IG.P10 Density, Pressure in Liquids and Change of State

EDEXCEL 4PH1 · Calculator allowed · about 60 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Define density as it is used in the context of solids and liquids, giving the equation and naming each symbol.

(Total for Question 1 is 1 mark)

2 State the density of water used for simple comparisons at standard conditions, and give its units.

(Total for Question 2 is 1 mark)

3 A small metal cube used in a school test has mass 0.48 kg and volume 60 cm^3. Calculate its density in kg/m^3.

(Total for Question 3 is 1 mark)

4 An object floats on oil but sinks in water. Explain, using density ideas, what this tells you about the density of the object compared with oil and water.

(Total for Question 4 is 2 marks)

5 Define pressure in a liquid at a depth and state the equation linking pressure, depth, fluid density and gravitational field strength, naming symbols.

(Total for Question 5 is 2 marks)

6 A diver swims at a depth of 12 m in seawater with density 1025 kg/m^3. Calculate the increase in pressure due to the water at that depth. Use g = 9.8 N/kg. Give your answer in Pa.

(Total for Question 6 is 3 marks)

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7 Explain why the pressure at the base of a tall tank of mercury is greater than at the base of a tall tank of water of the same depth, using the $p = h \rho g$ equation and particle ideas.

(Total for Question 7 is 3 marks)

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8 A sealed container has two immiscible liquid layers of equal depth 0.20 m. The lower layer is oil with density 850 kg/m^3 and the upper layer is water with density 1000 kg/m^3. Calculate the pressure at the interface between the oil and water due to the oil alone. Use g = 9.8 N/kg. Give your answer in Pa.

(Total for Question 8 is 2 marks)

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9 State a typical value for atmospheric pressure at sea level and give its units.

(Total for Question 9 is 1 mark)

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10 A block of aluminium of mass 270 g is heated, and its temperature rises from 20 degrees C to 80 degrees C. The specific heat capacity of aluminium is 900 J/kg degrees C. Calculate the energy required to heat the block. Show equation, substitution and final answer with units.

(Total for Question 10 is 3 marks)

11 A student uses 500 g of water at 20 degrees C and supplies 9,000 J of energy. Calculate the final temperature of the water. Use specific heat capacity of water as 4200 J/kg degrees C. Show equation, substitution and final answer with units.

(Total for Question 11 is 4 marks)

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12 Ice of mass 0.25 kg at 0 degrees C is melted to water at 0 degrees C. The specific latent heat of fusion of ice is 3.34×10^5 J/kg. Calculate the energy required. Show equation, substitution and final answer with units.

(Total for Question 12 is 3 marks)

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13 A kettle contains 0.35 kg of water at 100 degrees C and some of the water is converted to steam at 100 degrees C. If 4.6×10^5 J of energy is supplied to the kettle to boil water into steam, calculate the mass of water that becomes steam. Use specific latent heat of vaporisation L = 2.26×10^6 J/kg. Show equation, substitution and final answer with units.

(Total for Question 13 is 3 marks)

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14 Explain, using particle ideas, why the temperature of a substance stays constant during melting or boiling even while energy is still being supplied. Give four distinct points.

(Total for Question 14 is 4 marks)

15 A small sample of an unknown metal has volume 15.0 cm^3 and mass 120 g. Calculate its density in kg/m^3 and suggest which metal it could be from this list: aluminium (2700 kg/m^3), copper (8900 kg/m^3), iron (7800 kg/m^3), zinc (7100 kg/m^3). Show your working and final answer.

(Total for Question 15 is 3 marks)

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16 A cube of plastic has edge length 6.0 cm and density 950 kg/m^3. Calculate the mass of the cube in grams. Show equation, substitution and final answer with units.

(Total for Question 16 is 2 marks)

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17 Using $p = h \rho g$, calculate how much the pressure increases per metre depth in freshwater (ρ = 1000 kg/m^3). Give your answer in Pa per metre. Use g = 9.8 N/kg.

(Total for Question 17 is 2 marks)

Mark scheme · IG.P10 Density, Pressure in Liquids and Change of State

Question 1

- **B1** ρ = mass / volume, with ρ = density, mass = mass (kg) and volume = volume (m^3) or equivalent units
- **Answer: ρ = mass / volume, where ρ is density, mass is mass and volume is volume**

Question 2

- **B1** 1000 kg/m^3
- **Answer: 1000 kg/m^3**

Question 3

- **M1** convert 60 cm^3 to m^3 = 60 x 10^{-6} m^3 or 6.0 x 10^{-5} m^3
- **A1** density = 0.48 / 6.0 x 10^{-5} = 8000 kg/m^3 cao
- **Answer: 8000 kg/m^3**

Question 4

- **B1** floats on oil means object density < density of oil
- **B1** sinks in water means object density > density of water
- **Answer: Object density is less than oil density but greater than water density**

Question 5

- **B1** p = h x ρ x g with p = pressure, h = depth, ρ = fluid density, g = gravitational field strength
- **B1** states that pressure increases with depth and with fluid density
- **Answer: p = h ρ g, where p is pressure, h depth, ρ fluid density and g gravitational field strength; pressure increases with depth and density**

Question 6

- **M1** writes p = h ρ g
- **M1** substitutes p = 12 x 1025 x 9.8
- **A1** p = 120,540 Pa (give or take rounding) cao
- **Answer: 1.21 x 10^5 Pa (120540 Pa)**

Question 7

- **B1** states p = h ρ g and that h and g are same so difference is ρ
- **B1** mercury has higher density (more mass per unit volume) than water
- **B1** therefore weight of column above base is greater, so pressure at base is greater
- **Answer: Because mercury has a larger density, the term ρ is bigger so p = h ρ g is larger; a denser fluid means more mass in the same column and therefore more weight on the base**

Question 8

- **M1** uses p = h ρ g with h = 0.20, ρ = 850, g = 9.8
- **A1** p = 0.20 x 850 x 9.8 = 1666 Pa (rounding acceptable) cao
- **Answer: Approximately 1.67 x 10^3 Pa (1666 Pa)**

Question 9

- **B1** 1.01 x 10^5 Pa or 101,325 Pa
- **Answer: 1.01 x 10^5 Pa (approximately 101,325 Pa)**

Question 10

- **M1** writes E = m c DeltaT
- **M1** substitutes m = 0.270 kg, c = 900, DeltaT = 60 so E = 0.270 x 900 x 60
- **A1** E = 14,580 J cao with units
- **Answer: E = 1.46 x 10^4 J (14,580 J)**

Question 11

- **M1** writes E = m c DeltaT
- **M1** substitutes E = 9000, m = 0.500 kg, c = 4200 so 9000 = 0.500 x 4200 x DeltaT
- **M1** rearranges to DeltaT = 9000 / (0.500 x 4200)
- **A1** DeltaT = 4.29 degrees C so final temperature = 24.29 degrees C cao
- **Answer: Final temperature = about 24.3 degrees C**

Question 12

- **M1** writes E = m L
- **M1** substitutes m = 0.25, L = 3.34 x 10^5 so E = 0.25 x 3.34 x 10^5
- **A1** E = 8.35 x 10^4 J cao
- **Answer: E = 8.35 x 10^4 J (83,500 J)**

Question 13

- **M1** writes E = m L and rearranges to m = E / L
- **M1** substitutes m = 4.6 x 10^5 / 2.26 x 10^6
- **A1** m = 0.2035 kg (allow awrt 0.204 kg) cao
- **Answer: Approximately 0.204 kg of water becomes steam**

Question 14

- **B1** states that supplied energy is used to break bonds or overcome attractive forces between particles rather than increase kinetic energy
- **B1** states that average kinetic energy of particles (and so temperature) stays the same while bonds are being broken
- **B1** mentions change of arrangement or spacing of particles, e.g. particles move further apart when melting or boiling
- **B1** links these points to latent heat, energy required per kg for the change of state
- **Answer: Energy goes into breaking intermolecular forces and increasing particle separation rather than raising particle kinetic energy, so temperature stays constant during the change of state; this energy per kg is the latent heat**

Question 15

- **M1** converts mass to kg and volume to m^3: m = 0.120 kg, V = 15.0 x 10^{-6} m^3
- **M1** computes density = m / V = 0.120 / 15.0e-6 = 8000 kg/m^3
- **A1** identifies closest metal as iron (7800 kg/m^3) or states value 8000 kg/m^3 and suggests iron as reasonable match
- **Answer: Density = 8.00 x 10^3 kg/m^3, suggests iron as the closest match**

Question 16

- **M1** calculates volume = 6.0^3 cm^3 = 216 cm^3 = 216 x 10^{-6} m^3
- **A1** mass = density x volume = 950 x 216e-6 = 0.2052 kg = 205.2 g cao
- **Answer: Mass = 205.2 g**

Question 17

- **M1** uses p/h = ρ g = 1000 x 9.8
- **A1** pressure increases by 9,800 Pa per metre cao
- **Answer: Pressure increases by 9,800 Pa per metre**