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

$42 - 17 =$ **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; $1{,}200 \div 40 =$ **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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