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TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2024 A-Level H1 Physics Paper 1

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ANSWER KEY

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

WORKED SOLUTIONS

Q1 Answer B

The prefix deci (d) means 10^{-1}:

$$1\ \text{dm} = 0.1\ \text{m} = 100\ \text{mm} = 1 \times 10^{2}\ \text{mm}$$

Q2 Answer C

Both velocities make 30° with the wall, so their components perpendicular to the wall are $v \sin 30^\circ$.

Take the direction away from the wall as positive:

$$u_\perp = -4.0 \sin 30^\circ = -2.0\ \text{m s}^{-1}, \qquad v_\perp = +3.0 \sin 30^\circ = +1.5\ \text{m s}^{-1}$$

$$\Delta p_\perp = m(v_\perp - u_\perp) = (1.0)(1.5 - (-2.0)) = 3.5\ \text{kg m s}^{-1}$$

Q3 Answer B

Air resistance depends on the speed of the ball, and the speed changes throughout the flight. So the air resistance is not constant in either direction (A and C are wrong).

Vertically, the resultant force is the weight plus the changing vertical component of air resistance, so the vertical acceleration is not uniform. Horizontally, the only force is the changing horizontal component of air resistance, so the horizontal acceleration is not uniform either (D is wrong).

Q4 Answer B

For constant acceleration from rest:

- a is constant: a horizontal line.
- $v = at$: a straight line through the origin.
- $s = \frac{1}{2}at^2$: a parabola through the origin, curving upwards.

B shows constant a with a parabolic s. A pairs constant velocity with a curved s, C pairs a curved v with constant a, and D pairs an increasing a with a straight-line v. These pairs contradict each other.

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Q5 Answer **B**

Speed is the gradient of the distance–time graph.

- A: between 15 s and 19 s the graph rises by about 180 m, a gradient of about 45 m s^{-1}, so the maximum speed is well above 10 m s^{-1}.
- B: the car starts from rest (speed 0) and later reaches about 45 m s^{-1}. Speed changes continuously, so at some instant it is exactly 20 m s^{-1}. Correct.
- C: the first 200 m takes about 14.5 s, an average speed of about 14 m s^{-1}.
- D: from 20 s to 25 s the distance increases by about 60 m (12 m s^{-1}); from 15 s to 20 s it increases by about 220 m (44 m s^{-1}). D is wrong.

Q6 Answer **A**

- While P is less than the maximum friction, friction equals P, so the resultant force is zero and $a = 0$. The graph runs along the P-axis.
- Once P exceeds the maximum friction $f_{\max}$, the resultant force is $P - f_{\max}$, so

$$a = \frac{P - f_{\max}}{m}$$

This is a straight line with gradient $1/m$, starting from the P-axis at $P = f_{\max}$. Graph A shows this.

Q7 Answer **D**

The two forces act on the same object and cancel, so there is no resultant force. By Newton's first law, the object continues at constant velocity. The first law is used.

Newton's third law describes forces that two bodies exert on each other, which act on different bodies. These two forces act on the same object, so they are not a third-law pair. The third law is not used.

Q8 Answer **B**

Take right as positive. For an elastic collision, the relative speed of approach equals the relative speed of separation:

$$5 - (-2) = v_2 - v_1 \quad \Rightarrow \quad v_2 - v_1 = 7 \text{ m s}^{-1}$$

Only B and D satisfy this. Now apply conservation of momentum, with large mass M and small mass m:

$$5M - 2m = Mv_1 + mv_2$$

- B: $5M - 2m = 3M + 10m$, so $M = 6m$. The large mass is larger, so this is possible.
- D: $5M - 2m = 5M + 12m$, so $14m = 0$. This is impossible.

Q9 Answer **B**

The work done in stretching the spring (the increase in elastic potential energy) is $\int F \mathrm{d}l$, the area between the graph and the length axis between l_1 and l_2.

Here length is on the vertical axis, so this area is the horizontal strip between l_1 and l_2, bounded on the left by the length axis and on the right by the line: $P + Q$.

Q10 Answer **C**

For equilibrium, F_3 must be equal and opposite to the resultant of F_1 (upwards) and F_2 (to the right). The resultant of F_1 and F_2 points up and to the right, so F_3 points down and to the left.

F_2 is longer than F_1, so F_3 is closer to the horizontal than to the vertical. Diagram C shows F_3 pointing down and to the left at this angle.

Q11 Answer **C**

- Friction between two solid surfaces does not depend on the speed, so the frictional force stays the same.
- Viscous drag in a fluid increases as the speed increases.

Q12 Answer **C**

Speed of X at the bottom (energy conservation):

$$v = \sqrt{2gh}$$

X and Y stick together. By conservation of momentum (each of mass m):

$$mv = 2mv\prime \quad \Rightarrow \quad v\prime = \frac{v}{2}$$

The combined masses rise until their kinetic energy becomes potential energy:

$$t = \frac{v\prime^2}{2g} = \frac{(v/2)^2}{2g} = \frac{1}{4}\left(\frac{v^2}{2g}\right) = \frac{h}{4}$$

Q13 Answer **D**

F is the centripetal force:

$$F = \frac{mv^2}{r} \quad \Rightarrow \quad v = \sqrt{\frac{Fr}{m}}$$

Q14 Answer **D**

Gravity provides the centripetal force:

$$\frac{GMm}{r^2} = \frac{mv^2}{r} \quad \Rightarrow \quad v^2 = \frac{GM}{r} \quad \Rightarrow \quad r \propto \frac{1}{v^2}$$

If the speed becomes $v/4$, the radius becomes $4^2 = 16$ times larger: $16r$.

Q15 Answer **A**

The force on 1 kg is GM/d^2, where d is the distance from the centre of the planet.

P is at $d = R$. Q is $2R$ from the surface, so $d = 3R$.

$$\frac{F_\text{Q}}{F_\text{P}} = \frac{R^2}{(3R)^2} = \frac{1}{9}$$

Q16 Answer **B**

Arc length and angle (in radians) are related by $s = r\theta$. The graph of s against θ is a straight line through the origin with gradient r, the radius of the circle.

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Q17 Answer **C**

Power supplied by the cell:

$$P_{\text{cell}} = \frac{240}{2.00 \times 60} = 2.00 \text{ W}$$

Power delivered to the resistor:

$$P_R = VI = (1.50)(0.50) = 0.75 \text{ W}$$

The rest is converted into thermal energy in the internal resistance:

$$P_r = 2.00 - 0.75 = 1.25 \text{ W}$$

Q18 Answer **C**

The volume stays constant, so when the length becomes 4 times larger the cross-sectional area becomes 4 times smaller.

$$R = \frac{\rho l}{A} \quad \Rightarrow \quad R\prime = \frac{\rho(4l)}{A/4} = 16\frac{\rho l}{A} = 16R$$

Q19 Answer **D**

Use $E = I(R + r)$ for both readings:

$$E = 0.50(4.0 + r) = 0.25(10 + r)$$

$$2.0 + 0.50r = 2.5 + 0.25r \quad \Rightarrow \quad r = 2.0\,\Omega$$

$$E = 0.50(4.0 + 2.0) = 3.0 \text{ V}$$

Q20 Answer **A**

For every component to have the full 12 V, each must be connected directly across the battery, in parallel.

- The heater and the motor each need their own switch.
- The four lamps must be in parallel with each other (each with 12 V), all controlled by a single switch.

A satisfies all of these. In B each lamp has its own switch. In C the lamps are in series, so each gets only 3 V. In D the lamps are in two series pairs, so each gets only 6 V.

Q21 Answer **A**

The voltmeter measures the p.d. across the 3.0 Ω resistor.

- With the variable resistor at 0 Ω, the whole 6.0 V is across the 3.0 Ω resistor.
- With it at 12 Ω, the 6.0 V is shared in the ratio 3.0 : 12:

$$V = \frac{3.0}{3.0 + 12}(6.0) = 1.2 \text{ V}$$

The reading decreases to 1.2 V.

Q22 Answer **A**

As the light intensity increases, the resistance of the LDR decreases. The cell's p.d. is shared in the ratio of the resistances, so the LDR's share (its p.d.) decreases.

The cell has negligible internal resistance, so the two p.d.s always add up to the e.m.f. The p.d. across the variable resistor therefore increases.

Q23 Answer **D**

The field of a point charge is radial, and its strength depends only on the distance from the charge ($E \propto 1/r^2$). So at equal distances it has equal magnitude.

- A: the field of a positive charge points away from it.
- B: the field strength decreases with distance.
- C: the field lines are radial, not circular.

Q24 Answer **D**

Parallel currents in the same direction attract, and currents in opposite directions repel. The force is weaker at a larger distance. Let the separation of neighbouring wires be d.

- Q (out of the page): P repels it to the right and R repels it to the left, with equal forces. The resultant force on Q is zero.
- P: Q repels it to the left (distance d); R attracts it to the right, but more weakly (distance $2d$). The resultant force on P is to the left.
- R: by symmetry, the resultant force on R has the same size as on P but is to the right.

P and R have equal resultant forces in opposite directions.

Q25 Answer **B**

The magnetic force is $F = qv \times B$ in direction. Reversing the field reverses the force. Changing the charge from negative to positive reverses it again.

Two reversals bring the force back to its original direction: down and to the right, as in the first diagram. This is direction B.

Q26 Answer **D**

The field is into the page and the electron moves in the plane of the page, so its velocity is perpendicular to the field. The 60° is the angle to the edge of the field region, not to the field.

$$F = Bev = (3.0 \times 10^{-5})(1.60 \times 10^{-19})(1.5 \times 10^{7}) = 7.2 \times 10^{-17} \text{ N}$$

Q27 Answer **C**

Most α-particles pass straight through, and only a very few are deflected through large angles. This is direct evidence that the positive charge and most of the mass are concentrated in a nucleus much smaller than the atom.

The other statements are true, but they are not deduced from this experiment.

Q28 Answer **A**

Isotopes have the same number of protons. Number of protons = nucleons - neutrons:

- P: $22 - 11 = 11$
- Q: $23 - 12 = 11$
- R: $23 - 11 = 12$
- S: $22 - 12 = 10$

P and Q both have 11 protons, so they are isotopes.

Q29 Answer **A**

$$m_{\text{before}} = 235.044 + 1.00863 = 236.05263 \text{ u}$$
$$m_{\text{after}} = 140.914 + 91.926 + 3(1.00863) = 235.86589 \text{ u}$$
$$\Delta m = 0.18674 \text{ u} = (0.18674)(1.66 \times 10^{-27}) = 3.10 \times 10^{-28} \text{ kg}$$
$$E = \Delta m c^2 = (3.10 \times 10^{-28})(3.00 \times 10^{8})^2 = 2.79 \times 10^{-11} \text{ J}$$

Q30 Answer **B**

- Random: the readings fluctuate about the trend, so the moment at which any particular nucleus decays cannot be predicted.
- Spontaneous: the half-life stays the same even though the source gets warmer. The decay is not affected by external conditions such as temperature.

(The activity decreasing is true of any decaying source, and does not show either property.)

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