OCR A Physics: SI units, prefixes and homogeneous equations - solutions

Matching solutions and review cues | Total: 46 marks

Specification points: 2.1.2(a)-(f) - base and derived units, recognised unit symbols, homogeneity, prefixes, and graph/table labelling.

1. A climate chamber logger records the current in a heater, the temperature in the chamber and the amount of gas released. Give the S.I. base-unit symbol for each quantity. [3 marks]

Answer / mark points: current: A; thermodynamic temperature: K; amount of substance: mol.
Review cue: The base unit for temperature is kelvin, not degree Celsius.

2. A student writes these headings in a results spreadsheet: time (ms), potential difference - mV and current / microampere. Rewrite each using the OCR quantity / unit convention. [3 marks]

Answer / mark points: time / ms; potential difference / mV; current / μA. Award one mark per correctly ordered quantity / unit label.
Review cue: Use the slash rather than brackets, a dash or a written-out unit name.

3. A cart travels 0.48 km in 2.4 ms while a sensor records a current of 0.35 mA. Convert all three readings to S.I. units before they are used in a calculation. [3 marks]

Answer / mark points: 0.48 km = 480 m; 2.4 ms = 2.4×10^{-3} s; 0.35 mA = 3.5×10^{-4} A.
Review cue: Write the prefix factor before moving a decimal place.

4. A timing system offers the prefixes p, n, μ, m, c, d, k, M, G and T. Write the symbols in increasing multiplier order. Then state the factor from centi to kilo and from giga to tera. [3 marks]

Answer / mark points: p, n, μ, m, c, d, k, M, G, T. c to k: factor 10^5. G to T: factor 10^3.
Review cue: Prefix symbols are case-sensitive: m and M have very different multipliers.

5. A laser laboratory compares three pulse durations: A = 650 ns, B = 0.80 µs and C = 0.0012 ms. Identify the longest pulse and calculate the difference between the longest and shortest pulses in ns. [3 marks]

Answer / mark points: A = 650 ns, B = 800 ns and C = 1200 ns. C is longest; difference = 1200 - 650 = 550 ns.
Review cue: Convert to one unit before ranking or subtracting values.

6. Two protective coatings have thicknesses 7.5×10^{-9} m and 0.42 µm. Write both using suitable prefixes and state how many times thicker the larger coating is. [3 marks]

Answer / mark points: 7.5×10^{-9} m = 7.5 nm; 0.42 µm = 420 nm. The 0.42 µm coating is 420 / 7.5 = 56 times thicker.
Review cue: A micro-metre is 1000 nano-metres.

7. A high-voltage supply operates at 2.5 kV and provides a current of 0.40 A. Use P = VI to calculate the power in watts and then with a suitable prefix. [3 marks]

Answer / mark points: $V = 2.5 \times 10^{3}$ V. $P = VI = (2.5 \times 10^{3})(0.40) = 1.0 \times 10^{3}$ W = 1.0 kW.
Review cue: Convert a prefixed quantity into SI before substitution.

8. A charge sensor operates at 3.0 mV and transfers 0.24 µC. Use W = VQ to calculate the energy transferred in joules and then with a suitable prefix. [3 marks]

Answer / mark points: $V = 3.0 \times 10^{-3}$ V and $Q = 0.24 \times 10^{-6}$ C. $W = VQ = 7.2 \times 10^{-10}$ J = 0.72 nJ.
Review cue: The product of milli and micro gives a factor of 10^{-9}.

9. A test rig presses a pad with a force of 18 N over an area of 3.0 cm^2. Use p = F / A to calculate the pressure in pascals. State the S.I. base units of pressure. [3 marks]

Answer / mark points: A = 3.0 cm^2 = 3.0 × 10^{-4} m^2. p = 18 / (3.0 × 10^{-4}) = 6.0 × 10^4 Pa. Base units: kg m^{-1} s^{-2}.
Review cue: Area conversions square the length factor: 1 cm^2 = 10^{-4} m^2.

10. A 12.0 cm^3 polymer sample has a mass of 10.2 g. Calculate its density in kg m^{-3} and state the S.I. base units of density. [3 marks]

Answer / mark points: m = 0.0102 kg and V = 1.20 × 10^{-5} m^3. ρ = m / V = 8.50 × 10^2 kg m^{-3} = 850 kg m^{-3}. Base units: kg m^{-3}.
Review cue: Cubic centimetres require a factor of 10^{-6} when converted to cubic metres.

11. A crash-test report says that impulse and momentum can be directly compared. Use I = Ft and p = mv to show that they have the same S.I. base units. [2 marks]

Answer / mark points: I = Ft = (kg m s^{-2})(s) = kg m s^{-1}. p = mv = kg(m s^{-1}) = kg m s^{-1}.
Review cue: This is why impulse can be described as the change in momentum.

12. Energy transferred is given by E = VQ. Potential difference has base units kg m^2 s^{-3} A^{-1} and charge has units A s. Show that the equation gives the base units of energy. [2 marks]

Answer / mark points: VQ = (kg m^2 s^{-3} A^{-1})(A s) = kg m^2 s^{-2}, the base units of energy (J).
Review cue: The A^{-1} and A, and one factor of s, cancel.

13. Use S.I. base units to show that P = Fv is homogeneous, where P is power, F is force and v is speed. [2 marks]

Answer / mark points: Fv = (kg m s^{-2})(m s^{-1}) = kg m^2 s^{-3}, which is the base unit of power. The equation is homogeneous.
Review cue: A conclusion is needed after showing both sides have the same units.

14. For a simple harmonic oscillator, $a = -\omega^2 x$. Show that the base units of a and $\omega^2 x$ are the same. [2 marks]

Answer / mark points: a has units m s^{-2}. ω has s^{-1}, so $\omega^2 x = (s^{-1})^2(m)$ = m s^{-2}. The equation is homogeneous.
Review cue: Angular frequency has the same base unit as frequency: s^{-1}.

15. A trainee writes s = at as the distance travelled from rest. Use units to show why the equation is not homogeneous. Then check that $s = \frac{1}{2}at^2$ is homogeneous. [3 marks]

Answer / mark points: at has units (m s^{-2})(s) = m s^{-1}, not m, so s = at is not homogeneous. at^2 has units (m s^{-2})(s^2) = m, so $s = \frac{1}{2}at^2$ is homogeneous.
Review cue: The numerical factor ½ has no units and does not affect the check.

16. A vehicle damping model uses F = bv. A supplier gives b the units kg m s^{-1}. Use base units to decide whether this can be correct and state the correct units for b. [3 marks]

Answer / mark points: b = F / v = (kg m s^{-2})/(m s^{-1}) = kg s^{-1}. kg m s^{-1} is not correct because it contains an extra metre. Correct units: kg s^{-1}.
Review cue: Derive the units of an unknown constant by rearranging the model in unit form.

17. Two energy models are proposed: E = mc and $E = mc^2$. Use S.I. base units to decide which expression can have the units of energy. [2 marks]

Answer / mark points: mc has units kg m s^{-1}, so it is not energy. mc^2 has units kg$(m\ s^{-1})^2$ = kg m^2 s^{-2}, the base units of energy. Therefore $E = mc^2$ can be an energy model.
Review cue: Checking units cannot prove a model is physically true, but it can rule out an inconsistent one.