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TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2018 A-Level H1 Physics Paper 1

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ANSWER KEY

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

WORKED SOLUTIONS

Q1 Answer B

A world-class sprinter runs at roughly 10 m s^{-1}.

$$t \approx \frac{200}{10} = 20 \text{ s}$$

The Olympic 200 m winning time is about 19–20 s.

Q2 Answer A

The prefix micro (μ) means 10^{-6} and milli (m) means 10^{-3}.

$$2200\ \mu F = 2200 \times 10^{-6}\ \text{F} = 2.2 \times 10^{-3}\ \text{F} = 2.2\ \text{mF}$$

Q3 Answer D

For a cylinder, $A = \pi d^2/4$, so

$$\rho = \frac{RA}{L} = \frac{\pi R d^2}{4L}$$

The fractional uncertainties add, with the diameter counted twice because it is squared:

$$\frac{\Delta\rho}{\rho} = \frac{\Delta R}{R} + 2\frac{\Delta d}{d} + \frac{\Delta L}{L} = \frac{1}{68} + 2\left(\frac{0.1}{5.0}\right) + \frac{1}{25} = 0.0147 + 0.040 + 0.040 = 0.095$$

$$\Delta\rho = 0.095 \times 5.34 \times 10^{-2} = 0.5 \times 10^{-2}\ \Omega m$$

The uncertainty is quoted to 1 significant figure, and the value is rounded to the same decimal place:

$$\boxed{\rho = (5.3 \pm 0.5) \times 10^{-2}\ \Omega m}$$

Q4 Answer D

Find the initial speed u first, using $s = ut + \frac{1}{2}at^2$:

$$600 = 40u + \frac{1}{2}(0.50)(40)^2 = 40u + 400 \quad \Rightarrow \quad u = 5.0\ \text{m s}^{-1}$$

$$v = u + at = 5.0 + (0.50)(40) = 25\ \text{m s}^{-1}$$

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Q5 Answer **B**

The gradient of a velocity–time graph is the acceleration.

Air resistance: every sloping section is a straight line with the same gradient, both falling and rising. The acceleration is constant and equal to g throughout, so air resistance is negligible.

Energy at each bounce: at each bounce the velocity reverses, but the speed just after the bounce is smaller than the speed just before it, and the next peak is lower than the one before. Kinetic energy is lost at each bounce.

Q6 Answer **B**

Air resistance is negligible, so the only force on the ball is its weight. The acceleration is g, downwards, at every point: the same at Q as at P.

The horizontal velocity stays constant, while the vertical velocity grows from zero. At Q the speed is

$$v_Q = \sqrt{v_x^2 + v_y^2} > v_x$$

so the speed at Q is larger than at P.

Q7 Answer **D**

By Newton's second law, $a = F/m$, so the acceleration has the same shape as the force graph. The gradient of the speed–time graph is the acceleration.

- 0 to 5 s: the force rises from zero, so the gradient of the speed–time graph starts at zero and increases. The graph starts flat and curves upwards.
- 5 to 15 s: the force is constant, so the gradient is constant. The graph is a straight line rising at the gradient it had reached at 5 s.

Only D starts with zero gradient, curves upwards, and joins smoothly onto a straight line.

Q8 Answer **A**

Conservation of momentum (taking the original direction as positive):

$$m(2u) + 2m(u) = mv_1 + 2mv_2 \quad \Rightarrow \quad v_1 + 2v_2 = 4u$$

For an elastic collision, the relative speed of approach equals the relative speed of separation:

$$2u - u = v_2 - v_1 \quad \Rightarrow \quad v_2 = v_1 + u$$

Substituting:

$$v_1 + 2(v_1 + u) = 4u \quad \Rightarrow \quad v_1 = \frac{2}{3}u = 0.67u, \qquad v_2 = 1.67u$$

Q9 Answer **C**

Take the direction in which the ball is returned as positive. The initial velocity is then -3.0 m s^{-1}.

$$\text{impulse} = \Delta p = mv - mu$$

$$6.3 = 0.42v - 0.42(-3.0) = 0.42v + 1.26$$

$$v = \frac{6.3 - 1.26}{0.42} = 12 \text{ m s}^{-1}$$

Q10 Answer **D**

The third force must be equal and opposite to the resultant of the two given forces.

Add the two arrows tip to tail. Their vertical components (one up, one down) are equal and cancel. Their horizontal components are both to the right, so the resultant is horizontal, to the right, and about twice the horizontal component of each arrow. Measured on the diagram, this is about the length of arrow D.

The equilibrant is therefore horizontal, to the left, with this length: arrow D. Arrow B points the right way but is too short.

Q11 Answer **D**

The drop moves horizontally at constant velocity, so the resultant force on it is zero. Consider the directions of the four forces:

- gravitational force: vertically downwards
- air resistance: horizontal, opposite to the velocity
- electric force: horizontal, because the field between the vertical plates is horizontal
- magnetic force: perpendicular to both the velocity (horizontal) and the magnetic field (horizontal, from N to S), so it is vertical

The vertical forces must balance each other, so the magnetic force balances the weight. (The horizontal forces, drag and electric force, also balance each other.)

Q12 Answer **B**

From the graph, the spring constant is

$$k = \frac{F}{x} = \frac{10}{0.050} = 200 \text{ N m}^{-1}$$

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.

$$\Delta E = \frac{1}{2}k\left(x_2^2 - x_1^2\right) = \frac{1}{2}(200)\left(0.040^2 - 0.030^2\right) = 0.07 \text{ J}$$

This is the area under the graph between 0.030 m and 0.040 m.

Q13 Answer **C**

Elastic potential energy: pulling X down stretches the spring further, so the elastic potential energy increases.

Electric potential energy: the field points downwards, so the electric force on the positive charge is downwards. X moves in the direction of the electric force, so the field does positive work on it and the electric potential energy decreases.

Q14 Answer **C**

$$F = pA = (1.7 \times 10^8)(4.5 \times 10^{-5}) = 7650 \text{ N}$$

$$a = \frac{F}{m} = \frac{7650}{0.050} = 1.53 \times 10^5 \text{ m s}^{-2}$$

The bullet starts from rest and the force is constant:

$$v = at = (1.53 \times 10^5)(3.3 \times 10^{-3}) = 505 \approx 500 \text{ m s}^{-1}$$

Q15 Answer **B**

$$1 \text{ rad} = \frac{180^\circ}{\pi} = 57^\circ$$

Measured from the centre, A is about 30° from P, B is about 60°, C is about 120° and D is 180°. B is closest to 57°.

Q16 Answer **A**

A taut string pulls on whatever is attached to each end. The forces it exerts act along the string, towards the middle of the string:

- on the ball, the force points along the string towards the top of the pole
- on the pole, the force points along the string towards the ball

Diagram A shows a force at each end along the string, pointing inwards. C shows the string pushing outwards, which a string cannot do. B and D show horizontal forces, which are not along the string.

Q17 Answer **C**

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{3.70} = 1.698 \text{ rad s}^{-1}$$

The resultant (centripetal) force needed is

$$F_c = m\omega^2 r = (77.0)(1.698)^2(4.00) = 888 \text{ N}$$

The weight is $W = mg = (77.0)(9.81) = 755$ N.

At the top, the centre is below the passenger. Taking downwards as positive, with N the force from the ride:

$$N + W = F_c \quad \Rightarrow \quad N = 888 - 755 = 133 \text{ N(downwards)}$$

At the bottom, the centre is above the passenger. Taking upwards as positive:

$$N - W = F_c \quad \Rightarrow \quad N = 888 + 755 = 1640 \text{ N(upwards)}$$

Q18 Answer **A**

For a thermistor, resistance decreases as temperature increases. The decrease is not linear: the resistance falls steeply at low temperature, then levels off, never reaching zero.

Graph A shows this. B is linear and reaches zero resistance, which is not possible. C and D show resistance increasing with temperature.

Q19 Answer **D**

The current is the same in both resistances. Use the heat in the 36.0 Ω resistor to find it:

$$I^2Rt = 1800 \quad \Rightarrow \quad I^2 = \frac{1800}{(36.0)(100)} = 0.500 \quad \Rightarrow \quad I = 0.707 \text{ A}$$

The total energy supplied by the e.m.f. is $1800 + 200 = 2000$ J, so

$$EIt = 2000 \quad \Rightarrow \quad E = \frac{2000}{(0.707)(100)} = 28 \text{ V}$$

Q20 Answer **D**

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$$
$$R \propto \frac{l}{r^2}$$

Compare each option with the original wire:

- A: $l/r^2 \to 1/(1/2)^2 = 4$ times, so $4R$
- B: $l/r^2 \to 1/2^2 = 1/4$ times, so $R/4$
- C: $l/r^2 \to 2/(1/2)^2 = 8$ times, so $8R$
- D: $l/r^2 \to 2/2^2 = 1/2$ times, so $R/2$

Q21 Answer **C**

- Metallic conductor at constant temperature: resistance is constant, so $I \propto V$, giving a straight line through the origin. This is Y.
- Semiconductor diode: almost no current until a small forward voltage is reached, then the current rises very steeply. This is W.
- Filament lamp: as the current rises the filament gets hotter and its resistance increases, so the gradient I/V decreases and the graph bends towards the V-axis. This is Z.

(X, whose resistance falls as the current rises, behaves like a thermistor.)

Q22 Answer **B**

From 0 to 1.0 min, both switches are closed. The 3.0 Ω and 6.0 Ω resistors are in parallel:

$$R_{\parallel} = \frac{(3.0)(6.0)}{3.0 + 6.0} = 2.0\,\Omega, \qquad R = 4.0 + 2.0 = 6.0\,\Omega, \qquad I = \frac{6.0}{6.0} = 1.0\ \text{A}$$
$$Q_1 = It = (1.0)(60) = 60\ \text{C}$$

From 1.0 min to 3.0 min, S_2 is open, so only the 6.0 Ω resistor is in the parallel section:

$$R = 4.0 + 6.0 = 10\,\Omega, \qquad I = 0.60\ \text{A}, \qquad Q_2 = (0.60)(120) = 72\ \text{C}$$
$$Q = 60 + 72 = 132\ \text{C} \approx 130\ \text{C}$$

Q23 Answer **C**

The diode lets current pass only in the direction of its arrow: from right to left along the bottom wire, then up through the ammeter.

For current to flow this way round the circuit, the cell in the closed branch must drive current from left to right, so its positive terminal (longer plate) must be on the right.

- The cell in the S_1 branch has its positive terminal on the left. It would drive current the wrong way through the diode, so with S_1 closed the diode is reverse-biased and the current is almost zero.
- The cell in the S_2 branch has its positive terminal on the right, so with S_2 closed the diode is forward-biased.

So S_1 is open and S_2 is closed. The other component is a thermistor, whose resistance is lowest at high temperature, so the current is largest at high temperature.

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Q24 Answer **A**

The vertical sections of the loop are parallel to the field, so they experience no force. Only the horizontal sections, perpendicular to the field, experience a force $F = BIL$.

Apply Fleming's left-hand rule with the field upwards:

- On every horizontal section in the top half, the current flows to the right. The force is out of the page.
- On every horizontal section in the bottom half, the current flows to the left. The force is into the page.

The forces are equal in size, so there is no resultant force, but they form a couple. The top of the loop moves out of the page and the bottom moves into the page.

The observer on the right looks towards the left. For this observer, out of the page is to their left and into the page is to their right. The top moves to the observer's left and the bottom moves to the observer's right: an anticlockwise rotation.

Q25 Answer **C**

Use Fleming's left-hand rule, remembering that the conventional current is opposite to the motion of negative particles.

- Beam entering from the left, moving right: conventional current is to the left, field into the page, so the force is downwards. The beam curves down from the middle line into D, then on into C.
- Beam entering from below, moving up: conventional current is downwards, field into the page, so the force is to the right. The beam curves right from the middle line into C, then on into B.

The quadrant that both beams pass through is C.

Q26 Answer **A**

Take moments about the pivot. The 0.041 N force gives an anticlockwise moment. The weight of the wire and the magnetic force on it act at 4.8 cm on the other side, giving clockwise moments.

(Check of direction: current into the page, field to the right. Fleming's left-hand rule gives a downward force on the wire.)

$$(0.041)(7.2) = (0.036 + F)(4.8)$$

$$F = \frac{(0.041)(7.2)}{4.8} - 0.036 = 0.0615 - 0.036 = 0.0255 \text{ N}$$

$$B = \frac{F}{IL} = \frac{0.0255}{(2.9)(0.0170)} = 0.52 \text{ T}$$

Q27 Answer **D**

The α-particles and the gold nucleus are both positive, so the particles are repelled. Each path bends away from the nucleus:

- particles passing to the right of the nucleus are deflected to the right
- the closer a particle passes to the nucleus, the stronger the repulsion, so the larger the deflection

In A and B the paths bend towards the nucleus, which would need an attractive force. In C the particle passing farthest from the nucleus is deflected the most. D shows repulsion with the closest particle deflected the most.

Q28 Answer **B**

The radiation stops after about 6 cm of air.

- α-particles are strongly ionising and have a range of only a few centimetres in air.
- β-particles travel much farther in air (around a metre), and γ-rays are absorbed only weakly by air.

If β or γ were present, they would still be detected beyond 6 cm. Only α-radiation is emitted.

Q29 Answer **D**

A neutral zirconium-90 atom contains 40 protons, $90 - 40 = 50$ neutrons and 40 electrons.

$$m = 40(1.00728) + 50(1.00867) + 40(0.00055)$$
$$m = 40.2912 + 50.4335 + 0.0220 = 90.7467 \text{ u}$$

Q30 Answer **C**

Two days is tiny compared with the 33-year half-life, so the activity stays almost constant at 4.0×10^5 Bq over that time. The activity is the number of decays per second.

$$t = 2 \times 24 \times 3600 = 1.728 \times 10^5 \text{ s}$$
$$N_{\text{decayed}} = At = (4.0 \times 10^5)(1.728 \times 10^5) = 6.9 \times 10^{10}$$

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