S6 Geography Practice Paper (Set 4): plate tectonics and earthquakes, weathering and slopes, rivers and floods, coasts and reclamation, urban land use, climate and air qual

Level: S6 | Subject: Geography | Time: 75 min | Total: 100 marks | Items: 24

Question 1 Plate motion and earthquakes

Take $\log_{10}E = 4.8 + 1.5M$ with E in joules. Give answers to 3 s.f.

1. Two plates separate at a mid-ocean ridge at 25 mm per year. Find the time needed for the ocean floor to widen by 120 km, in million years. (4 marks)

Answer: Time = $120 \times 10^3 / (25 \times 10^{-3}) = 4.8 \times 10^6$ years = 4.8 million years.

2. In a region, P waves travel at 6.0 km s^{-1} and S waves at 3.5 km s^{-1}. A station records the S wave 20 s after the P wave. Find the distance from the focus to the station. (4 marks)

Answer: $d/3.5 - d/6.0 = 20$, so $d = 20 / 0.1190 = 168$ km.

3. Compare the energy released by magnitude 6.0 and 7.0 earthquakes. Find the energy ratio and the energy of the magnitude 7.0 event. (4 marks)

Answer: $\log E_6 = 13.8$, $E_6 = 6.31 \times 10^{13}$ J; $\log E_7 = 15.3$, $E_7 = 2.00 \times 10^{15}$ J; ratio = 10^1.5 = 31.6 times.

4. A submarine earthquake generates a tsunami in water of mean depth 4000 m. Find the deep-water tsunami speed in km h^{-1} and estimate the time to cross 1500 km. (5 marks)

Answer: $c = \sqrt{(gd)} = 198$ m $s^{-1} = 713$ km h^{-1}; $t = 1500 / 713 = 2.10$ hours.

Question 2 Weathering and slope processes

Take $g = 9.81$ m s^{-2}, $\sin 25° = 0.4226$ and $\cos 25° = 0.9063$.

5. A 3.0 m thick limestone bed is dissolved by rainwater at 0.05 mm per year. Find the time needed to dissolve the whole bed. (4 marks)

Answer: 3.0 m = 3000 mm; time = $3000 / 0.05 = 6.0 \times 10^4$ years.

6. A regolith has cohesion c = 15 kPa, normal stress σ = 60 kPa and angle of internal friction ϕ = 30°. The shear stress along the slip plane is 45 kPa. Find the factor of safety and state whether the slope is stable. (4 marks)

Answer: Shear strength = $c + \sigma \tan\phi = 49.6$ kPa; factor of safety = $49.6 / 45 = 1.10$. It just exceeds 1, so the slope is only marginally stable.

7. A 40 kg rock lies on a 25° slope. The coefficient of friction between rock and slope is 0.40. Find the net force acting down the slope. (4 marks)

Answer: Downslope force = $mg \sin 25° = 166$ N; friction = $\mu mg \cos 25° = 142$ N; net force = 24 N downslope.

8. Soil on a hillside creeps downslope at 8 mm per year. Find the cumulative displacement after 50 years and name this slope process. (5 marks)

Answer: Displacement = 8 × 50 = 400 mm = 0.40 m; this slow downslope movement is called soil creep.

Question 3 River discharge and flooding

Give answers to 3 s.f.

9. A river reach has cross-sectional area 45 m^2 and mean velocity 1.8 m s^{-1}. Find its discharge. (4 marks)

Answer: $Q = A \times v = 45 \times 1.8 = 81\ m^3\ s^{-1}$.

10. A 60 km^2 catchment receives 120 mm of rain in 6 hours; the runoff coefficient is 0.35. Find the total runoff volume and the mean discharge over that period. (4 marks)

Answer: Volume = $0.35 \times 0.120 \times 60 \times 10^6 = 2.52 \times 10^6\ m^3$; mean discharge = $2.52 \times 10^6 / (6 \times 3600) = 117\ m^3\ s^{-1}$.

11. At a gauging station the 50-year flood has a return period of 50 years. Find the probability that a flood of this size occurs at least once in the next 20 years. (4 marks)

Answer: P = 1 – (1 – 1/50)^20 = 0.332, i.e. 33.2%.

12. In the same reach (width 6.0 m) the stage rises from 1.5 m to 2.0 m while velocity stays at 1.8 m s^{-1}. Find the percentage increase in discharge. (4 marks)

Answer: Original $Q = 6.0 \times 1.5 \times 1.8 = 16.2\ m^3\ s^{-1}$; new $Q = 6.0 \times 2.0 \times 1.8 = 21.6\ m^3\ s^{-1}$; increase = 33.3%.

Question 4 Coastal processes and reclamation

Take deep-water wavelength $L = 1.56T^2$ with L in m and T in s.

13. Waves at a site have period 8.0 s. Find the deep-water wavelength and wave speed. (4 marks)

Answer: $L = 1.56 \times 8.0^2 = 99.8$ m; $c = L / T = 99.8 / 8.0 = 12.5\ m\ s^{-1}$.

14. A coast receives 30 000 m^3 and loses 45 000 m^3 of sediment per year. Find the net erosion and estimate the rate of coastline retreat (coast length 2.0 km, beach scarp height 2.0 m). (5 marks)

Answer: Net erosion = 45 000 – 30 000 = 15000 $m^3\ yr^{-1}$; retreat rate = 15000 / (2000 × 2.0) = 3.75 m yr^{-1}.

15. Longshore drift along a coast is 25 000 m^3 per year; a groyne traps 80% of it. Find the volume trapped in 5 years. (4 marks)

Answer: Annual trapping = 0.80 × 25 000 = 20000 m^3; over 5 years = $1.0 \times 10^5\ m^3$.

16. A reclamation scheme creates 300 ha of land, 45% of which is residential; residential land carries 1 200 persons per hectare. Find the population the new town can hold. (4 marks)

Answer: Residential land = 0.45 × 300 = 135 ha; population = 135 × 1 200 = 162,000.

Question 5 Urban land use

An urban district covers 12.5 km². Land use: residential 42%, commercial 8%, industrial 6%, transport 18%, open space 12%, others 14%.

17. Verify that the land-use percentages add up to 100%. (4 marks)

Answer: 42 + 8 + 6 + 18 + 12 + 14 = 100%, so the figures are consistent.

18. The district has 480 000 residents. Find the population density. (4 marks)

Answer: 480 000 / 12.5 = 38,400 persons km^{-2}.

19. A 2 000 m² site carries a building with 18 000 m² of gross floor area. Find the plot ratio. (4 marks)

Answer: Plot ratio = 18 000 / 2 000 = 9.0.

20. Assume the number of trips varies inversely with the square of the distance to the CBD. A point 2 km from the CBD generates 40 000 trips a day. Find the trips at 4 km and explain the pattern. (4 marks)

Answer: Trips vary as $1/d^2$, so doubling the distance cuts trips to one quarter, i.e. 10 000; this is distance decay, as accessibility is greatest at the CBD.

Question 6 Climate data and air quality

Monthly mean temperature (°C): 16.5, 17.0, 19.2, 23.0, 26.4, 28.6, 29.2, 28.9, 27.8, 25.4, 21.6, 18.0. Monthly rainfall (mm): 32, 38, 62, 118, 246, 382, 356, 332, 268, 96, 44, 28. Take 1 ppb NO_2 ≈ 1.88 μg m^{-3}.

21. Find the annual mean temperature and the annual temperature range. (4 marks)

Answer: Mean = 281.6 / 12 = 23.5 °C; range = 29.2 – 16.5 = 12.7 °C.

22. Find the annual total rainfall and state the wettest month. (4 marks)

Answer: Total rainfall = 2002 mm; the wettest month is month 6 (382 mm).

23. The 24-hour mean NO_2 concentration on a day is 45 ppb. Express it in μg m^{-3}. (4 marks)

Answer: 45 × 1.88 = 84.6 μg m^{-3}.

24. The annual mean PM2.5 in the district is 28.4 μg m^{-3} against an annual limit of 35 μg m^{-3}. Find the measured value as a percentage of the limit and comment on air quality. (5 marks)

Answer: 28.4 / 35 = 81.1%, below the limit but already four-fifths of it, so regional pollution and roadside emissions still need control.
