removed from the atmosphere and returned to marine sediments. [2]

(iii) From your knowledge, briefly describe the relationship between CO_2 in the atmosphere and global temperatures. [1]

(b) Global cooling in the last 40 Ma has been linked to uplift of the Himalayas/Tibetan plateau. **Figure 4b** shows the change in $^{87}Sr/^{86}Sr$ isotope ratio for marine carbonates in the Indian Ocean. **Figure 4c** shows three contrasting models for the rate of uplift of the Tibetan Plateau formed by the collision of India with Asia.

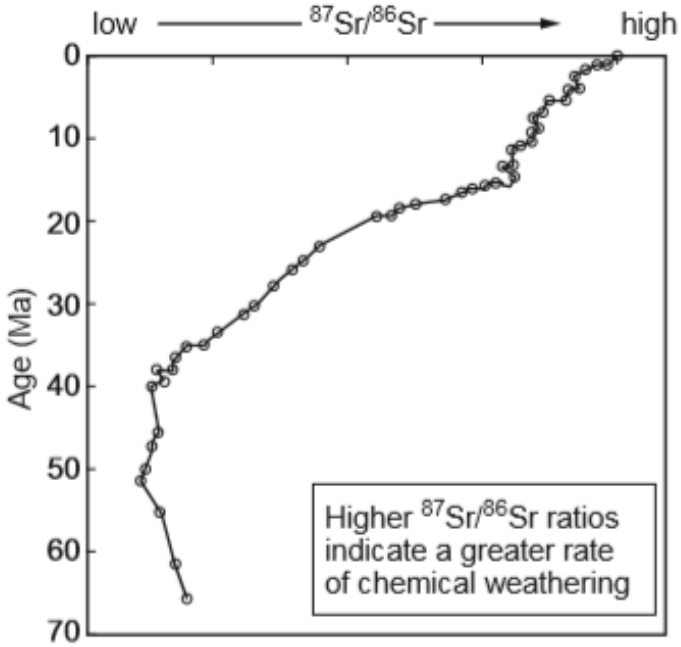

Figure 4b

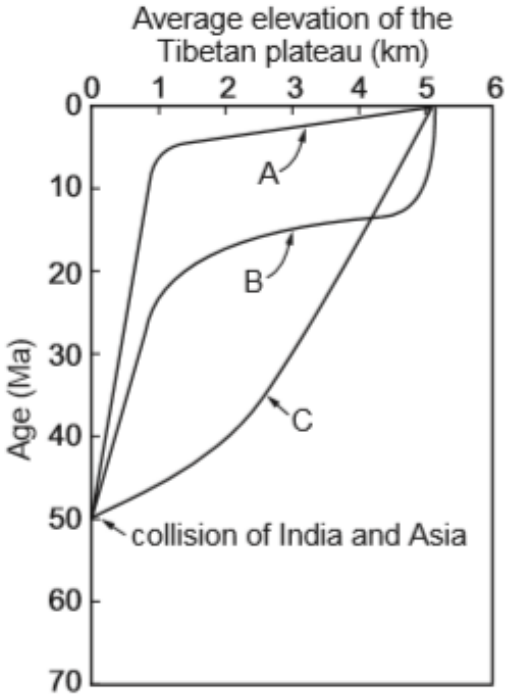

Figure 4c

Refer to **Figures 4b** and **4c**.

(i) Describe the relative change in $^{87}Sr/^{86}Sr$ ratios in **Figure 4b** over the last 40 Ma. [2]

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(ii) State which uplift model in **Figure 4c** (**A**, **B** or **C**) most closely correlates with the $^{87}Sr/^{86}Sr$ ratio data **(Figure 4b)**. Describe the degree of correlation between the two data sets. [3]

Model (**A**, **B** or **C**) ☐

Correlation .....

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(c) Refer to **Figures 4a**, **4b** and **4c**.

(i) Explain how an increase in the height of the Himalayas/Tibetan plateau might have caused global cooling in the last 40 Ma. [3]

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(ii) With reference to **Figure 4a** or your knowledge, suggest **one** other possible mechanism for global cooling in the last 40 Ma. [2]

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11 **Figure 4a** shows two fossil leaves used to indicate changes in climate based on leaf shape
Figure 4b shows the correlation between mean annual temperature and leaf shape in modern leaves.

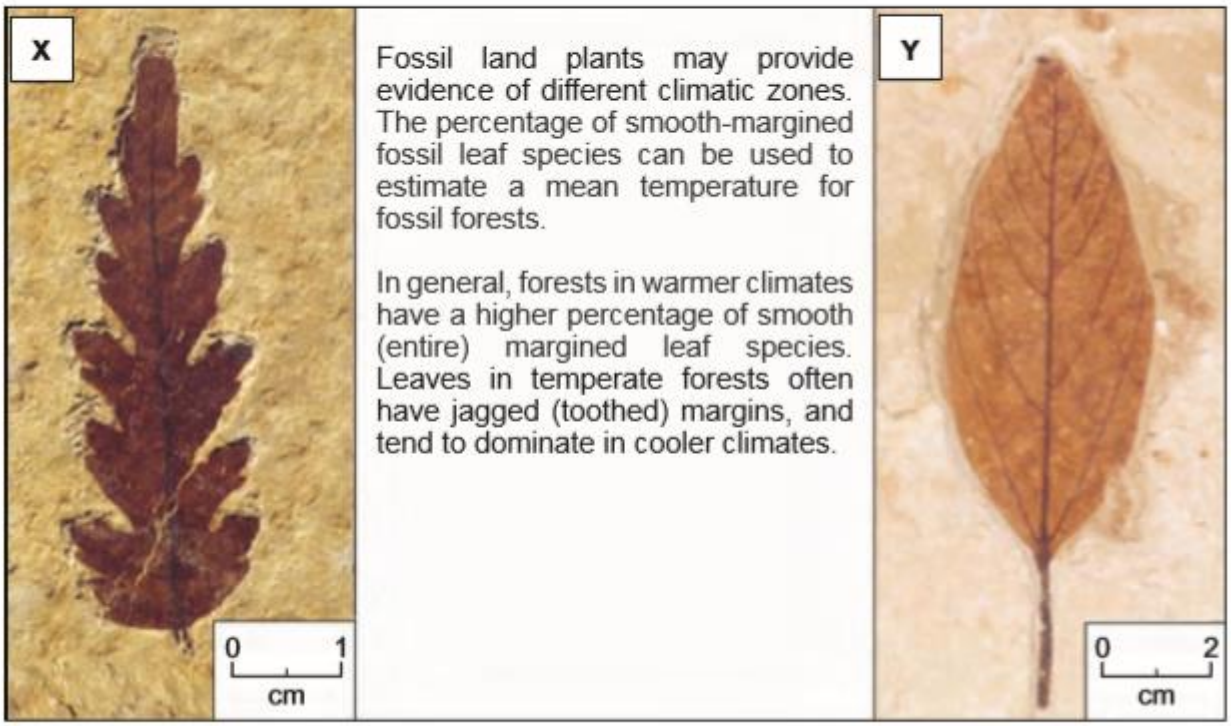

Figure 4a

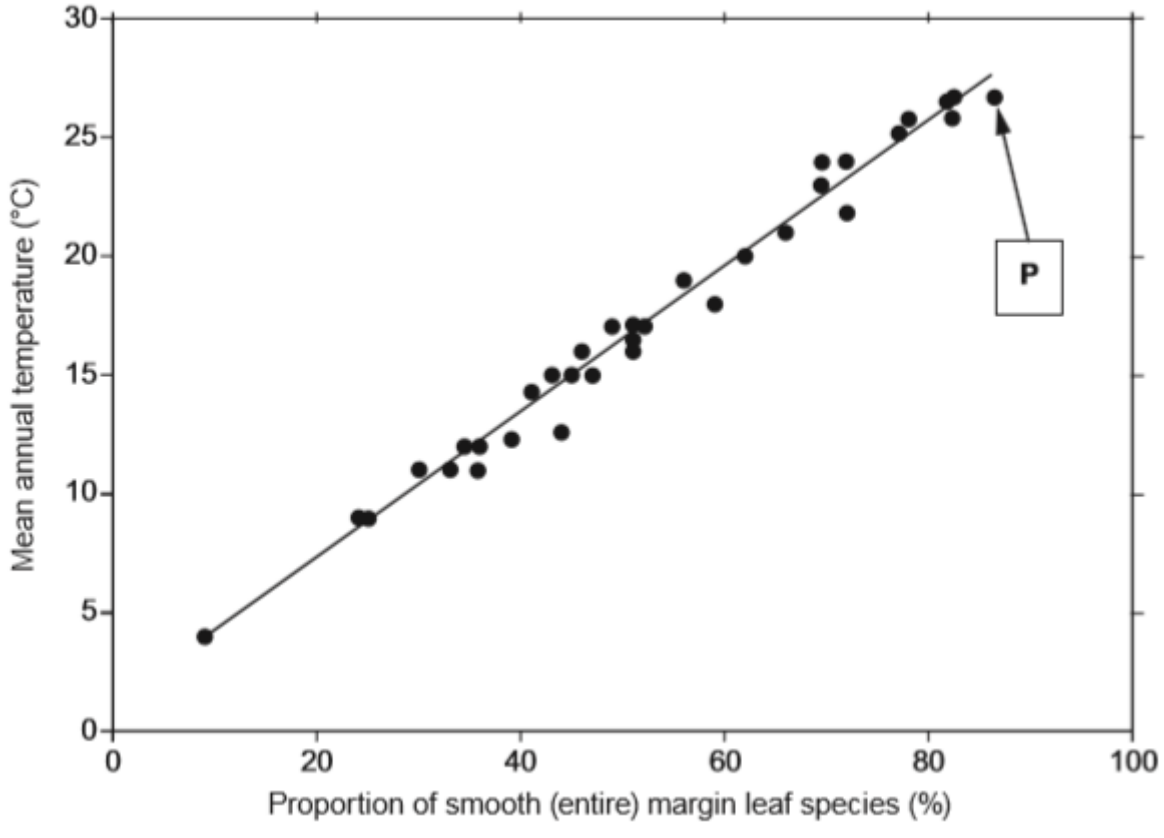

Figure 4b

(a) Refer to **Figure 4a**.

Describe **two** differences in the shapes of leaves **X** and **Y**. [2]

1. .....

2. .....

(b) Refer to **Figure 4b**.

(i) Describe the correlation in **Figure 4b**. [2]

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(ii) Identify which of the fossil leaves (**X** or **Y**) best represents the most common shape of leaf margin species at point **P** in **Figure 4b**. Explain your answer. [2]

Leaf (**X** *or* **Y**) ☐

Explanation .....

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(c) **Figure 4c** shows the estimated variation in mean annual temperature based on the outline shapes of fossil leaves during the last 60 million years. **Figure 4d** shows the variation in ^{18}O:^{16}O ratios measured in deep ocean sediments over the same period. (after Ruddiman: Earth's Climate, Past and Present).

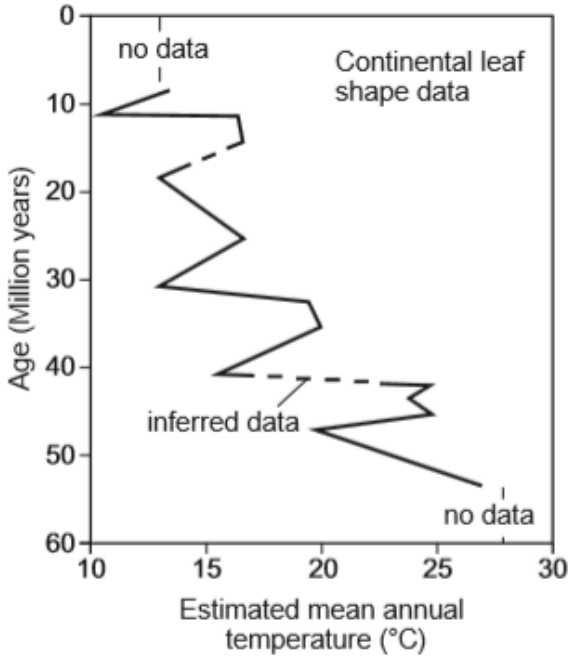

Figure 4c

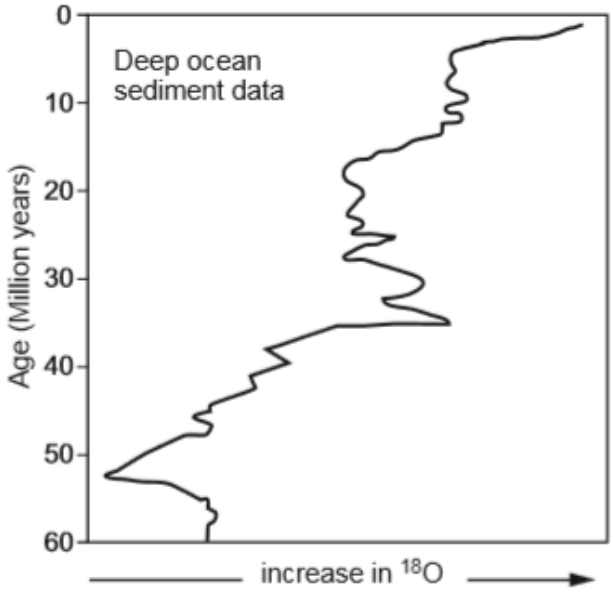

Figure 4d

(i) On **Figure 4c**, mark in a line of best fit for the data set. [1]

(ii) Describe the changes in the mean annual temperature during the last 60 million years based on leaf shape, in **Figure 4c**. [2]

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(iii) With reference to **Figure 4d**, explain the overall increase in ^{18}O recorded in deep ocean sediments during the last 60 million years. [3]

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(d) With reference to **Figures 4c** and **4d and your knowledge**, suggest why the continental temperature record, based on leaf shape, may be less reliable than the record obtained from deep ocean sediments. [3]

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12 **Figure 4a** shows the variation in ^{18}O:^{16}O ratios measured in marine sediments over the last 150,000 years. **Figure 4b** shows changes to atmospheric CO_2, trapped in the Antarctic ice, over the same time period.

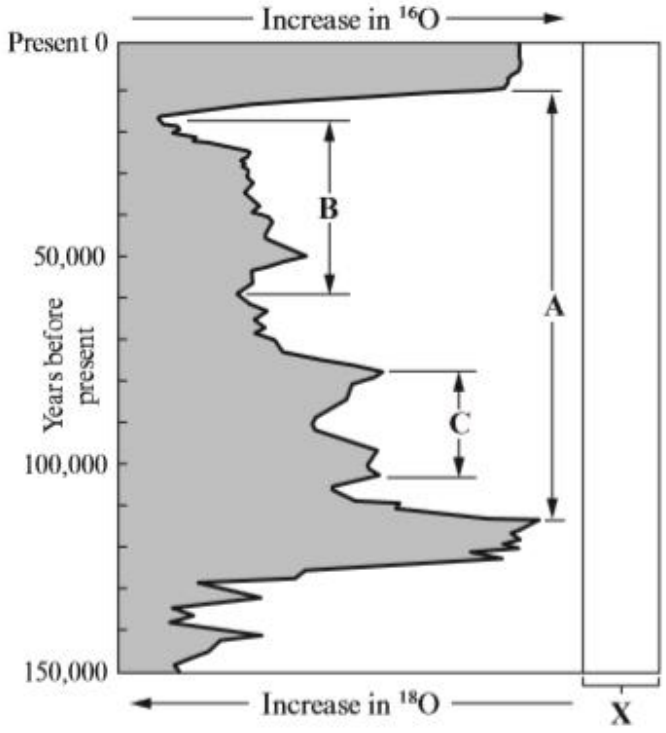

Figure 4a

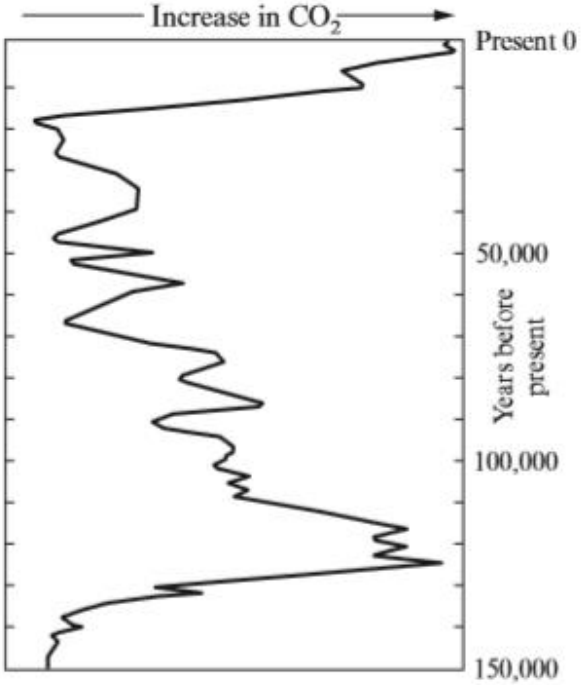

Figure 4b

(a) The variations in ^{18}O:^{16}O ratios are thought to indicate growth and decline of continental ice sheets.

(i) In the box labelled **X** on **Figure 4a**, mark with labelled arrows:

- the peak of **one** glacial period (← **G**)
- the peak of **one** interglacial period (← **I**) [2]

(ii) Explain why the ratio of ^{18}O:^{16}O in marine sediments varies during glacial and interglacial periods. [3]

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(b) From your knowledge, state **one natural** process that has been a major contributor in:

1. adding CO_2 to the atmosphere throughout geological time;

2. removing CO_2 from the atmosphere throughout geological time. [2]

1. .....

2. .....

(c) Refer to **Figures 4a** and **4b**.

(i) Describe the correlation between the ratio of ^{18}O:^{16}O in marine sediments and atmospheric CO_2 during the last 150,000 years. [2]

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(ii) *"Glacial and interglacial periods are a direct result of changes in the concentration of CO_2 in the atmosphere during geological time."*

Critically evaluate this statement. [2]

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