InkPhysics

ANSWER BOOK

Fluids: pressure, upthrust and viscosity

Materials · Year 12

CIE 4.3 · OCR A 3.2.4

12 questions · 32 marks

NAVY EDITION

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SECTION A · Warm-up

A1 $p = \rho g h$, where ρ is the density of the fluid, g the gravitational field strength and h the depth below the surface. It does not depend on the shape or width of the container (nor on the total volume of fluid). [2]

A2 $p = \rho g h = 1000 \times 9.81 \times 2.5 = 24525$ Pa $\approx 2.5 \times 10^4$ Pa. [2]

A3 Upthrust is the upward force a fluid exerts on a body in it, caused by pressure on the lower surface exceeding pressure on the upper surface. It equals the weight of fluid displaced by the body. [2]

SECTION B · Standard

B1 Upthrust = weight of water displaced = $\rho V g = 1000 \times 3.0 \times 10^{-4} \times 9.81 = 2.9$ N. [3]

B2 $p = \rho g h = 1025 \times 9.81 \times 30 = 301658$ Pa $\approx 3.0 \times 10^5$ Pa. Atmospheric pressure acting on the sea surface must be added for the total. [3]

B3 Pressure in a fluid increases with depth, so the pressure on the object's lower surface is greater than on its upper surface. The upward push on the bottom exceeds the downward push on the top, leaving a net upward force. [2]

B4 Floating: $\rho_{ice} V_{whole} g = \rho_{water} V_{sub} g$, so $V_{sub}/V_{whole} = 920/1000 = 0.92$. About 92% of the iceberg is submerged. [3]

B5 The sphere must be small and moving slowly enough that the flow around it is laminar (no turbulence), in a fluid of uniform viscosity. [2]

SECTION C · Stretch

C1 $F = 6\pi\eta r v = 6\pi \times 0.25 \times 1.5 \times 10^{-3} \times 0.12 = 8.48 \times 10^{-4}$ N $\approx 8.5 \times 10^{-4}$ N. [3]

C2 At terminal velocity, drag = weight − upthrust = 1.8×10^{-4} N. From Stokes' law, $v = F/6\pi\eta r = 1.8 \times 10^{-4} / (6\pi \times 0.85 \times 1.0 \times 10^{-3}) = 0.011$ m s^{-1} $\approx 1.1 \times 10^{-2}$ m s^{-1}. [4]

C3 $h = p/\rho g = 101000/(1000 \times 9.81) = 10.3$ m ≈ 10 m. Every 10 m of water adds about one atmosphere, so a diver at 20 m experiences roughly three atmospheres in total: two from the water plus one from the air above it. [3]

C4 The sphere must reach terminal velocity before the first mark, or the measured speed is not the steady Stokes' law speed; placing the marks deep allows the acceleration phase to finish. Viscosity falls steeply as temperature rises, so a result without its temperature cannot be compared with any other. [3]