S3 Science Practice Paper (Set 2)

S3 | Science | Time: 60 minutes | Total: 100 marks | 24 questions

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Part 1: Neutralisation and pH (18 marks)

Show the working, the substitution and the unit in every answer.

1. Hydrochloric acid of 0.20 M is used to neutralise 25.0 cm3 of 0.10 M sodium hydroxide solution. Find (a) the number of moles of sodium hydroxide, and (b) the volume of hydrochloric acid needed in cm3.

Answer: (a) n = c x V = 0.1 x 0.0250 = 0.0025 mol. (b) NaOH + HCl -> NaCl + H2O is 1:1, so 0.0025 mol of HCl is needed; volume = n / c = 0.0025 / 0.2 = 12.5 cm3.

2. A solution has pH 3. (a) Find its hydrogen ion concentration. (b) Find the new pH after the solution is diluted 100 times.

Answer: (a) [H+] = 10^(-3) = 1.0 x 10^-3 mol/dm3. (b) After diluting 100 times, [H+] = 10^-5 mol/dm3, so pH = 5.

3. 20.0 cm3 of 0.15 M sulfuric acid is neutralised by 0.30 M sodium hydroxide solution. Find the volume of sodium hydroxide solution needed.

Answer: Sulfuric acid: n = 0.15 x 0.0200 = 0.0030 mol. Each mole of H2SO4 gives 2 mol H+, so H+ = 0.0060 mol. H2SO4 + 2NaOH -> Na2SO4 + 2H2O needs 0.0060 mol NaOH; volume = 0.0060 / 0.3 = 0.0200 dm3 = 20.0 cm3.

4. Rain sample A has pH 4.0 and sample B has pH 5.5. How many times greater is the hydrogen ion concentration of A than that of B?

Answer: [H+]A = 10^-4.0 and [H+]B = 10^-5.5. Ratio = 10^(5.5 - 4.0) = 10^1.5 = 31.6 times, so A is about 32 times more acidic.

Part 2: Electric Heating and Electricity Cost (17 marks)

Show the formula and the unit; electricity costs $1.20 per kWh.

5. An electric kettle rated at 2,000 W runs for 15 minutes for each boil. Find the energy used per boil in kWh.

Answer: Power = 2.0 kW and time = 15 / 60 = 0.25 h. Energy = 2.0 x 0.25 = 0.50 kWh.

6. Using the previous result, find the monthly energy use and the monthly cost if the kettle is used once a day for 30 days.

Answer: Monthly energy = 0.50 x 30 = 15.0 kWh. Cost = 15.0 x 1.20 = $18.00.

7. A current of 3 A passes through a 20 ohm resistor for 5 minutes. Find (a) the power, and (b) the heat produced in kJ.

Answer: (a) P = I^2 R = 3^2 x 20 = 180 W. (b) t = 5 x 60 = 300 s, so E = 180 x 300 = 54,000 J = 54 kJ.

8. An appliance rated at 220 V, 1,500 W is protected by a fuse. Find the operating current and choose the most suitable fuse from 5 A, 10 A and 13 A, giving a reason.

Answer: Current = 1500 / 220 = 6.8 A. Choose 10 A: it is just above 6.8 A so it does not blow in normal use; a 5 A fuse would blow constantly and a 13 A fuse is too large to protect the circuit.

Part 3: Sound Waves (16 marks)

Take the speed of sound in air as 340 m/s and the speed of light as 3.0 x 10^8 m/s.

9. A sound has a frequency of 170 Hz. Find its wavelength.

Answer: v = f x wavelength, so wavelength = 340 / 170 = 2.0 m.

10. A student shouts towards a cliff and hears the echo 2.4 s later. Find the distance to the cliff.

Answer: The sound travels there and back, so one way takes 2.4 / 2 = 1.2 s. Distance = 340 x 1.2 = 408 m.

11. A tuning fork vibrates 500 times per second. Find (a) the frequency, and (b) the period.

Answer: (a) 500 vibrations per second means f = 500 Hz. (b) T = 1 / f = 1 / 500 = 0.002 s.

12. Thunder is heard 3.0 s after the lightning is seen. Find the distance to the strike and explain why the travel time of light can be ignored.

Answer: Distance = 340 x 3.0 = 1,020 m, about 1.0 km. Light needs only about 3.4e-06 s to cover 1,020 m, far less than 3.0 s, so it can be ignored.

Part 4: Reflection, Refraction and Colour (17 marks)

Show the working; all angles are measured from the normal.

13. A ray hits a plane mirror with an angle of incidence of 35 degrees. Find (a) the angle of reflection, and (b) the angle between the incident ray and the reflected ray.

Answer: (a) Angle of reflection = angle of incidence = 35 degrees. (b) The rays lie on opposite sides of the normal, so the angle between them is 35 + 35 = 70 degrees.

14. Light enters glass from air with an angle of incidence of 30 degrees and refracts at 19 degrees. Find the refractive index of the glass.

Answer: n = sin i / sin r = sin 30 / sin 19 = 0.500 / 0.326 = 1.54. The ray bends towards the normal when entering a denser medium, so a value above 1 is expected.

15. A 3 cm pencil stands 12 cm in front of a plane mirror. Find (a) the image distance from the mirror, (b) the distance between object and image, and (c) the image height.

Answer: (a) The image is as far behind the mirror as the object is in front: 12 cm. (b) Object to image = 12 + 12 = 24 cm. (c) Image height equals object height, 3 cm; it is upright, virtual and laterally inverted.

16. White light is dispersed by a prism. (a) Which colour is deviated most? (b) What colour does blue paper appear under red light? Explain.

Answer: (a) Violet light (about 400 nm) is deviated most and red (about 700 nm) least, so the spectrum spreads from red to violet. (b) It appears black: blue paper reflects only blue light, red light is absorbed and nothing reaches the eye.

Part 5: Solar System, Earth Movement and Moon Phases (16 marks)

Show the working; take the mean orbital radius of the Earth as 1.5 x 10^11 m.

17. Two places differ in longitude by 45 degrees. Find the time difference between them.

Answer: The Earth turns 360 degrees in 24 h, so 15 degrees corresponds to 1 h. Time difference = 45 / 15 = 3 h; the eastern place is ahead.

18. One lunar cycle from new moon to new moon takes about 29.5 days. Find the average number of days between two consecutive principal phases.

Answer: One cycle contains 4 intervals: 29.5 / 4 = 7.4 days. So new moon, first quarter, full moon and last quarter are about 7 days apart.

19. The Earth orbits the Sun in 365.25 days. Estimate the mean orbital speed in m/s.

Answer: Orbit circumference = 2 x pi x 1.5e+11 = 9.42e+11 m. Period = 365.25 x 86,400 = 3.16e+07 s. Speed = 9.42e+11 / 3.16e+07 = 3.0e+04 m/s, about 30 km/s.

20. A year is taken as 365.25 days. (a) How many days are there in four years? (b) What conditions are necessary for a solar eclipse?

Answer: (a) 365.25 x 4 = 1,461 days, so a leap year of 366 days is added every four years. (b) The Moon must lie between the Sun and the Earth on a straight line and its shadow must fall on the Earth; the lunar orbit is tilted by about 5 degrees, so not every new moon gives an eclipse.

Part 6: Classification, Food Chains and Microscopic Measurement (16 marks)

Show the working; relative atomic masses: C = 12, O = 16.

21. Producers in a food chain fix 50,000 kJ of energy. If only 10% of the energy passes to the next trophic level, find the energy at the primary, secondary and tertiary consumer levels.

Answer: Primary consumer = 50,000 x 10% = 5,000 kJ. Secondary = 5,000 x 10% = 500 kJ. Tertiary = 500 x 10% = 50 kJ; the rest is lost in respiration, excretion and heat.

22. List the seven main levels of biological classification from largest to smallest, and state the two parts of a binomial name.

Answer: From largest to smallest: kingdom, phylum, class, order, family, genus, species, seven levels in all. A binomial name is the genus name (capitalised) followed by the specific epithet in lower case, written in italics, for example Homo sapiens.

23. Photosynthesis absorbs 264 g of carbon dioxide. Find (a) the number of moles of carbon dioxide, and (b) the mass of oxygen produced at the same time.

Answer: (a) Molar mass = 12 + 2 x 16 = 44 g/mol, so n = 264 / 44 = 6.0 mol. (b) 6CO2 + 6H2O -> C6H12O6 + 6O2 gives 6.0 mol O2, mass = 6.0 x 32 = 192 g.

24. Cells are viewed through a 10x eyepiece and a 40x objective. A cell measures 20 mm on the micrograph. Find (a) the total magnification, and (b) the actual length of the cell in micrometres.

Answer: (a) Total magnification = 10 x 40 = 400x. (b) Actual length = 20 mm / 400 = 0.05 mm = 50 micrometres.