TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2017 O-Level Physics Paper 1

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ANSWER KEY

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WORKED SOLUTIONS

Q1 Answer **D**

Why D is correct

The base quantities are the quantities from which all others are built: length, mass, time, electric current, temperature, amount of substance and luminous intensity.

Temperature is on the list (SI base unit: kelvin, K), so it is a base quantity.

Why the rest are wrong

A — Charge is a derived quantity: charge = current × time, so its unit is the A s (coulomb).

B — Energy is derived from force and distance (work = force × distance), unit $\mathrm{kg\ m^2\ s^{-2}}$ (joule).

C — Force is derived from mass and acceleration ($F = m \times a$), unit $\mathrm{kg\ m\ s^{-2}}$ (newton).

Watch out for

A. Students pick charge because the coulomb sounds basic. The base electrical quantity is current (ampere), not charge.

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Q2 Answer **B**

Why B is correct

Main (sleeve) scale: the last mark showing before the thimble edge is the half-millimetre mark after 2 mm, so the sleeve reads 2.50 mm.

Thimble scale: the horizontal datum line lines up with the 38th division (between the 35 and 40 labels, three marks above 35). That adds $38 \times 0.01\ \text{mm} = 0.38\ \text{mm}$.

Reading for 20 sheets = $2.50 + 0.38 = 2.88\ \text{mm}$.

Thickness of one sheet = $2.88\ \text{mm} \div 20 = 0.144\ \text{mm}$.

Why the rest are wrong

A — $0.119\ \text{mm} \times 20 = 2.38\ \text{mm}$. This misses the 0.5 mm mark showing on the upper side of the sleeve.

C — $0.169\ \text{mm} \times 20 = 3.38\ \text{mm}$. This reads the sleeve as 3.0 mm, one whole millimetre too many.

D — $0.171\ \text{mm} \times 20 = 3.42\ \text{mm}$. This reads the sleeve as 3.0 mm and the thimble from the wrong side (42 instead of 38).

Watch out for

A. Students who forget the half-millimetre marks on the upper side of the sleeve read 2.38 mm and pick A. Always check whether a 0.5 mm mark is showing after the last whole millimetre.

The thimble reading was taken from the figure: the datum line sits three divisions above the 35 mark, giving 38.

Q3 Answer **D**

Why D is correct

At terminal velocity the object falls at a constant speed, so the height–time graph becomes a straight line. The gradient of that line gives the speed.

The straight part runs from (1.0 s, 3.0 m) to (2.5 s, 0 m).

speed = change in height ÷ time taken = $(3.0 - 0)\ \text{m} \div (2.5 - 1.0)\ \text{s} = 3.0 \div 1.5 = 2.0\ \text{m/s}$.

Why the rest are wrong

A — 1.0 m/s is roughly the speed early on, while the object is still speeding up (the curved part).

B — 1.3 m/s comes from a line not on the straight part of the graph, for example using a point in the curved section.

C — 1.6 m/s is total height ÷ total time = $4.0\ \text{m} \div 2.5\ \text{s}$. That is the average speed for the whole fall, not the terminal velocity.

Watch out for

C. Students who divide the total height by the total time get 1.6 m/s. Terminal velocity is the gradient of the straight section only.

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Q4 Answer **B**

Why B is correct

Distance travelled = area under the velocity–time graph.

From 0 to 4 s (triangle): $\frac{1}{2} \times 4\ \text{s} \times 8\ \text{m/s} = 16\ \text{m}$.

From 4 s to 10 s (rectangle): $6\ \text{s} \times 8\ \text{m/s} = 48\ \text{m}$.

Total distance = $16 + 48 = 64\ \text{m}$.

Why the rest are wrong

A — 48 m is only the rectangle from 4 s to 10 s; the triangle from 0 to 4 s has been left out.

C — 80 m is 8 m/s × 10 s, treating the object as if it moved at 8 m/s for the whole 10 s.

D — 96 m is 8 m/s × 12 s, using the end of the axis instead of $t = 10\ \text{s}$.

Watch out for

C. Students who multiply the final velocity by the total time get 80 m. The object was slower during the first 4 s, so you must add the triangle and the rectangle.

Q5 Answer **B**

Why B is correct

Weight $W = mg = 80\ \text{kg} \times 10\ \text{N/kg} = 800\ \text{N}$ (downwards).

Air resistance = 2400 N (upwards). Resultant force = $2400 - 800 = 1600\ \text{N}$ upwards, so he slows down.

Deceleration $a = F \div m = 1600\ \text{N} \div 80\ \text{kg} = 20\ \text{m/s}^2$.

Why the rest are wrong

A — $10\ \text{m/s}^2$ is just g; it ignores the air resistance completely.

C — $30\ \text{m/s}^2$ is 2400 ÷ 80, using the air resistance alone and forgetting that weight acts the other way.

D — $40\ \text{m/s}^2$ comes from adding the forces $(2400 + 800 = 3200\ \text{N})$; weight and air resistance act in opposite directions, so they subtract.

Watch out for

C. Students who divide 2400 N by 80 kg get $30\ \text{m/s}^2$. Use the resultant force, air resistance minus weight.

Q6 Answer **C**

Why C is correct

Inertia is the reluctance of an object to change its state of rest or of motion.

Mass is the measure of an object's inertia: the larger the mass, the harder it is to start, stop or change the direction of the object.

Why the rest are wrong

A — Acceleration is the result of a change in motion, not the property that resists it.

B — Density is mass per unit volume. Two objects of the same density can have very different inertia if their sizes differ.

D — Volume is the space an object takes up; a large polystyrene block has little inertia.

Watch out for

B. Students link 'heavy-feeling' materials with density. It is the total mass, not the density, that resists a change in motion.

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Q7 Answer **B**

Why B is correct

Mass does not change from planet to planet. Find it from the weight on Venus: $m = W \div g = 46\ \text{N} \div 8.9\ \text{N/kg} = 5.17\ \text{kg}$.

Weight on Mars: $W = mg = 5.17\ \text{kg} \times 3.7\ \text{N/kg} = 19.1\ \text{N} \approx 19\ \text{N}$.

Why the rest are wrong

A — 12 N is $46 \div 3.7 = 12.4$, which divides by the wrong field strength. That number is not the weight on Mars.

C — 110 N is 46 × 8.9 ÷ 3.7, the ratio turned upside down. Mars has a weaker field, so the weight must be smaller than 46 N.

D — 170 N is 46 × 3.7, multiplying the weight on Venus by g on Mars without first finding the mass.

Watch out for

C. Students who invert the ratio get 110 N. Check: Mars has the smaller g, so the rock must weigh less there than 46 N.

Q8 Answer **C**

Why C is correct

Volume of the object: $V = m \div \rho = 28\ \text{g} \div 3.5\ \text{g/cm}^3 = 8.0\ \text{cm}^3$.

The object sinks (it is denser than water) and pushes up the water level by its own volume.

Final reading = $52 + 8.0 = 60\ \text{cm}^3$.

Why the rest are wrong

A — $8.0\ \text{cm}^3$ is the volume of the object only, not the new reading on the cylinder.

B — $44\ \text{cm}^3$ subtracts the object's volume; the water level rises, it does not fall.

D — $98\ \text{cm}^3$ is $28 \times 3.5 = 98$, multiplying mass by density, which gives no meaningful volume.

Watch out for

A. Students stop after finding $V = 8.0\ \text{cm}^3$. The question asks for the reading, so add it to the $52\ \text{cm}^3$ already there.

Q9 Answer **B**

Why B is correct

If two vectors have equal size and point in opposite directions, they cancel and the resultant is zero. For example, 5 N to the left plus 5 N to the right gives 0 N.

So the resultant may sometimes be zero.

Why the rest are wrong

A — Adding two vectors always gives a vector. The resultant can never be a scalar.

C — If the two vectors point the same way, the resultant points that same way too, so its direction is not always different.

D — The magnitude is not always different. For example, two 5 N forces at 120° to each other give a resultant of 5 N.

Watch out for

D. Students think the resultant must be bigger or smaller than both vectors. Two equal vectors at 120° give a resultant equal in size to each of them.

Q10 Answer **D**

Why D is correct

Potential energy is energy stored because of position or arrangement: chemical (in bonds), elastic (in a stretched or squashed object) and gravitational (from height) are all stored energy.

Thermal energy of an object is mostly the kinetic energy of its moving particles, so it is the one listed that is not a form of potential energy.

Why the rest are wrong

A — Chemical energy is stored in the bonds between atoms, so it is potential energy.

B — Elastic energy is stored in a stretched spring or rubber band, so it is potential energy.

C — Gravitational energy is stored because of an object's height, so it is potential energy.

Watch out for

A. Students may not think of chemical energy as 'potential'. It is stored energy, released when bonds change, so it counts as potential energy.

Q11 Answer **C**

Why C is correct

Only the sand matters. Mass of sand = $15\,000 - 10\,000 = 5000\ \text{kg}$.

The sand starts at the bottom and ends at the top of the hill (it is unloaded there), a rise of 50 m.

Change in $GPE = mgh = 5000\ \text{kg} \times 10\ \text{N/kg} \times 50\ \text{m} = 2\,500\,000\ \text{J}$.

Why the rest are wrong

A — 250 000 J is ten times too small; it drops a factor of 10, for example leaving out g.

B — 750 000 J is 15 000 × 50, the whole loaded lorry without g.

D — 7 500 000 J is 15 000 × 10 × 50, the GPE gained by the whole loaded lorry, not just the sand.

Watch out for

D. Students use the total mass of 15 000 kg. The question asks only about the sand, which is 5000 kg.

Q12 Answer **B**

Why B is correct

Falling freely, all the gravitational potential energy becomes kinetic energy: $mgh = \frac{1}{2}mv^2$.

The mass cancels: $v^2 = 2\,\text{g}\,\text{h} = 2 \times 10\ \text{N/kg} \times 20\ \text{m} = 400\ \text{m}^2/\text{s}^2$.

$v = \sqrt{400} = 20\ \text{m/s}$.

Why the rest are wrong

A — 10 m/s is half the correct speed. It is the numerical value of g, not the speed; the energy equation gives $v^2 = 2\text{gh} = 400$, so $v = 20\ \text{m/s}$.

C — 200 m/s is $g \times h = 10 \times 20$, which is not a speed formula.

D — 400 m/s is v^2, forgetting to take the square root.

Watch out for

D. Students stop at $v^2 = 400$ and forget the square root.

Q13 Answer **B**

Why B is correct

Input power = $VI = 240\ \text{V} \times 0.11\ \text{A} = 26.4\ \text{W}$.

Efficiency = useful output power ÷ input power = $24\ \text{W} \div 26.4\ \text{W} = 0.91$.

Why the rest are wrong

A — 0.10 is 24 ÷ 240, dividing the output power by the voltage instead of by the input power.

C — 1.1 is 26.4 ÷ 24, the fraction turned upside down. Efficiency can never be more than 1.

D — 2.6 is 0.11 × 24, which has no meaning here.

Watch out for

C. Students divide input by output and get 1.1. Efficiency is output ÷ input and must be less than 1.

Q14 Answer **A**

Why A is correct

Pressure = force ÷ area, so the pressure is smallest when the slab lies flat on its largest face.

Largest area = $2.0\ \text{m} \times 0.80\ \text{m} = 1.6\ \text{m}^2$.

$p = F \div A = 1300\ \text{N} \div 1.6\ \text{m}^2 = 810\ \text{Pa} = 0.81\ \text{kPa}$.

Why the rest are wrong

B — 22 kPa is $1300 \div (2.0 \times 0.030) = 1300 \div 0.060\ \text{m}^2$, the slab standing on its long edge.

C — 27 kPa is half of 54 kPa; it does not match the pressure on any face of the slab. The smallest pressure uses the largest face.

D — 54 kPa is $1300 \div (0.80 \times 0.030) = 1300 \div 0.024\ \text{m}^2$, the slab standing on its short end. That gives the greatest pressure, not the smallest.

Watch out for

D. Students who pick the smallest area get the greatest pressure. Smallest pressure means largest area.

Q15 Answer **A**

Why A is correct

The gas is heated, so its temperature rises and the molecules move faster on average.

Faster molecules hit the piston harder. If they also hit it more often, the pressure would rise. But the pressure stays constant because the volume increases: the molecules have further to travel between collisions, so they hit each unit area of the piston less often.

So the speed increases and the rate of collision with the piston decreases.

Why the rest are wrong

B — If the molecules hit harder and more often, the pressure would rise. The question says the pressure stays constant.

C — Harder collisions at the same rate would also make the pressure rise.

D — The gas is heated, so its temperature rises and the molecules speed up; the speed cannot stay constant.

Watch out for

B. Students assume faster molecules must collide more often. With the pressure constant, the harder hits must be balanced by fewer collisions per unit area each second.

Q16 Answer **C**

Why C is correct

The scale is linear. 25 cm covers $110 - (-10) = 120°\text{C}$, so $1\ \text{cm} = 120 \div 25 = 4.8°\text{C}$.

15 cm above the −10 °C mark is $15 \times 4.8 = 72°\text{C}$ above −10 °C.

Temperature = $-10 + 72 = 62°\text{C}$.

Why the rest are wrong

A — 50 °C is 15/25 × 100 + (−10), using a 100 °C range instead of 120 °C.

B — 60 °C is 15/25 × 100, using a 100 °C range and forgetting the −10 °C start.

D — 82 °C is 72 + 10, adding 10 °C instead of starting from −10 °C.

Watch out for

B or D. Students forget that the scale starts $at -10°\text{C}$, not 0 °C. The range is 120 °C and you add the 72 °C to −10 °C.

Q17 Answer **D**

Why D is correct

All the blocks are copper, so they have the same specific heat capacity c. From $E = mc\Delta T$, $\Delta T = E \div (mc)$, so ΔT is largest when energy ÷ mass is largest.

$E \div m$: $A = 150 \div 0.10 = 1500\ \text{J/kg}$; $B = 380 \div 0.25 = 1520\ \text{J/kg}$; $C = 600 \div 0.45 = 1333\ \text{J/kg}$; $D = 1300 \div 0.80 = 1625\ \text{J/kg}$.

D has the largest value, so block D has the greatest temperature change.

Why the rest are wrong

A — A gets 1500 J per kg, less than D's 1625 J per kg. Its small mass does not make up for the small energy.

B — B gets 1520 J per kg, close to D but still less.

C — C gets only 1333 J per kg, the smallest of the four.

Watch out for

A. Students pick the lightest block because it heats up 'easily'. You must compare energy per kilogram for every block.

Q18 Answer **A**

Why A is correct

Boiling happens only at one specific temperature (the boiling point) for a given pressure, while evaporation happens at any temperature.

Boiling happens throughout the liquid (bubbles of vapour form inside it), while evaporation happens only at the surface.

Both differences appear in A.

Why the rest are wrong

B — Only at the surface is a property of evaporation, not boiling.

C — Occurring at all temperatures is a property of evaporation, not boiling.

D — Both properties listed belong to evaporation.

Watch out for

B. Students remember the specific temperature but forget that bubbles form throughout the liquid during boiling.

Q19 Answer **C**

Why C is correct

The flames do not touch the tray, and there is air between them. Air is a poor conductor, so very little heat reaches the tray by conduction.

Air heated by the flames becomes less dense and rises to the tray: convection carries most of the heat.

The flames also emit infrared radiation, some of which reaches the tray. So the heat passes mainly by convection and some by radiation.

Why the rest are wrong

A — Conduction needs contact or a good conductor between flame and tray. There is only air, a poor conductor, so conduction is not the main process.

B — Again, conduction through air is very small, so it cannot be the main process.

D — Radiation does reach the tray, but the rising hot air carries most of the heat upwards. Conduction through air is very small.

Watch out for

D. Students think 'flame not touching' means radiation. Hot air rising directly above a flame is the main carrier, so convection dominates.

Q20 Answer **C**

Why C is correct

Conduction and convection both need a medium (matter). Space is a vacuum, so the satellite cannot lose heat by either.

The only way it can lose heat is by radiation, even though shiny surfaces are poor emitters.

Why the rest are wrong

A — The block is in air, so it also loses heat by conduction to the air and by convection.

B — The block is in air, so it also loses heat by conduction and convection, even though its black surface radiates well.

D — The element is in water, so it loses most of its heat by conduction and convection into the water.

Watch out for

B. Students pick the black surface because black is a good emitter. The question asks which loses ALL its heat by radiation, which only happens in a vacuum.

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Q21 Answer **A**

Why A is correct

The period is the time for one complete vibration of the cone: $T = 1/f = 1/20 = 0.050\ \text{s}$.

In one period, one compression and one rarefaction pass a point. A rarefaction sits half a wavelength behind a compression, so it reaches P half a period after the compression.

Time = $T/2 = 0.050/2 = 0.025\ \text{s}$.

Why the rest are wrong

B — 0.050 s is a whole period: the time until the next compression reaches P, not the next rarefaction.

C — 10 s comes from 20 ÷ 2, treating the frequency as if it were a time. Frequency is vibrations per second, so the time must be found from 1 / f.

D — 20 s confuses the frequency, 20 Hz, with a time.

Watch out for

B. Students who work out $T = 1/f$ correctly often stop there. The question asks for the next rarefaction, which is only half a wave behind the compression, so halve the period.

Q22 Answer **D**

Why D is correct

The 20 m arrow runs from one trough to a trough two troughs further on, so it spans two complete wavelengths.

Wavelength: $\lambda = 20/2 = 10\ \text{m}$.

Speed: $v = f\lambda = 2.0 \times 10 = 20\ \text{m/s}$. So the row is $\lambda = 10\ \text{m}$, $v = 20\ \text{m/s}$.

Why the rest are wrong

A — 5.0 m treats the 20 m as four wavelengths, and 2.5 m/s comes from dividing λ by f instead of multiplying.

B — 5.0 m treats the 20 m as four wavelengths. With $\lambda = 5.0\ \text{m}$, $v = 2.0 \times 5.0 = 10\ \text{m/s}$, which matches the wrong wavelength.

C — The wavelength is right, but 5.0 m/s comes from $\lambda \div f$. The wave equation is $v = f\lambda$, so $v = 2.0 \times 10 = 20\ \text{m/s}$.

Watch out for

B. Students who count crests and troughs separately (4 half-waves look like 4 waves) get $\lambda = 5.0\ \text{m}$. Count from trough to the next trough: that distance is one wavelength, and the arrow covers two of them.

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Q23 Answer **B**

Why B is correct

Refraction happens because a wave changes speed when it goes into a different medium.

The frequency is set by the source, so it does not change: the same number of waves arrive at the boundary each second as leave it.

From $v = f\lambda$, if v changes and f stays the same, the wavelength λ must change in proportion to the speed. So speed changes, frequency stays constant, wavelength changes.

Why the rest are wrong

A — The frequency does not change at a boundary; it is fixed by the source.

C — If the speed changes and the frequency stays the same, $v = f\lambda$ forces the wavelength to change too.

D — Refraction is caused by a change of speed, so the speed cannot remain constant.

Watch out for

C. Students who remember that frequency stays fixed sometimes assume wavelength does too. Use $v = f\lambda$: with f fixed, λ must change whenever v does.

Q24 Answer **A**

Why A is correct

Compare the object distance with the focal length: $f = 3.0\ \text{cm}$, so $2f = 6.0\ \text{cm}$.

The object is 4.0 cm from the lens, which is between f and $2f$.

For a converging lens with the object between f and $2f$, the image forms beyond $2f$ on the other side of the lens. It is real, inverted and magnified.

Why the rest are wrong

B — A converging lens never forms a real image that is upright. Real images formed by a single lens are always inverted.

C — Virtual images formed by a converging lens are upright, not inverted, and a virtual image only forms when the object is closer than f.

D — A virtual, upright image (magnifying glass) needs the object nearer to the lens than the focal point, i.e. less than 3.0 cm away.

Watch out for

D. Students who see the object 'close' to the lens think of a magnifying glass. Check against f: 4.0 cm is beyond the focal point, so the image is real.

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Q25 Answer **D**

Why D is correct

Statement 1: light travels slower in glass than in vacuum. Speed in the fibre: $v = c/n = 3.0 \times 10^8 / 1.5 = 2.0 \times 10^8\ \text{m/s}$. So statement 1 is wrong: $3.0 \times 10^8\ \text{m/s}$ is the speed in vacuum (or air).

Statement 2: optical fibres carry signals with less loss of signal strength than copper cables, so signals can travel further before they need boosting. Statement 2 is correct.

Only statement 2 is correct.

Why the rest are wrong

A — Statement 2 is correct: optical fibres lose less signal than copper cables.

B — Statement 1 is wrong: in a material of refractive index 1.5 the speed is $2.0 \times 10^8\ \text{m/s}$, not $3.0 \times 10^8\ \text{m/s}$.

C — Statement 1 is the wrong one; $3.0 \times 10^8\ \text{m/s}$ is the speed of light in vacuum, not in glass.

Watch out for

B. Students who know that the signal is light assume it travels at $3.0 \times 10^8\ \text{m/s}$. That is the speed in vacuum; inside the fibre it is c / n.

Q26 Answer **D**

Why D is correct

The correct order, from longest wavelength to shortest, is: radio waves, microwaves, infra-red, visible light, ultra-violet, X-rays, gamma rays.

A and C put X-rays before gamma rays at the end of the spectrum, so they are in the wrong order. B and D have the right order, radio waves on the left to gamma rays on the right.

Going from radio waves to gamma rays, the wavelength gets shorter and the frequency gets higher. D's arrow points towards gamma rays labelled 'increasing frequency', which is correct.

Why the rest are wrong

A — Gamma rays and X-rays are swapped: gamma rays have the shortest wavelength and belong at the end.

B — The order is right, but the arrow is wrong: wavelength decreases from radio waves towards gamma rays, so 'increasing wavelength' should point towards radio waves.

C — Gamma rays and X-rays are swapped. The arrow direction would also be wrong for this order.

Watch out for

B. Students who check only the order of the regions pick B. Both B and D have the right order; the arrow decides it. Wavelength increases towards radio waves, frequency increases towards gamma rays.

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Q27 Answer **A**

Why A is correct

Loudness depends on how much energy the wave carries, which shows up as the amplitude: a larger amplitude gives a louder sound.

Pitch depends on the frequency: a higher frequency gives a higher pitch.

Why the rest are wrong

B — This swaps the two: amplitude decides loudness and frequency decides pitch.

C — The speed of sound depends on the medium, not on loudness. Pitch is linked to frequency; wavelength alone does not decide it because it also depends on the medium.

D — Loudness does not depend on wavelength, and pitch does not depend on amplitude.

Watch out for

B. Students who know the two pairs but mix them up pick B. Remember: Amplitude → loudness (a big shout), Frequency → pitch (a high note).

Q28 Answer **B**

Why B is correct

Sound travels by particles passing the vibration on to their neighbours. The closer and more tightly bound the particles, the faster the sound travels.

Gases are slowest, liquids are faster, solids are fastest. Typical values: air ≈ $330\ \mathrm{m/s}$, water ≈ $1500\ \mathrm{m/s}$, steel ≈ $5000\ \mathrm{m/s}$.

Lowest to highest: air → water → steel.

Why the rest are wrong

A — Steel is the fastest, not in the middle. Water is between air and steel.

C — Sound is slower in air than in water, so air comes first.

D — This is almost the reverse order. Air is slowest and steel is fastest.

Watch out for

C. Students who think water 'blocks' sound put water first. Sound actually travels about four times faster in water than in air.

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Q29 Answer **A**

Why A is correct

To demagnetise a magnet with a solenoid, the solenoid must carry alternating current. The a.c. makes the field keep reversing, so the magnetic domains are pushed one way and then the other.

The magnet is then withdrawn slowly from the solenoid (to a distance, say east–west). As it moves away, the reversing field gets weaker, so the domains end up pointing in random directions and the magnet loses its magnetism.

Of the options, only the use of a.c. is a necessary part of this procedure.

Why the rest are wrong

B — Direct current gives a steady field in one direction. It magnetises a magnet rather than demagnetising it.

C — How the magnet is inserted does not matter. What matters is the a.c. and how the magnet is removed.

D — The magnet must be withdrawn slowly so that the alternating field it feels dies away gradually. Pulling it out quickly could leave it magnetised.

Watch out for

D. Students who remember that 'withdrawing' is part of the method pick D. The magnet is withdrawn slowly, not quickly.

Q30 Answer **C**

Why C is correct

The negative rod repels the free electrons in the sphere. Because the sphere is earthed, these electrons flow away down the earth wire.

The earth wire is removed while the rod is still there, so the electrons cannot flow back.

When the rod is removed, Q is left with fewer electrons than protons. It is positively charged because negative charges (electrons) have left Q.

Why the rest are wrong

A — Electrons are repelled away from Q by the negative rod, not attracted onto it. Q ends up positive.

B — Positive charges (protons) are fixed in the nuclei and do not move in a metal. Only electrons move.

D — Q is positive, but not because positive charges arrived: only electrons move, and they left Q.

Watch out for

D. Students who get the sign right still pick D. In a metal only electrons move, so a positive charge always means electrons have left.

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Q31 Answer **D**

Why D is correct

An electric field is a region where an electric charge experiences a force. Any charge placed in it feels a force $F = qE$, whether it is moving or not.

So a charge always experiences a force in an electric field.

Why the rest are wrong

A — A current-carrying wire has equal amounts of positive and negative charge, so it is neutral overall. The force on a current-carrying wire comes from a magnetic field.

B — A magnet experiences a force in a magnetic field, not in an electric field.

C — A piece of uncharged aluminium has no net charge, so it does not always experience a force.

Watch out for

A. Students who link 'current' with 'force' pick A. A current-carrying wire feels a force in a magnetic field; in an electric field it is the charge that matters, and the wire has no net charge.

Q32 Answer **B**

Why B is correct

Current is the rate of flow of charge: $Q = It$, so $t = Q/I$.

Convert units: $Q = 84\mu C = 84 \times 10^{-6}$ C, $I = 35$ mA $= 35 \times 10^{-3}$ A.

$t = 84 \times 10^{-6} / 35 \times 10^{-3} = 2.4 \times 10^{-3}$ s $= 2.4$ ms.

Why the rest are wrong

A — 0.42 ms comes from $I \div$ Q (with the prefixes mixed up). Time is charge divided by current, $t = Q/I$.

C — 34 ms does not come from $Q = It$; check the unit conversion and the division.

D — 2900 ms is about $I \times$ Q without correct prefixes. Multiplying charge by current does not give a time.

Watch out for

A. Students who divide the wrong way round get $35 \div 84 = 0.42$. Rearrange $Q = It$ carefully: $t = Q/I$.

Q33 Answer **D**

Why D is correct

The potential difference across a component is the work done (energy converted) in driving unit charge (one coulomb) through it.

In symbols, $V = W/Q$, so 1 V $= 1$ J/C.

Why the rest are wrong

A — Power is energy per second, not energy per charge. And p.d. is defined per coulomb, not per electron.

B — Power is the rate of doing work. P.d. is work done per unit charge, not power per unit charge.

C — An electron carries only 1.6×10^{-19} C. P.d. is defined per unit charge (1 C), not per electron.

Watch out for

C. Students who think of charge as electrons pick C. The definition uses unit charge, one coulomb, which is a huge number of electrons.

Q34 Answer **B**

Why B is correct

The resistance of a wire is $R = \rho L/A$. Same material means the same ρ.

Doubling the length doubles R. Making the area four times bigger divides R by 4.

$R(Q) = 80 \times 2/4 = 40\Omega$.

Why the rest are wrong

A — 10Ω comes from dividing by 4 twice, or ignoring that a longer wire has more resistance. The length doubling makes R twice as big.

C — 160Ω only accounts for the doubled length and ignores the larger cross-sectional area.

D — 640Ω multiplies by 2 and by 4. A thicker wire has less resistance, so the area factor divides.

Watch out for

D. Students who think 'bigger wire, more resistance' multiply by 4. A larger cross-sectional area gives the current more room, so resistance goes down.

Q35 Answer **C**

Why C is correct

The LDR and thermistor are in series, so they share the battery's e.m.f. in the ratio of their resistances. The thermistor gets the largest p.d. when its resistance is as large as possible and the LDR's resistance is as small as possible.

A thermistor's resistance is high when it is cold.

An LDR's resistance is low when it is bright.

So bright and cold gives the largest p.d. across the thermistor.

Why the rest are wrong

A — In the dark the LDR has a high resistance, so it takes a large share of the p.d., leaving less for the thermistor.

B — Dark makes the LDR resistance high and hot makes the thermistor resistance low, so the thermistor gets the smallest p.d. in this case.

D — When hot, the thermistor's resistance is low, so it takes a smaller share of the p.d.

Watch out for

A. Students who look only at the thermistor ('cold means high resistance') forget the LDR. The share each gets depends on both resistances, so you also need the LDR to be low, which means bright.

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Q36 Answer **A**

Why A is correct

Each wire has a circular field around it. With the current coming up out of the page (as seen from above), the right-hand grip rule gives an anticlockwise field around each wire.

Between the wires the two fields point in opposite directions and cancel, so the field there is weak. Outside, the fields add, and the outer field lines go round both wires together. This is the pattern in A and C.

The force acts from the strong field region towards the weak field region. The fields are strong on the outside and weak in between, so each wire is pushed towards the other: the wires attract. That is diagram A.

Why the rest are wrong

B — B shows the fields around the two wires in opposite directions (one clockwise, one anticlockwise). That is the pattern for currents in opposite directions, not both upward.

C — The field pattern is right, but the forces are drawn apart. Currents in the same direction attract, so the forces point towards each other.

D — D shows the field for opposite currents, which repel. Both wires here carry current upward.

Watch out for

C. Students who learn 'like charges repel' carry it over to currents and pick C. For currents it is the other way round: currents in the same direction attract.

The diagrams are drawn looking along the wires, with both currents out of the page. Check the arrows: in A and C every loop is anticlockwise, and the outer loops enclose both wires.

Q37 Answer **A**

Why A is correct

For a 100% efficient transformer, input power = output power.

Output power: $P = VI = 110 \times 19 = 2090\ \text{W}$.

Input current: $I = P/V = 2090/240 = 8.7\ \text{A}$.

Why the rest are wrong

B — 13 A does not follow from equating input and output power. Use $V_\text{p} I_\text{p} = V_\text{s} I_\text{s}$.

C — 19 A is the output current. The input voltage is higher, so the input current is lower for the same power.

D — 41 A comes from 19 × 240 / 110, getting the ratio upside down. A step-down transformer has a smaller current on the primary side.

Watch out for

D. Students who scale the current the same way as the voltage get 41 A. Power is conserved: higher voltage means smaller current, so $I_\text{p} = 19 \times 110/240$.

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Q38 Answer **B**

Why B is correct

Before the magnet moves, the ammeter reads zero, so there is no cell driving a current in the circuit.

When the magnet moves towards the box, the needle deflects, and when the magnet stops, the needle goes back to zero. A current only while the magnetic field is changing is electromagnetic induction. This needs a coil.

So the box contains a coil only.

Why the rest are wrong

A — A cell in series with the coil would drive a steady current all the time, so the ammeter would not read zero at the start or after the magnet stops.

C — An LDR responds to light, not to a moving magnet. The cell would also give a steady reading all the time.

D — An LDR on its own has no source of e.m.f., so no current would flow at all.

Watch out for

A. Students who think a current needs a cell pick A. Here the moving magnet is the source of e.m.f.; a cell would make the reading non-zero even with the magnet at rest.

Q39 Answer **D**

Why D is correct

For a transformer, $V_\mathrm{s}/V_\mathrm{p} = N_\mathrm{s}/N_\mathrm{p}$, so $V_\mathrm{s} = V_\mathrm{p} \times N_\mathrm{s}/N_\mathrm{p}$. Check each row:

A: $24 \times 1000/200 = 120\ \mathrm{V}$. B: $24 \times 10\,000/200 = 1200\ \mathrm{V}$. C: $240 \times 10/2000 = 1.2\ \mathrm{V}$. D: $240 \times 100/2000 = 12\ \mathrm{V}$.

Only D gives the 12 V the lamp needs.

Why the rest are wrong

A — This is a step-up transformer: $24 \times 1000/200 = 120\ \mathrm{V}$, far too high for a 12 V lamp.

B — This steps up even more: $24 \times 10\,000/200 = 1200\ \mathrm{V}$.

C — The turns ratio is too small: $240 \times 10/2000 = 1.2\ \mathrm{V}$, so the lamp would be very dim.

Watch out for

A. Students who see a 24 V supply (close to 12 V) choose it without checking. The secondary voltage depends on the turns ratio, and here the secondary has more turns, so the voltage goes up.

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Q40 Answer **C**

Why C is correct

For a given power, $P = VI$. Transmitting at a high voltage means the current in the cables is small.

The power lost as heat in the cables is $P = I^2R$. A smaller current gives much less thermal energy produced in the cables, so less energy is wasted.

Why the rest are wrong

A — For the same power, a higher voltage makes the current smaller, not greater.

B — The resistance of the cables depends on their material, length and thickness, not on the voltage.

D — Real transformers do waste some energy (for example as heat in the coils and core). Using high voltage does not remove these losses.

Watch out for

B. Students who think 'less loss' means 'less resistance' pick B. The voltage changes the current, not the resistance; the loss falls because I^2R falls.

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