

External assessment 2023

Stimulus book

Earth & Environmental Science

Paper 2

General instruction

- Work in this book will not be marked.

Stimulus 1

A large population lives in a water basin supported by available groundwater. Water from the basin is also extracted for agriculture. The area used for agriculture has been increased to guarantee food security for the growing population.

Historical and predicted trends in groundwater recharge, rainfall and population are shown.

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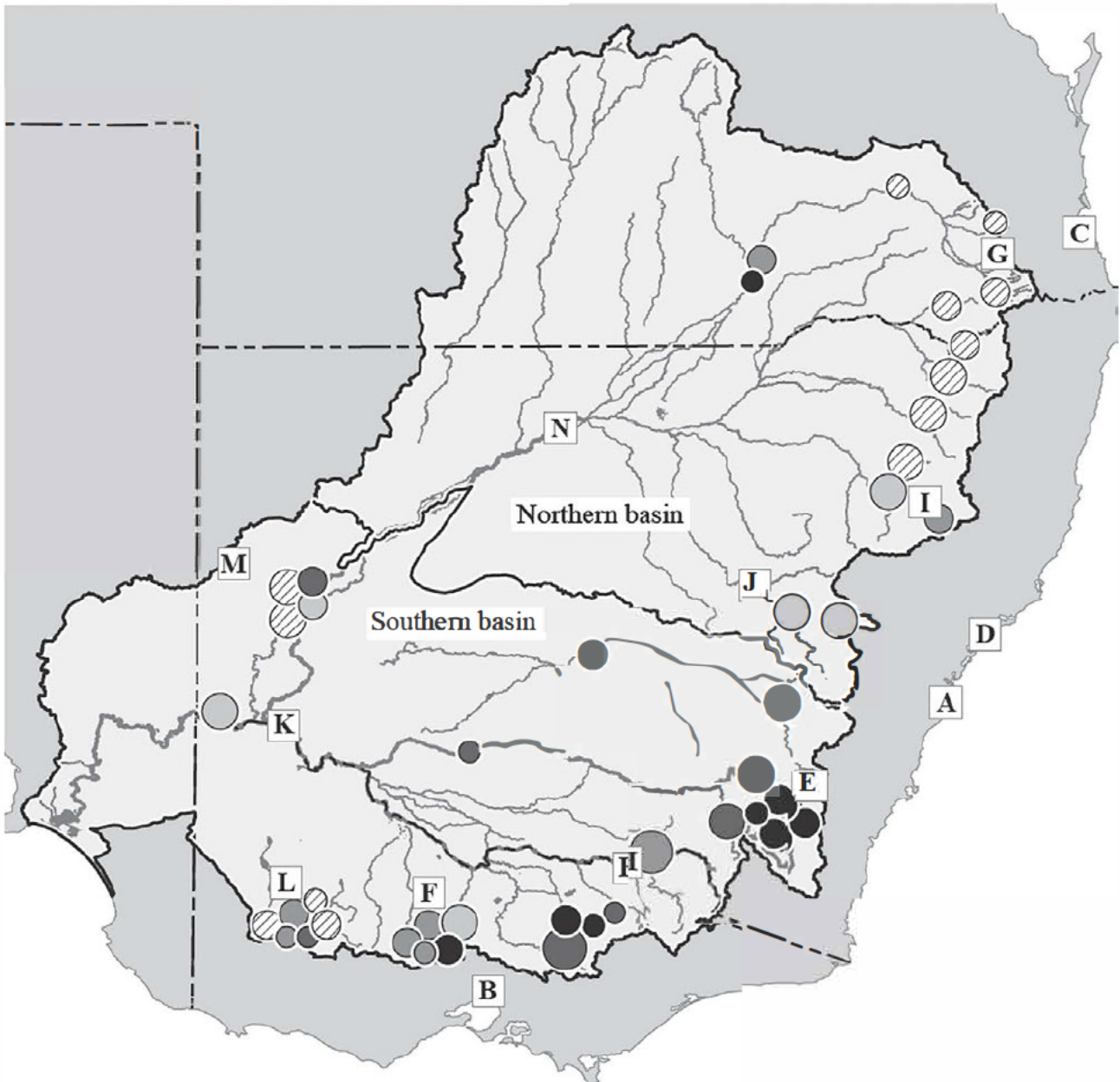
Stimulus 2

The map of Iceland shows the location of the capital city Reykjavík, tectonic plate boundaries, the *Eyjafjallajökull* active volcano and other volcanoes.

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Stimulus 3

The Murray–Darling Basin is a major agricultural area that produces 39% of Australia’s total value of agricultural production. A water storage map of the basin is shown.



| Key: Storage levels | |
|---------------------|-----------------------|
| Percentage full (%) | Storage capacity (GL) |
| 0–20 | 0–30 |
| 21–40 | 31–300 |
| 41–60 | 301–3000 |
| 61–80 | >3001 |
| >81 | |

Major towns by population, 2022

| | | | |
|---|-----------|---|--------|
| A | 5 361 466 | H | 97 274 |
| B | 5 096 298 | I | 43 330 |
| C | 2 582 007 | J | 39 363 |
| D | 505 000 | K | 33 444 |
| E | 431 611 | L | 20 600 |
| F | 103 575 | M | 16 661 |
| G | 100 032 | N | 1824 |

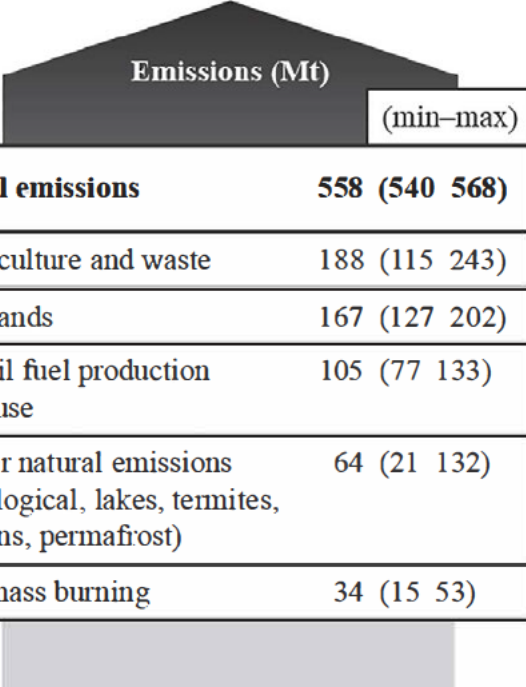
Stimulus 4

The graphs show global temperature change over the last 160 000 years and the type of pollen present in the fossil record over the last 150 000 years.

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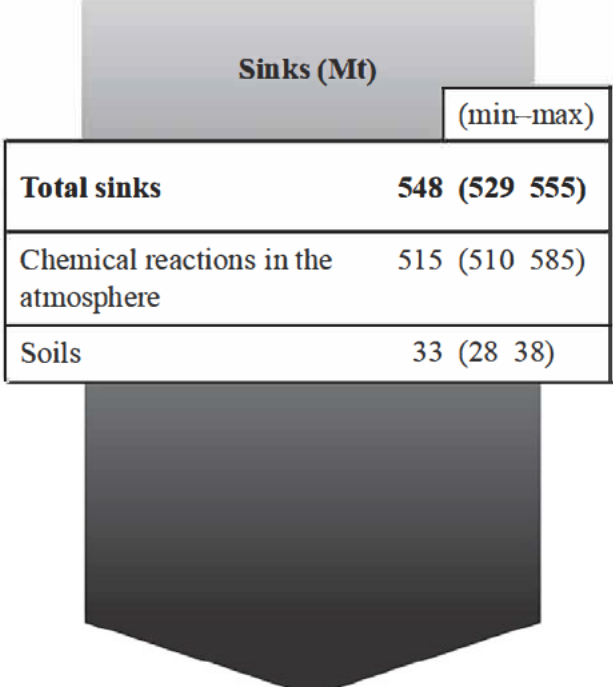
Stimulus 5

The diagram shows the global methane budget in megatonnes of CH₄ per year.



The diagram shows a table titled 'Emissions (Mt)' with a '(min-max)' label. The table lists various sources of methane emissions and their corresponding values in megatonnes per year, including a range in parentheses. The total emissions are 558 Mt, with a range of 540 to 568 Mt.

| Emissions (Mt) | | (min-max) |
|---|------------|------------------|
| Total emissions | 558 | (540 568) |
| Agriculture and waste | 188 | (115 243) |
| Wetlands | 167 | (127 202) |
| Fossil fuel production and use | 105 | (77 133) |
| Other natural emissions (geological, lakes, termites, oceans, permafrost) | 64 | (21 132) |
| Biomass burning | 34 | (15 53) |



The diagram shows a table titled 'Sinks (Mt)' with a '(min-max)' label. The table lists various sinks for methane and their corresponding values in megatonnes per year, including a range in parentheses. The total sinks are 548 Mt, with a range of 529 to 555 Mt.

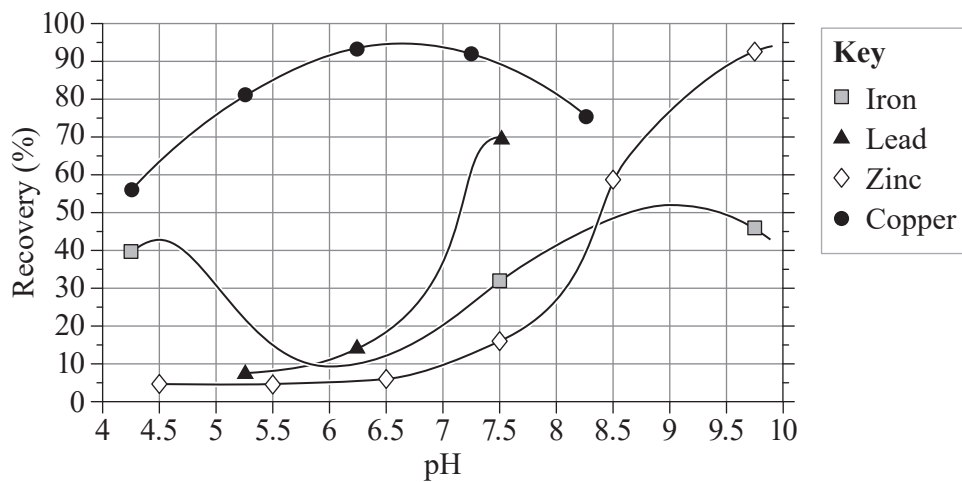
| Sinks (Mt) | | (min-max) |
|--------------------------------------|------------|------------------|
| Total sinks | 548 | (529 555) |
| Chemical reactions in the atmosphere | 515 | (510 585) |
| Soils | 33 | (28 38) |

Stimulus 6

A mining company has a 1000 kg sample of rock that is ready for valuable metals to be extracted using the froth flotation method. The sample can only be processed once at a specific pH. The sample of rock is made up of:

- 700 kg containing iron particles
- 100 kg containing lead particles
- 150 kg containing zinc particles
- 50 kg containing copper particles.

The graph shows the percentage recovery of these four metals for pH values between 4 and 10, and the table gives current prices for these metals.



| Base metal | Price (\$/kg) |
|------------|---------------|
| Iron | 0.17 |
| Lead | 1.90 |
| Zinc | 2.76 |
| Copper | 8.80 |

References

Stimulus 1

Adapted from Toure, A, Diekkrüger, B & Mariko, A 2016, 'Figure 13: Long-term groundwater recharge in million cubic meters (MCM) calculated using historical and future climate data from the RCP4.5 scenario based on the Thornthwaite Monthly Water Balance and rainfall (mm) from 1970 to 2050' in *Impact of climate change on groundwater resources in the Klela Basin, Southern Mali*, Hydrology, issue 3, vol. 2, <https://doi.org/10.3390/hydrology3020017>

Adapted from World Population Prospects 2023, 'Mali Population 2023 (live)', *World Population Review*, <https://worldpopulationreview.com/countries/mali-population>

Stimulus 2

Ridge shape and labels adapted from Global Volcanism Program 2011, 'Figure 16: Index map showing Iceland, some major plate-tectonic features and generalized spreading directions, and the location of Eyjafjallajökull volcano', *Report on Eyjafjallajökull (Iceland)*, ed. Wunderman, R, Bulletin of the Global Volcanism Network, vol. 36, issue 4, Smithsonian Institution, <https://doi.org/10.5479/si.GVP.BGVN201104-372020>

Island shape adapted from Tschubby 2020, 'Reliefkarte Island', *Wikimedia Commons*, https://commons.wikimedia.org/wiki/File:Reliefkarte_Island.png

Stimulus 3

Adapted from Murray Darling Basin Authority 2021, *Landscapes and climate of the Murray-Darling Basin*, Australian Government, <https://www.mdba.gov.au/publications/products-posters/landscapes-climate-murray-darling-basin>. Creative Commons Attribution 4.0 licence

Australia cutout adapted from Murray Darling Basin Authority 2022, 'Start and end of the Basin', Australian Government, <https://www.mdba.gov.au/basin/basin-location>. Creative Commons Attribution 4.0 licence

Storage volume sourced from Bureau of Meteorology 2023, 'Streamflows high in the south-east and low in south-west Western Australia', *Drought*, <http://www.bom.gov.au/climate/drought/#tabs2=Water>. Creative Commons Attribution 4.0 licence

Statistics from Australian Bureau of Statistics 2022, 'Regional population', <https://www.abs.gov.au/statistics/people/population/regional-population/2020-21#capital-cities>. Creative Commons Attribution 4.0 licence

Stimulus 4

Adapted from Almond, P, Barrell, D, Rother, H & Shulmeister, J 2011, 'Figure 34: Comparison of Okarito pollen and other records of climate change with summer insolation variation curves for the past 160,000 years' in *Quaternary geomorphology, stratigraphy, and paleoclimate of the central Southern Alps, South Island, New Zealand: INQUA 2007 Post Conference Field Trip*, Lincoln University, [ww.researchgate.net/profile/Peter-Almond/publication/45227344](http://www.researchgate.net/profile/Peter-Almond/publication/45227344)

Stimulus 5

Adapted from Saunio, M 2016, 'Global methane budget 2003–2012', Global Carbon Project, https://ameriflux.lbl.gov/year-of-methane/year-of-methane/gcp_methanecycle/

Stimulus 6

Adapted from Michaud, D 2015, 'Effect of pH on Copper – Lead – Zinc – Iron separation', 911 Metallurgist, <https://www.911metallurgist.com/blog/sequential-cu-pb-zn-flotation>



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