SPONSORED BY G-RESEARCH

Intermediate Physics Challenge 2025

MARK SCHEME

[There is a corrected answer to Q7 here]

Note to teachers

The paper is designed to be challenging. Questions based on unfamiliar physics require students to analyse the information given. The mathematical content may involve unfamiliar units. Students are asked to estimate reasonable values and evaluate or justify arguments.

The questions are designed to be accessible to all students independent of exam board or syllabus. If a question is deemed to be unfair due to the particular syllabus studied, teachers are encouraged to use the opportunity to comment on the paper. All comments are taken seriously and used to refine future papers.

Preamble

Please award marks as indicated below.

Equivalent valid reasoning should gain equal credit to the solutions presented here.

Error carried forward marks may be awarded where an incorrect answer is used as part of the data needed for a subsequent question, providing that the resulting answer is not plainly ridiculous.

If incorrect units are used more than once then a maximum of **one** mark should be deducted from the total.

If an inappropriate number of significant figures is given more than once in final answers then a maximum of **one** mark should be deducted from the total.

Section A – Multiple Choice Questions

[1 mark each]

1	2	3	4	5	6	7	8	9	10
A	D	B	C	C	B	A	A	A	B

Section B – Short Answer Questions

Marks for these two questions should be awarded for a clear explanation of the underlying physical principals using correct scientific terminology at a level appropriate for students of this age.

Answers can contain numerical or algebraic arguments as well as written explanations.

Answers that are incomplete, contain errors in physics or use terminology incorrectly cannot be awarded full credit.

Markers are **encouraged to be generous** and award credit where possible.

Question 11 (specific heat capacity and specific latent heat)

Award 0 marks:	No valid attempt
Award 1 to 3 marks	Correct reasoning for comparison of shc of each phase **or** comparison of L and c
Award 1 to 5 marks	Correct reasoning for comparison of shc of each phase **and** comparison of L and c

Note: The marks for the second part are for using data from the graph to derive the constants c and L, there is no suggestion that these quantities can be equated, the question asks for their derived numerical values in standard units to be compared.

Example solution

Let a unit time interval on the graph be denoted t

In the solid phase, $\Delta\theta = 40$°C in a time interval 2t, $\Delta\theta = 20$°C per unit time interval

In the liquid phase, $\Delta\theta = 60$°C in a time interval 4t, $\Delta\theta = 15$°C per unit time interval [1 mark]

$\Delta E = mc\Delta\theta$ applies to the material as a solid and as a liquid. In both cases m is the same and, in a unit time interval, ΔE is the same. Therefore $c\Delta\theta$ is constant (owtte) [1 mark]

In a unit time interval, $\Delta\theta$ is smaller for the liquid phase and therefore $c_{liquid} > c_{solid}$ [1 mark]

Rearranging equation for heating liquid gives $c_{liquid} = {}^{\Delta E}/_{m.60} = {}^{P.4t}/_{m.60}$ [1 mark]

Applying the equation for change of state gives $L_{fusion} = {}^{\Delta E}/_{m} = {}^{P.4t}/_{m}$ [1 mark]

Comparing **numerical** values in standard units gives, $L_{fusion} > c_{liquid}$ [1 mark]

Question 12 (bulb)

Award 0 marks: No valid attempt

Award 1 to 3 marks: Reason for initial heating **or** reason for steady final temperature explained

Award 1 to 5 marks: Reason for initial heating **and** reason for steady final temperature explained

Part 1: Answer may consider an electrical approach or a particle model approach i.e. ohmic heating

Part 2: Valid arguments that consider conduction and convection but do not consider radiation cannot gain full credit

Example solution

Current flows through the filament and there is a potential difference across the filament because it has electrical resistance [1 mark]

The electrical current transfers energy (E) to the filament (given by $E = VQ$ or $E = VIt$) [1 mark]

Or electrical power is given by $P = I^2R$, power is the energy transferred per unit time [1 mark]

The filament does not change state, the temperature increases ($\Delta E = mc\Delta\theta$) (owtte) [1 mark]

All objects (above absolute zero) absorb and radiate energy to the surrounding [1 mark]

The rate at which an object radiates energy to the surroundings increases as the temperature of the object increases [1 mark]

As the filament gets hotter, energy is radiated to the surrounds as a greater rate [1 mark]

At a certain temperature, the rate at which energy is radiated to the surroundings is equal to the rate at which energy is transferred to the filament by the electrical current. [1 mark]

At this temperature the nett change of internal energy of the filament is zero and therefore the change of temperature is also zero – the temperature remains constant [1 mark]

Section C – Longer Answer Questions

Question 13

a) Use of $\Delta p = \rho g \Delta h$ to give $\Delta p = 1000 \times 9.8 \times 0.10 = 980\ Pa \approx 1000$ Pa [1]

b) Use of $r = 2.5 \times 10^{-3} m$ and $L = 0.30\ m$ with $\Delta p = 980$ Pa [1]

To give ${}^{\Delta V}/_{\Delta t} = 5.6 \times 10^{-5}\ m^3/s \approx 6 \times 10^{-5}\ \mathrm{m}^3/s$ [1]

c) Use of volume (V) given by $V = \pi r^2 v$ [1]

Use of $V = 5.6 \times 10^{-5}\ \mathrm{m}^3$ as volume of water in 1 second [1]

Giving $v = 2.8\ \mathrm{m/s}$ (allow ecf from (b) or use of show that value [1]

d) Use of $m = \rho \times V$ [1]

Giving a mass of $m = 0.056\ \mathrm{kg/s}$ allow unit of kg for full credit [1]

e) Concept that power output is the difference between initial KE and final KE per second of water [1]

Initial KE (before turbine) $KE_i = 0.5 \times 0.056 \times 2.8^2 = 0.22$ J (allow ecf from c and d) [1]

Final KE (after turbine) $KE_f = 0.5 \times 0.056 \times (2.8/2)^2 = 0.056$ J [1]

Maximum power output $P_{max} = 0.22 - 0.056 = 0.17$ J/s allow Watts [1]

f) The marks are for the explanation, not the answer

For two straws in parallel, there is double the flow rate and therefore double the mass of water per second. However, the velocity of the water is the same so the incident KE is doubled. [1]

For a straw with twice the cross sectional area, $r \approx 3.5$ mm, the flow rate is 4 times greater [1]

The mass per second is 4 times greater and the velocity of the water leaving the pipe is (two times) greater. Therefore the incident kinetic energy is more than 4 (16) times greater [1]

Unsupported answer does not gain credit

Accept fully numerical argument i.e. when student has recalculated the power output by repeating part b, c and d

Accept a fully algebraic solution

Question 14 (Sonometer)

a) Two (or more) valid points chosen from graph e.g. (10, 32) and (24,50) [1]

Ratio of ${}^{f^2}/_{T}$ calculated (or inverse) for both (all) sets of data [1]

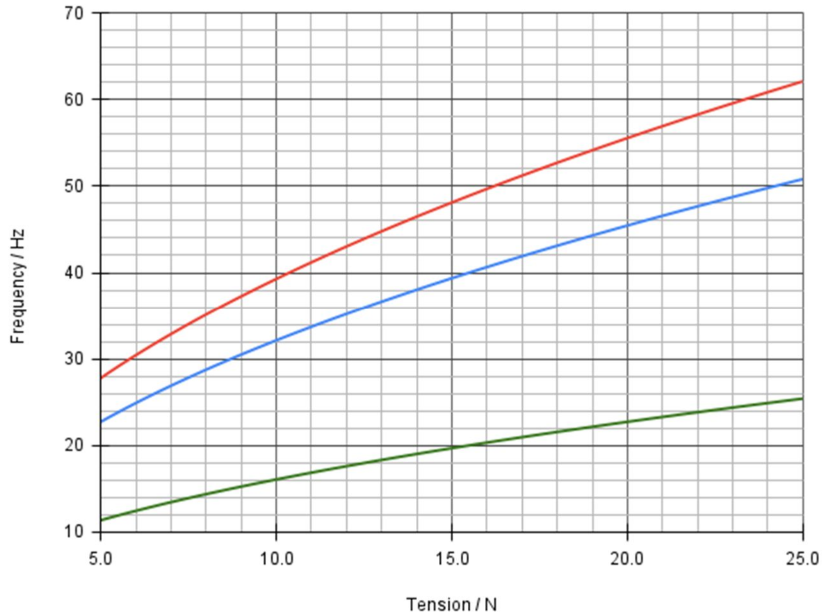
Values compared and valid conclusion stated [1]

e.g ${}^{32^2}/_{10} = 102$ and ${}^{50^2}/_{24} = 104$ giving $102 \approx 104$ so $f^2 \propto T$

b) One set of valid data from graph used in equation [1]

OR Average of two (or more) sets of data used in equation [2]

Giving $\mu = 0.0020 \ \ \mathrm{kg/m}$ [1]



c) On the graph above, this is the RED line

Line above the blue line [1]

Line correct shape and diverging from the blue line as T increases [1]

Correct start point (26 Hz to 28 Hz for 5 N) **OR** correct end point (61 Hz to 63 Hz for 25 N) [1]

d) On the graph above, this is the GREEN line

Line below the blue line [1]

Their part (d) line further below blue line than their part (c) line is above the blue [1]

Correct start point (11 Hz to 13 Hz for 5 N) **OR** correct end point (25 Hz to 27 Hz for 25 N) [1]

e) Thicker strings are used to produce notes with a lower pitch / frequency (owtte) or vice versa [1]

Longer strings are used to produce notes with a lower pitch / frequency (owtte) or vice versa [1]

The question asks for an explanation so there needs to be a valid reason [1]

e.g. If all the strings were the same thickness or length, the tension in the high pitch strings would be unreasonably high or the tension in the low pitch strings would be unrealistically low. Allowing for a range of thicknesses and a range of lengths allows for a greater range of notes on the piano.