© The Learning Cave

TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2022 A-Level H1 Physics Paper 1

The question paper is © UCLES/SEAB and is not reproduced here — have your own copy of the paper open. The worked solutions are original work by The Learning Cave and are for personal study only.

ANSWER KEY

1 **C**	2 **D**	3 **B**	4 **C**	5 **D**	6 **C**	7 **D**	8 **B**	9 **A**	10 **B**
11 **B**	12 **D**	13 **D**	14 **C**	15 **B**	16 **C**	17 **C**	18 **C**	19 **D**	20 **C**
21 **A**	22 **B**	23 **D**	24 **B**	25 **C**	26 **C**	27 **B**	28 **D**	29 **C**	30 **D**

WORKED SOLUTIONS

Q1 Answer C

For a product of powers, the percentage uncertainties are multiplied by the powers and added:

$$\frac{\Delta E}{E} = 3\frac{\Delta l}{l} + 2\frac{\Delta T}{T} = 3(2\%) + 2(2\%) = 10\%$$

The minus sign in T^{-2} does not reduce the uncertainty; uncertainties always add.

Q2 Answer D

$$\mathrm{W} = \mathrm{J\ s^{-1}} = \mathrm{N\ m\ s^{-1}} = (\mathrm{kg\ m\ s^{-2}})(\mathrm{m})(\mathrm{s^{-1}}) = \mathrm{kg\ m^2\ s^{-3}}$$

Q3 Answer B

The radius is $125\ \mu m = 1.25 \times 10^{-4}$ m and the length is 5.0×10^4 m.

$$V = \pi r^2 l = \pi(1.25 \times 10^{-4})^2(5.0 \times 10^4) = 2.5 \times 10^{-3}\ \mathrm{m^3}$$

Q4 Answer C

The initial vertical velocity is zero, so the horizontal velocity plays no part:

$$s = \frac{1}{2}gt^2 = \frac{1}{2}(9.81)(3.00)^2 = 44.1\ \mathrm{m}$$

Q5 Answer D

At the highest point the vertical velocity is zero, but the ball still has its horizontal velocity, which stays constant throughout. The only force is gravity, so the ball is still accelerating vertically downwards at g.

Q6 Answer C

The car decelerates from 10 s to 25 s, slowing from 30 m s^{-1} to 10 m s^{-1}. The distance is the area under the graph over this interval, a trapezium:

$$s = \frac{1}{2}(30 + 10)(25 - 10) = 300\ \mathrm{m}$$

Q7 Answer **D**

- The balloon is moving downwards, so both spheres start with the same downward velocity. Each graph starts at the origin with the same gradient.
- Both spheres are already moving through the air, so they experience the same air resistance at the start (same size, same speed).
- The hollow sphere has a smaller mass, so the same air resistance reduces its acceleration more ($a = g - D/m$). The solid sphere accelerates more, from the start.

So the solid sphere is always further from the release point, and the curves separate from the start. B shows the two curves together at first and separating only later, which would be the case only if they started from rest relative to the air.

Q8 Answer **B**

By Newton's second law, the force equals the rate of change of momentum. A constant braking force means the momentum decreases at a constant rate, from mv to zero: a straight line with a constant negative gradient.

Q9 Answer **A**

Take right as positive. By conservation of momentum:

$$(1.0)(4.0) + 0 = (1.0)v + (10.0)(0.50)$$

$$v = 4.0 - 5.0 = -1.0 \text{ m s}^{-1}$$

X moves at 1.0 m s^{-1} to the left.

$$E_{\text{k,before}} = \frac{1}{2}(1.0)(4.0)^2 = 8.0 \text{ J}$$

$$E_{\text{k,after}} = \frac{1}{2}(1.0)(1.0)^2 + \frac{1}{2}(10.0)(0.50)^2 = 0.50 + 1.25 = 1.75 \text{ J}$$

$$\Delta E_{\text{k}} = 8.0 - 1.75 = 6.3 \text{ J}$$

Q10 Answer **B**

The gas is fired backwards, so by conservation of momentum the satellite speeds up.

Mass of gas ejected in 5.0 s: $(0.20)(5.0) = 1.0$ kg. The impulse on the satellite equals the momentum given to the gas relative to the satellite:

$$\Delta v \approx \frac{(1.0)(2000)}{400} = 5 \text{ m s}^{-1}$$

The satellite's speed increases to just over 3000 m s^{-1}. The only option with an increase of this size is 3010 m s^{-1}.

(The value 3010 m s^{-1} comes out exactly if the gas speed of 2000 m s^{-1} is taken relative to the ground: $(400)(3000) = 399v - (1.0)(2000)$ gives $v = 3010$ m s^{-1}.)

Q11 Answer **B**

From the graph, the spring constant is

$$k = \frac{F}{x} = \frac{8.0}{0.040} = 200 \text{ N m}^{-1}$$

With 6.0 N the extension is $x_1 = 6.0/200 = 0.030$ m. After a further 0.010 m, $x_2 = 0.040$ m.

$$\Delta E = \frac{1}{2}k\left(x_2^2 - x_1^2\right) = \frac{1}{2}(200)\left(0.040^2 - 0.030^2\right) = 0.070 \text{ J}$$

Q12 Answer **D**

For a system of forces in equilibrium, there is no resultant force and no resultant torque.

- A: an object at rest or moving with uniform velocity has no resultant force on it, but forces can still act on it.
- B: equilibrium follows from Newton's first (and second) law. Third-law pairs act on different bodies.
- C: the forces need not be equal in magnitude.

Q13 Answer **D**

Three forces act on the climber:

- weight, vertically downwards
- the push of the smooth wall, horizontal, away from the wall (to the right). A smooth wall gives no friction, so this force is perpendicular to the wall.
- tension in the rope, along the rope, upwards towards the wall (up and to the left)

In equilibrium the three forces form a closed triangle with arrows head to tail. In D, the horizontal force points right, the weight follows it downwards, and the tension closes the triangle up and to the left.

Q14 Answer **C**

An object is in equilibrium only if there is no resultant force and no resultant torque.

- A and B: the forces do not cancel, so there is a resultant force.
- C: the upward force at the centre balances the two equal downward forces at the ends, and by symmetry their moments about the centre cancel.
- D: the up and down forces at opposite ends cancel as forces, but they form a couple, so there is a resultant torque.

Q15 Answer **B**

$$P = \frac{W}{t} = \frac{Fd}{t} = \frac{(ma)d}{t}$$

Q16 Answer **C**

At constant speed, the external force balances the component of the weight down the slope and the friction:

$$F = mg\sin 30^\circ + f = (4.00)(9.81)(0.5) + 8.00 = 27.6 \text{ N}$$

$$v = \frac{6.00}{3.00} = 2.00 \text{ m s}^{-1}$$

$$P = Fv = (27.6)(2.00) = 55.2 \text{ W}$$

Q17 Answer **C**

With no air resistance, the loss of gravitational potential energy is gained as kinetic energy:

$$mgh = (0.012)(9.81)(17) = 2.0 \text{ J}$$

$$E_\text{k} = 5.4 + 2.0 = 7.4 \text{ J}$$

Q18 Answer **C**

The satellite moves in a circle, so its velocity is changing direction and it is accelerating. The resultant force (the gravitational pull of the Earth) acts towards the centre of the circle, which is towards the Earth. It is perpendicular to the direction of motion, not along it.

Q19 Answer **D**

At the bottom, the centre of the loop is above the car. The resultant upward force provides the centripetal force:

$$N - mg = \frac{mv^2}{r}$$

$$N = (650)\left(9.81 + \frac{10.0^2}{12.0}\right) = (650)(18.14) = 1.18 \times 10^4 \text{ N} = 11.8 \text{ kN}$$

Q20 Answer **C**

One revolution is 2π radians, and there are n revolutions per second:

$$\omega = 2\pi n$$

The diameter is not needed.

Q21 Answer **A**

For an NTC (negative temperature coefficient) thermistor, resistance decreases as temperature increases. The decrease is not linear: it is steep at low temperature and levels off, never reaching zero. Graph A shows this.

Q22 Answer **B**

$$R = \frac{V}{I} = \frac{240}{4.00} = 60.0\ \Omega$$

$$A = \pi r^2 = \pi(2.00 \times 10^{-4})^2 = 1.257 \times 10^{-7}\ \text{m}^2$$

$$l = \frac{RA}{\rho} = \frac{(60.0)(1.257 \times 10^{-7})}{1.10 \times 10^{-6}} = 6.85\ \text{m}$$

Q23 Answer **D**

With every switch closed, the three resistors are in parallel, each with the full 2.00 V across it.

$$I = \frac{2.00}{4.00} + \frac{2.00}{8.00} + \frac{2.00}{12.00} = 0.500 + 0.250 + 0.167 = 0.917\ \text{A}$$

Q24 Answer **B**

The electron has mass, so the gravitational field exerts a force on it, whether it moves or not.

A magnetic field exerts a force only on a moving charge ($F = Bqv\sin\theta$). The electron is stationary, so there is no magnetic force.

Q25 Answer **C**

The field is from N to S, to the right. The proton's velocity makes angle θ with the dashed line, which is perpendicular to the field, so the angle between the velocity and the field is $90^\circ - \theta$.

$$F = Bev\sin(90^\circ - \theta) = Bev\cos\theta$$

Direction: only the component of velocity perpendicular to the field (upwards, $v\cos\theta$) contributes. The proton is positive, so the current is in the direction of motion. By Fleming's left-hand rule, with the field to the right and the current upwards, the force is into the page.

Q26 Answer **C**

Parallel wires attract when their currents are in the same direction, and repel when the currents are in opposite directions. Only C has parallel currents in the same direction.

(In B and D the wires are perpendicular, so there is no simple attraction between them.)

Q27 Answer **B**

The mass defect of the atom is the total mass of its separate particles (2 protons, 2 neutrons and 2 electrons) minus the mass of the atom:

$$\Delta m = 2(1.00728) + 2(1.00867) + 2(0.00055) - 4.00370$$
$$\Delta m = 4.03300 - 4.00370 = 0.0293 \text{ u}$$

Q28 Answer **D**

Number of neutrons = nucleon number - proton number:

- ^{238}Pu: $238 - 94 = 144$
- ^{239}Pu: $239 - 94 = 145$
- ^{241}Pu: $241 - 94 = 147$
- ^{242}Pu: $242 - 94 = 148$, not 152

Q29 Answer **C**

- A: the charge of a β-particle is $-e$, not $+2e$.
- B: γ-rays are uncharged, so they are not deflected by an electric field.
- C: α-particles travel only a few centimetres in air, while β-particles (around a metre) and γ-rays travel well beyond 0.2 m. Correct.
- D: γ-rays do cause ionisation, although weakly.

Q30 Answer **D**

$$\Delta m = (4.002603 + 8.005305) - 12.000000 = 0.007908 \text{ u}$$
$$\Delta m = (0.007908)(1.66 \times 10^{-27}) = 1.313 \times 10^{-29} \text{ kg}$$
$$E = \Delta m c^2 = (1.313 \times 10^{-29})(3.00 \times 10^{8})^2 = 1.18 \times 10^{-12} \text{ J}$$
$$E = \frac{1.18 \times 10^{-12}}{1.60 \times 10^{-19}} \text{ eV} = 7.38 \times 10^{6} \text{ eV} = 7.38 \text{ MeV}$$

THE LEARNING CAVE
thelearningcave.com.sg
Physics. Math. Chemistry.