Year 12 Science: Density, pressure and convection in the Earth system

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. A 54 g rock has a volume of 20 cm^3. Find its density.

2. Find the pressure from seawater ($\rho = 1025\ kg\ m^{-3}$) 200 m below the surface, ignoring the air. Use $g = 9.8\ N\ kg^{-1}$.

3. Explain why water under forming sea ice sinks.

4. Which kind of heat transfer carries most heat through the outer core, and which through the crust?

5. Does rising air or sinking air bring cloud, and why?

Exam-style question: hot pools in the Taupō Volcanic Zone

Hot pools in the Taupō Volcanic Zone are fed by rainwater that soaks down through cracks in the rock, is heated deep underground, and returns to the surface.

6. Describe two sources of the heat inside the Earth.

7. Explain how heat is carried from the outer core up through the mantle.

8. Discuss how the rainwater is heated and why it returns to the surface, linking heat transfer, density and pressure.

Fix the mistake

9. Correct this statement: "Hot air rises because heating makes its particles lighter."

10. Correct this statement: "The mantle is a sea of liquid magma, so it convects like water in a pot."

11. Correct this statement: "Heat rises."

12. Correct this statement: "The core stays hot because the Sun's heat soaks down into the Earth."

Answer key (for parents and tutors)

1. A 54 g rock has a volume of 20 cm^3. Find its density.
   $\rho = m \div V = 54 \div 20 = 2.7\ g\ cm^{-3}$.

2. Find the pressure from seawater (ρ = 1025 $kg\ m^{-3}$) 200 m below the surface, ignoring the air. Use g = 9.8 $N\ kg^{-1}$.
   $P = \rho gh = 1025 \times 9.8 \times 200 = 2\,009\,000$ Pa, about 2.0 MPa.

3. Explain why water under forming sea ice sinks.
   Sea ice holds little salt, so the water left behind is saltier and close to freezing, which makes it denser than the water around it.

4. Which kind of heat transfer carries most heat through the outer core, and which through the crust?
   Convection in the liquid outer core; conduction through the rigid crust.

5. Does rising air or sinking air bring cloud, and why?
   Rising air: it moves into lower pressure, expands and cools, so its water vapour condenses into cloud.

6. Describe two sources of the heat inside the Earth.
   Achieved: any two of heat left from Earth's formation (collisions and iron sinking to the core), radioactive decay of uranium, thorium and potassium isotopes releasing energy from their nuclei, and latent heat given out as the outer core freezes onto the inner core.

7. Explain how heat is carried from the outer core up through the mantle.
   Merit: the outer core heats the base of the mantle by conduction; that rock expands, becomes less dense than the rock above and rises; under the plates it loses heat by conduction, becomes denser and sinks, so the convection current carries heat outward. Excellence adds why: rock is a poor conductor, but hot mantle rock can flow, so moving rock carries the heat far faster.

8. Discuss how the rainwater is heated and why it returns to the surface, linking heat transfer, density and pressure.
   Excellence: hot rock above magma several kilometres down heats the water in the cracks by conduction, as fast-vibrating particles of rock collide with water particles. The heated water expands, so it becomes less dense than the cold water above and is pushed up, while cold, denser rainwater sinks in to replace it: a convection loop through the cracks. The high pressure at depth stops the water boiling even above 100 °C; as it rises the pressure falls, so some boils to steam near the surface. Naming conduction or saying hot water rises earns Achieved; the density explanation earns Merit; linking the heat source, conduction, convection and pressure into one chain earns Excellence.

9. Correct this statement: "Hot air rises because heating makes its particles lighter."
   The mass stays the same; the particles spread apart, so the volume increases and the density falls, and denser surroundings push it up.

10. Correct this statement: "The mantle is a sea of liquid magma, so it convects like water in a pot."
    The mantle is solid rock that flows very slowly because it is so hot; only small pockets melt, mostly where pressure drops.

11. Correct this statement: "Heat rises."
    Hot fluid rises because it is less dense; heat itself moves in every direction by conduction and radiation, from hotter to colder.

12. Correct this statement: "The core stays hot because the Sun's heat soaks down into the Earth."
    Sunlight only warms the top few metres; the interior's heat is left from Earth's formation and made by radioactive decay.