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TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2016 O-Level Physics Paper 1

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ANSWER KEY

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WORKED SOLUTIONS

Q1 Answer **C**

Why C is correct

A human hair is roughly 0.05 mm to 0.1 mm across, that is 5×10^{-5} m to 1×10^{-4} m.

To the nearest power of ten, this is 10^{-4} m.

Why the rest are wrong

A — 10^{-8} m is about the size of a large molecule. It is far too small to see.

B — 10^{-6} m (1 μm) is about the size of a bacterium, far too small to see with the naked eye. You can see a hair.

D — 10^{-2} m is 1 cm. That is the thickness of a pencil, not a hair.

Watch out for

B. Hair looks very thin, so students go too small. A quick check: about ten hairs laid side by side span roughly 1 mm, so one hair is about 0.1 mm = 10^{-4} m.

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Q2 Answer **D**

Why D is correct

Volume of copper = (area of copper in the cross-section) × (length of pipe).

The area of copper comes from the outer and inner diameters: area = $\pi(R^2 - r^2)$. Vernier calipers measure both. The outside jaws take the outer diameter (about 2 cm) and the inside jaws take the inner diameter.

The pipe is several metres long, so the length is measured with a tape.

Why the rest are wrong

A — A micrometer cannot measure an inner diameter, and a metre rule is awkward for a length of several metres.

B — Neither instrument can measure a length of several metres.

C — Neither a rule nor a tape can measure the diameters to the precision needed. The wall of a 2 cm pipe is only about 1 mm thick, so small errors in the diameters give large errors in the area.

Watch out for

A and B. A micrometer is the most precise instrument, so it is tempting. But it has no inside jaws, so it cannot measure the inner diameter. The inside jaws of the vernier calipers are what decide this question.

Q3 Answer **C**

Why C is correct

At the moment of release the speed is zero, so there is no air resistance. The only force is the weight, so both objects start with acceleration g.

As they speed up, air resistance grows. Terminal velocity is reached when air resistance equals weight.

The two objects have the same size and shape, so they meet the same air resistance at the same speed. The heavier object needs a larger air resistance to balance its weight, so it must reach a higher speed first.

Why the rest are wrong

A — The initial acceleration is g for both. With no air resistance at the start, a = W/m = g whatever the mass.

B — Both parts are wrong: the initial accelerations are equal, and the terminal velocities are not.

D — The heavier object needs more air resistance to balance its weight, so its terminal velocity is higher.

Watch out for

D. Students remember that "all objects fall at the same rate" and apply it to the whole fall. It is true only while air resistance is negligible, which is at the start. Once air resistance matters, the heavier object falls faster.

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Q4 Answer **C**

Why C is correct

Distance = area under the speed–time graph.

Accelerating: distance = ½ × 16 s × 20 m/s = 160 m.

Decelerating: distance = ½ × 18 s × 20 m/s = 180 m.

Constant speed: distance = 960 m − 160 m − 180 m = 620 m.

t = 620 m ÷ 20 m/s = 31 s.

Why the rest are wrong

A — 14 s comes from 960 ÷ 20 − 16 − 18 = 14. This wrongly assumes the train covers every section at 20 m/s.

B — 23 s does not come from 620 m ÷ 20 m/s. Work out the distances first, then the time.

D — 48 s = 960 ÷ 20. This is the time if the train moved at 20 m/s all the way, and ignores the speeding up and slowing down.

Watch out for

A. Subtracting the 16 s and 18 s from 48 s treats the train as moving at full speed while it speeds up and slows down. During those stages its average speed is only 10 m/s, so work out the distances with triangle areas first.

Q5 Answer **A**

Why A is correct

Mass is the amount of matter in the camera. It does not change when the camera goes into orbit.

Weight = mg. At this height g = 5.0 N/kg, so the camera still has a weight, half of its weight on the ground.

The camera stays at eye level because the camera, the astronaut and the space station are all falling towards the Earth together (in orbit), not because the weight has vanished.

Why the rest are wrong

B — The question tells you g = 5.0 N/kg at this height, so the weight is not zero. The camera only appears weightless.

C — Mass never disappears. The amount of matter in the camera is the same everywhere.

D — Mass never disappears. You cannot have weight without mass, because weight = mg.

Watch out for

B. "Weightless" astronauts make students think there is no weight in orbit. The data line g = 5.0 N/kg is there to tell you the weight is real. The floating happens because everything falls together.

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Q6 Answer **A**

Why A is correct

The nail does not move, so the three forces are in equilibrium. Drawn head to tail, they must form a closed triangle, with the arrows going round in one direction.

W acts vertically downwards. T acts along the string, upwards at 40° to the vertical and to the right. R must close the triangle.

In A, T runs upwards to the right at 40° to the vertical, W runs down from the head of T, and R runs from the foot of W back to the tail of T. The arrows go round in one direction, so the resultant is zero.

R points to the left. This is right: T pulls the nail to the right, away from the wall, so the wall must push to the left.

Why the rest are wrong

B — T is drawn pointing down and to the left. The string pulls up and to the right, so the direction of T is wrong. The arrows also do not follow round the triangle.

C — T and R both start from the same corner and W and R both end at the same corner. The arrows do not follow round the triangle, so the forces do not add to zero. R also points to the right, which the wall cannot supply.

D — T is drawn pointing down and to the left, which is the wrong direction for the pull of the string. The arrows do not follow round the triangle either.

Watch out for

C. It has T in the right direction, so it looks right at a glance. In a force triangle for equilibrium, check that the arrows chase each other round the triangle. In C, two arrows meet head to head, so the triangle is not closed.

Q7 Answer **C**

Why C is correct

Density = mass ÷ volume.

Volume of the sheet = area × thickness = 10 000 cm^2 × 0.011 cm = 110 cm^3 (0.11 mm = 0.011 cm).

Density = 80 g ÷ 110 cm^3 = 0.73 g/cm^3.

Why the rest are wrong

A — 0.073 g/cm^3 comes from converting 0.11 mm to 0.11 cm (10 times too thick).

B — 0.088 g/cm^3 is 10 times too small. Numbers like 0.088 and 0.88 come from multiplying 0.11 and 8 together, not from dividing mass by volume.

D — 0.88 g/cm^3 is 0.11 × 8, not mass ÷ volume. The correct value is 80 g ÷ 110 cm^3 = 0.73 g/cm^3.

Watch out for

A. The units are mixed: area in cm^2 and thickness in mm. Convert the thickness to cm before multiplying: 0.11 mm = 0.011 cm.

The label 80 g/m^2 is not needed. It matches the data given: 10 000 cm^2 = 1 m^2, and the sheet has a mass of 80 g.

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Q8 Answer **B**

Why B is correct

The sand is much denser than the water, so most of the mass is low down in the bottle. The centre of gravity starts at Y, in the sand just below the water.

When more sand is added, it settles on top of the sand already there. The top of the sand layer rises, and the water is pushed higher up the bottle.

Mass is being added above Y, and the water is being moved upwards. Both raise the centre of gravity, so it moves from Y towards X.

Why the rest are wrong

A — The centre of gravity cannot start at X, which is in the water. The heavy sand below keeps it lower down.

C — The new sand is not added below the old sand. It goes on top, above Y, so it raises the centre of gravity instead of lowering it.

D — The centre of gravity cannot start at Z, at the very bottom. The water and the upper part of the sand are above Z.

Watch out for

C. "Heavy material lowers the centre of gravity" is the usual rule, so students expect the centre of gravity to drop. That rule is for adding mass low down. Here the new sand lands on top of the old sand, above the present centre of gravity, so it raises it.

Q9 Answer **B**

Why B is correct

The pressure difference between the pump and the atmosphere is balanced by the difference in height between the two oil surfaces.

Pressure difference = hρg, where h is the vertical distance between the two oil levels. That distance is B.

Why the rest are wrong

A — A runs from the top of the tube to the oil level on the pump side. It is not a difference between the two oil levels.

C — C runs from the top of the tube to the oil level on the open side. The top of the glass has nothing to do with the pressure.

D — D runs from the lower oil level to the bottom of the U-tube. Oil at the same level in both arms is at the same pressure, so this oil does not affect the difference.

Watch out for

C. It is the longest length ending at the lower oil level, so it looks like a "height of oil". The pressure difference depends only on the vertical gap between the two oil surfaces.

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Q10 Answer **C**

Why C is correct

X is 20 m below the surface and Y is 26 m below the surface, so Y is 6 m deeper.

Pressure difference = hρg = 6 m × 1000 kg/m³ × 10 N/kg = 60 000 Pa.

Atmospheric pressure acts on both points, so it cancels in the difference.

Why the rest are wrong

A — 6000 Pa leaves out a factor of 10. Check: 6 × 1000 × 10 = 60 000.

B — 46 000 Pa comes from adding the two depths (20 m + 26 m = 46 m) and leaving out g. The difference needs the depths subtracted: 26 m − 20 m = 6 m.

D — 160 000 Pa = 60 000 Pa + 100 000 Pa. This adds atmospheric pressure to a difference. It cancels out when you subtract.

Watch out for

D. The atmospheric pressure is given, so students feel they must use it. It is needed for the total pressure at X or at Y, but not for the difference between them.

Q11 Answer **B**

Why B is correct

Load = mg = 1000 kg × 10 N/kg = 10 000 N.

The pressure is the same throughout the fluid, so F ÷ 100 cm² = 10 000 N ÷ 500 cm².

F = 10 000 N × 100 ÷ 500 = 2000 N.

Why the rest are wrong

A — 200 N uses 1000 N for the load. It forgets to multiply the mass by g.

C — 5000 N is half the load. The area ratio is 100 : 500 = 1 : 5, so F is one fifth of 10 000 N.

D — 50 000 N multiplies by the area ratio instead of dividing. The small piston needs the smaller force.

Watch out for

D. Getting the ratio upside down. The point of a hydraulic jack is that a small force on the small piston lifts a large load on the large piston, so F must be smaller than the load.

Q12 Answer **A**

Why A is correct

Power = work done ÷ time = force × distance ÷ time.

In every diagram the load moves 1.0 m along the force in 10 s. So the power is largest where the force is largest.

A has the largest force, 12 N. Power = 12 N × 1.0 m ÷ 10 s = 1.2 W.

Why the rest are wrong

B — Power = 8 N × 1.0 m ÷ 10 s = 0.8 W. Lifting is not special; the rope still does force × distance.

C — Power = 10 N × 1.0 m ÷ 10 s = 1.0 W. The slope does not change the work done by the rope, because the load moves along the rope.

D — Power = 4 N × 1.0 m ÷ 10 s = 0.4 W.

Watch out for

B or C. Students assume lifting or pulling up a slope must take more power. The work done by the rope depends only on the rope's force and the distance moved along it, and both are given.

Q13 Answer **B**

Why B is correct

The ball falls in a vacuum, so all the gravitational potential energy lost becomes kinetic energy.

From X to Y the ball falls h, so KE at Y = mgh.

From X to Z it falls 2h, so KE at Z = 2mgh.

Ratio = 2mgh ÷ mgh = 2.

Why the rest are wrong

A — √2 is the ratio of the speeds, not of the kinetic energies. KE ∝ v^2, so KE doubles when v increases by √2.

C — 2√2 does not follow. It mixes the speed ratio with the energy ratio.

D — 4 would be right if the speed doubled. The speed only increases by a factor of √2.

Watch out for

A. Working with speed instead of energy. It is quicker to use energy: kinetic energy gained = potential energy lost, and that is proportional to the distance fallen.

Q14 Answer **C**

Why C is correct

KE = ½mv^2.

P: ½ × 1.0 kg × (1.0 m/s)² = 0.50 J.

Q: ½ × 2.0 kg × (0.50 m/s)² = 0.25 J.

0.50 J is twice 0.25 J.

Why the rest are wrong

A — This is the wrong way round. P has twice the kinetic energy of Q.

B — Same kinetic energy would follow if KE ∝ mv. It does not: speed is squared.

D — Four times would follow from comparing v^2 alone and ignoring that Q has twice the mass.

Watch out for

B. The two objects have equal momentum (1.0 kg m/s each), so students expect equal kinetic energy. Kinetic energy depends on v^2, not v.

Q15 Answer **C**

Why C is correct

This is Brownian motion. The air molecules are too small to see and move fast in all directions.

At any instant, more molecules hit a smoke particle on one side than on the other. The particle is pushed that way, then another way a moment later. This gives the jerky, random path.

Why the rest are wrong

A — Vibrations inside a smoke particle do not push the whole particle from place to place.

B — Smoke particles are spread out and rarely meet each other. The movement is continuous, not only when two particles collide.

D — The light only makes the particles visible. The motion happens in the dark too.

Watch out for

B. It sounds like the kinetic model, but it has the wrong particles. The visible smoke particles are pushed by the invisible air molecules.

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Q16 Answer **B**

Why B is correct

P: heating the gas raises the average speed of the molecules. Faster molecules hit the walls harder, and they reach the walls more often. The collisions are harder and more frequent.

Q: the temperature is constant, so the molecules have the same average speed and hit no harder. In a smaller volume they reach the walls more often. The collisions are more frequent.

Why the rest are wrong

A — In Q the temperature is constant, so the molecules do not hit any harder.

C — In P the faster molecules reach the walls more often, not less often. In Q the hits are not harder.

D — In P the collisions become more frequent, not less frequent.

Watch out for

A. Students link a higher pressure with harder collisions every time. Harder collisions need faster molecules, which needs a higher temperature. In Q only the frequency changes.

Q17 Answer **A**

Why A is correct

The molecules of a liquid are close together with strong attractive forces between them. This holds them together, so the liquid keeps a fixed volume.

The molecules are not locked in fixed positions. They can slide past each other and move throughout the liquid, so the liquid flows and takes the shape of its container.

Why the rest are wrong

B — Vibrating about fixed positions describes a solid. That would give a fixed shape.

C — Small forces between molecules describes a gas. That would not keep a fixed volume.

D — Small forces with fixed positions does not describe any state of matter.

Watch out for

C. Liquids flow, so students assume the forces between the molecules must be weak. The forces are strong enough to keep the molecules close together (fixed volume), but the molecules can still move past each other.

Q18 Answer **D**

Why D is correct

Silver is a metal and a very good conductor of heat. Thermal energy from the boiling water is conducted quickly through the wall of the cup, so the outer surface is almost as hot as the water.

Why the rest are wrong

A — A shiny surface is a poor emitter of infra-red radiation, not a good one. In any case, how well a surface emits does not make it hot to touch.

B — The water is not changing state inside the cup, so no latent heat is given out. It is simply hot.

C — Convection moves heat around inside the water. It does not explain why the outside of the cup is hot.

Watch out for

A. A shiny surface is a poor emitter and a poor absorber of radiation. The question is about conduction through the metal wall.

Q19 Answer **A**

Why A is correct

A temperature scale needs a physical property that changes steadily with temperature.

The e.m.f. of a thermocouple (two different metals joined) changes with temperature. So does the volume, or length, of a liquid column. Both are used in thermometers.

Why the rest are wrong

B — Resistance of a metal wire works, but the mass of an object does not change with temperature.

C — Volume of a liquid column works, but mass does not change with temperature.

D — Volume of a liquid column works, but the weight of a trapped gas does not change with temperature. It is the pressure or volume of a gas that changes.

Watch out for

D. "Trapped gas" suggests a gas thermometer, which is a real thermometer. What changes with temperature is the gas's pressure or volume, not its weight.

Q20 Answer **D**

Why D is correct

Removing thermal energy lets the particles move closer together and be held more tightly.

Condensation (gas to liquid) and solidification (liquid to solid) both release energy, so both happen when thermal energy is removed.

Why the rest are wrong

A — Boiling and melting both need thermal energy to be supplied.

B — Solidification is right, but boiling needs thermal energy to be supplied.

C — Condensation is right, but melting needs thermal energy to be supplied.

Watch out for

B or C. Each has one correct change. Check both halves of the option.

Q21 Answer **B**

Why B is correct

The flat part of the graph is where the wax melts. It lasts from 3 minutes to 7 minutes, which is 4 minutes.

Thermal energy supplied = 12 000 J/minute × 4 minutes = 48 000 J.

Specific latent heat of fusion = 48 000 J ÷ 200 g = 240 J/g.

Why the rest are wrong

A — 180 J/g uses the first 3 minutes (12 000 × 3 ÷ 200). During that time the solid wax is warming up, not melting.

C — 420 J/g uses 7 minutes (0 to 7 minutes). That includes heating the solid wax before it melts.

D — 600 J/g uses 10 minutes, which is the whole graph.

Watch out for

C. Reading the time at the end of the flat section (7 minutes) instead of its length (7 − 3 = 4 minutes). Latent heat is only absorbed while the temperature is constant.

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Q22 Answer **C**

Why C is correct

The water at the bottom is warmed (1).

The warm water expands (4). Its mass is unchanged but its volume is larger.

So its density decreases (2).

The less dense water rises and cooler, denser water moves down to take its place (3).

Why the rest are wrong

A — Density cannot decrease before the water expands. The expansion is the reason the density falls.

B — The water cannot rise before it has become less dense. Rising is the result, not a cause.

D — The water rises only after its density has decreased, so 2 must come before 3.

Watch out for

A. Students know "less dense water rises" and may place expansion at the end. Expansion is the step that causes the density to fall, so it comes straight after the warming.

Q23 Answer **D**

Why D is correct

A compression is where the coils are closest together. There are compressions at Y and at Z. X is in the middle of a rarefaction.

The wavelength is the distance between two neighbouring compressions, so it is Y to Z.

Each coil makes 4.0 oscillations in 2.0 s, so frequency = 4.0 ÷ 2.0 s = 2.0 Hz.

Why the rest are wrong

A — X to Y is from a rarefaction to the next compression, which is half a wavelength. And 0.5 = 2.0 s ÷ 4.0 is the period in seconds, not the frequency.

B — The frequency is right, but X to Y is only half a wavelength.

C — The wavelength is right, but 0.5 is the period (in s), not the frequency (in Hz).

Watch out for

B. X is labelled and looks like a feature, so students start the wavelength there. Measure from one compression to the next compression (Y to Z).

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Q24 Answer **A**

Why A is correct

The frequency does not change when a wave passes into shallower water. It is set by the source.

Frequency = v ÷ λ = 9.6 cm/s ÷ 1.2 cm = 8.0 Hz.

Speed in shallow water = fλ = 8.0 Hz × 0.80 cm = 6.4 cm/s.

Why the rest are wrong

B — 8.0 is the frequency in Hz, not the speed.

C — 9.6 cm/s is the speed in deep water. The waves slow down in shallow water, as the shorter wavelength shows.

D — 14 cm/s comes from 9.6 × 1.2 ÷ 0.80. That assumes the speed increases as the wavelength falls, which is the wrong way round.

Watch out for

D. Scaling the speed the wrong way. Speed and wavelength change in the same proportion, because the frequency is fixed. A shorter wavelength means a slower wave.

Q25 Answer **B**

Why B is correct

Refractive index n = sin i ÷ sin r = sin 55° ÷ sin 33° = 0.819 ÷ 0.545 = 1.50.

Also n = (speed of light in vacuum) ÷ (speed of light in glass).

Speed in glass = 3.0×10^8 m/s ÷ 1.50 = 2.0×10^8 m/s.

Why the rest are wrong

A — 1.8×10^8 m/s is too small. It does not come from v = c ÷ n with n = sin 55° ÷ sin 33° = 1.50.

C — 3.0×10^8 m/s is the speed in a vacuum. Light slows down in glass.

D — 4.5×10^8 m/s multiplies by n instead of dividing. Nothing travels faster than light in a vacuum.

Watch out for

D. Multiplying by the refractive index. Light always travels more slowly in glass than in a vacuum, so the answer must be less than 3.0×10^8 m/s.

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Q26 Answer **A**

Why A is correct

The ray meets the top face. The normal to the top face is vertical, and the ray is at 40° to the horizontal, so the angle of incidence there is 90° − 40° = 50°.

50° is greater than the critical angle, 44°, so the ray is totally internally reflected.

The reflected ray meets the right-hand face at an angle of incidence of 40°. This is less than 44°, so the ray leaves the block. It bends away from the normal as it goes from the block into air, so it leaves at more than 40° to the normal.

Why the rest are wrong

B — The ray leaving the right-hand face bends towards the normal. Going from the block into air, it must bend away from the normal.

C — The ray leaves through the top face. At 50° incidence, which is more than 44°, it must be totally internally reflected.

D — The ray leaves through the top face. At 50° incidence, which is more than 44°, it must be totally internally reflected.

Watch out for

C or D. The 40° looks like the angle of incidence on the top face, and 40° is less than 44°. The 40° is measured from the normal to the side face. Against the normal to the top face the angle is 50°.

Q27 Answer **D**

Why D is correct

Gamma rays and ultra-violet are both electromagnetic waves. All electromagnetic waves travel at the same speed in a vacuum, 3.0×10^8 m/s.

Why the rest are wrong

A — They are in different parts of the electromagnetic spectrum, so they have different frequencies. Gamma rays have a much higher frequency.

B — Different frequencies at the same speed means different wavelengths. Gamma rays have a much shorter wavelength.

C — All electromagnetic waves are transverse.

Watch out for

A. Students sometimes think "same type of wave" means same frequency. They share their speed in a vacuum, not their frequency or wavelength.

Q28 Answer **B**

Why B is correct

A compression is a region where the air particles are squashed together, so the pressure is highest.

The highest point on the graph is B.

Why the rest are wrong

A — At A the pressure is at its normal (undisturbed) value, between a compression and a rarefaction.

C — At C the pressure is at its normal value, between a compression and a rarefaction.

D — D is the lowest pressure. That is a rarefaction.

Watch out for

D. Mixing up the two. Compression = particles close together = high pressure. Rarefaction = particles spread out = low pressure.

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Q29 Answer **C**

Why C is correct

In a metal, only the free electrons (negative charges) can move. The positive charges are fixed in the metal lattice.

Positively charged Y attracts electrons in X, so some electrons move to the right side of X, nearest Y. The left side of X is left with a positive charge.

X and Y do not touch, so no charge moves between them. The positive charges on Y stay where they are.

Why the rest are wrong

A — X and Y do not touch, so no charge can pass from Y to X.

B — Positive charges do not move in a metal. The left side becomes positive because electrons have left it.

D — This is the wrong way round. The positive charges in X do not move. The negative charges do.

Watch out for

B. It gives the right final arrangement (positive on the left, negative on the right), so it looks correct. Only the electrons move; the positive side is where electrons have left.

Q30 Answer **C**

Why C is correct

The lamp works at its rated values, so current $I = P \div V = 24\ W \div 12\ V = 2.0\ A$.

Time $t = 25\ h \times 3600\ s/h = 90\ 000\ s$.

Charge $Q = It = 2.0\ A \times 90\ 000\ s = 180\ 000\ C$.

Why the rest are wrong

A — 3000 C uses t in minutes ($25 \times 60 = 1500$ min) and multiplies by 2.0 A. Time must be in seconds.

B — 45 000 C uses $I = V \div P = 0.5$ A instead of $I = P \div V$.

D — 1 100 000 C uses 12 in place of the current ($12 \times 90\ 000 = 1\ 080\ 000$). 12 V is the voltage; the current is 2.0 A.

Watch out for

A. Converting hours to minutes instead of seconds. For $Q = It$, the time must be in seconds: 1 h = 3600 s.

Q31 Answer **D**

Why D is correct

Energy $E = VIt = 240\ V \times 4.0\ A \times 300\ s = 288\ 000\ J \approx 290\ 000\ J$.

The time must be in seconds: 5.0 min = 300 s.

Why the rest are wrong

A — $3.2\ J = 240 \times 4.0 \div 300$. It divides by the time instead of multiplying.

B — $190\ J \approx 240 \times 4.0 \div 5.0$. It divides by the time (in minutes) instead of multiplying.

C — 4800 J uses $t = 5.0$ instead of 300 s. The time must be in seconds.

Watch out for

C. Leaving the time in minutes. $240 \times 4.0 \times 5.0 = 4800$, which is exactly option C.

Q32 Answer **D**

Why D is correct

I_1 is the total current, which splits between the two branches, so $I_1 = I_2 + I_3$. That makes I_1 larger than both.

The two branches have the same p.d. across them. The I_2 branch has one lamp and the I_3 branch has two lamps in series, so the I_3 branch has twice the resistance.

So $I_2 = 2I_3$, and $I_1 > I_2 > I_3$.

Why the rest are wrong

A — The current splits at the junction, so I_1 cannot equal I_2 or I_3.

B — I_2 and I_3 would be equal only if the two branches had equal resistance. The lower branch has two lamps.

C — This puts I_3 larger than I_2. The branch with more resistance carries less current.

Watch out for

C. Students sometimes think the branch with more lamps "takes more current". The branch with the larger resistance carries the smaller current.

Q33 Answer **D**

Why D is correct

Two 4 Ω resistors in parallel: 1/R = 1/4 + 1/4, so R = 2 Ω.

Add the 4 Ω resistor in series: 2 Ω + 4 Ω = 6 Ω.

Why the rest are wrong

A — Three in series: 4 + 4 + 4 = 12 Ω.

B — Three in parallel: 1/R = 3/4, so R = 1.3 Ω.

C — 8 Ω in parallel with 4 Ω: R = (8 × 4) ÷ (8 + 4) = 2.7 Ω.

Watch out for

C. It also has two resistors in series and one on its own, so it looks like D. In C the pair is in series and the single resistor is in parallel with it; in D the pair is in parallel and the single resistor is in series.

Q34 Answer **C**

Why C is correct

A lamp lights only when there is a complete circuit through the live and neutral wires.

If the neutral wire is disconnected, the circuit is broken, so no current flows and the lamp does not light.

Why the rest are wrong

A — The earth wire does not carry current in normal use. The lamp still lights, but the case is no longer protected.

B — A fuse rated too high still lets current through. It is unsafe, but the lamp still lights.

D — Double insulation is a safety feature. It needs no earth wire and does not stop the lamp working.

Watch out for

A. Students think every wire in the plug is needed for the appliance to work. The earth wire is only a safety path; the current flows through the live and neutral wires.

Q35 Answer **B**

Why B is correct

X goes to the switch. The switch must be in the live wire, so that turning it off disconnects the appliance from the high voltage. X is live.

Y goes to the other end of the heating element and completes the circuit, so Y is neutral.

Z is joined to the metal case, so Z is earth.

Why the rest are wrong

A — Y cannot be earth, because it carries the current back from the heating element. Z joined to the case cannot be neutral.

C — The switch would be in the neutral wire. When switched off, the heating element would still be at mains voltage. The metal case would also be joined to the live wire.

D — The switch would be in the neutral wire. When switched off, the heating element would still be live, which is dangerous.

Watch out for

D. It gets the earth right. The appliance would still work with the switch in the neutral wire, which is why this is a safety question. The switch (and the fuse) must be in the live wire.

Q36 Answer **D**

Why D is correct

A compass needle must be a permanent magnet, so it must keep its magnetism.

Steel is a hard magnetic material: once magnetised, it stays magnetised.

Why the rest are wrong

A — Aluminium is not a magnetic material. It cannot be magnetised.

B — Brass is not a magnetic material. It cannot be magnetised.

C — Iron is a soft magnetic material. It is magnetised easily but also loses its magnetism easily, so it would not stay a magnet.

Watch out for

C. Iron is the magnetic material students think of first. Iron is used where the magnetism must switch on and off (electromagnets, transformer cores). A permanent magnet needs steel.

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Q37 Answer **A**

Why A is correct

The field of the magnet runs from N to S, left to right.

Viewed from the eye, the current in the side of the coil near N flows away from the viewer, and the current in the side near S flows towards the viewer.

Fleming's left-hand rule: the side near N is pushed down and the side near S is pushed up. As seen by the viewer, the coil turns anticlockwise.

Once the coil has turned through 90°, its plane is vertical. The forces on the two sides still act down and up, but now they pass through the axis, so there is no turning effect. With no commutator to reverse the current, the coil settles here: $\theta = 90°$.

Why the rest are wrong

B — The direction is right, but at 180° the forces would turn the coil back. It stops where the turning effect is zero, at 90°.

C — The rotation is anticlockwise. Check Fleming's left-hand rule on one side of the coil.

D — The rotation is anticlockwise, and the coil stops at 90°, not 180°.

Watch out for

B. Students picture a motor, which keeps turning. A motor needs a commutator to reverse the current every half turn. This coil has none, so it only turns until its plane is at 90° to the field.

Q38 Answer **D**

Why D is correct

Each compass needle points along the magnetic field at its position. The field there is the combined field of the two wires.

When both currents reverse, the field of each wire reverses everywhere. So the combined field reverses at every point.

All three needles turn round through 180°.

Why the rest are wrong

A — Reversing the currents reverses the field, so the needles must move.

B — The field reverses at every point, not only at the middle compass.

C — The field reverses at every point, including at the middle compass, where the two wires' fields add together.

Watch out for

B or C. Students think the fields of the two wires might cancel at some positions and cancel again after reversing. Reversing both currents simply reverses the whole field pattern, so every needle turns round.

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Q39 Answer **B**

Why B is correct

This is Lenz's law. The induced e.m.f. in the secondary coil always acts to oppose the change in magnetic field that produces it.

Why the rest are wrong

A — The core is iron because iron is easily magnetised and demagnetised. It carries the changing magnetic field from the primary to the secondary coil. Its electrical conductivity is not the reason; the core is laminated to reduce currents in it.

C — A transformer only works with a.c. It changes the size of an alternating voltage. It does not convert a.c. to d.c.

D — A transformer does not work with d.c. A steady current gives no changing magnetic field, so no e.m.f. is induced.

Watch out for

A. Iron is a metal and conducts electricity, so the reason sounds right. The core is chosen for its magnetic property: it is easily magnetised and demagnetised.

Q40 Answer **C**

Why C is correct

The transmission wires have a large resistance, so there is a p.d. across them. The p.d. across that resistance is proportional to the current in it.

With X and Y both on, the lamps are in parallel and the total current is large. So the p.d. across the wires is large, leaving less for the lamps.

When X is switched off, the total current falls. The p.d. across the wires falls, so the voltage across Y increases.

Y's resistance is unchanged, so the power supplied to Y ($P = V^2/R$) increases too.

Why the rest are wrong

A — Removing a lamp reduces the total current, so less voltage is lost in the wires. The voltage across Y goes up, not down.

B — The voltage across Y goes up, and the power goes up with it.

D — The voltage across Y goes up and Y's resistance is the same, so the power must go up too.

Watch out for

D. Students remember that lamps in parallel get the full supply voltage whatever else is switched on. That is only true when the wires have negligible resistance. Here they have a high resistance, so the current drawn affects the voltage left for the lamps.

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