Physics Challenge 2019

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 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	E	D	C	B	B	E	C	D

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]

It is not necessary for the student to refer to the photograph. The photograph is provided as a prompt to help students think about how the d.c. electric motor works.

- A current flows in the coil (armature) in the position shown due to the contacts between the brushes and the contact / contact wires (commutator).
- The current flowing along the long sides of the armature are perpendicular to the magnetic field due to the permanent magnets.
- As described by Fleming's Left Hand Rule (or any equivalent statement) each side of the armature will experience a force due to the current flowing in the magnetic field.
- The force on one side of the coil/armature will be upwards and the force on the other side will be down and therefore a turning effect is produced, the armature spins.
- When the brushes disconnect from the contacts on the commutator, the inertia of the armature keeps it rotating until electrical contact is re-established.
- The armature is now connected "the other way round" electrically so that the forces on the armature are in the same direction as before.
- The armature receives another turning force or kick and continues to spin.
- Note: an annotated diagram is not necessary. For full marks both the origin of the turning force and the action of the commutator must be considered.

Question 12: [5 marks]

- The weight of the 1 kg mass is 10 N.
- When the balance is stationary it is not accelerating and so the resultant force on the mass is 0 N. The weight is balanced by the upwards tension in the spring. The tension in the spring causes it to extend and the reading is 10 N.
- After the student has leapt off the table but not landed on the floor, the mass is in free fall. The mass is accelerating at 10 m/s^2 and so the resultant force acting on the mass is 10 N. The 10 N resultant force is due to the weight of the object. No force is provided by the spring balance, since it is also accelerating downwards at 10 m/s^2, at the same rate as the student, so the spring is not extended. The reading on the scale is 0 N.
- When the student lands the mass must decelerate and so a resultant force is required in the upwards direction. To make this upwards resultant force the force from the spring balance must be greater than the weight. As the upwards force due to the tension in the spring is > 10 N, the spring is extended beyond the 10 N mark.
- Must address all three situations for full credit. Partial credit (4/5) can be gained for a clear explanation of just one of the three situations.

Section C – Longer Answer Questions

13 (a) Drawing with Sun, Earth and Moon in the right order in a line [1]
Explanation that the plane of the Moon's orbit and the plane of the Earth's orbit are not the same and so the Moon does not usually pass directly behind the Earth [1]

13 (b) Use of two correct positions – either B&D or C&E [1]
Calculation of time interval as 2 hours 9 minutes, correct conversion (do not allow 2.09 hrs) [1]
Use of speed = 9200 km / 2.15 hours to give speed = 4280 km h^{-1} [1]
Do not allow answers that make use of measurements from the diagram

13 (c) Use of two correct positions – either B&C or D&E (not measurements from diagram) [1]
Calculation of time interval and size. Size = 4280 kmh^{-1} x 1.12 hours = 4780 km [2]

13 (d) Distance travelled = 4280 km h^{-1} x (27.3 x 24) hours = 2.8 x 10^6 km [1]
Distance travelled = $2\pi R$ [1]
Earth – Moon distance = 446,000 km [1]

13 (e) Realistic estimate of size of thumb and eye – thumb distance [1]
Calculation of ratios of size to distance or angular size for thumb and Moon [1]
Valid comment to justify or not the claim in the question [2]

E.g: Thumb ≈ 2 cm diameter and eye – thumb distance ≈ 60 cm therefore ratio is about 1:30 (giving an angular size for the thumb of about 2°). Ratio of calculated Moon diameter to Earth – Moon distance is 4780:44600 ≈ 1:90 (and an angular size for the Moon of about 0.6°). Therefore the claim is not valid, the thumb would more than cover the Moon.

14 (a) Use of p = F / A and correct units [1]
giving p = 13 / (π x 0.02^2) = 10,300 Pa [1]

14 (b) pressure = atmospheric – 14 (a) therefore p = 101,000 – 10,300 = 90,700 Pa [2]

14 (c) Use of Δp = 10,300 Pa and ΔT = (80 – 38) = 42 °C [1]
Therefore $\Delta p/\Delta T$ = 245 Pa /°C [1]
Pressure falls from 101,000 Pa giving a change in temperature of 101,000 / 245 = 412 °C [1]
Giving absolute zero = 80 – 412 = -332 °C [1]
Alternatively pressure falls from 90,700 Pa giving a change in temperature of 90,700 / 245 = 370 °C and a value for absolute zero of 38 – 370 = -332 °C

14 (d) Assumption: the relationship between temperature and pressure is linear or p/T = constant [1]
Accept: Volume or amount of gas don't change

14 (e) The volume of the container makes no difference to the temperature [1]
Because the volume doesn't change during the experiment (the lid hardly moves in at all) [1]
and therefore has no effect on the change in pressure as the jar cools (owtte) [1]

14 (f) The values for diameter of the lid, atmospheric pressure and initial temperature are unlikely to be wrong as they are more straight forward to measure.
Either the force measured to depress the lid was too small OR the temperature of the air in the jar at which the lid popped was measured as too low – the air was still warmer than 38 °C [1]
Because Δp / ΔT was too small so either Δp was too small or ΔT was too high [2]

But **be generous** and allow any valid reason for any of the measured quantities. For full marks the explanation must explain why the calculated value of absolute zero was too low, not just incorrect.