S3 Integrated Science Practice Paper | density and floating, circuits, photosynthesis, pH, pressure, heat

Junior Secondary Integrated Science

S3 Integrated Science practice paper with answers: density and floating, circuits, photosynthesis, pH, pressure and heat capacity.

Question 1 Density and floating

A wooden block has a mass of 24.0 g and a volume of 30 cm3. A metal block has a mass of 270 g and a volume of 100 cm3. Take the density of water as 1.00 g/cm3.

#	Question	Answer and marking notes
1	(a) Find the density of the wooden block and state whether it floats or sinks in water.	Answer: density = 24.0 / 30 = 0.80 g/cm3, which is less than 1.00 g/cm3, so the block floats.
2	(b) When the wooden block floats, what volume of it is under water, and what volume stays above water?	Answer: submerged volume = 30 x (0.80 / 1.00) = 24 cm3; above water = 30 - 24 = 6 cm3.
3	(c) Find the density of the metal block and explain why it sinks in water.	Answer: density = 270 / 100 = 2.70 g/cm3. The upthrust from the water it displaces is less than its weight, so the block sinks.
4	(d) The same block is placed in salt water of density 1.05 g/cm3. How does the submerged volume change? Explain.	Answer: submerged volume = 30 x (0.80 / 1.05), about 22.9 cm3, slightly less than the 24 cm3 in pure water, because denser salt water needs a smaller displaced volume for the same upthrust.

Question 2 Series and parallel circuits

Two resistors of 6 ohm and 12 ohm are connected to a supply of 9 V.

#	Question	Answer and marking notes
5	(a) The resistors are connected in series. Find the total resistance and the current.	Answer: total resistance = 6 + 12 = 18 ohm; current = 9 / 18 = 0.5 A.
6	(b) Find the power of each resistor in the series circuit and the total power supplied.	Answer: P1 = 0.5^2 x 6 = 1.5 W; P2 = 0.5^2 x 12 = 3.0 W; total = 9 x 0.5 = 4.5 W, equal to the sum of the two.
7	(c) The resistors are now connected in parallel. Find the total resistance and the current in each.	Answer: parallel resistance = (6 x 12) / (6 + 12) = 4.0 ohm; I1 = 9 / 6 = 1.5 A, I2 = 9 / 12 = 0.75 A, total 2.25 A.
8	(d) With the same supply, how many times larger is the total power in parallel than in series? Explain.	Answer: parallel total power = 9 x 2.25 = 20.25 W, which is 4.5 times the 4.5 W in series, because the parallel network has a lower resistance and draws a larger current at the same voltage.

Question 3 Photosynthesis and energy in food chains

Photosynthesis is 6CO2 + 6H2O -> C6H12O6 + 6O2. In a food chain the producers fix 200000 kJ, and only ten per cent of the energy passes to each higher trophic level.

#	Question	Answer and marking notes
9	(a) Check that the numbers of carbon, hydrogen and oxygen atoms balance on both sides.	Answer: left side C = 6, H = 12, O = 6 x 2 + 6 x 1 = 18; right side C = 6, H = 12, O = 6 + 6 x 2 = 18. All three elements balance, so the equation is balanced.
10	(b) Find the relative molecular mass of glucose (C = 12, H = 1, O = 16).	Answer: Mr = 6 x 12 + 12 x 1 + 6 x 16 = 180.
11	(c) Find the energy available to the tertiary consumer and the overall transfer efficiency.	Answer: primary consumer 20000 kJ, secondary 2000 kJ, tertiary 200 kJ; overall efficiency = 200 / 200000 x 100 = 0.10 per cent.
12	(d) One pondweed releases 40 bubbles per minute at 10 cm from a lamp but only 10 at 20 cm. Predict the rate at 40 cm and explain.	Answer: doubling the distance reduces the light intensity to one quarter, because intensity falls with the square of the distance, so only about 2.5 bubbles per minute are produced at 40 cm; the bubble rate measures the rate of photosynthesis, which falls as the light dims.

Question 4 Neutralisation and pH

Hydrochloric acid of concentration 0.10 M is used to neutralise 25.0 cm3 of sodium hydroxide solution: HCl + NaOH -> NaCl + H2O.

#	Question	Answer and marking notes
13	(a) Find the number of moles of HCl in 25.0 cm3 of 0.10 M acid.	Answer: moles = 0.10 x 0.0250 dm3 = 0.0025 mol.
14	(b) If the sodium hydroxide has a concentration of 0.2 M, what volume is needed to neutralise it?	Answer: the 1 to 1 ratio needs 0.0025 mol of NaOH; volume = 0.0025 / 0.2 = 0.0125 dm3 = 12.5 cm3.
15	(c) A solution of pH 2 is diluted a hundred times with water. What is the new pH?	Answer: diluting a hundred times reduces the hydrogen ion concentration a hundredfold, so pH rises by two units to 4.
16	(d) Write the ionic equation for the neutralisation, name the salt formed, and state the colour change of methyl orange at the end point.	Answer: H+ + OH- -> H2O; the salt is sodium chloride; methyl orange changes from red to yellow as the solution goes from acidic to neutral.

Question 5 Pressure in solids and liquids

A student of weight 600 N stands with both feet on the floor, the total contact area being 0.02 m2. Take the density of water as 1000 kg/m3 and g as 10 m/s2.

#	Question	Answer and marking notes
17	(a) What pressure does the student exert on the floor when standing on both feet?	Answer: pressure = 600 / 0.02 = 30000 Pa.

#	Question	Answer and marking notes
18	(b) What is the pressure when the student stands on one foot only? Explain.	Answer: pressure = 600 / 0.01 = 60000 Pa. The weight is unchanged but the area is halved, so the pressure doubles.
19	(c) Find the pressure due to the water alone at a depth of 1.5 m in a pool.	Answer: pressure = 1000 x 10 x 1.5 = 15000 Pa.
20	(d) What is the total pressure there if atmospheric pressure is 101000 Pa? Why must a diver rise slowly?	Answer: total pressure = 15000 + 101000 = 116000 Pa. Rising too fast makes dissolved gas come out of solution as bubbles that block blood vessels, so a diver must ascend slowly.

Question 6 Specific heat capacity and heat transfer

The specific heat capacity of water is 4200 J/(kg degC). Ignore heat losses.

#	Question	Answer and marking notes
21	(a) How much energy is needed to heat 0.50 kg of water from 20 degC to 100 degC?	Answer: temperature rise = 100 - 20 = 80 degC; energy = 0.50 x 4200 x 80 = 168000 J.
22	(b) A kettle rated at 2000 W heats the same amount of water. What is the shortest time needed?	Answer: time = 168000 / 2000 = 84 s, about 1.4 minutes; in practice it takes longer because some energy is lost to the surroundings.
23	(c) 0.20 kg of water at 90 degC is mixed with 0.30 kg of water at 20 degC. Find the final temperature.	Answer: heat lost by the hot water equals heat gained by the cold water, so the mixture reaches (0.20 x 90 + 0.30 x 20) / 0.50 = 48 degC.
24	(d) Give one example each of conduction, convection and radiation, and explain how a vacuum flask reduces all three.	Answer: conduction, a metal spoon handle warms in hot tea; convection, an air conditioner circulates room air; radiation, sunlight warms your skin. A vacuum flask has a vacuum between two glass walls to stop conduction and convection, silvered walls to reflect radiation, and a cork stopper to cut conduction at the neck.