Physics Challenge 2018

Mark-scheme

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 **one** mark should be deducted from the total.

If an inappropriate number of significant figures is given more than once in final answers then **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
B	C	A	D	C	E	C	A	C	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.

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.

Award 0 marks:	No valid attempt made to answer question
Award 1 mark:	Single valid point presented but other-wise incorrect or incomplete
Award 2 marks:	Partially correct answer but major error(s) or omission(s) in reasoning
Award 3 marks:	Mostly correct answer, only minor error(s) or omission(s) in reasoning
Award 4 marks:	Essentially correct answer, no errors or omissions of reasoning but answer is not clear on first reading, is confused or uses terminology incorrectly
Award 5 marks:	Completely correct answer, no errors, omissions of reasoning or incorrect use of terminology, clear on first reading

Any valid explanation should be awarded credit

Example solutions might include, but are not limited to:

Question 11: [5 marks]

- The Metal and the Wood are both initially at the same low temperature
- Metal is a (much) better thermal conductor than wood
- There is a temperature difference between the cold metal and the warm skin on the hand
- Due to this temperature difference, thermal energy is conducted from the hand to the metal
- Because the metal is a good conductor, energy is transferred at a high rate
- The rapid transfer of thermal energy from the skin lowers the internal energy of the molecules in the skin of the hand and this is the sensation of feeling something as being cold
- On the other hand, wood is a relatively poor conductor and so energy transferred from the skin on the hand at a much lower rate, even though the temperature difference is the same. The molecules in the skin have time to transfer energy from within the body to keep their internal energy relatively constant. Therefore, there is less of a sensation of coldness.
- (must compare metal and wood to earn full credit)

Question 12: [5 marks]

- In the initial circuit both bulbs have the same potential difference and, as they are in series, take the same current. Therefore they have the same power output and brightness. (given in Qn)
- For 6 V 12 W bulb: I = 12/6 = 2 A and therefore R = 6/2 = 3 Ω
- For replacement 6 V 24 W bulb: I = 24/6 = 4 A and therefore R = 6/4 = 1.5 Ω
- As the bulbs are in series they both have the same current flowing through them
- However, as they have different resistances, the potential difference across the 12 W bulb is (2x) higher than the potential difference across the 24 W bulb.
- P = I x V and therefore the 12 W bulb will be a higher power and be brighter
- (statement of which is brighter can be implicit in explanation, marks awarded for explanation)
- (in reality the filament resistance changes with current but the same argument applies)
- (arguments using I^2R may be used)

Section C – Longer Answer Questions

13 (a)	45 mph = 45 x 1.6 x 1000 / (60 x 60) m/s = 20 m/s	[1]
13 (b)	Both axes labelled with appropriate scales	[1]
	Straight line from v = 20 m/s at t = 0 s descending to v = 0 m/s at t = 6.7 s	[1]
	Line horizontal with v = 20 m/s for 1.2 s and then descending parallel to first line to t = 7.9 s	[1]
13 (c)	Difference between the areas under each graph = 20 x 1.2 = 24 m	[1]
13 (d)	Δ Area under the graph = speed x reaction time ∴ max safe speed = 30/1.2 = 25 m/s	[1]
13 (e)	Time is constant ∴ at any speed (v) distance between cars = 2v	[1]
	minimum braking distance = 1.2v and so braking distance always < separation	[1]
14 (a)	P = F x v P = 2000 x 1.5 = 3000 W = 3 kW	[1]
14 (b)	Increase in KE of passengers = ½ x 800 x 1.5^2 = 900 J W.d. = 1800 J due to inelastic collision	[1]
	Time taken to travel length of walkway = 60/1.5 = 40 s	[1]
	Work done against friction = 3000 x 40 = 120,000 J therefore total = 121,800 J	[1]

14 (c) Increase in KE of passengers = ½ x 800 x 1.5^2 = 900J (as before therefore no credit)
Increase in KE of walkway = ½ x 8000 x 1.5^2 – ½ x 8000 x 0.5^2 = 8000J [2]
Work done against friction = 3000 x 40 = 120,000J (as before, ignoring time to accelerate)
Total = 129,800J where W.d. accelerating passengers = 1800J [1]

14 (d) **Any reasonable answer** can score credit but it must be based on the previous parts of the question and clearly justified to score full credit.

For example: It takes more energy to speed up than it does to run at normal speed and so it is worth running at normal speed for a short time in case more passengers come along. However, eventually the energy used running at normal speed is greater than the energy running at the slower speed + energy needed to speed up. This time (t) is given by 3000t = 1000t + 8000 ∴ t = 4s.

Realising power to maintain idle speed = 2000 x 0.5 = 1000W [1]
Suggesting a time between 0s and 4s [1]
Justified using data [1]

15 (a) Use of $\Delta p = \rho g \Delta h$ giving $\Delta p = 1000 \times 10 \times 0.4 = 4000 \text{ Pa}$ [1]

15 (b) Atmospheric pressure acts on the surface of the water and at the end of the tube and therefore cancels out. The only pressure difference is due to the head of water [1]

15 (c) If water level changes, pressure difference changes [1]
and therefore the experiment is not a fair test [1]

15 (d) 22 cm^3 = 22 x 10^{-6} m^3 (correct conversion to m^3) [1]
22 x 10^{-6} / 60 = 3.7 x 10^{-7} m^3/s [1]

15 (e) $\eta = \frac{\pi r^4 \Delta p}{8L\left({\Delta V}/{\Delta t}\right)}$ (correct manipulation, can be implied in working) [1]
$\eta = \frac{\pi \times (0.5\times10^{-3})^4 \times 4000}{8\times0.3\times3.7\times10^{-7}}$ (correct values, even if manipulation wrong) [1]
$\eta = 8.8 \times 10^{-4}\ Pa\ s$ (correct calculation) [1]

15 (f) Award credit for alternative solutions. Any from:

Show ${\Delta V}/{\Delta t} \propto r^4$, Show $\sqrt[4]{\left({\Delta V}/{\Delta t}\right)} \propto r$ or Calculate η for each set of values

For example:

Internal radius of the tube / mm	Volume of water collected in 1 minute / cm^3	$\sqrt[4]{\left({\Delta V}/{\Delta t}\right)}$	$\left[\sqrt[4]{\left({\Delta V}/{\Delta t}\right)}\right] \div r$	Viscosity / Pa s
0.3	3	1.31	4.4	8.5 x 10^{-4}
0.5	22	2.17	4.3	8.9 x 10^{-4}
0.7	84	3.03	4.3	9.0 x 10^{-4}
1.0	350	4.33	4.3	9.0 x 10^{-4}

Any valid attempt to use the data [1]
With correct calculated values of ratio to show proportionality or values for η [1]
And a valid conclusion (based on their calculations) [1]