S3 Integrated Science Practice Paper: Cells and Life Processes, The Particle Model and Changes of State, Acids Bases and Neutralisation, Forces and Motion, Basic Electricity, Energy and Energy Sources

S3 | Science | Time: 75 minutes | Total: 100 marks | 24 questions

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Part 1 Cells and Life Processes

Study the data, show all working and give the answer.

1. Source 1: the eyepiece of a microscope magnifies 10x and the objective lens magnifies 40x. Find the total magnification, and state how the field of view changes if the objective lens is replaced by one with a higher magnification. [4]

Answer: Total magnification = 10 x 40 = 400x. With a higher power objective lens the magnification rises but the field of view becomes smaller and the image appears dimmer.

2. Source 2: a potato strip is placed in distilled water, so the water potential inside and outside the cells differs. State the direction of net water movement, whether the strip becomes firmer or softer, and explain why. [4]

Answer: Water moves by osmosis from the higher water potential (distilled water) into the cells, so the strip becomes firmer (turgid). Pure water outside has the highest water potential, and the cell wall prevents the cell from bursting.

3. Source 3: a potato strip has a mass of 4.80 g before the experiment and 5.28 g after 30 minutes in distilled water. Find the percentage increase in mass. [4]

Answer: Percentage increase = (5.28 - 4.80) / 4.80 x 100% = 10.0%. The mass rises because water enters the cells by osmosis.

4. Source 4: a culture starts with 4 cells and the number of cells doubles every 30 minutes. Find the number of cells after 3 hours and name this type of division. [5]

Answer: Number of divisions = 180 / 30 = 6; cells = 4 x 2^6 = 256. The division is mitosis, and the daughter cells have the same chromosome number as the parent cell.

Part 2 The Particle Model and Changes of State

Study the data, show all working and give the answer.

5. Source 1: a piece of metal has a mass of 270 g and a volume of 100 cm3. Find its density and decide whether it is more likely aluminium (2.7 g/cm3) or iron (7.9 g/cm3). [4]

Answer: Density = 270 / 100 = 2.7 g/cm3, which matches aluminium at 2.7 g/cm3, so the metal is most likely aluminium.

6. Source 2: an ice cube is heated slowly from -10 C to 110 C and its temperature is plotted against time. Identify the two stages where the temperature stays constant, name them, and explain why the temperature does not change. [4]

Answer: The temperature is constant at 0 C (melting) and at 100 C (boiling). The energy supplied breaks the forces between particles or separates them into a gas, so it becomes latent heat instead of raising the average kinetic energy of the particles.

7. Source 3: gas in a sealed cylinder has a pressure of 100 kPa at 300 K. If the cylinder is heated to 360 K at constant volume, find the new pressure and name the gas law used. [4]

Answer: At constant volume P is proportional to T, so P2 = 100 x 360 / 300 = 120 kPa. The law used is the pressure law (Gay-Lussac law).

8. Source 4: one drop of ink is added to water at 20 C and another to water at 80 C. Use the particle model to explain why the ink spreads faster in the hot water. [4]

Answer: At the higher temperature the particles have greater average kinetic energy and move faster, so random collisions are more frequent and the ink particles spread out evenly more quickly.

Part 3 Acids, Bases and Neutralisation

Study the data, show all working and give the answer.

9. Source 1: solution A has a pH of 2.0 and solution B has a pH of 5.0. State which solution is more acidic and find the ratio of their hydrogen ion concentrations. [4]

Answer: The lower the pH the more acidic the solution, so solution A is more acidic. The ratio of [H+] is 10^(5 - 2) = 1000, so solution A is 1000 times more concentrated in hydrogen ions.

10. Source 2: 25.0 cm3 of sodium hydroxide solution of concentration 0.100 M needs 20.0 cm3 of hydrochloric acid for complete neutralisation. Find the concentration of the acid. [4]

Answer: NaOH and HCl react in a 1:1 ratio: moles = 0.100 x 25.0 / 1000 = 0.002500 mol, so the acid concentration is 0.125 M.

11. Source 3: calcium carbonate is CaCO3 (relative atomic masses: Ca = 40, C = 12, O = 16). Find its relative formula mass and write the balanced equation for its reaction with dilute hydrochloric acid. [4]

Answer: Relative formula mass = 40 + 12 + 3 x 16 = 100. Equation: CaCO3 + 2HCl -> CaCl2 + H2O + CO2, so each mole of calcium carbonate gives one mole of carbon dioxide.

12. Source 4: 10.0 g of calcium carbonate reacts with excess dilute hydrochloric acid (molar volume of gas at room temperature is 24 dm3/mol). Find the mass and the volume of carbon dioxide produced. [5]

Answer: Moles = 10.0 / 100 = 0.100 mol; mass of CO2 = 0.100 x 44 = 4.40 g; volume = 0.100 x 24 = 2.4 dm3.

Part 4 Forces and Motion

Study the data, show all working and give the answer (take g = 10 N/kg).

13. Source 1: a student runs 150 m in 12 s. Find the average speed in m/s and in km/h. [4]

Answer: Average speed = 150 / 12 = 12.5 m/s; in km/h = 12.5 x 3.6 = 45 km/h.

14. Source 2: a force of 240 N acts perpendicular to a surface of area 0.06 m2. Find the pressure on the surface in Pa. [4]

Answer: Pressure = force / area = 240 / 0.06 = 4000 Pa, that is 4.0 kPa.

15. Source 3: a 3 kg object on a smooth horizontal surface is pushed by a net force of 12 N. Find its acceleration, and state how the acceleration changes if the net force doubles while the mass stays the same. [4]

Answer: Acceleration = F / m = 12 / 3 = 4 m/s2. Since a = F/m, doubling the net force doubles the acceleration to 8 m/s2.

16. Source 4: a worker raises a 20 kg bag steadily through 3 m in 4 s. Find the work done and the average power. [5]

Answer: Work done = mgh = 20 x 10 x 3 = 600 J; average power = 600 / 4 = 150 W.

Part 5 Basic Electricity

Study the data, show all working and give the answer.

17. Source 1: the voltage across a resistor is 6 V and its resistance is 12 ohms. Find the current through it. [4]

Answer: From V = IR, I = 6 / 12 = 0.5 A.

18. Source 2: resistors of 4 ohms and 6 ohms are connected in series to a 12 V supply. Find the total resistance, the current, and the voltage across the 4 ohm resistor. [4]

Answer: Total resistance = 4 + 6 = 10 ohms; current = 12 / 10 = 1.2 A; voltage = 1.2 x 4 = 4.8 V.

19. Source 3: a 60 W lamp is on for 5 hours a day and electricity costs $1.20 per kWh. Find the daily energy use and the daily cost. [4]

Answer: Energy used = 0.06 kW x 5 h = 0.30 kWh; cost = 0.30 x $1.20 = $0.36.

20. Source 4: two resistors of 6 ohms each are connected in parallel. Find the equivalent resistance and state whether it is larger or smaller than either resistor. [4]

Answer: 1/R = 1/6 + 1/6 = 2/6, so R = 3 ohms, which is smaller than either resistor (6 ohms) because parallel connection provides more paths for current.

Part 6 Energy and Energy Sources

Study the data, show all working and give the answer (take g = 10 N/kg).

21. Source 1: a machine takes in 500 J of energy and produces 150 J of useful output. Find its efficiency. [4]

Answer: Efficiency = useful output / total input x 100% = 150 / 500 x 100% = 30%. The remaining 350 J is lost as heat and sound.

22. Source 2: a 2.0 kg ball is released from rest at a height of 5 m (ignore air resistance). Find its gravitational potential energy at the start and its speed on reaching the ground. [4]

Answer: GPE = mgh = 2.0 x 10 x 5 = 100 J. All of it becomes kinetic energy, so 0.5 x m x v2 = 100 J and v = sqrt(2 x 10 x 5) = 10 m/s.

23. Source 3: consider four energy sources: coal, solar energy, natural gas and wind energy. Classify them as renewable or non-renewable, and give one advantage and one limitation of solar energy. [4]

Answer: Non-renewable: coal and natural gas, which are fossil fuels with limited reserves. Renewable: solar and wind energy. Solar power produces no pollutants when generating electricity, but its output depends on weather, daylight and cloud cover and needs a large area.

24. Source 4: an electric motor has an input power of 2.0 kW and a useful output power of 1.5 kW. Find its efficiency and the energy lost as heat each second. [5]

Answer: Efficiency = 1.5 / 2.0 x 100% = 75%. The power wasted is 2.0 - 1.5 = 0.5 kW = 500 W, that is 500 J of heat lost every second.
