S2 Integrated Science Practice Paper 1 with Answers

Science · S2 · Data-response

S2 integrated science practice paper on heat transfer, circuits, sound and light, density, neutralisation and ecosystem energy flow, with full answers and mark scheme.

1. Heat transfer and specific heat capacity (16 marks)

0.50 kg of water is heated from 20 °C to 50 °C. The specific heat capacity of water is 4200 J/(kg·K). The kettle is rated 1500 W; 70% of the energy heats the water and the rest is lost.

#	Question	Answer and marking notes
1	Calculate the energy gained by the water, in kJ.	Answer: E = mcΔT = 0.50 × 4200 × 30 = 63000 J = 63 kJ.
2	Calculate the time in seconds needed to heat the water to 50 °C.	Answer: useful power = 1500 × 70% = 1050 W; t = 63000 ÷ 1050 = 60 s.
3	The kettle loses 20 J each second. Find the energy lost in 5 minutes and its percentage of the energy gained by the water.	Answer: 5 minutes = 300 s, loss = 20 × 300 = 6000 J; percentage = 6000 ÷ 63000 × 100% = 9.5%.
4	Explain why a metal spoon gets hot faster than a wooden spoon in hot water.	Answer: metals contain free electrons that carry energy quickly by conduction; wood is an insulator that transfers heat mainly by particle vibration, which is much slower.

2. Resistance, electrical power and running cost (16 marks)

A 6 Ω and a 3 Ω resistor are connected to a 12 V supply. In another circuit a 100 W lamp is used 5 hours a day for 30 days; electricity costs $1.2 per kWh.

#	Question	Answer and marking notes
5	Find the equivalent resistance of the two resistors in parallel.	Answer: 1/R = 1/6 + 1/3 = 1/2, so R = 2.0 Ω.
6	In parallel, find the total current from the supply and the current through the 3 Ω resistor.	Answer: I = 12 ÷ 2.0 = 6.0 A; the 3 Ω resistor has 12 V across it, so I = 12 ÷ 3 = 4.0 A (the 6 Ω takes 2.0 A).
7	The two resistors are now in series; find the total resistance and the power delivered by the supply.	Answer: R = 6 + 3 = 9 Ω; I = 12 ÷ 9 = 1.33 A; P = VI = 12 × 1.33 = 16.0 W.
8	Calculate the energy used by the lamp over 30 days in kWh and the cost.	Answer: energy = 0.100 kW × 5 h × 30 = 15 kWh; cost = 15 × 1.2 = $18.0.

3. Sound and reflection of light (17 marks)

The echo of a sound is heard 1.5 s after it is made; the speed of sound in air is 340 m/s. A tuning fork of 170 Hz is sounded, and light falls on a plane mirror at 35° to the normal.

#	Question	Answer and marking notes
9	Calculate the distance between the source and the reflecting surface.	Answer: the sound travels there and back in 1.5 s, so one way takes 0.75 s; d = 340 × 0.75 = 255 m.
10	Find the wavelength of the sound made by the tuning fork.	Answer: λ = v ÷ f = 340 ÷ 170 = 2.0 m.
11	Find the angle of reflection and the angle between the incident and reflected rays.	Answer: angle of reflection = angle of incidence = 35°; angle between the rays = 35 + 35 = 70°.
12	Explain why astronauts on the surface of the Moon cannot talk to each other directly.	Answer: the Moon has almost no atmosphere; sound needs a medium to carry vibrations and cannot travel through vacuum, so radio must be used.

4. Particle model, density and solutions (16 marks)

A metal block has a mass of 240 g and a volume of 30 cm³. There is 200 g of salt solution containing 12% sodium chloride by mass; half of the water is then evaporated.

#	Question	Answer and marking notes
13	Calculate the density of the metal.	Answer: ρ = m ÷ V = 240 ÷ 30 = 8.0 g/cm³.
14	Find the mass of sodium chloride and of water in the solution.	Answer: salt = 200 × 12% = 24 g; water = 200 − 24 = 176 g.
15	After half the water has evaporated, find the new percentage by mass of sodium chloride.	Answer: 88 g of water remains; percentage = 24 ÷ (24 + 88) × 100% = 21.4%.
16	Use the particle model to explain why the temperature stays at 0 °C while ice melts.	Answer: the energy supplied overcomes the forces between particles so that they can slide past one another; the average kinetic energy does not rise, so the temperature stays constant.

5. Neutralisation and dilution (18 marks)

25.0 cm³ of 0.10 M sodium hydroxide is titrated with hydrochloric acid to the end point. A solution of pH 3 is diluted 100 times with water.

#	Question	Answer and marking notes
17	Calculate the amount in moles of sodium hydroxide used.	Answer: n = 0.10 × 0.0250 = 0.0025 mol.
18	Find the volume of 0.10 M hydrochloric acid needed to neutralise it.	Answer: the ratio is 1:1, so n(HCl) = 0.0025 mol; V = 0.0025 ÷ 0.10 = 0.0250 dm³ = 25.0 cm³.
19	If 0.050 M hydrochloric acid is used instead, find the volume needed.	Answer: V = 0.0025 ÷ 0.050 = 0.0500 dm³ = 50.0 cm³; halving the concentration doubles the volume.

#	Question	Answer and marking notes
20	Find the pH of the diluted solution and explain your answer.	Answer: pH 3 means $[H^+] = 1 \times 10^{-3}$ M; after a 100-fold dilution it is 1×10^{-5} M, so pH = 5 - less acidic but still acidic.

6. Ecosystems and energy flow (17 marks)

In a grassland ecosystem the producers fix 20000 kJ of energy and 10% of the energy passes to each next trophic level. Water plants release 12 cm^3 of oxygen per square metre per hour; the total leaf area is 0.5 m^2 with 8 hours of sunlight.

#	Question	Answer and marking notes
21	Calculate the energy available to the primary, secondary and tertiary consumers in kJ.	Answer: 2000 kJ, 200 kJ and 20 kJ (each step keeps 10%).
22	Why does a food chain usually have no more than four or five trophic levels?	Answer: only about one tenth of the energy is passed on; the rest is lost in respiration, excretion and uneaten material, so too little reaches higher levels to support more consumers.
23	Calculate the total volume of oxygen produced during the sunny period.	Answer: $12 \times 0.5 \times 8 = 48$ cm^3.
24	Predict the effect on the producers and on the secondary consumers if primary consumers greatly decrease.	Answer: fewer producers are eaten so their numbers may rise at first, but nutrient cycling slows; secondary consumers face a food shortage and their numbers fall.