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OCR GCSE Physics B

Twenty First Century Science J259

CHAPTER P2

Sustainable Energy

Higher Tier

Systematic lesson notebook

Teaching and worked examples, lesson practice, a chapter assessment, complete indicative answers and a knowledge organiser.

Read the explanation, try the practice independently, then use the answers to improve your reasoning and calculations.

Name _____ Class _____

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How to use this notebook

Follow the lesson sequence. Each assessed lesson includes an explanation, a worked example and practice. Keep your working and units visible. Check the numbered lesson answers after attempting the questions; equivalent correct scientific wording can receive credit.

Specification reference: Cambridge OCR J259, Version 5.0, July 2026. References identify the intended outcomes; this independent notebook does not replace the official specification.

Foundation and Higher

Higher contains shared outcomes and Higher-only requirements. Some additional questions simply increase demand within shared content; they do not imply that the entire lesson is Higher-only.

Separate Physics content belongs to J259 at both tiers unless the specification explicitly marks an outcome as Higher-only.

Working and marking

Use the maximum mark shown for each question. The answer sections are indicative classroom guidance, not official OCR mark schemes. Credit valid alternatives and avoid awarding the same idea twice. This assessment is diagnostic; no GCSE grade boundary is implied.

Numerical tariffs, example data and model situations are classroom examples, not current prices or real safety estimates.

Lesson map

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2	Power ratings, time and energy use	P2.1.2
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Use lesson numbers to locate the matching practice and answers. Pagination differs between editions because the assessed scope differs.

Lesson map continued

Lesson	Focus	References
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Use lesson numbers to locate the matching practice and answers. Pagination differs between editions because the assessed scope differs.

Lesson 1 Energy transfers by electric current

P2.1.1 | Higher

describe how energy in chemical stores in batteries, or in fuels at power stations, is transferred by an electric current to domestic devices.

Energy can be stored chemically in a battery or fuel. In a power station, energy from a fuel is transferred through a sequence of processes before an electric current transfers energy through the grid.

Electricity is a transfer pathway, not an energy store. A motor transfers energy mechanically to moving parts; a heater transfers energy to thermal stores.

A precise answer names both the starting store and the destination or effect. Avoid saying that electricity is 'used up'.

Worked example

A battery drives a motor that lifts a load. Chemical store of battery → electrical transfer → mechanical work by motor → gravitational potential store of load–Earth system. Include heating of the motor and surroundings in a complete account.

Lesson 1 practice

Energy transfers by electric current

Answer independently. Show a clear method, substitutions and units for calculations.

1. Write a complete store-transfer-store description from fuel at a power station to a lifting motor in a home. [4]

2. Explain why an electric current can transfer energy without charge being used up. [3]

3. Compare the energy transfers in an electric heater and an electric motor. [4]

4. Explain why a power station fuel should be described as an energy store rather than 'energy itself'. [3]

5. Give one example of mechanical working and one of heating in an electrical device. [2]

Practice total 16 marks

Self check Write one correction you made and why it matters.

Lesson 2 Power ratings, time and energy use

P2.1.2 | Higher

explain the relationship between appliance power rating, time in use and changes in stored energy.

Power is the rate of energy transfer. A 2000 W device transfers 2000 J each second.

For the same operating time, a higher-power appliance transfers more energy. For the same energy transfer, a lower-power appliance must operate for longer.

Power does not tell you total energy use unless time is also known.

Worked example

A 750 W appliance runs for 40 s. E = Pt = 750 × 40 = 30,000 J. The same transfer at 1500 W takes 30,000/1500 = 20 s.

Lesson 2 practice

Power ratings, time and energy use

Answer independently. Show a clear method, substitutions and units for calculations.

1. A 2.4 kW kettle and 800 W microwave run for the same time. Compare their energy transfers quantitatively. [3]

2. Explain how a low-power device can transfer more total energy than a high-power device. [3]

3. A motor transfers 36 kJ in 15 s. Calculate its power. [3]

4. A 60 W lamp and 600 W heater transfer the same energy. Compare their operating times. [3]

5. Explain the difference between power and energy using units. [3]

Practice total 15 marks

Self check Write one correction you made and why it matters.

Lesson 3 Energy transferred E = Pt, kWh and cost

P2.1.3 | Higher

apply energy transferred = power × time in joules or kilowatt-hours.

Use E = Pt. Pair units correctly: W × s gives J; kW × h gives kWh.

For domestic energy, convert watts to kilowatts and minutes to hours before calculating kWh.

Cost = energy in kWh × tariff. Write units beside each converted value before substituting to avoid mixing scales.

Worked example

A 1.2 kW heater runs for 45 minutes. Time = 45/60 = 0.75 h; E = 1.2 × 0.75 = 0.90 kWh. At an invented tariff of 30 p/kWh, cost = 0.90 × 30 = 27 p.

Lesson 3 practice

Energy transferred: E = Pt, kWh and cost

Answer independently. Show a clear method, substitutions and units for calculations.

1. A 2.2 kW kettle transfers 0.165 kWh. Calculate time in minutes. [4]

2. A 45 W lamp transfers the same energy as a 450 W fan used for 40 min. Find lamp time. [4]

3. A 1.6 kW heater runs 75 min/day for 30 days at 31 p/kWh. Calculate cost. [5]

4. An appliance transfers 5.4 MJ in 45 min. Calculate average power in kW. [4]

5. Give two unit checks before using E = Pt. [2]

Practice total 19 marks

Self check Write one correction you made and why it matters.

Lesson 4 Conservation of energy and dissipation

P2.1.4-5 | Higher

describe energy transfers in systems and explain that dissipated energy is stored in less useful ways.

In a closed system, total energy does not change. Energy is transferred between stores, but is not created or destroyed.

Dissipated energy spreads into thermal stores of the surroundings and becomes less useful for the intended purpose.

Use the phrase 'less useful' rather than 'lost' unless you explain that total energy is still conserved.

Worked example

A motor receives 800 J and lifts a load by 600 J of gravitational potential energy. The remaining 200 J is transferred to other stores, mainly by heating. 800 = 600 + 200 J: no energy has disappeared.

Lesson 4 practice

Conservation of energy and dissipation

Answer independently. Show a clear method, substitutions and units for calculations.

1. Explain conservation and dissipation for a car braking. [4]

2. A motor receives 8.0 kJ and transfers 5.6 kJ mechanically. Calculate dissipated energy. [2]

3. Explain why dissipated energy becomes less useful without ceasing to exist. [3]

4. Compare the energy-transfer description of an efficient and inefficient heater. [3]

5. Write a precise closed-system statement for an electric motor and its surroundings. [3]

Practice total 15 marks

Self check Write one correction you made and why it matters.

Lesson 5 Reducing unwanted transfer and building insulation

P2.1.6-7 | Higher

explain ways of reducing unwanted energy transfer and describe effects of wall thickness and thermal conductivity on cooling.

Lubrication reduces unwanted transfer caused by friction. Thermal insulation reduces energy transfer by heating to the surroundings.

Thicker walls or insulation generally reduce the rate of cooling. Materials with lower thermal conductivity transfer energy more slowly.

For an insulation investigation, control water volume, starting temperature, container, exposed area and timing. Change only the insulation variable.

Worked example

Compare two insulating sleeves with the same thickness. Use identical containers and equal masses of water at the same starting temperature. Record temperature at equal time intervals in the same surroundings, repeat, and compare cooling curves over the same temperature range.

Lesson 5 practice

Reducing unwanted transfer and building insulation

Answer independently. Show a clear method, substitutions and units for calculations.

1. Design an investigation comparing two insulation materials using cooling curves. [6]

2. Explain why a whole cooling curve is more informative than final temperature alone. [3]

3. A curve has gradient -1.8 °C/min initially and -0.7 °C/min later. Explain. [3]

4. Distinguish random and systematic error in this investigation. [4]

5. Explain how thickness and thermal conductivity affect rate of energy transfer. [3]

Practice total 19 marks

Self check Write one correction you made and why it matters.

Lesson 6 Efficiency calculations

P2.1.8 | Higher

calculate energy efficiency for any energy transfer; Higher also describes ways to increase efficiency.

Efficiency = useful energy transferred / total energy transferred. Give as a decimal or multiply by 100 for a percentage.

The useful and dissipated outputs together equal the input if all relevant transfers are included.

Foundation assesses the calculation. The specification marks 'describe ways to increase efficiency' as Higher-only.

Worked example

A device receives 240 J and transfers 180 J usefully. Efficiency = 180/240 = 0.75 = 75%. The other 60 J is dissipated. Always divide useful output by total input, not by wasted energy.

Lesson 6 practice

Efficiency calculations

Answer independently. Show a clear method, substitutions and units for calculations.

1. A motor receives 4.8 kJ and transfers 3.6 kJ mechanically. Calculate percentage efficiency. [3]

2. A machine is 72% efficient and gives 18 kJ useful output. Calculate input. [4]

3. Suggest and explain two ways to increase the efficiency of a bicycle drive system. [4]

4. Explain why increasing useful output does not automatically prove efficiency increased. [3]

5. A heater transfers 2.0 MJ, of which 1.7 MJ heats the room. Calculate efficiency and dissipated energy. [4]

Practice total 18 marks

Self check Write one correction you made and why it matters.

Lesson 7 Sankey diagrams

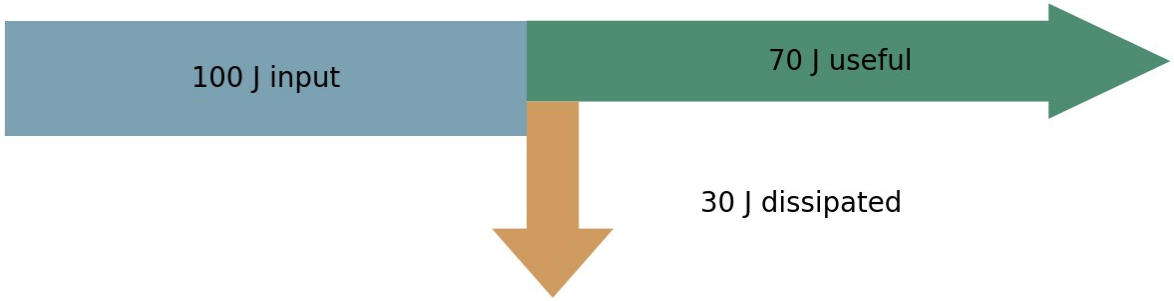
P2.1.9 | Higher

interpret and construct Sankey diagrams to show that energy is conserved.

A Sankey diagram uses arrow width to represent the amount of energy transferred.

The input arrow equals the sum of useful and dissipated output arrows.

Label arrows with both the type of transfer and, where given, numerical energy values.



Worked example

For a 100 J input with 65 J useful output, dissipation = 35 J. Draw input width 20 mm, useful width 13 mm and waste width 7 mm. Widths, not just arrow lengths, represent energy.

Lesson 7 practice

Sankey diagrams

Answer independently. Show a clear method, substitutions and units for calculations.

1. A 2.5 kJ input is 64% efficient. Calculate useful and dissipated outputs for a Sankey diagram. [4]

2. Explain how a Sankey diagram demonstrates conservation of energy. [3]

3. A Sankey diagram's outputs sum to 950 J from a 1000 J input. Give two possible explanations. [3]

4. Construct numerical Sankey arrow labels for a 100 J input with 35% dissipation. [3]

5. Explain why arrow direction alone is not enough to show efficiency. [2]

Practice total 15 marks

Self check Write one correction you made and why it matters.

Lesson 8 Energy resources and electricity generation

P2.2.1-3 | Higher

describe main energy resources, distinguish renewable/non-renewable, and compare how they generate electricity.

Main resources: fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, tides and the Sun.

Renewable resources are replenished on a human timescale; non-renewable resources are finite.

Many power stations heat water so steam turns a turbine connected to a generator. Wind, hydro and tidal systems can drive turbines directly. Solar photovoltaic panels generate electricity without a turbine.

Worked example

A town compares wind and gas. Wind has no fuel combustion during operation but variable output; gas can provide controllable output but burns finite fuel and emits CO_2. A useful comparison uses the same delivered energy and considers storage or backup.

Lesson 8 practice

Energy resources and electricity generation

Answer independently. Show a clear method, substitutions and units for calculations.

1. Compare nuclear and gas generation using reliability, carbon emissions and response to demand. [6]

2. Explain why renewable does not mean no environmental impact. [3]

3. A wind farm is rated 120 MW but averages 42 MW. Calculate average as % of rated. [3]

4. Explain why a national grid uses a mix of resources. [4]

5. Evaluate tidal, diesel and wind for a remote island and state extra data needed. [6]

Practice total 22 marks

Self check Write one correction you made and why it matters.

Lesson 9 a.c., d.c. and UK mains

P2.2.4 | Higher

recall UK mains as a.c. at 50 Hz and about 230 V, and explain the difference between direct and alternating voltage.

UK domestic mains is alternating voltage, about 230 V at 50 Hz.

In d.c., the polarity does not reverse. In a.c., the potential difference changes direction repeatedly.

A 50 Hz supply completes 50 cycles each second.

Worked example

A 50 Hz supply completes 50 cycles in 1 s. Period T = 1/f = 1/50 = 0.020 s. The nominal 230 V value is an effective mains value, not the peak height of a voltage-time sine wave.

Lesson 9 practice

a.c., d.c. and UK mains

Answer independently. Show a clear method, substitutions and units for calculations.

1. Sketch and label one cycle of an a.c. voltage-time graph. [3]

2. Calculate the period of a 50 Hz supply. [3]

3. Compare a.c. mains and d.c. battery voltage. [3]

4. Explain why 'a.c. electrons travel from the station to the house and back 50 times each second' is misleading. [3]

5. A supply is 25 Hz. Calculate the period. [3]

Practice total 15 marks

Self check Write one correction you made and why it matters.

Lesson 10 The National Grid and transformers

P2.2.5 | Higher

recall the use of transformers to transfer power at high voltage and then reduce voltage for local/domestic use.

The National Grid transfers electrical power from power stations to consumers.

Transformers increase voltage before long-distance transmission and decrease it again before local/domestic use.

High-voltage transmission reduces energy losses in cables. Detailed transformer equations belong mainly to later P3 learning, not this P2.2 outcome.

Worked example

A grid line delivers fixed power. Increasing its voltage by a factor of 10 reduces current by a factor of 10. Since cable heating power is I^2R, with unchanged cable resistance it becomes 1/100 of the original.

Lesson 10 practice

The National Grid and transformers

Answer independently. Show a clear method, substitutions and units for calculations.

1. Explain the causal chain: high voltage -> lower current -> reduced cable heating. [4]

2. Why does a high current increase energy dissipation in transmission cables? [3]

3. Explain qualitatively how current changes when voltage rises for the same power. [3]

4. Why must voltage be reduced before domestic use? [2]

5. Distinguish energy, power and voltage in a National Grid explanation. [4]

Practice total 16 marks

Self check Write one correction you made and why it matters.

Lesson 11 Live, neutral and earth wires

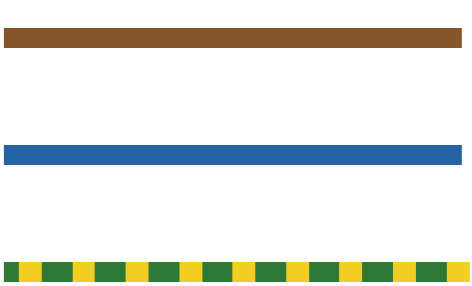
P2.2.6 | Higher

recall wire functions and potential differences, and explain mains hazards.

Live wire: high alternating potential relative to Earth. Neutral wire: close to Earth potential and completes the circuit. Earth wire: protective connection to the metal case.

A live wire can remain dangerous even with a switch open because the supply side of the live wire remains at high potential.

A connection between live and an earthed object can produce a large current and serious shock/heating hazard.



Live
Brown • alternates at high p.d.

Neutral
Blue • near Earth potential

Protective earth
Green and yellow • fault path

Worked example

If live touches a correctly earthed metal case, fault current can flow through the protective earth conductor. A suitable fuse or circuit breaker disconnects the live supply. The earth wire and protective device work together; the earth wire normally carries no operating current.

Lesson 11 practice

Live, neutral and earth wires

Answer independently. Show a clear method, substitutions and units for calculations.

1. Explain how earthing reduces risk if live touches a metal case. [4]

2. A switch is placed in the neutral wire. Explain the hazard when switched off. [4]

3. Compare live, neutral and earth potentials and relate them to risk. [4]

4. Explain why protective devices complement an earth wire. [3]

5. Write a complete fault-path explanation from live contact to protective action. [4]

Practice total 19 marks

Self check Write one correction you made and why it matters.

Lesson 12 Energy-use patterns, sustainability and decisions

P2.2.7 | Higher

explain patterns and trends in energy-resource use in domestic, workplace and national contexts.

Energy-use patterns can change with technology, price, policy, population and demand.

A good trend statement identifies direction and supports it with data. Avoid simply quoting two values without explaining the pattern.

Energy decisions consider reliability, cost, environmental effects, resource availability, public acceptance and future demand. Different groups may reasonably choose differently.

Worked example

Renewable share rises from 20% to 30%. That is a 10 percentage-point increase, or a 50% relative increase in share. If total electricity output changes, these percentages alone do not determine the change in renewable kWh.

Lesson 12 practice

Energy-use patterns, sustainability and decisions

Answer independently. Show a clear method, substitutions and units for calculations.

1. A graph shows renewable share rising but large year-to-year variation. Explain what can and cannot be concluded. [4]

2. Evaluate replacing a gas station with intermittent wind capacity using four factors. [6]

3. Distinguish a scientific claim from a value judgement in energy policy. [3]

4. Explain why percentage share alone may not show change in absolute generation. [3]

5. Suggest two uncertainties or missing data that could alter a policy decision. [4]

Practice total 20 marks

Self check Write one correction you made and why it matters.

End of chapter assessment

Higher | Total 50 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

1. Describe a complete energy-transfer chain from fuel at a power station to an electric motor lifting a load. [4]

2. A 2.4 kW appliance runs for 35 min. Calculate energy transferred in kWh. [4]

3. A machine transfers 18 kJ usefully from 24 kJ input. Calculate efficiency and describe one suitable way to increase it. [4]

4. Explain conservation and dissipation for a braking vehicle. [4]

5. Design an investigation comparing two insulation materials using cooling curves. [6]

End of chapter assessment continued

Higher | Total 50 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

6. A 2.5 kJ input is 64% efficient. Calculate the useful and dissipated outputs for a Sankey diagram. [4]

7. Compare nuclear, wind and gas generation using reliability, emissions and response to demand. [6]

8. Explain a.c. and d.c. and why a live wire can remain dangerous when a mains switch is open. [5]

9. Explain why the National Grid uses high transmission voltages. [4]

10. Evaluate a proposal to replace a gas power station with wind generation using evidence and trade-offs. [5]

End of chapter assessment continued

Higher | Total 50 marks across all assessment parts

Answer every question. Use additional paper for diagrams or longer explanations when needed.

11. Explain why percentage-share data alone may not show whether total renewable electricity generation increased. [4]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 1 Energy transfers by electric current

1. Fuel chemical store decreases; heating increases internal energy of steam; steam drives a turbine and generator; current transfers energy through the grid to a motor; the motor lifts the load, increasing its gravitational potential energy. Credit a coherent chain with the required stores and pathways, up to four marks. [maximum 4]

2. Charge circulates and is conserved; the supply does work on charge, and components transfer energy from that charge to other stores. Charge is not consumed as fuel. [maximum 3]

3. Both receive energy by electrical working. A heater transfers it mainly into internal energy of material and surroundings. A motor does mechanical work, increasing kinetic or gravitational potential energy, while also dissipating some energy as heating. [maximum 4]

4. Fuel contains a chemical energy store. A change in the fuel and its surroundings releases energy through transfers. Energy is a conserved quantity, rather than a material identified with the fuel. [maximum 3]

5. Mechanical: a motor lifting a load. Heating: a current-carrying resistance element warming water. [maximum 2]

Lesson 2 Power ratings, time and energy use

1. 2.4 kW = 2400 W. Energy ratio = 2400/800 = 3 at equal time; the kettle transfers three times as much. [maximum 3]

2. Energy depends on duration as well as power. A sufficiently long run time can outweigh the smaller power; for example 100 W for 10 h exceeds 500 W for 1 h. [maximum 3]

3. 36 kJ = 36,000 J. P = E/t = 36,000/15 = 2400 W = 2.4 kW. [maximum 3]

4. At equal energy, time is inversely proportional to power. The 60 W lamp needs 600/60 = 10 times as long. [maximum 3]

5. Energy is the amount transferred, measured in joules. Power is the transfer rate, measured in watts; 1 W = 1 J/s. [maximum 3]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 3 Energy transferred E = Pt, kWh and cost

1. Use t = E/P = 0.165/2.2 = 0.075 h. Convert to minutes: 0.075 × 60 = 4.5 min. [maximum 4]

2. Fan energy = 450 × 40 in W min. Lamp time = (450 × 40)/45 = 400 min = 6 h 40 min. [maximum 4]

3. Time = 75/60 = 1.25 h/day; energy = 1.6 × 1.25 × 30 = 60 kWh. Cost = 60 × 31 = 1860 p = £18.60. [maximum 5]

4. E = 5.4×10^6 J; t = 45 × 60 = 2700 s. P = E/t = 2000 W = 2.0 kW. [maximum 4]

5. For joules, use W and s; for kWh, use kW and h. Convert prefixes and minutes before substitution. [maximum 2]

Lesson 4 Conservation of energy and dissipation

1. The car's kinetic energy decreases. Friction transfers energy to internal stores of brakes, tyres, road and surroundings. It spreads out and becomes less useful for driving. Total energy remains conserved. [maximum 4]

2. 8.0 − 5.6 = 2.4 kJ dissipated. [maximum 2]

3. Dissipated energy spreads through many particles in the surroundings. It is difficult to collect for the intended task. The total energy still exists in those stores. [maximum 3]

4. For the same input, an efficient water heater transfers a larger fraction to the water. A less efficient one transfers more to unwanted surroundings. Usefulness depends on the specified system and task. [maximum 3]

5. For a closed motor-plus-surroundings system, total energy is constant. A decrease in the supply store equals increases in mechanical and internal energy stores, accounting for all transfers. [maximum 3]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 5 Reducing unwanted transfer and building insulation

1. Use identical lidded containers with equal water masses and starting temperatures. Fit equal thicknesses/areas of the two materials. Record temperature at fixed intervals using checked thermometers in the same room conditions. Repeat complete trials and compare mean cooling curves or cooling rates over the same temperature interval. Use safe hot-water handling. [maximum 6]

2. The curve shows changing rate, unusual readings and differences at several times. One final temperature conceals the earlier pattern and can be affected by one reading. [maximum 3]

3. The magnitude of cooling gradient decreases from 1.8 to 0.7 °C/min. The temperature difference from the room decreases, reducing the rate of energy transfer. [maximum 3]

4. Random: varying thermometer readings or timing produce scatter; repeat and average. Systematic: a thermometer zero offset biases readings; check/calibrate against a reference. Repeats do not remove that offset. [maximum 4]

5. With other conditions fixed, lower conductivity reduces conduction rate and greater thickness also reduces it. A thinner or higher-conductivity layer transfers energy faster. [maximum 3]

Lesson 6 Efficiency calculations

1. Efficiency = 3.6/4.8 × 100 = 75%. [maximum 3]

2. Input = useful/efficiency = 18/0.72 = 25 kJ. Dissipated energy would be 7 kJ. [maximum 4]

3. Lubricate chain and bearings to reduce frictional heating. Align/maintain the chain and gears to reduce rubbing and unwanted mechanical resistance. Link each measure to reduced unwanted transfer. [maximum 4]

4. Efficiency is useful output divided by input. Output can rise while input rises by a larger proportion, giving lower efficiency. [maximum 3]

5. Efficiency = 1.7/2.0 = 0.85 = 85%; dissipated energy = 2.0 − 1.7 = 0.30 MJ. [maximum 4]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 7 Sankey diagrams

1. Useful = 0.64 × 2.5 = 1.6 kJ; dissipated = 2.5 − 1.6 = 0.90 kJ. [maximum 4]

2. Input width represents total incoming energy. Output widths represent useful and dissipated transfers, and their sum equals the input width, showing conservation. [maximum 3]

3. An unlabelled transfer of 50 J may be omitted, or a numerical/scaling error may have occurred. If energy is being stored during the interval, that change must also be accounted for. [maximum 3]

4. For the stated 100 J input: useful output 65 J and dissipated output 35 J. Widths sum to 100 J and show a 65% efficiency. [maximum 3]

5. Direction identifies the type of output, but efficiency depends on the relative amount. The ratio of useful output width to input width is required. [maximum 2]

Lesson 8 Energy resources and electricity generation

1. Both can supply controllable, reliable electricity when available. Nuclear has low operational CO_2 but long construction times, waste and generally slower output changes. Gas emits CO_2 but can usually start and change output faster; fuel supply and price matter. [maximum 6]

2. Renewable describes replenishment, not absence of impacts. Dams flood habitats, turbines affect landscapes/wildlife, and manufacture uses materials and energy. [maximum 3]

3. 42/120 × 100 = 35%. [maximum 3]

4. A mix balances intermittent and controllable output, seasonal/daily demand, fuel security, costs and environmental impacts. It reduces dependence on one resource. [maximum 4]

5. Tidal is predictable but site-dependent and cyclic; wind is low-carbon but variable; diesel is controllable but needs imported fuel and emits pollution/CO_2. A mixed system with storage may be suitable. Obtain local resource/output profiles, demand, costs and ecological constraints before a firm choice. [maximum 6]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 9 a.c., d.c. and UK mains

1. Draw voltage vertically and time horizontally, with a smooth alternating curve above and below zero. Label one full repeat interval T and show both polarities. Do not label a 230 V mains value as the peak. [maximum 3]

2. T = 1/f = 1/50 = 0.020 s = 20 ms. [maximum 3]

3. Mains voltage alternates polarity and has frequency 50 Hz. A battery supplies a p.d. of fixed polarity, giving one-direction current in a simple resistive circuit. [maximum 3]

4. Electrons in the conductors oscillate locally rather than travelling from station to house and back each cycle. The energy transfer propagates through the circuit; 50 Hz describes waveform repetition. [maximum 3]

5. T = 1/25 = 0.040 s. [maximum 3]

Lesson 10 The National Grid and transformers

1. Power P = VI. At fixed transferred power, raising V lowers I. Cable loss P_loss = I^2R therefore falls, leaving less unwanted heating and more useful power at the destination. [maximum 4]

2. The cable has resistance. Current transfers energy to its internal energy store by heating; the rate is I^2R, so increasing current greatly increases dissipation. [maximum 3]

3. For fixed P, I = P/V. Doubling voltage halves current; a tenfold rise reduces current to one tenth. [maximum 3]

4. High transmission voltages would present unacceptable shock/insulation demands for domestic appliances. Step-down transformers provide suitable lower supply voltages. [maximum 2]

5. Energy is an amount transferred (J); power is its rate (W); voltage is energy transferred per unit charge (J/C). Raising voltage does not itself mean creating energy. [maximum 4]

Lesson practice answers

Indicative answers. Credit equivalent correct wording, up to the maximum in the question.

Lesson 11 Live, neutral and earth wires

1. Earthing joins the case to Earth via a low-resistance path. A live-to-case fault drives a large fault current. A correctly rated protective device disconnects live, limiting the duration of the hazard. [maximum 4]

2. Opening neutral interrupts the normal circuit but leaves internal parts connected to live. They remain at a dangerous potential relative to Earth. Touching them can complete a path through a person. [maximum 4]

3. Live alternates at about 230 V effective p.d. relative to neutral/Earth. Neutral is near Earth potential in a normal installation, and protective earth is at Earth potential. A large p.d. across a person can drive dangerous current; neutral must not be assumed safe during faults. [maximum 4]

4. An earth wire provides the fault path; the fuse or breaker disconnects when an appropriate fault current flows. Without disconnection a fault could persist. Correct selection and installation matter. [maximum 3]

5. Live contacts metal case → current flows through the case and earth conductor → sufficiently large fault current operates fuse/breaker → live supply disconnects, reducing shock duration. [maximum 4]

Lesson 12 Energy-use patterns, sustainability and decisions

1. There is a long-term rise in share with short-term variation. This does not establish a rise every year or an increase in absolute generation without total-output data. [maximum 4]

2. Compare actual annual energy and availability rather than nameplate capacity alone. Wind reduces operational fuel use/emissions but needs balancing, storage or backup. Consider lifetime costs, grid capacity, habitat/landscape effects and demand. A conditional decision must use local output and demand data. [maximum 6]

3. A scientific claim is testable, such as an estimate of CO_2 per kWh. A value judgement concerns priorities, such as how much landscape change is acceptable; evidence informs but does not alone decide it. [maximum 3]

4. Absolute renewable output = share × total generation. A larger share of a sufficiently smaller total can still be a smaller quantity. [maximum 3]

5. Examples: uncertain future demand/fuel prices; uncertain local wind yield/storage costs. Explain how different values could change cost, reliability or the preferred mix. [maximum 4]

Assessment answers

Indicative marking guidance. Award distinct valid points and correct method, up to the stated maximum.

1. Fuel chemical store decreases; heating increases internal energy of steam; steam drives a turbine and generator; current transfers energy through the grid to a motor; the motor lifts the load, increasing its gravitational potential energy. Credit a coherent chain with the required stores and pathways, up to four marks. [maximum 4]

2. Time = 35/60 h (1). E = Pt (1) = 2.4 × 35/60 (1) = 1.4 kWh (1). [maximum 4]

3. Efficiency = 18/24 = 0.75 = 75% (2). A suitable improvement such as lubrication reduces frictional dissipation (2). [maximum 4]

4. The car's kinetic energy decreases. Friction transfers energy to internal stores of brakes, tyres, road and surroundings. It spreads out and becomes less useful for driving. Total energy remains conserved. [maximum 4]

5. Use identical lidded containers with equal water masses and starting temperatures. Fit equal thicknesses/areas of the two materials. Record temperature at fixed intervals using checked thermometers in the same room conditions. Repeat complete trials and compare mean cooling curves or cooling rates over the same temperature interval. Use safe hot-water handling. [maximum 6]

6. Useful = 0.64 × 2.5 = 1.6 kJ; dissipated = 2.5 − 1.6 = 0.90 kJ. [maximum 4]

7. Nuclear: reliable base output with low operational CO_2, but slower/less flexible output changes and waste (2). Wind: variable output dependent on weather with low operational CO_2 (2). Gas: controllable and generally faster response, but emits CO_2 and depends on fuel (2). [maximum 6]

Assessment answers continued

Indicative marking guidance. Award distinct valid points and correct method, up to the stated maximum.

8. a.c. reverses direction periodically (1), whereas d.c. flows one way (1). An open appliance switch can interrupt the usual current path (1) while live remains at a dangerous p.d. relative to Earth (1); a person contacting live and Earth can complete another path (1). [maximum 5]

9. Power $P = VI$. At fixed transferred power, raising V lowers I. Cable loss $P_{loss} = I^2R$ therefore falls, leaving less unwanted heating and more useful power at the destination. [maximum 4]

10. Compare actual energy output and availability with demand (1). Wind reduces fuel use/operational emissions (1), but is variable and needs balancing or storage/backup (1). Consider whole-life cost and environmental/site effects (1). State a conditional recommendation linked to local evidence and trade-offs (1). [maximum 5]

11. Absolute renewable generation = renewable share × total generation (1). The total may rise or fall (1), so a larger percentage need not mean more kWh (1). Obtain both totals or actual generation values before concluding (1). [maximum 4]

Knowledge organiser

Lesson 1 Energy transfers by electric current

Energy can be stored chemically in a battery or fuel. In a power station, energy from a fuel is transferred through a sequence of processes before an electric current transfers energy through the grid.

Lesson 2 Power ratings, time and energy use

Power is the rate of energy transfer. A 2000 W device transfers 2000 J each second.

Lesson 3 Energy transferred E = Pt, kWh and cost

Use E = Pt. Pair units correctly: W × s gives J; kW × h gives kWh.

Lesson 4 Conservation of energy and dissipation

In a closed system, total energy does not change. Energy is transferred between stores, but is not created or destroyed.

Lesson 5 Reducing unwanted transfer and building insulation

Lubrication reduces unwanted transfer caused by friction. Thermal insulation reduces energy transfer by heating to the surroundings.

Lesson 6 Efficiency calculations

Efficiency = useful energy transferred / total energy transferred. Give as a decimal or multiply by 100 for a percentage.

Lesson 7 Sankey diagrams

A Sankey diagram uses arrow width to represent the amount of energy transferred.

Lesson 8 Energy resources and electricity generation

Main resources: fossil fuels, nuclear fuel, biofuel, wind, hydroelectricity, tides and the Sun.

Retrieval task Explain each idea without notes, then check it. For calculations, state the equation and SI units.

Knowledge organiser continued

Lesson 9 a.c., d.c. and UK mains

UK domestic mains is alternating voltage, about 230 V at 50 Hz.

Lesson 10 The National Grid and transformers

The National Grid transfers electrical power from power stations to consumers.

Lesson 11 Live, neutral and earth wires

Live wire: high alternating potential relative to Earth. Neutral wire: close to Earth potential and completes the circuit. Earth wire: protective connection to the metal case.

Lesson 12 Energy-use patterns, sustainability and decisions

Energy-use patterns can change with technology, price, policy, population and demand.

Retrieval task Explain each idea without notes, then check it. For calculations, state the equation and SI units.

Publication notes and references

Independent resource

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Use supervised practical methods approved by the teaching centre. Written activities support, but do not replace, practical experience.