3.3 Option: Extreme environments

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS extreme environment • moraine • permafrost • active layer • opportunity • challenge

Objective

Build the skills to answer Paper 1 questions on the **extreme environments** option: cold (mountains, polar, glacial) and dry (hot desert) places, glacial and desert landforms, **permafrost** , the opportunities and challenges these places offer, and how climate change is changing them.

You must be able to:

- describe where extreme environments are and why they are extreme
- explain glacial landforms (U-shaped valleys, moraines) and desert landforms (dunes, wadis)
- explain the challenges of building on permafrost and how engineers respond
- explain the opportunities extreme environments offer, with examples
- explain the effects of climate change on glaciers, permafrost and people

1 Key knowledge and worked examples

■ Cold and dry places

- **Cold**: high mountains, polar and glacial areas. Ice erodes valleys into a **U shape** and leaves piles of rock called **moraines** .
- **Dry**: hot deserts (under about 250 mm of rain a year). Clear skies give a large daily temperature range. Wind builds dunes; rare **flash floods** cut steep valleys (wadis).
- **Permafrost**: ground frozen for at least two years in a row. The top layer that thaws each summer is the **active layer** .

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Opportunities and challenges

opportunities	challenges
minerals, oil and gas	cold or heat, little water
tourism, adventure sport	poor access, high building costs
solar and wind energy	a fragile environment that recovers slowly
scientific research	small, often Indigenous, populations whose culture is under pressure

Case study: the Qinghai–Tibet Railway (opened 2006). Much of the line crosses permafrost. Heat from the track could thaw it and make the track sink, so engineers built bridges, embankments of crushed rock (cold air sinks between the stones) and heat pipes (thermosiphons) that carry heat out of the ground. It brings tourists and trade to Tibet; it also brings pressure on a fragile environment and on local culture.

Climate change

Mountain glaciers are shrinking, which first adds meltwater and later reduces the water that rivers carry in the dry season. Lakes held by moraines can burst (**glacial lake outburst floods**). Thawing permafrost damages roads and buildings and releases methane.

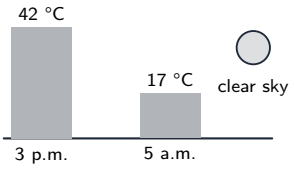
Worked example. A glacier was 6.0 km long in 1985 and 4.8 km long in 2025. Retreat = 1.2 km in 40 years = 1,200 ÷ 40 = 30 m a year.

2 Practice

2.1 Define **permafrost** and the **active layer**. [2]



2.2 In a hot desert town, the temperature is 42 °C at 3 p.m. and 17 °C at 5 a.m. Calculate the daily range, and explain why it is so large. [3]

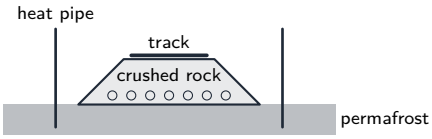


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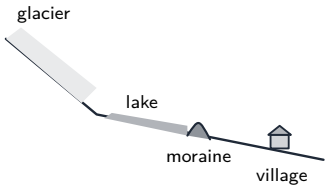
2.3 State **two** opportunities that extreme environments offer to people. [2]



2.4 Explain how engineers protected the Qinghai–Tibet Railway from thawing permafrost. [3]



2.5 Explain **two** ways in which shrinking mountain glaciers affect people living downstream. [4]



3 Exam-style questions

3.1 *(Paper 1 style.)* The table shows the length of a mountain glacier (illustrative data).

(a) Calculate the average rate of retreat, in metres per year, from 1985 to 2025. [2]

year	1985	1995	2005	2015	2025
length (km)	6.0	5.8	5.5	5.2	4.8

(b) Describe **two** landforms the glacier left behind as it retreated, and how each formed. [4]

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3.2 "The opportunities of extreme environments are greater than the challenges." Discuss this statement. [10]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

permafrost: ground that stays frozen for at least two years in a row; active layer: the top layer above it that thaws in summer and freezes again in winter

2.2

$42 - 17 = \mathbf{25}$ °C; clear skies and dry air let strong sunlight heat the ground by day; at night there are no clouds and little water vapour to hold the heat, so it escapes quickly

2.3

any two: minerals, oil or gas; tourism, e.g. trekking or skiing; solar or wind energy; scientific research, e.g. in Antarctica

2.4

any three: bridges raise the track above the ground in the most sensitive areas; crushed-rock embankments let cold air sink and circulate between the stones, which cools the ground; heat pipes (thermosiphons) carry heat out of the ground in winter; so the permafrost stays frozen and the track does not sink

2.5

any two, explained: at first more meltwater, but later less water in rivers in the dry season for farming, drinking and hydropower; lakes held by moraines grow and can burst, causing sudden floods that destroy villages and roads; less snow and ice for tourism, so local jobs are lost

3.1

(a) $6.0 - 4.8 = 1.2$ km $= 1{,}200$ m; $1{,}200 \div 40 = \mathbf{30}$ m a year

(b) any two: a U-shaped valley: the glacier eroded the sides and floor by plucking and abrasion; a terminal or lateral moraine: rock carried by the ice was dropped at the snout or sides; a lake held behind a moraine: meltwater filled the hollow

3.2

Mark with the markbands: [9-10] focused on the command term, detailed and accurate knowledge, well-developed explanation, specific named examples (places, dates, numbers), balanced evaluation and a supported conclusion; [7-8] mostly focused, good knowledge and examples, some evaluation; [5-6] relevant knowledge and examples, explanation partly developed, little evaluation; [3-4] general knowledge, few examples, mostly description; [1-2] little that is relevant. Points that may be included: opportunities: minerals and energy, e.g. oil and gas in the Arctic; tourism: the Qinghai–Tibet Railway brings tourists and trade to Tibet; solar energy in hot deserts with strong sunshine; research in Antarctica and high mountains; challenges: cold, heat and poor access make building costly, e.g. thawing permafrost under the railway; fragile environments recover slowly

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from roads, mines and tourism; local and Indigenous cultures can be put under pressure; climate change adds new risks: thawing permafrost, glacial lake outburst floods; technology turns challenges into opportunities, but at high cost; conclusion: the opportunities are large, but mostly for outside companies and governments; for local people and ecosystems the challenges are often greater

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