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TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2025 O-Level Physics Paper 1

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ANSWER KEY

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WORKED SOLUTIONS

Q1 Answer D

Why D is right

X and Y are several metres apart, so the length must be measured with a measuring tape — a caliper reads only a few centimetres.

A ball rolling several metres down a slope takes a few seconds, which is exactly what a stop-watch is for.

So: tape for the distance, stop-watch for the time.

Why the rest are wrong

• A, B — calipers are precision instruments for small lengths (a few cm, to 0.1 mm). They cannot span several metres.

• A, C — a simple pendulum measures time only in whole multiples of its period; it cannot be started and stopped on the ball passing X and Y.

Watch out for

C. Students who remember "a pendulum can be used as a timer" pick it without asking whether it can be started and stopped at will. Choose an instrument by its range first, then by its precision.

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Q2 Answer **B**

Why B is right

Both forces act at O. Tip-to-toe (or parallelogram) addition of two perpendicular forces gives resultant = $\sqrt{3.0^2 + 4.0^2} = \sqrt{25} = 5.0\ \text{N}$

The 3.0 N force points from O towards P and the 4.0 N force points from O towards R. Adding a "leftwards" and a "downwards" vector gives a resultant that points down-left, i.e. along the diagonal OQ.

Why the rest are wrong

• A — correct magnitude, but PR is the other diagonal and does not start from the point where the forces act.

• C, D — 7.0 N is 3.0 + 4.0, the simple scalar sum. That is only valid for forces acting in the same direction.

Watch out for

A. Getting 5.0 N and then guessing the direction. The resultant always runs from the common point of application (O) to the opposite corner of the parallelogram — here, O to Q.

Q3 Answer **B**

Why B is right

$W = mg$

$m = 85\ \text{g} = 0.085\ \text{kg}$, $g = 10\ \text{N/kg}$

$W = 0.085 \times 10 = 0.85\ \text{N}$

Why the rest are wrong

• A — 0.0085 N is ten times too small (dividing by 10 instead of multiplying).

• C — 8.5 N comes from using $m = 0.85\ \text{kg}$: the mass has been divided by 100 instead of 1000.

• D — 850 N uses $m = 85\ \text{kg}$; the gram-to-kilogram conversion has been skipped entirely.

Watch out for

C. It looks like a "sensible" number for an apple in newtons. The check: an apple weighs about 1 N, so 0.85 N is the only answer of the right order.

Q4 Answer **D**

Why D is right

The particle starts from rest $(u = 0)$ with constant acceleration n over a distance d.

$s = ut + \frac{1}{2}at^2$

$d = 0 + \frac{1}{2}nt^2$

$t^2 = 2d/n$

$t = \sqrt{2d/n}$

Why the rest are wrong

• A — d/n is what you would write if n were a speed, not an acceleration.

• B — $d/2n$ is the same error with a stray factor of 2.

• C — $\sqrt{d/n}$ drops the factor of 2, i.e. it uses $d = nt^2$ instead of $d = \frac{1}{2}nt^2$.

Watch out for

C. It has the right shape (a square root) and is only "off by a 2". Check dimensions and the ½ in the equation of motion.

Q5 Answer B

Why B is right

The surface is smooth and the object moves at constant velocity, so the resultant horizontal force is zero:

$F_1 = F_2$

But an action–reaction pair must act on two different bodies. F_1 and F_2 both act on the same object, so they are not a Newton's third law pair — they are simply balanced forces.

Why the rest are wrong

• A — equal and opposite, yes; but both act on the same body, so not an action–reaction pair.

• C — W is vertical; it is balanced by the normal contact force, not by the horizontal forces.

• D — if $F_2 > F_1$ there would be a resultant force and the object would accelerate, not move at constant velocity.

Watch out for

A. "Equal and opposite" is not the test for a third-law pair. The test is: do the two forces act on different objects? Here they do not.

Q6 Answer C

Why C is right

Read the time axis carefully: it is in minutes.

Deceleration runs from 20 min to 30 min, i.e. $10\,\text{min} = 600\,\text{s}$.

distance = area under the graph = ½ × base × height

= $\frac{1}{2} \times 600\,\text{s} \times 60\,\text{m/s} = 18\,000\,\text{m}$

$W = F \times d = 30\,000\,\text{N} \times 18\,000\,\text{m} = 5.4 \times 10^8\,\text{J}$

Why the rest are wrong

• A — $9.0 \times 10^6\,\text{J} = 30\,000 \times 300$; the "600" was left in minutes, giving a distance of $\frac{1}{2} \times 10 \times 60 = 300\,\text{m}$.

• B — $1.8 \times 10^7\,\text{J} = 30\,000 \times 600$; the time (600 s) has been used as the distance.

• D — $1.1 \times 10^9\,\text{J}$ uses 20 min (1200 s) instead of the 10 min over which the train actually decelerates.

Watch out for

A. The graph's time axis is in minutes, not seconds — the single most common mark-loser on this question. Convert before you take the area.

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Q7 Answer **C**

Why C is right

The property that resists a change in the state of rest or motion is inertia, and the measure of inertia is mass.

Why the rest are wrong

• A — acceleration is the change in motion; it cannot be the property that resists it.

• B — density is mass per unit volume; a small dense object can have very little inertia.

• D — volume says nothing about how much matter there is (a balloon has a large volume and tiny inertia).

Watch out for

B. "Dense" feels like "hard to move", but a $1\ \text{cm}^3$ block of lead is far easier to accelerate than a $1\ \text{m}^3$ block of polystyrene. Inertia depends on mass alone.

Q8 Answer **C**

Why C is right

Newton's third law: the propeller pushes the water backwards with 2000 N, so the water pushes the propeller forwards with an equal and opposite 2000 N.

The action–reaction pair is propeller on water / water on propeller — both 2000 N, whatever else is happening.

Why the rest are wrong

• A — 200 N is the resultant force on the boat (2000 − 1800), not the force from the water on the propeller.

• B — 1800 N is the resistive force on the hull, a different force on a different body.

• D — 3800 N adds two forces that act on different objects in different directions.

Watch out for

A. The question asks for the third-law partner, not the resultant. A third-law pair is never affected by any other force in the problem — including friction and drag.

Q9 Answer **A**

Why A is right

All three statements are correct.

• 1 — pivoted at the centre of gravity, the weight acts through the pivot, its moment about the pivot is zero, and the object balances in any orientation.

• 2 — the centre of gravity is a single point (it may lie outside the material of the object, e.g. for a ring).

• 3 — that is the definition: the point at which the whole weight of the object may be taken to act.

Why the rest are wrong

Each of B, C and D leaves out a statement that is in fact true.

Watch out for

D. Students reject statement 1 because they picture an object balanced on a knife edge and think the pivot must be below the centre of gravity. Pivoting at the centre of gravity gives zero moment, so it balances.

Q10 Answer **D**

Why D is right

$p = \rho g h$

The pressure at the base depends only on the density of the liquid and the depth. Both beakers hold water filled to the same level, so the depth h is the same and the pressures at the bases are equal.

Why the rest are wrong

• A, B — force = $p \times A$. The pressures are equal but the base areas are not, so the force on the base of S (smaller area) is smaller than on T, not greater and not the same.

• C — pressure does not depend on the base area at all.

Watch out for

A. Reasoning about force when the question rewards pressure. Pressure at a depth is independent of the shape and cross-section of the container — the "hydrostatic paradox".

Q11 Answer **B**

Why B is right

The instrument balances the atmospheric pressure against a liquid column:

$p = \rho g h$

On Earth: $p = \rho_{Hg} \times g \times 0.760$

On planet Z: density is $\rho_{Hg}/2$, gravitational field strength is $2g$, atmospheric pressure is unchanged.

$p = (\rho_{Hg}/2) \times (2g) \times h = \rho_{Hg} \times g \times h$

The halving of density and the doubling of g cancel exactly, so

$h = 760\ \text{mm}$

Why the rest are wrong

• A — 190 mm applies both factors in the wrong direction (÷4).

• C — 1520 mm applies only the halved density (which doubles h) and ignores the doubled g.

• D — 3040 mm applies both factors as if they both increased h.

Watch out for

C. Halving the density alone would double the column, but the stronger gravity makes each millimetre of liquid press twice as hard. The two changes cancel — always substitute into $p = \rho g h$ rather than reasoning one factor at a time.

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Q12 Answer **D**

Why D is right

Air resistance is ignored, so the total energy of the ball is conserved between X and Y:

KE at X = KE at Y + gain in GPE

KE at $X = 2.0\ \text{J} + 8.0\ \text{J} = 10\ \text{J}$

Why the rest are wrong

• A — 2.0 J is the kinetic energy at Y, not at X.

• B — 6.0 J subtracts instead of adds.

• C — 8.0 J assumes the ball is momentarily at rest at Y, which is only true for a ball thrown straight up. This ball still has 2.0 J at the top.

Watch out for

C. The instinct "at maximum height the ball is at rest" is wrong here: the question tells you there is 2.0 J of kinetic energy at Y, so the ball must have a horizontal velocity component at the top.

Q13 Answer **D**

Why D is right

A gas has no fixed shape (it takes the shape of its container) and no fixed volume (it expands to fill the container). Its particles are far apart, in random high-speed motion, with negligible forces between them.

Why the rest are wrong

• A — fixed shape and fixed volume describes a solid.

• B — fixed shape but not fixed volume describes nothing.

• C — not fixed shape but fixed volume describes a liquid.

Watch out for

C. The liquid row. Read the two columns as a pair: only a gas is free in both respects.

Q14 Answer **C**

Why C is right

$E_\text{k} = \frac{1}{2}mv^2$

Let car Q have mass m and speed v. Then car P has mass $4m$ and speed $v/2$.

$E_\text{P} = \frac{1}{2}(4m)(v/2)^2 = \frac{1}{2} \times 4m \times v^2/4 = \frac{1}{2}mv^2$

$E_\text{Q} = \frac{1}{2}mv^2$

$E_\text{P} : E_\text{Q} = 1$

The fourfold increase in mass is exactly cancelled by the halved speed, because speed is squared.

Why the rest are wrong

• A, B — 1/4 and 1/2 come from squaring the speed ratio but mishandling the mass factor.

• D — 2 comes from not squaring: $4 \times \frac{1}{2} = 2$.

Watch out for

D. Forgetting the square on v. Halving the speed cuts the kinetic energy to a quarter, not a half.

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Q15 Answer **D**

Why D is right

The cold metal tubes cool the surrounding air. Cooled air contracts, so the same mass occupies a smaller volume:

$\rho = m/V$, V decreases $\rightarrow$ ρ increases

Denser air sinks, and warmer, less dense air moves up to take its place. This is why the cooling unit is placed at the top of a refrigerator — the convection current it drives sweeps downwards through the whole cabinet.

Why the rest are wrong

- A, B — cooling makes air more dense, not less.
- C — more dense air sinks; it cannot rise.

Watch out for

A. The memorised phrase "warm air rises" applied without checking the direction of the temperature change. Always go through density first: cooler ▮ denser ▮ sinks.

Q16 Answer **C**

Why C is right

Internal energy increases when the substance absorbs energy. Heating water from 0 °C to 100 °C raises the average kinetic energy of its molecules, so its internal energy increases.

Why the rest are wrong

- A — steam condensing to water at 100 °C releases latent heat of vaporisation; internal energy falls.
- B — cooling from 100 °C to 0 °C releases energy; internal energy falls.
- D — water freezing to ice at 0 °C releases latent heat of fusion; internal energy falls.

Watch out for

A. A change of state at constant temperature does change the internal energy — but condensation and freezing give energy out. Ask in every case: is energy going in or out?

Q17 Answer **A**

Why A is right

The heater's power is already known, so the energy supplied is

$E = P \times t$

and the current is not needed. (Current would only be used to find the power from $P = VI$.)

The remaining measurements are all essential:

$E = mc\Delta\theta$ ▮ you need m, and $\Delta\theta$ = final − initial temperature, and t to get E.

Why the rest are wrong

- B — the initial temperature is needed to work out the temperature rise.
- C — the mass appears directly in $E = mc\Delta\theta$.
- D — without t you cannot convert the known power into an energy.

Watch out for

D. Students who always start from $E = VIt$ decide that they need the current and therefore look for something else to discard — usually time. Read the stem: "a heater of known power" removes the electrical measurements, not the timing.

Q18 Answer **C**

Why C is right

$E = VIt = 240 \times 10 \times 100 = 2.4 \times 10^5\ \text{J}$

"Greatest possible mass" means assume all of that energy goes into the water (no losses).

$E = mc\Delta\theta$

$\Delta\theta = 70 - 30 = 40^\circ\text{C}$

$m = E/(c\Delta\theta) = 240\,000/(4.2 \times 40) = 1428.6\ \text{g} \approx 1400\ \text{g}$

Why the rest are wrong

- B — 820 g comes from using $\Delta\theta = 70^\circ\text{C}$ (the final temperature) instead of the rise.
- D — 1900 g comes from using $\Delta\theta = 30^\circ\text{C}$ (the initial temperature).
- A — 230 g is far too small; no single standard slip produces it, so treat it as a decoy.

Watch out for

B and D. Both come from putting a temperature into the equation where a temperature change belongs. Write $\Delta\theta = 70 - 30 = 40^\circ\text{C}$ on the page before substituting.

Q19 Answer **A**

Why A is right

L is the energy needed to melt a stated mass m of ice. Energy for a particular mass is latent heat; energy per unit mass is specific latent heat.

Melting (solid [redacted] liquid) is fusion.

So L is the latent heat of fusion of a mass m of ice. (The specific latent heat of fusion would be L / m.)

Why the rest are wrong

- B, D — vaporisation is liquid [redacted] gas; this change is solid [redacted] liquid.
- C — "specific" means per unit mass; L is for the whole mass m, so it is not a specific quantity.

Watch out for

C. By far the most tempting distractor, because "specific latent heat of fusion" is the phrase students have drilled. The word specific is doing all the work: no "per kilogram" in the question means no "specific" in the answer.

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Q20 Answer **B**

Why B is right

Speed of the wave (from the crest travelling 20 m in 5.0 s):

$v = d/t = 20/5.0 = 4.0\ \text{m/s}$

Period (one crest passes a fixed point every 2.0 s):

$T = 2.0\ \text{s}$

$\lambda = vT = 4.0 \times 2.0 = 8.0\ \text{m}$

(Equivalently $f = 1/T = 0.50\ \text{Hz}$ and $\lambda = v/f = 4.0/0.50 = 8.0\ \text{m}$.)

Why the rest are wrong

• A — 4.0 m is the speed in m/s, quoted as a length.

• C — $10\ \text{m} = 20/2.0$, mixing the travel distance with the period.

• D — $50\ \text{m} = 20 \times 5.0/2.0$, a scrambled combination.

Watch out for

A. The number 4.0 appears early in the working and carries the wrong unit. Finish with $\lambda = v \times T$ and check the unit is metres.

Q21 Answer **C**

Why C is right

• Ultraviolet is part of the electromagnetic spectrum, and all electromagnetic waves are transverse.

• Ultrasound is sound of frequency above about 20 kHz. All sound waves are longitudinal.

Why the rest are wrong

• A, B — ultraviolet is never longitudinal.

• D — ultrasound is never transverse; it is a pressure wave in a material medium.

Watch out for

A and D. The shared prefix "ultra-" invites students to give the two waves the same nature. Classify by what the wave is (electromagnetic vs sound), not by what it is called.

Q22 Answer **D**

Why D is right

• Statement 1 is false. Ultrasound has a frequency above the audible range (above about 20 kHz), not below it.

• Statement 2 is false. The image is built from ultrasound reflected back to the probe, not from ultrasound that passes right through the patient.

• Statement 3 is true. Partial reflection occurs at every boundary between tissues of different density, and the time delay of each echo gives the depth of that boundary.

So only statement 3 is correct.

Why the rest are wrong

A, B and C each include a false statement (1 or 2).

Watch out for

Statement 2. It describes an X-ray radiograph, which does use radiation transmitted through the patient. An ultrasound scan is an echo technique — nothing that passes through is used.

Q23 Answer **B**

Why B is right

• A television remote controller uses infrared — short range, blocked by walls, cheap emitters and detectors.

• Thin glass fibres for medical examination (an endoscope) carry visible light, so the doctor can see the image directly.

Why the rest are wrong

• A — microwaves are not used in endoscopes; they are not guided by thin glass fibres and would not form a visible image.

• C, D — microwaves are used for satellite and mobile-phone communication and in microwave ovens, not for the short line-of-sight signal from a remote.

Watch out for

D. Because some modern remotes use radio, students choose "microwaves". The 6091 answer for a television remote controller is infrared.

Q24 Answer **D**

Why D is right

The light enters along a normal to the curved surface, so it passes into the glass undeviated and travels to the centre of the flat top surface.

At the top surface the angle of incidence is less than the critical angle, so the light is partly refracted out into the air and partly reflected back into the glass.

• Glass ▮ air means less dense medium, so the refracted ray bends away from the normal: angle of refraction > angle of incidence.

• The reflected ray obeys angle of reflection = angle of incidence.

Measured from the diagram, D shows an incident ray at about 30° to the normal, an emergent ray at about 52° (bent away — and $\sin 52^\circ / \sin 30^\circ \approx 1.5$, the refractive index of glass) and a reflected ray at about 30° on the other side of the normal. Only D is consistent.

Why the rest are wrong

• A — the structure is right (one ray out, one reflected at 30°) but the emergent ray is drawn at about 22°, i.e. bent towards the normal. That is what happens on entering a denser medium, not leaving one.

• B — the second ray inside the glass leaves at about 59°, which is not equal to the 30° angle of incidence, so it is not a valid reflected ray.

• C — the light emerges along the surface (angle of refraction 90°). That happens only when the angle of incidence is exactly the critical angle, not below it.

Watch out for

A. It is the mirror-image trap: correct rays, wrong bending direction. Fix the rule once — entering a denser medium, bend towards the normal; leaving it, bend away — and check which side of the normal the ray moves to.

Q25 Answer **D**

Why D is right

Protons all carry a positive charge, and like charges repel. So protons repel other protons. (It is the strong nuclear force, not electrostatics, that holds the nucleus together against this repulsion.)

Why the rest are wrong

- A — electrons are all negative, so they repel one another, not attract.
- B — electrons and protons carry opposite charges, so they attract; this is what binds the atom.
- C — neutrons are uncharged, so they exert no electrostatic force on electrons.

Watch out for

B. Reversing the electron–proton interaction. If electrons repelled protons, no atom could hold together.

Q26 Answer **C**

Why C is right

The sphere is a conductor on an insulating stand, and it is uncharged overall — no charge can enter or leave it.

Bringing a negatively charged rod near repels the free electrons in the metal to the far side. This leaves:

- the near side (facing the rod) positive, and
- the far side negative,

with equal amounts of each, so the total charge is still zero. That is charging by induction (separation, not transfer).

Why the rest are wrong

- A — shows a net negative charge; the sphere is insulated, so no charge has been added.
- B — shows a net positive charge, for the same reason. Charge is not conserved in A or B.
- D — the polarity is reversed: negative charge cannot be attracted towards a negative rod.

Watch out for

B. Students correctly remember "the near side becomes positive" and stop there. On an isolated conductor, an equal negative charge must appear on the far side.

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Q27 Answer **B**

Why B is right

Charge stored during charging:

$Q = It = 0.50 \times (6.0 \times 3600) = 0.50 \times 21\,600 = 10\,800\ \text{C}$

Battery e.m.f.: three cells in series

$V = 3 \times 4.0 = 12\ \text{V}$

Energy stored (charging is 100% efficient):

$E = QV = 10\,800 \times 12 = 1.296 \times 10^5\ \text{J}$

Discharge time at 40 W:

$t = E/P = 129\,600/40 = 3240\ \text{s} = 54$ minutes

Why the rest are wrong

- A — 18 minutes uses the e.m.f. of one cell (4.0 V) instead of the 12 V battery.
- D — 3200 minutes is the correct number 3240 with the unit left as seconds mislabelled as minutes.
- C — 160 minutes does not follow from any single standard slip; it is a decoy.

Watch out for

D. The arithmetic is right and the unit is wrong. Convert 3240 s to minutes on the page (÷ 60) rather than in your head.

Q28 Answer **D**

Why D is right

Same material, same length, so resistance depends only on cross-sectional area:

$R \propto 1/A$ and $A \propto d^2$

W_1 has half the diameter of W_2, so its area is one quarter, so

$R_1 = 4R_2$

The wires are in parallel across 6.0 V and the battery current is 0.15 A:

$R_{\text{parallel}} = V/I = 6.0/0.15 = 40\Omega$

$1/40 = 1/R_1 + 1/R_2 = 1/R_1 + 4/R_1 = 5/R_1$

$R_1 = 5 \times 40 = 200\Omega$

(Check: $R_2 = 50\Omega$, and 200 ∥ 50 = 40Ω ✓)

Why the rest are wrong

- A — 50Ω is R_2, the resistance of the thicker wire.
- B — 60Ω does not satisfy the parallel condition.
- C — 120Ω comes from taking $R \propto 1/d$, giving $R_1 = 2R_2$ and $1/40 = 3/R_1$.

Watch out for

C. Using $R \propto 1$/diameter instead of $R \propto 1$/diameter^2. Halving the diameter quarters the area, so the resistance rises by a factor of 4, not 2.

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Q29 Answer **B**

Why B is right

The two lower 10Ω resistors are in parallel:

$1/R_{\text{p}} = 1/10 + 1/10 = 2/10 \rightarrow R_{\text{p}} = 5.0\Omega$

This combination is in series with the upper 10Ω resistor:

$R_{\text{total}} = 10 + 5.0 = 15\Omega$

I is marked in the main circuit, before the junction, so it is the total current:

$I = V/R = 12/15 = 0.80\ \text{A}$

Why the rest are wrong

• A — 0.40 A is the current in one of the parallel branches (half of 0.80 A).

• C — 1.8 A treats the network as 10Ω in series with 10Ω in parallel with 20Ω.

• D — 3.6 A treats all three resistors as being in parallel $(R = 3.3\Omega)$.

Watch out for

A. Reading I as a branch current. Trace the wire: the arrow sits between the supply and the first junction, so all the current passes through it.

Q30 Answer **D**

Why D is right

In a series circuit:

• there is only one path, so the current is the same at every point — the supply current equals the current in each component;

• energy is conserved, so the e.m.f. of the supply equals the sum of the p.d.s across the components.

Why the rest are wrong

• A, B — "the sum of the currents in each component" is the rule for a parallel circuit.

• A, C — "equal to the p.d. across each component" is the parallel rule for potential difference.

Watch out for

B. It pairs the parallel current rule with the correct series p.d. rule, so half of it looks right. Check both columns before choosing.

Q31 Answer **C**

Why C is right

The two resistors of a potential divider are in series, so the same current I passes through both:

$V_1 = IR_1$ and $V_2 = IR_2 \rightarrow V_1/V_2 = R_1/R_2$

The supply p.d. is therefore shared in direct proportion to the resistances — the larger resistor takes the larger share.

Why the rest are wrong

• A, B — the current is not split at all; the resistors are in series, so the current is the same in both.

• D — sharing in inverse proportion to resistance is how current divides between two resistors in parallel.

Watch out for

D. The "bigger resistance gets less" instinct is imported from parallel circuits. In a potential divider, bigger resistance means more p.d.

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Q32 Answer **A**

Why A is right

Water is a conductor, and damp skin has a much lower resistance than dry skin. A socket in a damp bathroom therefore creates a serious risk of a large current passing through a person — an electric shock hazard. (This is why UK-style bathrooms allow only shaver sockets, and why sockets are kept out of wet areas.)

Why the rest are wrong

• B — a dark cupboard is inconvenient, not dangerous.

• C — sockets close to the floor are normal domestic practice.

• D — warmth alone is not a hazard; it is the water in a kitchen or bathroom that matters.

Watch out for

D. "Kitchen" sounds risky because kitchens contain water too — but the option specifies only that the place is warm, which is harmless. Read what the option actually says.

Q33 Answer **A**

Why A is right

The field pattern of a bar magnet must satisfy three rules:

• lines run from N to S outside the magnet (and S to N inside), so every arrow outside points away from N and towards S;

• lines are continuous and never cross;

• lines emerge from the ends of the magnet as well as curving round the sides.

Only A satisfies all three: the arrows on the upper and lower loops point from the N end towards the S end, arrows leave the left (N) end and enter the right (S) end.

Why the rest are wrong

• B — the correct shape, but every arrow is reversed (running S to N outside the magnet).

• C, D — the lines at the ends curl round and re-enter the same pole. A field line can never leave and return to the same pole; it must run from N to S.

Watch out for

B. Identical geometry to A with the arrows the wrong way round. Check one arrow at the N pole — it must point away from N.

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Q34 Answer **C**

Why C is right

The original situation: current to the right, magnetic field downwards in the plane of the page. Fleming's left-hand rule (first finger = field, second finger = current, thumb = force) gives a force into the page. So F is into the page, and we need an arrangement giving a force out of the page.

C: a beam of positive particles moving to the right is a conventional current to the right (unchanged), but the field arrows point upwards — the field has been reversed. One reversal reverses the force, so the force is out of the page

Why the rest are wrong

• A — the current is reversed and the field is reversed. Two reversals cancel, so the force is still into the page.

• B — a beam of negative particles moving left is a conventional current to the right; the field is still downwards. Nothing has changed, so the force is into the page.

• D — the field is parallel to the current, so there is no force at all $(F = 0)$, not a reversed force.

Watch out for

B. Forgetting that conventional current is opposite to the flow of negative charge. B looks like a double reversal and is actually no reversal at all.

Q35 Answer **C**

Why C is right

nucleon number = number of protons + number of neutrons

atomic (proton) number of nitrogen = 7

nucleon number = $7 + 8 = 15$

Why the rest are wrong

• A — 7 is the proton number.

• B — 8 is the neutron number.

• D — $22 = 7 + 8 + 7$, i.e. the electrons have been counted as well.

Watch out for

D. Nucleon number counts only the particles in the nucleus. Electrons are not nucleons and never appear in the top number.

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Q36 Answer **C**

Why C is right

The chain of cause and effect in a magnetic circuit breaker:

Q — a (too large) current passes through the coil wound on the iron bar

S — the current magnetises the iron bar, turning it into an electromagnet

P — the electromagnet becomes strong enough to attract the pivoted arm and pull that end down

R — the arm rotates about the pivot, the contacts separate and the circuit is broken

So the order is Q → S → P → R.

Why the rest are wrong

- A — begins with the magnet acting before there is any current to create it.
- B — begins correctly with Q, but pulls the arm before the bar has been magnetised.
- D — begins with the contacts opening, which is the result, not the cause.

Watch out for

B. It has the right first step, which makes it feel safe. Every ordering question of this type is decided by finding the cause of each step: the arm cannot move until the bar is magnetised.

Q37 Answer **A**

Why A is right

Isotopes of the same element have the same number of protons (same atomic number, so the same chemical element) but different numbers of neutrons, and therefore different mass numbers.

Why the rest are wrong

- B — same mass number, different atomic number describes isobars, which are different elements.
- C — the first half is right (same number of protons), but isotopes are not necessarily radioactive: $^{12}\mathrm{C}$ and $^{13}\mathrm{C}$ are both stable isotopes of carbon.
- D — same number of neutrons but different numbers of protons means different elements, not isotopes.

Watch out for

C. A statement that is half true is still false. Radioactivity is not part of the definition of an isotope.

Q38 Answer **C**

Why C is right

Alpha decay (nucleon number − 4, proton number − 2):

$^{238}_{92}\mathrm{U} \rightarrow Th + He$

Beta decay (nucleon number unchanged, proton number + 1, because a neutron becomes a proton):

$^{234}_{90}Th \rightarrow Pa + \mathrm{e}$

So the protactinium isotope is $^{234}_{91}Pa$.

Why the rest are wrong

- A — $^{234}_{89}Pa$ subtracts 1 from the proton number in the beta decay instead of adding 1.
- B — $^{242}_{90}Pa$ adds 4 to the nucleon number in the alpha decay instead of subtracting 4.
- D — $^{235}_{92}Pa$ changes neither number correctly.

Watch out for

A. Beta-minus emission increases the proton number by one: the nucleus loses a negative charge, so its positive charge goes up. The mass number does not change.

Q39 Answer **B**

Why B is right

Turns (ideal transformer):

$N_s/N_p = V_s/V_p$

$N_s = 400 \times (200/1000) = 80$ turns

Current (ideal [redacted] power in = power out):

$V_p I_p = V_s I_s$

$1000 \times 0.50 = 200 \times I_s$

$I_s = 500/200 = 2.5$ A

This is a step-down transformer: the voltage falls by a factor of 5, so the current rises by a factor of 5.

Why the rest are wrong

• A — the turns are right, but 0.10 A has the current falling as well as the voltage. That would mean the output power is only 20 W from a 500 W input.

• C, D — 2000 turns inverts the ratio; a transformer that reduces the voltage must have fewer turns on the secondary.

Watch out for

A. Assuming the current changes the same way as the voltage. In an ideal transformer power is conserved, so voltage down means current up.

Q40 Answer **D**

Why D is right

An alpha particle is a helium nucleus (2 protons + 2 neutrons), so its charge is $+2e$ — positive.

It is very strongly ionising and therefore loses energy quickly: it is stopped by a few centimetres of air or a sheet of paper, so it cannot penetrate a few sheets of paper.

Why the rest are wrong

• A, B — a negative charge describes a beta-minus particle (an electron).

• C — the charge is right but the penetrating power is that of beta radiation, which passes through paper and is stopped by a few millimetres of aluminium.

Watch out for

C. Remembering "alpha is positive" and then guessing the penetration. Fix the ladder once: alpha — paper; beta — a few mm of aluminium; gamma — thick lead.

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