S5 Combined Science Practice Paper: Motion and Forces, Waves and Light, Moles and Concentration, Acids, Alkalis and Titration, Circuits and Electrical Power, Ecology and Energy Flow

S5 | Combined Science | Time: 75 minutes | Total: 100 marks | 24 questions

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Part A - Motion and Forces (20 marks)

Show the formula, substitute the values and give units. Use g = 10 metres per second squared.

1. A car accelerates uniformly from rest to 25 metres per second in 10 seconds. Find its acceleration and the distance travelled in these 10 seconds. [5]

Answer: Acceleration = (25 - 0) / 10 = 2.5 metres per second squared; distance = 0.5 x 2.5 x 10^2 = 125 m.

2. The car above has a mass of 1,200 kg and friction on it is 500 N. What thrust must the engine provide to give 2.5 metres per second squared? [5]

Answer: Net force = 1,200 x 2.5 = 3,000 N; thrust = 3,000 + 500 = 3,500 N.

3. A 0.5 kg ball is dropped from a height of 1.8 m. Find its speed and kinetic energy on reaching the ground, ignoring air resistance. [5]

Answer: Speed = square root of (2 x 10 x 1.8) = 6 metres per second; kinetic energy = 0.5 x 0.5 x 6^2 = 9 J.

4. A 2 kg object moving at 3 metres per second hits a stationary 1 kg object and they stick together. Find their common speed and the kinetic energy lost in the collision. [5]

Answer: By conservation of momentum, 2 x 3 = 3 x v so v = 2 metres per second; kinetic energy is 9 J before and 6 J after, so 3 J is lost.

Part B - Waves and Light (18 marks)

Give frequency in hertz and wavelength in metres; give angles to one decimal place.

5. A sound wave has a frequency of 250 Hz and a wavelength of 1.36 m in air. Find the speed of sound. [4]

Answer: Speed = frequency x wavelength = 250 x 1.36 = 340 metres per second.

6. Light enters water at an angle of incidence of 45 degrees; the refractive index of water is 1.33. Find the angle of refraction. [5]

Answer: By Snell law, sin r = sin 45 degrees / 1.33 = 0.532, so r is about 32.1 degrees.

7. A ship sonar sends an ultrasound pulse and receives the echo from the seabed after 0.08 s. Ultrasound travels at 1,500 metres per second in water; find the depth. [4]

Answer: Round-trip distance = 1,500 x 0.08 = 120 m; depth = 120 / 2 = 60 m.

8. An object is 10 cm in front of a convex lens and the image forms 30 cm behind the lens. Find the focal length and the magnification. [5]

Answer: 1/f = 1/10 + 1/30 = 0.1333, so f = 7.5 cm; magnification = 30 / 10 = 3.

Part C - Moles and Concentration (18 marks)

Use Ca = 40, C = 12, O = 16, Na = 23, Cl = 35.5 and the Avogadro constant 6.02 x 10^23.

9. Find the molar mass of calcium carbonate and the number of moles in 25 g of it. [4]

Answer: Molar mass = 40 + 12 + 16 x 3 = 100 grams per mole; moles = 25 / 100 = 0.25 mol.

10. 5.85 g of sodium chloride is dissolved in water to make 250 cubic centimetres of solution. Find the concentration in moles per cubic decimetre. [5]

Answer: Moles = 5.85 / 58.5 = 0.1 mol; volume = 0.25 cubic decimetres; concentration = 0.1 / 0.25 = 0.4 moles per cubic decimetre.

11. A reaction has a theoretical yield of 12.0 g but only 9.6 g is obtained. Find the percentage yield. [4]

Answer: Percentage yield = 9.6 / 12.0 x 100 = 80%.

12. At room temperature the molar volume of a gas is 24 cubic decimetres. Find the volume of 0.15 mol of the gas and estimate the number of molecules in it. [5]

Answer: Volume = 0.15 x 24 = 3.6 cubic decimetres; molecules = 0.15 x 6.02 x 10^23 = 9.03 x 10^22.

Part D - Acids, Alkalis and Titration (16 marks)

Show the mole ratio in titration; give energy answers to three significant figures.

13. 25.0 cubic centimetres of sodium hydroxide solution is neutralised by 20.0 cubic centimetres of 0.10 moles per cubic decimetre hydrochloric acid. Find the concentration of the alkali. [4]

Answer: Moles of acid = 20.0 x 0.10 / 1000 = 0.0020 mol and the ratio is 1 to 1; concentration = 0.0020 / 0.025 = 0.08 moles per cubic decimetre.

14. A solution has a hydrogen ion concentration of 1.0 x 10^-3 moles per cubic decimetre. Find its pH, and the pH after it is diluted 100 times with water. [4]

Answer: pH = 3; after diluting 100 times the concentration is 1.0 x 10^-5 and the pH is 5.

15. 50 cubic centimetres of 1.0 moles per cubic decimetre hydrochloric acid is mixed with 50 cubic centimetres of 1.0 moles per cubic decimetre sodium hydroxide and the temperature rises by 6.7 degrees. Taking the specific heat capacity as 4.2 joules per gram per degree and density as 1 gram per cubic centimetre, find the enthalpy of neutralisation in kilojoules per mole. [4]

Answer: Mass is 100 g; energy = 100 x 4.2 x 6.7 = 2,814 J; water formed is 0.05 mol; enthalpy = 2,814 / 0.05 / 1000 = 56.3 kilojoules per mole.

16. How many moles and how many grams of sodium hydroxide are needed to neutralise 0.05 mol of sulphuric acid? (Na = 23, O = 16, H = 1) [4]

Answer: Sulphuric acid has two replaceable hydrogen atoms, so the ratio is 1 to 2 and 0.10 mol of sodium hydroxide is needed; molar mass is 40 grams per mole, so the mass is 0.10 x 40 = 4.0 g.

Part E - Circuits and Electrical Power (16 marks)

Give cost in Hong Kong dollars to two decimal places; take the charge per mole of electrons as 96,500 coulombs.

17. A 4 ohm resistor is connected across a 12 volt battery. Find the current through it. [4]

Answer: I = V / R = 12 / 4 = 3 amperes.

18. A 6 ohm and a 3 ohm resistor are connected in series to a 9 volt battery. Find the current and the voltage across the 6 ohm resistor. [4]

Answer: Total resistance is 9 ohms so the current is 9 / 9 = 1 ampere; the voltage across 6 ohms is 1 x 6 = 6 volts.

19. A 2,000 watt heater runs for 3 hours. Find the energy used in kilowatt hours and the cost at 1.2 Hong Kong dollars per kilowatt hour. [4]

Answer: Energy = 2 x 3 = 6 kilowatt hours; cost = 6 x 1.2 = 7.20 Hong Kong dollars.

20. A current of 2 amperes passes through an electrolytic cell for 30 minutes. Find the charge passed and estimate the number of moles of electrons. [4]

Answer: Time is 1,800 s; charge = 2 x 1,800 = 3,600 coulombs; moles = 3,600 / 96,500 which is about 0.0373 mol.

Part F - Ecology and Energy Flow (12 marks)

Give units with every answer and use 10% for energy transfer efficiency.

21. A cell appears 40 millimetres long under a microscope and its actual length is 0.05 millimetres. Find the magnification. [3]

Answer: Magnification = 40 / 0.05 = 800 times.

22. Complete respiration of each gram of glucose releases 16 kilojoules. Find the total energy released from 5 g of glucose. [3]

Answer: Total energy = 16 x 5 = 80 kilojoules.

23. Producers in a food chain contain 50,000 kilojoules. If only 10% of the energy passes to each next trophic level, find the energy at the primary, secondary and tertiary consumer levels. [3]

Answer: Primary = 5,000 kilojoules; secondary = 500 kilojoules; tertiary = 50 kilojoules.

24. A person breathes 15 times a minute and each breath takes in 500 cubic centimetres of air. Find the volume breathed each minute and each day in cubic decimetres. [3]

Answer: Each minute = 15 x 500 = 7,500 cubic centimetres, which is 7.5 cubic decimetres; each day = 7.5 x 1,440 = 10,800 cubic decimetres.